United States Patent

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[72] Inventor **M. David Freedman**
Southfield, Mich.

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[73] Assignee **The Bendix Corporation**

[54] **PROXIMITY-FOCUSED IMAGE STORAGE TUBE**
5 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** ..... **313/65 R,** 250/213, 313/95
[51] **Int. Cl.** **H01j 31/26,** H01j 31/50
[50] **Field of Search** 313/67, 95; 250/213

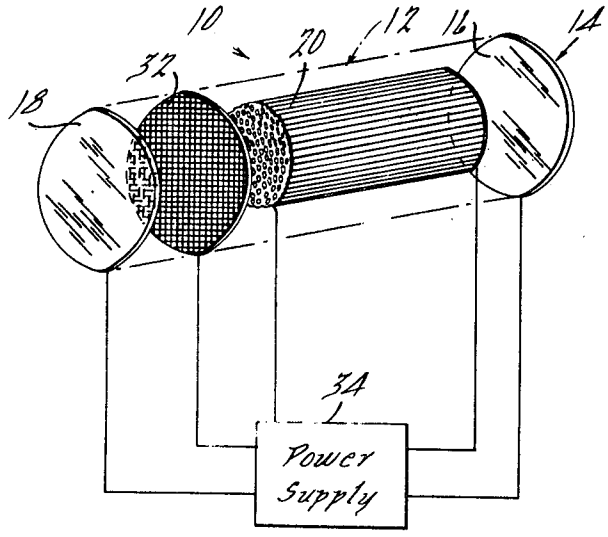
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Primary Examiner—Roy Lake
Assistant Examiner—V. Lafranchi
Attorneys—William F. Thornton and Plante, Hartz, Smith and Thompson

ABSTRACT: A proximity-focused image storage tube having a high-potential readout surface, a passageway structure spaced from the readout surface for transmitting electrons to the readout surface, and a thin, nonconductive charge storage surface formed on the input end of the passageway structure. The passageway structure comprises an array of glass tubes. A first conductive surface is disposed on the input end of the array between the glass tubes and the storage surface. A second conductive surface is formed on the output end of the array. Voltage potentials are maintained on these conductive surfaces. The voltage potential of the second surface isolates the storage surface from the field produced by the high-potential readout surface so that the storage surface can be placed very close to the high-potential readout surface. The storage tube described herein therefore provides a highly focused output image because readout electrons will travel only short distances from one surface to another and therefore have little opportunity to defocus. A potential gradient is maintained between the two conductive surfaces during readout to provide both electron multiplication and a collimated electron output flow from each passageway. The electron multiplication allows an image to be read out of this tube for a relatively long time without degrading the stored image because relatively few electrons need approach the storage surface to produce a given output signal.



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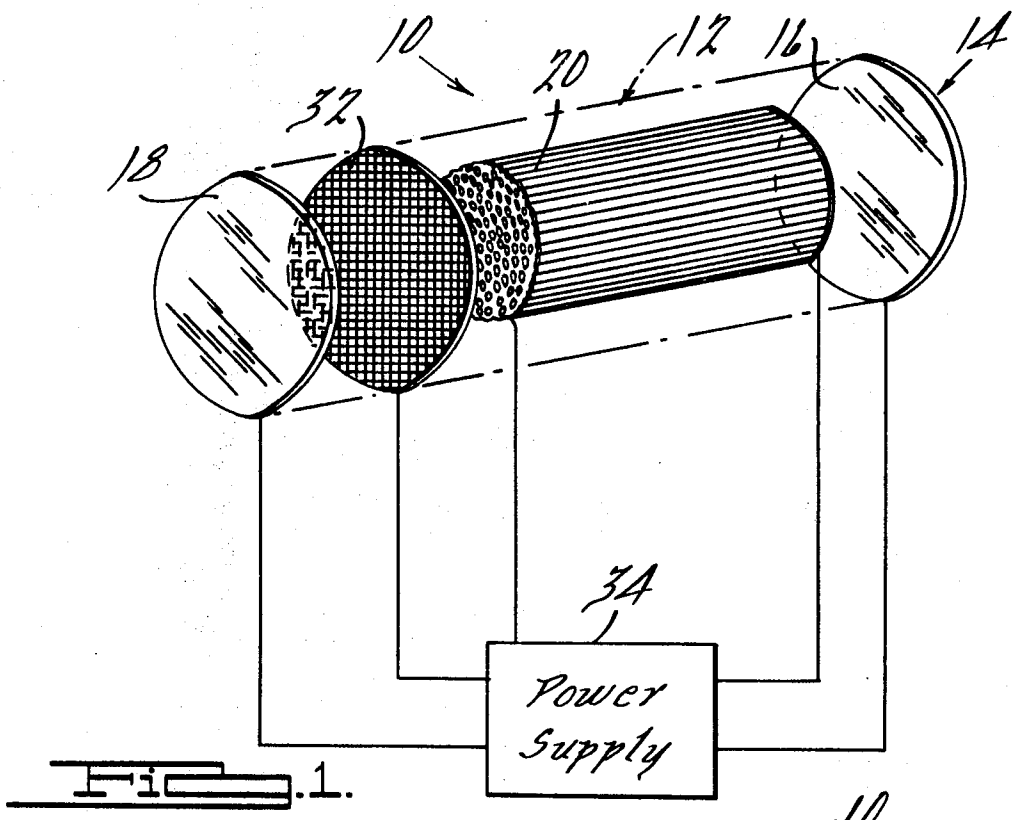


Fig. 1.

