

Aug. 29, 1972

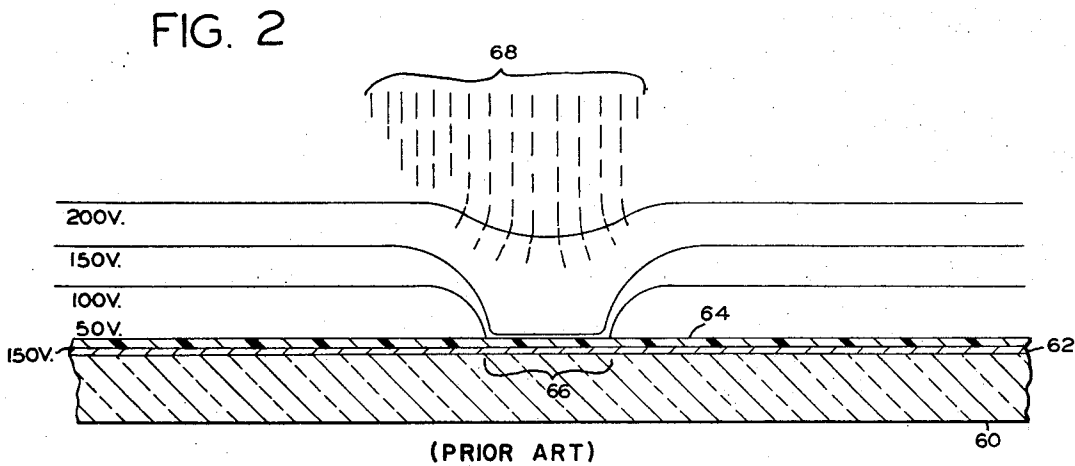
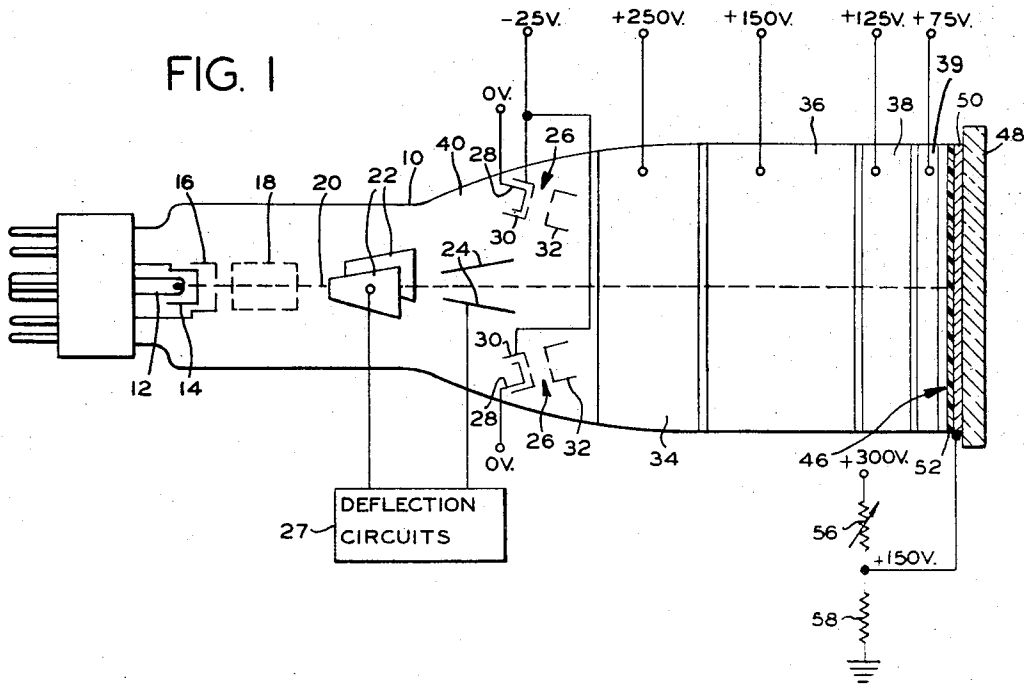
R. A. FRANKLAND

