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**Hayes et al.**

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[45] **Jan. 9, 1973**

[54] **STORAGE TUBE HAVING TRANSMISSION TARGET WITH LOW DIFFERENTIAL CUTOFF**

[75] Inventors: **Raymond Hayes; Wesley H. Hayward,** both of Beaverton, Oreg.

[73] Assignee: **Tektronix, Inc.,** Beaverton, Oreg.

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[52] **U.S. Cl.**..................**315/12,** 313/68 A, 313/92 R
[51] **Int. Cl.**..............................................**H01j 29/41**
[58] **Field of Search**...........313/68 R, 68 A, 89, 92 R; 315/12, 13 ST

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*Primary Examiner*—Leland A. Sebastian
*Attorney*—Stephen W. Blore et al.

[57] **ABSTRACT**

A direct viewing charge image storage tube is described including a transmission type storage target having an extremely low differential cutoff of about 0.1 to 0.2 volt and faster writing speed of about 100 to 500 centimeters per microsecond. This is achieved by employing a thick storage dielectric on the mesh electrode of the target, providing a low electrical field adjacent the rear of the target and applying a positive preparation pulse to the target electrode during bombardment by the low velocity flood electrons until the potential of such dielectric is decreased to the cutoff voltage. The side portions of the dielectric surrounding each of the mesh openings continues to charge negatively after the front surface portion of the dielectric reaches the flood gun cathode potential so that the potential of each front surface portion decreases below such cathode potential until it reaches the cutoff voltage for the adjacent mesh opening before termination of the preparation pulse. The thick storage dielectric layer may be made of low density secondary emissive, such as magnesium oxide having a density of less than about 5 percent of its bulk density. While the storage tube can contain only one transmission storage target and phosphor viewing screen, it may also employ a second transmission storage target of thinner dielectric of higher density between the first target and such phosphor screen so that a charge image formed on the first target may be transferred to such second target for storage viewing and over a longer time.

**18 Claims, 8 Drawing Figures**

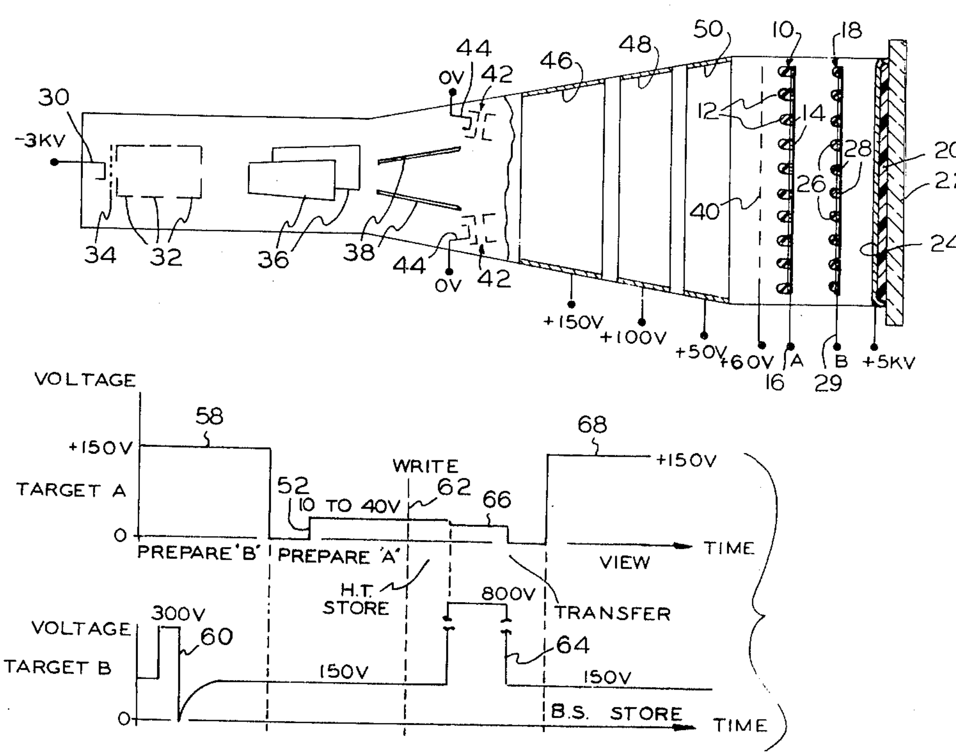
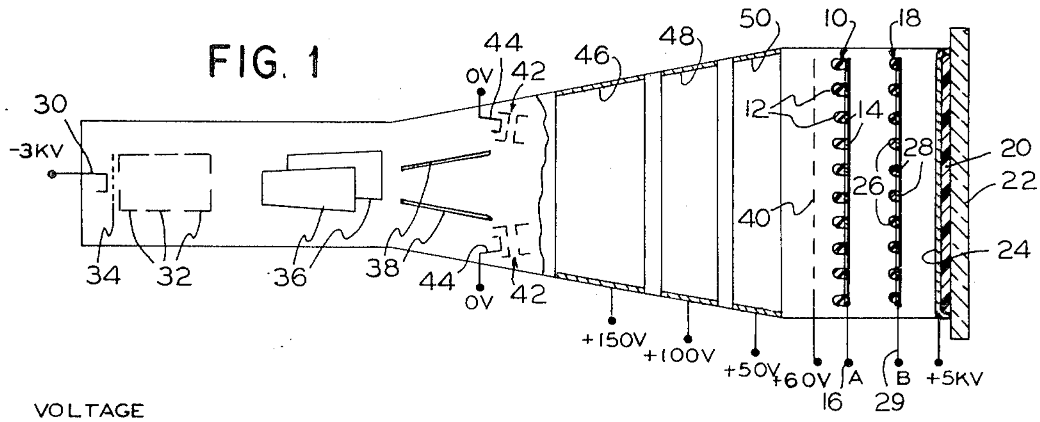


