United States Patent

Salgo

[15] **3,649,866**

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[54] **TELEVISION CAMERA STORAGE TUBE HAVING CONTINUAL READOUT**

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[52] **U.S. Cl.** **315/11,** 315/12
[51] **Int. Cl.** **H01j 31/48**
[58] **Field of Search** 315/11, 12

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

A television camera storage tube having the photoconductor deposited on a mesh positioned between the conductive coating and the source of electrons, the photoconductor being on the side of the mesh facing the conductive coating, and acting as a potential barrier to flow of electrons to the conductive coating, such flow of electrons varying in proportion to the degree of illumination on elemental areas of the photoconductor, and the method of operating such a tube in which a charge pattern on the photoconductor is erased by the impingement of electrons on it.

7 Claims, 2 Drawing Figures

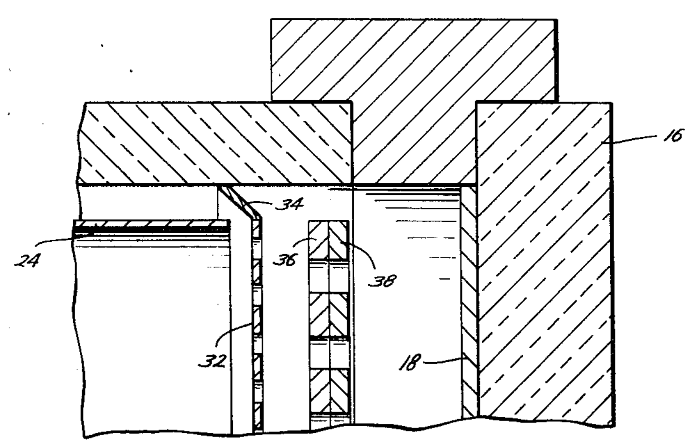


Fig. 1

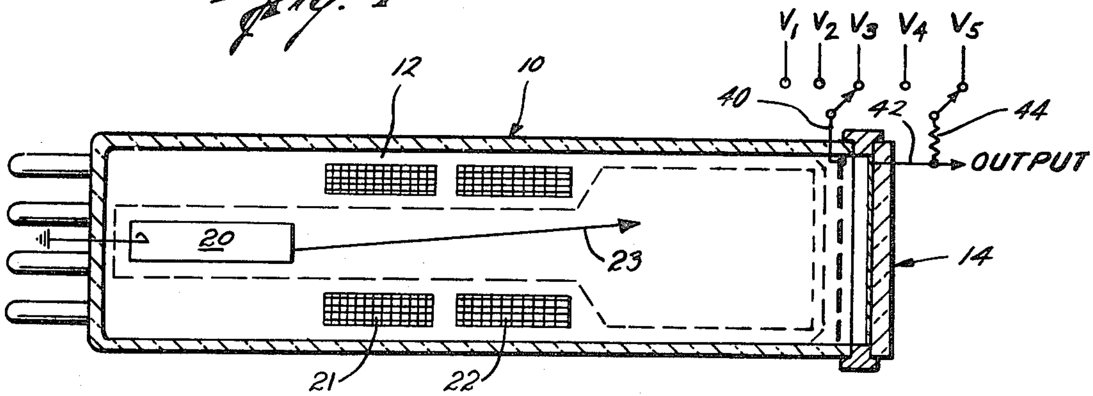
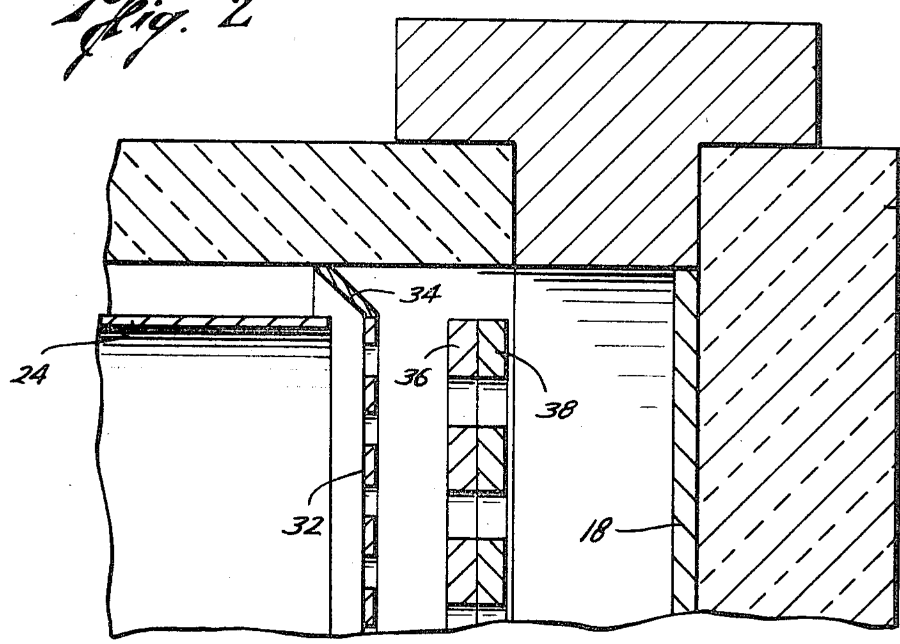


