United States Patent

[11] **3,567,984**

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[33] **Great Britain**
[31] **19,456/67**

[54] **CATHODE-RAY STORAGE TUBE HAVING SEMICONTINUOUS PHOSPHOR LAYER ON CONTINUOUS ELECTRON BOMBARDMENT INDUCED CONDUCTIVITY LAYER**
4 Claims, 5 Drawing Figs.

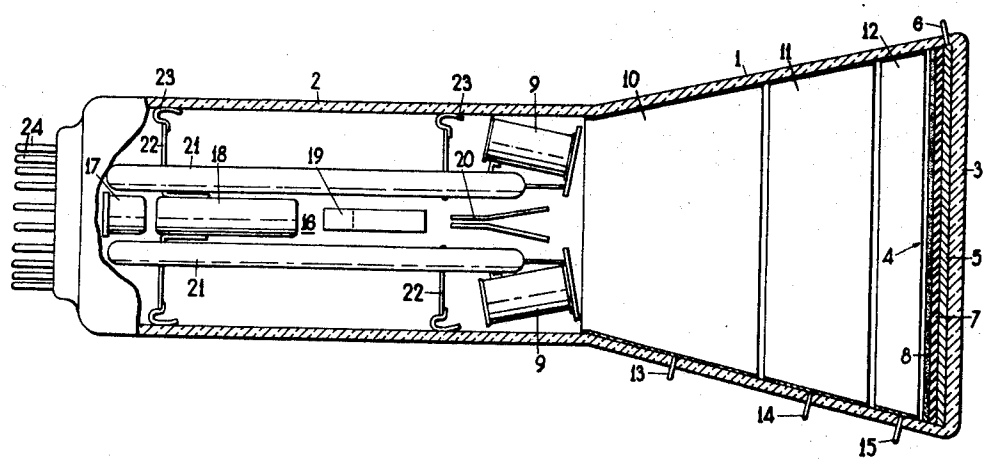
[52] **U.S. Cl.** **313/68,** 315/12, 313/92
[51] **Int. Cl.** **H01j 31/58,** H01j 31/62
[50] **Field of Search** ..... 313/68 (A)

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ABSTRACT: A cathode-ray storage tube wherein the storage screen comprises an electrically conducting control layer overlaid with a layer of insulating material, having electron bombardment induced conductivity properties, which in turn is overlaid by a semicontinuous layer of charge-storage material. A writing gun bombards the insulating layer with electrons to produce localized paths of low conductivity between the charge-storage layer and the control layer, which is at a potential above the first crossover value of the secondary electron characteristic of the charge-storage material. Thereafter, electrons from a gun flooding the screen maintain a charge-storage pattern on the charge-storage layer by secondary electron emission at regions of the charge-storage layer corresponding to the localized conductive paths.



