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C. S. SZEGHO ET AL

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STORAGE ELECTRODE FOR SIGNAL-CONVERTING DEVICES

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Fig. 1

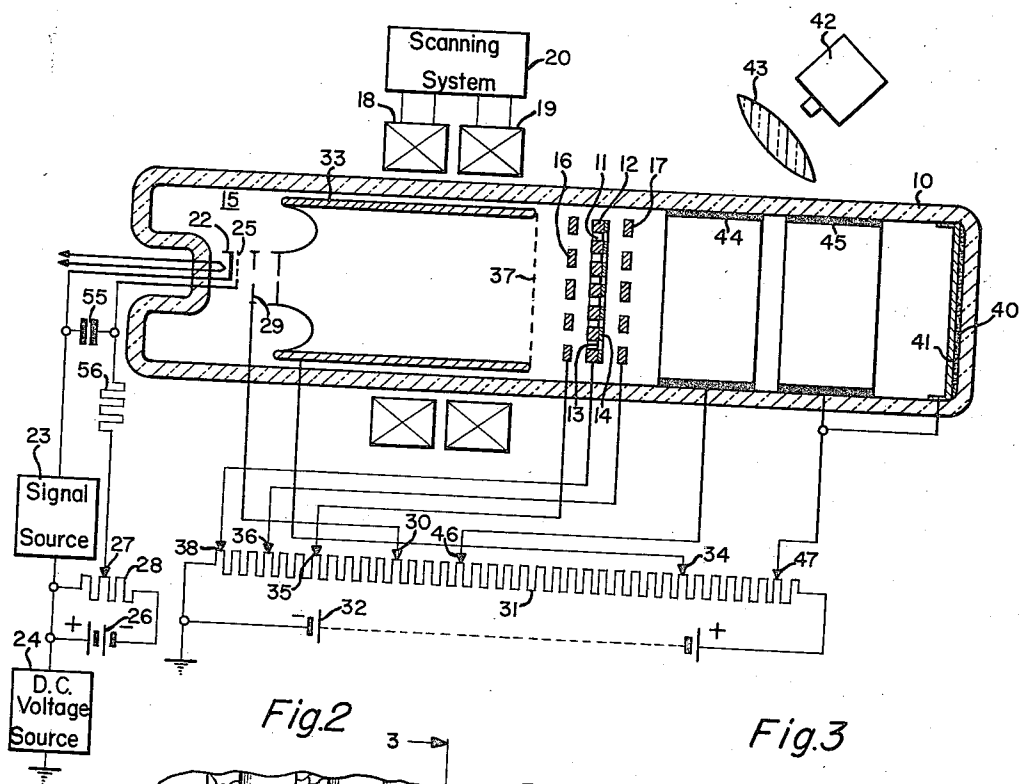


Fig. 2

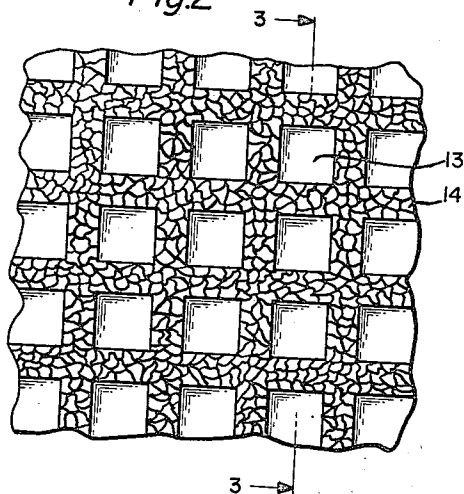
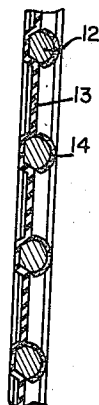


Fig. 3



CONSTANTIN S. SZEGHO
WILLIAM O. REED
INVENTORS

BY *Francis W. Corbett*
THEIR ATTORNEY

UNITED STATES PATENT OFFICE

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STORAGE ELECTRODE FOR SIGNAL-CONVERTING DEVICES

Constantin S. Szegho and William O. Reed, Chicago, Ill., assignors to The Rauland Corporation, a corporation of Illinois

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3 Claims. (Cl. 313—346)

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This invention relates to signal-converting devices, and more particularly to a new and improved storage electrode for a directly-viewed signal converter.