3,687,665

METHOD OF MANUFACTURING CATHODE RAY STORAGE TUBE TARGET

Original Filed Feb. 28, 1967

2 Sheets-Sheet 1



ROGER A. FRANKLAND
INVENTOR

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FIG. 3

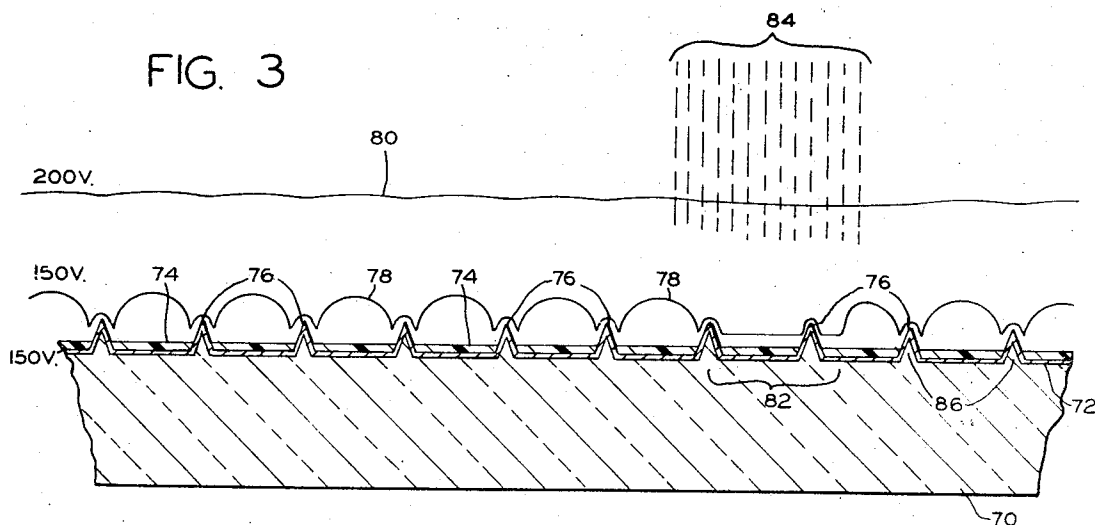


FIG. 4

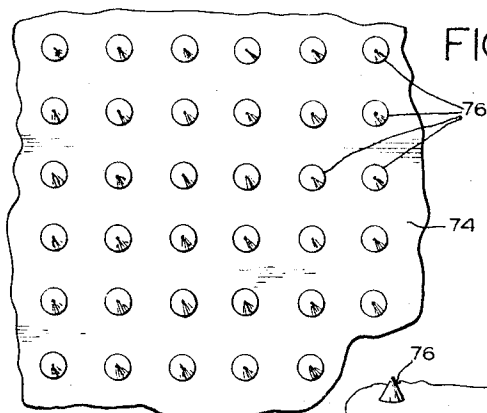
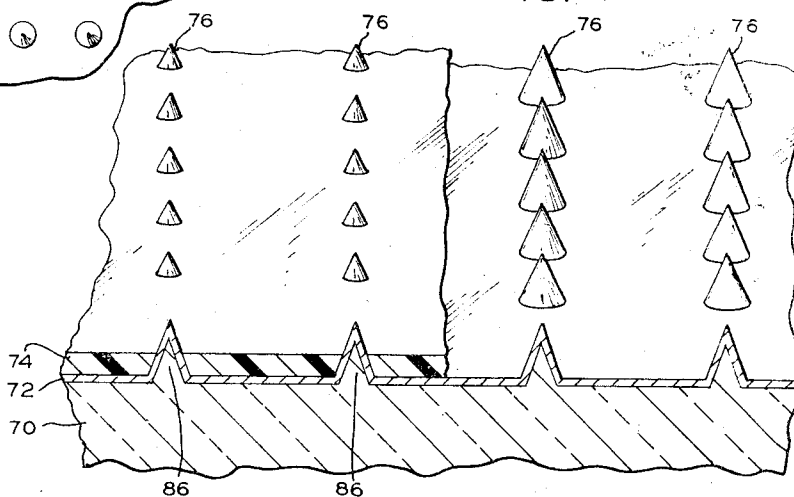


FIG. 5



ROGER A. FRANKLAND
INVENTOR

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METHOD OF MANUFACTURING CATHODE RAY STORAGE TUBE TARGET

Roger A. Frankland, Portland, Oreg., assignor to Tektronix, Inc., Beaverton, Oreg.

