Nov. 25, 1969 A. PICKER 3,480,482

METHOD FOR MAKING STORAGE TARGETS FOR CATHODE RAY TUBES

Original Filed Oct. 22, 1965 2 Sheets-Sheet 1

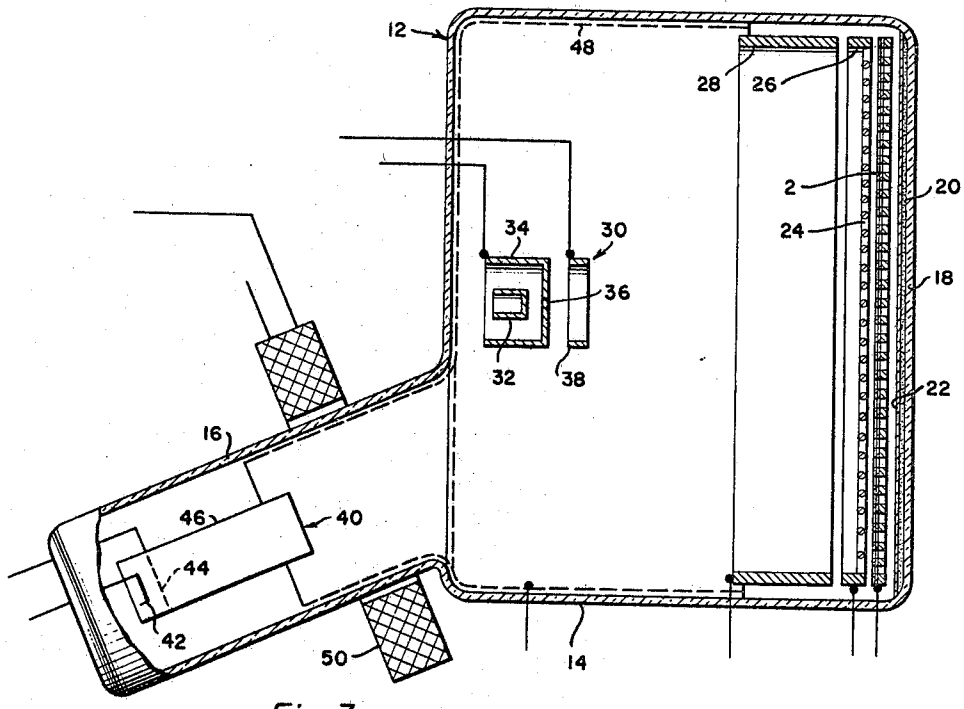


Fig. 3.

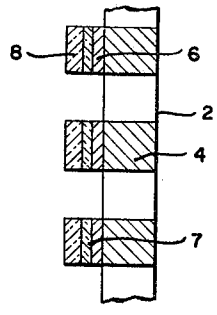


Fig. 1.

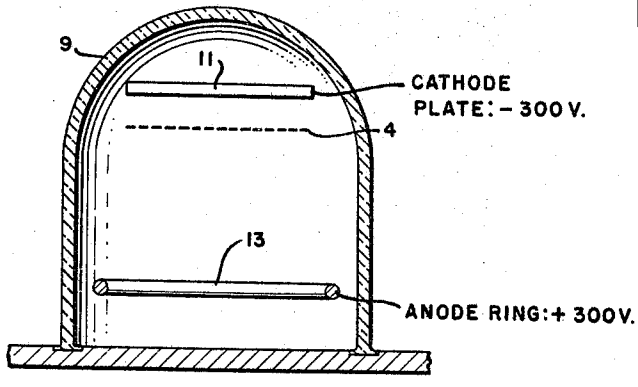


Fig. 2.

