

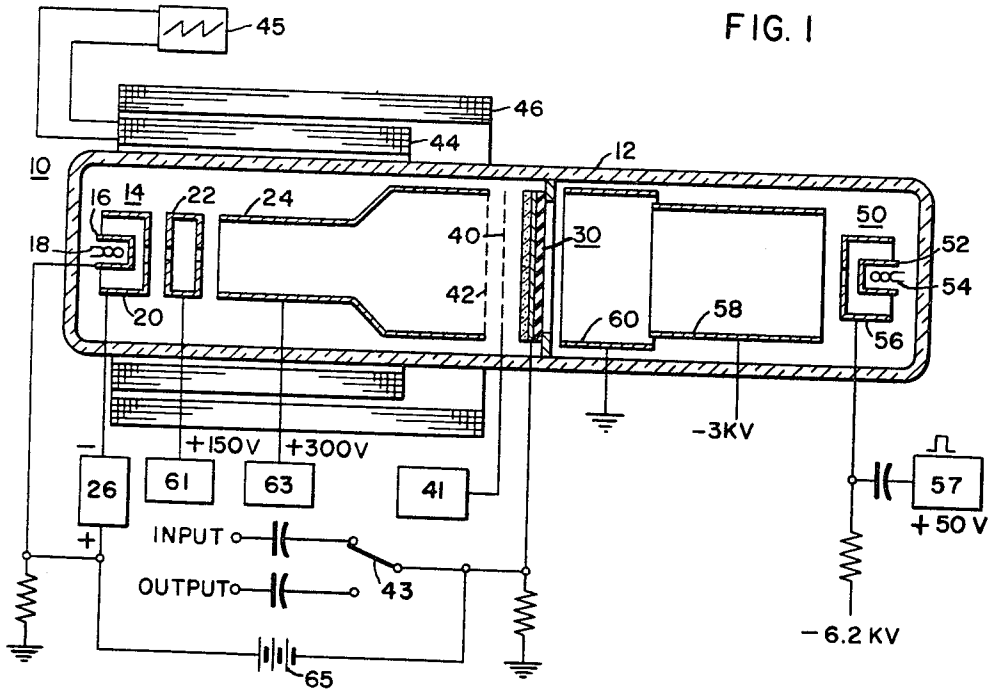
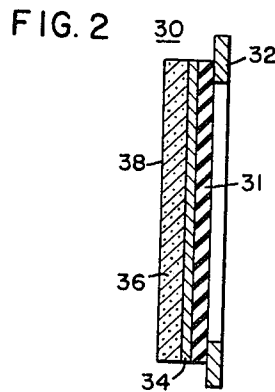
Oct. 29, 1968

G. W. GOETZE ET AL

3,408,531

STORAGE SYSTEM

Filed June 10, 1966



WITNESSES

Wm. B. Sellers.
James H. Young

INVENTORS
Gerhard W. Goetze and
Arthur E. Anderson
BY *R. Lewis Noble*
ATTORNEY

1

3,408,531

STORAGE SYSTEM

Gerhard W. Goetze, Elmira, N.Y., and Arthur E. Anderson, Pittsburgh, Pa., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed June 10, 1966, Ser. No. 556,634

8 Claims. (Cl. 315—12)

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a storage device including a storage target having a layer of an insulating material with a density less than 10% of its bulk density and an electrically conductive member, a first electron gun for writing a charge pattern upon the storage target by modulating a writing electron beam and for directing a reading electron beam of sufficient current density to derive an output signal corresponding to the pattern of charges stored upon the target, and a second electron gun for directing a flood beam of electrons with sufficient energy to pass through the conductive member into the porous layer to prime the exposed surface of the porous layer to a substantially uniform potential.

This invention relates to an image storage system and more particularly to a storage system including an electron image device in which information may be stored on a target member and read out by means of an electron beam.

In an increasing number of applications, there has arisen a need for a system or device that can receive information in the form of electrical signals, store it, and release it after a predetermined period. This function could be accomplished by an electrical delay line which has a capability of storing information for extremely short periods in the order of several microseconds. Alternatively, information may be stored on magnetic drums or video tape for longer periods of time in the order of a second or more. However, none of these means are practical if the stored information must also be retrieved at information rates different from those associated with the original or recorded signals. This limitation is primarily due to the mechanical characteristics of these devices.

