United States Patent [19]

Kazan

[11] **3,774,066**

[45] **Nov. 20, 1973**

[54] **INTERACTIVE-DISPLAY STORAGE CATHODE RAY TUBE**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[22] Filed: **Jan. 31, 1972**

[21] Appl. No.: **222,251**

[52] **U.S. Cl.** ..... **315/10,** 315/11, 315/12, 340/324 A

[51] **Int. Cl.** **H01j 31/26**

[58] **Field of Search** ..... 315/10, 11, 12; 250/217 CRT; 340/324 A; 365/10, 12

[56] **References Cited**

UNITED STATES PATENTS

2,547,638	4/1951	Gardner	315/12
2,855,589	10/1958	Baker et al.	315/12 X
3,189,889	6/1965	Bridgett	315/12 X
3,325,673	6/1967	Anderson	315/12
3,426,236	2/1969	Mepham	178/7.2 X
3,586,861	6/1971	Wernikoff	250/217 CRT

Primary Examiner—Benjamin R. Padgett
Assistant Examiner—P. A. Nelson
Attorney—George Baron et al.

[57] **ABSTRACT**

Modification of a display storage cathode ray tube that employs an electron beam for impingement on an insulating phosphor to switch the latter from an OFF state (low voltage) to its ON state (high voltage), using a flood beam of electrons to maintain the phosphor stably either at high or low voltage. Modification consists in using a light pen, having a higher intensity or different spectral distribution than the ambient light of the cathode ray tube, which is used to shift the voltage of the phosphor by photoconductive action toward the potential of a backplate to achieve either writing or erasing, depending on the backplate potential.