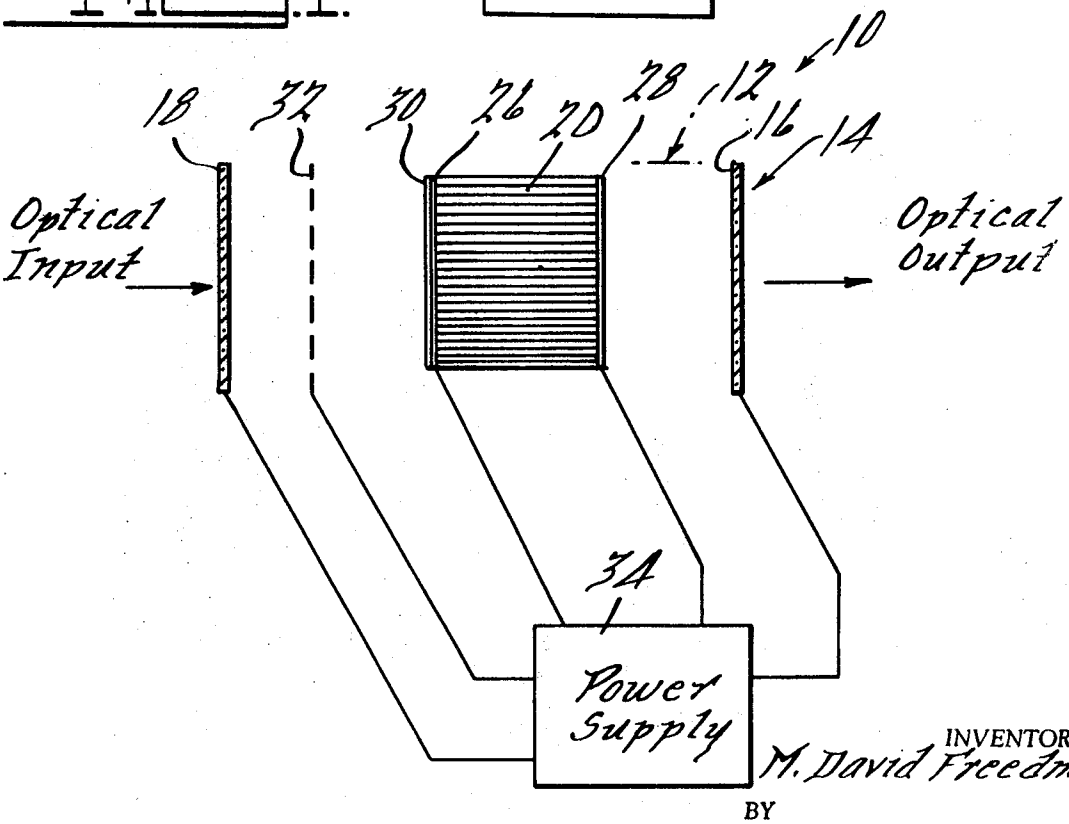


Fig. 2.

INVENTOR.
M. David Freedman
BY
ATTORNEY. William F. Thornton

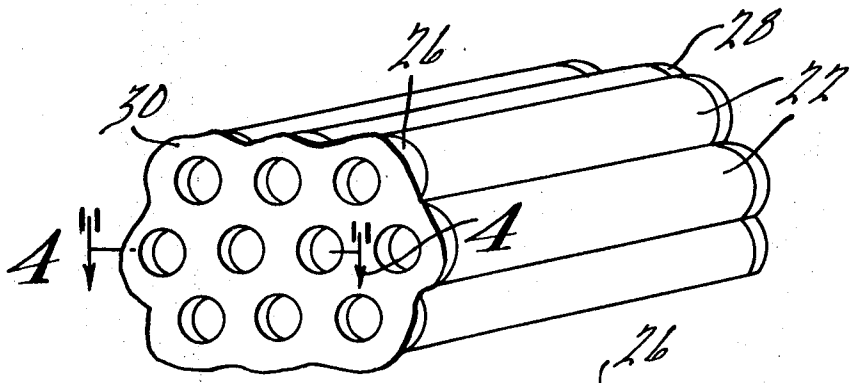


FIG. 3.

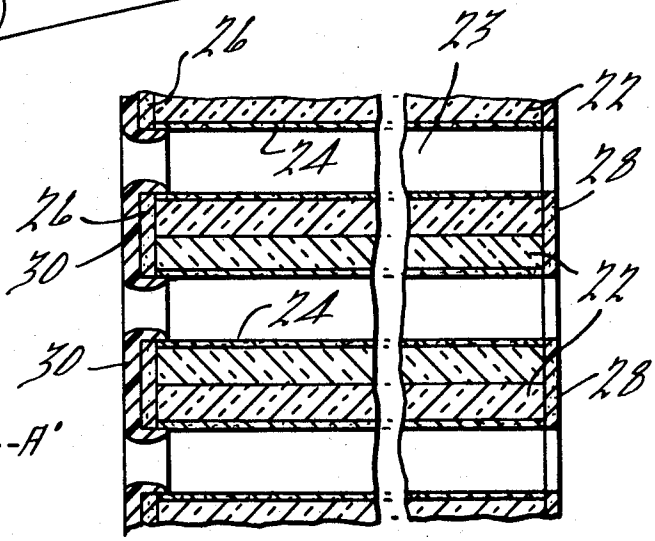


FIG. 4.