As may be seen from the above-discussion, the time interval between approximately 10 microseconds and 1 second is covered by neither electrical delay lines nor magnetic or video tape. Such delay times are of special interest to video signal processing, wherein the normal repetition rate for a video frame is 30 per second. A special effort has been made in the video field in recent years to fill this gap.

An electronic storage tube offers in principle a solution to this problem, since its delay or storage time can be adjusted from a few nanoseconds up to many seconds. A typical electronic storage tube comprises a storage member upon which information may be written by an electron gun or by an electron image generated by a photocathode element and means for retrieving this information such as an electron gun whose beam is scanned across the surface of the target member. Further, means are provided to prime the surface of the storage member in preparation for receiving the information. However, existing storage tubes suffer from one or several of the following shortcomings: (1) insufficient dynamic range or grey tone representation, i.e. low signal to noise ratio, (2) insufficient resolution or frequency handling capacity, and (3) incomplete erasure in preparation for new information to be stored.

Further, there exists the problem of accurately retriev-

2

ing the information placed on the storage member. In many electronic storage tubes, the information is written upon the storage member by one electron gun or photocathode element and is retrieved by a separate electron gun. If the second electron gun which performs the operation of retrieving the stored information is disposed on the same side of the storage member as the first electron gun, it is often necessary to offset one of the electron guns thereby creating optical problems of accurately placing the electron beams upon the storage member. Further, if the electron gun is placed on the other side of the storage member, there exists the problem of accurately aligning or registering the retrieving electron gun so as to scan the precise portion of the storage member upon which the information is stored. Further, in such systems there is a necessity of providing a complex, fragile storage member to ensure sensitivity and resolution.

The problem of precise information retrieval may be partially solved by using a single electron gun to perform the operations of writing the information upon the storage member and retrieving this information. However, in known electronic storage tubes, there exists another problem created by the necessity of changing the potentials applied to the various focusing electrodes of these tubes between the writing and reading cycles. Further, potentials applied to the storage member are often changed in order to prepare or to prime the storage member for the writing cycle. As a result, it may be also necessary to change the potential applied to the means provided for deflecting or scanning the electron beam over the storage member. As a result, it is difficult, if not impossible, to obtain precise registration of the electron beams directed onto the storage member for the writing and reading cycles. When the interelectrode voltages are changed during the various cycles of operation, the angle of incidence of the electron beam upon the storage member will correspondingly change and it becomes necessary to compensate for these changes by refocusing the electron beam or adjusting the voltage applied to the scanning means to compensate for the differing projections of the electron beams used to write and read the information.

It is accordingly an object of this invention to provide an improved image storage system.

It is a further object of this invention to provide an improved storage system having a capability of storing information for periods of between a few microseconds and many seconds.

It is a further object of this invention to provide an improved system having an electron image device utilizing a high gain, sensitive storage member.

It is a more particular object of this invention to provide an improved storage system having an electron image device with a storage member upon which information can be placed with a single scan of an electron beam.

It is a still further object of this invention to provide an improved storage system having an electron image device capable of precisely retrieving the information placed on its storage member.

It is a further object of this invention to provide an improved storage system having an electron image device which is capable of achieving a precise registration between the scan of the electron beam used to place the information upon the storage member and the scan of an electron beam for retrieving this information.

It is a still further object of this invention to provide an improved storage system which is capable of retrieving the stored information entirely within a single read cycle.

In accordance with these objects, this invention provides an improved storage system having an electron image device utilizing a high gain storage member whose volume is uniformly porous and which is capable of being charged throughout its volume by a flow of high energy electrons.

3
A low energy electron gun is disposed to emit an electron beam intercepting the target storage member and is used for both writing and reading the information upon and from the storage member. Further, means are provided for maintaining uniform voltage differences between the electron gun and the storage member and for applying suitable voltages to the electron gun during both the reading and retrieving cycles of the storage tube. In a preferred embodiment of this invention, the information is placed on the storage member by modulating the voltage applied to the storage member.

These and other objects are effected by our invention as will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic representation of a storage system including an electron image device in accordance with the teachings of this invention; and

FIG. 2 is an enlarged sectional view of the target structure utilized in the electron image device shown in FIGURE 1.

