United States Patent

Heyman

[15] **3,700,804**

[45] **Oct. 24, 1972**

[54] **METHOD OF IMPROVING CATHODOCHROMIC SENSITIVITY**

[72] Inventor: **Philip Michael Heyman,** Trenton, N.J.

[73] Assignee: **RCA Corporation**

[22] Filed: **Oct. 8, 1970**

[21] Appl. No.: **79,036**

[52] **U.S. Cl.** .....**178/7.5 D,** 178/DIG. 31, 350/160 R

[51] **Int. Cl.**.....**G02f 1/28**

[58] **Field of Search**....178/5.4 R, 5.4 BD, 7.87, DIG. 31, 178/7.5 D; 313/91; 350/160 P, 160 R

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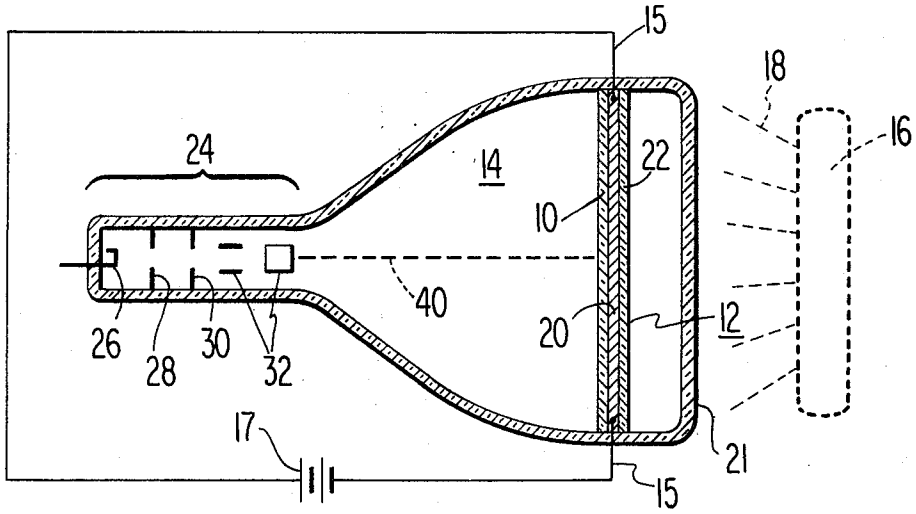
Primary Examiner—Robert L. Richardson
Assistant Examiner—George G. Stellar
Attorney—Glenn H. Bruestle

[57] **ABSTRACT**

Method of operating a display tube comprising a screen including a cathodochromic material. The method comprises steps of heating the cathodochromic material to a temperature below the total erase temperature and writing information on the cathodochromic material (by electron impingement thereon) while the heating is continued.

Heating can be done by the writing electron beam and/or supplemental heating means.

8 Claims, 5 Drawing Figures



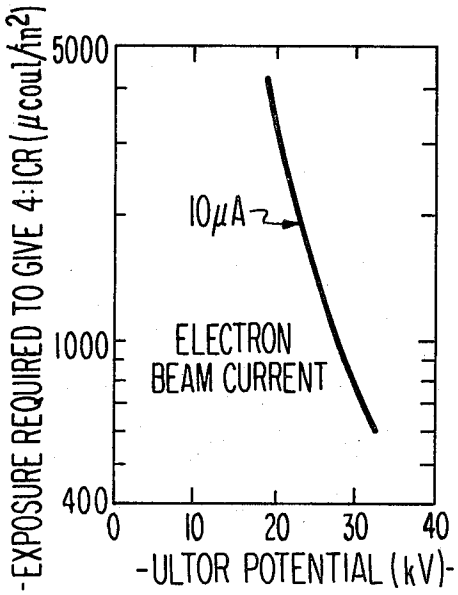


Fig. 1.