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SHEET 1 OF 2

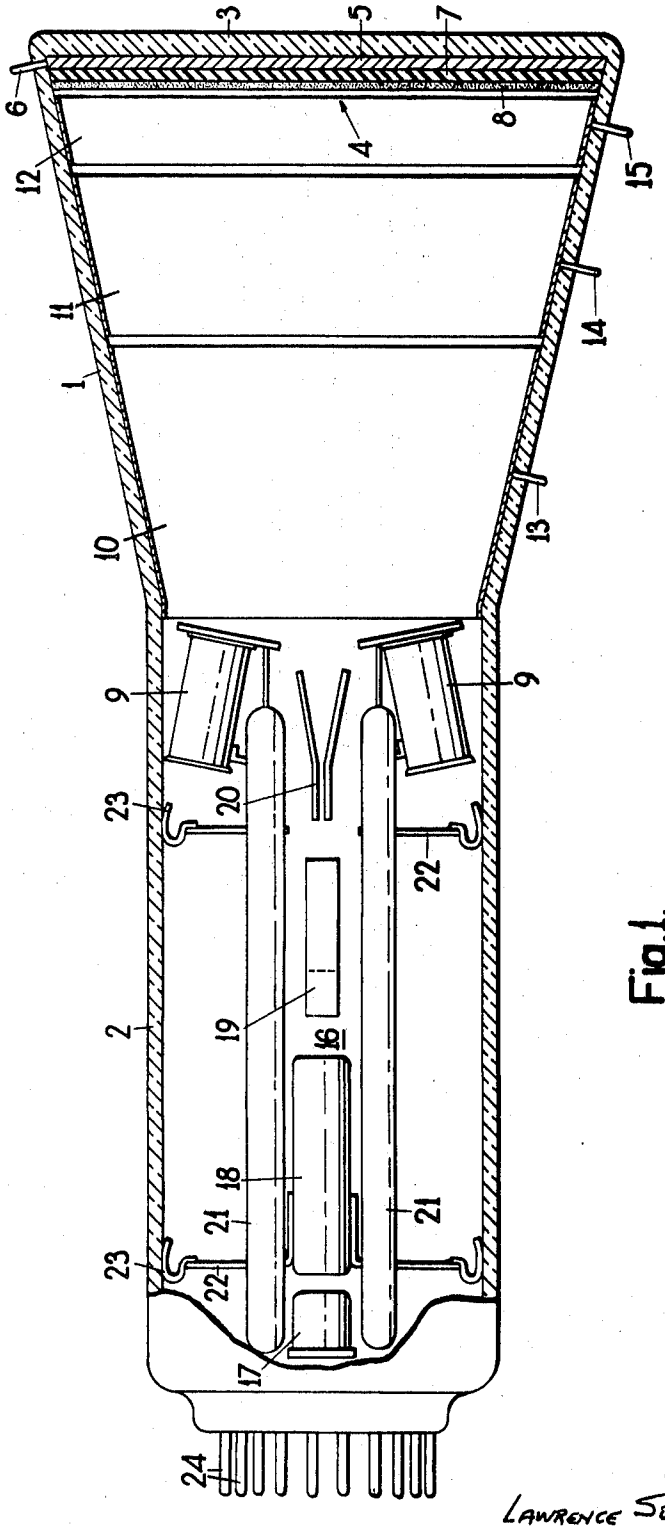


Fig. 1.

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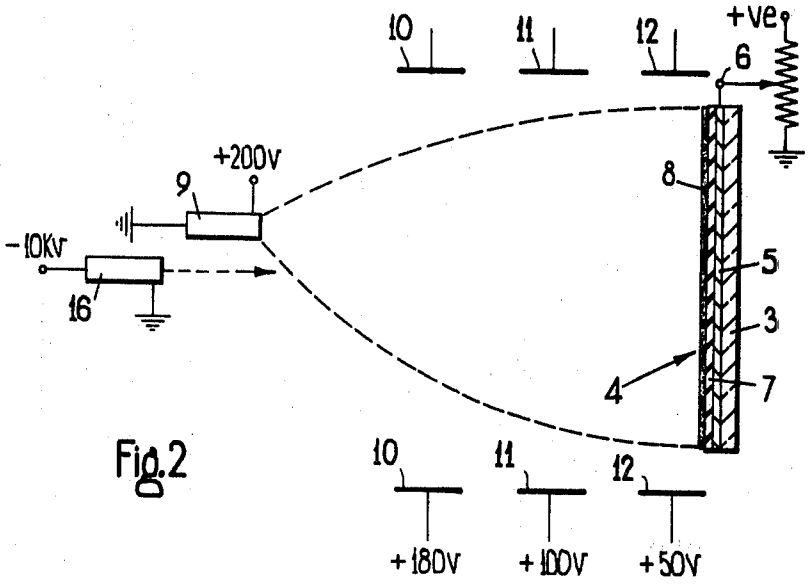