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METHOD FOR MAKING STORAGE TARGETS FOR CATHODE RAY TUBES

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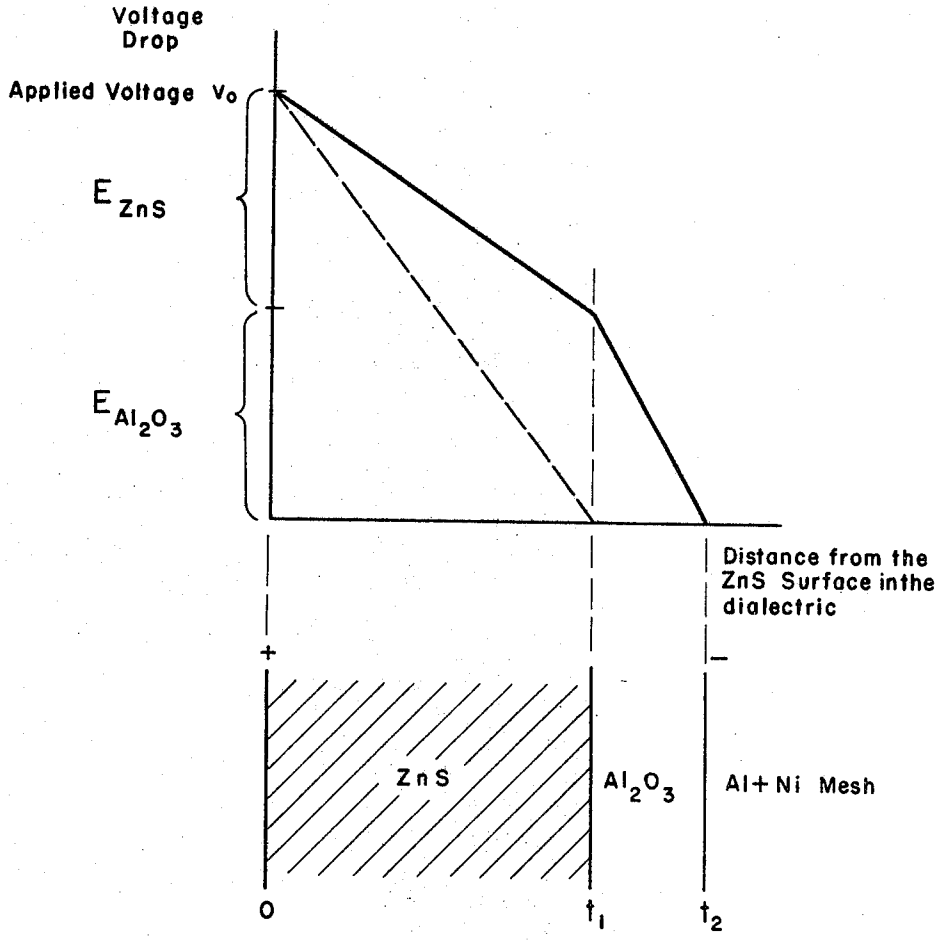


Fig. 4.

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METHOD FOR MAKING STORAGE TARGETS FOR CATHODE RAY TUBES

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Continuation of application Ser. No. 501,191, Oct. 22, 1965. This application Oct. 18, 1967, Ser. No. 684,581
Int. Cl. C23c 13/02, 17/00
U.S. Cl. 148—6.3 1 Claim

ABSTRACT OF THE DISCLOSURE

Method of fabricating a storage target for storage tubes wherein zinc sulfide is deposited on and insulated from a mesh support member by a layer of aluminum oxide or titanium oxide formed by glow discharge.

This is a continuation of Ser. No. 501,191 filed Oct. 22, 1965 now abandoned, by the same inventor and assigned to the instant assignee.

This invention relates to storage targets, particularly but not necessarily exclusively for visual display cathode ray tubes, and to methods for making such targets. More specifically, the invention relates to storage targets utilizing the phenomenon of bombardment induced conductivity and including a film or layer of zinc sulfide on a metallic mesh support.

In U.S. Patent No. 3,086,139, N. H. Lehrer discloses a novel bombardment induced conductivity storage target for use in direct-viewing storage display tubes. This target comprises a nickel mesh screen having a film of zinc sulfide disposed on one surface thereof. One of the methods described in this patent for forming the storage target, and which method is largely the one in use heretofore, comprises depositing zinc sulfide by an evaporation process onto a nickel mesh which has been etched in an acid bath to expose its lattice structure. After vapor-depositing the zinc sulfide onto such etched mesh, the thus-coated mesh member is aged at a temperature of from about 80° to 100° F. for a few days, followed by heating the coated mesh assembly in air at about 300° C. for about 15 minutes. This practice was followed in order to stabilize the bombardment induced target thus formed so as to prevent subsequent deterioration in its electrical properties. Even then the consistency of targets thus produced left something to be desired since some targets tended to exhibit a deterioration in the resistivity of the zinc sulfide dielectric. Since it was suspected that interaction between the nickel mesh member and the zinc sulfide caused such deterioration, it was subsequently proposed to coat the nickel screen member with a metal which did not react with the zinc sulfide nor with the nickel mesh member which procedure is taught in U.S. Patent No. 3,089,050 to N. H. Lehrer and R. A. Solivan. In actual practice, the nickel mesh support member was coated with aluminum and then baked prior to sulfiding as described above. As a result of these procedures, it was found that an improvement in the storage time of the target was obtained.

