

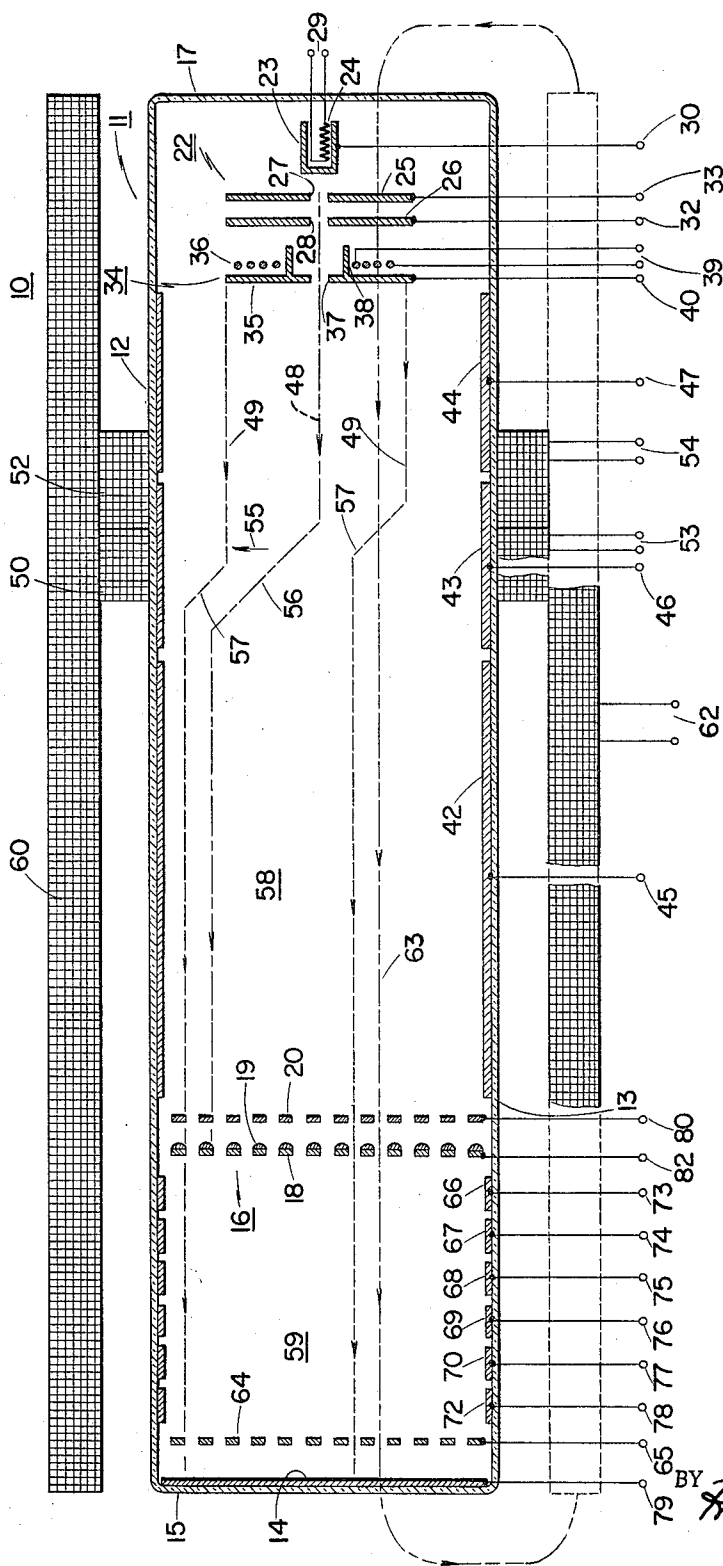
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DISPLAY STORAGE TUBE WITH SOLENOIDAL FOCUS AND SIMULTANEOUS
DEFLECTION OF WRITING AND FLOOD BEAMS

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DISPLAY STORAGE TUBE WITH SOLENOIDAL FOCUS AND SIMULTANEOUS DEFLECTION OF WRITING AND FLOOD BEAMS**Robert H. Clayton, Fort Wayne, Ind., assignor to International Telephone and Telegraph Corporation, Nutley, N.J., a corporation of Maryland**Filed Feb. 11, 1964, Ser. No. 343,975
12 Claims. (Cl. 315-12)

This invention relates generally to signal-to-image display storage tubes and more particularly to a display storage tube in which both the image and scanning sections are focused by a continuous axial magnetic field.

