United States Patent

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[54] **CATHODE RAY TUBE WITH PHOSPHOR AND SCOTOPHOR LAYERS IN SCREEN**
12 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **313/91,** 313/71; 315/13
[51] **Int. Cl.** **H01j 29/14,** H01j 29/50
[50] **Field of Search** ..... 313/91, 71; 178/7.87; 315/13ST, (Storage tube)

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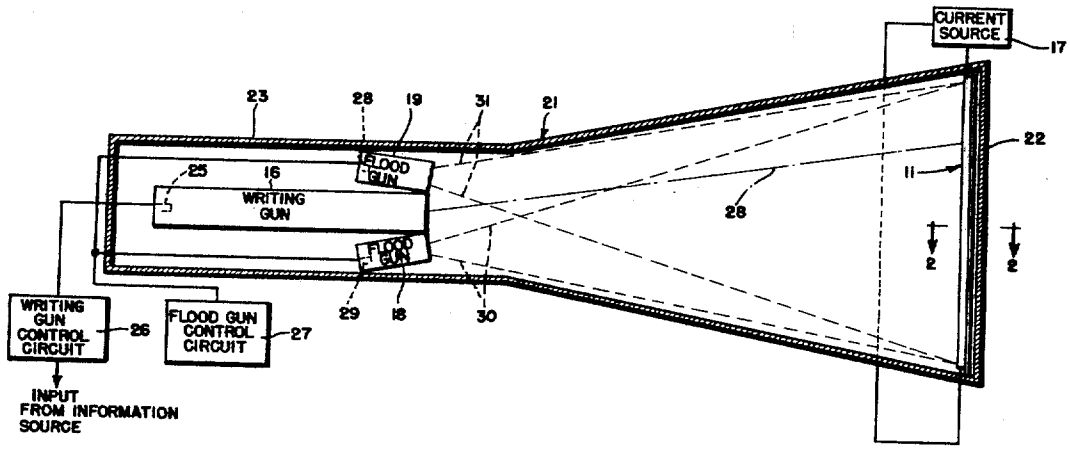
ABSTRACT: A cathode ray tube is described comprising a target screen including a transparent conductive layer, a scotophor layer, and a luminescent layer. A first electron beam is directed at the target screen with sufficient energy to darken preselected areas of the scotophor layer. Such areas are made visible by flooding the luminescent layer with a second electron beam of lower energy. Selected areas also may be further brightened by selectively operating the first beam at an energy level insufficient to darken the scotophor.