FIG. 1



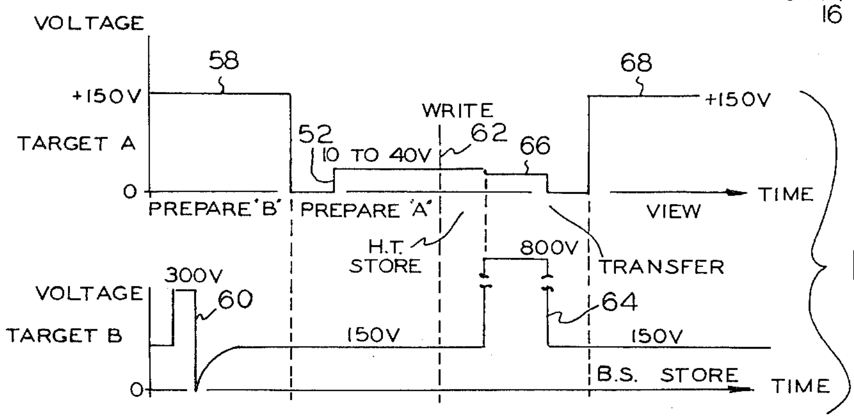




FIG. 2

FIG. 3

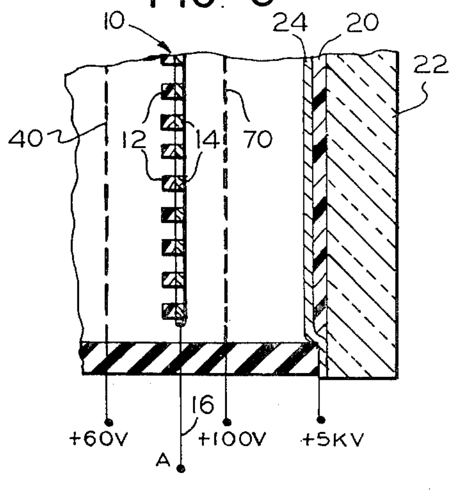
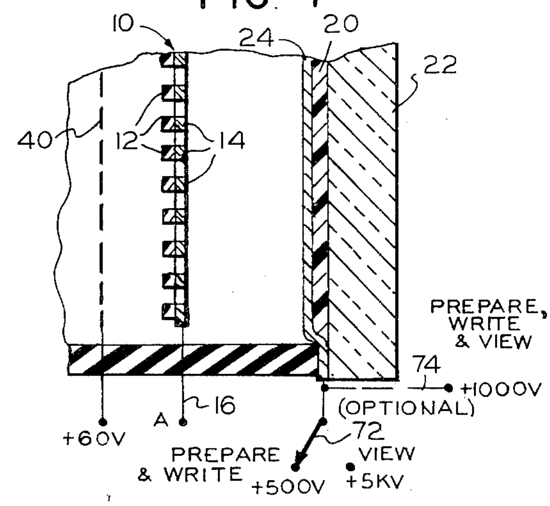