Referring in detail to FIGS. 1 and 2, an electron image device 10 is provided comprising an evacuated envelope 12 of a suitable material such as glass. Within one end of the envelope 12, there is disposed axially of the envelope 12 an electron gun 14 comprising a cathode electrode 16, a heater element 18 for energizing the electron emissive material coated upon the cathode electrode 16, and a control grid 20. A voltage source 26 is interconnected between the control grid 20 and the cathode electrode 16 to apply a negative voltage to the control grid 20. Further, accelerating electrodes 22 and 24 are axially aligned of the envelope 12 to accelerate a beam of electrons emitted by the cathode electrode 16. Potential sources 61 and 63 are connected respectively to the accelerating electrodes 22 and 24 to apply the necessary voltages to accelerate the electron beam. The electron beam is directed upon a storage member 30 which is disposed perpendicular to the axis of the envelope 12. A first mesh 40 is disposed adjacent to the storage member 30 and perpendicular to the axis of the envelope 12. In addition, a second mesh 42 is disposed parallel to the first mesh 40 and is electrically connected to the accelerating electrode 24. A set of deflection coils 44 are disposed about the envelope 12 to provide the regular scanning of the electron beam emitted by the cathode electrode 16 across the surface of the storage member 30. A potential source 45 is connected to the deflection coils 44 for providing an appropriate sawtooth wave signal to the coils 44. Further, a focusing coil 46 is likewise disposed about the envelope 12 for precisely focusing the electron beam upon the storage member 30.

Within the opposite end of the envelope 12, there is axially disposed a flood gun 50 to emit a uniform dispersion of electrons upon a rear surface of the storage member 30. The flood gun 50 comprises a cathode electrode 52, a heater element 54, and a grid 56 for controlling the flow of electrons emitted by the cathode electrode 52. Further, cylindrical, accelerating grids 58 and 60 are disposed about the beam of electrons emitted by the cathode electrode 52 for directing the electrons upon the storage member 30. Further, a pulse voltage source 57 is capacitively tied to the control grid 56.

Referring specifically to FIG. 2, the storage member 30 is now be described in greater detail. The storage member 30 is disposed upon an annular support ring 32, which is in turn mounted in a manner well known in the art within the envelope 12. The support ring 32 may be made of a suitable material such as Kovar alloy (Westinghouse Electric Corporation trademark for an alloy of nickel, iron and cobalt). The storage member 30 further includes a support layer 31 which is made of a suitable insulating material such as aluminum oxide, of about 1000 angstroms thickness, and is supported on the support ring 32. Next, a conductive layer 34 of a material such as aluminum having a thickness of approximately

500 angstroms is deposited upon the support layer 31 typically by vacuum evaporation. A storage layer 36 is then disposed upon the conductive layer 34 and has an exit surface 38 facing the electron gun 14. The storage layer 36 is characterized by a volume of a uniformly porous nature which exhibits the property of generating electrons in response to electron bombardment. The porous nature of the storage layer 36 is necessary, as will be explained in greater detail later, so that the storage layer 36 may be uniformly charged and to provide a high gain, high resistivity storage member 30. The storage layer 36 may be made of any suitable material such as an alkaline or alkaline earth metal compound, such as potassium chloride, magnesium chloride or magnesium oxide. The mesh 40, as will be explained later, is provided to control the charge deposited upon the storage member 30 and is interconnected with a voltage source 41 which may be varied in accordance with the charge to be deposited upon the storage member 30. Further, a potential source 65 as shown in FIG. 1 is interconnected between the cathode element 16 and the conductive layer 34 to apply an appropriate accelerating potential to the electrons beam formed by the electron gun 14.

In a preferred embodiment of this invention, the input and output signals of the electron image device 10 may be alternately applied by a switch 43 to the conductive layer 34 of the storage member 30 across a resistance to ground.

In one specific embodiment of this invention, the storage layer 36 may be applied to the conductive layer 34 by evaporating a layer of potassium chloride in an inert gas such as argon at a pressure of a few millimeters of mercury. A boat of a suitable material such as tantalum is provided with a resistive heater element therein within the evacuated atmosphere. A predetermined amount such as 16 milligrams of potassium chloride is placed in the boat. The boat is then positioned at a distance of approximately 3 inches below the conductive layer 34 and current is applied to the resistive heater element of the boat. The heat is applied until the potassium chloride has just melted at which temperature the material is then maintained. This temperature is considerably less than the melting point of potassium chloride at atmospheric pressure. The vapor pressure of potassium chloride at its melting point under these evacuated conditions is found sufficient to cause vaporization at a sufficient rate. The potassium chloride is evaporated to completion and it is found that the density of the evaporated storage material on the conductive layer 34 is approximately 1 to 10% of its bulk density. A typical thickness of approximately 25 microns is achieved which corresponds to a mass per unit area of 100 micrograms per square centimeter. Thus, there has been described a storage member 30 having a storage layer 36 which is characterized by the high resistivity and the uniform, porous nature of its volume which allows electrons incident upon its surface to penetrate its surface and to generate secondary electrons throughout its volume thereby accounting for the high gain and sensitivity of this member.