Original application Feb. 28, 1967, Ser. No. 619,904, now Patent No. 3,531,675, dated Sept. 29, 1970. Divided and this application Dec. 1, 1969, Ser. No. 879,954

Int. Cl. G03c 5/00

U.S. Cl. 96—36

3 Claims

ABSTRACT OF THE DISCLOSURE

A cathode ray storage tube is provided with a storage target having a multiplicity of collector electrodes extending through the storage target's dielectric layer. These collector electrodes act to collect secondary electrons and control the electric field configuration near the surface of the storage target for the prevention of trace shadowing. The target is manufactured by a photo-etching process wherein an insulating substrate body is coated with metal which is etched to a dot pattern. The insulating substrate is then etched resulting in conical shaped protrusions which are provided with a conductive layer and surrounded with dielectric material.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of my application Ser. No. 619,904, filed Feb. 28, 1967, now U.S. Pat. No. 3,531,675, granted Sept. 29, 1970, entitled, Cathode Ray Storage Tube Having Decreased Field Distortion.

BACKGROUND OF THE INVENTION

The present invention relates to cathode ray storage tubes, and particularly to cathode ray storage tubes providing improved storage accuracy.

A type of cathode ray storage tube includes electron beam generating means and one or more flood electron sources directed toward a storage target structure. The electron beam writes and sometimes detects information on the target surface and the flood electrons are employed for retaining selected areas of the target at one of two stable potentials. In areas where the electron beam has not written, such areas are retained at the negative potential of the flood electrons. However, areas of the target struck by the electron beam become positive due to secondary emission from the target. The flood electrons act to maintain these areas in a positive state inasmuch as the flood electrons are attracted to these areas and given a higher velocity causing continued emission of secondary electrons. In such a tube, collector electrode means are generally employed for collecting secondary electrons, such electrode means being suitable maintained at approximately the same potential as a storage target electrode included at the back of the storage target. In one successful storage tube, the target electrode itself acts as a collector electrode, and the dielectric or phosphor layer on the surface of the target electrode is sufficiently thin and porous so that secondary electrons may pass there-through to the target electrode. In other devices, other collector electrodes in the form of rings or screens are employed for the collection of secondary electrons.

Unfortunately, one difficulty encountered in a number of cathode ray storage tubes is the presence of trace shadowing. Trace shadowing takes place when a display of information written by the electron beam is only partially illuminated by flood electrons. This shadowing, seen as an indistinct edge on the stored trace, is the result of aberrations in the electric field close to the target at locations where information has been written by the

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electron beam. A field of this type is illustrated in FIG. 2. Flood electrons entering this field are given a transverse velocity and tend to land non-uniformly on the target with resultant trace shadowing.

SUMMARY OF THE INVENTION

In accordance with the present invention, a cathode ray storage tube includes a target comprising a substrate body provided with a target electrode in the path of a writing electron beam and flood electrons. On the side of the target towards the electron source, a dielectric layer of phosphor is supported on the substrate. A multiplicity of collector electrodes protrude through the dielectric phosphor layer and act to provide a potential surface near the forward side of the storage target at substantially the same potential as the target electrode. As a result, the field close to the target on the electron source side thereof is substantially less distorted where written upon and trace shadowing is substantially eliminated. Flood electrons are no longer given such transverse velocity as causes the undesired distortion.

According to method aspects of the present invention, a target is advantageously formed by a photo-etching process wherein an insulating substrate body of the target is coated with metal after which a layer of photoresist is applied. The target surface is then exposed to a dot pattern mask, and the photoresist and metal between the dots is removed. The surface is etched resulting in conical shaped protrusions from above a surface of the substrate body. A thin transparent conductive layer is applied to this body and then a dielectric layer of phosphor material is applied which is substantially semi-continuous, except for the locations of the collector electrodes. The result is a regular pattern of collector electrodes whose apices extend above the surface of the phosphor layer and which are actually a protruding extension of the thin target electrode at the rear of the phosphor material.

It is accordingly an object of the present invention to provide a cathode ray storage tube having improved storage capabilities because of the substantial elimination of trace shadowing.

It is another object of the present invention to provide a cathode ray storage tube wherein the appearance of a visible display is improved, such tube having enhanced stored resolution capability as well as improved stored display readout accuracy.

It is another object of the present invention to provide a cathode ray storage tube wherein the collimation of flood gun electrons is improved.

It is a further object of the present invention to provide a cathode ray storage tube with improved means for collecting secondary electrons.