Conventional signal-to-image display storage tubes are of the cathode ray type and comprise a phosphor display screen, a storage screen, a writing gun, and a flood gun. The storage screen conventionally comprises a fine mesh metal screen coated on the side facing the writing and flood guns with dielectric material having secondary emission properties. The writing gun directs a pencil electron beam toward the storage screen, the pencil beam being modulated in accordance with an input electrical signal and scanned over the dielectric surface of the storage screen. Scanning of the modulated pencil beam over the storage screen "writes" a charge pattern on the storage screen corresponding to the input signal. The flood gun directs a low velocity flood beam of electrons toward the storage screen, the flood beam electrons passing through the apertures in the storage screen to the display screen being modulated by the incremental charges on the storage screen thereby providing a visible image on the display screen corresponding to the charge pattern on the storage screen.

In conventional signal-to-image display storage tubes, the flood electrons are neither focused nor collimated as they approach the storage screen. Each aperture in the storage screen in essence forms an individual electron lens which focuses the flood electrons in a plane very close to the plane of the storage screen with the result that the flood electrons subsequently diverge to a large circle of confusion at the phosphor display screen, thus adversely affecting the resolution of the displayed image. It is therefore desirable to provide a signal-to-image display storage tube in which the flood electrons are reconverged or re-focused in the image section of the tube, i.e., between the storage screen and the display screen, thereby to improve the resolution of the displayed image.

It is accordingly an object of the invention to provide an improved signal-to-image display storage tube.

Another object of the invention is to provide an improved signal-to-image display storage tube providing improved resolution of the displayed image.

A further object of the invention is to provide an improved signal-to-image display storage tube employing axial magnetic focusing of the flood electrons in the image section.

Solenoidal magnetic fields have been employed in storage image converter tubes, such as that described and illustrated in Patent No. 2,983,836 to Paul Rudnick and Richard K. Orthuber and assigned to the assignee of the present application, to focus an electron image formed at the plane of a storage screen into the plane of a phosphor display screen. In such storage image tubes, however, the charge pattern which is written onto the storage screen is derived from an extended area photocathode which is arranged essentially parallel to the plane of the storage screen; the input to the storage image tube is optical. In the signal-to-image display storage tube, however, the input is a time-based signal employed to modulate the pencil or writing electron beam which must be scanned over the storage screen in order to generate the charge

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pattern. Subjection of the image section of the tube alone to an axial or solenoidal magnetic focusing field would provide the desired focusing of the stored electron image, however, the end effects of such focusing field would prevent effective scanning of the writing beam over the storage screen or flooding of the storage screen with the flood beam. In conventional signal-to-image display storage tubes, only the writing beam is scanned over the storage screen, and if a solenoidal magnetic focusing field is extended throughout the entire length of the tube, conventional methods of writing beam deflection are ineffective to provide the requisite scanning of the writing beam over the storage screen.

I have found that the flood beam in both the image and the scanning sections of a signal-to-image display storage tube may be focused by a continuous solenoidal magnetic field extending throughout the length of the tube by providing concentric writing and flood electron beams and by providing magnetic deflection fields for simultaneously deflecting both beams. This axial magnetic focusing of the flood beam in both the scanning and image sections of the tube provides not only the anticipated improvement in resolution in the image section, but an unexpected improvement in resolution of the stored image on the storage screen, the result being the provision of a displayed image having a resolution significantly improved over that provided by conventional signal-to-image display storage tubes.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

The single figure of the drawing schematically illustrates the improved signal-to-image display storage tube of the invention.

Referring now to the drawing, the improved signal-to-image display storage tube of the invention, generally indicated at 10 comprises a conventional axially-elongated evacuated envelope 11 having a conventional phosphor display screen 14 deposited on the inner surface of faceplate 15 which closes one end of the envelope. A conventional charge storage screen 16 is positioned in the envelope 11 between the display screen 14 and the other end 17 of the tube, the storage screen being in a plane parallel with that of the display screen 14 and normal to the longitudinal axis of the tube. Storage screen 16 may in accordance with conventional practice comprise a fine mesh metal backing screen 18 having its side which faces end 17 of the envelope 11 coated with suitable dielectric material having secondary emission properties, as at 19. A conventional collector screen 20 is positioned in the envelope 11 between storage screen 16 and end 17 for collecting secondary electrons emitted from the dielectric coating 19 of the storage screen, as is well known to those skilled in the art.