Subsequent investigations demonstrated that it was not the aluminum per se that resulted in the improvement. Thus, targets made with air-exposed aluminum substrates were superior as far as current leakage properties were concerned when compared with targets prepared with non-exposed aluminum. Because of the fast decay characteristic observed for air-exposed aluminum-coated targets and the apparent failure of tubes employing such targets after moderate use, it was surmised that the baking of the aluminum coated targets in air produced a barrier of aluminum trioxide of high resistivity. Such high resistivity

Al_2O_3 apparently acts as a voltage divider between the zinc sulfide and the support substrate and when the Al_2O_3 barrier failed, the current leakage increased by a large factor thus giving rise to the aforementioned fast decay characteristic. FIG. 4 demonstrates this property. With Al_2O_3 being of much higher resistivity than the ZnS, one can assume (for demonstration only) that the thin Al_2O_3 film supports 50% of the potential drop across the dielectric. Thus if, for example, 15 volts is to be the applied voltage, only 7.5 volts would be sustained by the ZnS. By virtue of the non-linear V–I characteristics of the ZnS this would reduce the current leakage by as much as a factor of 4 or 9, thus reducing the charge leakage drastically. Such targe leakage, however, was minimized by the aging and stabilization process described. Apparently aging the deposited zinc sulfide, which was initially of hexagonal crystal structure, at 60° C. for six days and then air-baking at 300° C. for one-half hour converted the hexagonal zinc sulfide to cubic zinc sulfide which is of much higher resistivity than the hexagonal form. It is now believed that the aging and stabilization process in air inherently also caused a slow diffusion of air through the zinc sulfide onto the aluminum substrate, thus forming a layer of Al_2O_3. Since, however, the ZnS is usually not uniformly in intimate contact with the aluminum surface, the oxidation of the aluminum was found to be patchy, hence giving rise to the aforementioned current leakage characteristic and subsequent failure of the target after moderate use.

It is therefore an object of the present invention to provide an improved method for fabricating zinc sulfide-type storage targets for cathode ray storage tubes.

Another object of the invention is to provide an improved method for incorporating an improved aluminum oxide barrier layer in zinc sulfide-type storage targets for cathode ray storage tubes.

These and other objects and advantages of the invention are achieved by providing a storage mesh member with an oxide coating by a glow discharge technique which forms a uniform, "non-patchy" layer of oxide. While the invention will be described with particular reference to an aluminum oxide coating it is not limited thereto. Other oxides, such as titanium oxide, which are compatible with zinc sulfide may also be used.

The invention will be described in greater detail by reference to the drawings in which:

FIGURE 1 is a partial, cross-sectional view in elevation of a storage target according to the present invention;

FIGURE 2 is a schematic view of apparatus for processing a storage target according to the invention;

FIGURE 3 is a partially cross-sectional and partially schematic view of a cathode ray direct-viewing storage tube; and

FIGURE 4 is a graphical showing of the voltage drop across the zinc sulfide—aluminum oxide film coatings on the storage target according to the invention.

With reference to FIGURE 1, the storage target **2** of the present invention comprises an electroformed nickel mesh member **4** having a layer **6** of aluminum metal disposed on one surface of the mesh member **4**. Superimposed on and formed from the aluminum layer **6** is a layer **7** of aluminum oxide and coated over the aluminum oxide layer **7** is a layer **8** of zinc oxide. The nickel screen **4** may have about 350 meshes per inch and a thickness of about 1 to 2 mils, for example.

To prepare the storage target **2** of the invention, the nickel mesh or screen member **4** is first provided with a coating or layer of aluminum **6** on one surface thereof as by conventional and well-known aluminum vapor-deposition procedures. The thickness of the aluminum layer **6** as thus deposited may be about $\frac{1}{250}$ mils, for example.

Thereafter the aluminum-coated mesh member **4** is placed in an evacuable container or bell jar **9** as shown in FIGURE 2. The bell jar **9** is then evacuated to remove air and oxygen is introduced therein to form a partial pressure of from 10 to 50 microns. The glow-discharge apparatus within the bell jar **9** comprises a cathode plate **11** and an anode ring **13**. In a typical arrangement, the cathode plate **11**, formed of a round aluminum ring about 8 inches in diameter, and an aluminum anode ring **13** of about ¼ inch in cross section and 8 inches in diameter were employed with the mesh member **4** being mounted near the cathode plate **11**. A potential difference of about 600 volts was then maintained between the cathode plate **11** and the anode ring **13** so as to form an oxygen green-yellow glow discharge within the bell jar **9**. The glow may be maintained for about one-half hour, for example, depending on the extent of oxidation of the aluminum layer **6** desired. Typically the aluminum oxide layer **7** may be about 40–100 angstrom ($40–100\times10^{-8}$ cm.) thick.