It is a further object of the present invention to provide an improved storage target having integral collector electrode means adapted for providing a more even field over written and unwritten portions of such storage target.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention, however, both as to organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like reference characters refer to like elements.

DRAWINGS

FIG. 1 is a schematic representation of a cathode ray storage tube according to the present invention;

FIG. 2 is a cross sectional view of one prior type of storage target;

FIG. 3 is a cross sectional view of a storage target according to the present invention;

FIG. 4 is a partial forward view of a storage target according to the present invention; and

FIG. 5 is a perspective view, partially broken away and partially in cross section of a storage target according to the present invention.

DETAILED DESCRIPTION

Referring to FIG. 1 a cathode ray storage tube includes a storage tube envelope 10 formed of insulating material housing a principal electron gun including a filament 12, a cathode 14 for connection to a high negative voltage source, a control grid 16 and a focusing and accelerating structure 18. The electron beam 20 produced by the principal electron gun is deflected horizontally by means of horizontal deflection plates 24. The deflection plates are connected to conventional deflection circuits 27 for causing selective positioning of electron beam 20. The beam is in general directed towards a target 46 at the opposite end of the tube. The storage tube is additionally provided with one or more flood type electron guns 26 each having a cathode 28, a control grid 30 and an anode 32, and which are supported inside the envelope 10 adjacent the end of the vertical deflection plates 24 closest the target. Cathodes 28 are conveniently maintained at a low voltage level, e.g. ground level, while grids 30 are suitably connected to a minus 25 volts. Low velocity electrons emitted from the flood guns diverge into a wide beam which is desirably uniformly distributed towards target 46.

A plurality of electrodes are also located on the inner surface of envelope 10. These electrodes may be provided as spaced wall coatings of conductive material, such as silver tin oxide, aluminum, or graphite, on the interior surface of the envelope. The first electrode wall coating 34 functions primarily as a focusing electrode for the flood electrons emitted from the flood guns. It is connected to a suitable source of electrical potential, e.g. a positive 250 volts. A second electrode wall coating 36 is spaced from such first electrode and electrically connected to a positive voltage, e.g. 150 volts and functions as a focusing and collimating electrode. A third electrode wall coating 38 spaced from coating 36 is electrically connected to a positive voltage, e.g. 125 volts and also functions as a focusing and collimating electrode. Due to the collimating action of the electrode wall coatings, the electrons from the flood guns are desirably substantially uniformly distributed over the surface of storage target 46 and approach such target at approximately right angles thereto. A fourth electrode wall coating 39 is positioned between and spaced from the wall coating 38 and the storage target 46, and is connected to a positive voltage, e.g. a positive 75 volts. In addition to focusing and collimating the flood electrons the wall coating 38 may function to some extent as a collector electrode to collect part of the secondary electrons emitted from the storage target 46.

It should be noted that a conventional resistive coating 40, e.g. Aquadag (trademark) or similarly conductive material, is suitably provided on the interior of a portion of the envelope's neck portion and is electrically connected to an isolation shield (not shown) in the writing gun in such neck portion so that it serves as an extension of a second anode (also not shown) in such writing gun. The voltages applied to electrode wall coatings 34, 36, 38, and 39 are by way of example and are suitably adjusted to provide optimum collimation of the flood electrons.

Storage target 46 is provided upon insulative end plate 48 and comprises a transparent storage target electrode 50 over which is disposed a photosensitive dielectric 52; suitably an at least semi-continuous or integral phosphor layer of a P-1 type phosphor. Target electrode 50 is a thin deposited transparent coating such as tin oxide or the like and is suitably connected to the midpoint of a voltage

divider comprising resistors 56 and 58 disposed between a plus 300 volts and ground. Resistor 56 is variable and is suitably adjusted so that a voltage of approximately plus 150 volts is applied to target electrode 50. In addition, the target electrode 50 may be connected to amplifying means for providing an electrical readout of information stored on the storage target.

Information may be written on this storage target via electron beam 20. This information may be in the form of a waveform applied to the vertical deflection plates 24 while the beam is scanned horizontally with the deflection circuits 27, or intensity information may be applied to grid 16 while the beam is scanned both vertically and horizontally by deflection circuits 27. In addition to electrical readout, the information written on the storage target is visibly displayed through end plate 48 wherein such end plate is formed of transparent material, e.g. glass.