FIG. 4




RAYMOND HAYES
WESLEY H. HAYWARD
*INVENTORS.*

*BY*

*BUCKHORN, BLORE, KLARQUIST & SPARKMAN*
*ATTORNEYS*

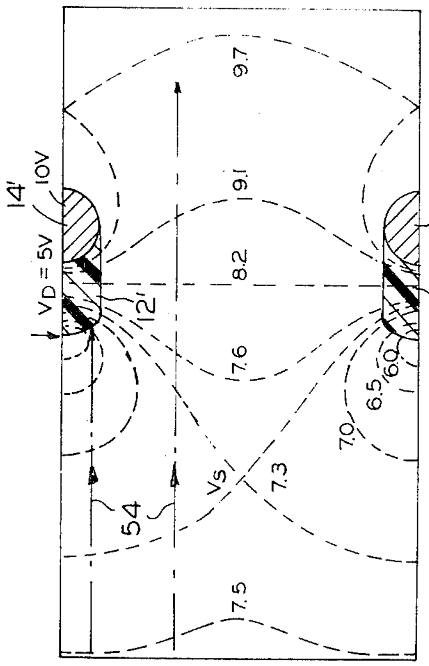



FIG. 5B

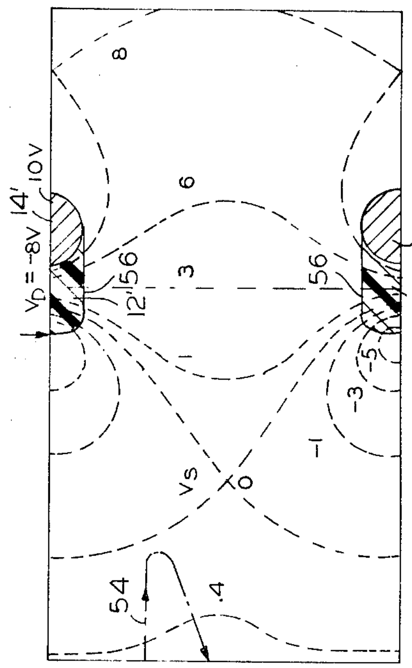



FIG. 5D

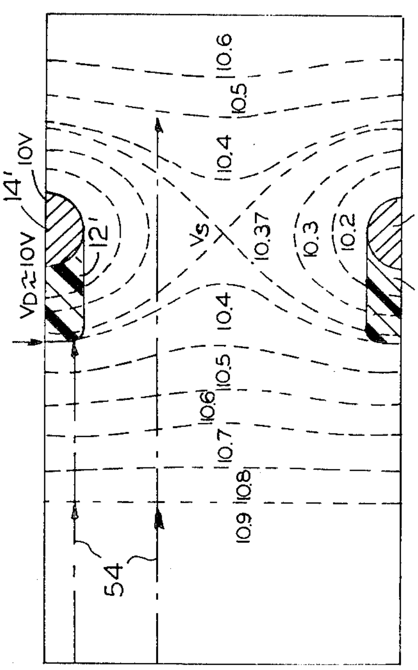



FIG. 5A

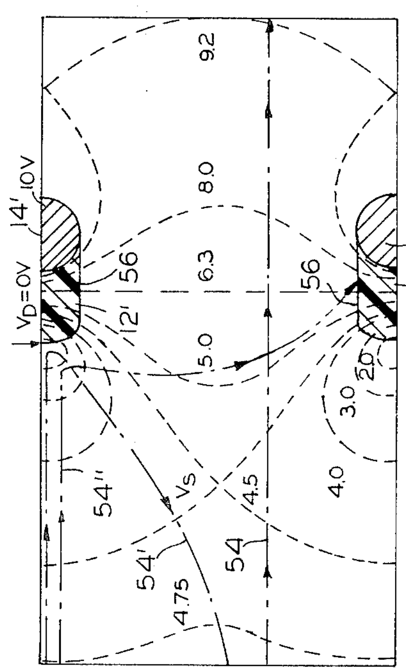



FIG. 5C

RAYMOND HAYES
WESLEY H. HAYWARD
INVENTORS.

BY

BUCKHORN, BLORE, KLARQUIST & SPARKMAN
ATTORNEYS

# STORAGE TUBE HAVING TRANSMISSION TARGET WITH LOW DIFFERENTIAL CUTOFF

## BACKGROUND OF THE INVENTION

The subject matter of the present invention relates generally to charge image storage tubes having transmission type mesh storage targets and methods of operation, and in particular, to such storage tubes and methods of operation in which a low differential cutoff is achieved for the mesh target. The differential cutoff of a transmission storage target is the difference between the maximum and minimum cutoff voltages over the entire surface of the target, and this limits the minimum voltage of any charge image which can be stored or the maximum writing speed of the storage tube. A relatively thick storage dielectric layer is employed on the mesh target electrode along with a low electrical field on the rear side of the target facing away from the flood gun or other source of low velocity electrons and a preparation pulse positive relative to the flood gun cathode voltage is applied to the target electrode during bombardment by the low velocity flood electrons until the potential of such dielectric is decreased below such cathode voltage to cutoff. The low differential cutoff is accomplished by "side charging" in which the side portions of the thick storage dielectric surrounding each mesh opening continue to charge negatively due to bombardment by the flood electrons after the front surface of the dielectric reaches the flood gun cathode voltage until the potential of each front surface portion decreases below such cathode voltage to the cutoff voltage for its adjacent mesh opening before termination of the preparation pulse. Thus, the front surface portions of the storage dielectric surrounding each mesh opening automatically decrease to the minimum cutoff voltage which prevents flood electrons from being transmitted through such mesh opening. Once this cutoff voltage is reached, further reduction in the dielectric potential by side charging is prevented because the low velocity flood electrons can no longer reach the storage dielectric. As a result, the present mesh storage target has a much lower differential cutoff of 0.1 to 0.2 volt and a higher maximum writing speed of 100 to 500 centimeters per microsecond as compared with about 2.0 volts and 1 to 10 centimeters per microsecond for a conventional transmission storage tube. Thus, the storage tube of the present invention has a differential cutoff of about one-tenth and a maximum writing speed of more than 10 times that of previous transmission tubes.

Another advantage of the storage tube of the present invention is that the unwritten background areas on the display screen are of a more uniform brightness at the higher writing speeds. Furthermore, the charge image transfer embodiment of the present storage tube has a much longer storage time than that of conventional transmission storage tubes and has a display of higher brightness than previous tubes employing non-mesh storage targets of phosphor material as the display screen. A related charge image transfer storage tube is shown in copending U.S. Pat. application, Ser. No. 47,005 filed June 17, 1970, of Hutchins et al. which employs such a non-mesh storage target of phosphor material as the second target.

It is, therefore, one object of the present invention to provide an improved charge image storage tube having a transmission storage target of an extremely low differential cutoff voltage which is capable of a faster maximum writing speed.

Another object of the present invention is to provide such a storage tube and method of operation in which side charging of the storage dielectric by the flood electrons causes the potential of the front surface portions of such dielectric to decrease below the flood gun cathode voltage until reaching their cutoff voltage.

A further object of the present invention is to provide such a storage tube and method of operation in which a relatively thick storage dielectric layer is employed on a mesh target electrode, a low electrical field is provided adjacent the rear of such target, and a positive voltage preparation pulse is applied to the mesh target electrode during bombardment of the dielectric by low velocity flood electrons to cause charging of the side portions of such dielectric surrounding the mesh openings until the potential of the front surface portions of the dielectric reaches cutoff before such pulse is terminated.

Still another object of the present invention is to provide such an improved storage tube and method of operation of fast writing speed and long storage time and having high brightness display in which another transmission storage target capable of bistable storage is employed between the first mentioned target and a separate phosphor viewing screen so that a charge image written on the first target can be transferred to the second target for subsequent storage and viewing on such screen.

An additional object of the present invention is to provide such a storage tube and method of operation in which the first storage target has a storage dielectric layer of greater thickness and less density than that of the second storage target to provide the first target with a lower capacitance and faster writing speed while the second target has a higher capacitance and longer storage time.

## BRIEF DESCRIPTION OF DRAWINGS

Other objects and advantages of the present invention will be apparent from the following detailed description of certain preferred embodiments thereof and from the attached drawings of which:

FIG. 1 is a schematic view of one embodiment of a charge transfer storage tube made in accordance with the present invention in which a charge image is written on a first target and transferred to a second target for viewing;

FIG. 2 shows the voltages applied to the target electrodes of the first and second storage targets in the tube of FIG. 1;

FIG. 3 is an enlarged view of a portion of another embodiment of a transmission storage tube made in accordance with the present invention;

FIG. 4 is an enlarged view of a portion of the third embodiment of a storage tube in accordance with the present invention; and

FIGS. 5A, 5B, 5C, and 5D are schematic diagrams showing the side charging operation during preparation of the transmission storage target of FIGS. 1, 3 or 4 for writing a charge image thereon, which provides such target with a low differential cutoff.

## DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in FIG. **1**, one embodiment of the charge image storage tube of the present invention includes a first transmission type storage target **10** having a relatively thick storage dielectric layer **12** coated on the front surface of a mesh electrode **14** connected by lead **16** to an external voltage source which applies the voltage pulses shown in FIG. **2** to such mesh electrode. The first storage dielectric **12** has a thickness greater than 5 microns and with mesh electrodes of 250 and 500 lines per inch is preferably about 10 to 30 microns to provide forward projecting side portions for the dielectric around the mesh opening. A second transmission type storage target **18** is provided in the storage tube between the first target **10** and a phosphor viewing screen **20** coated on the inner surface of a glass face plate **22** forming a portion of the sealed evacuated envelope. The phosphor screen **20** is covered by an electron permeable conductive layer **24** of aluminum which acts as an accelerating electrode for the flood electrons and is connected to an external voltage source of about +5 kilovolts so that the display image emitted by the phosphor is of high brightness. It should be noted that this brightness is further increased by the light reflecting characteristics of the conductive layer **24** in a conventional manner. The second storage target **18** includes a storage dielectric **26** coated on the front surface of a mesh electrode **28**, such second dielectric being of less thickness than the first storage dielectric **12** so that the second target **18** has a greater capacitance and longer storage time than the first target **10**.

The first storage dielectric **12** may be of a low density secondary emissive material such as porous magnesium oxide, aluminum oxide, or potassium chloride having a density less than about 10 percent of its bulk density and preferably on the order of 2 to 5 percent of such bulk density, while the second storage dielectric **26** is of a high density material even though it may also be formed of the same compound. The low density of dielectric **12** enables it to be provided as a thicker coating and further reduces the capacitance of the first storage target **10** so that it is capable of extremely high writing speeds when struck by a writing beam of high velocity electrons to form the charge image stored on such target.

A writing gun cathode **30** connected to a high negative DC voltage of about −3 kilovolts is provided at the opposite end of the storage tube envelope from the phosphor screen. The writing electrons emitted by cathode **30** are focused into a narrow beam by the writing gun anodes **32** and the current density of such beam is determined by the negative bias voltage on a control grid **34** which may also be used as a blanking electrode to cut off the writing beam during storage. The writing beam is transmitted between a pair of vertical deflection plates **36** and a pair of horizontal deflection plates **38** which deflect the beam in the conventional manner of a cathode ray oscilloscope in accordance with a vertical input signal and a ramp voltage horizontal sweep signal, respectively applied thereto to produce a charge image of the vertical signal waveform on the storage dielectric **12** of the first target **10**. The high velocity writing electrons form a positive voltage charge image on the first storage dielectric **12** by secondary electron emission, such secondary electrons being collected by a collector mesh electrode **40** positioned in front of the first target and connected to a positive DC voltage source of about +60 volts.

A pair of flood guns **42** having grounded cathodes **44** are provided within the storage tube to uniformly bombard the first target **10** with low velocity flood electrons. A portion of these flood electrons are transmitted through the apertures of the first mesh electrode **14** of storage target **10** in the written areas of such target which have been bombarded by the writing beam. Depending upon whether the tube is operated for halftone storage or charge transfer such transmitted flood electrons are caused to strike the phosphor screen **20** to produce the light image of the halftone charge image stored on the first target **10**, or are caused to strike the storage dielectric **26** of the second target **18** in order to transfer the charge image formed on the first dielectric **12** to the second dielectric **26** in a manner hereafter described. A plurality of collimating electrodes **46, 48** and **50** are provided as conductive bands coated on the inner surface of the storage tube envelope which are spaced axially from each other between the flood guns **42** and the first target **10**. The collimating electrodes **46, 48** and **50** are respectively connected to DC voltage sources of + 150 volts, +100 volts, and +50 volts. These collimating electrodes provide electrostatic fields which cause the low velocity flood electrons to be uniformly distributed over the surface of the first storage target **10** and to strike the storage dielectric **12** perpendicular to such target.