4 Claims, 3 Drawing Figures

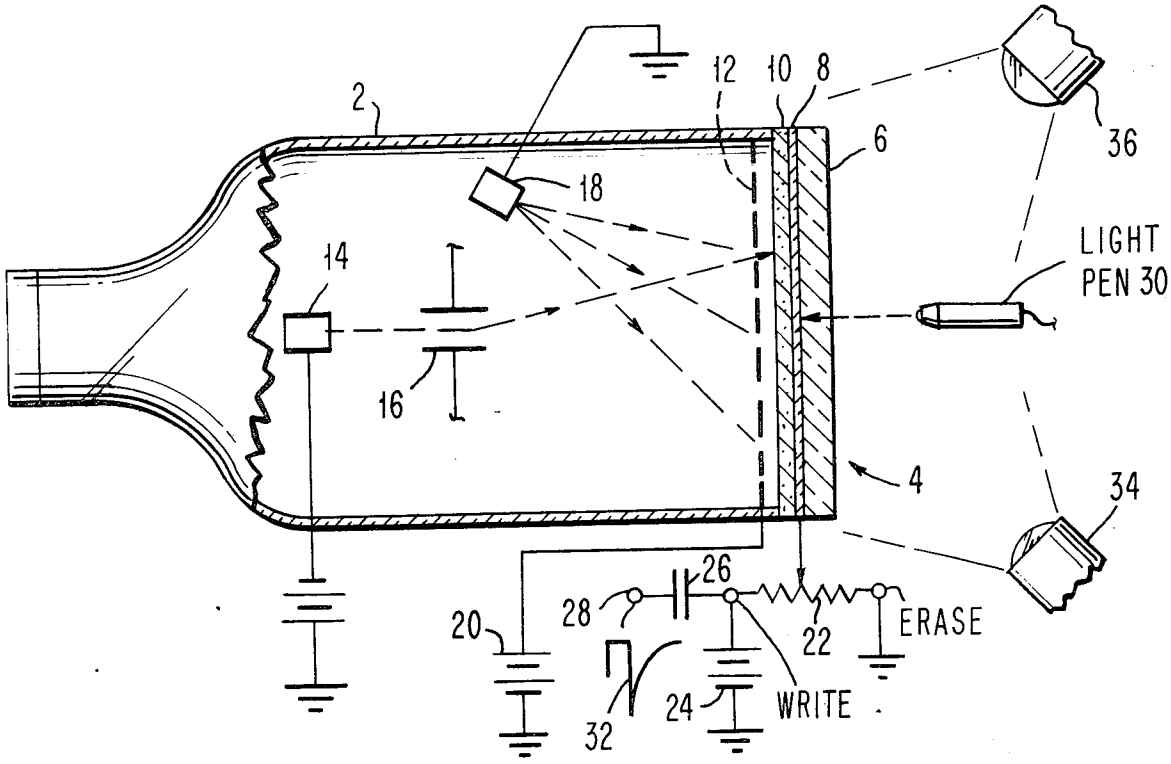


FIG. 1

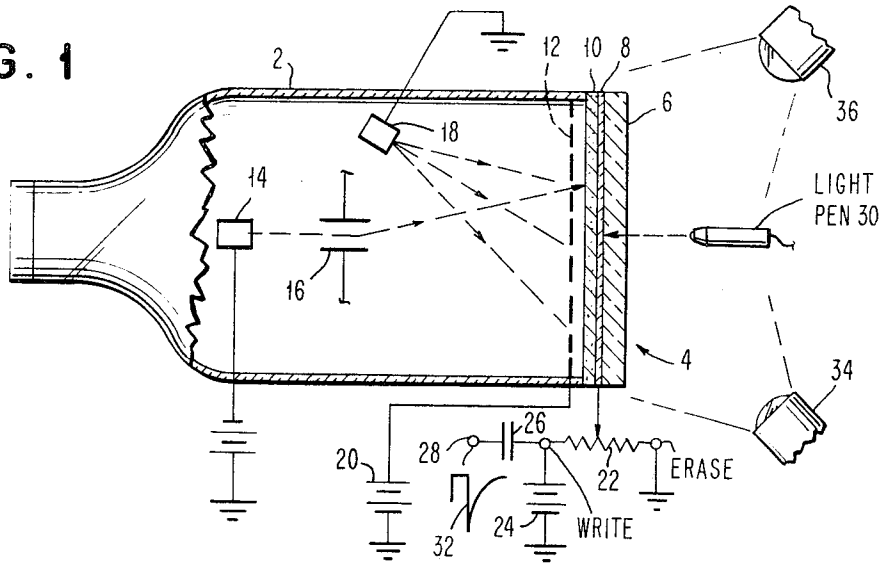


FIG. 2

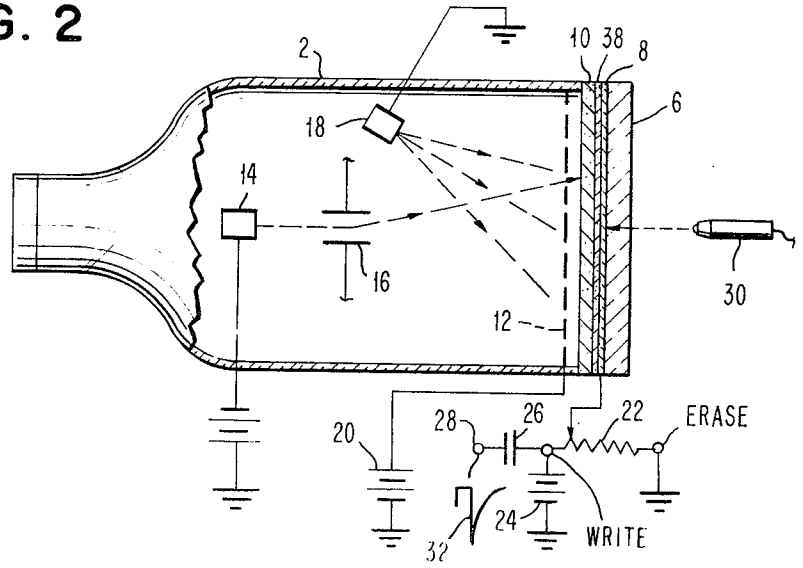
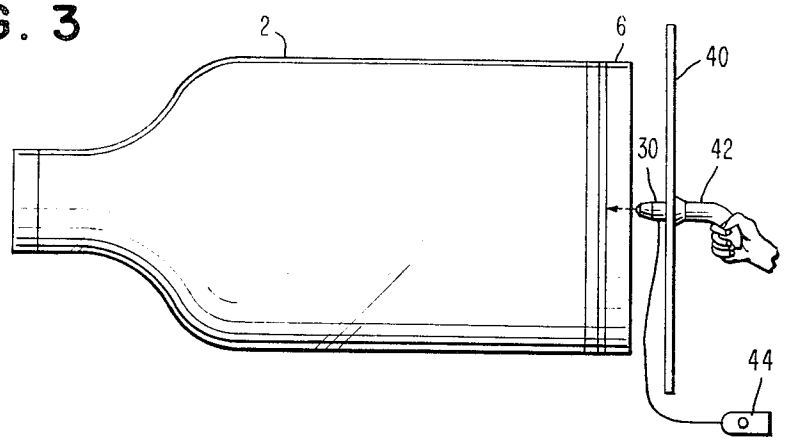


