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H. O. HOOK ET AL

DIRECT-VIEW ELLECTRICAL STORAGE TUBE AND METHODS OF OPERATING SAME

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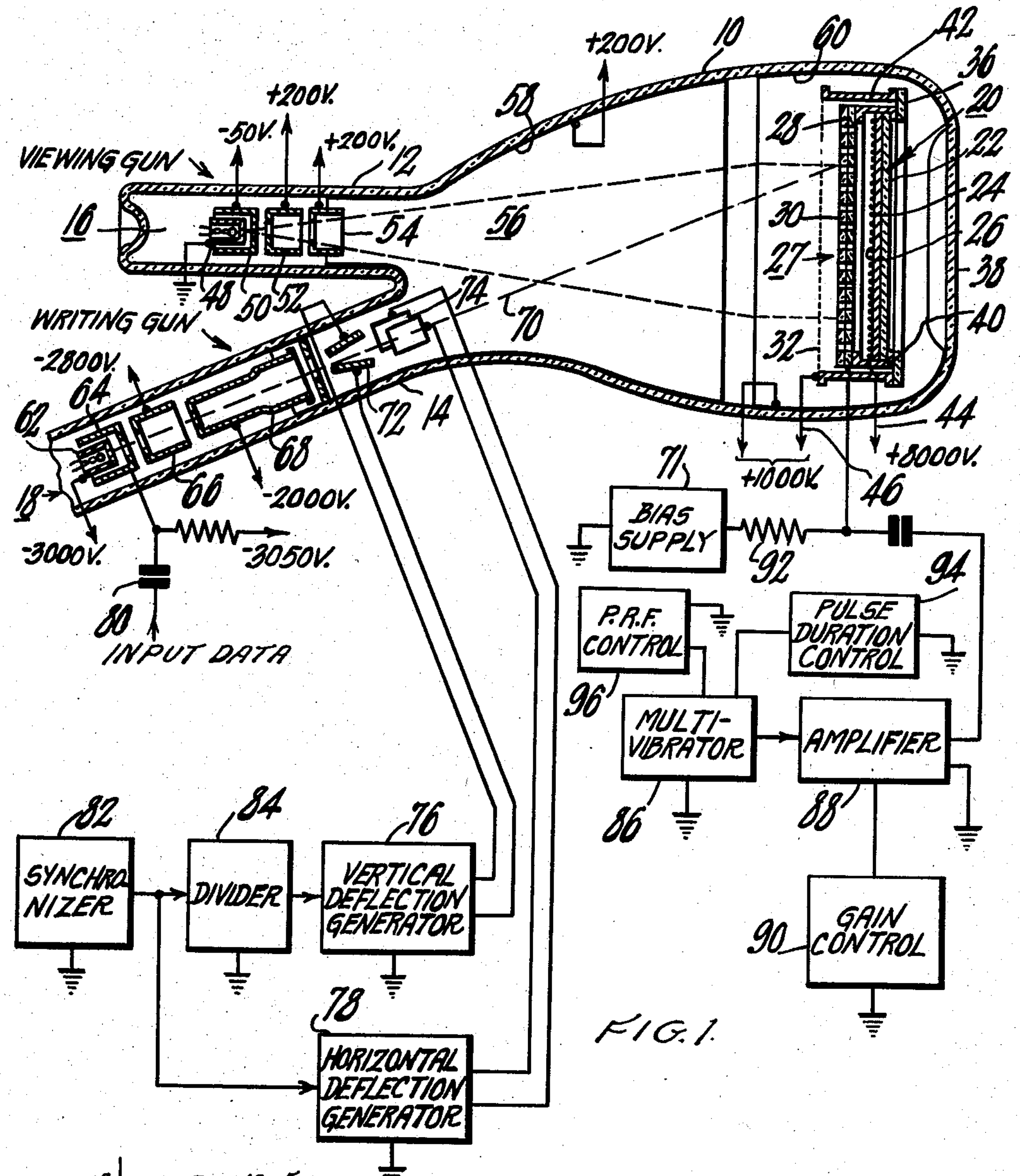

FIG. 1.

