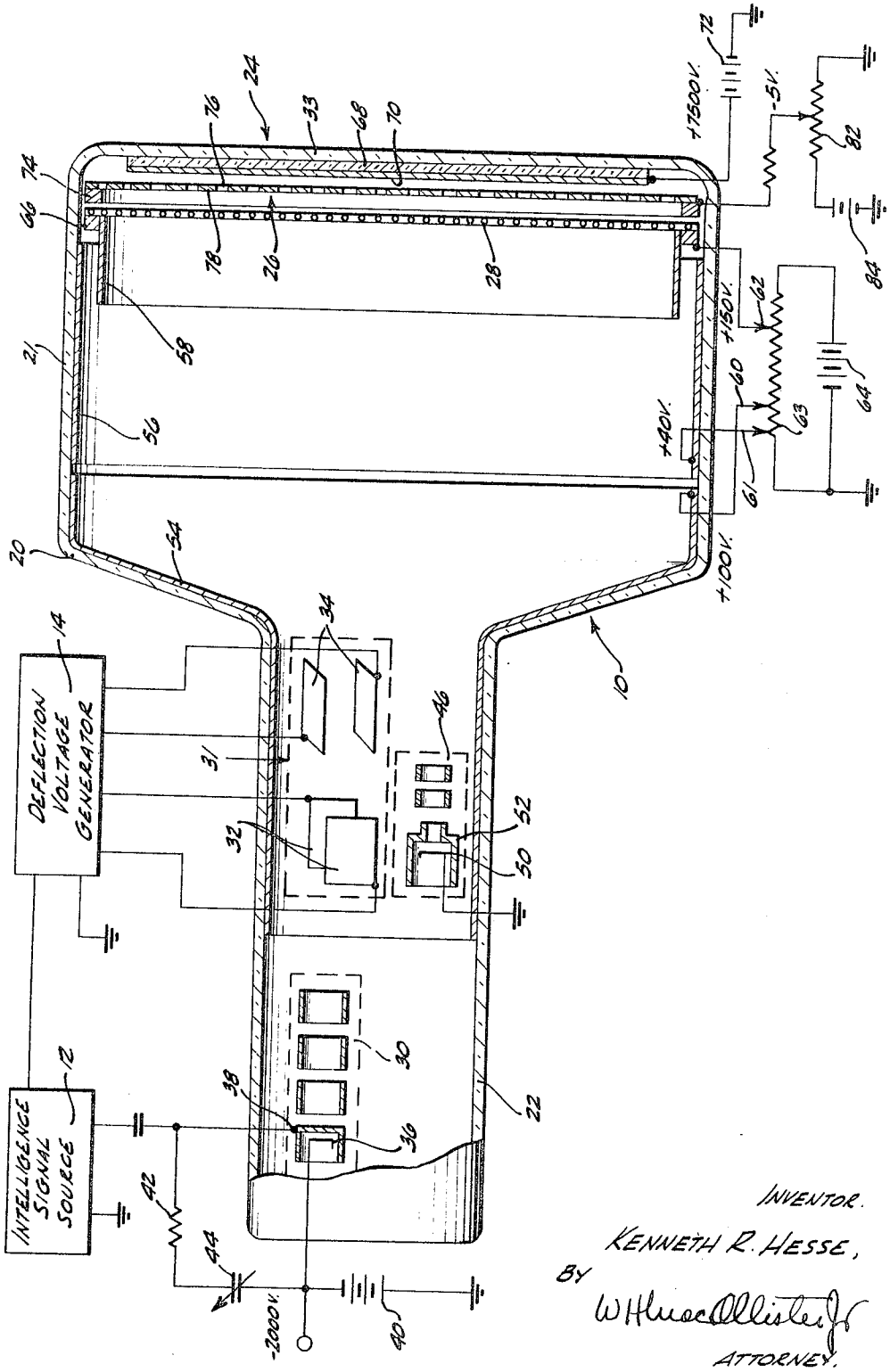
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DIRECT-VIEW STORAGE TUBE AND METHOD OF ERASURE

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DIRECT-VIEW STORAGE TUBE AND METHOD OF ERASURE

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ABSTRACT OF THE DISCLOSURE

Direct-viewing storage tube employing a storage target having a mesh electrode and a storage dielectric thereon facing the scanning and flood electron guns. The storage dielectric exhibits both field induced and controlled conductivity and, by means of an electric field established across the dielectric, the leakage of electrical charges to the mesh electrode and hence erasure of the display may be selectively controlled.