During operation, the tube potentials are adjusted such that beam 20 has a relatively high velocity for writing and is capable of producing secondary electrons when it strikes storage dielectric 52. Secondary electrons are then collected in a manner hereinafter more fully described. An elemental area of the target can be driven positive or "written" as a result of the secondary emission produced by electron beam 20.

A written area is retained at a relatively positive potential after beam 20 has passed such elemental area because of the action of flood electrons from flood guns 26. Flood guns 26 produce relatively low velocity electrons which strike the target but which ordinarily have insufficient velocity for writing information. When the electrons from flood guns 26 strike areas of the target upon which a positive charge has not been written, these flood electrons tend to maintain such areas at a relatively low potential near the potential of the flood gun cathode. This is the stable negative potential level of the target. However, the flood gun electrons are attracted by a positive elemental area and attain a high velocity with respect to these areas for producing continued secondary emission therefrom. Therefore these areas are maintained relatively positive or near the potential of target electrode 50. This comprises the stable positive potential level of the target. The target thus has bistable properties and is capable of retaining information written thereon inasmuch as the flood beam of electrons drives target areas to one of the two stable potentials depending upon the information previously written thereon with beam 20.

Referring to FIG. 2 a prior type of storage target is illustrated in cross section including a substrate body in the form of a glass and plate 60. The substrate body is provided with a target electrode 62 comprising a very thin transparent conductive coating such as tin oxide or the like. Over the target electrode is disposed a photosensitive dielectric 64, which is suitably an integral layer of P-1 type phosphor that may be sufficiently porous to enable secondary electrons to be transmitted therethrough and collected by the target electrode. A target of this type has previously been employed in a cathode ray storage tube of the type illustrated in FIG. 1.

Region 66 on the target electrode has been written by electron beam 20 so that its voltage level has been changed from a low voltage produced by flood electrons to a higher voltage near the 150 volt level of target electrode 62, through the process of secondary emission. The electric field in front of a portion of the target in the direction of the electron sources is illustrated by equipotential electric field lines comprising the cross-section of equipotential field surfaces in front of a portion of the target. This field pattern is produced between the target and the electrode wall coatings 34, 36, 38 and 39. In regions other than region 66, the field voltage next to the surface of the target is at a low voltage level, e.g. 50 volts. However, in region 66, the front surface of the target is at a higher

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voltage, e.g. 150 volts, being the voltage level of the target electrode 62, for example when such target electrode acts as a collector through a porous phosphor dielectric layer 64. The resulting distortion in the electric field pattern in this region is illustrated out to the 200 volt level. Paths of flood electrons from the flood guns are illustrated at 68 on the drawing. The paths of these flood electrons encounter the distorted electric fields and are given a transverse velocity so that the paths become curved or spread whereby such electrons land non-uniformly on the target causing trace shadowing. These flood electrons are thus not properly collimated and the region 66 left by the writing gun is not correctly or completely illuminated by the flood electrons. The resultant aberration in the near field of the target electrode thus tends to result in an indistinct edge or multiple edge of the written information.

Referring to FIG. 3 there is illustrated a cross section of an improved storage target in accordance with the present invention. This target is employed with the cathode ray storage tube of the type illustrated in FIG. 1. The target includes a substrate body which is suitably transparent and formed of insulative material, e.g. taking the form of glass end plate 70. The substrate body is further provided with a target electrode 72 suitably comprising a very thin transparent deposited conductive coating such as tin oxide or the like supported on the glass end plate 70. Upon the target electrode 72 there is supported a substantially integral, or at least semi-continuous dielectric layer 74 suitably comprising a layer of phosphor, e.g. of the P-1 type. This layer may be somewhat porous, like phosphor layer 64, but need not be.

According to the present invention, a multiplicity of collector electrodes 76 extend from the target electrode 72 and through the substantially semi-continuous dielectric layer 74 to the side of the target nearest the electron sources. These conductive electrodes desirably protrude from the otherwise substantially planar surface of dielectric layer 74 and act as collectors for the secondary electrons generated when electron beam 20 strikes the storage target. The collector electrodes extend forward about two mils from the target electrode 72, in the illustrated embodiment, and extend above the otherwise substantially planar and continuous dielectric layer 74. However, the collector electrodes 76 may protrude farther if so desired. The collector electrodes in the illustrated embodiment are approximately conical in shape with the base of each electrode being substantially coincident with the plane of target electrode 72, and with the apex of the cone extending forwardly above the level of dielectric layer 74. However, it is to be understood the electrodes may take other shapes. Thus, these electrodes may be pyramidal in shape and may come to a point where they extend above the dielectric layer 74, or such point may be somewhat flattened. If desired the electrodes may alternatively be cylindrical. The collector electrodes 76 are electrically connected at their base to target electrode 72.