The use of signal-storage devices incorporating image-storage electrodes for developing a space-modulated charge image of an incoming electrical signal by scanning the storage electrode with a signal-modulated cathode-ray beam is well known in the art. Arrangements of this type have been found particularly useful for radar display purposes and the like in which it is desired to convert radar pulse-type input signals to television-type output signals for application to an image-reproducing device. Such devices as have been employed in the past are characterized by several undesirable limitations. In the first place, conventional image-storage electrodes are incapable of satisfactory half-tone reproduction, so that conventional signal-storage devices may be operated only at a full-signal condition or a no-signal condition. Thus, for example, radar signals from an object passing through a cloud are obscured by the signals returning from the cloud itself.

Furthermore, conventional signal-storage devices are usually operated at relatively high voltages, thereby imposing severe power supply requirements.

It is an important object of the present invention to provide an improved signal-storage device of the directly-viewed type, particularly applicable for radar display purposes and the like, which is capable of half-tone storage and reproduction.

A further object of the invention is to provide an improved directly-viewed signal storage device adapted to be operated at relatively low power supply voltages.

Still a further object of the invention is to provide a novel storage electrode for a signal-converting device.

In the copending application of Constantin S. Szegho et al., Serial No. 99,421, filed June 16, 1949, for "Signal Storage Devices," and assigned to the present assignee, there is disclosed and claimed a novel signal-storage device of the type comprising a storage electrode and a pair of electron gun structures for respectively storing a space-modulated charge image on the storage electrode and releasing the stored information. The storage electrode comprises a conductive mesh screen and a dielectric film distributed across the interstices of the screen in substantially coplanar relation therewith. The storage

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electrode structure disclosed and claimed in the copending application is capable of half-tone storage and reproduction and is particularly adapted to use in scanning converters, memory tubes, and the like. The present invention is directed to a modification of the storage electrode which is adapted to use in a directly-viewed signal-converting device.

In accordance with the present invention, a storage electrode for a signal-converting device comprises a conductive grid-like structure having a plurality of interstices. A dielectric film is distributed on a single surface of the conductive structure and extends into and across the interstices in substantially coplanar relation with the conductive structure. Photoemissive material is supported adjacent the exposed surface of the conductive structure, preferably being deposited directly thereon.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals indicate like elements, and in which:

Figure 1 is a sectional view, partly schematic, of a signal-storage device including a storage electrode constructed in accordance with the present invention, together with a schematic representation of suitable external circuit connections;

Figure 2 is a fragmentary plan view of the storage electrode of the device of Figure 1, and Figure 3 is a sectional view taken along the line 3—3 of Figure 2.

The signal-storage device of Figure 1 comprises an evacuated glass envelope 10 which encloses a storage electrode 11 comprising a conductive grid-like structure 12, a dielectric film 13, and photoemissive material 14 deposited on the surface of the conductive structure 12 opposite dielectric film 13.

The construction of storage electrode 11 is more readily apparent from a consideration of Figures 2 and 3 to which reference is now made. The grid-like conductive structure 12 is preferably formed as a conductive mesh screen, although a parallel-wire grid structure may be used, on one surface and across the interstices of which is distributed a thin dielectric film 13 which is preferably of substantially uniform thickness. Dielectric film 13 extends into and

across the interstices of conductive mesh screen 12 in substantially coplanar relation with the screen in order to present a substantially planar surface with the mesh screen. Photoemissive material 14 is supported adjacent the exposed surface of conductive mesh screen 12, preferably being deposited directly thereon in a manner to be hereinafter described in detail.

With reference again to Figure 1, envelope 10 also encloses an electron gun 15 which constitutes an electrode system for projecting a recording or writing cathode-ray beam on storage electrode 11 during writing intervals. A decelerating electrode 16 and an accelerating electrode 17 are disposed on opposite sides of storage electrode 11. Magnetic focussing coils 18 and deflection coils 19 are associated with electron gun 15 and are connected to a suitable scanning system 20 which operates to cause the writing beam to scan storage electrode 11 during writing intervals. Scanning system 20 may be a conventional television-type sweep-signal generator; alternatively a circular-sweep system or any other desired type of scanning system may be employed.

It is preferred that the image to be stored on storage electrode 11 be recorded from the insulator side thereof, and that the photoemissive material 14 be deposited on the opposite, exposed, surface of the conductive mesh 12.

The cathode 22 of electron gun 15 is returned to ground through a signal source 23 and a suitable source of unidirectional operating potential 24. The control grid 25 of electron gun 15 is maintained at a fixed direct potential relative to cathode 22 by means of a suitable negative biasing potential source, here shown as a battery 26; the bias of control grid 25 relative to cathode 22 may be adjusted as desired by means of a variable tap 27 on a resistor 28 shunting battery 26. A coupling condenser 55 is connected between cathode 22 and control grid 25, and a decoupling resistor 56 is connected between control grid 25 and variable tap 27. The first accelerating electrode 29 of electron gun 15 is maintained at a constant positive unidirectional operating potential with respect to cathode 22 by connection to a tap 30 associated with a potentiometer 31 which in turn is connected in shunt with a battery 32 or other suitable constant-potential source. The second accelerating electrode 33 of electron gun 15 is connected to a second tap 34 associated with potentiometer 31.