This invention relates to electronic storage devices and especially to direct-viewing storage tubes capable of half-tone presentations of given information. More particularly, the invention relates to methods and means for erasing storage displays in such a tube and especially for establishing the rate of erasure and/or the duration of the display.

One of the types of direct-view storage tubes to which the present invention relates is described in U.S. Patent 2,790,929 to E. E. Herman and G. F. Smith, assigned to the instant assignee. This storage tube comprises a target assembly which includes a storage target and a viewing screen. Two electron guns are provided: one gun (hereinafter called the "writing" gun) causes the formation of a charge pattern on the storage target corresponding to the information to be presented; the other gun (hereinafter called the flood or viewing gun) renders the charge pattern visible on the viewing screen. Information-representative signals are employed to modulate the intensity of the electron beam produced by the writing gun. The storage target is initially uniformly charged negatively. When the writing beam strikes the storage target, a less negative potential is produced at the point of impingement by the phenomenon of secondary emission. It should be understood that as used herein in describing the storage or charge pattern on the storage target, the term "positive" designates those portions which are less negatively charged than other portions of the target. The potentials on the storage target are always negative with respect to the potential of the flood gun cathode except when erasing. Thus by scanning the storage target an overall charge pattern corresponding to the information to be presented is obtained. Thereafter this charge pattern controls the passage of flood electrons from the viewing gun to the viewing screen; flood electrons, properly collimated over the entire area of the storage target, are only passed through areas of the storage target which are less negatively charged. It should be understood that the potentials capable of being stored range from a uniformly negative "black" value to a uniformly positive "white" value: at intermediate potentials only a portion of the flood electrons passes through the storage element to the viewing screen thereby producing intermediate or half-tone shades.

The present invention may also be used in direct-viewing half-tone storage tubes of the type described in U.S. Patent 3,086,139 to N. H. Lehrer, assigned to the instant assignee, often referred to as a multi-mode storage tube because of the ability of this tube to present both stored and non-stored displays and to selectively erase portions of the stored display. In such a multi-mode storage tube, the phenomenon of bombardment induced conductivity

as well as secondary emission is utilized to provide the storage mechanism. The bombardment induced conductivity storage target is responsive to the energy level of an electron beam impinging thereon whereby at one beam energy level the principal effect is secondary electron emission greater than unity so as to permit the development of an electrostatic storage pattern corresponding to that utilized in the aforementioned patent to E. E. Herman and G. F. Smith. At a different energy level the principal effect is bombardment induced conductivity which permits the storage target to be charged in an opposite electrical sense so that previously stored charges may be selectively erased by scanning the target with a beam at this second energy level. It is also possible, by utilizing an electron beam having an intermediate energy level, to cause some of the beam to pass through the storage target without having the portion of the beam which strikes the storage target appreciably alter the stored charge pattern or other potential conditions of the storage dieelectric. Thus, the electron beam of such intermediate energy level can be used to establish the display of nonstored or live information simultaneously with the stored information. In both of the types of tubes described, display of the stored information is achieved by the penetration of flood electrons through the storage target in accordance with the storage potentials thereon.

In both of the aforementioned types of storage display tubes, erasure of the stored information may be achieved by the application of a train of pulses to the backing electrode for overall or general erasure. In the multi-mode storage tube described above, selective erasure is also possible by utilizing a high energy writing gun as mentioned. In either instance, both tubes require the utilization of additional circuitry to obtain general or overall erasure which thereby adds complexity to the display system.

It is therefore an object of the present invention to provide a direct-viewing storage tube the duration of whose stored displays may be controllably established with a minimum amount of complex circuitry.

Another object of the present invention is to provide an improved direct-viewing storage tube capable of having the stored displays thereon erased by means other than electrical pulses applied to the backing electrode thereof.

Yet another object of the present invention is to provide a direct-viewing storage tube having improved erasing means.