FIG. 3



INTERACTIVE-DISPLAY STORAGE CATHODE RAY TUBE

BACKGROUND OF THE INVENTION

Present bistable storage phosphor tubes depend on local areas of the phosphor screen (which may be porous or in the form of a mosaic of small elements) being maintained at either zero or +150 volts relative to a flood gun cathode by the secondary emission action of the flood beam. Since flood beam electrons can land with significant energy only at the positive areas, only the latter areas of the screen emit light. To write, zero potential (OFF state) phosphor areas are charged positive by means of the secondary emission action of a high-voltage writing electron beam in the tube and are then held at the stable potential by the flood beam in the tube. Such areas that are so maintained at +150 volts appear visible.

A U. S. Pat. No. 3,426,236, issued on Feb. 4, 1969 to H. J. Mepham, uses a phosphor storage dielectric so that one can direct both a light image and an electron beam onto the phosphor storage dielectric to produce corresponding charge images on the phosphor material that are stored bistably. Such prior art Mepham tube achieves optical writing and display without having to employ external or regenerative circuits to maintain the image nor does it require high speed deflection circuits and components to maintain the image flicker-free.

The present invention wishes to exploit the bistable storage capacity of a storage-display tube of the type shown and described in the Mepham patent noted above with the important additional feature of allowing such tube to employ a light pen for erasure, as well as for writing. That is, the light pen of Mepham can write on to the face of his phosphor, but it cannot erase with that pen. Thus, if the letter "P", for example, were to be converted to the letter "B", the prior art is capable of doing it merely by employing the light pen to add the feature " " to the bottom of the P. But if it is desired to convert the "B" to a "P", then the feature " " should be erasable from "B" by a light pen to attain the image "P". By the same token, entire words, phrases, parts of diagrams or pictorial representations may likewise be deleted or added.

The substraction or erasure of information depends on the use of a tube structure employing a collector mesh in front of a photoconductive phosphor which is backed by an electrically conductive backplate that abuts the inner surface of the face of the display tube. In the stored state, the letter "B", for example, is retained because every point of the letter is charged to the potential of the +150 volt collector mesh which serves as the collector electrode for secondary electrons produced at the phosphor surface by the flooding electron beam, while surrounding areas are held at zero potential. If the phosphor backplate is maintained at zero voltage, than a potential of 150 volts will exist across all the ON elements of the phosphor, or all the elements that make up the stored letter "B". If only the lower portion " " of the "B" is illuminated, the photoconductivity of the phosphor will increase causing a discharge of the " " from the letter "B", so that the discharge causes that portion " " to reach the zero potential of the backplate. The removal of the erasing light pen does not alter the erasure because the discharged phosphor elements or areas are kept in the OFF state

by the holding action of the flood beam of the tube. By judicious choice of the filter in front of the tube, one can prevent the tube from being affected by ambient light but allow it to respond to the wavelength of the light pen to cause either writing or erasing of stored information.