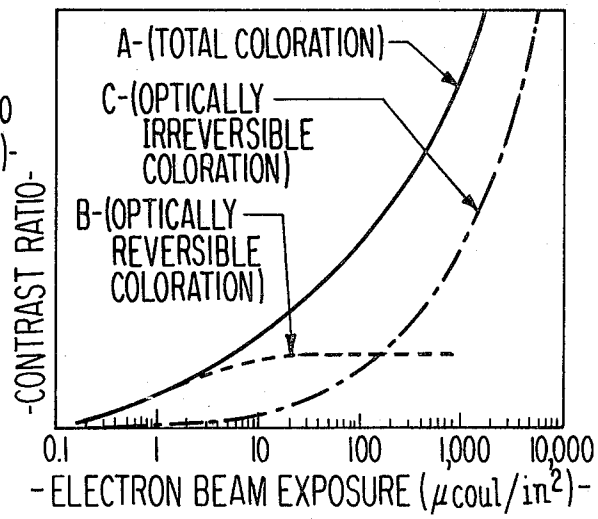


Fig. 2.

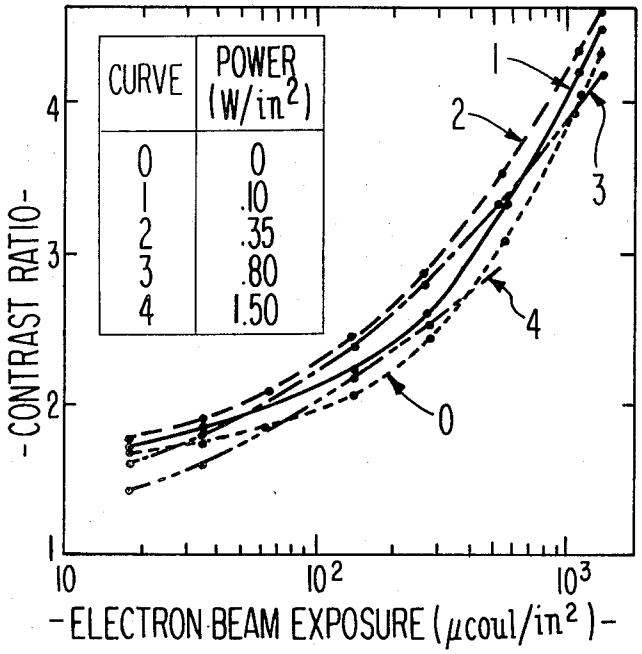


Fig. 3.

INVENTOR.
Philip M. Heyman
BY
ATTORNEY

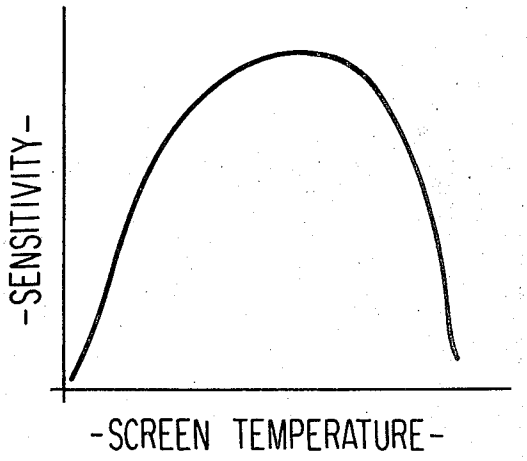


Fig. 4.

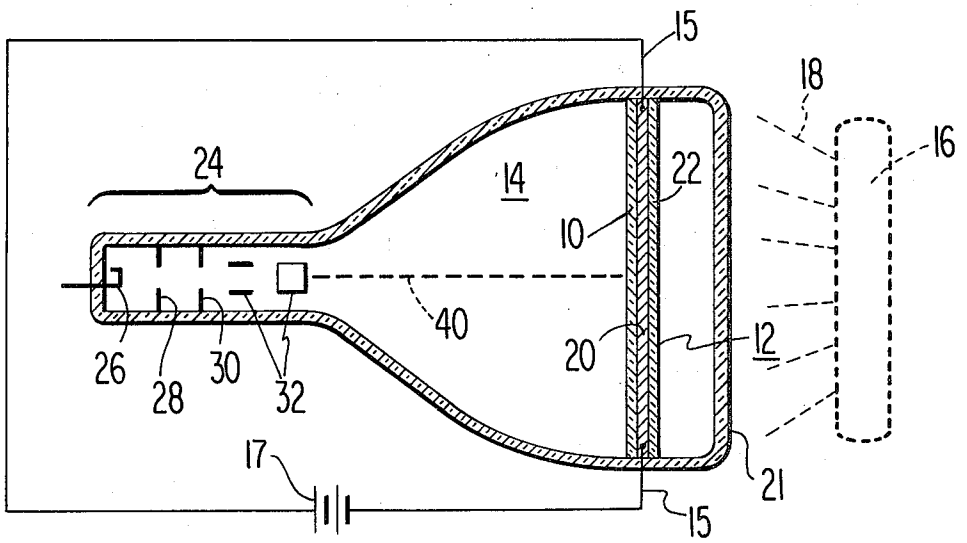


Fig. 5.

