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ELECTRON DEVICE WITH STORAGE CAPABILITIES

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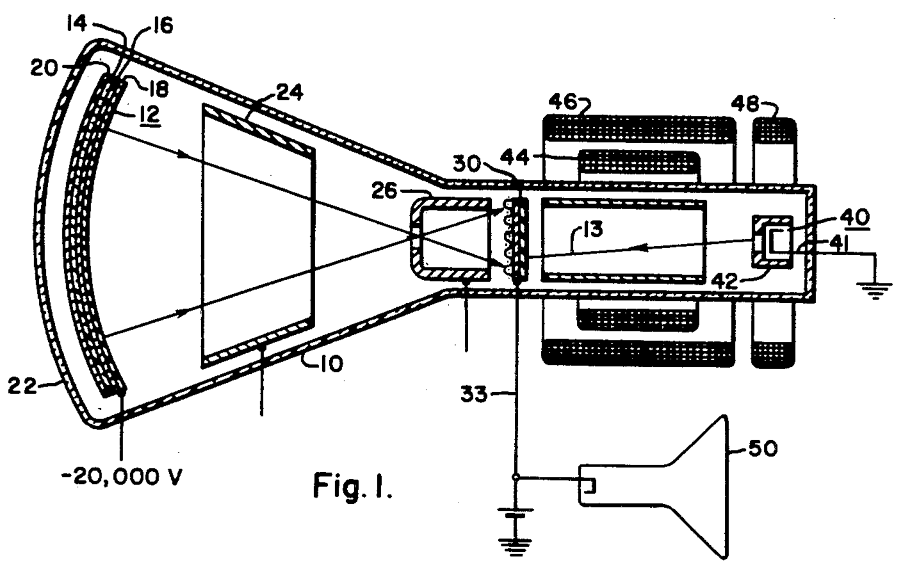

Fig. 1.

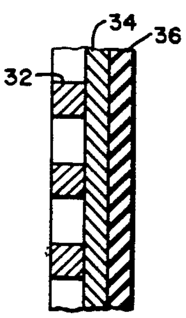

Fig. 2.

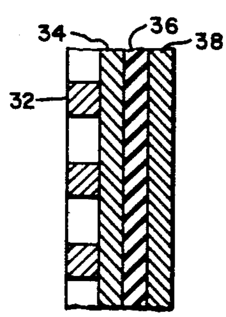

Fig. 3.

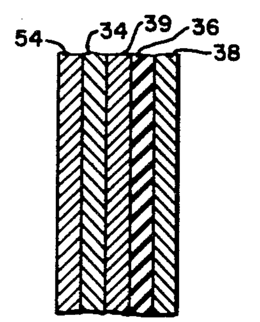

Fig. 4.

WITNESSES:

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ELECTRON DEVICE WITH STORAGE CAPABILITIES

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This invention relates to a storage system and more particularly to an electronic tube which may be utilized to store information and provide multiple copy read-out.

In U.S. Patent 3,046,431, entitled "A Storage System," by J. F. Nicholson and assigned to the same assignee, there is described a special type photoconductive target member which may be mounted in a substantially vidicon tube type structure and utilized as a storage tube to provide multiple copy read-out information. In the above-mentioned patent, a radiation image is directed onto the special type photoconductive target for a period of time and the resulting conductivity image set up within the photoconductive target is read out by utilization of an electron scanning beam. It is found that the device will provide multiple copy read-out without erasing the conductivity image on the photoconductivity target. This type of device is limited by the response characteristics of the photoconductive target and, therefore, is not adaptable to all types of radiation as well as providing a wide spectral range of radiation sensitivity. The device is also limited in sensitivity and it is, accordingly, an object of this invention to provide an improved storage type system utilizing the storage properties of the target disclosed in the above mentioned patent.

It is another object to provide an improved pickup tube having high sensitivity and high signal to noise ratio.

It is another object to provide a storage pickup tube in which an electron image is directed onto one side of a target electrode and multiple copy information is removed from the opposite side of the target.

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

FIGURE 1 illustrates a diagrammatic view of a storage system in accordance with the teachings of our invention;

FIGURE 2 is an enlarged sectional view of a portion of the storage taget utilized in FIG. 1;

FIG. 3 is a sectional view of a modified target structure that may be embodied in FIG. 1; and

FIG. 4 is a sectional view of another modified form of target structure that may be embodied in FIG. 1.