The charge transfer storage tube of FIG. **1** is an improvement over the previous charge transfer storage tube shown in U.S. Pat. No. 3,165,664 of Callick, as well as that shown in co-pending U.S. patent application. Ser. No. 47,005 of Hutchins et al. referred to above. Among other things, the present storage tube differs from these previous tubes by providing a side charging of the first dielectric **12** which produces a lower differential cutoff. Thus, the side portions of storage dielectric **12** surrounding the mesh apertures of target electrode **14** are caused to continue to charge negatively after the potential of the front surface of the storage dielectric **12** reaches the voltage of the flood gun cathode so that the proper cutoff voltage is automatically achieved, as shown in FIGS. **5A** through **5D**.

Prior to the formation of a charge image on the first storage target **10** by the writing beam, such target is prepared by applying a preparation pulse **52** to lead **16** during the bombardment of the storage dielectric **12** by the low velocity flood electrons. The preparation voltage pulse **52** has an amplitude in the range of about 10 to 40 volts and is of sufficient time duration greater than about 0.5 second to cause the side charging operation hereafter described. FIGS. **5A, 5B, 5C,** and **5D** show four different consecutive stages during the preparation of the transmission storage target **10**, when a preparation pulse **52** of 10 volts is applied to a target electrode **14'**. It should be noted that the field lines of the electrostatic potential distribution shown in these figures are only approximate and were calculated by a computer based on parallel target electrode wires **14'** rather than a mesh electrode. However, these figures are believed to accurately show the side charging effect which occurs during the operation of the storage tube of the present invention.

As shown in FIG. 5A, when a preparation pulse **52** of 10 volts is applied to the mesh target electrode **14'** the potential of the storage dielectric **12'** increases to about 10 volts due to capacitance coupling. At this time, the crossover point $V_s$ where the field or potential gradient is zero occurs in the same plane as the wires **14'** at a voltage of 10.37 volts. Some of the low velocity flood electrons **54** pass through the mesh apertures while others strike the storage dielectric **12'** to begin negatively charging such dielectric. It should be noted that the low velocity flood electrons **54** are deposited on the surface of the storage dielectric so that they tend to charge such storage dielectric negatively since a fewer number of secondary electrons are emitted than the primary electrons bombarding such dielectric. In other words, at these low acceleration voltages, the secondary emission ratio of the storage dielectric **12'** is less than unity. As shown in FIG. 5B, sometime after the preparation voltage pulse is applied, the storage dielectric **12'** has charged to a front surface voltage, $V_D$ of +5 volts. The crossover point $V_s$ now occurs at 7.3 volts and has moved to the left toward the flood gun cathode to a position in front of the storage dielectric. FIG. 5C shows the storage target at a still later time after the preparation pulse is applied when the front surface voltage, $V_D$, of the dielectric is equal to the 0 volts flood gun cathode voltage. At this time, the crossover point $V_s$ is still at a positive voltage of 4.5 volts so that some of the flood electrons **54** still pass through the mesh apertures. Other flood electrons **54'** are repelled back towards the collector electrode when they approach the front surface of the storage dielectric. However, some flood electrons **54''** are attracted to the positively charged side portions **56** of the adjacent storage dielectric portions since such side portions have a voltage between +5.0 and +8.0 volts. As a result, the side portions **56** of the storage dielectric continue charging negatively toward the zero voltage of the flood gun cathode. This side charging continues until the crossover point $V_s$ reaches 0 volts as shown in FIG. 5D. When this happens, all of the flood electrons **54** are prevented from passing through the mesh apertures or from striking the storage dielectric by the zero potential plane in front of such dielectric so that the mesh target is cut off and further charging stops. The front surface of the storage dielectric is then at a cutoff voltage $V_D$ of about −8 volts below the flood gun cathode voltage, where it has been driven due to capacitive coupling to the side portions **56**. Thus, due to the thickness and high dielectric constant of the storage dielectric, the front surface portion is provided with a lower voltage than the side portions of the storage dielectric surrounding the mesh apertures. When the front surface portions reach the cutoff voltage of the adjacent mesh openings, this automatically stops any further charging of the storage dielectric since no further flood electrons are permitted to bombard such dielectric or pass through the mesh apertures. As a result, the storage dielectric portions surrounding each mesh aperture are automatically charged to the lowest cutoff voltage possible and the differential cutoff of the target is reduced to an extremely small value on the order of 0.10 to 0.25 volt. This means that charge images formed by the high velocity writing electrons with voltage greater than the differential cutoff voltage of about 0.2 volt may be stored on storage target **10** so that such target has a much faster maximum writing speed.