Fig. 2



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TELEVISION CAMERA STORAGE TUBE HAVING CONTINUAL READOUT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to television camera storage tubes and more particularly it relates to such a tube having the capability of storing and reading an image for times adjustable from a few seconds to an hour or more, and of storage in the dark for several weeks or longer.

2. Description of the Prior Art

There are available in the prior art storage devices in which there is provided a storage electrode for storing a series of signals of variable intensity representative of an image and means for reading out the stored information at a later time. Such devices normally consist of a storage target member made of a normally insulating material in an evacuated envelope, upon which member there is established a pattern of charges representative of the stored series of signals or image. The charge pattern is normally established by directing an electron beam or electromagnetic radiation, such as visible light, onto the storage surface.

In storage tubes of the type described above, it is desirable in many applications to perform the operation of reading out of the charge image or pattern without destroying the charge image, thus permitting reading out of the information for as many times as desired. A tube of this type is referred to as a multicopy type of storage tube. It is also desirable in such tubes that the information readout include half tones, that is signals having intensities between a maximum and a minimum value, in all copies.

Various storage devices of this type are known in the prior art. Examples of such devices are disclosed in U.S. Pat. Nos. 3,046,431, 3,249,783 and 3,423,237, and in the article at pages 740 to 747 of the July, 1950 issue of "Proceedings of the I.R.E.", entitled "The Recording Storage Tube", by Hergenrother et al.

The storage devices described in the aforesaid patents consist essentially of a tubular envelope having a face plate closing one end and a target, formed with a light transmissive electrically conductive coating supported on the face plate and a layer of a photoconductor deposited on the conductive coating. This target structure is mounted within the evacuated envelope and the exposed surface of the photoconductor faces an electron gun assembly. The electron gun assembly generates a low velocity beam substantially normal to the surface of the photoconductor. The electrons in the beam approach the target with very low energies, normally below the first crossover potential of the target surface. These electrons are deposited on the photoconductive surface and drive the surface to substantially the potential of the cathode of the electron gun.

In such a tube the electrically conductive layer or signal plate of the target is usually held at a potential of about 10 volts positive with respect to the cathode. In this manner there is established a potential gradient across the two layers of photoconductor and signal plate. Due to the photoconductive properties of the target material used, a light image directed thereon will cause a charge pattern to be established on the surface scanned by the electron beam. This change in charge or potential will be toward the potential of the signal plate. The scanning of the photoconductor by the electron beam will thereby generate a signal in the conductive signal plate corresponding with the charge pattern which has been established on the photoconductor. In such tubes the charge image gradually deteriorates, the time of deterioration depending upon the characteristics of the selected photoconductor and the voltages used.

Such deterioration of the charge image means that in the latter part of the storage period a very poor picture will be read from the storage surface. Such storage tubes are also of a comparatively low sensitivity, since the impedance across the photoconductive coating may be 10,000 ohms or more, thereby greatly reducing the flow of current through the lighted areas. Also, in the usual vidicon type of storage tube the electron beam impinges directly upon the photoconductor and gradually causes a chemical change in the photoconductor which deteriorates it.

The Hergenrother device is useful for recording an input electrical signal, but cannot be used to store a visual input image.