Referring in detail to FIGS. 1 and 2, a vacuum tight enclosure or envelope **10**, which may be of any suitable material, such as glass, is provided. The envelope **10** has an input screen **12** positioned therein at one end of the envelope **10**. The input screen **12** is comprised of a thin glass curved support plate **14** coated on its inner concave surface with a thin layer **16** of a radiation transmissive electrically conductive material, such as stannic oxide and the exposed surface of this stannic oxide layer **16** is coated with a layer **18** of a suitable photoemissive material, such as cesiated antimony. In some applications the layer **16** may be omitted. The convex or outer surface of the curved plate **14** is coated with a layer **20** of a suitable fluorescent material, such as zinc cadmium sulfide. It is obvious that in those applications where the photoemissive material in layer **18** is sensitive to the incoming radiations, such as ordinary light, that the fluorescent layer may be dispensed with.

A radiation image, such as X-rays is projected onto this input screen **12** through the face plate **22** of the enclosure **10**, and light is generated within the excited fluorescent layer **20** by the X-rays and this excited light image corresponding to the X-ray image is then transmitted through the transmissive glass support member **14** and conductive coating **16** to the photoemissive layer **18**. It is also obvious that the conductive coating **16** may be dispensed with if suitable photoemissive materials are utilized. The light image from the fluorescent layer **20** generates an electron image at the surface of the photoemissive layer **18** which is a replica of the X-ray image incident on the input screen **12**. A suitable electron lens assembly such as illustrated by the electrodes **24** and **26** provided with suitable voltages focuses and accelerates a contracted replica of the electron image from the input screen **12** onto a target **30**.

The target **30** is comprised of a planar support member **32** of a metal mesh of a suitable material such as copper. The support mesh has a large ratio of open space to solid area. The support mesh **32** is provided with an aluminum layer **34** thin enough to be permeable to electrons, but thick enough to provide electrical conductivity. The layer **34** is deposited on the surface of the mesh **32** opposite to the input screen **12**. The aluminum layer **34** serves as the back plate or signal plate of the target **30** and is connected by means of a lead-in **33** to the exterior of the tube for application of a suitable voltage and also deriving an output signal from the target structure. The normal voltage differential between the input screen **12** and the target structure **30** may be of the order of 10 to 20 kilovolts. This voltage provides the necessary acceleration of the electrons from the screen **12** into incidence with the target structure **30**. The completely exposed surface of the aluminum backing layer **34** is coated with a thin layer **36** of a semiconductive material which exhibits the property of electron bombardment induced conductivity. The layer **36** also exhibits the property of storage of a pattern including half tones in response to an electron excitation in the absence of electron bombardment for a predetermined time and also exhibits the property of retaining the stored pattern for a greater length of time than said predetermined time in response to electron excitation. It has been found that a suitable material that exhibits this property is a layer comprised of a mixture of arsenic and selenium. The layer **36** may be deposited onto a self-supporting thin film of aluminum of about 2000 angstroms in thickness and thus remove the necessity for the support mesh **32**.

The exposed face of the semiconductive layer **36** of the target **30** is scanned by an electron beam **13** generated by a suitable cathode ray gun **40** including at least a cathode **41** and a control electrode **42**. Deflection means **44**, focusing means **46** and alignment means **48** provide means of deflecting and focusing the beam over the target. The cathode **41** of the electron gun **40** is normally operated at ground potential while the signal plate **34** of the target **30** is operated at a potential of about 3 to 50 volts positive with respect to the cathode of electron gun **40**.

Referring in more detail to the structure of the target **30** and specifically to the semiconductive layer **36**, the layer **36** is a homogeneous mixture of arsenic and selenium. The layer **36** may be prepared by placing 300 milligrams of high purity selenium and 150 milligrams of chemically pure arsenic in a hard glass test tube and then heating the mixture slowly to about 400° C. in atmosphere thus causing the selenium to melt and take the arsenic into solution. It is then necessary to continue to heat this mixture slowly with agitation until a homogeneous mixture is obtained. It is necessary to agitate the mixture to prevent segregation of the selenium. This heating is continued for approximately 5 minutes and a homogeneous mixture is obtained in the melt without evaporation of the selenium. After a homogeneous mixture has been obtained, the mixture is allowed to solidify and when cooled, the test tube may be broken away and the material stored in a clean container. The specific example given above provides a two to one ratio by weight of selenium to arsenic and this has been found to yield excellent results. It has also been found that other proportions are possible, such as one to one.

The homogeneous mixture of arsenic and selenium as obtained above may then be evaporated onto the conductive layer **34**. This may be accomplished by placing the layer **34** and support **32** in a closed container capable of being evacuated. A small quantity, about 60 milligrams, of the homogeneous mixture is suitable for depositing a layer on a one inch diameter target. The amount of material utilized, of course, will depend on the area and the thickness of the layer desired. The mixture is placed in a boat of a suitable material, such as nickel-chromium base alloy and sold under the trade name Nichrome and inserted into the container. The boat may be positioned at a distance approximately 4 inches from the target. The system is then exhausted to a pressure less than about .5 micron. The boat is heated to approximately 400° C. The temperature is dependent on the desired speed of evaporation. The heating is continued for approximately 3 to 4 minutes until a target thickness of about 5 microns is obtained. When the desired thickness is obtained, the heat is turned off and the layer **36** of the mixture of arsenic and selenium is completed.