These and other objects and advantages of the invention are realized by providing a direct-viewing storage tube with a storage target which exhibits field-induced conductivity and/or sustained bombardment induced conductivity. By maintaining the backing electrode of the storage target sufficiently negative, field-induced conductivity currents are caused to flow through the storage insulator. Positive areas are formed or "written" by means of secondary emission and a scanning electron or "writing" gun, for example. These positive areas will be gradually discharged toward the backing electrode potential at a rate dependent upon the field across the insulator material. Hence, by varying the voltage on the backing electrode, this discharge rate may be controllably established so that stored displays having persistencies in the range of fractions of seconds to many seconds may be achieved.

Another advantage attendant with the use of the present invention is the improved contrast of the displays which result from the method of erasure. The method of erasure used in the direct-view storage tubes of the prior art employing the flood electrons to achieve erasure resulted in a general or overall background light due to the erase pulses applied to the backing electrode. Since the background brightness and associated contrast ratio are dependent upon the duty cycle of the erase pulse train, the

higher the duty cycle, the higher the background brightness and the poorer the contrast ratio between stored information and the background. Such degradation is avoided, in the prior art, by applying a pulse to the viewing screen in synchronism with the erase pulse. However, the amplitude of such pulse must be of the order of 6,000 to 8,000 volts which produces an increase in both the complexity of the necessary circuit and in radio frequency interference radiation. In employing the present invention, contrast is not only improved but these disadvantages are avoided since flood electrons are not used for erasure.

The invention will be described in greater detail by reference to the drawings in which the sole figure is a schematic diagram of a direct-viewing half-tone storage tube device according to the present invention.

Referring now to the drawing, a direct-viewing storage tube **10** is shown which comprises an evacuated envelope **20** having an enlarged cylindrical portion **21** and a neck portion **22**. The end portion **33** of the cylindrical portion **21** is generally flat and transparent. Disposed adjacent the flat end portion **33** is the target assembly according to the present invention comprising a viewing screen **24**, and a storage screen **26**. An electron gun **30**, hereinafter called the "writing" gun, is disposed in the neck portion **22** of the envelope **20**. Also disposed in the neck portion and adjacent the electron gun **30** is a deflection system **31** for directing the electron beam produced by the writing gun **30** over selected elemental areas on the storage screen **26**. While an electrostatic deflection system is shown in the drawing comprising horizontal and vertical deflecting plates **32** and **34**, respectively, deflection of the beam produced by the electron gun **30** could also be achieved electro-magnetically as is well-known in the cathode ray tube art. The electron beam produced by the writing gun is of elemental cross-sectional area.

More particularly, the writing electron gun **30** includes a cathode **36** and a grid **38** which controls the intensity of the writing electron beam in accordance with signals supplied thereto by a connection from the signal source **12**. Illustratively, the cathode **36** may be maintained at a potential of about several thousand volts negative with respect to ground. An adjustable quiescent potential of about 50 volts negative, for example, with respect to the cathode potential may be maintained on the intensity grid **38**.

By means of appropriate connections, horizontal and vertical deflection potentials may be applied to the electrostatic deflection system **31**. These deflection potentials may be developed by a deflection generator **14** in synchronism with signals through a connection to the signal source **12**.

The viewing screen **24** of the target assembly comprises a phosphor coating **68** disposed on the inner surface of the flat transparent end portion **33** of the envelope **20**. An electron transparent conductive coating or film **70** may be then disposed over the phosphor coating **68**. The conductive coating **70** may be a thin film of aluminum, for example. The conductive coating **70** may be maintained at a potential of from 5 to 10 kv. by means of a connection to the positive terminal of a battery **72** whose negative terminal is connected to ground.

The storage screen **26** comprises an electroformed nickel mesh **76** having, for example, about 250 linear openings per inch and a thickness of the order of 0.001". The optical light transmissivity of this screen is approximately 40% to 50%. The outer periphery of the screen may be welded to a support ring **74**. A coating **78** is provided on the surface of the screen facing the electron gun **30**. This coating is produced from a dielectric material which exhibits the properties of both secondary electron emission and field-induced conductivity. A typical material is calcium fluoride applied to a thickness of from 0.3 to 0.6 micron, for example.