The maximum writing speed of a cathode ray tube storage target in CM/sec. is given by the formula

$$S_w = \frac{I_b \times (R-1)}{C \times d \times \Delta V} \times \frac{4}{\pi}$$

where $I_b$ is the writing beam current, R is the secondary emission ratio of the storage dielectric at the writing beam voltage, C is the target capacitance per unit area, $d$ is the writing beam diameter and ΔV is the voltage change on the target due to the charge image produced by the writing beam. From the above formula, it is clear that the maximum writing speed occurs when the minimum resolvable voltage change, ΔV, is produced and this is determined by the differential cutoff of such target. Thus, in order to write a charge image anywhere on a target, the voltage change, ΔV, of such charge image must be greater than the differential cutoff voltage. The differential cutoff voltage of a conventional transmission storage target is on the order of 2.0 to 10.0 volts and is typically limited by non-uniformities in the storage target, such as different size mesh openings, target electrode thickness variations, and storage dielectric thickness variations, as well as by nonuniformities in the flood electron system including changes in current density and differences in the angle at which the flood electrons strike the storage target. However, the side charging technique of the present invention provides the minimum differential cutoff voltage possible of about 0.1 to 0.25 volt which is much lower than the 2.0 to 5.0 volts differential cutoff of the conventional tubes. This results in an increase in maximum writing speed to about 100 to 500 centimers per microsecond for the present tube as compared to a conventional transmission storage tube writing speed of about 1 to 10 centimeters per microsecond. With a conventional transmission storage tube, the halftone storage target is prepared by pulsing the target electrode positive until the storage dielectric is charged to the zero voltage of the flood gun cathode by the flood electrons. At this time, the storage target still transmits the flood electrons and this transmission is only stopped after the preparation pulse terminates because when the target electrode returns to ground potential the storage dielectric is capacitively coupled to a negative voltage which is sufficient to cut off the target. In our storage tube, the side charging operation automatically causes the storage dielectric to reach the minimum cutoff voltage before the prepare pulse is terminated by a type of internal negative feedback within the storage dielectric.

The side charging operation of FIGS. 5A to 5D is possible only with a relatively low electric field adjacent the rear side of the storage target **10** facing away from the flood gun which is provided by the second storage target **18** since it isolates the first target from the high field produced by the +5 kilovolts potential on the viewing screen electrode **24**. Thus, the field adjacent the rear of the first storage target **10** must be less than the voltage gradient across the storage dielectric **12** and is preferably less than about 10 percent of such voltage gradient. In addition, it has been found that the storage dielectric layer must have a thickness greater than about 5 microns sufficient to provide the necessary side portions **56** which can be charged to different voltage than the front portions of such dielectric. Expressed otherwise, the storage dielectric layer should have a thickness of at least 5 percent of the centerline distance between the centers of the adjacent mesh elements.

In the preferred embodiment, the storage dielectric **12** of the first target is made of porous, low density magnesium oxide having a density of less than 5 percent of its bulk density. This storage dielectric is provided with a thickness of about 10 microns on a target electrode **14** of electroformed nickel mesh of about 250 to 500 lines per inch. Other porous storage dielectrics can also be employed including aluminum oxide, magnesium fluoride, potassium chloride, or even high density dielectric including magnesium oxide. However, the low density magnesium oxide has the added advantage that it can be applied in layers of greater thicknesses and high strength so that it does not fall off the mesh electrode during processing or handling of the tube. The other advantage of the porous dielectric is that it has an effective dielectric constant close to that of a vacuum and a resulting lower capacitance which together with the relatively high thickness, provides an extremely low capacity target having a very high maximum writing speed. The disadvantage of such low capacitance is that it may severely limit the storage time of such target to a few seconds. However, this is not a great disadvantage in the charge transfer tube of FIG. **1** since the charge image written on the first target **10** is immediately transferred to the second storage target **18** for viewing purposes. The second target **18** is made of lesser thickness and higher capacitance for a long storage time. Thus, the second target may be a bistable type storage target, preferably made of a thin layer of high density magnesium oxide, having an indefinite storage time on the order of 1 hour or more.

It is also possible to make the phosphor viewing screen **20** in FIG. **1** out of a phosphor such as $P_1$ type phosphor (manganese activitated zinc orthosilicate) which is capable of bistable storage in the manner of copending U.S. Pat. application, Ser. No. 47,005, referred to previously in which case the second mesh target **18** would be eliminated.

The charge transfer operation of the storage tube of FIG. **1** is best understood by referring to the voltage waveforms of FIG. **2**. In order to prepare a second storage target **18** for the storage of another charge image, a voltage **58** of about +150 volts is applied through lead **16** to the target electrode **14** of the first target which enables the flood electrons to uniformly pass through such first target and bombard the second target **18**. At the same time, an erase voltage pulse **60** is applied through lead **29** to the target electrode **28** of the second target **18**. The erase pulse **60** increases from a quiescent lever of about 150 volts to a maximum of about 300 volts which is above the first crossover voltage of the storage dielectric **26** so that the flood electrons cause the dielectric to "fade positive" to a uniform potential across the surface of the target, thereby erasing any previously stored charge image. Then, the erase pulse voltage decreases to zero so that the potential of storage dielectric **26** is brought down by capacitive coupling below the "retention threshold" below which bistable storage is not possible and then the target electrode **28** is gradually increased in voltage to the operating level of 150 volts. This is done sufficiently slowly so that the storage dielectric is not capacitively coupled to 150 volts, but remains at the zero voltage level of the flood gun cathode due to the bombardment by the flood electrons.