In the operation of the device illustrated in FIGS. 1 and 2, a radiation image is directed onto the photocathode or input screen **12**. This radiation excites the fluorescent layer **20** to cause it to emit light image corresponding to the radiation image. The light emitted by the fluorescent layer **20** is transmitted through the transmissive glass support member **14** to the photoemissive layer **18**. This light image induces the photoemissive layer **18** to emit an electron image corresponding to the light image. The electrons in the electron image emitted by the photoemissive layer **18** are accelerated and focused onto the target **30**. The photoelectrons are accelerated to a velocity of the order of 10 to 20 kilovolts and also focused to a reduced size upon the target electrode. These electrons directed onto the target penetrate through the thin electron permeable layer **34** and may substantially penetrate through the layer **36** of arsenic and selenium. This electron bombardment of the target **30** induces a conductivity image within the arsenic and selenium layer **36** corresponding to the radiation input image. The necessary time of exposure to the image may vary with the intensity of the image. An exposure time of less than $\frac{1}{30}$ of a second has been found to give satisfactory results.

In the scanning section of the tube, the electron beam **13** is provided to scan the exposed surface of the arsenic and selenium layer **36** to bring the entire surface to a potential substantially the same as that of the cathode of the electron gun **40**. With no radiations directed onto the input screen **12**, the face of the semiconductive layer **36** facing the electron gun **40** is maintained at the cathode potential, normally ground of the electron gun **40**, while the other surface of the semiconductive layer **36** by means of the aluminum backing layer **34** is retained at a positive potential with respect to the gun cathode of the order of 3 to 50 volts. When the X-ray image is projected onto the input screen, photoelectrons from the input screen **12** bombard the bombardment surface of the target **30** and induce conductivity in the semiconductive layer **36** to cause the exposed surface of the layer **36** to change from the electron gun cathode potential to some positive potential less than the signal plate potential. This effect on the semiconductive layer **36** may be referred to as a conductivity image. The change in potential of elements on the exposed surface of the layer **36** roughly corresponds to the intensity of bombardment. When the electron scanning beam from the electron gun **40** scans the surface of the layer **36**, a signal will be derived from the signal plate **34** in a conventional manner for transmission or direct connection to a conventional display device. In the specific device illustrated in FIG. 1, the signal is connected through an amplifier to a suitable display tube **50** for presentation of the image by well known television circuitry means. It has been found by utilizing the arsenic and selenium layer **36** that the conductivity image impressed on the target **30** is not erased by the scanning electron beam. We have found that even after the removal of the radiation image directed onto the input screen **12**, that one is able to derive a plurality of copies of the conductivity image impressed on the target member **30**. It has been found that the conductivity image does not extinguish and the image may be retained anywhere from 5 minutes to an hour on a conventional 30 frame per second television type of scanning operation. The device also provides means of detecting a weak radiation by building up the signal on the target **30** with the time of exposure. The image stored on the target may be erased by various methods. The target **30** may be flooded with suitable radiation such as visible light with or without the scanning beam on. It is also possible to erase by bringing the voltage applied to the signal plate to zero or raising it above first crossover potential with the scanning beam turned on. It is also possible to erase by turning the scanning beam off. This last method takes a longer length of time.

In FIG. 3 there is shown a modified structure which provides an additional layer **38** of material on the exposed surface of the arsenic and selenium layer **36**. The layer **38** is antimony trisulfide. The layer **38** may be of the order of 2 to 3 microns in thickness and may also be evaporated in a vacuum. In one specific example, after the arsenic and selenium layer had been deposited, the target was removed from the vacuum for a period of approximately 2 minutes and a boat inserted containing antimony trisulfide. The system was again evacuated to a pressure less than .5 micron and the antimony trisulfide boat heated to approximately 450° to deposit a layer of about 2 to 3 microns of thickness. The utilization of this antimony trisulfide layer enchances the sensitivity of the target with regard to the charge retention or storage of the image. The operation of the device is similar to that previously described with respect to FIGS. 1 and 2. It has also been found that a layer of indium between the layer **34** and the layer **36** will enhance the storage effect. While the target layers described use vacuum deposits, it is possible to use smoke deposits.