The preferred method of application of the calcium fluoride coating **78** is by vacuum evaporation and condensation. This method is well known in the art and is described by L. Holland in "Vacuum Deposition of Thin Films," published by John Wiley & Sons, New York. Briefly, a small amount of calcium fluoride, approximately one gram, is placed in a molybdenum boat. This boat is formed of thin molybdenum sheet, 0.003" thick, and is made approximately ¾" wide and 2" long. The ends of the boat are clamped between two electrodes by which a low voltage current is passed through the boat for the purpose of heating the same. The storage screen and the boat are disposed in a vacuum with the screen positioned over the boat. Sufficient spacing between the boat and the screen is provided so that the condensation of the dielectric material occurs in a uniform layer upon the storage screen. Approximately 13 inches has been found adequate for a nominal 5-inch diameter screen.

A vacuum of the order of 10^{-6} torr is maintained in the bell jar during the evaporation of the calcium fluoride. Total evaporation time is approximately 20 to 40 minutes for the deposition of a 0.50 micron thick layer.

The storage screen **26** is disposed adjacent the viewing screen **24** and is co-extensive therewith and may be positioned at approximately 0.150" away from the viewing screen, for example. The storage screen **26** may be connected through a variable resistor **82** to the negative terminal of a battery **84** as shown. Disposed adjacent the storage target **26** is a collector screen or target member **28** which may be maintained at a positive potential of about 150 volts with respect to ground by means of a connection to a tap **62** of the potentiometer **63**.

In operation, upon the application of appropriate signals to the writing electron gun **30** and its associated deflection system **32**, the electron beam formed by the electron gun **30** is intensity modulated and caused to strike the storage screen **26** with such energy that the secondary emission from this surface is very high; i.e., many secondary electrons are emitted for each incident primary electron. These secondary electrons are attracted away from the storage surface to the collector grid **28**, thus causing the formation of a charge pattern on the storage surface in accordance with the intensity of the scanning electron beam which, in turn, is modulated according to the applied intelligence signals.

Thus, those areas of the storage surface which are charged positive in this manner with respect to the flood gun cathode **50** permit the flood electrons therefrom to pass through the storage screen assembly to strike the viewing screen thereby producing a visual presentation, in accordance with the number of impinging flood electrons which number, in turn, depends upon the potentials of the storage surface.

In a typical embodiment, a quiescent potential of about 5 volts negative with respect to ground may be maintained on the storage screen **76**. The initial quiescent potential established on the storage surface **78** is zero. In this state, the storage screen transmits the maximum number of flood electrons and the tube is at its maximum brightness. (Previously, it was customary to "erase" stored charges from the storage surface and to restore it to its quiescent potential by periodically pulsing the storage screen **26** with a series of pulses to achieve a slow "fade-out" or with a single pulse to achieve instantaneous erasure.)

According to the present invention, however, the potential of the storage screen or backing electrode **76** is increased or made more negative (i.e., —10 volts) with respect to the flood gun cathode so that flood electrons cannot penetrate therethrough except where "positive" areas are established on the storage surface by the writing gun. By means of this negative potential on the backing electrode, field induced currents are caused to flow through the storage dielectric **78** so that the positive areas thereof, written by means of secondary emission

with the writing gun **30** as described previously and at compartively low energy (i.e., about 2,000 volts), are gradually discharged toward the backing electrode potential at a rate determined by the field established across the storage dielectric **78**. The voltage established on the backing electrode **76** permits the rate of erasure to be controlled so as to achieve persistencies of display ranging from fractions of a second to many seconds. The exact voltage which must be applied to the backing electrode **76** to produce a specific persistence, is primarily dependent upon the thickness of the dielectric layer. Thus, with a dielectric layer of about 0.3 to 0.6 micron in thickness, and a backing electrode potential of about 10 volts negative, as described, a persistency of about two seconds is obtained. The backing electrode voltage range may be from approximately 5 volts to 25 volts negative with respect to flood gun cathode to obtain persistencies of from about 200–300 milliseconds to about 15–20 seconds.

In this manner the leakage rate of the stored positive charges is controlled so as to establish displays of any desired period or persistency which displays fade and are erased automatically according to any desired erasure of fade program. In this connection the invention is related to the erasure technique taught in Iams 2,259,507 except that Iams taught that different storage or erase periods could be obtained only by changing the dielectric material itself so as to provide storage dielectrics of different specific resistivities to obtain the desired rate of leakage. Thus, the present invention is a considerable improvement over Iams since the leakage rate may be changed at will in a given storage tube without having to replace the storage dielectric.