SUMMARY OF THE INVENTION

According to the present invention the photoconductor is not put in the path of the electron beam and is not discharged when the electron beam is used for reading the video charge pattern thereon. Instead, the photoconductor is positioned on a screen spaced away from the signal plate of the tube and in the path of the electron beam, the photoconductor facing away from the electron beam, and the focusing of the video image thereon produces a charge pattern which creates a field to control the flow of electrons from the electron gun through the screen and thereby controls the impingement of electrons on the signal plate. The impingement of electrons on the signal plate creates the output signal.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat schematic elevational view, partly in section, of one embodiment of the storage vidicon of this invention; and

FIG. 2 is an enlarged fragmentary sectional view of a portion of the target end of the embodiment shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 of the drawing shows a vidicon-type camera tube, indicated generally by the reference numeral **10**, which comprises an evacuated envelope **12** having an electron gun **20** in the left end thereof, as shown in the drawing. The electron gun **20**, as is well known in the vidicon art, produces an electron beam **23** directed toward the target **14** in the other end of the envelope **12**. The electron beam **23** is focused and scanned over the exposed surface of the target electrode by suitable horizontal and vertical deflection coils **21** and **22**, it being understood that any conventional deflection system maybe employed.

The target electrode **14** comprises essentially a supporting insulating transparent plate **16**, such as glass, for example, which, in the tube shown in the drawing, is a flat end wall portion or face plate of the envelope **12**. The face plate **16** must be transparent to visible light. The face plate is coated on its surface facing the electron gun with a transparent conductive film or signal plate **18**. Such a conductive film may be formed from an evaporated conductive metal or of such material as stannic oxide. The output signal from the tube is taken from this signal plate through the lead-in **42**. As shown, the lead-in **42** may be alternately connected, through resistance **44**, to voltage sources V_4 and V_5, for a purpose which will hereinafter be explained.

The tube includes an accelerating and focusing electrode **24** comprising a tubular member centrally disposed within the envelope **12** and extending to a point closely adjacent to the target electrode **14**. Positioned in front of the electrode **24** is a fine mesh screen **32** which is mounted in the tube envelope adjacent the target electrode and which is biased at a positive potential of 300–400 v. This mesh **32** may be circumferentially engaged by a particle shield **34** of the type, for example, disclosed in U.S. Pat. No. 2,897,389.

Intermediate the screen **32** and the signal plate **18** there is positioned a conductive target mesh **36** having a photoconductive material deposited in a layer **38** on the side of the target mesh facing the signal plate. The mesh **36** is preferably very close to the field mesh **32**, and may be as close as 40 mils or less. Mesh **36** may be from about 100 mils or less to about one-fourth inch from the face plate, depending on the potentials used.

The photoconductor used is one which is responsive to visible light, and may be of the selenium-sulfur type such as that described in the aforesaid U.S. Pat. Nos. 3,249,783 and 3,423,237, and may be deposited on the mesh **36** by evaporation, as is well known in the art.

The target mesh or screen **36** comprises a thin perforated metal sheet which may be prepared by photographic techniques well known in the art. The mesh selected for the screen **36** is dependent upon the degree of resolution desired in the readout, and may be as low as 750 lines per inch (assuming a 1-inch-diameter tube) or as high as 2,500 lines per inch or more. As shown in FIG. **1**, the screen **36** is preferably connected by means of lead-in **40** to alternate voltage sources V_1, V_2 and V_3 for a purpose which will hereinafter be explained.

To prepare the photoconductive surface **38** for establishment of a charge pattern thereon, any existing charge pattern must first be erased. Two alternative modes of operation may be employed to accomplish this. In the first of these methods, the erasing operation is performed at potentials above the first crossover of the photoconductor. For this purpose the signal plate or collector **18** is connected to a voltage source V_4 which has a negative potential sufficient to repel the electron beam, for example, −150 to −300 volts, and preferably −150 to −200 volts. The target mesh **36** is connected to voltage source V_1, which has a potential substantially above the first crossover of the photoconductor, and may be in the range of about 150 volts to 300 volts. For most applications a potential of about 250 to 300 volts is preferred. Since the cathode is usually at or near ground potential, this produces a beam energy of 250 to 300 volts.

When the cathode is energized, the electron beam passes through the mesh **36** and is thus reflected from the signal plate, so that electrons impinge upon the photoconductor at high velocity, causing the emission of secondary electrons, thereby raising the potential of the photoconductor to approaching 400 volts, and in the process erasing any image which may be stored thereon. At such potentials, this erasing operation may be completed very quickly, usually in one frame time (normally one-thirtieth second).