A layer **8** of zinc sulfide, which may be in the cubic lattice form, is disposed over the Al_2O_3 layer **7** by an evaporation process performed in a conventional manner with the mesh member **4** maintained at a temperature of about 200° C. during evaporation. The zinc sulfide layer **8** may be formed to a thickness of about a ¼ to two microns, for example. After formation of the zinc sulfide layer **8**, it may be desirable to aluminize by evaporation the reverse (or metallic) side of the mesh member **4** in order to cover any dielectric particles which may be inadvertently formed or deposited on this side.

After the storage target **2** has been prepared as described, it may then be incorporated in a direct-viewing cathode ray storage tube **12** as shown in FIG. 3. The tube **12** comprises an evacuated envelope formed by a comparatively large cylindrical section **14** and a narrower neck portion **16** communicating therewith at one side thereof (hereinafter referred to as the neck or gun side). The neck section **16** may be disposed, as shown, at an angle with respect to the main longitudinal axis of the larger cylindrical section **14**. The side of the large cylindrical section **14** opposite the neck side comprises a face-plate **18** over the inner surface of which is a layer **20** of phosphor material covered with a thin film of aluminum **22**. Adjacent and coextensive with the face-plate or viewing screen **18** is the storage target **2** as described previously and shown in FIG. 1. Continuing to proceed from the viewing screen end of the tube toward the gun section, a collector grid **24** is disposed adjacent and coextensive with the storage target **2**. The collector grid **24** comprises a conductive screen supported about its periphery by an annular ring **26**. The transparency of this screen is preferably of the order of 80%; the function of the grid **24** is to collect secondary electrons emitted from the storage target **2**. Adjacent the collector grid **24** is a collimating electrode **28** in the form of a cylindrical can the purpose of which is to collimate flood or viewing electrons from the flood gun **30** which is disposed at the gun side of the tube section **14**. The flood gun **30**, which may be on the longitudinal axis of the larger cylindrical portion **14** of the tube **12**, comprises a cathode **32** and an intensity electrode **34** which encloses the cathode **32** except for a small aperture **36** disposed over the central portion of the cathode **32**. An annular electrode **38** is disposed adjacent the intensity electrode **34** and coaxially with respect to the longitudinal axis of the tube **12** which also passes through the center of the aperture **36** in the intensity electrode **38**.

The neck portion **16** of the tube **12** houses an electron gun **40** which may be of conventional construction. The gun **40** comprises a cathode **42**, an intensity electrode grid **44**, and a cylindrical beam-forming section **46**.

An equipotential region is maintained throughout the neck portion **16** of the larger cylindrical section **14** of the tube **12** by means of a conductive layer **48** which may be coated over the interior surfaces of the tube as shown. During operation, a potential of about 5 volts positive may be maintained on this conductive layer.

Operation of a selective erasure storage tube may be accomplished with the storage target backplate potential negative as follows. A potential of about 9 volts negative relative to ground is applied to the nickel mesh support **4** of the storage target. The flood or viewing gun cathode **32** may be maintained at ground potential while the intensity electrode **34** and the annular electrode **38** may be maintained, respectively, at potentials of about 20 volts negative and 100 volts positive with respect to ground. Under these circumstances flood electrons from the gun **30** will be prevented from penetrating the storage target **2** (because of the 9 volt negative potential thereon). Hence the flood or viewing electrons cannot reach the viewing screen and excite it into luminescence. This is the initial "dark" condition of the tube and in this mode of operation, information is displayed as "white on black."

To store and display information, the storage target **2** is scanned by an electron beam of elemental cross-sectional area having an energy level of about 2.5 kilovolts. This beam may be generated by means of the electron gun **40** in the neck portion **16** of the tube. The electron beam produced by this gun is modulated and scanned in accordance with information-representative signals derived and applied by conventional techniques. The beam is deflected horizontally and vertically electromagnetically, as shown, by means of the deflection yoke **50** which is positioned around the neck **16** of the tube.

Areas of the storage target **2** impinged by the 2.5 kv. beam in accordance with the information to be stored and displayed are charged positively due to the emission of electrons therefrom which are collected by the collector grid **24** which may be maintained at a potential of 120 volts positive with respect to ground in order to accomplish this function. Viewing or flood electrons from the flood gun **30** may then pass through the storage target **2** at these areas of positive potential and are then accelerated to the viewing screen by means of a potential of about 6,000 volts positive with respect to ground which may be maintained on the aluminum film **22** of the viewing screen. In this manner, the information is displayed as "white on black" and the display may be maintained and viewed as long as desired.