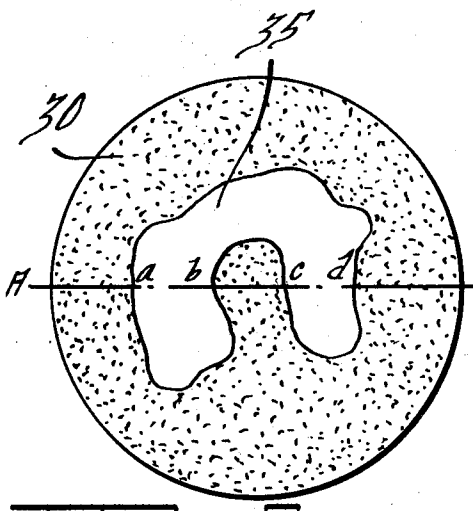


FIG. 6.

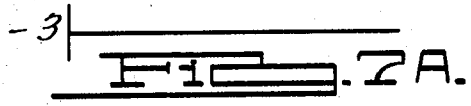


FIG. 7A.

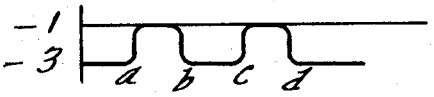


FIG. 7B.



FIG. 7C.

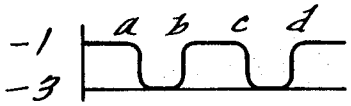


FIG. 7D.

INVENTOR.
M. David Freedman
BY
ATTORNEY William F. Thornton

Operating Conditions

Operating Modes →	Optical Input To Photo Cathode	Photo Cathode (Volts)	Collector Grid (Volts)	Array Input Backing Electrode (Volts)	Array Output Electrode (Volts)	Phosphor Screen (Volts)
Erase	High Intensity Floodlight	−200	+20	+5	+500	+8000
Prime	High Intensity Floodlight	−20	+20	+5	+500	+8000
Positive Write	Image	−200	+20	+5	+500	+8000
Read After Positive Write	Low Intensity Floodlight	0	+20	+5	+800	+8000
Negative Write	Image	−20	+200	+5	+500	+8000
Read After Negative Write	Low Intensity Floodlight	0	+20	+7	+800	+8000

Fig. 5.