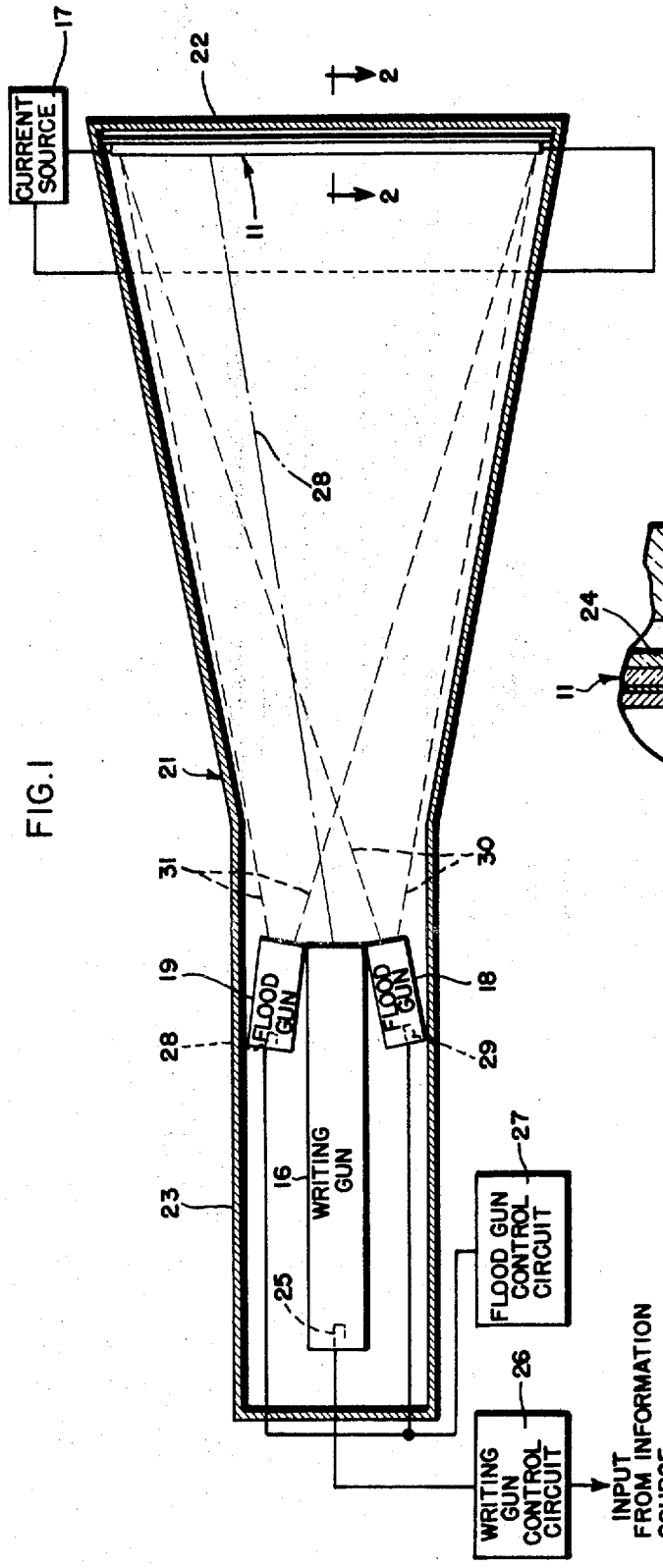


FIG. 1

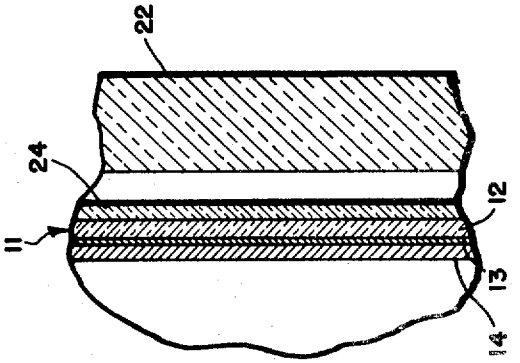


FIG. 2

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CATHODE RAY TUBE WITH PHOSPHOR AND SCOTOPHOR LAYERS IN SCREEN

This invention relates generally to cathode ray tubes. More particularly, the invention relates to an improved cathode ray tube for storing information, and to an improved method for using such a tube.

Many different types of cathode ray tubes have heretofore been designed for storing various kinds of information. One particular advantage of this type of information storage is that, by proper tube design, visual types of information, such as characters and graphs, may be stored without changing their form and may be visibly read out. Not all cathode ray storage tubes are suitable for storing visual information, however.

Although many types of cathode ray tubes have been used for information storage in a wide variety of applications, known types of cathode ray storage tubes have certain undesirable limitations. Resolution of stored information may deteriorate with time in some types of cathode ray storage tubes. Moreover, the resolution attainable for reading out stored visual information in many types of cathode ray storage tubes is unsatisfactory where a high degree of resolution is desired. In many such tubes, contrast may be inadequate for satisfactory visual observation and readout. Certain types of cathode ray storage tubes are undesirably restricted in the manner in which stored information may be displayed and, for many applications, may require high-speed circuitry, thereby increasing required power levels and operational costs.

Accordingly, it is an object of the invention to provide an improved cathode ray tube for storing information and which is not subject to many or all of the foregoing difficulties.

Another object of the invention is to provide a cathode ray storage tube offering improved resolution of stored visual information during readout, which is not subject to deterioration with time and which may be presented with superior contrast.

A further object of the invention is to provide a cathode ray storage tube of high versatility in the presentation of visual information.

It is another object of the invention to provide an improved cathode ray storage tube which is operable at relatively low power levels.

Other objects of the invention will become apparent to those skilled in the art from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a schematic side view of a cathode ray tube and associated circuitry constructed in accordance with the invention; and

FIG. 2 is an enlarged fragmentary section view taken along the line 2–2 of FIG. 1.