Decelerating electrode 16 and accelerating electrode 17 are connected to respective variable taps 35 and 36 associated with potentiometer 31. Anode cylinder 33 is preferably provided with a wide mesh screen 37 closing the output end of the cylinder, in order to insure a substantially uniform electrostatic field between anode 33 and decelerating electrode 16.

The conductive portion 12 of storage electrode 11 is connected to an additional variable tap 38 associated with potentiometer 31.

In order to achieve visual reproduction of the charge image recorded on storage electrode 11, a fluorescent screen 40 is positioned at the end of envelope 10 opposite electron gun 15; an electron-permeable metal backing layer 41, preferably constituted by an aluminum film, is provided to prevent charge accumulation and to increase the brightness of the reproduced image in a manner well known in the art. Conductive film 41 also serves effectively to prevent spurious excitation of photosensitive mosaic 14 by light

originating at the fluorescent screen 40. Light radiation from an external source 42 is directed and focussed onto photoemissive material 14 deposited on the conductive portion of the storage electrode 11 by means of a suitable collimating system, here schematically represented as a single lens 43. A pair of accelerating electrodes 44 and 45, which may conveniently assume the form of metal coatings on the inner wall of envelope 10, are provided between accelerating electrode 17 and fluorescent screen 40. Accelerating electrodes 44 and 45 are connected to taps 46 and 47, respectively, associated with potentiometer 31, and conductive film 41 may be connected to accelerating electrode 45. Bypass condensers (not shown) may be inserted between each of the several taps associated with potentiometer 31 and ground, in order to prevent signal-frequency variations in the potentials of the various electrodes.

As explained in the above-identified copending application, the storage properties of electrode 11 are dependent upon the secondary electron emission characteristics of that electrode, which in turn are primarily determined by the secondary emission properties of dielectric film 13. Three distinct operating conditions may be obtained for the composite storage electrode 11. Within a first range of primary electron voltages less than a first cross-over voltage V_{c1} , the secondary electron emission ratio (the number of secondaries released for each incident primary electron) of the composite storage electrode is less than unity and the net electron flow is to the storage electrode, i. e., negative current. For primary electron voltages within a second range greater than the first cross-over voltage V_{c1} and less than a second cross-over voltage V_{c2} , the secondary electron emission ratio is greater than unity and the net electron flow is away from storage electrode 11, i. e., positive current. Within a third range of primary electron voltages greater than the second cross-over voltage V_{c2} , the secondary electron emission ratio is again less than unity, and negative current flows in the storage electrode 11. At the two cross-over voltages V_{c2} and V_{c1} , the secondary electron emission ratio is exactly unity, and the current flow in storage electrode 11 is zero.

Similar characteristics obtain for each of the components of the storage electrode. Thus, the secondary-electron emission characteristic of the dielectric or insulating portion of the storage electrode exhibits two well defined cross-over voltages V_{n1} and V_{n2} . The cross-over voltages for the dielectric film 13 do not necessarily coincide with those of the composite storage electrode.

The preferred mode of operation of the device of Figure 1 will now be described and explained in detail, bearing in mind the secondary electron emission properties of the storage electrode and its component parts.

In order to condition storage electrode 11 for recording incoming signals from source 23, the potential of conductive portion 12 of storage electrode 11 is raised by means of tap 38 on potentiometer 31 to a value between the first and second cross-over voltages V_{n1} and V_{n2} of the insulator portion 13 of composite storage electrode 11. An unmodulated cathode-ray beam is projected from electron gun 15 onto dielectric film 13; because the primary electron voltage is greater than V_{n1} , the number of secondary electrons emitted is greater than the number of incident primary electrons, and a positive charge is built up on the

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surface of storage electrode 11. This action is cumulative until such time as the charge potential of insulator portion 13 of storage electrode 11 is substantially the same as the potential applied to decelerating electrode 16, which is maintained at or near the potential applied to conductive mesh 12 by suitable adjustment of tap 35 on potentiometer 31, and which serves to maintain a substantially uniform field for the incident primary electrons. When the charge on insulator portion 13 of storage electrode 11 has reached a potential substantially equal to that of decelerating electrode 16, an equilibrium condition is reached, and further scanning of storage electrode 11 by the unmodulated electron beam has no further substantial effect on the charge accumulation.

