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METHODS AND MEANS FOR UTILIZING A DIRECT-VIEW TYPE ELECTRICAL STORAGE TUBE

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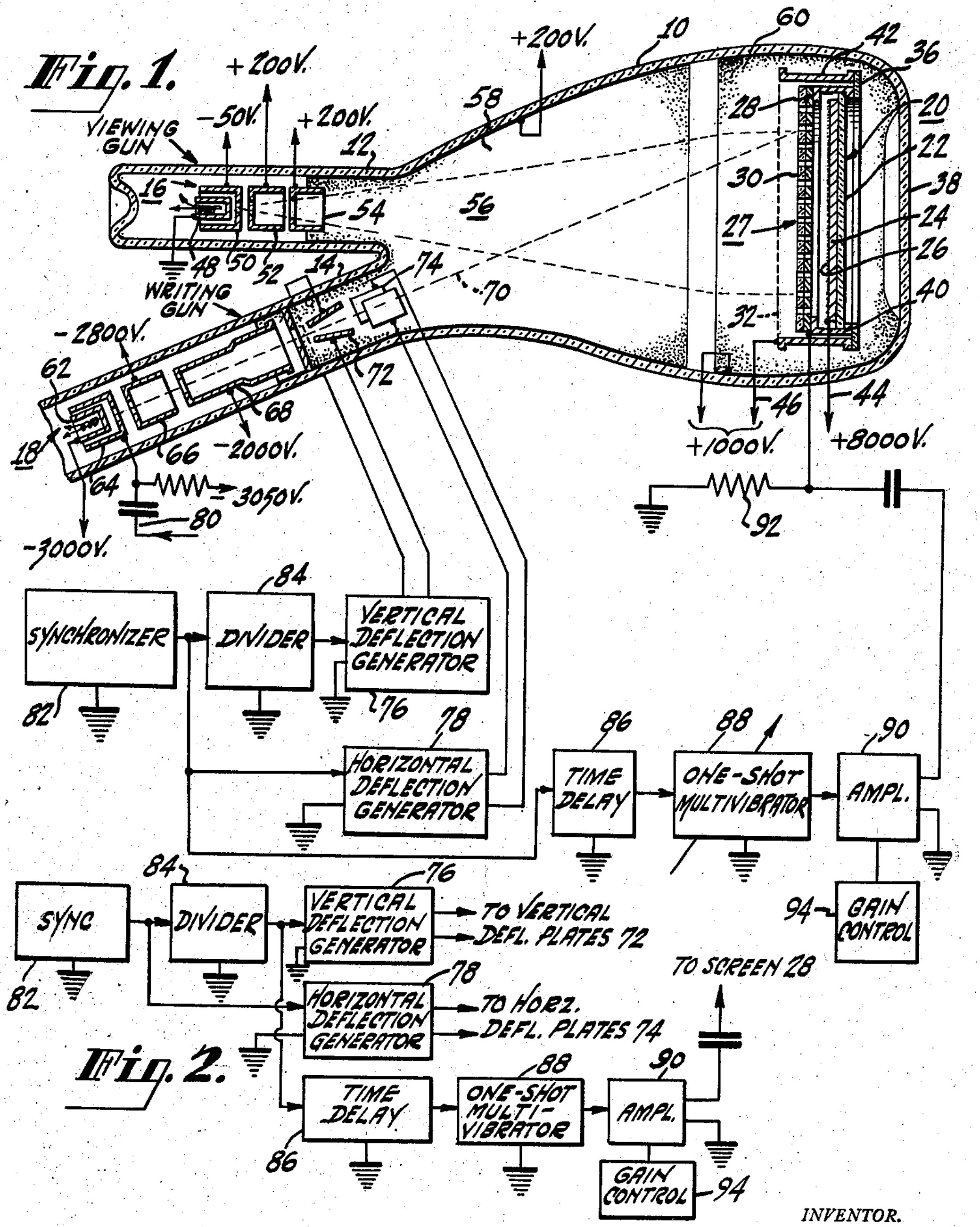

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METHODS AND MEANS FOR UTILIZING A DIRECT-VIEW TYPE ELECTRICAL STORAGE TUBE

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10 Claims. (Cl. 315—12)

This application is a continuation-in-part of my original application Serial No. 306,709, filed August 27, 1952, assigned to the same assignee as the instant application and which is now abandoned.

This invention relates generally to signal storage and display and more particularly to improved methods and means for utilizing a direct-view type electrical storage tube for displaying signal intelligence.

A number of presently known signal display systems are used in connection with radar systems, ground-to-air private line communication systems, and other systems. Such systems generally are complex and cumbersome. To obtain the features of both signal storage and signal display such systems usually require a pictorial display tube and also one or more electrical storage tubes. Since at least two cathode ray devices are required, it will be seen that the circuitry for use therewith (i. e., deflection generators, synchronizers, deflection yokes and/or sweep resolvers, amplifiers, etc.) is extensive. This is prohibitive not only economically and practically but also spatially (particularly in airborne systems). It is desirable to employ a system utilizing a single cathode ray device in which there is provided the features of both signal storage and display.

Such a tube has been developed and is described in detail in now abandoned patent application, Serial No. 254,999, filed November 6, 1951, by Max Knoll and in a continuation-in-part thereof Serial No. 295,768, filed June 26, 1952, by the same inventor. In addition to the combined storage and display features mentioned above, other advantages of the direct-view storage tube include greater picture brightness for a given anode voltage, less flicker for a given signal bandwidth, a picture storage time of several minutes substantially without picture decay, and less extensive associated system circuitry.

In the aforementioned Knoll patent applications, data displayed by the direct-view tube is completely and instaneously erased by manually adjusting the amplitude and polarity of potentials which are applied to certain electrodes contained therein. According to the present invention these potentials periodically and recurrently are controlled in a predetermined manner to achieve a desired result. For example, in one mode of operation information stored and displayed in the above tube incrementally may be erased during the interval following the writing of each line of data. A fractional portion of the overall stored electrical charge pattern is erased in the time interval between the end of the writing of one line of data and the beginning of the writing of the next succeeding line of data. By controlling the extent of incremental erasure during each such interval, it will be seen that a given line of "old" data may be completely erased substantially immediately before being replaced with "new" data.

Signal integration and noise discrimination also may be achieved, according to a further feature of the invention, by modifying the erasing system operation to erase data incrementally during the intervals between the writing of successive frames of information. While both desired and undesired signals (noise) are partially erased during a given erase period, the desired signals are rewritten in each succeeding frame and are integrated. The noise signals, however, are statistical in nature and occur randomly. Thus over several frame times the undesired noise signals are almost completely eliminated.

In the line-by-line and frame-by-frame erasing and integrating arrangements mentioned above pulses are applied to the tube to control erasure. According to another feature of the invention long time storage of electrical data is afforded, without erasure, by writing a frame of data during predetermined writing intervals and by applying pulses to the tube, between successive writing intervals, which have amplitudes greater than the pulse amplitude required for erasure. By this means electrical charge data stored on a storage insulator is maintained for an extremely long period of time.

An object of the invention is to provide improved methods of and means for storing electrical data.

An object of the instant invention is to provide an improved and simplified signal display system.

Another object of the invention is to provide a signal display system which is flexible in its field of application.

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

A further object of the invention is to provide improved methods and means for erasing data stored and displayed in the direct-view storage tube.

A still further object of the invention is to provide an improved signal display system providing signal integration and noise discrimination.

A still further object of the invention is to provide an improvjed signal storage and display system providing long time storage of electrical data.

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

Figure 1 is a cross-sectional schematic diagram, partially in block form, of a direct-view storage tube and an erasing system therefor, according to the invention; and

Figure 2 is a schematic diagram, in block form, of a modification of the erasing system shown in Figure 1.

Similar reference characters are applied to similar elements throughout the drawings.

Storage tube structure

Figure 1 of 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 layer **26** formed from a phosphor material which fluoresces under electron bombardment.

In the direction towards the electron guns from the surface of the fluorescent layer **26** is a storage target assembly **27** including a fine mesh metal screen **28** spaced at a distance of several millimeters from the fluorescent layer **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 ten 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 stainless steel screen of the order of 230 lines per inch while the conductive screen **28** and the storage screen **30** may have a fineness of the order of 200 lines per inch.

Assembly **20** is mounted on a ring **36** of insulating material fixed within the envelope **20** 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 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 at ground potential for writing or at a more positive potential of the order of twenty volts for erasure, 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. The inner surface of the envelope **10** has applied thereto a conductive coating **58** of colloidal graphite which coating may be maintained at the same positive potential as the second accelerating electrode **54**. A second 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 **58** 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 focussed 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 screen **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 up to 1,000 volts through the metal mesh screen **32**. The potential of conductive screen **28** 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 cross-over point on the secondary ratio curve of the silica (or magnesium fluoride) film. The first crossover point for a silica storage film 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 completely erased to a uniform potential as described above in a fraction of a second.

The potential applied to the conductive screen **28** is then set to approximately 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 to ground potential, the potential of screen **30** changes by a corresponding amount from viewing gun cathode potential (ground potential) to approximatley 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 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 crossover 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 screen **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 layer **26** and cause luminescence. This luminescence appears only on areas of the fluorescent layer **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

Figure 1 shows an erasing system, according to one feature of the invention, for use with the direct-view storage tube which system is adapted for cyclically and incrementally erasing data stored and displayed thereby. A synchronizer **82** repetitively produces pulses at a predetermined pulse repetition rate which pulses simultaneously are coupled to a horizontal deflection wave generator **78** and to a pulse rate divider circuit **84**. The divider circuit produces one output pulse in response to a predetermined number of input pulses. Assuming that the erasing is to be utilized in connection with a typical B-scan radar system, the divider circuit **84** may produce one output pulse in response to each 6,000 pulses input thereto. This assumes a synchronizer pulse repetition rate of 1,000 cycles per second and an azimuth scanning rate of one 360° search every six seconds. 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 **70** 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 predetermined charge pattern on the storage screen **30** and a corresponding visual display on the fluorescent layer **26**.

Simultaneous with the application of synchronizer pulses to the divider circuit **84** and to the horizontal deflection generator **78**, the synchronizer pulses also are successively applied to a time delay circuit **86** and to a one-shot multivibrator **88**. The time delay provided by the circuit **86** is adjusted such that the leading edges of the one-shot multivibrator pulses each occur slightly after the writing of each line of information. The multivibrator pulses thus produced are applied to an amplifier **90**, preferably a cathode-follower, output signals of which are developed across a load inpedance **92** to periodically and instantaneously drive the conductive screen **28** of the storage tube approximately 20 volts positively with respect to ground potential to effect partial erasure of the stored data. By this means information stored in the direct-view tube incrementally is erased in the "flyback" interval following each writing interval.

The erase interval may be controlled by controlling the multivibrator pulse duration and the extent or "depth" of erasure may be controlled by suitable adjustment of the amplitude of the erasing pulse. The erasing pulse duration may be controlled, for example, by varying circuit constants in the charging circuit of the one-shot multivibrator **88** while the erasing pulse amplitude may be controlled by means of a gain control circuit **94** associated with the amplifier **90**. By properly adjusting the amplitude and duration of the erasing pulse, it will be seen that a given line of data is partially erased during each flyback interval and is completely erased in one frame time and just prior to being replaced with a line of new data. Thus an up-to-date display of information is provided wherein old data cyclically may be erased and replaced with new information.

Signal integration and noise discrimination are afforded according to a further feature of the invention. According to this feature of the invention and referring to Figure 2 of the drawing, signals applied to the input of the time delay circuit **86** are derived from the output circuit, rather than the input circuit, of the pulse rate divider circuit **84**. Thus erasing pulses are produced only in the time intervals between the writing of successive frames of information.

In this mode of operation, it will be seen that both desired signals and noise signals are written during a given frame time and are partially erased just prior to the writing of the next frame of data. In the next frame time the desired (and partially erased) signals are rewritten to enhance the charge pattern established during the writing of the preceding frame. The noise signals, however, because of their random occurrence are not rewritten in the same areas on the tube storage screen **30** in successive frames. Thus the desired signals are integrated and noise signals are erased. Since the normal tendency of the human eye is to integrate the displayed information and since the last few lines of data written in a given frame are viewed for a relatively short time compared to other lines of data previously written, it may be desirable to employ a shading circuit such as a variable gain amplifier (not shown) to bring up the level of data last written so that the overall display appears to be of constant brightness.

The above erasing system has been described in connection with the writing, erasing, and displaying of a recti-linear B-scan type radar presentation. It is pointed out, however, that the "pulsing" techniques herein proposed are of general applicability. Television displays, PPI (plan-position indication), and other such displays may be incrementally erased with equal facility.

Long-time signal storage

The circuitry described with reference to Figure 1 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 **94** is set to control the gain of the pulse amplifier **90** 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, above the first crossover point.

Under such conditions, for the durations of these 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 layer **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 **88** 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**. Then the 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 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 storage tube for repetitively generating pulses at a predetermined pulse repetition rate for periodically pulsing said charge storage member with respect to said flood beam generating means.

2. A system as claimed in claim 1, wherein said pulse generating means includes means for controlling the pulse duration of pulses produced thereby.

3. A system as claimed in claim 1, wherein said pulse generating means includes means for controlling the pulse amplitude of pulses produced thereby.

4. A system as claimed in claim 1, wherein said pulse generating means includes means for controlling the amplitude and duration of pulses produced thereby.

5. A system as claimed in claim 1, wherein said pulse generating means produces time spaced pulses which are equal in amplitude.

6. A signal storage system including, an electrical storage tube having a charge storage member, a fluorescent screen spaced from one side of said charge storage member, means for generating a focused beam of electrons, means for deflecting said focused beam across said charge storage member in a predetermined manner, connection means for a source of signal data for modulating said beam during said deflection to write an electrical charge pattern on said charge storage member, means located on the other side of said charge storage member for generating a beam of electrons for flooding a major portion of the surface area of said charge storage member to translate the charge pattern stored thereon into a corresponding visual presentation on said fluorescent screen, means for generating time-spaced pulses of electrical energy at a predetermined pulse repetition rate, and means coupled between said pulse generating means and said charge storage member for applying said pulses to said member during predetermined time intervals in which said focused beam is undeflected.

7. A signal storage system including, an electrical storage tube having a charge storage member, a fluorescent screen, spaced from one side of said charge storage member, means for generating a focused beam of electrons, means for deflecting said focused beam across said charge storage member in a predetermined manner, connection means for a source of signal data for modulating said beam during said deflection to write an electrical charge pattern on said charge storage member, means located on the other side of said charge storage member for generating a beam of electrons for flooding a major portion of the surface area of said charge storage member to translate the charge pattern stored thereon into a corresponding visual presentation on said fluorescent screen, means for generating time-spaced pulses of electrical energy at a predetermined pulse repetition rate, and means coupled between said pulse generating means and said charge storage member for applying said pulses to said member in the time intervals between successive deflections of said focused beam.

8. A signal storage system including, an electrical storage tube having a charge storage member, a fluorescent screen spaced from one side of said charge storage member, means for generating a focused beam of electrons, means for deflecting said focused beam across said charge storage member in a predetermined manner, connection means for a source of signal data for modulating said beam during said deflection to write an electrical charge pattern on said charge storage member, means located on the other side of said charge storage member for generating a beam of electrons for flooding a major portion of the surface area of said charge storage member to translate the charge pattern stored thereon into a corresponding visual presentation on said fluorescent screen, means for generating time-spaced pulses of electrical energy at a predetermined pulse repetition rate, and means coupled between said pulse generating means and said charge storage member for applying said pulses to said member in the time intervals between the establishing of successive electrical charge patterns.

9. A signal storage system including, an electrical storage tube having a charge storage member, a fluorescent screen spaced from one side of said charge storage member, means for generating a focused beam of electrons, means for deflecting said focused beam across said charge storage member in a predetermined manner, connection means for a source of signal data for modulating said beam during said deflection to write an electrical charge pattern on said charge storage member, means located on the other side of said charge storage member for generating a beam of electrons for flooding a major portion of the surface area of said charge storage member to translate the charge pattern stored thereon into a corresponding visual presentation on said fluorescent screen, means for generating time-spaced pulses of electrical energy at a predetermined pulse repetition rate, and means coupling said pulse generating means to said storage tube to pulse said storage member with respect to said flood beam generating means during predetermined time intervals in which said focused beam is undeflected.

10. 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 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.

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