Dec. 20, 1960 P. M. JAFFE 2,965,783

STORAGE DEVICE

Filed Oct. 27, 1958

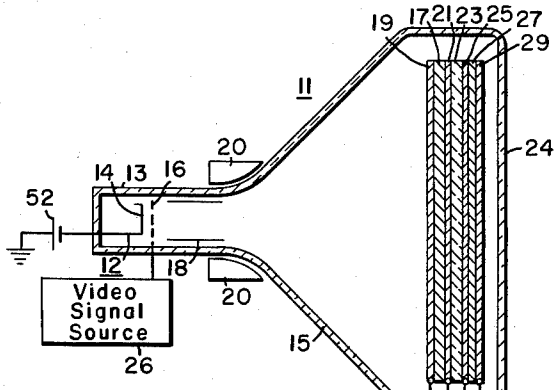

Fig. 1

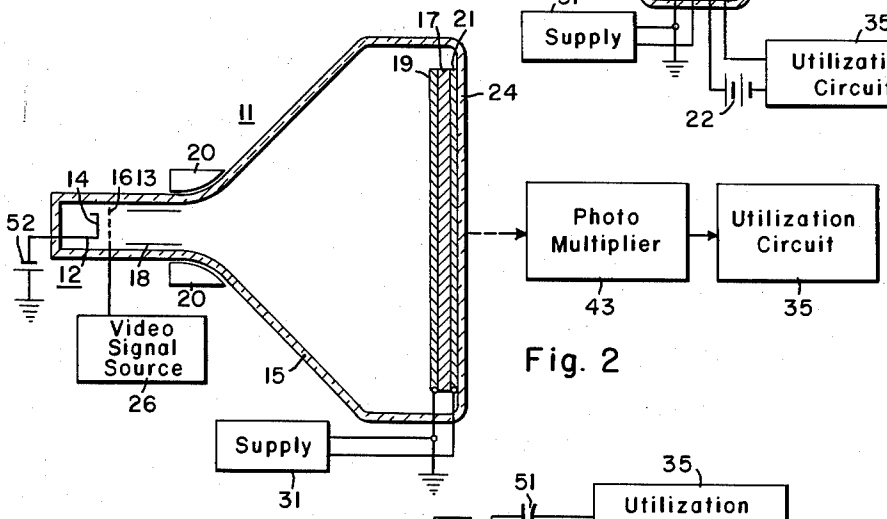

Fig. 2

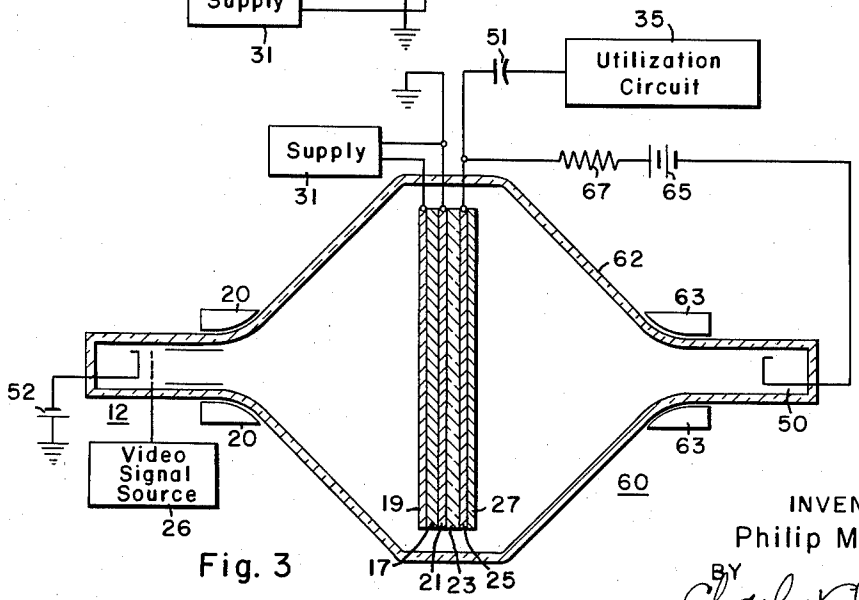

Fig. 3

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STORAGE DEVICE

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6 Claims. (Cl. 313—108)

This invention relates to electron discharge tubes and more particularly to storage tubes in which a cathode-ray beam is utilized.