The collector electrodes 76 in the illustrated embodiment are distributed over the storage target in a regular pattern with a regular spacing between electrodes as illustrated in FIG. 4. In the illustrated embodiment, the center-to-center distance between adjacent electrodes was approximately six mils, this being less than the approximate diameter of the electron beam 20 employed in writing on the storage target. The diameter of such electron beam (or the trace produced thereby) is about 10 mils across from points halfway up the Gaussian distribution. The distance between collector electrodes is also related to the resolution properties of the target and the cathode ray storage tube employing the same. Thus, the collector electrodes six mils apart result in an approximately six mil resolution capability. For reasonable resolution it is preferred the spacing of the collector electrodes be under 15 mils. The density of collector electrodes positioned 6 mils apart on a 5" cathode ray tube results in about 300,000 of such electrodes on the storage target. The electrodes may be

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placed closer together if desired. In the illustrated embodiment, the exposed raised collector area, that is the area rising above the phosphor, comprises approximately 10 percent of the storage target surface, viewed from electron source side of the target, as thus illustrated in FIG. 4. The target construction partly broken away and including a completed phosphor layer only on the left side, is illustrated in FIG. 5.

In operation, the target electrode illustrated in FIGS. 3, 4 and 5 has the advantage of providing a much more uniform or undistorted near field at and near the surface of the target electrode oriented towards the electron sources. Illustrative equipotential lines comprising cross sections of equipotential surfaces of this field are shown in FIG. 3. The field line 78 is close to the target and is at a voltage level of substantially 150 volts, this being the voltage of target electrode 72 and of the collector electrodes 76. The 200 volt field line 80 is nearly flat. Region 82 illustrates the location where information has been written on the target by means of electron beam 20. In this region, the dielectric layer 74 has been raised to a potential of approximately 150 volts, or the potential of target electrode 72, due to secondary emission from this region. Therefore, equipotential line 78 is closer to the dielectric layer 74 in this region. However, since there is always a relatively close-in 150 volt field line due to the action of electrodes 76, the overall effect of writing upon the electric field is comparatively slight. The region of change of field line 78 is confined to the region between substantially adjacent electrodes 76, and close in to the target. Therefore, the more remote equipotential line 80 is substantially unaffected and remains substantially flat and undistorted as compared with the distorted field as in the case of the FIG. 2 device. Therefore, flood electrons 84 from the flood guns 26 are not substantially deflected transversely but rather proceed in a more collimated manner to the storage target. When the flood electrons almost reach the target, some distortion in the field is not capable of a serious effect on collimation. It has been found that trace shadowing is substantially eliminated in the storage target illustrated in FIG. 3, resulting in a sharper image. The substantial removal of trace shadowing improves the general appearance of the display, improves stored resolution capability, and improves stored display readout accuracy. The electric field configuration is illustrated to aid an understanding of the invention and it is understood the invention is not limited thereby.

Of course, the collector electrodes also provide advantageous means for collecting the secondary electrons produced at the storage target. Therefore, dielectric layer 74, e.g. of phosphor or the like, need not be porous and may be thicker or multi-layer without the requirement that secondary electrons be able to pass therethrough.

The collector electrodes 76 are suitably formed as forwardly protruding raised extensions of target electrode 72. Moreover, the substrate body 70 is suitably raised at the locations of collector electrode 76 to provide an inner body of these collector electrodes with the extension of target electrode 72 providing a conducting exterior electrically connected to the remainder of target electrode 72. An exemplary method of manufacturing the storage target is described as follows. First, the glass end plate such as 70 in FIG. 3 is annealed and coated with a thin layer of nickel followed by a thin layer of gold, the nickel being used to adhere the gold to the glass end plate. The metals are suitably evaporated onto the end plate. Then a layer of photoresist material is applied over the layer of gold and the plate is baked. The surface is then exposed photographically to provide a dot pattern on the metal layer having the same general configuration as the collector electrodes as illustrated in FIG. 4, but with dots somewhat larger in diameter to correspond to the base diameter of electrodes 76, e.g. about 5 mils. The areas around the