Non-stored or "live" information may also be simultaneously displayed by switching the potential of the cathode **42** of the charging gun **40** to about 4.5 kilovolts. A beam of this energy level does not produce any change in the potential of the storage surface as taught in U.S. Patent 3,086,139 to N. H. Lehrer. Hence, the beam passes through the storage target **2** without altering the potential of either positively or negatively charged portions.

Stored potentials on the storage target **2** may be selectively erased by switching the potential of the cathode **42** of the charging gun **40** to about 7.0 kilovolts and scanning the storage target with the beam of this energy level in accordance with signals representing the information to be erased. The impingement of a beam of 7.0 kv. on portions of the storage target results in these portions being charged negatively to about the potential of the nickel support mesh **4** (−9 volts) by means of the phenomenon of bombardment induced conductivity, as explained in the aforementioned patent to N. H. Lehrer.

It will be noted that the storage tube shown in FIG. 3 and described herein has but one charging electron gun whose cathode potential is switched to provide beams of different energy levels (2.5 kv., 4.5 kv. and 7.0 kv.) so as to permit storing, "writing through" and erasing selectively. When only a single charging gun is provided the operations of storing, "writing-through" and erasure cannot be accomplished simultaneously unless a multiple gun cathode ray storage tube is utilized. By incorporating

more than one electron gun (other than the flood gun) in the tube, any two of the three operations (i.e., storing, erasing and write-through) may be accomplished simultaneously. As used herein when reference is made to the number of electron guns, the flood gun is not intended to be included therein. By including three electron guns in the envelope, all three operations may be achieved simultaneously.

With reference to FIG. 4, it will be seen that, with an aluminum oxide film which is of much higher resistivity than that of the zinc sulfide film, the thin oxide film supports 50% of the potential drop across both dielectric layers. Thus, if, for example, 15 volts are applied across the zinc sulfide-aluminum oxide layers, only 7.5 volts are sustained by the zinc sulfide layer. By virtue of the non-linear V–I characteristics of the zinc sulfide film, the leakage current is reduced by as much as a factor of 4, thus reducing the charge leakage drastically.

There thus has been described a novel and improved storage target for cathode ray tubes utilizing the phenomenon of bombardment induced conductivity effectively and in a practical manner. While the storage target of the present invention has been described with particular reference to the use thereof in a direct-viewing cathode ray storage tube, the usefulness of the storage target of the invention is not necessarily limited to such tubes but may be employed in any storage tube wherein the storage of electrical charges representative of information is desired to be obtained by means of the phenomenon of bombardment induced conductivity through the use of zinc sulfide. Thus, the target may also be used in electrical output storage tubes, for example.

The fabrication of a zinc sulfide storage target utilizing the flow-discharge oxidation technique according to the invention results in an extremely uniform oxide film. As used herein and in the appended claims the term "uniform" where applied to the oxide film is intended to mean non-patchy and pin-hole free. Targets formed according to the invention have been found to be far less "leaky" than heretofore and, in addition, the relatively long and costly aging and stabilizing practices for the zinc sulfide are eliminated thus shortening tube production time from two weeks to from three to five days. Because of the uniformity of the oxide layer and its lower leakage properties, the tendency of prior art direct-viewing storage tubes of this type to "lose" stored images is lessened or reduced. It has also been found that retention of "non-store images," which heretofore plagued direct-viewing storage tubes of this type, is minimized thus increasing usefulness and production yields of such tubes.

What is claimed is:

1. The method of making a storage target for cathode ray storage tubes comprising the steps of: depositing a layer of metal selected from the group consisting of aluminum and titanium upon the surface of a nickel substrate member, exposing said substrate member to a glow discharge in an oxygen atmosphere to form a uniform layer of oxide on the surface of said metal layer, and thereafter depositing zinc sulfide upon said layer of oxide.

References Cited

UNITED STATES PATENTS

2,527,981	10/1950	Bramley	313—68 X
3,086,139	4/1963	Lehrer	315—12
3,089,050	5/1963	Lehrer et al.	315—12 X
3,109,954	11/1963	Morris	313—68 X
3,270,242	8/1966	Charles	315—12 X
3,287,243	11/1966	Ligenza	204—164 X

OTHER REFERENCES

Terry et al., Chemical Abstracts, vol. 61 (1964), p. 12756h.

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U.S. Cl. X.R.

117—33.5; 313—68; 315—12