In several types of storage tubes, it is necessary to utilize a low velocity electron beam. In the low velocity beam type of device, the electrons in the electron beam normally reach the target with essentially zero velocity. It is also required that the landing electrons strike the target substantially normal to its surface. Low energy electrons are difficult to control and it is necessary to use elaborate and expensive deflection and focusing systems in order to insure the proper landing of the electrons. One method of overcoming these problems is described in a copending application Serial No. 580,855, entitled "Electron Discharge Device" by R. J. Schneeberger, filed April 26, 1956, and assigned to the same assignee as the present invention. This invention overcomes this problem by utilizing a different type of storage target which enables the use of high energy easily controlled electrons.

Certain electroluminescent materials exhibit the property of enhanced luminous output when excited by an electron beam and simultaneously placed within the influence of a time varying electric field. That is, when the electron beam is modulated by an electrical signal and caused to scan a raster over the electroluminescent material, while an electric field is present across the electroluminescent material, the image formed on the material, representative of the modulated signal, will be brighter than an image produced by an electron beam without the simultaneous application of an electric field. This phenomenon is described in a copending application Serial No. 518,321 by E. F. G. Arnott and H. F. Ivey, entitled "Cathode Ray Screen and Method," filed June 27, 1955 and assigned to the same assignee now Patent 2,863,084, issued December 2, 1958.

It has been found that these materials will also store the information applied by the modulated electron beam when simultaneously placed within the influence of an electric field. The stored information, which may be in the form of a latent image, may be released by removing the electric field and scanning the material with a beam of electrons of uniform intensity. The information is released in the form of a transient image.

It is an object of this invention to provide an improved storage tube.

It is another object to provide an improved storage tube which utilizes a high energy electron beam.

It is another object to provide an improved storage tube, the output of which is amplified in relation to the input.

It is a further object to provide a method for storing and subsequently releasing a luminous output due to electron excitation of a fluorescent screen.

An additional object is to provide a method for storing and subsequently releasing with an enhanced output the response due to electron excitation of a fluorescent screen.

An auxiliary object is to provide an improved storage device in which the stored information may be applied by a series of writing steps.

These and other objects are effected by this invention as will be apparent from the following description taken in accordance with the accompanying drawing throughout which like reference characters indicate like parts, and in which:

Fig. 1 is a sectional view of one embodiment of a storage tube in accordance with the teachings of this invention.

Fig. 2 is a sectional view of another embodiment of a storage tube in accordance with the teachings of this invention; and

Fig. 3 is a sectional view of a third embodiment of a storage tube in accordance with the teachings of this invention.

In Fig. 1 there is shown an envelope member **11** having a neck portion **13** a flared portion **15** and a face plate **24**. A suitable type of electron gun **12** is disposed within the neck portion **13** to generate a beam of electrons. The electron gun **12** comprises at least a cathode **14**, a control electrode **16** and an anode **18**. The cathode **14** is connected to one terminal of a direct current supply **52** and the control electrode **16** is connected to the source **26** of the video signal to be stored. Suitable electrostatic or electromagnetic deflection means may be positioned within the region of the neck portion **13** for deflecting the electron beam from the gun **12** in both a horizontal and vertical direction to scan a raster. In the specific embodiment shown, the electron beam from the gun **12** is caused to scan a raster by deflection means **20** which may be any suitable type of deflection yoke as is well known in the art.

A screen structure is positioned in the flared portion **15** of the envelope member **11** near the face plate **24**. The screen contains a layer of electroluminescent material **17** sandwiched between electrically conductive layers **19** and **21**. The electroluminescent layer **17** may be a homogeneous layer of electroluminescent material or a mixture of electroluminescent material and a light transmissive dielectric material such as polyvinyl-chloride acetate. Where a mixture is preferred, the electroluminescent phosphor may be embedded in the dielectric material. Positioned adjacent to the electrically conductive layer **21** furthest removed from the electron gun **12** is a support layer **23** of a material which is transmissive to the radiation emitted by layer **17**, such as glass. On the opposite surface of the support layer **23** an electrically conductive layer **25** is disposed. Adjacent to the exposed surface of conductive layer **25** is positioned a layer of photoconductive material **27**. The photoconductive material is provided with another electrically conductive layer **29** on the opposite side thereof. The conductive layers **19** and **21** between which is disposed the electroluminescent material **17** are connected across a source **31** of a time varying voltage. The layer of photoconductive material **27** is also provided with a source **22** of direct current which is connected across the layers **25** and **29**. A utilization circuit **35** is connected in series with the source **22** to use the information stored by the tube in any number of ways that may be desired.