Very generally, the cathode ray tube of the invention comprises a target screen **11** including a transparent substrate **24**, a scotophor layer **13** and a luminescent layer **14**. Means **16** are provided for directing an electron beam at the target screen to darken preselected areas of the scotophor layer. Means **18** and **19** are provided for flooding the luminescent area with an electron beam or beams to visibly define darkened areas of the scotophor layer.

Referring now more particularly to FIG. 1, the cathode ray tube illustrated therein comprises an outer evacuated envelope **21** of glass and having a transparent face plate **22**. The envelope tapers in frustoconical configuration from the face plate **22** to a cylindrical neck portion **23**. Electron beam producing apparatus is contained in the neck portion **23**, as explained subsequently.

The target screen **11** is positioned adjacent the face plate **22** and extends nominally parallel therewith. An enlarged cross section of the target screen may be seen in FIG. 2. The thicknesses in FIG. 2 are exaggerated for clarity. The target screen includes a supporting substrate **24** upon which a transparent electrically conductive layer **12**, scotophor layer **13**, and luminescent layer **14** are deposited. The layers are positioned in the above stated order in the direction extending away from the face plate **22** and toward the neck portion **23**.

The supporting substrate **24** may be of any transparent material of suitable strength, such as glass, and is secured to the tube envelope. Although the face plate **22** may be used as a supporting substrate, better thermal characteristics, as described below, are obtainable with the relatively thinner substrate **24**.

The particular construction of the target screen **11** enables operation of the cathode ray tube as what is sometimes referred to as a dark trace storage tube. The scotophor layer **13** may be comprised of any material which is normally transparent, which is rendered optically absorbent to light of certain wavelengths upon bombardment thereof by an electron beam of sufficient energy, and which may be rendered transparent again by raising it to an elevated temperature for a sufficient length of time. A satisfactory material for this purpose is potassium chloride which, when subjected to electron bombardment, absorbs light in a band centered at about 560 millimicrons. The scotophor layer may be produced by vapor deposition or slurry depositing techniques.

The depth of electron penetration and the total number of electrons received generally determines the number of color absorbing centers produced in the scotophor layer. The production of a relatively lasting image for storage purposes usually requires a total charge in excess of 0.3 microcoulomb per square centimeter, and electron beam energies in the range of 8 to 10 k.v. are typical.

Erasure of dark trace or opaque portions of the scotophor layer is accomplished by raising its temperature for a period of time. The erase speed is a function of temperature and different erase speeds may be desired for various operating conditions. A temperature of 150° C. will normally result in complete erasure of all opaque portions in less than 1 second, and by maintaining the scotophor layer **13** at such a temperature, darkening thereof may be prevented if desired.

The transparent layer **12** is comprised of any suitable resistive material which will exhibit a temperature rise upon the passage of an electrical current therethrough. By heating the transparent layer in this manner, the scotophor layer **13** may be heated so the information stored in the form of dark areas on the scotophor layer may be erased. A current source **17** is coupled across the transparent layer to provide such a heating current at desired times. Satisfactory materials for the layer **12** include metals or metal alloys (which may be vapor deposited) or stannous oxide (which may be chemically produced).

The luminescent layer **14** is disposed toward the electron beam producing apparatus **16**, **18** and **19** with respect to the dark trace scotophor layer **13**. The material of the luminescent layer may be a suitable luminescent phosphor and it is preferred that the output color of the phosphor match the absorption band of the dark trace scotophor layer **14**. In this manner, the illumination provided by the luminescent layer may be selectively absorbed by darkened areas of the scotophor layer. Commercially available phosphors which are satisfactory for this purpose are types P1, P2 and P20.

The writing gun **16** is disposed in the neck **23** of the tube envelope **21** and operates to produce an electron beam. The writing gun may be constructed in any suitable known manner and may include an electron-producing cathode **25** and a plurality of deflection plates and accelerating electrodes (not shown). A writing gun control circuit **26** is coupled to the writing gun cathode **25** to control the potential thereon, and is also coupled to the deflection plates and accelerating electrodes to control the potentials thereon. The control circuit **26** operates in a known manner to translate input signals from an information source, not illustrated, to cause the writing gun to direct the electron beam in a desired manner and with a desired intensity.