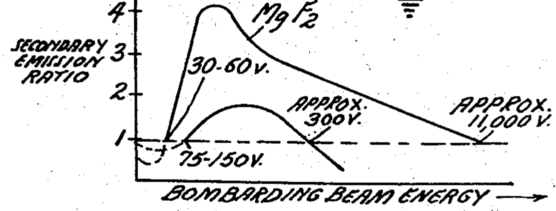

FIG. 2.

INVENTORS
HARVEY O. HOOK
& MAX KNOLL

BY J. L. Whittaker

ATTORNEY

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DIRECT-VIEW ELECTRICAL STORAGE TUBE AND METHODS OF OPERATING SAME

Harvey O. Hook and Max Knoll, Princeton, N. J., assignors to Radio Corporation of America, a corporation of Delaware

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8 Claims. (Cl. 315—12)

This invention relates generally to electrical storage tubes and signal display systems and particularly to improved methods of and means for utilizing a direct-view type of electrical storage tube for storing and displaying signal intelligence. The present application is related to a copending application Serial No. 358,361, filed May 29, 1953, by Harvey O. Hook.

A number of presently known signal storage and display systems are used in connection with radar systems, ground-to-air private line communication systems, and the like. In order to obtain the features of both signal storage and signal display these storage and display systems generally require one or more electrical storage tubes in combination with a separate display tube. Such arrangements are complicated, relatively expensive, and occupy excessive amounts of space which could be used to better advantage, particularly in airborne systems. It is highly desirable in such instances to combine the features of storage and display in a single tube.

Such a tube has been developed and is described in detail in patent application Serial No. 295,768, filed June 26, 1952, by Max Knoll. In said application data stored and displayed by the direct view tube is completely and almost instantaneously erased by manually adjusting potentials applied to certain electrodes contained therein. Such an erasing technique may be satisfactory for erasing stored transients and the like. However, the erasure requirements for radar and various other systems are more exacting.

In radar systems providing either rectilinear B-scan or polar coordinate P. P. I. (plan-position-indication) type presentations, it is undesirable to completely erase a stored frame of information before commencing to write a new frame of data derived in a succeeding search interval. In most of such radar systems four to six seconds is required for completely displaying data derived during a 360° azimuth search. If there is instantaneous and complete erasure the four to six second time interval must again transpire before the new frame of information is completely displayed. A further disadvantage of complete erasure at the end of the writing of a given frame is that the eye does not integrate the data last written and there is an apparent intensity variation or "shading" effect. Moreover, information available during the erase period is not stored and therefore is lost.

In a more recently filed patent application of Harold Borkan, Serial No. 306,706, filed August 27, 1952, an erasing technique is disclosed for the direct-view tube which is adapted for erasing B-scan or P. P. I. type displays. According to this technique the tube storage electrode assembly includes a plurality of individually insulated charge storage sections. The potential of each storage section automatically is controlled for erasure in an orderly sequence so that old data stored on a given storage section is erased substantially immediately before new data is to be written thereon.

In the application of Harvey Hook, cited above, Serial No. 358,361, filed May 29, 1953, a further erasing technique is disclosed wherein a fractional portion of the total stored image pattern is erased during either the line or frame deflection "flyback" interval. By erasing a small portion of the overall stored charge pattern during each line deflection flyback interval a given line of old data may be completely erased just prior to being replaced with a line of new data. By performing erasing during the frame deflection flyback time signal integration may be achieved.

An object of the present invention is to provide improved methods and means for storing and displaying signal intelligence.

Another object of the invention is to provide improved methods and means for utilizing a direct-view storage tube.

Another object of the invention is to provide improved methods and means for either erasing or "holding" data stored and displayed by the direct-view storage tube.

A further object of the invention is to provide a system of erasure for use with the direct-view tube in which 'old" stored and displayed data is erased just prior to being replaced with "new" data.

A further object of the invention is to erase data stored in a tube of the above type in a non-synchronous manner so that time-sharing of writing and erasing is not required.