Following erasure by this method, the target is then primed to prepare it to receive a new image. The erasing operation has resulted in a potential difference between the mesh **36** and the photoconductor of 100 to 150 volts. In priming, the mesh **36** is switched to a voltage V_2 which is substantially below the first crossover potential of the photoconductor, and may for example be at a positive potential of 20 to 50 volts. Due to capacitive effect, this reduces the potential of the surface of the photoconductor. The mesh potentials are selected so that the potential at the surface of the photoconductor is reduced to or below the first crossover potential, and may be in the range of 100 to 150 volts.

The electron beam being continuously scanned across the target mesh **36** is still repelled from the signal plate **18**, and since the photoconductor potential is below the first crossover, electrons are now absorbed from the beam to lower the photoconductor potential to near cathode potential, i.e., to below the potential of mesh **36**. The target is now ready for the write and read portion of the cycle.

In the write and read portion of the cycle, the signal plate **18** is connected to voltage source V_5, which has a positive potential below the first crossover of the signal plate material, e.g., about 10 to 90 volts (70 volts in the preferred embodiment) when tin oxide is used for the signal plate. The target mesh is then connected to voltage source V_3, which has a potential sufficiently lower than V_2 that the photoconductor potential is reduced by capacitive effect to at least about 10 volts negative with respect to the cathode. To accomplish this, V_3 should preferably be 10 to 20 volts less than V_2.

The image to be viewed is then focused on the photoconductor, thereby imparting a charge image whose potential in any incremental area is proportional to the light intensity. Thus in those areas which are unlighted the potential of the photoconductor acts as a barrier to the electron beam; in dimly lighted areas some electrons flow through and in brightly lighted areas a large flow of electrons is permitted. This flow of electrons to the signal plate constitutes the picture signal.

In the second method of operation, erasing is achieved at potentials below the first crossover potential of the photoconductor. Thus in this method the mesh **36** is connected to a first voltage source V_1 which may be, for example, 25 to 75 volts, preferably about 50 volts, positive, for about 1 second, or long enough to accomplish erasure. Erasure may be speeded up if the signal plate **18** is connected to a voltage source V_4, which may have a potential either negative or positive relative to the cathode, a potential of 10 to 30 volts being sufficient. If the signal plate is made negative a retarding field formed between the photoconductive layer **38** and the signal plate **18** causes the beam passing through the openings in the screen to turn back before contacting the signal plate, thereby scanning the photoconductive coating and bringing it to cathode potential very quickly.

If the erasing operation is performed with the signal plate at a positive potential, the electrons strike the signal plate at sufficient velocity to be deflected back into contact with the photoconductor. However, this method of erasing is slower than that which utilizes a negative signal plate.

After the erasing operation, the potential of the screen **36** is reduced enough for the capacitive effect to reduce the potential at the surface of the photoconductor to a negative value, a potential of +10 to +25 volts generally being satisfactory. If the potential of the screen is reduced from +50 to +15 volts, and the surface of the photoconductor has been brought to ground potential, the potential of the surface of the photoconductor is reduced to −35 volts. This negative potential produces a field which prevents the electrons from the electron gun from penetrating the screen **18**, and therefore keeps them from impinging upon the signal plate.

The lens of the camera is then opened to allow the image to be viewed to be focused upon the photoconductive layer **38**, causing a charge image to be formed thereon. The negative charge in these lighted areas is therefore reduced to nearer ground potential, or may even become positive in some areas, depending upon the light intensity at any particular area. It will be apparent that the intensity of the field which prevents the flow of electrons through the screen is proportional to the amplitude of the negative charge in a particular area of the photoconductor, so that at lower negative potentials some electrons will pass through the screen, and at positive potentials a higher proportion of electrons will pass through, thereby creating a picture signal of greater amplitude.

During the reading part of the cycle, the lead-in **42** is connected to voltage source V_5 to raise the potential on the signal plate to a positive voltage of, for example, 10 to 90 volts, preferably about 70 volts, so that it will collect all electrons which pass through the screen and thereby provide an output picture signal. The camera lens is covered, of course, except during the "write" part of the cycle. The potential pattern on the photoconductor determines the pattern of electrons which are collected on the signal plate. Thus the scanning of the screen by the electron beam, during the reading part of the cycle, produces a modulated picture signal representative of the charge image on the photoconductor. When the electron beam has scanned the entire screen **36** an electron pattern has been fed to the signal plate, taken off through the output lead **42** and supplied to a display tube which is coordinated with the tube **10**. It will be appreciated that the reading operation can be continued to provide a continuous display on the display tube so long as the charge pattern remains on the photoconductor. This period may be from a few seconds to an hour or more, depending upon the photoconductor used and the selection of operating voltages. Eventually the negative charge will leak off, causing the negative field to decay until the dark current is equal to the signal current.