INVENTOR.
M. David Freedman
BY
ATTORNEY William F. Thornton

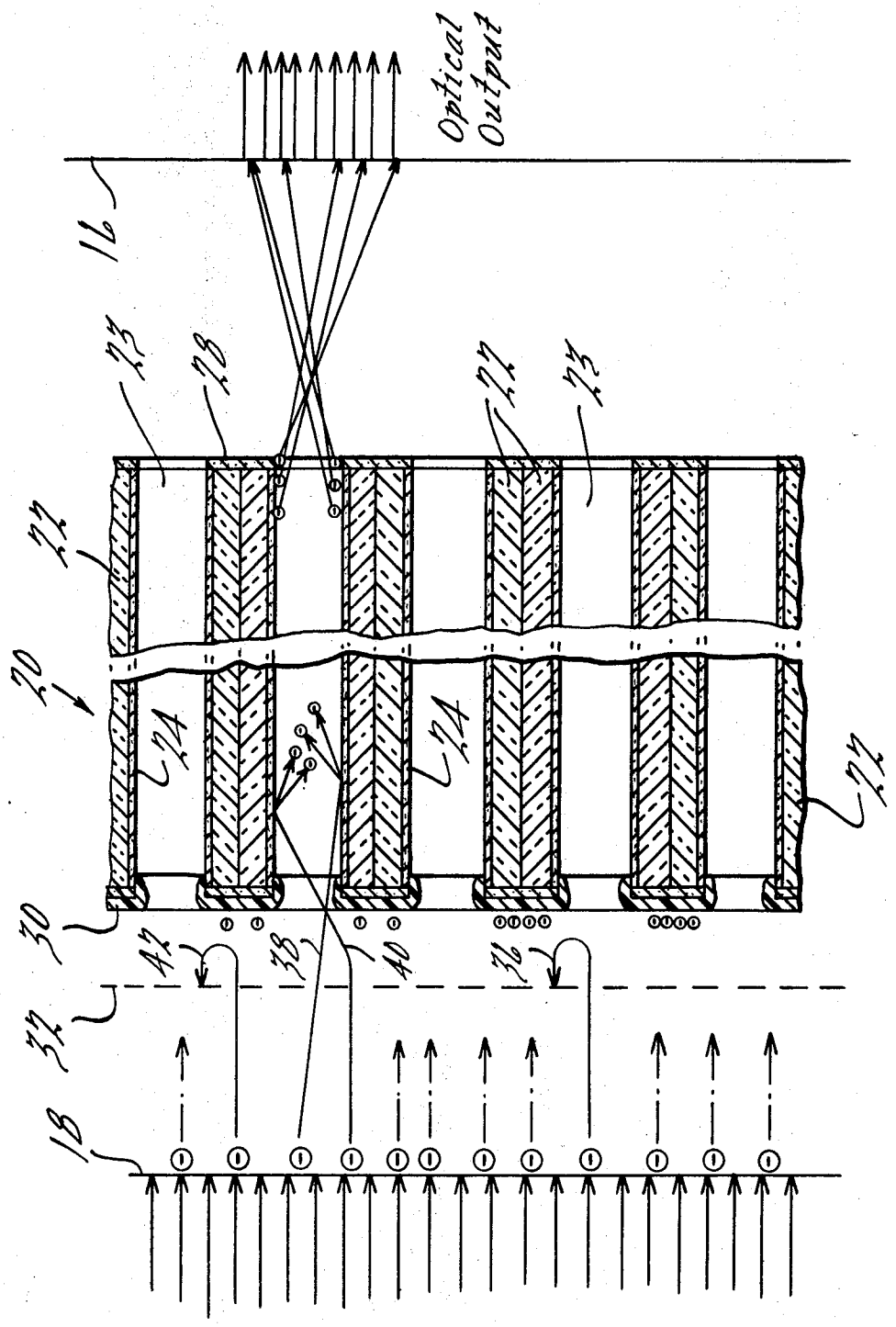


Fig. 8

INVENTOR.
M. David Freedman
BY
ATTORNEY William F. Thornton

PROXIMITY-FOCUSED IMAGE STORAGE TUBE

BACKGROUND OF THE INVENTION

1. Field of the Invention

Image storage tubes.

2. Description of the Prior Art

Conventional image storage tubes include a phosphor readout surface, a nonconductive storage screen spaced a measured distance from the readout surface, a photocathode or other means for placing a charge pattern on the storage screen spaced from the storage screen on the side opposite the readout surface, a collector grid for collecting secondary electrons emitted from the storage screen, placed between the storage surface and the photocathode, and a conductive backing screen placed adjacent the storage surface and away from the photocathode. Electrical potentials which can be varied during operation are maintained on the photocathode, collector grid, and backing screen. These potentials determine the paths electrons will travel through the storage tube. The electric potential of the backing screen acts to attract electrons to the storage screen when a charge pattern is being placed on that screen, and subsequently acts to prevent further electrons from striking the storage screen during readout. In operation, when light strikes the photocathode, electrons are emitted from the photocathode and accelerated toward the storage screen. These electrons strike the storage screen and therefore place a charge pattern on that screen which corresponds to the pattern of light striking the photocathode. The stored charge pattern can be either positive or negative with respect to the rest of the storage surface. That is, if the electrons strike and are held by a portion of the storage, that portion will be negatively charged with respect to the rest of the storage surface. If, however, electrons strike a portion of the storage surface with such velocity that they cause the emission of secondary electrons, that portion of the storage surface will be positively charged with respect to the rest of the storage surface. To read out a storage pattern in these conventional tubes, the entire photocathode is uniformly illuminated and the resulting flood beam of electrons moves toward the storage screen. These electrons have just enough energy relative to the combined potentials of the storage surface and backing screen so that electrons approaching a relatively negative portion of the storage screen will be repelled by the charge on that screen, reverse their direction of travel, and be absorbed by the collector grid. However, electrons approaching a relatively positive portion of the storage screen will not be so repelled by the combined potentials of the storage surface and backing screen. In an ideal image-storage tube, all electrons approaching a relatively positive portion of the storage screen during readout would pass through the storage screen, strike the phosphor readout surface, and produce an output signal. Many electrons do, of course, move through the screen and produce an output image. However, a number of electrons in the readout electron flood beam will be directed toward the elements of the storage screen itself instead of toward the holes in that screen. Some of these electrons will strike the storage screen. Although equal numbers of electrons will be directed toward all portions of the storage screen during readout, more electrons will strike the relatively positive portions of the storage screen than will strike the relatively negative portions of that screen because there will be a greater attraction between those portions and the electrically negative electrons. Flood beam electrons which strike the storage surface cause each portion of the storage surface struck to be more negatively charged than it had been prior to being struck. Since more electrons strike the relatively positively charged portions of the storage surface than strike the relatively negatively charged portions of that surface, the potential differences between the various portions are reduced. In other words, the image is degraded. Therefore, the image is degraded during readout, and in practice the total useful readout time is limited in a conventional tube.

Furthermore, the prior art image storage tubes, such as the one described above, will not produce a well-focused output image. Electrons will not travel along a straight line path from one surface or screen to another, but will diverge to produce unfocused stored and output images. Therefore, conventional image storage tubes designed to provide sharply focused output images include apparatus for providing an electrostatic or electromagnetic field which focuses electrons as an optic lens focuses light. In one common construction of such a device a large magnet surrounds the image storage tube assembly described above. The magnetic field causes electrons emitted from the photocathode to converge at the storage screen and phosphor readout surface, and therefore provides a focused charge pattern and output image. However, electrostatic and electromagnetic lenses both provide aberrated output images. An electromagnetic lens causes both rotational distortion and astigmatism. An electrostatic lens produces an aberration known as pin cushioning by those skilled in the art in which various portions of the output image are of different magnification.

However, there are a number of well-known electrostatically focused image storage tubes which do not include lenslike focusing fields. These tubes are called proximity-focused storage tubes. In a proximity-focused tube, the photocathode, storage screen, and phosphor readout surface are placed as close together as practical to minimize the distances electrons must travel from one surface or screen to another. This, of course, also minimizes the opportunity for electrons to diverge and thus produce a defocused image. The degree of focus that can be obtained with proximity-focused image storage tubes is limited, however. The photocathode can quite easily be placed very close to the storage screen so that a "focused" charge pattern will be stored on the storage surface. There is a problem, however, in placing the storage screen near the high-potential phosphor output surface. If this spacing is made very small in an attempt to provide a high degree of focus, the high-potential field of the phosphor surface will attract electrons approaching the storage surface. Thus, during a writing or storage operation, most of the electrons approaching the storage screen will be drawn past that screen to the phosphor readout surface so that only a small fraction of the charge pattern can be stored on the storage screen. During a read operation, the high potential of the phosphor surface influences the flood electrons before they reach the storage grid and causes them to acquire significant transverse energy as they pass through the grid. This acquiring of transverse energies causes defocusing of the output image.