Fig.2

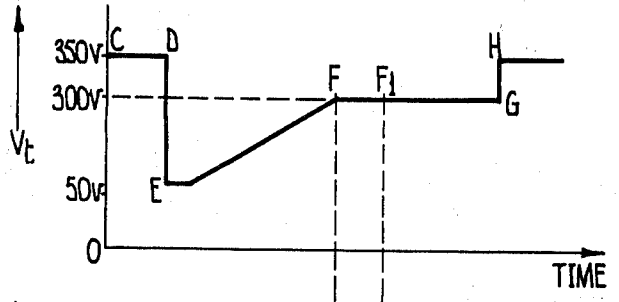


Fig.3

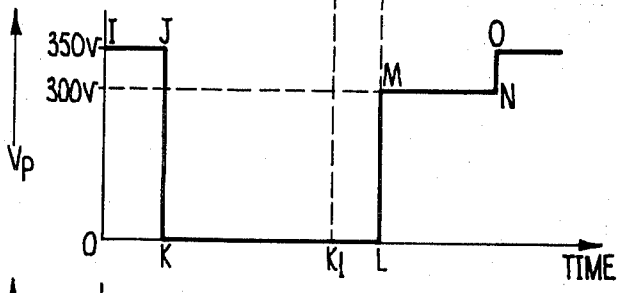


Fig.4

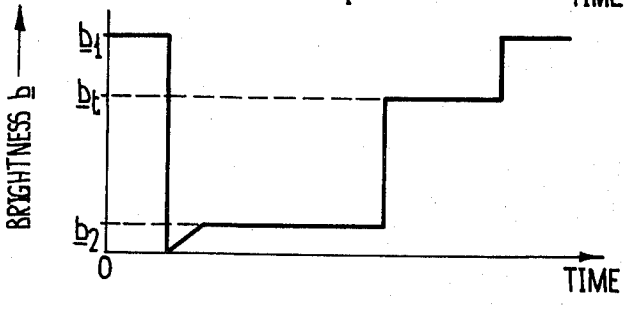


Fig.5

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CATHODE-RAY STORAGE TUBE HAVING SEMICONTINUOUS PHOSPHOR LAYER ON CONTINUOUS ELECTRON BOMBARDMENT INDUCED CONDUCTIVITY LAYER

This invention relates to cathode-ray storage tubes which are designed to receive electrical input signals, to store such signals for a controllable time, and to reproduce such signals as radiation images for direct viewing or photographic reproduction, or as electrical output signals.

The invention relates also to combinations of such tubes with the circuit arrangements adapted to apply the necessary operating potentials and signals to the tube electrodes.

One well-known type of directly viewed storage display tube used hitherto, termed the transmission type, incorporates a complex target comprising a conducting wire mesh having dielectric material deposited on the side thereof facing the electron guns and is provided with a separate phosphor viewing screen situated on the opposite side of and spaced from such mesh target. In use this type of storage display tube is characterized by the storage of a charge image on the dielectric layer, formed by means of an electron beam from a writing gun and by virtue of the secondary emission properties of the dielectric, the charge image exerting grid control on flood electrons which are arranged to pass through the mesh apertures from a target flooding gun and fall upon the phosphor screen so as to cause it to luminesce.

Another known type of storage and display tube incorporates a unified target and display device comprising a layer of an electrically conductive material overlaid with a thin semicontinuous layer of a phosphor and depends on localized secondary emission charging of the phosphor layer under the action of the writing gun.

An object of this invention is to provide an improved form of tube of this second kind with which relatively high writing speeds can be attained.

According to the invention, a cathode-ray storage tube designed for storing on a screen an electron charge pattern representative of an input signal includes within an evacuated envelope a storage screen, a flood electron gun designed to flood the screen with a wide beam of relatively low energy electrons and a writing electron gun designed to direct a narrow beam of relatively high energy electrons at the screen and to deflect the beam over the screen on the application of an input signal to the writing gun, the storage screen comprising a support member consisting of or carrying on the side facing the electron guns a control layer of electrically conductive material overlaid with a layer of insulating charge-storage material having electron bombardment induced conductivity (hereinafter referred to as e.b.i.c.) properties which is in turn overlaid with a semicontinuous layer of secondary electron emissive charge-storage material, the arrangement being such that with suitable potentials applied to the tube electrodes, including the maintenance of the control layer at a potential above the first crossover value of the secondary electron emission characteristic of the material of said semicontinuous layer, the surface of the latter can be maintained at a potential below that of the first crossover value but on the application of an input signal to the writing gun is locally raised to potentials above the first crossover value at the regions where the writing beam is incident thereon by virtue of localized conductive paths to the control layer induced through the thickness of the e.b.i.c. material as a result of bombardment of the latter by the writing gun electrons, the electrons incident on the screen from the flood gun then maintaining the required pattern of electric charge on the semicontinuous layer by virtue of secondary electron emission produced at said regions by locally increased potential.