When it is desired to erase the charge image on the photoconductive surface the erasing step previously described is repeated.

There has therefore been disclosed a nondestructive read photosensitive storage tube in which the photosensitive layer is deposited on a mesh located between the field mesh and the face plate. The face plate is coated with a transparent conductive layer only. When an optical image is focused on the target mesh it assumes a charge pattern proportional to the scene, thereby becoming transparent to the electron beam according to the amount of light incident upon it. The portion of beam that successfully passes through the target mesh is thus modulated with video information. It is then collected by the conductive layer on the face plate and the video signal is taken off and processed in standard fashion.

Since the photoconductive coating does not serve as the collector of electrons, the process of modulating the beam does not erase the picture information as it does in a vidicon. The picture can thus be viewed for several minutes. The viewing period can be increased by decreasing the target mesh voltage during the period of viewing, thereby resulting in viewing times as long as an hour or more.

Various embodiments of the invention are shown in the drawing and described in the specification, but many variations thereof will be apparent to those skilled in the art. It is not practical to show or describe all the variations included within the invention, and therefore the embodiments described should be considered illustrative only, and not limiting, the scope of the invention being as broad as is defined by the appended claims. The form of the claims and the specification, including the Abstract, is adopted solely for easier reading and understanding, and should not be considered in interpreting the scope of the invention claimed.

I claim:

1. A method for storing and reading out a video image comprising

causing an electron beam from an electron gun to scan across a conductive mesh having a photoconductive coating on the surface of the mesh facing away from the electron gun whereby electrons pass through the apertures of said mesh,

biasing said mesh positive,

deflecting electrons back to the photoconductive coating to change its potential,

reducing the potential of said mesh to a lesser positive value, thereby reducing the potential of the photoconductive coating by capacitive effect,

focusing an image onto said photoconductive coating,

further scanning the conductive mesh with said electron beam,

and collecting the electrons passing through said mesh.

2. A method as defined by claim 1

wherein said electrons are collected on a signal plate which is biased positive relative to said electron gun.

3. A method as defined by claim 2 wherein said signal plate is biased negative relative to said electron gun during the first scanning by the electron beam.

4. Process comprising

biasing a mesh support member and a photoconductor thereon to different potentials, the mesh being positive and the photoconductor being negative with respect to a cathode which generates an electron beam adapted to scan said mesh,

focusing a light image on said photoconductor to cause it to conduct in incremental areas in proportion to the light intensity, thereby rendering portions of the photoconductor more positive,

scanning the mesh with the said electron beam, whereby electrons pass through areas of the mesh where the photoconductor is more positive,

and collecting electrons passing through the mesh to form a picture signal.

5. Process as defined by claim 4, followed by

raising the potential of the mesh to above the first crossover potential of the photoconductor,

raising the potential of the element used for collecting electrons enough to repel electrons of the electron beam,

scanning with the electron beam to cause emission of secondary electrons from the photoconductor, thereby raising its potential and erasing any charge image thereon,

reducing the potential of the mesh to below the first crossover of the photoconductor, thereby reducing the potential of the photoconductor by capacitive effect to below its first crossover, and

scanning with the electron beam to lower the potential of the photoconductor to near cathode potential.

6. A storage vidicon comprising:

a tubular envelope,

a transparent face plate closing one end of said envelope,

a transparent conductive coating on the internal face of said face plate,

an electron gun at the other end of said envelope,

means for directing electrons from said electron gun toward said conductive coating,

a conductive screen positioned adjacent but spaced away from said conductive coating in the path of the electrons from said electron gun,

a photoconductive coating on the side of said conductive screen facing said conductive coating,

means for applying at least two different potentials to said conductive screen,

means for focusing a light image on said photoconductive coating through said face plate and said conductive coating, and

means for selectively applying negative and positive potentials to said conductive coating.

7. In a storage tube for storing video images for readout over an extended period of time,

a transparent signal plate,

means for producing an electron beam and scanning it over a surface of the signal plate,

a conductive screen positioned parallel to and spaced away from said surface so that the electrons of said electron beam must pass through the apertures of said screen to scan the surface of the signal plate,

a photoconductive coating on the side of the conductive screen facing said surface,

means for applying at least two different potentials to said conductive screen, and

means for selectively applying negative and positive potentials to said signal plate.

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