INVENTOR.
Philip M. Heyman
BY Leon Gregorian
ATTORNEY

METHOD OF IMPROVING CATHODOCHROMIC SENSITIVITY

STATEMENT

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–586 (72 Stat. 435; 42U.S.C. 2457).

Background of the Invention

The present invention relates to an improved method of operating a cathodochromic display tube.

In the operation of cathodochromic tubes, which are known in the art, a layer of cathodochromic material is impinged upon by electrons, thereby producing optically active centers (i.e., F-centers, or color-centers) in the layer, such centers manifesting themselves as colored areas in a lighted ambient. In this way, an image can be produced in the cathodochromic layer, the electron-impinged areas exhibiting ambient light-reflective properties different from those areas of the cathodochromic layer that are not impinged upon, as is known in the art.

In the operation of prior art cathodochromic tubes, the response of the cathodochromic material to the electron impingement thereon (i.e., the sensitivity of the cathodochromic material) is comparatively slow (i.e., comparatively extended electron exposure times are required to achieve higher contrast ratios), thereby resulting in an inherent limitation on the usefulness of such tubes, particularly in higher-speed writing applications. One approach that might be used in increasing the sensitivity of such tubes involves operating the tube at a high screen (i.e., ultor) voltage so that the electrons strike the cathodochromic material at the screen with greater energy. As shown in FIG. 1, the exposure time required for attaining a contrast ratio of about 4:1 decreases with increasing screen voltage, it being desirable to operate at the highest possible screen (ultor) voltage. The upper limit of screen voltage is limited, however, by the rapid increase in the rate at which x-rays are generated, a screen voltage of 30KV resulting in an undesirable level of x-rays.

SUMMARY OF THE INVENTION

The present invention comprises a method of operating a display tube that includes a screen with cathodochromic material. The method comprises the steps including heating the cathodochromic material to a temperature below the total erase temperature of the cathodochromic material (the total erase temperature being that at which substantially all coloration, both optically reversible and irreversible, can be erased) and writing information on the cathodochromatic material by electron impingement thereon, such heating of the cathodochromic material being carried out during substantially the entire writing operation. In one embodiment, the heating can be carried out during the balance of the time that the tube is in operation, including the reading time.

Such heating may be achieved by means of supplemental heating means (e.g., an electrically conducting film, proximate to the cathodochromic material which film acts as a resistance heater) and/or an electron beam, which beam is also used in the information — writing operation, the supplemental heating means being independent of the electron beam.

The present invention provides, inter alia, a method for imparting to a cathodochromic display tube an increased sensitivity in conjunction with relatively high contrast ratios of images produced in the cathodochromic material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general plot of the amount of exposure of cathodochromic material to an electron beam, that is required for various ultor (screen) potentials in a cathodochromic display tube to achieve a certain image contrast ratio.

FIG. 2 is a general plot of the image contrast ratio that can be attained for various electron beam exposures of cathodochromic material, the total coloration of the image having optically reversible and irreversible components.

FIG. 3 is a general plot of the achievable image contrast ratio against electron beam exposure for various values of power (i.e., heat) applied to the cathodochromic material.

FIG. 4 is a generally representative plot of the sensitivity that is attainable for cathodochromic material as the screen (cathodochromic material) temperature is increased.

FIG. 5 is an axial sectional view schematically illustrating a cathodochromic display tube with which the present invention can be practiced.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The total coloration (by electron impingement thereon) of the cathodochromic material (which is usually included in the form of a layer) in the screen of a display tube comprises two coloration components. One such coloration component is optically reversible; that is, this component of the total coloration produced by electron impingement can be substantially erased by exposure of the colored areas (color centers) of the cathodochromic material to light of a suitable wavelength (e.g., about 5550 angstrom units for sodalite including bromine) and/or by heating. The other such coloration component is substantially immune to optical erasure thereof (e.g., it is optically irreversible) and to thermal erasure at about room temperature, but can be substantially erased by heating the cathodochromic material to a temperature (referred to as the "total erase temperature") substantially above room temperature. Erasure of the optically irreversible coloration component can be carried out with a screen containing sodalite as the cathodochromic material, by heating the screen to about 200° to 300° C., for example.