Consequently, it is an object of this invention to add to a bistable storage cathode ray tube having the capacity to both write and erase information by using a light source external to the tube.

It is yet another object to achieve both writing and erasure of bistably stored information on a photoconductive phosphor coating of a cathode ray tube by employing a potential-shifting means for said phosphor.

It is yet another object to achieve such writing and erasure capability using a light pen or its equivalent.

Still another object is to provide write and erase capability on a cathode ray storage tube using a light pen in an environment having ambient light.

Still another object is to record complete images either as a positive or negative of the image projected onto the storage tube screen.

These and other objects, features, and advantages of the invention will be apparent from the following more particular description of the preferred embodiments of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a preferred embodiment of the invention wherein information may be added to or subtracted from electrically stored information on a phosphor screen using a light pen.

FIG. 2 is a modification of the screen portion of the invention shown in FIG. 1.

FIG. 3 is yet another modification of the invention as shown in FIG. 1.

FIG. 1 shows schematically the main features of the invention comprising a charge image storage tube 2 having a bistable-phosphor storage face 4 that includes a transparent glass plate 6 that forms the front viewing area of the tube. Inward of said plate 6 is a transparent backplate electrode 8 made of tin oxide or In_2O_3, and overlying this backplate 8 is a phosphor 10, wherein Zn_2SiO_4 or silver activated ZnS are acceptable phosphors that are somewhat photoconductive. A transparent secondary electron collector mesh 12 is located adjacent the continuous phosphor layer 10. Writing gun cathode 14, deflection plates 16 and flood gun 18 are conventional elements of the cathode ray tube 2 and are shown schematically in that they do not form part of this invention. For a more detailed description of the electrical circuitry for the writing and readout circuitry for translating a luminescent pattern on the faceplate 6 into electrical signals for transmission to remote TV monitors or other remotely located viewing stations see the text entitled "Electronic Image Storage" by B. Kazan and M. Knoll, published 1968 by Academic Press, New York and London (for example, pp. 225–230), or the above-noted U.S. Pat. No. 3,426,236.

In the operating mode of storage-display tube 2, mesh 12 is maintained at +150 volts by battery 20 and backplate 8 is illustratively shown by potentiometer 22 to be switchable from +150 volts of battery 24 to zero potential and vice-versa. Capacitor 26 and input terminal 28 allow for electrical erasure. Light pen 30, operable at will, is employed both as an erasing or a writing

pen, depending upon the location of the arm of the potentiometer 22 and the potential of the backplate 8.

Erase Operation

Conventional electrical erasure of the storage cathode-ray tube is achieved by applying the erase pulse 32 to input terminal 28 as is described on page 228 of the above-cited Kazan and Knoll text. The initial positive portion of the pulse capacitively shifts the surface of phosphor 10 so that all portions or elements of the phosphor that were initially at their low-potential equilibrium are raised with respect to the flood-gun cathode. These elements are allowed to shift positive to the +150 volt potential of the collector 12 during the positive portion of pulse 32. Since elements or portions of the phosphor 10 previously scanned in writing are already at a positive potential (having a secondary emission ratio greater than unity), the entire phosphor area is uniformly shifted to the collector 12 potential. During application of the negative portion of pulse 32 the phosphor 10 target surface is suddenly capacitively shifted to a negative value below the first cross-over potential of the surface and, as the pulse gradually rises to zero, the flood beam from cathode gun 18 then supplies sufficient negative charge to maintain the entire phosphor 10 at zero or erased voltage.

While the entire storage display tube of FIG. 1 is erasable electrically as described above, it is also erasable optically. To achieve optical erasure, the potentiometer switch 22 is put in the ERASE position. The phosphor 10 is then locally excited with light from pen 30 or its entire area flooded by the large sources of light 34 and 36. As a result of such light exposure, the photoconductivity of the phosphor 10 causes its surface, where illuminated, to reach a potential close to ground (OFF Or erased state), which ground potential is then maintained by the flood beam from cathode gun 18. Erasure or writing can be expedited, in some instances, by using potentials different than those specified, for example, greater than 150 volts for writing or voltages less than zero for erasing. For this purpose, the positive voltage of the WRITE terminal may be greater than 150 volts and that of the ERASE terminal may be negative.