In FIG. 4 there is illustrated another modified target structure which includes a layer **39** of a high sensitive electron bombardment induced conductivity type material, such as amorphous selenium. The thickness of the layer **39** may be about .03 micron to 3 microns in thickness. The amorphous selenium layer **39** may be evaporated in a vacuum system with a pressure of about .5 micron. In this embodiment the layer **39** is deposited on the signal plate **34**. The support is provided in this embodiment by layer **54** of aluminum oxide. This type of support layer is described in U.S. Patent 2,898,499 and assigned to the same assignee as the present application. Deposited on the exposed surface of the amorphous selenium layer **39** is the layer **36** of a mixture of arsenic and selenium deposited in the manner previously described herein. A layer **38** of antimony trisulfide may also be deposited on the exposed surface of the arsenic and selenium mixture layer **36** which will further enhance the sensitivity of the target structure. The layer **39** enhances the sensitivity of the target to the electron bombardment from the image section. Electron multiplier structures suitable for imaging may be provided in the image section to further enhance the sensitivity of the device.

If additional sensitivity is desired, an image orthicon return beam multiplier type gun may be substituted for the vidicon type gun structure. The output signal would be derived from the return beam rather than the target. In other applications, it may be desirable to substitute a scanning electron beam for the image section and write the information to be stored on the target. The information to be stored would be used to modulate the scanning electron beam.

While we have shown our invention in only a few forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit and scope thereof.

We claim as our invention:

1. An electron discharge system comprising an envelope, a photoelectrically emissive input screen positioned at one end of said envelope, a target member comprising a thin sheet of a material of a mixture of arsenic and selenium spaced from said input screen and provided with a thin electrically conductive layer on the surface thereof facing said input screen, said target exhibiting the property of storing information in response to electron bombardment of one side of said target and discharge of said pattern in the absence of electron bombardment on the other side of said target in a predetermined time, said target also exhibiting the property of retaining said information for a greater length of time than said predetermined time in response to electron bombardment of said other side of said target, an electron lens system for accelerating and focusing electrons emitted from said input screen of a first energy onto the conductive layer of said target member to penetrate said conductive layer and enter said sheet of arsenic and selenium material to establish a charge pattern on said target, means for scanning the opposite side of said target with respect to said conductive layer with an electron beam of a lower energy than the energy of electrons bombarding said target from said input screen to simultaneously derive an electrical signal from said target and retain said charge pattern on said target to provide multiple copy readout.

2. An electron discharge device comprising a target member including a layer of an electrically conductive material and having a layer of semiconductive material exhibiting the property of storage of information in response to bombardment of high energy electrons and discharge of said information in a predetermined time in the absence of electron excitation by low energy electrons, said layer of semiconductive material also having the property of retaining said stored pattern for a greater length of time than said predetermined time in response to electron excitation, means for directing high energy electrons through said conductive layer into said semiconductive layer to modify the conductivity of said semiconductive layer and thereby establish a charge pattern on the exposed surface of said semiconductive layer and means for directing a low energy electron beam onto the exposed surface of said semiconductive layer to provide means for deriving an electrical signal from said target corresponding to said charge pattern and also to simultaneously retain said stored pattern on said exposed surface of said semiconductive layer.

3. An electron camera tube comprising a target for electrons including a first layer of insulating material which exhibits the property of electron bombardment induced conductivity, a second layer deposited on one surface of said first layer of a mixture of arsenic and selenium, a third layer of electrically conductive material provided on the opposite surface of said first layer, means for bombarding said conductive surface of said target with electrons of a first energy capable of penetrating through said conductive layer and into said first and second layers and thereby establishing a charge pattern on the exposed surface of said second layer and means for scanning the exposed surface of said second layer of said target with a beam of electrons of an energy lower than said first energy to provide means of deriving a signal representative of the charge pattern on said exposed surface and simultaneously retaining said charge image thereon.

4. An electron camera tube comprising a target for electrons including a first layer of insulating material which has the property of becoming electrically conductive when bombarded with electrons of sufficient energy to substantially penetrate said layer, a second layer of a mixture of arsenic and selenium deposited on one surface of said first layer and a third layer of antimony trisulfide deposited on the exposed surface of said second layer, means for bombarding said target to penetrate said first layer with electrons of a high velocity and means for scanning the exposed surface of said third layer with a beam of low velocity electrons.

5. A system for generating a plurality of copies of radiation image comprising an envelope, a target including a thin film of a mixture of arsenic and selenium mounted within said envelope, a photo-emissive cathode positioned within said envelope for providing a photoelectron emission corresponding to a radiation image directed onto said photoemissive cathode, means for directing said photoelectron emission image toward said target, a conductive coating on one surface of said arsenic and selenium film facing said photoemissive cathode, means within said envelope for accelerating said photoelectron emission image to sufficient energy to penetrate said conductive layer and enter said arsenic and selenium film to establish a charge image, means within said envelope for forming a beam of electrons, means for scanning said electron beam over the opposite surface of said arsenic and selenium film with respect to said conductive coating to derive a signal representative of said charge image while simultaneously causing retention of said charge image on said target to permit multiple copy readout.

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