A pencil or writing beam electron gun 22 is provided in the envelope 11 adjacent end 17 thereof and comprises a cathode sleeve 23 concentric with the longitudinal axis of the tube and having a heater 24 therein, a planar control grid 25 concentric with the tube axis, and normal thereto, and a planar anode 26 likewise concentric with the tube axis and normal thereto, control grid 25 and anode 26 respectively having central apertures 27, 28 formed therein concentric with the tube axis. Heater 24 is connected to terminals 29 for connection to a suitable source of energizing potential, cathode 23 and anode 26 are respectively connected to terminals 30, 32 for connection to suitable potentials, and control grid 25 is connected to input terminal 33 adapted to be connected to receive a time-based electrical input signal for modulating

the pencil or writing electron beam which is provided by the writing gun 22 and directed toward the storage screen 16.

A flood electron gun 34 is provided comprising an extended area planar cathode 35 concentric with and normal to the longitudinal axis of the tube, and a suitable heater 36. Cathode 35 has a central aperture 37 concentric with the longitudinal axis of the tube and with the writing gun 22 through which the writing beam passes. A sleeve portion 38 is formed on cathode 35 concentric with the axis of the tube and extending toward anode 26 of the writing gun 22. Heater 36 of the flood gun 34 is connected to terminals 39 for connection to a suitable source of energizing potential and cathode 35 is connected to terminal 40 which is adapted to be connected to a suitable source of potential.

In order to provide planar accelerating equipotentials for the flood cathode 35, suitable conductive coatings 42, 43, and 44 are formed on the interior surface of the envelope 11 between the flood cathode 35 and the collector screen 20, coatings 42, 43, 44 being respectively connected to terminals 45, 46 and 47 adapted to be connected to suitable potentials; while separate conductive electrodes or coatings 42, 43, 44 are shown, the planar accelerating equipotentials may be provided by a continuous conductive coating or electrode.

It will now be seen that a pencil electron beam, shown by the dashed line 48 is provided by the writing gun 22 and that a concentric flood beam, having lower electron velocity than the writing beam 48 is provided by the flood gun 34, as shown by the dashed line 49.

In order to provide for deflection of both the writing electron beam 48 and the flood electron beam 49 and thus to scan both beams over the storage screen 16, vertical and horizontal magnetic deflection coils or yokes 50, 52 are respectively provided on the exterior of envelope 11 between the flood gun 34 and the collector screen 20. Deflection yokes 50, 52 are connected to terminals 53, 54 for connection to suitable sources of sweep voltages to provide the desired type and rate of scanning, for example raster scanning. It will be seen that the magnetic fields provided by the deflection yokes 50, 52 are respectively transverse with respect to the longitudinal axis of the tube and thus, assuming that the direction of the field provided by the vertical deflection yoke 50 is as shown by the arrow 55, it will be seen that both the writing beam 48 and the flood beam 49 will be deflected as at 56, 57.

In order to focus the flood beam 49 in the image section 59 of the tube, and to focus the writing beam 48 in the writing section 58 of the tube, a solenoid coil 60 is provided surrounding envelope 11 and the deflection yokes 50, 52, and extending axially between ends 14, 17 of the envelope. Solenoid coil 60 has leads connected to terminals 62 adapted to be connected to a suitable source of direct current voltage and provides a solenoidal magnetic field extending axially through the tube parallel with its longitudinal axis, as shown by the dashed line 63; the polarization of the solenoid coil 60 and of the axial magnetic field provided thereby is not important.