Examples of the phosphors suitable for use in the electroluminescent layer **17** are zinc sulfide, cadmium sulfide or mixtures thereof activated by manganese, manganese-silver or manganese-gold. A specific example of the phosphor may be 7 mole parts zinc sulfide and 1 mole part cadmium sulfide activated by 4×10^{-3} mole manganese. This phosphor may be prepared by ball-milling the aforementioned ingredients and firing in an oxygen free atmosphere for about one hour at 1100° C. Other examples of the composition of the phosphor and

the preparation thereof can be found in the above-mentioned copending application by Arnott and Ivey.

The conducting layers may be fabricated of any suitable electrically conductive materials which may be coated as a thin sheet and are transmissive to electrons in the case of conductive layer **19** and transmissive to radiation emitted by layer **17** in the case of conductive layers **21** and **25**. The conductive layer **19** closest to the electron gun may be of aluminum which may be applied by well-known vacuum-metalizing techniques onto one surface of the electroluminescent layer **17**. The conductive layers **21** and **25** on both surfaces of the support member **23** may be of a wire mesh, a thin metallic layer which is transmissive to radiation from layer **17**, or a thin layer of tin oxide, such as sold under the trademark "NESA" by Pittsburgh Plate Glass Company, Pittsburgh, Pa. Conductive layer **29** may be either a thin metallic layer or a layer of tin oxide. Other suitable thin conducting coatings such as oxides of cadmium, indium, titanium or silicon may also be used. The layer of photoconductive material **27** may be of any suitable material such as antimony trisulfide, cadmium sulfide, antimony selenide, cadmium selenide, antimony telluride or cadmium telluride. The thickness of the photoconducting layer **27** may be approximately 0.0002 inch, for example, to prevent lateral conductivity within the layer **27**. The photoconductive layer **27** may also be deposited in the form of a mosiac by evaporating the photoconductive material through a masking member. When cadmium sulfide is used as the photoconductive layer **27** it may be prepared as described by R. E. Aitchison in the science periodical Nature, vol. 167, No. 4255, May 19, 1951, pages 812 and 813. To obtain the maximum amplification of the stored information the photoconductive material should have its peak response at approximately the same wavelength of light emitted by the electroluminescent layer.

In the operation of the device, as shown in Fig. 1, the electron beam generated by the electron gun **12** is modulated by a time sequential information bearing signal from a video signal source **26** which is an electrical signal of the information to be stored on the fluorescent screen **17**. The video signal source **26** may be in the form of a radar or television receiver. For purposes of simplicity, the beam generated by the electron gun **12** during this phase of operation will be called the writing beam. A suitable accelerating voltage on the order of 4000 volts, for example, may be applied between the cathode **14** of the electron gun **12** and the conductive layer **19** by means of a direct current source **52**. When the writing beam is operating, a time varying electric field on the order of 4,000 volts/cm. is applied across the electroluminescent layer **17**. The intensification of the output of electroluminescent layer **17** appears to be independent of the frequency of the time varying electric field. Therefore, it is preferable to use a frequency of 60 cycles per second but this is not a requirement since other frequencies may be used, if desired. As the writing beam scans the electroluminescent layer **17**, in a point by point manner, a space distributed energy pattern is formed on the electroluminescent layer **17** in which the energy condition of different elemental portions is representative of successive portions of the information bearing signal. This energy pattern is representative of the signal applied to modulate the writing electron beam. The information is now stored on the electroluminescent layer **17**. If it is desired to apply additional information to the electroluminescent layer **17** the writing beam will again be operated. The time sequential information bearing signal to be applied will be utilized to modulate the electron beam while the time varying electric field is applied across the conductive layers **19** and **21** on either side of the electroluminescent layer **17**. By such a procedure the information stored can be built-up by a series of writing operations. It is also possible to scan the electroluminescent layer **17** with a uniform beam of electrons while a field is impressed across layer **17** and thereby obtain a multiple number of copies while still retaining the stored information on the electroluminescent layer **17**. To release the information stored by the electroluminescent layer **17** the time varying electric field is removed from across the electroluminescent layer **17**. After removal of the electric field, the electron gun **12** is made to generate a beam of electrons having a uniform intensity. This beam is scanned over the electroluminescent layer **17** in any desired raster so that the beam impinges on layer **17** point by point. For simplicity this beam will be called the reading beam. As the reading beam scans the electroluminescent layer **17** in a point by point manner, it causes elemental areas of the electroluminescent layer **17** which contain stored information to fluoresce with a transient enhanced luminous output in a radiation pattern of the information stored by the electroluminescent layer **17** due to the action of the writing beam. The light output from the elemental areas of the electroluminescent layer **17** causes a reduction in the resistance of corresponding elemental areas of the photoconducting layer **27** thereby modifying the current flow from the D.C. source **22** through the photoconducting layer **27**, to the utilization circuit as an electrical time sequential signal which corresponds to the original signal utilized to modulate the writing beam but which is amplified with respect to the original signal. The different time sequential portions of the signal are representative of the energy of the successively scanned elemental areas.