By a semicontinuous layer of charge-storage material is meant a layer composed of particles so closely spaced as to appear as a continuous uniform layer in its gross microscopic properties but which particles are in fact not in good electrical contact with each other, so that localized electric charges induced thereon will not leak away to produce broadening of the signal line traces on the storage screen, and so that the layer is permeable to the writing beam of electrons so as to permit the latter to reach and activate the e.b.i.c. layer.

For producing a visible display of the stored charge pattern under the influence of the flood gun electron beam, the semicontinuous layer may consist of a phosphor suitable for such use, for example manganese-activated zinc silicate, and the screen can then be transparent for direct viewing or opaque and reflecting for indirect viewing. Alternatively, the tube might be adapted for photographic recording of the charge pattern, in which case a phosphor emitting invisible (e.g. ultraviolet) radiation could be used if desired.

In other cases the tube might be adapted to produce electrical output signals by scanning of the storage screen by an electron beam, which might be derived from the writing electron gun, and the semicontinuous layer material need not then be a phosphor.

The reference to the first crossover value of the secondary electron emission characteristic of the material of the semicontinuous layer means, of course, the value of the potential of the material at which the ratio of secondary electrons liberated to primary electrons incident first equals unity as the energy of the primary electrons (i.e. the electron beam produced by the flood gun) is gradually increased from zero.

An e.b.i.c. material is one which is initially of relatively low conductivity but whose conductivity can be greatly increased by bombardment with electrons of sufficiently high energy. Suitable e.b.i.c. materials for use in accordance with the invention are cadmium sulfide magnesium fluoride, zinc sulfide, and aluminum oxide.

With a storage tube in accordance with the invention, the writing time is determined by the time taken for the writing beam of electrons to induce a conductive path through the e.b.i.c. material, and this can be many times faster than the time required to build up a sufficiently high positive charge on the semicontinuous layer by the secondary electron emission action of the writing beam on the layer, as would be necessary to store a charge pattern in a similar tube not including an e.b.i.c. layer.

One cathode ray storage tube in accordance with the invention and its mode of operation will now be described by way of example with reference to the accompanying drawing in which:

FIG. 1 is a part diagrammatic sectional elevation of the tube;

FIG. 2 illustrates the operation of the tube;

FIG. 3 shows how the control layer potential is varied during operation of the tube;

FIG. 4 shows the corresponding variations in potential of the phosphor storage layer; and

FIG. 5 shows how the brightness of the phosphor layer varies during operation of the tube.

Referring to FIG. 1, the tube includes a sealed glass envelope having a flared bulb portion 1 which, at its narrower end, coaxially adjoins a tubular neck portion 2. At its wider end the bulb portion is closed by a flat end wall 3. The end wall 3 forms the support member for the storage screen 4 of the tube, the screen 4 further including a thin light transparent and electrically conductive control layer 5 formed on the inner surface of the end wall 3 and connected to an external terminal 6, a light transparent layer 7 of e.b.i.c. material formed on the control layer 5, and a thin semicontinuous charge-storage layer 8 consisting of a phosphor material. The control layer 5 may suitably consist of tin oxide, the e.b.i.c layer 7 may suitably consist of zinc sulfide and the storage layer 8 may suitably consist of manganese-activated zinc silicate.

The neck portion 2 of the envelope is closed at its end remote from the flared portion 1 and houses an electrode structure comprising two flood electron guns 9 which are capable of flooding the whole of the nearer surface of the storage screen 4. The electrons emitted by the flood guns 9 are

focused and collimated, so as to strike the screen **4** orthogonally, by the electric fields produced by three annular electrodes **10**, **11** and **12** constituted by graphite coatings on the inner surface of the bulb portion **1** of the envelope, each of these electrodes **10**, **11** and **12** being connected to a separate external terminal **13**, **14** or **15**.