Referring to FIG. 2, the contribution of the optically reversible (Curve B) and the optically irreversible (Curve C) coloration components to the contrast ratio of an image produced in the layer of cathodochromic material is plotted as a function of electron beam exposure of the cathodochromic material. In FIG. 2, Curve "A" is the total coloration of the cathodochromic material achievable by electron impingement, Curve A being determinable from the Curves B and C. Higher

contrast ratios can be achieved with increased exposure of the cathodochromic material to an electron beam, as shown in FIG. 2, the optically reversible coloration component for sodalite materials generally reaching a maximum contrast ratio of about 1.5-to-one. The optically irreversible coloration component can reach much higher contrast ratios (e.g., about 10 to 1 for sodalite materials including chlorine or bromine) than can the optically reversible component.

In prior art applications, where a comparatively low ultor voltage is employed in a display device to prevent the generation of x-radiation and where contrast ratios exceeding about two-to-one are desired, it is necessary to operate the cathodochromic display tube for comparatively long writing times in order to provide the necessary amount of electron beam exposure (FIG. 2) that will bring about more of the optically irreversible coloration component (Curve C in FIG. 2). The necessity for such longer writing times limits the usefulness of such a cathodochromic tube.

In the operation of a cathodochromic display tube of the type shown in FIG. 5, for example, according to the present invention, the sensitivity of the tube is significantly improved by heating the cathodochromic layer (12 in FIG. 5) of the tube, to an elevated temperature that is significantly less than the total erasing-temperature range for such a cathodochromic screen but, preferably, significantly above room temperature. Then, information is written on the cathodochromic layer 12 of the tube (i.e., coloration, or color-centers, is produced therein) by causing electrons (in the form of an electron beam, shown as 40 in FIG. 5) to impinge upon the cathodochromic layer 12, the electron beam 40 scanning the layer in raster fashion or operating in some other manner familiar to the art. The heating of the cathodochromic material is carried out at substantially all times during the writing (electron impingement) operation. An elevated temperature can also be maintained during the balance of the operating time of the tube, including the information readout operation. When erasure of the written information (i.e., the colored areas of the cathodochromic material of the screen) is desired, the screen temperature is raised to at least total erase temperature of the particular cathodochromic material (e.g., 200° to 300° C. for sodalite materials). The speed of a cathodochromic display device operated according to the present invention, is such as to allow utilization of the tube for higher-speed applications.

The increase in the sensitivity of a cathodochromic tube is generally represented in FIG. 3, where the image contrast ratio achievable with a cathodochromic screen tube operated according to the present invention, is plotted as a function of electron beam exposure of the cathodochromic screen. The image contrast ratio is plotted in FIG. 3 for various power levels (indicated as numerals "0" through "4," which indicate increasing power levels, and, therefore, temperature levels) provided to the screen by the supplemental heating means, which are discussed below. The particular cathodochromic material to which these data (FIG. 3) apply is bromine — containing sodalite. However, other cathodochromic materials, including apatite and other halogen — containing sodalites can be used in practicing the present invention.

It can be seen from FIG. 3 that there is an optimum heat (temperature) level for achieving improved sensitivity of the cathodochromic screen, the optimum heat (e.g., about 100° C.) for sodalite, containing bromine being achievable with a total power level (provided to the screen by both the supplemental heating means used with the screen and the electron beam that impinges on the screen) of about 0.75 watt/square inch of screen area. While a power level of 0.75 watt/in^2 is preferred, there can generally be used a total power value (i.e., power from both the supplemental means and the electron beam) up to about 1.5 watts/square inch for many sodalite materials. For example, with a screen including a cathodochromic layer of sodalite and having an area of about 100 in^2, a power value of about 0.75 watt/square inch can be achieved with a 200μ A electron beam and an ultor voltage of 25KV. (0.05 watt/square inch) which beam will produce about 5 watts of power, the remaining power of approximately 70 watts (0.70 watt/square inch) being providable by the supplemental heating means.

