April 28, 1959 G. F. SMITH 2,884,558

CATHODE-RAY TUBE FOR PRESENTING STORED AND NON-STORED DISPLAYS

Filed Dec. 19, 1955 2 Sheets-Sheet 1

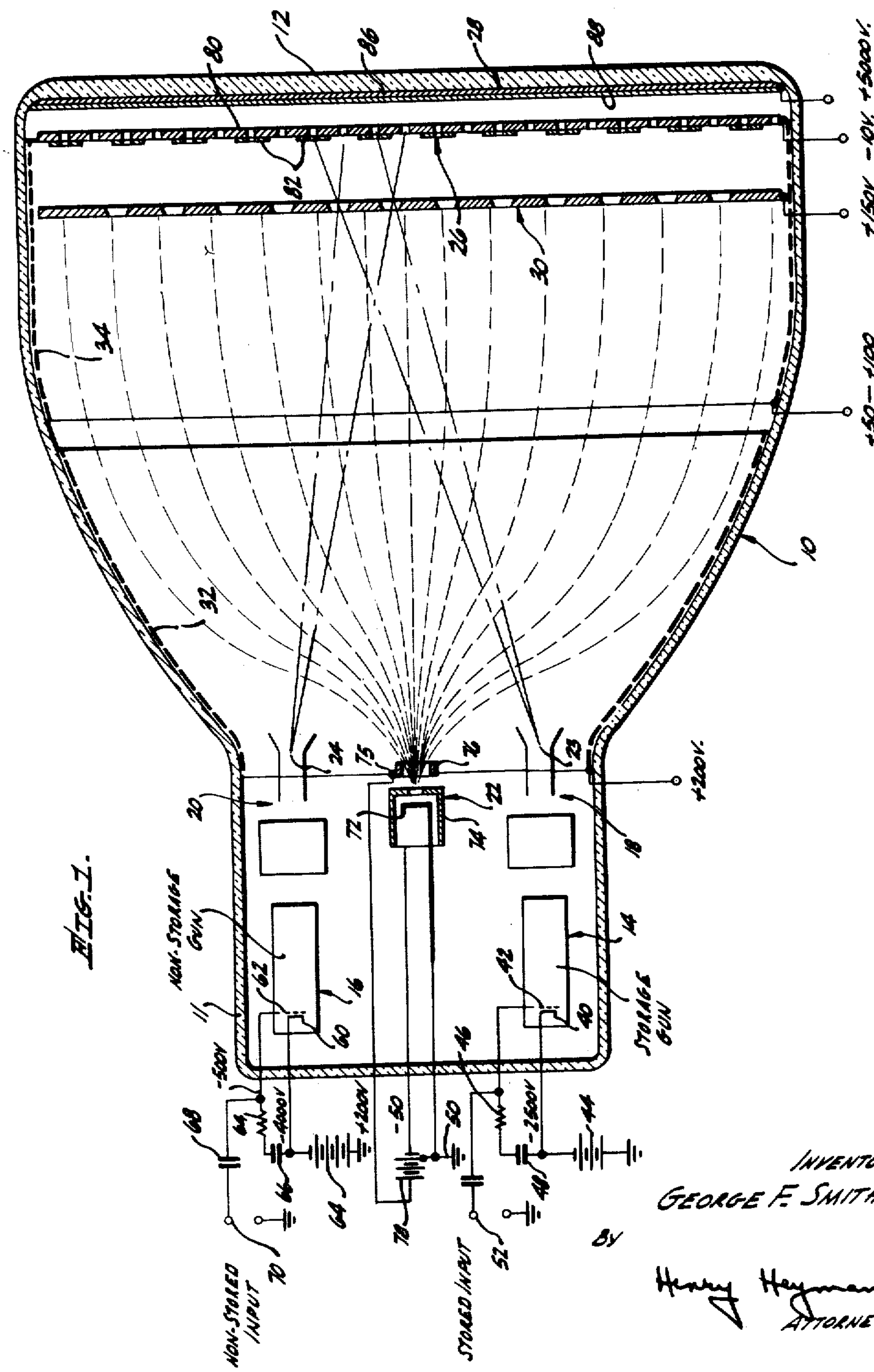

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FIG. 2.

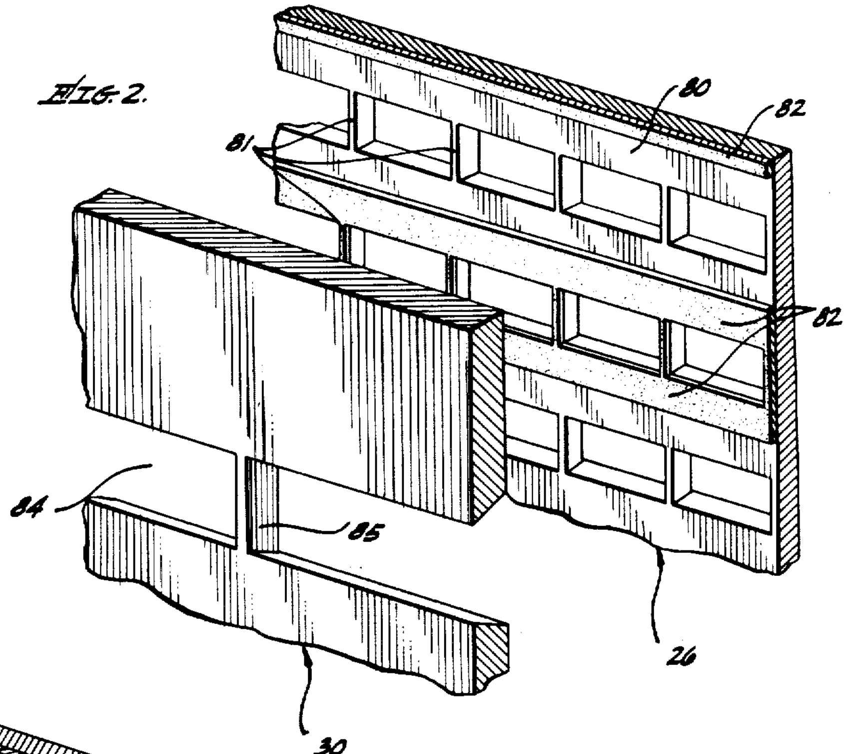
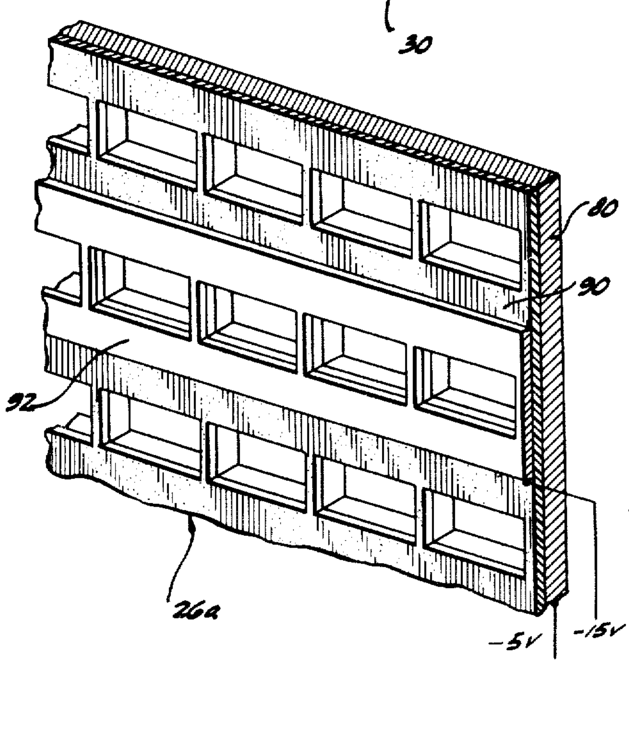


FIG. 3.



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CATHODE-RAY TUBE FOR PRESENTING STORED AND NON-STORED DISPLAYS

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Application December 19, 1955, Serial No. 553,880

4 Claims. (Cl. 315—12)

This invention relates to direct-viewing storage tubes and more particularly to a cathode-ray tube incorporating apparatus for simultaneously presenting stored and non-stored information in an integrated display.

There are numerous applications for a cathode-ray tube capable of simultaneously presenting both stored and non-stored information in an integrated display wherein the stored information is retained for periods of the order of from several milliseconds to several minutes, or longer, if desired. One example of such an application is to provide a display for a moving-target-indication radar system wherein the non-stored portion of the display is used to present moving targets and the stored portions to provide a low intensity background corresponding to the position of the aircraft.

In accordance with the present invention, a storage electron gun and a non-storage electron gun, together with associated electron beam deflection apparatus, are spaced a predetermined distance apart and generate "writing" and "direct-reading" electron beams, respectively, which are directed towards a target assembly. A conductive mask, interposed between the target assembly and the electron guns, has openings disposed so that the writing and direct-reading electron beams are incident on mutually exclusive integrated areas of the target assembly. A layer of dielectric material having secondary electron emission characteristics is disposed within the areas on which the writing beam is incident to provide a storage surface within these areas. In addition, the device includes apparatus for directing a broad beam of electrons, that is, a beam of flood electrons uniformly through the conductive mask towards the target assembly and a viewing screen disposed adjacent to and coextensive with the target screen on the side thereof farthest from the electron guns.

In operation, a portion of the current of the direct-reading electron beam penetrates through the conductive mask and the interstices of the target assembly to the viewing screen to function in a manner similar to a conventional cathode-ray tube. The portion of the current of the writing electron beam which penetrates through the conductive mask, on the other hand, produces a charge pattern on the storage surface of the target assembly which in turn controls the flow of flood electrons to the viewing screen to produce a visual presentation of the stored information. If desired, the storage portion of the target assembly may be operated to reproduce half-tones in the manner described, for example, in a copending application for patent Serial No. 459,403 entitled, "Direct-Viewing Half-Tone Storage Device" filed by Elvin E. Herman and George F. Smith on September 30, 1954, now U.S. Patent 2,790,929, and assigned to the assignee of the present application.

It is therefore an object of the present invention to provide a cathode-ray tube capable of simultaneously presenting stored and non-stored displays in an integrated presentation.

Another object of this invention is to provide a cathode-ray tube incorporating a target electrode having first and second integrated portions for storage and non-storage purposes, respectively.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a diagrammatic sectional view of an embodiment of the cathode-ray tube of the invention;

Fig. 2 is an enlarged perspective view showing the relationship of the mask with respect to the target assembly; and

Fig. 3 is an enlarged perspective view of an alternative embodiment of the target assembly.

Referring to Fig. 1, there is shown a diagrammatic view of the cathode-ray tube of the present invention. The tube comprises an evacuated bulbous envelope **10** having a neck portion **11** and a flat end portion **12** disposed at opposite extremities thereof, as shown in the drawing. The neck portion **11** of the envelope **10** houses storage and non-storage electron guns **14**, **16** for producing writing and direct-reading electron beams, respectively; deflecting means **18**, **20** for the writing and direct-reading electron beams; and a flood gun **22** for producing a beam of flood electrons. Deflecting means **18**, **20** are disposed about the paths of the writing and direct-reading electron beams, respectively, and have a predetermined distance between their respective centers of deflection **23**, **24**, as will be hereinafter explained. In addition, the deflecting means **18**, **20** are energized with appropriate beam deflection control signals to cause the electron beams to trace desired rasters on a target assembly **26** disposed adjacent to a viewing screen **28** disposed on the inner surface of the flat end portion **12** of the envelope **10**. A mask electrode **30** is interposed between the target assembly **26** and the electron guns **14**, **16** and **22** at a distance from the target assembly **26** necessary to intercept the appropriate portions of the current of the writing and direct-reading electron beams so that the remaining portions of the current thereof are incident on mutually exclusive integrated elemental areas of the target assembly **26**. Conductive coatings **32**, **34** are disposed concentrically about the inner surface of envelope **10** in the intervening space between the flood gun **22** and the target assembly **26**.

More particularly, storage electron gun **14** for producing the electron writing beam includes a cathode **40** and a control grid **42**. The cathode **40** is maintained at a potential of the order of —2500 volts negative with respect to ground. This is accomplished by means of a connection therefrom to the negative terminal of a battery **44**, the positive terminal of which is referenced to ground. The control grid **42** is maintained at a quiescent potential in the order of 50 volts negative with respect to the potential of cathode **40**. To this end, control grid **42** is connected through a resistor **46** to the negative terminal of a battery **48**, the positive terminal of which is referenced to the cathode **40**. Means for intensity modulating the current of the writing beam is provided by a connection from the control grid **42** through a capacitor **50** to stored input terminals **52**.

Similarly, non-storage electron gun **16** includes a cathode **60** and a control grid **62**. The cathode **60** is maintained at a potential of the order of −4000 volts negative with respect to ground by means of a connection therefrom to the negative terminal of a battery **64**, the positive terminal of which is referenced to ground. Also, in a manner similar to the electron gun **14**, the control grid **62** is maintained at a negative quiescent potential of the order of 50 volts negative with respect to the cathode **60**. This is effected by means of a connection therefrom through a resistor **64** to the negative terminal of a battery **66**, the positive terminal of which is referenced to the potential of cathode **60**. In addition to the above, the control grid **62** is coupled through a capacitor **68** to non-stored input terminals **70** to provide a means for intensity modulating the current constituting the direct-reading electron beam.

The flood gun **22**, for producing the broad beam of electrons, includes a cathode **72** and intensity grid **74** having a circular opening **75** in alignment with the electron emitting surface of cathode **72**, and an annular anode **76** disposed concentrically about the opening **75**, as shown in the drawing. In operation the cathode **72** is maintained at ground potential, the intensity grid **74** at a potential of the order of 50 volts negative with respect to ground and the anode **76** at a potential of the order of 200 volts positive with respect to ground. The foregoing may be accomplished, for example, by referencing an intermediate terminal on a battery **78** to ground along with the cathode **72**, and connecting an appropriate negative terminal of the battery **78** to the intensity grid **74** and an appropriate positive terminal to the anode **76**. Flood gun **22**, in conjunction with conductive coatings **32, 34**, produces a broad beam of flood electrons which are directed uniformly over the mask electrode **30**. For this purpose the conductive coatings **32, 34** may be maintained at potentials of the order of +200 volts and of from +50 to +100 volts with respect to ground, respectively.

The target assembly **26**, which together with mask electrode **30** is shown in perspective in Fig. 2, is disposed at the opposite extremity of the envelope **10** adjacent the viewing screen **28**. The target assembly **26** comprises a metallic sheet **80** which has on the order of from 250 to 400 parallel longitudinal slots per lineal inch which are disposed normal to a line joining the centers of deflection **23** and **24** of the deflecting means **18, 20**. The metallic sheet **80** is of a thickness of the order of 0.001 inch, and composed of a metal such as, for example, nickel, and has cross-members **81** periodically disposed across the slots for reinforcing purposes. A thin layer **82** of dielectric material having secondary electron emission characteristics such as, for example, magnesium fluoride is disposed along alternate rows of longitudinal slots across the entire width of the target assembly **26** and extends from the edge of each of the alternate slots to a point approximately half-way towards the next adjacent slot. In the event that magnesium fluoride is used, the thickness of the thin layer **82** of dielectric material need only be of the order of two microns thick. Slots having the thin layer **82** of dielectric material disposed therealong are referred to as storage slots and the remaining slots as direct-reading slots. The direct-reading slots may, of course, be made wider to increase the efficiency of the non-storage phase of operation. In the operation of the device the metallic sheet **80** of the target assembly **26** is maintained at a potential of the order of 10 volts negative with respect to ground.

Disposed in front of and adjacent to target assembly **26** is the mask electrode **30**. The mask electrode **30** has one longitudinal opening **84** with reinforcing members **85** for each pair of storage and non-storage slots of the target assembly **26**. These openings **84** have a width somewhat less than the distance between centers of adjacent slots in the target assembly **26** and may, for example, be tapered so that only the surface facing the electron guns **14, 16, 22**, intercepts the beam electrons. At the center of the mask electrode **30** the openings **84** are disposed midway between the center lines of the corresponding storage and non-storage slots in the target assembly **26**. As the outer periphery of the mask electrode **30** is approached, however, suitable allowances must be made for parallax of the electron beam. In addition, the actual distance between the mask electrode **30** and the target assembly **26** is made proportional to the distance of the target assembly **26** from the centers of deflection **23, 24** and the center-to-center distance between slots in target **26** and inversely proportional to the distance between the centers of deflection **23, 24**. In operation the mask electrode **30** also functions as a collector electrode and it is accordingly maintained at a potential of the order of +150 volts positive with respect to ground.

The viewing screen **28** comprises a transparent conductive coating **86** and a fluorescent screen **88** disposed in the order named on the inner surface of the flat end portion **12** of the envelope **10**. A suitable potential to impress on the transparent conductive coating **86** is of the order of +5000 volts positive with respect to ground.

In the operation of the device, the signal for producing the non-stored portion of the display is applied to the non-stored input terminals **70** to intensity modulate the direct-reading electron beam produced by the non-storage electron gun **16**. The direct-reading electron beam is scanned over the target assembly **26** in synchronism with the non-stored signal by means of appropriate deflection signals applied to the deflecting means **20**. Upon being scanned over the target assembly **26**, the portion of the beam current not intercepted by the mask electrode **30** is incident only over the non-storage slots in target assembly **26** and hence does not effect a charging of the storage surface along the adjacent storage slots of the target assembly **26**. Because of the high velocity of the direct-reading electron beam, the electrons constituting the beam are not affected by the small bias applied to the metallic sheet **80** of the target electrode **26** and hence proceed therethrough to the viewing screen **28** to produce the non-stored portion of the visual presentation.