Write Operation

Writing is achieved both electrically and optically. The potentiometer setting is placed in the WRITE position, any information which had been previously written being still stored on the face of the tube. One may still, if desired, write new information by using the writing electron beam to charge local areas of the phosphor screen 10 to a voltage of +150 volts, which voltage is maintained by the flood beam from cathode gun 18. Compatibly with such electron beam writing, one can write optically by directing light from pen 30 onto the face of tube 2 to manually trace a pattern of information the operator chooses to store. Such light pattern causes phosphor 10 to rise to the +150 voltages ages of the backplate, which voltage is maintained by flood-beam electrons from gun cathode 18 and the action of collecting grid 12.

If the operator has made a mistake in the information he just manually traced, or for any reason chooses to change or delete either the newly entered information or any of the previously stored information, he shifts the potentiometer 22 smoothly (to avoid sudden capacitive potential shifts on the phosphor 10 surface) from its Write position to its ERASE position and positions the pen 30, to the desired location. Once reaching that desired location, the operator switches on the light from pen 30, thus erasing any information stored at the illuminated area. Erasure is effected because the light beam directed onto the phosphor 10 through transparent backplate 8 temporarily increases its conductivity, thus lowering the potential of positive areas to the backplate potential (zero voltage), which zero voltage (OFF state) is then maintained by flood gun 18, the latter also maintaining the unerased portions (ON states) of phosphor 10 screen at their respective +150 volts.

The role of the transparent collector mesh 12 is to collect secondary electrons produced at the phosphor surface by the writing gun 14 and the flooding gun 18, thus determining the equilibrium potential of ON elements. The function of the transparent backplate electrode 8 is to produce a field across phosphor layer 10 either at areas that are in the OFF condition or the ON condition in accordance with whether writing or erasing is desired. Then by employing a light source, such as pen 30, charges are allowed to leak across the phosphor at local areas. Alternatively, an entire image can be projected onto the face 6 of tube 2 during writing or erasing. By flooding the entire screen, using lights 34 and 36, erasure of the entire screen can take place. If desired, a photographic negative can be projected onto the face of the tube 2 during an ERASE operation so that, in effect, the bistable-storage capability of the tube allows one to see the projected negative as a luminescent positive image. That is, light going through the light-transmitting portions of the photographic negative will darken or erase local portions of the tube screen, whereas the opaque portions of the negative which do not transmit light, will prevent erasure, leaving the corresponding portions of the tube face in the ON or luminescent condition. The novel storage tube thus can serve as an image polarity reverser, allowing one to inspect or evaluate the quality of a photographic negative before deciding to print it.

FIG. 2 depicts that aspect of the invention wherein the phosphor layer 10, although luminescent, it not significantly photoconductive. For example, phosphor 10 could be a form of Zn_2SiO_4 that emits light when bombarded with electrons but is not strongly photoconductive. When such a phosphor is used, the optical sensitivity may be increased by using a photoconductive layer 38 of ZnS or ZnS:CdS interposed between phosphor 10 and transparent backplate electrode 8. The device of FIG. 2 operates in a manner identical to that of FIG. 1 save that a photoconductive layer is used in conjunction with a porous phosphor layer whenever the phosphor, per se, is not photoconductive. If desired, the phosphor layer 10 can be deposited on the underlying photoconductive layer 38 in the form of a mosaic of discrete elements, with insulating fillers in between such phosphor particles. In the case of a mosaic of phosphor elements, the phosphor need not be insulating and may be conductive, consisting for example of ZnO.