The unidirectional operating potential applied to conductive mesh 12 is now lowered by means of variable tap 38 on potentiometer 31 to a value below the first cross-over potential V_{n1} of the insulator, in order to bias the conductive mesh 12 to a lower voltage than that to which the insulator portion 13 is charged, thereby to reduce the tendency of subsequently stored negative charges to leak off through the insulator to the mesh. The charge on the insulator portion 13 remains at a potential well above the first cross-over voltage V_{n1} , since secondary electrons emitted from the insulator are either collected by decelerating electrode 16 or returned to insulator portion 13 thereby slightly lowering the charge potential. However, the charge on the dielectric film 13 is still maintained at a potential higher than its first cross-over potential V_{n1} .

Writing gun 15 is now prepared to store an image on electrode 11 by reducing the bias on control grid 26 by means of variable tap 27 on potentiometer 28, and the unidirectional operating potential of cathode 22 is adjusted to a small positive value by means of D. C. voltage source 24 so that electrons from writing gun 15 impinge on insulator portion 13 of storage electrode 11 at an effective potential below the first cross-over voltage V_{n1} of the insulator. Signals representing the image to be stored are supplied to cathode 22 from source 23 to effect velocity modulation of the writing beam, and deflection coils 18 are energized by scanning system 20 to cause the writing beam to scan the storage electrode. Because the writing electrons impinge on insulator portion 13 at an effective voltage below the first cross-over potential V_{n1} of the insulator, the number of secondary electrons emitted is less than the number of incident primary electrons, and the insulator assumes a negative charge distribution to form a space-modulated charge image of the input signal from source 23.

Alternatively, the potential of cathode 22 may be adjusted to a large negative value by means of D. C. voltage source 24 so that the writing electrons impinge on insulator portion 13 of storage electrode 11 at an effective voltage greater than the second cross-over voltage V_{n2} of the insulator; this mode of operation also establishes a negative charge distribution on dielectric film 13 constituting a space-modulated charge image of the input signal from source 23.

In order to reproduce a visual image of the space-modulated charge pattern stored on dielectric film 13, photoemissive material 14 is illuminated by light radiation from external source 42. The electrostatic field induced by the stored charges extends through the dielectric

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film 13 and influences the intensity of the photoemission from each elemental portion of the photoemissive mosaic 14 in accordance with the charge distribution, since the field induced by the stored charges retards the photoelectrons and opposes the field set up by accelerating electrode 17. This effect is large owing to the substantial coplanarity of the dielectric film 13 and the conductive mesh 12. Thus, a beam of photoelectrons varying in intensity throughout its cross-section is emitted by photoemissive mosaic 14; electrodes 17, 44, and 45 serve to accelerate and focus the photoelectron beam and project it toward fluorescent screen 40. Consequently, fluorescent screen 40 is excited in accordance with the stored charge image. Due to the intensity-control action of the stored charge image on the photoemission from mosaic 14, and due to the space-modulation of the stored charge image in accordance with the input signal, half-tone storage and reproduction are obtained.

The storage time obtainable with the device of Figure 1 is determined primarily by the leakage time constant of the insulator employed as the dielectric film 13. In the event that it should be desired to change the stored signal before the insulator has become completely discharged through leakage, it is always possible to accelerate the discharge by raising the potential of conductive mesh 12 above the first cross-over potential V_{n1} and scanning the storage electrode with an unmodulated cathode-ray beam, as in the conditioning process outlined above.

As a further alternative, a second primary electron source, for projecting either a focussed beam which is caused to scan the storage electrode or a flooding beam, may be provided to perform the conditioning function. Moreover, amplitude modulation rather than velocity modulation may be used on the writing beam from electron gun 15; to achieve this mode of operation, cathode 22 is maintained at a fixed potential, and the potential of control grid 25 is varied in accordance with the incoming signal. This mode of operation is particularly advantageous when it is desired to utilize a writing beam of high voltage above the second cross-over potential but may also be used to advantage with low-voltage writing beams below the first cross-over potential.

It may also be desired to store a white signal on a black background, and for this purpose it is possible to bias storage electrode 11 negatively by scanning with an unmodulated electron beam below the first cross-over potential or above the second cross-over potential and subsequently writing with electrons between the first and second cross-over potentials to produce a positive charge distribution on storage electrode 11 which corresponds to a space-modulated charge image of the input signal.