A still further object of the invention is to provide an improved signal storage and display system in which data may be stored for a relatively long period of time.

According to the present invention, improved methods and means are provided for operating the direct-view storage tube. The technique employed herein does not require the special target assembly described in application Serial No. 306,706 nor does it require the time-sharing arrangement described in application Serial No. 358,361.

In the present case pulses are generated non-synchronously with respect to deflections of the tube writing beam, and are applied to the tube so that either data erasure or longer signal storage time is provided. With the amplitude of the non-synchronous pulses adjusted below a predetermined level, each applied pulse causes a fractional portion of the overall stored charged pattern to be erased. By suitably controlling the pulse duration and/or amplitude either signal integration or cyclical erasure of the stored data is attainable. With the amplitude of these pulses adjusted to be greater than the above-mentioned predetermined level erasure is not afforded but the storage time of the stored data is increased considerably.

The invention will be described in detail with reference to the accompanying drawing in which:

Figure 1 is a schematic circuit diagram, partially in block form, of a system in accordance with the invention for utilizing the direct view storage tube; and,

Figure 2 is a diagram illustrating the secondary emission ratios for silica and magnesium fluoride as a function of bombarding beam energy.

Storage tube structure

The drawing shows a direct-view type storage tube consisting of an evacuated envelope **10** having two neck sections **12** and **14**, respectively. Within the envelope neck **12** is an electron gun **16**, hereinafter referred to as the "viewing gun." Within neck **14** is a second or "writing" electron gun **18** for providing a modulated beam of electrons which is accelerated into the envelope portion **10**.

Mounted at the large end of the envelope portion **10** is an assembly **20** including a glass support sheet **22** having a thin conductive film **24** disposed on one surface thereof and facing the electron guns. The film **24** may be formed, for example, of a metal or metallic compound such as tin oxide. On top of the conductive film **24** is a material **26** such as phosphor which fluoresces under electron bombardment.

In the direction towards the electron guns from the surface of the fluorescent material **26** is a storage target assembly **27**. The assembly **27** includes a fine mesh metal screen **28** which is spaced several millimeters from the fluorescent material **26**. A storage screen **30** is formed, by evaporation or some other convenient means, on the surface of the conductive screen **28** and comprises a dielectric insulating material such as a film of silica or magnesium fluoride of the order of several microns in thickness. At a distance of the order of several millimeters from the conductive screen **28** in the direction towards the electron guns is a second fine mesh metal screen **32**. Screen **32** may be a woven or electroformed mesh of the order of 100 to 500 mesh per inch. The conductive screen **28** and the mesh storage screen **30** also may have a fineness of the order of 100 to 500 mesh per inch.

Assembly **20** is mounted on a ring **36** of insulating material fixed within the envelope **10** and adjacent the tube face plate **38**. Fixed to the ring **36** is an annular metal support ring **40** which supports intermediate its ends the glass support sheet **22** and across its open end the conductive screen **28**. Also mounted on the insulating ring **36** is a second annular metal support ring **42** across the ends of which is mounted the woven or electroformed metal mesh screen **32**. The conductive tin oxide film **24** is insulated from the support ring **42** by the glass sheet **22** and is connected by a lead **44** to a source of positive potential outside the envelope **10**. Mesh screen **32** also is connected to a source of positive potential via lead **46**. The conductive screen **28** during the tube operation, is set either to a predetermined bias potential for writing or at a more positive potential for erasure or for "holding" a stored picture as will be shown hereinafter.

The viewing gun **16** comprises a cathode electrode **48**, a control electrode **50**, a first accelerating electrode **52**, and a second accelerating electrode **54** mounted successively along the axis of the gun **16** toward the face plate **38**. During the tube operation these electrodes are maintained at appropriate voltages to form the electron emission from the cathode **48** into a wide beam or spray **56** of electrons for flooding a major portion of the surface of the storage screen. The inner surface of the envelope **10** has applied thereto a conductive coating **58** of colloidal graphite or tin oxide which coating may be maintained at the same positive potential as the second accelerating electrode **54**. A second conductive wall coating **60** extends from a point spaced from but adjacent coating **58** over the bulb wall enclosing the assemblies **20** and **27**. This coating is at a potential different from that of coating **58** and thus provides a collimating electron lens to align the electrons of the spray beam **56** in a direction axially with respect to the target assemblies.

The writing electron gun **18** comprises a cathode electrode **62**, a control electrode **64** and, successively spaced toward the target, a first accelerating electrode **66** and a second accelerating electrode **68**. The wall coating **58** extends into the neck **14** of the writing gun and forms a third accelerating electrode for forming the electrons of gun **18** into a sharply defined and focused beam **70**.

The voltages applied to the electrodes of the above tube are illustrative of typical suitable operating voltages but should not be considered as limiting. For example, the mesh screens **32** may be operated at between 200 and 2,000 volts positive with respect to ground. The conductive coating **24** may be operated within a range of from 2,000 to 20,000 volts positive relative to ground, while the potential applied to the conductive screen **28** may be varied from minus 100 volts to positive 2,000 volts relative to ground.

Tube operation

To prepare the storage target for storing a charge pattern on the mesh storage screen **30**, it is necessary to establish a uniform potential thereover. With the viewing gun turned on, the electrons of the spray beam **56** are accelerated with energies of the order of 1,000 volts through the metal mesh screen **32**. The conductive screen **28**, initially biased by a bias source **71** to a potential such as zero volts, is set to a potential sufficiently positive (of the order of 20 volts positive relative to ground) that the electrons of the spray beam **56** strike the surface of the storage screen film **30** at velocities or energies to initiate secondary emission from all portions of the film. In the present example the positive potential of 20 volts which is applied, as described hereinafter, to the conductive screen **30** is below the first crossover point on the secondary ratio curve of the silica (or magnesium fluoride) film. The first crossover point for a silica storage film (see Figure 2) is of the order of 75 to 150 volts while the first crossover point for a magnesium fluoride film is approximately 30 to 60 volts. Thus secondary emission is initiated having a ratio less than unity and the storage screen **32** assumes a uniform potential, in this instance viewing gun cathode potential. The entire surface of the storage screen may be brought to a uniform potential as described above in a fraction of a second.

The potential of the conductive screen **28** is then adjusted to approximately zero volts (ground potential). Because of the thinness of the storage screen **30**, screen **30** is closely coupled capacitively to the screen **28**, hence the relative potential difference therebetween is maintained; i. e., as the potential of screen **28** is changed from a 20 volts positive relative to ground potential, the potential of screen **30** changes by a corresponding amount from viewing gun cathode potential (ground potential) to approximately minus 20 volts relative to ground. The electrons of the spray beam **56** are accelerated through the mesh screen **32** and enter a retarding field adjacent the screen **30**, the retarding field turning the electrons back to the metal screen **32** which serves as a collector therefor. The 8,000 volt potential applied to the tin oxide film **24** creates a field which tends to extend through the interstices of the storage screen **30** to draw electrons through the screen to bombard the fluorescent layer **26**. The voltage to which the storage screen **30** is set (minus 20 volts), however, just prevents any electrons from passing therethrough.

The writing gun **18** is then turned on and produces a sharply defined and focused beam **70** which may be deflected to scan over the surface of the storage insulator **30**. The deflection may be accomplished, for example, by supplying vertical and horizontal pairs of deflection plates **72** and **74**, respectively, with suitable deflection signals from deflection signals from deflection generators **76** and **78**, respectively. While the writing beam **70** is being deflected in the desired pattern, the beam **70** is modulated by video signals applied to the writing gun control grid **64** from an input circuit **80**. The writing beam impinges on the mesh storage screen **30** at a voltage of approximately 3,000 volts which is between the first and second cross-over points on the secondary emission ratio curve thereof.

In this manner the writing beam initiates secondary emission from the surface of the storage screen such that more electrons leave the surface than impinge thereon. In those areas where the beam **70** strikes, the storage screen surface is driven positively from its potential of minus 20 volts toward viewing gun cathode potential or ground. Provided the ratio of the spray beam average current density to the average current density of the writing beam over a given time interval is unity or greater, no point on the insulator surface will stay positively charged with respect to ground since electrons from the spray beam **56** land continuously at that point and drive it back to ground potential, or slightly negative with respect to ground. In the areas where the storage screen **30** has been driven positively (from minus 20 volts), the positive field of the fluorescent layer **26** now penetrates to draw the low energy electrons of the spray beam **56** through the interstices of screens **30** and **28** to strike the fluorescent screen **26** and cause luminescence. This luminescence appears only on areas of the fluorescent screen **26** corresponding to areas of the storage insulator driven positively by secondary emission and hence corresponding to the image pattern of the writing beam.

This type of writing provides a visual display in which stored information appears as "white" on a dark background. Once a signal has been stored and displayed, theoretically it should remain stored and displayed indefinitely since the mode of tube operation described above is such that the low velocity spray beam **56** normally does not come in contact with the charged areas of the storage screen **30** and therefore does not disturb the established charge pattern. Actually, however, the charges established thereon gradually are dissipated by spurious ions produced within the tube.

Erasing

A synchronizer **82**, a pulse generator, produces pulses at a predetermined pulse repetition rate which simultaneously are coupled to a horizontal deflection wave generator **78** and to a pulse divider circuit **84**. The divider circuit produces an output pulse in response to a predetermined number of input pulses. Assuming that the instant method of erasing is to be utilized in connecion with a typical B-scan radar system, and that in the radar system the pulse repetition rate is 1000 pulses per second and six seconds is required for a 360° azimuth search, the divider circuit **84** produces one output pulse in response to each 6,000 input pulses. Each output pulse derived from the divider **84** is applied to a vertical deflection wave generator **76**. The horizontal and vertical deflection generators **78** and **76**, respectively, produce sawtooth deflection signals which are applied to the pairs of deflection plates **72** and **74** of the storage tube to deflect the writing beam to rectilinearly scan the storage screen **30**.

During the horizontal deflection intervals video signals are applied to the writing gun control electrode **64** via input circuit **80** and modulate the intensity of the writing beam **70** to establish a charge pattern on the storage screen **30** and a corresponding visual display on the fluorescent layer **26**.

Entirely independently of the generation of the writing deflection signals, a free-running multivibrator **86** produces pulses at some selectable repetition rate. A multivibrator which is particularly suitable for use in the present erasing system is a free running positive-bias multivibrator of the type illustrated at page 269 of Reference Data for Radio Engineers (third edition) published by the Federal Telephone and Radio Corporation. The multivibrator pulses are amplified in a pulse amplifier **88** having a gain control **90**. The amplifier output is developed across a load impedance **92**, each pulse developed thereacross driving the conductive screen **28** of the storage tube approximately 20 volts positive with respect to ground potential.

The erase process is controlled so that each pulse applied to the screen **28** causes a fractional portion of the overall stored electrical charge pattern to be erased. For example, if the multivibrator **86** generates 800 pulses per 360° radar search interval, the duration of each pulse is adjusted by means of a pulse duration or width control **94** so that a given pulse causes the overall erasure of an eight-hundredth of the stored charge pattern. If 1000 pulses are to be generated during this interval the pulse repetition frequency control **96** and the pulse duration control **94** are adjusted so that the desired number of pulses are produced and only one one-thousandth of the charge pattern is erased. Thus either or both the pulse repetition rate and the pulse duration may be varied for erasure as desired by suitably varying circuit constants in the charging circuit of the multivibrator. By employing the above erasing technique, erasure is provided independently with respect to the writing process and a given line of "old" data (derived during one search interval) may be completely erased just prior to being replaced with a line of "new" data obtained in the next succeeding search interval.

Long-time signal storage

The circuitry described above may be used to achieve long time storage of electrical data rather than incremental erasure as heretofore shown. According to this mode of operation the gain control **90** is set to control the gain of the pulse amplifier **88** so that the pulses applied to the conductive screen **28** have amplitudes of the order of 60 volts for a magnesium fluoride insulator and amplitudes of the order of 100 volts for a silica insulator, in each case, just above the first crossover point.

Under such conditions, for the durations of those pulses, portions of the storage insulator **30** which are carried above first crossover potential are charged in a positive direction and portions of the insulator below the first crossover point are charged in a negative direction. The portions carried above the first crossover potential correspond to highlight portions of the display provided on the fluorescent material **26** while the insulator portions below first crossover correspond to dark areas of the display. A single frame of data stored in the manner described above may be retained for a period of time approximately 10^3 times longer than without pulsing.

In this mode of operation the pulses produced by the multivibrator **86** have durations short enough so that no area of the storage insulator **30** remains equal to or greater than the first crossover voltage in the intervals between pulses. If the pulse duration is too great, electrons from the viewing beam **56** drive these storage areas to the potential of the collector screen **32**. Thenthe insulator **30** either may break down or the size of stored charge may increase or diminish thereby effectively "creeping" across the insulator.

What is claimed is:

1. A signal storage system including, an electrical storage tube having an electron permeable charge storage member, means spaced from one side of said charge storage member for providing a stream of electrons for flooding a major portion of the surface of said member, a fluorescent viewing screen spaced from the opposite side of said charge storage member, means for providing a sharply defined and focused beam of electrons, means for deflecting said sharply defined and focused electron beam across said charge storage member, connection means for a source of signals for modulating said beam during said deflection to write an electrical charge pattern on said member, the charge pattern written on said member modulating the flow of said stream of electrons so that electrons passing through said electron permeable member impinge on said viewing screen and produce a visual display corresponding to said charge pattern, means for generating time-spaced pulses at a predetermined pulse repetition rate, and means coupling said pulse generating means to said storage tube to pulse said charge storage member with respect to said flood beam generating means while said focused electron beam is deflected across said charge storage member.

2. Apparatus as claimed in claim 1 including means for adjusting the pulse duration of said pulses.

3. Apparatus as claimed in claim 1 including means for adjusting the pulse repetition rate of said pulses.

4. Apparatus as claimed in claim 1 including means for adjusting both the pulse duration and the pulse repetition rate of said pulses.

5. Apparatus as claimed in claim 1 including means for adjusting the amplitude level of said pulses.

6. A signal storage tube system comprising, an electrical storage tube having an electron permeable charge storage member, means spaced from one side of said charge storage member for providing a stream of electrons for flooding a major portion of the surface of said member, a fluorescent viewing screen spaced from the opposite side of said charge storage member, means for providing a sharply defined and focused beam of electrons, means for deflecting said sharply defined and focused electron beam across said storage member, connection means for a source of signals for modulating said beam during said deflection to write an electrical charge pattern on said member, the charge pattern written on said member modulating the flow of said stream of electrons so that electrons passing through said electron permeable member impinge on said viewing screen and produce a visual display corresponding to said charge pattern, a free-running multivibrator for repetitively generating pulse signals, and an amplifier coupled to the output of said multivibrator and to said charge storage member for pulsing said member with amplified multivibrator signals while said focused electron beam is deflected across said charge storage member.

7. Apparatus as claimed in claim 6 including a gain control circuit for adjusting the gain of said amplifier.

8. A signal storage tube system comprising, an electrical storage tube having an electron permeable charge storage member, means spaced from one side of said

charge storage member for providing a stream of electrons for flooding a major portion of the surface of said member, a fluorescent viewing screen spaced from the opposite side of said charge storage member, means for providing a sharply defined and focused beam of electrons, means for deflecting said sharply defined and focused electron beam across said storage member, connection means for a source of signals for modulating said beam during said deflection to write an electrical charge pattern on said member, the charge pattern written on said member modulating the flow of said stream of electrons so that electrons passing through said electron permeable member impinge on said viewing screen and produce a visual display corresponding to said charge pattern, and means coupled to said charge storage member for repetitively generating pulses at a predetermined pulse repetition rate for periodically pulsing said storage member while said focused electron beam is deflected across said charge storage member.

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