The operation of the electronic storage tube of this invention may be explained in three steps: priming of the storage layer, "writing" or placing the information upon the storage member, and "reading" or retrieving the information.

The first step of operating this device involves flooding the storage member 30 with a burst or dispersion of high energy electrons. In a typical mode of operation, the cathode electrode 52 is operated at a negative potential of several kilovolts with respect to the storage member 30; in the particular embodiment shown in FIG. 1, a negative potential of 6 kilovolts is applied to the cathode electrode 52. During the remaining steps of operating the storage tube, the control grid 56 is biased at a potential negative with respect to the potential placed upon the cathode electrode 52. A positive pulse generated by voltage

source 57 is applied through a capacitor to the control grid 56 to allow a burst of high energy electrons to be accelerated by grids 60 and 58 toward the storage member 30. In one particular mode of operation, the voltage source 57 applies a positive impulse of 50 volts for a duration of one millisecond or less. The storage member 30 will respond to this uniform burst of electrons and the exit surface 38 of the storage layer 36 will charge to a potential of several volts positive with respect to the conductive layer 34. The placement of a positive charge upon the exit surface 38 of the storage layer 36 is due to the burst of high energy electrons which are accelerated with sufficient energy to penetrate the support layer 31 and the conductive layer 34 and to be absorbed by the storage layer 36. The high energy electrons entering the storage layer 36 will be able to penetrate substantially the entire volume of the layer 36 due to its porous nature. As the electrons penetrate the layer 36, secondary electrons are generated within the volume and in part, are emitted from the exit surface 38 of the storage layer 36 to be collected by the first mesh 40 and are in part collected by the conductive layer 34. In this manner, electrons are taken from the storage layer 36 thereby leaving a positive potential charge upon the exit surface 38 of the storage layer. The potential of the charge placed upon the storage layer 36 is determined by the voltage applied to the first mesh 40 by a voltage source 41. The potential of the voltage source 41 is set below the first cross-over potential for the material of which the storage layer 36 is composed. For a storage layer 36 made of a potassium chloride, the potential applied to the first mesh 40 may be set at approximately 10 to 20 volts. It is noted that the porous and electron transmissive nature of the storage layer 36 provides a sensitive, high gain storage layer which in turn allows the storage member 30 to be primed within an extremely short period of approximately one millisecond or less. Therefore, priming could be timed to coincide with the return time of the vertical deflection of the electron beam used for writing and reading, thus eliminating any dead time in the operation of this tube.

After the exit surface 38 of the storage layer 36 has been charged, the writing of information upon the storage member 30 takes place. A low energy electron beam is produced by the cathode element 16 and it is accelerated by the electrodes 22 and 24, and the second mesh 42. In the illustrative mode of operation shown in FIG. 1, positive voltage potentials of approximately 150 volts and 300 volts are respectively applied to the electrodes 22 and 24. Further, the density of an electron beam emitted by the cathode electrode 16 is determined by the negative potential applied to the control grid 20; in one particular mode of operation, a negative voltage of approximately 40 volts is applied by the voltage source 26 to the control grid 20. The electron beam generated by the cathode electrode 16 is focused by the coils 46 and is scanned by the deflection coils 44 in a typical video raster upon the storage layer 36 of the storage member 30. With the switch 43 thrown to the input position, an input signal is applied through the conductive layer 34 to modulate the beam of electrons scanned across the surface of the storage layer 36. Correspondingly, the previously uniform charge placed upon the storage layer 36 will be modulated in direct proportion to the signal applied to the conductive layer 34. Typically, an input signal varying between 0 and -10 volts may be applied to the conductive layer 34. As a result of the high gain and sensitivity of the storage member 30, a complete frame or pattern of information can be written upon the storage layer 36 during a single scan of the electron beam. It is preferred in order to provide a more linear response that the input signal be applied to the target member 30 rather than that the modulating signal be applied to the control grid 20. Due to the high resistivity of the storage member 30 (10^{18} ohm-cm.) the charge pattern representing the information to be stored will remain unchanged for long time intervals. Experi-

ments have shown that charge storage of many hours is possible without loss of resolution.