With reference again to Figures 2 and 3, the storage electrode construction comprises a conductive grid-like structure 12 having a plurality of interstices. A dielectric film 13 is distributed on one surface of structure 12 and extends into and across the interstices in substantially coplanar relation with the conductive structure. Photoemissive material or mosaic 14 is supported adjacent the exposed surface of conductive mesh 12, preferably by being deposited directly thereon. In accordance with a preferred embodiment of the invention, grid-like structure 12 may consist of a conductive mesh screen constructed of gold, chromium, gold-plated or chromium-plated cop-

per, or other suitable material, and dielectric film 13 may be constructed of silicon dioxide, aluminum oxide, chromic oxide, a fluoride of calcium, barium or magnesium, or other suitable material. Photoemissive mosaic 14 preferably comprises a conventional antimony-caesium composite photoemissive surface although other types of photoemissive mosaics may be used. For example, if a composite silver oxide-caesium film is employed as mosaic 14, improved contrast may be obtained by using infra-red light to illuminate the mosaic; moreover, photoelectrons emitted by a mosaic of this type have lower velocities and are therefore more readily controlled by the charges stored on dielectric film 13.

Merely by way of illustration, a method for producing the storage electrode which has been successfully employed comprises forming a layer of antimony on one surface of a gold mesh screen of as fine a mesh as possible. An organic film, of nitrocellulose or the like, is disposed in contact with the same antimony-coated surface of the mesh screen, and silicon dioxide is evaporated in a low pressure of oxygen onto the mesh side of the organic film. This process is repeated a number of times from different approach angles to provide uniformity of dielectric film thickness and to insure complete coverage of the mesh by the dielectric film. The nitrocellulose film is drawn into the interstices of the gold mesh by surface tension, so that the dielectric film extends into and across the interstices in substantially coplanar relation with the mesh. After dielectric film evaporation, the nitrocellulose film is dissolved in amyl acetate or other suitable solvent, and the structure is immersed in a mixture of alcohol and ether to remove any remaining traces of organic film. The storage electrode is then mounted within envelope 10, and the latter is evacuated in any convenient manner. The antimony layer on the gold mesh is caesiumated to render the layer 14 photoemissive; for this purpose a tubulation (not shown) on envelope 10 may be provided. The techniques of forming photoemissive mosaics are well known in the art and are therefore not described in detail.

The mesh size of screen 12 determines the resolution of the reproduced image and is preferably made as fine as practicable. A 0.0002-inch thick gold screen having four hundred openings or interstices per inch has been successfully used for structure 12, and a dielectric film thickness of from 1,000 to 8,000 Angstrom units has been found satisfactory. Other methods of producing the desired structure may occur to those skilled in the art, and the invention is not restricted to electrodes produced in accordance with the foregoing illustrative example.

While any of a number of insulating materials may be used in the preparation of dielectric film 13, it is preferred that the film be constituted of silica (silicon dioxide) to avoid the possibility of caesium deposits combining with or adhering to the insulator when the antimony layer is caesiumated. The other conventionally used oxides and fluorides are more difficult to process without encountering leakage in or across the insulator film.

Thus, the present invention provides a novel

storage electrode for use in a signal-converting device of the directly-viewed type. The improved storage electrode is eminently suitable for half-tone storage and reproduction, and satisfactory operation may be attained at materially lower operating potentials than in the case of conventional prior art devices, thereby materially reducing the stringency of the power supply requirements.

While a particular embodiment of the present invention has been shown and described, it is apparent that various changes and modifications may be made, and it is therefore contemplated in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:

1. A storage electrode for a signal-converting device comprising: a conductive grid-like structure having a plurality of interstices; a thin dielectric film of substantially uniform thickness less than that of said grid-like structure distributed on a single surface of said conductive structure and extending into and across said interstices in substantially coplanar relation with said structure; and photoemissive material supported adjacent the exposed surface of said conductive structure.

2. A storage electrode for a signal-converting device comprising: a conductive grid-like structure having a plurality of interstices; a thin silica film of substantially uniform thickness less than that of said grid-like structure distributed on a single surface of said conductive structure and extending into and across said interstices in substantially coplanar relation with said structure; and photoemissive material supported adjacent the exposed surface of said conductive structure.

3. A storage electrode for a signal-converting device comprising: a conductive mesh screen having a plurality of interstices; a thin silica film of substantially uniform thickness less than that of said mesh screen distributed on a single surface of said screen and extending into and across said interstices in substantially coplanar relation with said screen; and an antimony-caesium photoemissive layer deposited on the exposed surface of said screen.

CONSTANTIN S. SZEGHO.
WILLIAM O. REED.

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