In addition to the writing gun **16**, the neck portion **23** of the tube envelope **21** also contains means for flooding the luminescent layer **14** with an electron beam or beams. Such means, in the illustrated embodiment, consist of a pair of flood guns **18** and **19** containing suitable elements for producing a wide or diverse electron beam. Each flood gun is disposed to

flood the entire screen, however, as an alternative, the plurality of flood guns may be utilized for flooding separate but contiguous areas on the target screen **11**. Moreover, although two flood guns are used in the illustrated embodiment, only one may be sufficient. The intensity of the beams produced by the flood guns is controlled in a suitable manner by a flood gun control circuit **27** coupled to the cathodes **28** and **29** of the flood guns.

In operating the illustrated cathode ray tube, input signals from the information source are translated by the writing gun control circuit **26** into suitable signals for operating the writing gun **16**. The writing gun directs the electron beam produced thereby, indicated by the dash-dot line **28**, at the target screen **11**. The electron beam **28** is of sufficient energy, typically 16,000 electron volts, to penetrate through the phosphor layer **14**, and to enter the scotophor layer **13** with sufficient remaining energy to darken it in those areas upon which the electron beam impinges. Accordingly, visual information is stored on the target screen in the scotophor layer thereof.

When it is desired to read out visual information stored on the scotophor layer **13** of the target screen **11** in the illustrated cathode ray tube, the flood gun control circuit **27** applies a signal to the flood guns **18** and **19**. The flood guns thereby produce widely diverse electron beams which flood the target screen and the luminescent layer **14** thereof. The beams produced by the flood guns **18** and **19**, the envelopes of which are indicated by the dotted lines **30** and **31**, respectively, are of sufficient energy to cause the luminescent layer **14** to glow or luminesce, but are of insufficient energy to penetrate the layer **14** and darken additional areas on the scotophor layer **23**. Operation of the flood guns is typically at less than 6 k.v. total. With the entire luminescent layer **14** luminescing sharply visibly defined. In other words, the darkened areas on the scotophor layer will be silhouetted against the luminescing layer.

When the information stored upon the scotophor layer **13** is to be erased, the current source **17** is actuated. This passes an electrical current through the conductive transparent layer **12** to heat the scotophor layer and render the darkened areas on the scotophor layer transparent.

By causing illumination of the entire luminescent layer **14** in the target screen **11**, the visual information stored on the scotophor layer may be visually read out and the assistance of any further pickup or detection device is not required. By using a separate electron gun or guns for flooding the luminescent layer, the writing gun **16** may be operated at very low speeds without producing a flicker in the visual display. The phosphor for the luminescent layer **14** may be of any desired persistence depending upon needs, and in fact may have either a relatively long persistence or a relatively short persistence without having a deleterious effect on the quality or operation of the information storage and retrieval system in which the tube is used. Since no time sharing of any of the electron beam guns is required for operation as above described, all of the control circuits **26** and **27** may be low speed type of circuits. Accordingly, a correspondingly lower amount of power is required for their operation, reducing operational costs. Moreover, the cost of the control circuitry itself may be lessened.

The cathode ray tube of the invention may also be operated in a time sharing mode to produce three identifiable brightness levels in the visual display, rather than the two as previously described. This may be accomplished by operating the writing gun **16** periodically at a voltage or current level (i.e. energy level) which is below that required to darken the scotophor layer **13** but above the energy density level of the flood beams **30** and **31**. The considerations involved in selecting suitable beam energies for various excitation levels and characteristics are discussed in Soller, Stan, Valley, "Cathode Ray Tube Displays," Radiation Lab. Series, Vol 22, McGraw-hill. Such periodic operation of the writing gun may be used to produce periodic excitation at selected areas of the phosphor in the luminescent layer **14**. This excitation raises the selected areas of the luminescent layer to a higher brightness level, thus producing a pattern thereon which is brighter than the luminescent background produced by the flood guns **18** and **19**. By operating the tube in this manner, intermediate shades may be produced for visual display of pictorial representations, either with a dark background or with a bright background. Of course, when operating in the three brightness level mode, information storage is not provided by the bright trace pattern.