In order to retrieve or read the stored information, the storage member 30 is scanned again after a suitable time interval with a low velocity electron beam emitted by the cathode electrode 16. During this step, a constant potential will be applied by the source 65 to the conductive layer 34 of the storage member 30. To take out the signal, the switch 43 is turned to the output position and the signal which is derived from the storage member resistor during the scan will be an exact copy (reverse polarity) of the original frame or pattern. After this step is completed, the exit surface of the storage layer 36 will be primed again as described above in preparation for the next sequence.

Further, it is noted that during the reading and writing steps that the potential sources 61 and 63 apply substantial constant accelerating potentials to electrodes 22 and 24 and that the source 45 maintains a sawtooth wave of the same waveform and amplitude upon the deflection coils 44. Further, a constant D.C. potential is applied by the source 65 between the cathode element 16 and the conductive member 34. As a result, the electron beams emitted from the cathode electrode 16 are accelerated upon and scanned across the target member 30 with substantially the same potentials to thereby ensure exact registration of the reading and writing electron beams upon the target member 30.

It will, therefore, be apparent that there is disclosed an improved storage system which is capable of storing and accurately retrieving the information after a predetermined time interval. More specifically, the storage system of this invention includes an electron image device having a high gain, high sensitivity storage member or target of a porous nature which is combined with a single electron gun for both the writing and reading operations to thereby assure maximum registration of the information stored on the target storage member. In order to prime the storage member, a high velocity burst of electron is directed upon the storage member in preparation for the writing cycle. To further insure registration, the electrode arrangement of this storage tube does not require switching of the electrode voltages for the transition from the writing to the reading modes of operation. Further, there has been disclosed in one embodiment of this invention an electron image device wherein the reading and writing gun is electrically isolated from the high energy priming gun by a storage member disposed between the two guns. The electronic storage tube disclosed herein may be characterized by a high signal to noise ratio, the capability of writing and reading a charge pattern of high definition, high speed of response whereby priming can be accomplished in one millisecond or less, and a capability of writing and/or reading within a single frame, and simplicity and compactness of construction.

Since numerous changes may be made in the above-described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

We claim as our invention:

1. An information storage system comprising a storage member including a porous layer of less than 10% of the normal bulk density of a high resistive material exhibiting the property of emitting secondary electrons from a first surface thereof in response to electron bombardment and an electrically conductive member disposed on a second surface of said porous layer, first means for emitting a flow of electrons having substantially uniform distribution with sufficient energy to be directed through said electrically conductive member into the volume of said porous layer to thereby establish a substantially uniform potential upon said first surface, second unitary

7
means for directing first and second electron beams towards said first surface of said porous layer, third means for modulating said first electron beam with the information to be stored upon said storage member, and fourth means for maintaining the current level of said second electron beam at a value sufficient to derive an output signal from said storage member.

2. An information storage system as claimed in claim 1, wherein said first and second means are disposed on opposite sides of said storage member to thereby be isolated from each other by said storage member.

3. An information storage system as claimed in claim 1, wherein said second means is an electron gun including a cathode element and an accelerating electrode, and means for maintaining substantially constant potentials between said cathode element, said accelerating electrode and said electrically conductive member of said storage member during the emission of said first and second electron beams.

4. An information storage system as claimed in claim 3, wherein there is included deflection means for scanning said first and second electron beams across said first surface of said porous layer, and means for applying substantially similar wave signals to said deflection means to thereby assure that said first and second electron beams will be scanned across substantially the same portions of said first surface of said porous layer.

5. An information storage system as claimed in claim

1, wherein there is included a mesh electrode disposed in a spaced relationship with said porous layer of said storage member, and fifth means for applying to said mesh electrode a potential of such magnitude to limit said uniform potential to a value below the first cross-over of said high resistive material.

6. An information storage system as claimed in claim 1, wherein said high resistive material is selected from a group of materials consisting of potassium chloride, magnesium chloride and magnesium oxide.

7. An information storage system as claimed in claim 1, wherein said storage member further includes a supporting layer of insulating material disposed upon said electrically conductive member.

8. An information storage system as claimed in claim 7, wherein said electrically conductive member is made of aluminum, and said support layer is made of aluminum oxide.

References Cited

UNITED STATES PATENTS

3,148,297	9/1964	Schweeberger et al.	313—65
3,164,743	1/1965	Koda et al.	315—12 X
3,242,367	3/1966	Szegho	313—89

RODNEY D. BENNETT, *Primary Examiner*.

J. P. MORRIS, *Assistant Examiner*.