The spacing between the high-potential readout surface and the storage surface that must be maintained in conventional proximity focused tubes is reduced somewhat in one embodiment which includes a thick conductive backing screen formed integrally with the storage screen and extending from the storage screen toward the high-potential output surface. An electric potential is maintained on this backing screen which attracts electrons toward the storage screen when a charge pattern is being placed on that screen and prevents other electrons from striking that screen during storage and readout. This potential also acts to isolate the storage screen from the high potential of the phosphor readout surface.

The thickness of the metal backing screen must be increased as the storage screen is moved closer to the high-potential readout surface in an attempt to provide a high degree of focusing. The backing screen must be thick enough so that even though the high-potential field of the readout surface penetrates past the edges of the backing screen it does not reach the storage screen and influence the flight of electrons approaching that screen. The precise dimension of this backing screen would, of course, depend upon the exact distance to be maintained between the storage screen and readout surface, and therefore the amount of shielding necessary to isolate the storage screen from the readout surface. However, the backing screen, since it is formed from a conductive material, absorbs electrons which strike its surface.

Since very few electrons travel along a perfectly straight path from the photocathode, through the backing screen, to the phosphor readout surface, a thick backing screen absorbs a substantial number of electrons during readout of the stored image. Therefore, when the thickness of the metal backing screen is increased in order to move the storage screen closer to the high-potential readout surface to provide proper focusing of the output image, the signal attenuation, or electron loss, of the image storage tube is also increased. In other words, if a specific embodiment of the above-described tube is designed to provide a highly focused output image, that tube will also provide a relatively weak output image. And in addition, a high density flood beam of electrons must be provided during readout to compensate for the electron absorption of the thick metal backing screen in order to obtain even a weak output signal. The strong flood beam degrades the stored image very quickly and thereby limits the total readout time of an image stored in the tube. If, on the other hand, the tube is designed to minimize signal attenuation, it will provide a relatively poorly focused output image.

SUMMARY OF THE INVENTION

This invention comprises a proximity-focused image storage tube which provides a sharply focused output signal, and in which there is an extremely small degree of image degradation during readout so that a stored image can be read out for a long period of time. The storage tube includes a high-potential readout surface, and a rigid structure having a plurality of passageways formed therein spaced a small distance from the high-potential readout surface. A nonconductive charge storage coating or surface is formed on one end of the rigid passageway structure. The storage tube of this invention also includes means for placing a charge pattern of the charge storage surface, and collector electrode means for absorbing electrons emitted by the charge storage surface. In the preferred embodiment described herein, the rigid passageway structure is formed from an array of glass tubes. An appropriate high-resistance, semiconductive layer forms the inside surfaces of these tubes. These semiconductive inner surfaces are formed from a material which also emits secondary electrons when struck by a high-energy primary electron. The image storage tube thus provides an intensified output signal since each electron which strikes the inner surface of a glass tube will cause one or more electrons to be emitted by that surface. A metallic conductive coating is formed on the input end of the tube array between the glass tubes and the charge storage surface, and on the output end of the tube array. These coatings are formed so that uniform electric potentials can be maintained on the input and output surfaces of the tube array. The electric potential maintained on the conductive surface disposed at the input side of the tube array acts to attract electrons to the storage surface when a charge pattern is being placed on that surface and subsequently acts to prevent further electrons from reaching portions of the storage surface during storage and readout. The electric potential maintained on the conductive surface forming the output side of the tube array acts to isolate the storage surface from the high potential of the readout surface. Thus, the storage surface can be placed close to the readout surface without having the high-potential field of that surface attract electrons approaching the storage surface and draw them past the storage surface toward the readout surface so that no charge pattern could be stored on the storage surface. Furthermore, electrons which enter the tube passageways during readout are constrained from spreading in a lateral direction by the tube walls. They therefore exit the tube passageways in a collimated output having low-energy components in the direction transverse to the readout surface. The image storage tube of this invention therefore produces a well-focused output image because of both the collimated electron flow provided during readout and because the various elements and surfaces of this tube are placed in such close proximity to each other that electrons have little opportunity to defocus in travelling from one surface to another.

Since the conductive surfaces are separated be the nonconductive glass tubes and by the high-resistance, semiconductive layer forming the inside surfaces of these tubes, different potentials can be maintained on the two conductive surfaces. Further, these potentials can be varied independently of each other during the various stages of operation of this image storage tube. For instance, when an image is being read into the tube, an optimum potential for attracting electrons emitted from the photocathode toward the storage surface is maintained on the conductive surface disposed immediately behind the storage surface, and an optimum potential for isolating the storage surface from the high potential of the readout surface in maintained on the conductive surface forming the output side of the tube array. During readout, potentials are maintained on the input and output conductive surfaces to establish an electric current flow in the semiconductive passageway walls, and to establish a potential gradient along the entire length of the passageways which acts to accelerate electrons toward the readout surface. Adjustment of the potential gradient and current flow between the conductive surfaces at the input and output sides of the tube array structure controls the gain, and thereby the intensity of the output image of the storage tube. Intensification is increased when the potential gradient and current flow between the conductive surfaces is increased because an increased number of secondary electrons will be emitted from the passageway walls. When the conductive surface potentials are set to provide significant intensification during readout, only a comparatively few electrons from the photocathode need move toward the storage surfaces to provide a given output image intensity. Therefore, since only a comparatively few electrons approach the storage surface there will be only a very small number of electrons which strike the storage surface and thereby degrade the stored image during readout. But, a sufficient number of electrons will strike the readout surface to provide an output signal of any desired intensity even though very few electrons approach the storage surface because of the addition of secondary electrons, emitted from the passageway walls, to the output signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of this invention, which is defined by the appended claims, will become apparent from a consideration of the following description and the accompanying drawings in which:

FIG. 1 is a schematic, three-dimensional view of the proximity-focused image storage tube of this invention;

FIG. 2 is a cross-sectional, plan view of the image tube illustrated in FIG. 1;

FIG. 3 is an enlarged, three-dimensional view of a portion of the channel passageway and storage surface structure illustrated in FIGS. 1 and 2;

FIG. 4 is a cross-sectional view of the passageway array structure illustrated in FIG. 3 taken along the plane of line 4—4;

FIG. 5 is a chart showing representative voltage values to be maintained on the various surfaces of the image storage tube illustrated in FIGS. 1 and 2 during different operational modes of that storage tube;

FIG. 6 is a view of the charge storage surface illustrated in FIGS. 1 and 4 showing a charge pattern thereon; FIGS. 7A through 7D illustrate the potential distribution along the line A—A' running across the storage surface illustrated in FIG. 6 during various modes of operation of the image storage tube on this invention;

FIG. 8 is a horizontal cross-sectional view of the image storage tube of FIG. 1 showing the paths followed by various electrons during readout of a stored image.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, FIGS. 1 and 2 illustrate an image storage tube device 10 which includes an evacuated envelope 12 having a faceplate 14 at one end thereof. A phosphor readout surface 16 which provides an optical output signal when struck by electrons is deposited on the inside surface of the faceplate 14. A photocathode 18 which emits electrons when illuminated is disposed at the other end of the evacuated envelope 12 opposite the phosphor readout surface 16. A passageway structure 20 comprising an array of tubes 22 is suitably supported within the envelope 12 between the photocathode 18 ad phosphor readout surface 16. FIGS. 3 and 4 provide a detailed illustration of the construction of this passageway array. Each of the tubes 22 define a passageway 23. The tubes 22 are bonded or otherwise suitably joined together to form the array 20. A high-resistance semiconductive coating material 24 which emits secondary electrons when struck with sufficient force by a primary electron forms the inner surface of each of the glass tubes 22. A number of methods for forming this semiconductive layer are well known to those skilled in the art. For example, a semiconductive layer can be formed by depositing an appropriate material such as tin oxide or any one of a number of carbon compounds on the glass surface. Or, if a suitable glass has been selected to form the tubes, such layer can be formed by chemically reducing the inside surface of the glass tubes. Metallic conductive coatings 26 and 28 are formed over the input and output surfaces to the passageway array 20 so that uniform electric potentials can be maintained across these input and output surfaces. A thin, nonconductive coating or charge storage surface 30 is formed over the passageway array input-side conductive surface 26.

Referring again to FIGS. 1 and 2, the longitudinal axis of tube array 20 may be slightly tilted with respect to a straight line running perpendicular to and connecting the planes of the readout surface 16 and the photocathode 18 to insure that readout electrons travelling from the photocathode 18 to the phosphor readout surface 16 do strike the walls of the tubes 22 and cause the emission of secondary electrons. A collector electrode screen 32 is disposed between the photocathode 18 and the passageway structure 20. The collector electrode 32 comprises a thin mesh screen so that it will provide only minimal interference to electrons travelling from the photocathode toward either the storage surface 30 or the phosphor readout surface 16. A photoetching process is one convenient way of forming an electrode screen 32 having the desired fine mesh or porosity. A variable and multipotential power supply 34 provides operating electric potentials to the photocathode 18, collector electrode 32, passageway array input-side conductive surface 26, passageway array output side conductive surface 28, and phosphor readout surface 16. FIG. 5 illustrates typical or representative potential values to be supplied to these elements during various stages of operation.

FIGS. 5 through 8 illustrate the operation of one embodiment of the image storage tube of the present invention illustrated in FIGS. 1 and 2. Operation is begun by first priming the storage tube. That is, a uniform distribution of electrons is deposited on the charge storage surface 30, as follows. With the voltages listed in the table of FIG. 5 maintained on each of the indicated elements of the storage tube 10, the photocathode 18 is illuminated with a high-intensity flood light; a uniform, negative charge distribution will begin to accumulate on the storage surface 30. Charge is allowed to accumulate until the potential distribution on the insulator storage surface 30 and the potential distribution of the conductive surface 26 just behind the insulator surface provide a net distribution of −3 volts. If a +5 volt potential is supplied to the conductive surface 26, then a uniform 8-volt distribution of electrons on the stored surface 30 will produce the desired −3-volt net potential. As is the case with all of the potentials shown on the table of FIG. 5, this −3-volt level is merely a representative value, and it is understood that the storage tube can be operated by priming to some value other than exactly −3 volts. The −3-volt potential represents one convenient beginning potential value because a relatively positive charge pattern can be stored on a surface primed to this value without having the net potential of the storage surface 30 and conductive coating 26 for any portion of the storage surface at a greater than ground potential. When this net potential is less than ground for all portions of the storage surface 30 after a charge pattern has been stored on that surface, readout electrons travelling from the photocathode 18 to the readout surface 16 will not be attracted and absorbed by the storage surface. FIG. 7A illustrates the −3-volt net potential of the storage surface 30 conductive coating 26 which is maintained uniformly from one edge of the surface to the other after a priming operation.