While the conduct of the writing operation with the cathodochromic screen at an elevated temperature causes a reduction in the sensitivity of the optically reversible coloration component (presumably, because of the emptying of filled metastable electron centers), there results an increase, over a range of temperatures, in the sensitivity of the optically irreversible coloration component (presumably, because of an increase in the ion mobility in the cathodochromic material, such an increase being thought to lead to a stabilization of electrons trapped in the optically reversible centers). The gain in sensitivity of the optically irreversible component exceeds the loss in sensitivity of the optically reversible component, so that there results a net increase in the general sensitivity of the cathodochromic screen over a range of temperatures. At screen temperatures above this temperature range, in which there is a net increase in the sensitivity of the cathodochromic material, there is a reduction (FIG. 4) in the sensitivity of the optically irreversible component, too, so that the screen sensitivity might be impaired at these temperatures. The sensitivity of the cathodochromic screen is shown generally in the plot in FIG. 4, the sensitivity first rising with increasing screen temperature, reaching a maximum level, and then decreasing as the screen temperature is further increased.

The cathodochromic layer 10 FIG. 5) of the screen 12 of a display tube 14 can be heated in any one of a number of ways to carry out the present invention. For instance, the heating can be accomplished by the electron (writing) beam that impinges upon the cathodochromic material and/or supplemental heating means. Such supplemental means can be either an infra-red radiator that is internal or external to the tube and that projects such radiation on the screen (an external radiator 16 and the infra-red rays 18 emitted therefrom being shown in dotted line in FIG. 5) or an electrical resistance heater (that is in heat-transfer relationship with the cathodochromic layer 10) in the form of a electrically conducting layer 20 (FIG. 5) at the screen 12, such a layer 20 being, for example, a transparent thin coating of metal located between the layer 10 of cathodochromic material and a transparent sub-

strate 22 (e.g., glass) that acts as the supporting member of the screen 12. Alternatively, the conducting layer 20 can be a transparent electrically conducting material, such as indium oxide or tin oxide, located between the transparent substrate 22 and the cathodochromic layer 10. Where heat is generated in the cathodochromic material by the electron beam that impinges thereon, the above-mentioned heating means can be used to supplement the electron beam. In FIG. 5 the cathodochromic-screen display tube 14 includes means 15 for electrically connecting a source 17 of electrical potential to the conducting layer 20 of the screen 12, a transparent faceplate 21, and an electron gun 24. The electron gun includes a cathode 26, a control electrode 28, an accelerating electrode 30, and electrostatic deflection electrodes 32, according to known practices.

The present invention allows the attainment of higher contrast ratios (i.e., largely those achievable with optically irreversible coloration component) with comparatively short writing times.

I claim:

1. A method of operating a display tube including a screen comprising a layer of cathodochromic material, said cathodochromic material being characterized by the generation of color centers therein in response to electron impingement thereon and the elimination of said color centers by exposure of said cathodochromic material to a total erase temperature, said method comprising:

a. writing information on said cathodochromic material by directing an electron beam thereon; and

b. heating said cathodochromic material to an elevated temperature above room temperature and below said total erase temperature during said writing operation using a heating means independent of said electron beam.

2. The method defined in claim 1, wherein said information is read, said heating being continued during said reading operation.

3. The method defined in claim 1, wherein said cathodochromic material is sodalite and said heating is executed by applying to said cathodochromic material a total power up to about 1.5 watts per square inch of said cathodochromic layer.

4. The method defined in claim 1, wherein said cathodochromic material is sodalite and said elevated temperature is between room temperature and about 200° C.

5. The method defined in claim 1, wherein said heating is executed at least in part by said electron beam.

6. The method defined in claim 1, wherein said cathodochromic material is further characterized by an initial increase in the sensitivity thereof with increasing temperature and a subsequent decrease in said sensitivity with further increase in temperature.

7. The method defined in claim 1, wherein said heating is executed by passing electrical current through a electrically conducting element in heat transfer relationship with said cathodochromic material.

8. The method defined in claim 1, wherein said heating is executed by projecting infra-red radiation on said cathodochromic material.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,700,804 Dated October 24, 1972

Inventor(s) Philip Michael Heyman

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

IN THE CLAIMS:

Claim 1, column 6, line 6: after "operation" insert ---for increasing the contrast ratio achievable by said writing step---.

Signed and sealed this 22nd day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334