In order to provide optimum resolution of the displayed image on the display screen 14, it is necessary that the flood electrons arrive at the display screen 14 after an integral number of full loops of focus, preferably one (1) loop of focus between the storage screen 16 and the display screen 14. This may be accomplished by selection of the axial length of the image section 59 between the storage screen 16 and the display screen 14 and/or adjustment of the strength of the magnetic field provided by the solenoid coil 60. However, in order to reduce the axial length of the image section 59 and/or reduce the focusing field strength, a field mesh 64 is provided in the image section 59 adjacent the display screen 14 and parallel therewith. Field mesh 64 is connected to terminal 65 which is adapted to be connected to a suitable

source of potential, the field mesh 64 thus serving to decrease the average velocity of the flood electrons from the storage screen 16 to the display screen 14 and in turn increasing their transit time. In order further to control the transit time of the flood electrons in the image section 59, a plurality, shown here as being six (6) in number, of axially spaced ring electrodes 66, 67, 68, 69, 70, and 72 are provided in the image section 59 between the storage screen 16 and the field mesh 64, the ring electrodes 66-72 being respectively connected to terminals 73, 74, 75, 76, 77 and 78 respectively adapted to be connected to potentials increasing in equal steps from the storage screen 16 toward the field mesh 64.

In order to provide optimum resolution of the charge image written onto the storage screen 16 by the writing beam 48, it is further desirable that the writing beam electrons arrive at the dielectric surface 19 of the storage screen 16 after an integral number of full loops of focus, preferably a multiple number of loops, such as three (3) to five (5); this is preferably accomplished by selection of the axial length of the writing section 58 of the tube.

Display screen 14 is connected to terminal 79 adapted to be connected to a suitable source of high voltage, collector screen 20 is connected to terminal 80 adapted to be connected to a suitable source of collector potential, and the backing screen 18 of the storage screen 16 is connected to terminal 82 adapted to be selectively connected to suitable sources of writing and erasing potentials, as is well known to those skilled in the art.

In a specific embodiment of the tube of the invention in which a solenoid focus coil 60 is energized to provide a field strength of sixty (60) gauss, satisfactory operation may be provided by the application of the following potentials:

Display screen 14	10,000 volts (+).
Field mesh 64	400 volts (+).
Ring electrodes 66-72	0 to 400 volts (+) in equal steps.
Backing screen 18	{ 10 volts (-) (writing). 10 volts (+) (erase).
Collector screen 20	150 volts (+).
Wall coatings 42, 43, 44	100 volts (+).
Flood cathode 35	Ground.
Writing gun anode 28	Ground.
Writing gun cathode 23	400 volts (-).
Writing gun control grid 25	400 volts (-) to 500 volts (-).

It will now be seen that the use of magnetic deflection for both the writing and flood electron beams permits the extension of the axial focusing field throughout the entire length of the tube since both electron beams will follow the curvature of the composite field comprising the superimposed axial focus and transverse deflection fields. It will be observed by reference to the above tabulation of typical potentials that the writing beam is of relatively low velocity which permits its deflection in the presence of the axial focusing field; the usual relatively high velocity or "stiff" writing beam would require substantially greater deflection fields for its deflection in the presence of the focusing field.

While the flood beam 49 is scanned over the storage screen 16 and the display screen 14 simultaneously with the scanning of the writing beam, in contrast with conventional signal-to-image display storage tubes in which the flood beam continuously floods the entire area of the storage screen, it has been found that if the frame rates for writing are "flicker free," i.e., any rate in excess of approximately twenty (20) frames per second, human visual persistence will mask the difference between the display resulting from the scanned flood beam and the conventional static flood beam display so that simultaneous writing and display may be employed. Erasure of the stored image on the storage screen 16 may be accomplished during the active scanning time by the ap-

plication of erase pulses having a repetition rate which is some multiple of the scanning frequency or a continuous erase pulse may be applied during retrace.

A surprising and unexpected result of the provision of axial magnetic focusing has been a conspicuous improvement in the resolution of the stored image written onto the storage screen by the writing beam, which when combined with the improvement in the resolution in the image section provided by the axial focusing field, provides substantially improved resolution of the displayed image. This is believed to be attributable to the fact that in a solenoidal focusing field, magnification is unity, whereas in the case of the usual electrostatically focused writing electron gun, the object-to-lens distance is significantly less than the lens-to-storage screen distance which gives rise to a magnification of the spot produced on the storage screen by the writing beam.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention.

What is claimed is:

1. In a signal-to-image display storage tube having a display screen and apertured charge storage screen means spaced from said display screen: means for forming and directing concentric pencil and flood electron beams toward said storage screen means; magnetic deflection means acting upon both of said beams for scanning the same over said storage screen means; means for modulating said pencil beam in accordance with an input signal whereby said pencil beam writes a charge pattern on said storage screen means corresponding to said input signal and said flood beam passes through the apertures in said storage screen means to said display screen being modulated by said charge pattern; and means for providing a magnetic field extending axially between said display screen and said beam forming and directing means for focusing said pencil beam onto said storage screen means and said modulated flood beam onto said display screen.

2. A signal-to-image display storage tube comprising: an evacuated envelope having a longitudinal axis and spaced opposite ends; a phosphor display screen in said envelope at one end thereof and normal to said axis; first electron gun means in said envelope at the other end thereof and concentric with said axis for forming and directing a pencil electron beam toward said one end of said envelope; second electron gun means in said envelope at said other end thereof normal to and concentric with said axis for forming and directing a flood electron beam toward said one end of said envelope, apertured charge storage screen means in said envelope between said ends and normal to said axis; deflection means acting upon both of said beams for scanning the same over said storage screen means; means for modulating said pencil beam in accordance with an input signal whereby said pencil beam writes a charge pattern on said storage screen means corresponding to said input signal and said flood beam passes through the apertures in said storage screen means to said display screen being modulated by said charge pattern; and means for providing a magnetic field extending axially through said envelope and parallel with said axis for focusing said pencil beam onto said storage screen means and said modulated flood beam onto said display screen.

3. The tube of claim 2 wherein said second electron gun means includes a planar cathode normal to said axis and having an aperture therein concentric with said axis through which said pencil beam passes.

4. The tube of claim 2 wherein said deflection means is magnetic and is positioned between said second electron gun means and said storage screen means.

5. The tube of claim 2 wherein said magnetic field is solenoidal.

6. The tube of claim 2 wherein said means for providing a magnetic field comprises a solenoid coil surrounding said envelope and extending substantially between said ends thereof.

7. A signal-to-image display storage tube comprising: an evacuated envelope having a longitudinal axis and spaced opposite ends; a phosphor display screen in said envelope at one end thereof and normal to said axis; first electron gun means in said envelope at the other end thereof and concentric with said axis for forming and directing a pencil electron beam toward said one end of said envelope; second electron gun means in said envelope between said first electron gun means and said one end and including a planar cathode normal to and concentric with said axis for forming and directing a flood electron beam toward said one end of said envelope, said planar cathode having an aperture concentric with said axis through which said pencil beam passes; apertured charge storage screen means between said planar cathode and said one end and normal to said axis; magnetic deflection means on the exterior of said envelope and between said planar cathode and said storage screen means and acting upon both of said beams for scanning the same over said storage screen means; means for modulating said pencil beam in accordance with an input signal whereby said pencil beam writes a charge pattern on said storage screen means corresponding to said input signal and said flood beam passes through the apertures in said storage screen means to said display screen being modulated by said charge pattern; and a solenoid coil surrounding said envelope and said magnetic deflection means and extending substantially between said ends for providing a solenoidal magnetic field extending axially through said envelope and parallel with said axis for focusing said pencil beam onto said storage screen means and said modulated flood beam onto said display screen.

8. The tube of claim 7 further comprising a screen electrode in said envelope adjacent said display screen and normal to said axis for increasing the transit time of the flood beam electrons between said storage screen means and said display screen.

9. The tube of claim 8 further comprising a plurality of ring electrodes concentric with said axis and axially spaced apart between said storage screen means and screen electrode for evenly dividing the potential between said storage screen means and said screen electrode.

10. The tube of claim 7 wherein said first electron gun means includes a cathode and control and accelerating electrodes positioned between said other end and said second electron gun means.

11. The tube of claim 7 wherein the axial distance from said storage screen means to said display screen is substantially equal to an integral number of full loops of focus of said flood beam, and wherein the axial distance from said storage screen means to said first electron gun means is substantially equal to an integral number of full loops of focus of said pencil beam.

12. The tube of claim 7 wherein said second electron gun means includes electrode means in said envelope between said planar cathode and said storage screen means for providing planar accelerating equipotentials for said flood beam.

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