It may therefore be seen that the invention provides an improved cathode ray tube and a method for operating same wherein visual information may be readily stored and retrieved directly, such as through visual observation. The tube of the invention is susceptible of at least two modes of operation, one producing two brightness level contrasts and the other producing three brightness level contrasts. In the former, low-speed circuitry may be utilized for lower operational cost. High quality resolution which does not decay with time, sharp contrast, and versatility of operation are all attainable in accordance with the invention.

Various modifications of the invention in addition to those shown and described herein will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such other modifications are intended to fall within the scope of the appended claims.

I claim:

1. A cathode ray tube comprising a target screen including a scotophor layer and a luminescent layer, an electron beam gun for producing and directing a first electron beam at the luminescent layer side of the target screen, said first electron beam being of sufficient energy as to penetrate through said luminescent layer and darken selected areas of said scotophor layer, at least one additional electron beam gun for simultaneously producing and directing a second electron beam at said luminescent layer for flooding said luminescent layer, said second electron beam being of insufficient energy to penetrate through said luminescent layer but being of sufficient energy to cause said luminescent layer to luminesce and thereby visibly define darkened areas of said scotophor layer.

2. A cathode ray tube according to claim **1** wherein said electron beam-directing means include means for directing an electron beam at the target screen to brighten selected areas of said luminescent layer to a substantially greater level of brightness than that produced by said flooding means.

3. A cathode ray tube according to claim **1** wherein said luminescent layer is of a material having relatively long persistency.

4. A cathode ray tube according to claim **1** including a transparent layer in thermal proximity to said scotophor layer, and means for heating said transparent layer to render darkened areas of said scotophor layer transparent.

5. A cathode ray tube according to claim **4**, wherein said transparent layer is electrically conductive and said heating means comprise means for passing an electric current through said transparent layer.

6. A cathode ray tube according to claim **1**, including means to selectively reduce the energy of the first electron beam to a level insufficient to darken said scotophor layer but sufficient to brighten selected areas of said luminescent layer to a substantially greater level of brightness than that produced by the second electron beam.

7. A method of using a dark trace storage tube having a target screen comprised of a scotophor layer and an adjacent layer of luminescent material capable of luminescing at a lower energy level than the energy level at which darkening of the scotophor layer occurs, said method comprising, directing an electron beam at the target screen of sufficient energy to darken selected areas of the scotophor layer to store information thereon, and subsequently flooding the luminescent layer with at least one electron beam of sufficient energy to visibly define the darkened areas of said scotophor layer without darkening additional areas of said scotophor layer to thereby read out the stored information.

8. A method according to claim 7 wherein the electron beam used to flood the luminescent layer is distinct from that used to darken selected areas of the scotophor layer.

9. A method according to claim 8 wherein the energy of the electron beam which is used to darken selected areas of the scotophor layer is intermittently attenuated to an energy level which is below that necessary to darken areas of the scotophor layer, but sufficient to produce a substantially higher level of luminescence in the luminescent layer than the level of brightness produced therein by the flooding beam, whereby selected areas of the luminescent layer may be brightened.

10. A cathode ray tube comprising a target screen including a scotophor layer and a luminescent layer, an electron beam gun for producing and directing a first electron beam at the luminescent layer side of the target screen, said first beam being of sufficient energy to darken selected areas of said scotophor layer, and at least one additional electron beam gun for simultaneously producing and directing a second electron beam at said luminescent layer for flooding said luminescent layer with a second electron beam to visibly define darkened areas of said scotophor layer, said second beam being of insufficient energy to darken said scotophor layer.

11. A cathode ray tube according to claim 10 wherein said screen includes a transparent conductive layer, and said tube includes means for heating said transparent conductive layer to render darkened areas of said scotophor layer transparent.

12. A cathode ray tube according to claim 10 including means to intermittently attenuate said first electron beam to an energy level which is insufficient to darken areas of the scotophor layer but sufficient to produce a higher level of brightness in selected areas of the luminescent layer than the level of brightness produced therein by the flooding beam.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,560,782 Dated February 2, 1971

Inventor(s) Omer F. Hamann

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

Column 3, line 32 - for "23", read "13".

Column 3, line 33 - after "luminescing" insert: "and at a generally uniform level of brightness, the darkened areas on the scotophor layer 13 will be".

Signed and sealed this 1st day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER,
Commissioner of Patent