Fig. 2 is similar to Fig. 1 with the exception that a photomultiplier tube **43** is utilized to convert the stored information into a pulsed electrical signal. In this embodiment a conducting layer **21** such as described above, may be applied to the internal surface of the face portion **24** of the envelope member **11**. The electroluminescent layer **17** is disposed adjacent to this conducting coating **21** and a second conducting layer **19** is disposed on the opposite surface of the electroluminescent layer **17**. A photomultiplier tube **43** is positioned in such a manner as to receive the luminous response of the electroluminescent layer **17**. It may be desired in some instances to provide an optical means between the face portion **24** and the photomultiplier tube **43** to focus the output of the electroluminescent layer **17** unto the photomultiplier tube **43**. Because of the amplification of the signal due to the transient enhanced output of the electroluminescent layer **17** and the amplification of the photomultiplier tube **43**, the original signal is greatly multiplied which results in a greatly amplified output signal.

The operation of the device shown in Fig. 2 is similar to that described above for Fig. 1. The time sequential information bearing signal to be stored is used to modulate the writing electron beam which is operated simultaneously with the time varying electric field applied across the electroluminescent layer **17**. As the modulated writing beam scans the electroluminescent layer **17** in a point by point manner, a space distributed energy pattern is formed on the electroluminescent layer **17** in which which the energy condition of different elemental portions is representative of successive portions of the information bearing signal. When the space distributed energy pattern is to be released, the field is removed from the electroluminescent layer **17** and the electron gun **12** is operated to generate a uniform intensity electron beam (i.e. reading beam) which is caused by deflection means **20** to scan the electroluminescent layer **17** in a point by point manner. As the reading beam scans the electroluminescent layer **17**, the energy stored by each elemental area is released successively in the form of a luminous output. The photomultiplier will convert the luminous output into an amplified electrical signal representative of the time sequential information bearing signal utilized to modulate the writing electron beam.

Fig. 3 shows a third embodiment of this invention which utilizes a vidicon type scanning means to derive the electrical signal representative of the stored information. The entire structure may be enclosed within a single evacuated envelope **60**, or an ordinary vidicon may be disposed closely adjacent to the face portion **24** of the envelope member **11** as shown in Fig. 2.

The structure of the device to the left of the support layer **23** as shown in Fig. 3 is identical with that shown in Fig. 2. Positioned adjacent the opposite side of the support layer **23** is an electrically conducting layer **25**. A photoconductive layer **27** is disposed adjacent the conducting layer **25**. The right side of Fig. 3, or the vidicon portion **62** is provided with the necessary, well known components (not shown) needed to produce a beam of electrons and deflection means **63** to control this beam so that it may be scanned across the photoconductive layer **27** in point by point manner. The cathode of the electron gun **50** and the electrically conductive layer **25** are connected through load resistor **67** to a source of direct current **65**. The cathode is at a potential of about 30 volts negative with respect to conductive layer **25**. As the electron beam from the gun **50** scans the photoconductive layer **27**, the surface of the photoconductive layer **27** nearest the gun is charged to cathode potential leaving a potential difference across the photoconductive layer **27** of about 30 volts.