After priming, any desired image can be stored in this image storage tube simply by projecting that image on the photocathode 18 and adjusting the operating potentials of the storage tube 10 as indicated by the table of FIG. 5. A representative charge distribution or pattern 35 is shown stored on the storage surface 30 in FIG. 6. A distribution of electrons which form the pattern 35 are emitted from the photocathode 18 when a correspondingly shaped visual image is projected onto that surface. These electrons are accelerated toward the storage surface 30 by the potential gradient maintained between the photocathode 18 and storage surface 30. They strike the storage surface 30 to create the storage pattern 35. By properly controlling this potential gradient, the stored charge pattern 35 can be made either more positive or more negative than the charge maintained on the remaining portion of the storage surface 30. A charge pattern which is more positive than the remaining portion of the storage surface 30 is placed on that surface during a positive writing operation and will be referred to herein as a positive charge pattern. A positive writing operation is one in which each electron emitted by the photocathode is accelerated to strike the storage surface 30 with enough energy to cause the emission of more than one secondary electron. Electrons striking the storage surface therefore cause the struck portion of the surface to become more positively charged than had been the case previously. FIG. 7B illustrates the potential distribution along the line A—A′ when the stored charge pattern 35 is a relatively positive pattern. During a negative writing operation electrons are given smaller accelerations than during a positive writing operation so that those electrons will just reach and be stored on the storage surface 30. They will not have sufficient energies to cause the emission of secondary electrons, and will therefore cause portions of the storage surface 30 to become more negatively charged than they had been. FIG. 7C illustrates the potential distribution along the line A—A′ of FIG. 6 when the stored pattern 35 is a negative potential distribution.

The chart of FIG. 5 illustrates representative potentials to be maintained on the various image storage tube elements to accomplish both positive and negative writing operations. It is believed that the selection of most of the values listed in that table and the limits over which those values can be varied will be obvious to all those skilled in the art. Discussion will only be provided with respect to those values whose selection may not be obvious to those skilled in the art. A +200-volt potential is maintained on the collector electrode 32 during a negative writing operation so that electrons are accelerated from the photocathode toward the storage surface at sufficient velocities to prevent defocusing. They will, however, slow down after passing the collector electrode and strike the storage surface at low enough velocities so that they will not cause emission of secondary electrons. The 500-volt potential maintained on the conductive surface 28 forming the output side of the passageway structure 20, isolates the storage surface 30 from the 8,000-volt potential of the phosphor readout surface 16 during both positive and negative writing opera-

tions. Electrical isolation is needed so that the electrons approaching the storage surface **30** will be able to strike that surface and therefore produce the stored charge pattern instead of being drawn past that surface by the +8,000-volt potential. Since effective electrical isolation is provided, the photocathode **18**, the storage surface **30**, and readout surface **16** are all placed extremely close to each other so that electrons will not have a chance to defocus in travelling from one surface to another. The secondary electrons which are knocked from the storage surface **30** by high energy incoming electrons are absorbed by the collector electrode **32** and therefore do not interfere with further operation of the image storage tube.

The trajectories followed by various electrons during readout of a stored image are illustrated in FIG. **8**. Various electrons will follow each of the trajectories shown in FIG. **8** during both the readout of a positive image and the readout of a negative image. In both cases, electrons will generally be repelled as they approach a relatively negative portion of the storage surface, will follow a trajectory similar to trajectory **36**, and will be absorbed by the collector electrode **32**. Electrons approaching a relatively positive portion of the storage surface will generally follow paths similar to paths **38** and **40** and cause the emission of secondary electrons from the semiconductive coating **24** of glass tubes **22**. These secondary electrons exit the channel structure having much higher energy components directed toward the readout surface **16** than did the electrons entering the passageways **23** because the potential gradient along those passageways. They will have only very slight energy components directed transverse to the readout surface **16** because of the constraint of the passageway walls. These electrons therefore strike the phosphor readout surface **16** and produce a visual output signal which accurately corresponds to the stored charge pattern. When a positive charge pattern is stored on storage surface **30**, the visual output signal will correspond affirmatively to the stored charge pattern. When a negative charge pattern is stored on storage surface **30**, the visual output signal will correspond inversely to the stored charge pattern. That is, there will be a visual output from all portions of the phosphor surface **16** except those directly aligned with the stored charge pattern.

In some instances, it may be necessary to adjust the potential of the conductive surface **26**, in order to have electrons approaching various portions of the storage surface **30** behave as shown in FIG. **8** so that a stored image can be read out. For example, when a negative charge pattern is stored on the storage surface **30**, as is illustrated in FIG. **7C**, the entire storage surface **30** may become so negatively charged that an electron approaching any portion of that surface will be repelled, will follow a path similar to path **36**, and will be absorbed by the collector electrode **32**. A storage tube is said to be at cutoff when no stored pattern can be read out of the tube because all electrons approaching the storage surface are repelled to the collector electrode. The cutoff condition can be avoided for the tube **10** by raising the potential of the conductive backing surface **26** from that maintained during a negative writing operation so that the combined potentials of the backing surface **26** and storage surface **30** act to repel electrons approaching relatively negative portions of the storage surface, and allow electrons approaching relatively positive portions of the storage surface to pass through to the output surface **16**. The table of FIG. **5** teaches that in order to avoid cutoff and read out a stored negative image, the potential of the conductive surface **26** should be raised from +5 to +7 volts. When this is done, the combined potential distribution of the storage surface **30** and backing conductor **26** along the line A—A′ of FIG. **6** appears as illustrated in FIG. **7D**. During readout, electrons approaching a portion of the storage surface having a net −1-volt potential will pass by that surface and produce a visual output signal. Electrons approaching a portion of the surface having a net −3-volt potential will be repelled, and will not produce an output signal.