What is claimed is:

1. A direct-viewing half-tone storage display tube comprising, in combination:

(A) a first electron gun for providing a scanning electron beam of elemental cross-sectional area;

(B) a second electron gun for providing a flood beam of electrons;

(C) a viewing target positioned within the target area of said electron guns adapted to luminesce in response to the impingement of electrons thereon;

(D) a storage target disposed between said electron guns and said viewing target and including:

(1) an electron permeable electrode member;

(2) a storage dielectric layer on the surface of said electrode member facing said electron guns and exhibiting field induced and controlled conductivity;

(E) means including said storage target for forming a pattern of electrical charges on the surface of said dielectric layer in response to the impingement thereon of said scanning electron beam;

(F) means for selectively controlling the leakage of said electrical charges to said electrode member comprising means for establishing a predetermined electrical field across said dielectric layer.

2. A direct-viewing half-tone storage display tube comprising, in combination:

(A) a first electron gun for providing a scanning electron beam of elemental cross-sectional area;

(B) a second electron gun for providing a flood beam of electrons;

(C) a viewing target positioned within the target area of said electron guns adapted to luminesce in response to the impingement of electrons thereon;

(D) a storage target disposed between said electron gun and said viewing target and including:

(1) a mesh electrode member;

(2) a secondary emissive storage dielectric layer on the surface of said mesh electrode member facing said electron guns and exhibiting field induced and controlled conductivity;

(E) means including said storage target for forming a pattern of electrical charges on the surface of said dielectric layer in response to the impingement thereon of said scanning electron beam;

(F) means for selectively controlling the leakage of said electrical charges to said electrode member comprising means for establishing a predetermined electrical field across said dielectric layer.

3. A direct-viewing half-tone storage display tube comprising, in combination:

(A) a first electron gun for providing a scanning electron beam of elemental cross-sectional area;

(B) a second electron gun for providing a flood beam of electrons;

(C) a viewing target positioned within the target area of said electron guns adapted to luminesce in response to the impingement of electrons thereon;

(D) and a storage target disposed between said electron guns and said viewing target and including:

(1) a mesh electrode member;

(2) a bombardment induced conductivity storage dielectric layer on the surface of said mesh electrode member facing said electron guns and exhibiting field induced and controlled conductivity;

(E) means including said storage target for forming a pattern of electrical charges on the surface of said dielectric layer in response to the impingement thereon of said scanning electron beam;

(F) means for selectively controlling the leakage of said electrical charges to said electrode member comprising means for establishing a predetermined electrical field across said dielectric layer.

4. A multi-mode direct-viewing half-tone storage display tube comprising, in combination:

(A) a first electron gun for providing a scanning electron beam of elemental cross-sectional area;

(B) a second electron gun for providing a flood beam of electrons;

(C) a viewing target positioned within the target area of said electron guns adapted to luminesce in response to the impingement of electrons thereon;

(D) a storage target disposed between said electron guns and said viewing target and including:

(1) a mesh electrode member;

(2) a storage dielectric layer disposed on the surface of said mesh electrode member facing said electron guns and exhibiting both secondary electron emission and bombardment induced conductivity at different energy levels of said scanning electron beam, said storage dielectric layer further exhibiting field induced and controlled conductivity;

(E) means including said storage target for forming a pattern of electrical charges on the surface of said dielectric layer in response to the impingement thereon of said scanning electron beam;

(F) means for selectively controlling the leakage of said electrical charges to said electrode member comprising means for establishing a predetermined electrical field across said dielectric layer.

5. A direct-viewing half-tone storage display tube comprising, in combination:

(A) a first electron gun for providing a scanning electron beam of elemental cross-sectional area;

(B) a second electron gun for providing a flood beam of electrons;

(C) a viewing target positioned within the target area of said electron guns adapted to luminesce in response to the impingement of electrons thereon;

(D) and a storage target disposed between said electron guns and said viewing target and including:

(1) an electron permeable electrode member;

(2) a storage dielectric layer on the surface of said electrode member facing said electron guns

and exhibiting field induced and controlled conductivity;

(E) means including said storage target for forming a pattern of electrical charges on the surface of said dielectric layer in response to the impingement thereon of said scanning electron beam;

(F) means for selectively controlling the leakage of said electrical charges to said electrode member comprising means for impressing a predetermined potential on said electrode member.

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