The operation of the writing electron beam to store the information on the electroluminescent layer **17** and the reading beam to release the stored information is similar to that described above for Figs. 1 and 2. The information is stored by utilizing a time sequential information bearing signal to modulate the writing beam and causing the beam to scan the electroluminescent layer **17** in a point by point manner while a time varying voltage is applied across the electroluminescent layer **17**. The information is released from the electroluminescent layer **17** by scanning with an electron beam of uniform intensity in a point by point manner after the removal of the time varying voltage.

In the device shown in Fig. 3, the reading beam may be, if desired, a flood of electrons. If a scanning type beam is utilized as the reading beam, however, it may be desirable to have the electron beam of the electron gun **50** of the vidicon portion **62** in synchronism with the reading beam. As the reading beam releases the stored information from elemental areas of the electroluminescent layer **17** in the form of a light output the conductivity of an adjacent elemental area of the photoconductive layer **27** is modified causing the charge deposited on the surface thereof to leak through the photoconductive layer **27** at a rate determined by the intensity of the illumination to which this elemental area is subjected. The charge deposited the next time the photoconductive layer **27** is scanned will be sufficient to replace those electrons that have been lost by the leakage since the last passage of the electron beam. The charge the electron gun **50** deposits varies with time in accordance with the variations in the illumination of the successive elemental areas of the photoconductive layer **27**. The current through the load resistor **67**, and hence the output voltage, therefore reproduces the variations in the light intensity of the successive portions of luminous output of the electroluminescent layer **17** in the form of a time sequential information bearing signal.

The structure of the vidicon and its operation are explained more fully on pages 984 through 986 of Electronic and Radio Engineering, by F. E. Terman, Fourth edition published by McGraw-Hill Book Company, Incorporated, 1955.

It can readily be seen that the storage tube of this invention not only provides a means of storing information for a predetermined period of time but also provides a means for obtaining an amplified time sequential information bearing signal. This device also eliminates the need for the utilization of a low velocity electron beam and thus simplifies the construction.

While the present invention has been shown in several forms, it will be obvious to those skilled in the art that it is not so limited but is susceptible of various changes and modifications without departing from the spirit and scope thereof.

I claim as my invention:

1. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen including phosphor material which exhibits the property of displaying an enhanced luminous output upon the simultaneous application of electrons and an electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying a time varying electric field across said fluorescent screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensitive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released in the form of a luminous response to said reading electron beam.

2. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen of a material which exhibits the property of displaying an enhanced luminous output upon the simultaneous application of electrons and an electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying an alternating electric field across said fluorescent screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensitive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released in the form of a luminous response to said reading electron beam, said photosensitive means being a photoconductive layer positioned closely adjacent to said fluorescent screen.

3. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen of a material which exhibits the property of displaying an enhanced luminous output upon the simultaneous application of electrons and an electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying an alternating electric field across said fluorescent screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released in the form of a luminous response to said reading electron beam, said photosensitive means being a photomultiplier positioned to receive the luminous response of the fluorescent screen upon operation of said reading electron beam.

4. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen of a material which exhibits the property of displaying an enhanced luminous output upon the simultaneous application of electrons and an electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying an alternating electric field across said fluorescent

screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensitive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released in the form of a luminous response to said reading electron beam, said photosensive means including a layer of photoconductive material disposed adjacent said fluorescent screen and a source of electrons positioned so that electrons emitted by said source will charge the exposed surface of said photoconductive layer.

5. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen, including a finely divided material exhibiting the property of information storage upon the simultaneous application of an electron beam containing said information to be stored and a time varying electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying a time varying electric field across said fluorescent screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensitive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released by said reading electron beam.

6. A storage tube for storing information for a predetermined period of time and subsequently releasing said information comprising a fluorescent screen including phosphor material which exhibits the property of displaying an enhanced luminous output upon the simultaneous application of electrons and an electric field, means for generating a writing electron beam modulated with a time sequential information bearing signal to be stored on said fluorescent screen in a space distributed energy pattern, means for applying an electric field across said fluorescent screen during the operation of said writing electron beam, means for generating a reading electron beam of uniform intensity to scan said fluorescent screen, and photosensitive means positioned adjacent said fluorescent screen to derive a time sequential information bearing signal representative of said energy pattern released in the form of a luminous response to said reading electron beam.

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