An extremely low-density uniform flood beam of electrons, that is a flood beam comprised of relatively few electrons, is used to read out both positive and negative stored images that image degradation is minimized. A strong visual output signal can be produced using a very low-density flood beam of electrons because during readout the potentials maintained on the two conductive surfaces **26** and **28** at the opposite ends of the channel array structure **20** are adjusted to provide whatever gain or electron multiplication is desired. Electron multiplication is increased as the potential gradient and therefore the current flow through the semiconductive passageway surfaces between these two conductive surfaces is increased as is well known to those skilled in the electron multiplication art.

As is the case with all image storage tubes, there will, of course, be some image degradation. All electrons approaching a relatively positively charged portion of the storage surface will not follow trajectories similar to trajectories **38** and **40** illustrated in FIG. **8**. Some electrons will follow trajectories similar to trajectory **42**, will be repelled from the storage surface, and will be absorbed by the collector electrode **32**. Others will approach the storage surface with such energy that they will not be deflected into a passageway **23** by the stored charge pattern as is the electron following trajectory **40**, but will strike the storage surface and therefore degrade the stored image. However, only a small fraction of the number of flood beam electrons needed by an image storage tube having no electron multiplication apparatus need approach the storage surface **30** of this storage tube to produce a given output signal. The amount of image degradation will therefore be significantly less in this tube than in other tubes. In addition to providing electron multiplication, the potential gradient and current flow between the two conductive surfaces **26** and **28**, drives electrons through the passageway structure **20** so that no space charge is allowed to build up within the passageways.

An operator can erase any stored image simply be adjusting the potentials of the various conductive elements as taught by the table of FIG. **5** and illuminating the photocathode **18** with a high-intensity flood beam so that a high-density flood beam of electrons will accelerate toward the storage surface. After an erase operation, the tune is then primed to bring the entire storage surface **30** to a preselected potential value which has been chosen to be −3 volts in this example. Once the tube is primed, a new image can be stored and read out of the image storage tube **10** as desired.

The above-described embodiment is presented for the purpose of illustration. A number of modifications of this embodiment will be apparent to those skilled in the art. For example, the illustrated storage tube includes a photocathode **18** for placing a charge pattern of the storage surface **30**. Any other means for placing a charge pattern on that surface, such as an electron beam writing gun, can also be used with this invention. The illustrated embodiment also includes a high-potential phosphor readout surface which produces a visual output signal. There are a number of high-potential readout surfaces which provide electrical rather than visual output signals. These structures can, of course, also be used with this invention. Also, operation of the storage tube embodiment has been illustrated using images which contrast completely with their backgrounds. That is, stored charge patterns which produce a completely white image surrounded by a completely black background and a completely black image surrounded by a completely white background have been illustrated. These examples were selected to simplify the explanation of this invention. It is understood that more complex images having intermediate shadings can be stored in and read out of the storage tube of this invention. These and other modifications will immediately be obvious to those skilled in the art.

Therefore, what is claimed is:

1. A proximity-focused image storage tube comprising:

input means for providing an electron pattern representative of an object whose image is to be stored;

storage means disposed proximate said input means for storing said pattern;

output means disposed proximate said input means and said storage means for receiving electrons and providing an output representing the stored pattern, said output means requiring a high electric potential be maintained thereon in order to provide said output image; and

multiplier means disposed between said storage means and said output means receiving electrons from said input means for transmitting electrons to said output means, and for emitting sufficient electrons to increase the number of electrons in transmission to said output means, said multiplier means including an element for receiving an electron potential to isolate said storage means from said potential of said output means.

2. The image storage tube of claim 1 in which:

said input means comprises a photocathode;

said output means comprises a phosphor screen;

said multiplier means comprise an array of tubes having semiconductive, secondary electron emissive material comprising the inner surfaces of said tubes;

said element of said multiplier means for receiving said isolating electric potential comprises a conductive coating on the output surface of said array;

a second conductive coating is formed on the input surface of said array; and

said storage means comprises an electrically nonconductive coating disposed on said second conductive coating.

3. The image storage tube of claim 2 further including collector electrode means for collecting electrons emitted from said storage means.

4. The image storage tube of claim 2 in which said first and second conductive coatings are adapted to have different electric potentials maintained thereon to provide a selected potential gradient between said two surfaces, said potential gradient providing an electric current flow generally parallel to said tubes in said semiconductive, secondary electron emissive material, and also providing an electric field along said tubes of sufficient strength to maintain a net electron flow through said tubes toward said phosphor screen, and to provide electrons in said tube with sufficient energy so that each electron that impacts against said semiconductive material causes secondary electrons to be emitted by said semiconductive material.

5. The image storage tube of claim 2 further including means for supplying electric potentials to said photocathode, said two conductive coatings, and said phosphor screen.