In the practice of the invention, it may be necessary to prevent the storage phosphor of tube 2 of FIG. 2 or the photoconductor of tube 2 of FIG. 2 from being actuated by the ambient light incident on the tube. Assume that the chosen phosphor 10, such as ZnS, is capable of being photoconductively excited by blue light so as to produce a stored luminescent image of green light. In such a case, a green transmitting filter 40 is

placed in front of the glass faceplate 6 as shown in FIG. 3 and the light pen 30, now containing a magnetic handle, is interposed between such filter 40 and faceplate 6. A magnetic bar 42 is placed on the filter 40 side opposite the side on which the light pen 30 is located in a position to allow for an operator to manually relocate the light pen 30 in front of filter 40. A switch 44 permits the operator to switch on the light pen 30 at will. The phosphor-actuating pen 30 will emit prominently in the visible blue, and filter 40 is chosen to absorb highly in the visible blue region, but transmit readily in the green, the main frequencies given off by the light-emitting phosphor 10. When a photoconductive layer 38, separate from the phosphor layer 10, is employed then that photoconductive layer is chosen to transmit readily in the green but absorb light in the blue. Obviously, filters 40 of different absorption and transmission characteristics may be used to be compatible with the choice of phosphor, choice of light pen and color of the ambient light in which tube 2 is used.

A bistable phosphor storage tube has been devised which is capable of writing and erasing using a source of light and such optical recording is compatible with present storage cathode-ray tubes that employ electron beam recording. Besides being simple in its design and operation, the novel features of this storage and display tube do not require external storage or regenerative circuits and avoid the need for high-speed deflection circuits and components to maintain a flicker-free stored image.

What is claimed is:

1. Charge image storage apparatus capable of bistable storage comprising a transparent photoconductive phosphor,

a transparent mesh electrode, adjacent said phosphor, connected to a source of electrical energy and acting as a collector of secondary electrons,

means for bombarding said phosphor surface facing said mesh with electrons to cause secondary electrons to be emitted from said phosphor whereby said mesh electrons collects said secondary electrons,

a transparent backplate electrode on the opposite surface of and in electrical contact with said phosphor,

means for maintaining one of two reference potentials on said transparent electrode, said reference potentials being selectable at will, and

a light-emitting pen for shining a pattern of light through said backplate electrode while the latter is maintained at a potential substantially below said collector mesh electrode potential so as to extinguish light emission from previously light-emitting areas of said phosphor.

2. Charge image storage apparatus capable of bistable storage comprising a storage target including a phosphor,

a transparent mesh electrode, adjacent said phosphor, connected to a source of electrical energy and acting as a collector of secondary electrons,

means for bombarding said phosphor surface facing said mesh with electrons to cause secondary electrons to be emitted from said phosphor whereby said mesh electrode collects said secondary electrons,

a transparent photoconductor layer on the opposite surface of and in contact with said phosphor,

a transparent backing electrode in contact with said photoconductor layer,

means for maintaining one of two different reference potentials on said backplate electrode, and

a light-emitting pen for shining a pattern of light through said backplate electrode while the latter is maintained at a potential substantially below said collector mesh electrode potential so as to extinguish light emission from previously light-emitting areas of said phosphur.

3. The apparatus of claim 2 including a filter in front of both said light-emitting pen and said storage target, said filter being highly absorbent of both ambient light and light which photoconductively excites said phosphor, but is highly transmissive of the radiation emitted by aid phosphor.

4. The apparatus of claim 3 wherein means are provided for actuating both the position and light-emission of said light-emitting pen while the relative position of said filter with respect to said light-emitting pen and said storage target remains fixed.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,774,066 Dated Nov. 20, 1973

Inventor(s) Benjamin Kazan

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

Column 1, line 40; " " should be --"⊃"--

Column 1, line 61; " " should be --"⊃"--

Column 1, line 63; " " should be --"⊃"--

Column 1, line 64; " " should be --"⊃"--

Column 4, line 61; FIG. 2 should be --FIG. 1--

Column 5, line 41; electrons should be --electrodes--

Column 6, line 38; aid should be --said--

Signed and sealed this 7th day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

PO-1050
(5/69)

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