The electrode structure also includes a writing electron gun **16** which incorporates a cathode **17**, a beam blanking and accelerating and focusing electrode system **18**, shown diagrammatically in FIG. **1**, and two pairs of deflector plates **19** and **20** for deflecting the electron beam over the screen **4** in horizontal and vertical directions respectively.

The flood and writing electron guns **9** and **16** are supported from four glass rods **21** which extend parallel to the axis of the neck portion **2** of the envelope, and which are supported by centrally apertured metal discs **22** which carry spring members **23** at their outer edges which resiliently engage the internal surface of the neck portion **2**.

Leads (not shown) from the various electrodes of the electrode structure are connected to pins **24** sealed through the closed end of the neck portion **2**.

It will be appreciated that in the drawings, the thickness of the layers **5**, **7** and **8** of the storage screen **4** are exaggerated for the sake of clarity.

Referring now to FIG. **2**, in operation the annular collimating electrodes **10**, **11** and **12** are typically maintained respectively at potentials of **180** volts, **100** volts and **50** volts positive with respect to the cathodes of the flood guns **9**, which are earthed, and the anodes of the flood guns **9** are maintained at a potential of **200** volts positive with respect to earth. The flood guns **9** then emit a continuous spray of electrons as indicated in FIG. **2**. In FIG. **2** only one flood gun **9** is shown for the sake of clarity.

The cathode **17** of the writing gun **16** is maintained continuously at **10** kilovolts negative with respect to earth and the final anode of the writing gun **16** is earthed. The beam produced by the writing gun **16** is blanked off in the absence of an input signal to be stored and displayed. The input signal, when present, is applied to the deflector plates **19** and **20**, the beam produced by the gun **16** being then unblanked and tracing out a signal path on the phosphor storage layer **8** determined by the input signal. The external terminal **6** for the layer **5** is connected to a source of variable positive potential, this positive potential being the controlling variable with regard to the maintenance or the eradication of any signal stored on and displayed by the screen **4**.

The collimating electrodes **10**, **11** and **12** have very little effect on the writing beam as their potentials are negligible compared to the potential difference between the cathode **17** of the writing gun **2** and the control layer **5**.

The in operation the tube is allowed to warm up (assuming thermionic cathodes are employed, as is at present usual) and the potential of the layer **5** is raised to about **+350** volts at which level it is maintained for a time. It is then rapidly lowered in potential to approximately **+50** volts and following this is slowly raised in potential to around **+300** volts, at which level it is maintained for the duration of the period for which writing and storage is required. This alteration in potential is indicated by the part C to G of the graph of FIG. **3** of layer **5** potential (V_t) against time. Such alteration of the potential V_t is transmitted by capacitor action through the e.b.i.c. layer **7** to the phosphor layer **8**, but the potential at the exposed surface of the phosphor layer **8** is additionally determined by the secondary electron emission properties of the phosphor layer **8** and by the effect of the writing gun **16**, as is indicated by the graph of FIG. **4**, which shows the variation with time of the phosphor surface potential V_p and will now be explained.

Thus over the period IJ corresponding to the period CD in FIG. **3**, the phosphor surface potential V_p is substantially the same as that of the control layer **5** which is chosen to be above the so-called first "crossover" value of potential at which the secondary electron emission ratio for the phosphor layer **8** is greater than unity, so that as a result of the incidence of electrons from the flood guns **9** the while of the phosphor layer **8** acquires a substantially uniform positive charge and the phosphor is excited to a high brightness which clears away any previously stored signal trace.

The fall of potential DE of the control layer **5** carries the potential of the surface of the phosphor layer **8** below the said "crossover" value; electrons from the flood guns **9** are then captured and carry the phosphor surface potential V_p to earth value as indicated by the line JK in FIG. **4**, also holding it at this potential as the potential V_t of the control layer **5** is slowly increased to F as in FIG. **3**, despite this value F being greater than the said "crossover" value.

The screen **4** is now ready to receive and store a signal trace from the writing gun **16** over a period of time represented schematically by the interval between F and G in FIG. **3** (i.e. the interval between K_1 and N in FIG. **4**) and which may of course be relatively very much longer than as shown.