electrodes are illuminated and exposed, for example, using a light source and a contact negative comprising a pattern of opaque dots. The photoresist is developed with the areas around the dots being dissolved. The plate is then baked. The NiAu layer is etched away around the dots using gold and nickel etchants in succession with an intermediate rinse. An etchant is then applied which acts to remove the glass around the dots, the latter being protected with metal. A suitable etchant includes one part HF and one part dimethyl sulfoxide. The surface of the glass end plate 70 is lowered around these dots by etching. The etchant also has the effect of etching the glass away from underneath the exposed dots to provide conical raised protrusions 86 as illustrated in FIG. 3. The glass is removed under the metal dots at the same rate as the glass is etched downwardly. A cone results, the sides of which have an approximately 45 degree slope. Then, the glass is cleaned and a thin transparent conductive coating such as tin oxide or the like is deposited thereon to form target electrode 72 as well as completing the multiplicity of collector electrodes 76. The target now appears as illustrated on the right side of FIG. 5. The thickness of target electrode layer 72 is exaggerated for ease of illustration. Then dielectric phosphor material, e.g. a P-1 type phosphor is cast into the etched end plate, e.g. using an Elvax (trade-mark) binder and toluene solvent, between the collector electrodes in the form of substantially semi-continuous phosphor layer interrupted only by the collector electrodes 76. The plate is baked to complete the target. The completed target is illustrated on the left side of FIG. 3.

The forward portion of the target electrode may be extended or shaped as desired to control the near field potential. The target electrodes may be extended forwardly to a greater height, or the forward protruding ends of the collector electrodes may be connected with very narrow strips of aluminum or gold or the like evaporated to connect between the ends of the protruding collector electrodes. The selected material should be easy to evaporate and have a sufficient integrity to maintain its shape. In any case, it is desired that the exposed dielectric phosphor comprise the majority of the target surface and that the collector electrodes be spaced approximately as close as the desired resolution of the target.

The raised collector's inner body may be transparent or opaque, insulative or electrically continuous. A random array rather than a regular array of collector electrodes may be fabricated. For example, in one instance a glass frit material was attached to the end photo and then a conductive coating was applied to complete the collector electrodes, and the target electrode. The phosphor was then applied as before.

While I have shown and described preferred embodiments of my invention, it will be apparent to those skilled

in the art that many changes and modifications may be made without departing from my invention in its broader aspects. I therefore intend the appended claims to cover all such changes and modifications as fall within true spirit and scope of my invention.

I claim:

1. The method of manufacturing a cathode ray tube storage target comprising depositing a layer of metal upon a substrate body of electrically insulating material, depositing a layer of photoresist material over said metal layer, photographically exposing said layer of photoresist employing a mask including an array of regularly spaced dots and developing the same to provide corresponding dot areas of photoresist on said layer of metal, etching the thereby uncovered areas of said metal layer to leave an array of metal dot areas on said substrate, etching said substrate material to form conical protrusions of said material above the etched surface thereof in the position of said metal dot areas as the substrate material is etched under and around said metal dot areas, depositing a thin layer of electrically conductive transparent material over the etched body of substrate material to form a plurality of protruding collector electrodes and target electrode areas between said collector electrodes, and depositing a layer of dielectric material over said target electrode areas between said protruding collector electrodes to a given level to form a substantially continuous layer except where interrupted by said collector electrodes extending above the given level.
2. The method according to claim 1 wherein said substrate body of electrically insulated material is glass.
3. The method according to claim 1 wherein said electrically conductive layer is tin oxide.

References Cited

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J. TRAVIS BROWN, Primary Examiner

J. WINKELMAN, Assistant Examiner

U.S. Cl. X.R.

96—36.1; 117—33.5 C

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,687,665 Dated August 29, 1972

Inventor(s) Roger A. Frankland

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

Col. 1, line 55, "suitable" should be --suitably--

Col. 1, line 67, "when" should be --as--

Col. 7, line 48, "photo" should be --plate--

Col. 8, line 35, claim 2, line 2, "insulated should be
--insulating--

Signed and sealed this 22nd day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents