

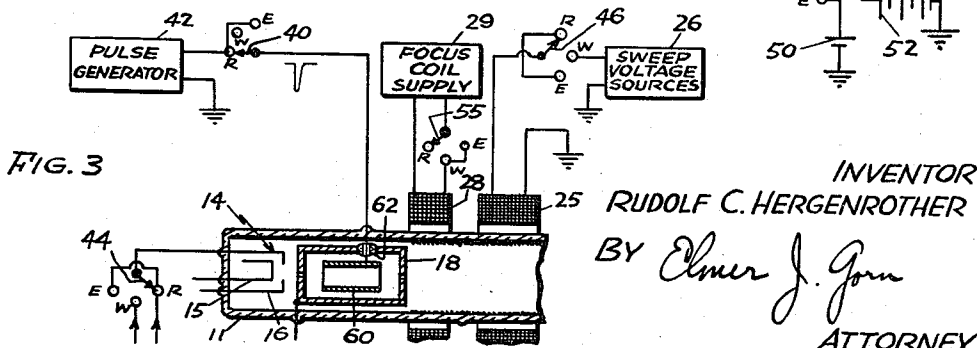
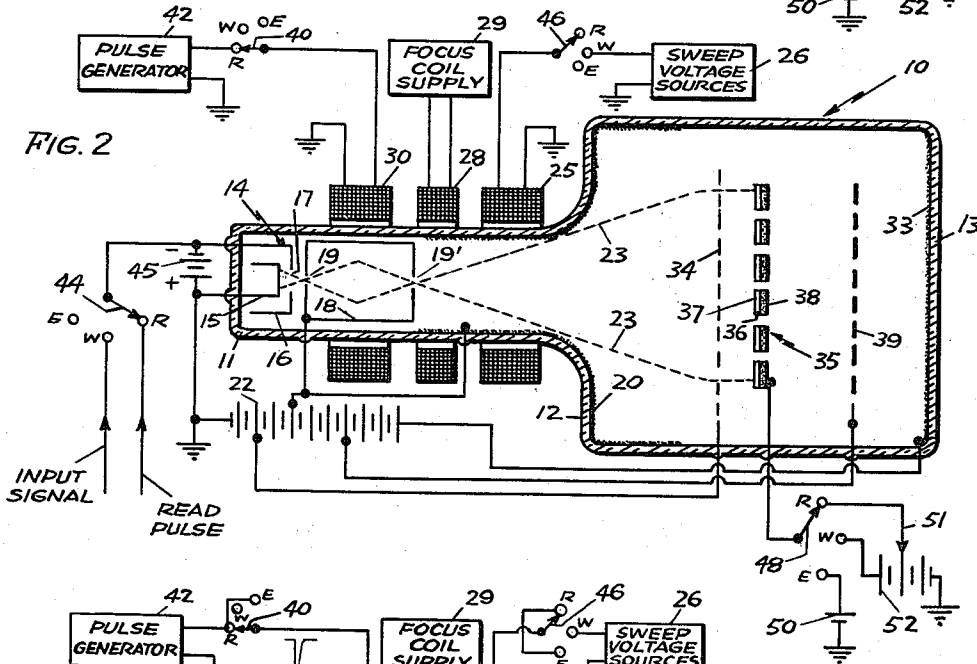
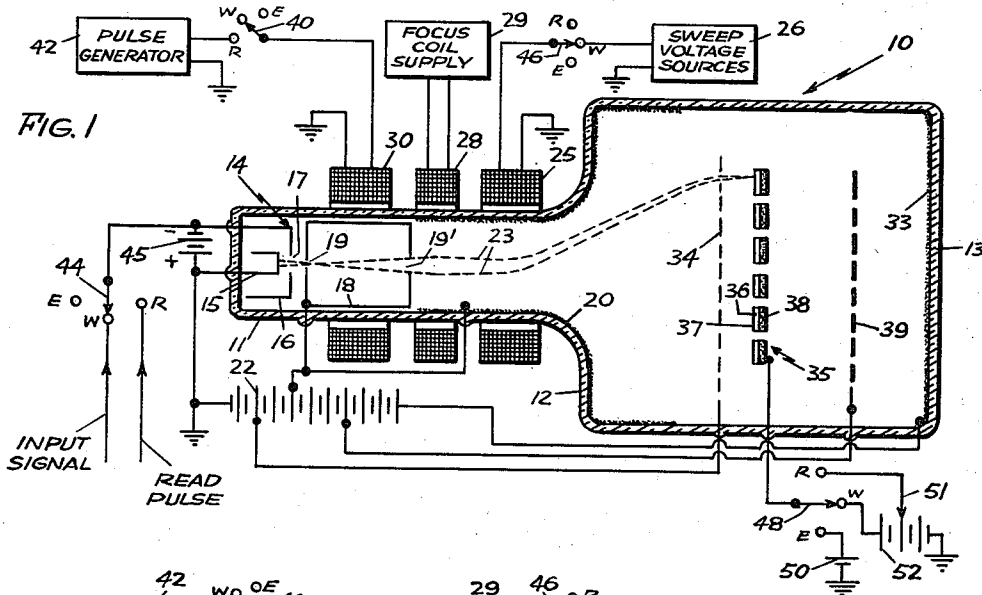
Jan. 19, 1960

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2,922,071

DIRECT-VIEWING STORAGE TUBES

Filed June 24, 1955



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DIRECT-VIEWING STORAGE TUBES

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Application June 24, 1955, Serial No. 517,830

13 Claims. (Cl. 315—12)

This invention relates to a direct-viewing recording storage tube, and, more particularly, to a storage tube having a single electron gun for both reading and writing.

In a direct-viewing storage tube, it is desirable to write information into the surface of a dielectric storage layer by scanning a well-focused electron beam past the storage surface whose intensity is a function of an input modulating signal. It is likewise desirable to read information from the entire area of the storage layer by means of a wide angle reading beam which floods the entire storage layer. These operations may be accomplished by means of separate electron guns.

In accordance with this invention, however, the change from a scanned narrow writing beam, converging to a focus at the storage surface, to a wide angle reading beam is accomplished with a single electron gun. This change is effected by increasing the electron beam current, for example, by application of a positive-going potential to the control grid of the electron gun, and by means of a flash focusing means comprising either a coil or an electrostatic cylindrical element mounted adjacent the electron gun and energized, as by a large amplitude pulse, during the reading operation. The increase in cathode electron emission from the electron source, together with the magnetic or electrostatic lens produced by the energized flash focusing means, causes the electron beam, which normally converges at the storage surface, to diverge in such a manner as to flood the storage surface whenever information is to be read out of the storage tube.

Further advantages of this invention will be apparent as the description progresses, reference being had to the accompanying drawing wherein:

Fig. 1 is a view showing a storage tube in cross section, and the associated circuitry which is required for the erasing and writing operations;

Fig. 2 is a view showing the storage tube of Fig. 1 with the modifications in circuitry necessary for reading information from the tube; and

Fig. 3 is a fragmentary view showing a modification of the circuitry of Figs. 1 and 2.

Referring to Fig. 1, an image recording storage tube 10 is shown, comprising an envelope which may be made of glass, having an elongated neck portion 11, and an enlarged portion 12 terminating in an end face 13. An electron gun 14, including a cathode 15, a control grid 16 containing an aperture 17, a first cylindrical anode 18 containing centrally located apertures 19 and 19' at opposite ends thereof, and a second anode 20 is positioned within the neck 11 of tube 10. The second anode 20 may, for example, comprise an electrically conductive coating on the inner surface of the tube and may extend well into the enlarged portion thereof. The necessary potentials for the electron gun electrodes, as well as for other electrodes of the storage tube, are derived from a unidirectional source of energy, shown by way of ex-

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ample as a battery 22, having taps therealong for connection to the various electrodes.

Electrons emitted by cathode 15 are urged through the aperture of control grid 16 by the accelerating field between grid 16 and first anode 18. The electrons passing through the control grid aperture 17 form a beam which, because of the electron lens comprising the grid 16 and first anode 18, converges to a first cross-over point on the longitudinal axis of the storage tube adjacent the first aperture 19 in cylindrical anode 18. Beyond the cross-over point, the beam starts to diverge, as clearly shown in Figs. 1 and 2. The course of the electron beam is indicated by the dotted rays 23. The angle at which the electron beam diverges after leaving the cross-over region may be referred to as the "beam angle." This angle may be shown to increase as the beam current increases.

Surrounding the neck of tube 10 are horizontal and vertical deflection coils, indicated by the single reference numeral 25, which are energized by appropriate sweep generators 26. Although the deflection system shown is electromagnetic, an electrostatic deflection system may be used, in which case the deflection coils would be replaced by the usual perpendicular pairs of deflection plates. The vertical and horizontal sweep rates are governed largely by the degree of flicker permissible and may be those used in ordinary television techniques.

A magnetic focus coil 28, energized from an appropriate focus coil supply 29, surrounds the neck of the storage tube in the region of tube 10 just beyond the accelerating anode 18. The focus coil 28, when energized by the current from supply 29, serves as a converging lens for focusing the electron beam on storage member 35, to be described subsequently.

A flash focus coil 30 is positioned about the neck of the tube in the region of first anode 18 and is energized during closure of switch 40 by a pulse from pulse generator 42. As will be indicated later, an electrostatic lens may be substituted for the magnetic lens or flash focus coil 30.

A fluorescent screen 33 is mounted on or near the face of tube 10, and serves as an electron collector during the reading operation, as will be explained more fully later. Screen 33 may consist of a fluorescent material applied directly to the inner surface of the face 13 of tube 10.

A decelerating electrode 34, which may be cylindrical, at the end of tube 10 nearest fluorescent screen 33, is positioned near the storage member 35 on the electron gun side. Electrode 34 is maintained considerably more negative than accelerating anode 20 and, together with electrode 20, forms a decelerating lens owing to the retardation field between these electrodes; the electrons are thereby directed through the decelerating electrode 34 generally perpendicular thereto over a large deflection angle.

A storage member 35 is positioned within the enlarged portion of tube 10; between the decelerating electrode 34, and fluorescent screen 33, and generally parallel thereto. Storage member 35 consists of a storage material 36 in the form of a layer of dielectric material having a relatively high electrical resistivity such as calcium fluoride coated on an electrically conductive supporting mesh 38. The storage layer or material 36 is deposited upon the side of mesh 38 facing electron gun 14.

Storage tube 10 also includes an accelerating electrode 39 positioned between storage member 35 and fluorescent screen 33. Electrode 39 is maintained at a potential intermediate that of the storage member and the fluorescent screen. It thus provides an accelerating field in the region between the storage member and the fluorescent screen for improving the brightness of the storage tube.

The operation of the storage tube consists of three

separate operations, namely, erasing, writing and reading. These operations will be described in detail later.

An input signal containing the information to be written into the storage tube may be applied to control grid 16 when input switch 44 is in the position designated "W," and a pulse which is positive with respect to the cathode may be supplied to the control grid during the reading operation when input switch 44 is in the position indicated as "R." During the erasing operation the potential of control grid 16 is determined only by the fixed bias from source 45.

Before writing on the storage member 35, an erasing operation is achieved. During this erasing operation, switch 40 is in the position designated as "E" so that flash focus coil 30 is deenergized. When switch 40 is open, that is, in position "E," there is no current flow in flash focus coil 30; in the absence of magnetic lens action, therefore, the electron beam passing through anode cylinder 18 continues to diverge, as shown in Fig. 1. After passing through aperture 19' in anode cylinder 18, the electron beam enters the magnetic field produced by focus coil 28. The action of the magnetic field in the region of focus coil 28 is to converge the electron beam so that it becomes focused on storage member 35, as indicated in Fig. 1.

When switch 46 is closed, that is, in position "E," the sweep voltages are applied to deflection coils 25 and the converging electron beam is scanned over the elemental areas of the storage surface 37 of storage member 35. When switch 48 is in the position designated "E," a potential is supplied to the electrically conductive mesh 38 of storage member 35 by means of a battery 50, whose negative terminal is connected to ground (potential of cathode 15). During the erasing operation, the storage member potential, that is, the potential of the storage mesh 38 relative to the cathode 15, is maintained below the critical voltage, that is, the voltage at which the secondary emission ratio of storage surface 37 is unity, by means of the aforesaid battery 50. When the storage surface potential is less than this critical potential, which in one example was of the order of 40 volts, storage surface 37 will charge negatively until it reaches equilibrium at the cathode potential. The entire storage surface 37 of storage material 36 scanned by the electron beam is thereby uniformly charged to the cathode potential. Switch 44 in the grid circuit of storage tube 10 is in the position designated as "E" while the storage surface is being erased negatively.

It is possible to erase in two separate steps, that is, to first erase positively by biasing the conductive mesh 38 above the critical potential of storage member 35, and then to bias the mesh negatively in the manner already described. This two-step erasing operation sometimes results in more rapid erasure of storage material 36.

The writing operation will now be described. The movable contacts of switches 40, 44, 46 and 48 are now moved to the position indicated as "W." With input switch 44 in the position designated as "W," signal information is applied to the beam intensity control grid 16 of storage tube 10, and modulates the electron beam. During the writing operation, sweep voltages are still applied to sweep coils 25 and the flash focus coil 30 remains deenergized. It is necessary, when changing from the erasing operation to the writing operation, to vary the potential applied to storage mesh 38, so that this potential is above the critical potential instead of below the critical potential, as in the erasing operation. As shown in Figs. 1 and 2, battery 52 supplies a potential to storage mesh 38 through switch 48, which is more positive than that supplied by battery 50 during the erasing operation. Although the potential of storage mesh 38 is indicated as positive with respect to the cathode in both erasing and writing operations, this need not always be true.

The electron beam, as modulated by the input signal, is caused to scan surface 37 of storage material 36 and the storage surface 37 is charged by the modulated beam current toward the storage screen potential. The amount of charge on each element of the storage surface is dependent upon the beam current amplitude when that element is scanned. The charge that is formed on the elements of the storage surface is thus determined by the content of the input information. Care must be taken, however, that the writing time is sufficiently short as not to produce saturation.

When it is desired to read the stored information out of storage tube 10, the switch contacts are moved to the position designated as "R." When switch 46 is in the "read" position, the sweep voltages are removed from coils 25. Simultaneously, switch 40 is closed, and a current pulse from generator 42 flows through flash focus coil 30. A focusing magnetic field is thus set up about cylindrical anode 18 and an electron lens is introduced into the path of the electron beam. The action of this lens is to cause the diverging beam within anode 18 to converge, as shown in Fig. 2, until it crosses over adjacent aperture 19' in anode 18. Since the deflection voltages are now removed, the beam continues to diverge, subject to some converging action from the focus coil 28, until it impinges upon storage surface 37. Focus coil 28 may be deenergized during the reading operation, if desired, as by a switch 55 shown in Fig. 3. In the interest of circuit simplicity, however, it may be preferable to continuously energize focus coil 28 provided the amount of convergence produced by coil 28 is not too serious.

In order to increase the beam angle, previously referred to, sufficiently to obtain the desired flood beam width, the control electrode 16 is made increasingly positive during the reading operation. This also results in an increase in beam current which is helpful in brightening the image on the fluorescent screen. This may be accomplished either by varying the supply 45 or, preferably, by means of a positive-going read pulse, such as shown in the drawing. Since the flash focus coil 30 is energized by means of a pulse of large amplitude but short duration, the read pulse voltage applied to the grid should be of sufficient amplitude to insure adequate divergence angle of the beam during the flash focus current pulse. Since the electron beam is a wide angle beam the entire area of the storage surface is flooded.

When reading the stored information, the storage member mesh voltage is dropped to such a level as to cause uncharged areas of the storage surface 37 to attain a negative voltage sufficient to cut off an electron beam aimed at these areas. This may be accomplished when switch 48 is in the "read" position, indicated by "R," by means of a variable tap 51 on battery 52. Alternatively, a battery of smaller voltage reading than battery 52 could have its ungrounded terminal connected through contact "R" to mesh 32. If the mesh potential is, for example, 50 volts positive relative to the cathode during the writing operation, and the maximum storage surface potential at the end of writing periods at areas corresponding to the maximum input signal strength were 20 volts positive with respect to the cathode, the mesh potential would be reduced to a value of, say, 20 volts positive with respect to the cathode during the reading operation, so that the entire storage surface potential becomes 30 volts more negative than during the writing operation. The storage surface potential pattern written on the storage surface is carried to a negative level by electrostatic induction, that is, the storage surface potential would vary from minus 30 volts for uncharged areas of the storage surface to about minus 5 volts for maximum charge, all with respect to the cathode. Since the entire storage surface 37 is now negative, electrons attracted to fluorescent screen 33 by the accelerating field between storage member 35 and fluorescent screen 33 are prevented from falling upon

storage member 35 and thus altering the charge on the storage surface during the reading operation. The potential reduction is effected before the reading beam is turned on, that is, during the interval between the switching from position "W" to "R." The magnitude of the beam current passing through a given element of the storage member is proportional to charge on the corresponding elemental area of storage surface 37. The beam, upon striking fluorescent screen 33, produces an image thereon whose intensity at any given elemental area depends upon the beam current passing a corresponding element of the storage member 35.

Although the erasing operation already described involves scanning a narrow beam past storage member 35, it is also feasible to erase by flooding the storage member with a wide angle beam in the same manner as in the reading operation. If it is desired to erase by means of the wide angle beam rather than by the narrow scanning beam, it is necessary only to modify switches 44 and 46 in the manner shown in Fig. 3, or to use two-position switches in which one position is used for both erasing and reading, while the other position is used for writing.

Fig. 3 also includes a switch 55 which removes the focusing potential from focus coil 38 during the intervals in which a wide angle beam is required. As previously mentioned, this switch is not always essential, provided the converging effect on the beam produced by the focus coil is not too severe.

The flash focus coil 30 shown in Figs. 1 and 2, may be replaced by an electrostatic lens consisting of a cylindrical element 60 mounted within the cylindrical anode 18, as shown in Fig. 3. The cylindrical lens 60 is connected to pulse generator 42 by means of a lead electrically insulated from the anode cylinder, as by a ceramic bead 62. The effect of the electrostatic lens on the electron beam is similar to that of the flash focus coil previously described. It should be understood, of course, that the electrostatic lens 60 of Fig. 3 may be used in storage tubes in which erasing is accomplished by a scanned narrow beam, as well as in storage tubes using a flood beam for erasing.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation, commensurate with the scope of the invention within the art.

What is claimed is:

1. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said member and for reading said information stored thereon, said beam-producing means including an electron beam source, a control grid, and a cylindrical beam accelerating electrode for forming the electron beam as it passes therethrough, and a focusing coil surrounding said accelerating electrode and de-energized during the storing of information, and means for increasing the breadth of said electron beam sufficient to cover all elemental areas of said storage member simultaneously during reading of information in response to energization of said focusing coil and application of a positive-going potential to said control grid.

2. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said member and for reading said information stored thereon, said beam-producing means including an electron beam source, a control grid, and a cylindrical beam accelerating electrode for forming the electron beam as it passes therethrough, and a focusing coil surrounding said accelerating electrode and de-energized during the storing of information, and means for increasing the breadth of said electron beam sufficient to cover all elemental areas of said storage member simul-

aneously during reading of information in response to energization of said focusing coil and application of a positive-going potential to said control grid, said device further including a fluorescent screen interceptive of the portion of said electron beam passing through said storage member.

3. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said member and for reading said information stored thereon, said beam-producing means including an electron beam source, a control grid, and a cylindrical beam accelerating electrode for forming the electron beam as it passes therethrough, and a focusing coil surrounding said accelerating electrode and de-energized during the storing of information, and means for increasing the area of impingement of said beam on said storage member during reading of information in response to energization of said focusing coil.

4. An information storage device comprising a single electron gun including an electron beam source, a control electrode, and beam-forming means including an apertured cylindrical accelerating electrode, and a focusing coil adjacent said beam-forming means, an electron permeable storage member having a storage surface in the path of projection of said beam, said beam-forming means being productive of a narrow beam focused upon an elemental area of said storage surface during de-energization of said focusing coil, means for scanning said beam past elemental areas of said storage surface during de-energization of said focusing coil, and means for establishing a charge pattern over the storage surface in response to an electron beam intensity modulating signal applied to said control electrode, means for deriving a wide beam which impinges upon the entire storage surface simultaneously during energization of said focusing coil.

5. An information storage device comprising a single electron gun including an electron beam source, a control electrode, and beam-forming means including an apertured accelerating electrode for diverging said beam as it enters said accelerating electrode, and a focusing coil adjacent said beam-forming means, an electron permeable storage member having a storage surface in the path of projection of said beam, said beam-forming means being productive of a narrow beam focused upon an elemental area of said storage surface during de-energization of said focusing coil, means for scanning said beam past elemental areas of said storage surface during de-energization of said focusing coil, and means for establishing a charge pattern over the storage surface in response to an electron beam intensity modulating signal applied to said control electrode, means for deriving a wide beam which impinges upon the entire storage surface simultaneously during energization of said focusing coil and in response to a positive-going variation of the control electrode potential for increasing the divergence angle of said beam.

6. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said member and for reading said information stored thereon, said beam-producing means including an electron beam source, a control grid, and a cylindrical beam accelerating electrode for forming the electron beam as it passes therethrough, an electrostatic lens including a cylindrical member surrounding said accelerating electrode and de-energized during the storing of information, and means for increasing the area of impingement of said beam on said storage member during reading of information in response to energization of said electrostatic lens.

7. An information storage device comprising a single electron gun including an electron beam source, a control electrode, and beam-forming means including an apertured cylindrical accelerating electrode for diverging

said beam as it enters said accelerating electrode, and first and second focusing coils adjacent said beam-forming means, an electron permeable storage member having a storage surface in the path of projection of said beam, said beam-forming means being productive of a narrow beam focused upon an elemental area of said storage surface during the energization of said first focusing coil, means for scanning said beam past elemental areas of said storage surface during de-energization of said first focusing coil, means for establishing a charge pattern over the storage surface in response to an electron beam intensity modulating signal applied to said control electrode, and means for deriving a wide beam which impinges upon the entire storage surface simultaneously during energization of said first focusing coil and de-energization of said second focusing coil and in response to a positive going variation of the control electrode potential for increasing the divergence angle of said beam.

8. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said member and for reading said information stored thereon, said beam-producing means including an electron beam source and a beam accelerating electrode for forming the electron beam as it travels adjacent thereto, and an element electrostatically coupled to said accelerating electrode and de-energized during the storing of information, and means for increasing the breadth of said electron beam sufficient to cover substantially all elemental areas of said storage member simultaneously during reading of information in response to energization of said element.

9. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said storage member and for recording said information stored thereon, said beam-producing means including an electron beam source and a beam accelerating electrode for forming the electron beam as it travels adjacent thereto, and a focusing means juxtaposed with said accelerating electrode and de-energized during the storing of information, and means for increasing the area of impingement of said beam on said storage member during reading of information in response to energization of said element.

10. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said storage member and for recording said information stored thereon, said beam-producing means including an electron beam source and a beam accelerating electrode for forming the electron beam as it travels adjacent thereto, and a focusing means juxtaposed with said accelerating electrode and de-energized during the storing of information, beam deflection means positioned between said focusing means and said storage member, and means for increasing the

area of impingement of said beam on said storage member during reading of information in response to energization of said element, said beam deflection means being de-energized during reading of information.

11. An information storage device comprising a storage member and a single electron beam-producing means for storing information on said storage member and for recording said information stored thereon, said beam-producing means including an electron beam source and a beam accelerating electrode for forming the electron beam as it travels therethrough, and a focusing coil juxtaposed with said accelerating electrode and de-energized during the storing of information, and means for increasing the area of impingement of said beam on said storage member during reading of information in response to energization of said focusing coil.

12. An information storage device comprising a storage member and a single electron beam-producing and forming means for storing information on said member and for reading said information stored thereupon, said beam-producing and focusing means including an electronically adjustable electron focusing lens for increasing the area of impingement of the beam on said storage member during reading of said information, said lens including a beam intensity control grid and a lens electrode, means for supplying a positive-going signal to said control grid for increasing the angle of convergence of said beam in the vicinity of said control grid.

13. An information storage device comprising a storage member and a single electron beam-producing and focusing means for storing information on said member and for reading said information stored thereon, said beam-producing and focusing means including a beam intensity control grid and an accelerating electrode having an aperture at each end thereof, means for establishing an accelerating field in the region between said grid and said accelerating electrode for converging the beam to a focus in the vicinity of that one of said apertures nearer said grid, means for applying a positive-going signal to said grid for increasing the angle of convergence of said beam during reading of said information, and means for effecting divergence of said beam in the region of said accelerating electrode between said apertures during reading of said information.

References Cited in the file of this patent

UNITED STATES PATENTS

2,276,359	Von Ardenne	Mar. 17, 1942
2,438,709	Labin et al.	Mar. 30, 1948
2,532,339	Schlesinger	Dec. 5, 1950
2,547,638	Gardner	Apr. 3, 1951
2,642,550	Williams	June 16, 1953
2,675,499	Sears	Apr. 13, 1954
2,700,151	Flory	Jan. 18, 1955