The instant at which the writing gun **16** is energized is represented by L in FIG. **4**. Then, everywhere on the screen **4** where the writing beam is incident it produces a conductive path through the e.b.i.c. layer **7** as a result of the local bombardment of this layer **7** by the very high energy electrons of the writing gun **16** passing through the phosphor layer **8**. The surface of the phosphor layer **8** then immediately assumes the positive potential F_1 of the layer **5** each region of incidence of the writing beam, which positive potential is then maintained by the positive charge formed by secondary electron emission from these regions of the phosphor layer **8** under the action of the electrons from the flood guns **9**. At the same time these flood electrons increase the brightness of fluorescence at these regions and accordingly the trace written by the writing gun **16** is maintained by the flood guns **9** until erased, either by deenergization of the tube or by rapidly raising the potential of the control layer **5** to its initial value of **+350** volts as from G to H in FIG. **3**, corresponding to N to O in FIG. **4**.

This effect is further illustrated by the graph of FIG. **5**, which shows the variation in brightness *b* of the regions of the phosphor layer **8** on which the writing beam is incident over the time intervals indicated in FIG. **4**

Thus over the initial "screen clearing" period corresponding to the high uniform potential period OK in FIG. **4**, the brightness is at a relatively high level b_1, which falls to zero as the phosphor layer potential V_p falls rapidly to zero at time K. However, for a reason which is not entirely understood, instead of remaining at zero brightness the phosphor layer quickly attains a relatively low brightness b_2 which persists over the whole of the layer as a general background illumination.

At the time L in FIG. **4** the regions of the phosphor layer **8** on which the writing beam is incident are raised to an intermediate level of fairly high brightness b_t to delineate the trace marked out by the writing beam against the relatively faint background illumination.

I claim:

1. A bistable cathode-ray storage tube with a high writing speed characteristic comprising:

A. an evacuated envelope;

B. a storage screen within said envelope comprising:

1. a control layer of electrically conductive material;
2. a continuous layer of insulating charge-storage material having electron bombardment induced conductivity which overlays said control layer; and
3. a semicontinuous layer of secondary electron emissive charge-storage material which overlays said layer of insulating material;

C. a writing electron gun disposed within said envelope on the semicontinuous layer side of the storage screen, for scanning over the storage screen a narrow beam of relatively high energy electrons which penetrate said semicontinuous layer and impinge on the insulating layer, thereby to provide localized conductive paths through the insulating layer between the semicontinuous layer and the control layer so that, when the surface of the semicon-

tinuous layer nearer the writing electron gun and the control layer are initially at potentials respectively below and above the first crossover value of the secondary electron emission characteristic of the material of the semicontinuous layer, the potential of said surface of the semicontinuous layer at regions corresponding to said localized conductive paths is raised to a value above said first crossover value; and

D. a flood electron gun, disposed within the envelope on the semicontinuous layer side of the storage screen, for flooding the whole of said surface of the semicontinuous layer with relatively low energy electrons so as to maintain a charge-storage pattern on the semicontinuous layer by virtue of secondary electron emission at said regions where said surface of the semicontinuous layer is at a potential above the first crossover value, the surface of said semicontinuous layer facing said guns being completely exposed over its entire area to direct impingement by electrons emitted by said guns, said semicontinuous layer being a phosphor emissive of radiation at a potential above said first crossover value, whereby the electron bombardment induced conductivity layer accelerates the formation by the writing gun of a charge storage pattern on said surface.

2. A cathode-ray storage tube according to claim 1 wherein said insulating layer comprises at least one of the group of semiconducting materials comprising cadmium sulfide, magnesium fluoride, zinc sulfide and aluminum oxide.

3. A cathode-ray storage tube according to claim 1 wherein said storage screen is carried on a support member of insulating material adjacent said control layer and said support member, said control layer and said insulating layer are transparent to the radiation emitted by said semicontinuous layer.

4. A cathode-ray storage tube according to claim 3 wherein said support member forms a part of said envelope of the tube.