The first storage target **10** is prepared by applying the preparation pulse **52** thereto which is a step pulse having a maximum voltage of about +10 to +40 volts to enable the side charging operation of FIGS. 5A to 5D previously described. This causes the storage dielectric **12** to charge to a cutoff voltage before termination of the preparation pulse **52**, thereby preventing the flood electrons from passing through such target. Next, at time **62**, a first charge image is written on the storage dielectric **12** of the first target **10** by the high velocity writing electrons emitted by writing gun cathode **30** and deflected by the horizontal deflection plates **36** and the vertical deflection plates **38** in a conventional manner to form a charge image of the vertical signal waveform. Thus, the writing beam is normally cut off and is transmitted to the storage target **10** only during the writing time **62** when a positive unblanking voltage is applied to the control grid **34** of such writing gun. Due to the high velocity of the writing electrons, the secondary emission ratio of the storage dielectric **12** is greater than unity for such writing electrons so that a charge image of positive potential is produced on the storage dielectric. As a result of this positive potential, flood electrons are transmitted through the first target **10** in the written areas of such target and may also pass through the second target **18** to strike the phosphor screen, thereby producing a light image corresponding to the charge image when the tube is operated as a conventional transmission type storage tube of the halftone type. However, during the charge transfer operation, some of the flood electrons transmitted through the written areas of the first target **10** strike the storage dielectric **26** of the second target **18** to form a second charge thereon corresponding to the first charge image on target **10**.

A transfer pulse **64** of about +800 volts maximum amplitude is applied through lead **29** to the target electrode **28** of the second storage target for sufficient time to enable the flood electrons transmitted in the written areas of the first target **10** to form the second charge image on the second storage dielectric **26** with a potential greater than its first crossover voltage to enable bistable storage. At the same time as the transfer pulse **64**, a voltage **66** is applied through lead **16** to the first target electrode **14** which is about one-half volt less than the preparation voltage **52** in order to compensate for the higher field created adjacent the rear of the first target **10** by the 800 volt transfer pulse **64** on the second target **18** which might otherwise tend to draw flood electrons through the unwritten areas of the first target.

Finally, a viewing pulse **68** of +150 volts is applied to the first target electrode **14** after the transfer pulses **64** and **66** terminate to enable the flood electrons to be uniformly transmitted through all areas of such first target and to bombard the second storage dielectric **26** to cause bistable storage of the second charge image. Of course, some of the flood electrons are transmitted through the second target **18** to produce a light image on the phosphor screen **20** corresponding to the bistable charge image. It should be noted that for best charge image transfer from the first target **10** to the second target **18**, such transfer should be made when the potential of the first charge image is at the point of greatest slope on the flood electron transmission characteristic curve of the first target. If this is done, better contrast is achieved between the light image display of the stored charge image and the unwritten background areas.

In addition to the charge transfer method of operation, the storage tube of FIG. **1** can also be provided with a bistable storage operation merely by connecting the first target electrode **14** at about +150 volts and maintaining the second target electrode **28** at +150 volts so that the writing beam forms a charge image directly on the second storage dielectric **26**. This charge image is stored bistably by the flood electrons bombarding the second target which are transmitted uniformly through the first target when it is held at +150 volts. In addition, the tube of FIG. **1** can be operated to provide only half-tone storage merely by connecting the second target electrode **28** to approximately the same voltage as the viewing screen electrode **24**, and applying the same voltages including the preparation pulse **52** to the first target electrode **14**. In addition, a "variable persistence" operation with half-tone storage may be provided with the same voltages if a train of positive voltage pulses are applied to the first target electrode after the writing time **62**. It should be noted that the half-tone storage time or persistence can then be varied by changing the amplitude or duty cycle of such positive pulses.

Another embodiment of the storage tube of the present invention is shown in FIG. 3 which is similar to that of FIG. **1** except that the second storage target **18** has been replaced by a field mesh electrode **70**. The field electrode **70** is connected to an external DC voltage source of about +100 volts and is positioned adjacent the rear surface of the first target to provide the low electrical field required for the side charging operation of FIGS. 5A to 5D, while enabling a high acceleration field to be provided for the flood electrons between such field electrode and the viewing screen electrode **24** to provide a light image of high brightness. This storage tube is not capable of charge transfer operation. However, if the viewing screen **20** and **24** is replaced by a nonmesh bistable phosphor storage target, as shown in copending U.S. Pat. application, Ser. No. 47,005, as discussed previously, the charge transfer operation would be possible.

Another embodiment of the present invention is shown in FIG. **4** which is similar to that of FIG. **3** except that the field electrode **70** is omitted and the viewing screen electrode **24** is connected by a switch **72** either to a low positive DC voltage of about +500 volts during preparation and writing, or to a high positive DC voltage source of about +5 kilovolts during viewing. This +500 volts potential provides the required low field adjacent the rear surface of the storage target to enable side charging during target preparation. Since it may be impractical to provide a switch capable of switching between 500 volts and 5,000 volts, it may be necessary to compromise by connecting the viewing screen electrode **24** by an optional lead **74** to an intermediate DC voltage source of about +1,000 volts during preparation, writing and viewing. This +1,000 volts voltage is low enough to enable the side charging operation referred to previously, but does not provide as bright a light image to be emitted by the phosphor.

It will be obvious to those having ordinary skill in the art that many changes may be made in the details of the above-described preferred embodiments of the invention without departing from the spirit of the invention. For example, the high velocity writing electrons may be emitted by a photocathode in a television camera type storage tube and an electrical readout signal may be produced by scanning the charge image in a conventional raster pattern rather then using a phosphor viewing screen. Therefore, the scope of the present invention should only be determined by the following claims.

We claim:

**1**. A charge image storage tube apparatus in which the improvement comprises:

a transmission storage target including a mesh electrode having a plurality of mesh openings therethrough and a thick storage dielectric layer provided on said mesh electrode without covering said mesh openings, said dielectric layer having a sufficient thickness to provide dielectric side portions surrounding each mesh opening which can be charged to a different potential than the front surface of said dielectric layer facing away from said mesh electrode;

means for uniformly bombarding the storage dielectric with low velocity electrons emitted by a first cathode;

writing means for bombarding the storage dielectric at written target areas with a writing beam of high velocity electrons emitted from a second cathode more negative than said first cathode to form a positive charge image thereon which enables the low velocity electrons to be transmitted through said written areas;

field means for providing a low electrical field adjacent the rear side of said storage target away from said first cathode, said field being less than the voltage gradient produced across said dielectric layer during operation of said tube; and

preparation means for applying a preparation voltage pulse to said mesh electrode prior to formation of said charge image thereon but during bombardment of the storage dielectric by the low velocity electrons, said pulse being of a sufficiently positive voltage relative to said first cathode to cause the storage dielectric to charge negatively to a cutoff voltage before termination of said pulse, said cutoff voltage being sufficiently more negative than said first cathode potential to stop said low velocity electrons from being transmitted through said target at the unwritten target areas.

**2**. A storage tube in accordance with claim **1** which includes a phosphor screen positioned on the opposite side of the transmission target from said first cathode which is a flood gun cathode, so that said low velocity electrons are transmitted through the written areas of said target to form a light image on said screen corresponding to said charge image.

3. A storage tube in accordance with claim 1 in which the storage dielectric is of a low density less than about 5 percent of its bulk density.

4. A storage tube in accordance with claim 1 in which the storage dielectric layer has a thickness of at least 5 microns.

5. A storage tube in accordance with claim 1 in which the storage dielectric layer has a thickness of about 10 to 30 microns.

6. A storage tube in accordance with claim 1 in which said field is less than about 10 percent of said voltage gradient across the dielectric layer.

7. A storage tube in accordance with claim 2 which also includes a second mesh electrode between said storage target and said phosphor screen, and said low field is between said second mesh electrode and said storage target.

8. A storage tube in accordance with claim 7 in which the second mesh electrode is part of a second transmission storage target of greater capacitance than the first mentioned target, including a second storage dielectric layer provided on said second mesh electrode, and also includes means for transferring the charge image written on the first target to said second target and for storing said charge image on said second target.

9. A storage tube in accordance with claim 8 in which the first storage dielectric layer is of greater thickness than said second dielectric layer.

10. A storage tube in accordance with claim 8 in which the first storage dielectric is of less density than said second dielectric.

11. A storage tube in accordance with claim 2 in which the phosphor screen also forms a nonmesh storage target capable of bistable storage, and also includes means for transferring the charge image written on the first target to said second target and for storing said charge image bistably on said second target.

12. A method of operating a charge image storage tube with a transmission storage target including a mesh electrode having a thick storage dielectric layer thereon in which the improvement comprises:

bombarding the storage dielectric substantially uniformly with low velocity electrons emitted by a first cathode;

producing a low electrical field adjacent the rear side of the storage target away from the first cathode, which is less than the voltage gradient produced across said dielectric layer;

applying a preparation voltage pulse to the mesh electrode during bombardment of the storage dielectric by the low velocity electrons to prepare the target for formation of a charge image thereon, said pulse being of a sufficiently positive voltage relative to said first cathode to cause the side portions of said dielectric surrounding each target mesh opening to continue to charge negatively after the front surface of said dielectric layer reaches the first cathode potential until the potential of each front surface portion decreases to the cutoff voltage for its adjacent mesh opening before termination of said pulse, said cutoff voltage being sufficiently more negative than said first cathode potential to stop said low velocity electrons from being transmitted through said target at the unwritten target areas; and

bombarding the prepared storage dielectric with a writing beam of high velocity electrons emitted by a second cathode more negative than said first cathode to form a charge image on written areas of said dielectric and to enable said low velocity electrons to be transmitted through said written areas.

13. A method in accordance with claim 12 in which the storage tube includes a phosphor screen and the low velocity electrons are transmitted through the written areas of the storage target to the phosphor screen to produce a light image corresponding to said charge image.

14. A method in accordance with claim 11 in which the storage tube includes a second transmission storage target and the charge image is transferred from the first target to said second target by the low velocity electrons transmitted through the written areas of said first target.

15. A method in accordance with claim 14 in which the charge image is stored for a longer time on said second target than on said first target.

16. A method in accordance with claim 15 in which the charge image is stored bistably on the second target and the low velocity electrons are transmitted through said second target to a phosphor screen in order to produce the corresponding light image on the phosphor screen.

17. A method in accordance with claim 14 in which said low electrical field is produced between the first and second storage targets and has a value of less than about 10 percent of the voltage gradient across the first storage dielectric.

18. A method in accordance with claim 12 in which the storage dielectric has a thickness greater than about 5 microns.

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