The signal for producing the stored portion of the display, on the other hand, is applied to the stored input terminals **52** to intensity modulate the writing beam produced by the electron storage gun **14**. The writing electron beam is scanned over the target assembly **26** in synchronism with the signal to be stored by means of appropriate deflection signals applied to deflecting means **18**. In this instance, however, the portion of the current of the writing beam not intercepted by the mask electrode **30** is incident on the storage slots of the target assembly **26** to produce a charge pattern thereon corresponding to the signal to be stored. A portion of the writing beam current also passes through the storage slots of the target assembly **26** to the viewing screen **28** to produce an initial visual indication of the charge pattern.

Simultaneously with the above, the flood gun **22**, in conjunction with electrodes **32, 34**, directs a flood beam of electrons uniformly over the mask electrode **30** which is maintained at 150 volts positive with respect to ground. The electrons penetrating through the openings in the mask electrode **30** are decelerated by the bias potential applied to the metallic sheet **80** whereby they are diffused uniformly over the target assembly **26**. In that the cathode **72** of the flood gun **22** is maintained at ground potential, the −10 volt biasing potential applied to the metallic sheet **80** will prevent the flood electrons from penetrating through the non-storgae slots of the target assembly **26** to the viewing screen **28**. In the case of the storage slots, however, the effect of this biasing potential is neutralized by the potentials constituting the charge pattern to the extent that flood electrons are allowed to pass through the storage slots in proportion to the charge on the immediately adjacent storage surface whence they are accelerated to the viewing screen 28 to produce the stored portion of the visual display. This portion of the device may, of course, be operated in accordance with the teachings of the aforementioned application by Herman and Smith to reproduce half-tones in the stored portion of the display.

Under certain circumstances it may happen that the biasing potential applied to metallic sheet 80 will not provide optimum contrast in the stored portion of the display and simultaneously prevent flood electrons from penetrating through the non-storage slots to the viewing screen 28 where they illuminate the screen without conveying any information. This condition may exist, for example, if the width of the non-storage slots is increased to improve the efficiency of the direct-reading beam. In view of the above, an alternative target assembly *26a* is shown in Fig. 3. Referring to this figure, target assembly *26a* comprises the metallic sheet 80 shown in Figs. 1 and 2 in connection with the description of target assembly 26. Unlike the target assembly 26, however, target assembly *26a* has a uniform layer 90 of dielectric material having secondary electron emission characteristics such as, for example, magnesium fluoride, evaporated over the meshes on one side of sheet 80 facing the electron guns 14, 16 and 22. Thin layers 92 of metal such as, for example, aluminum, are evaporated along both sides of the non-storage slots, each of which have widths that extend approximately half-way towards the next adjacent slot. In operation the metallic sheet 80 may now be maintained at a potential to produce optimum contrast in the stored portion of the presentation such as, for example, −5 volts negative with respect to ground. The thin layers 92 of metal, on the other hand, are maintained at a sufficiently negative potential to prevent any flood electrons from penetrating through the non-storage slots of the target assembly *26a* and yet not produce a negative electric field across the storage slots. A suitable potential for this purpose is of the order of 15 volts negative with respect to ground.

What is claimed is:

1. A cathode-ray tube comprising a target assembly having manually exclusive integrated elemental areas of storage surface and conductive surface on one side thereof with at least one interstice through each of said elemental areas; a view screen disposed adjacent the other side of and coextensive with said target assembly; means for producing first and second high energy electron beams of elemental cross-sectional area and so disposed with respect to said target assembly so as to permit said beams to be directed toward said one side thereof; means for individually controlling the intensity of said first and second electron beams with first and second signals; first and second deflecting means disposed about the paths of said first and second electron beams, respectively, the centers of deflection of said deflecting means being spaced a predetermined distance apart in a plane parallel to said target assembly; a mask electrode disposed coextensive with and at a predetermined distance from said one side of said target assembly, said mask electrode having openings to allow said first electron beam to impinge only on said elemental areas of conductive surface and said second electron beam to impinge only on said elemental areas of storage surface of said target assembly; means for energizing said first deflecting means to scan said first electron beam over said elemental areas of conductive surface on said one side of said target assembly in synchronism with said first signal, whereby a portion of the current of said first electron beam proceeds through the interstices of said target assembly to said viewing screen to produce a non-stored display representative of said first signal; means for energizing said second deflecting means to scan said second electron beam over said elemental areas of storage surface on said one side of said target assembly in synchronism with said second signal to produce a charge pattern on said storage surface; and means for directing a broad beam of flood electrons uniformly over said target assembly, whereby the flood electrons penetrate through the interstices of said target assembly within the elemental areas of storage surface in proportion to the charge thereon and proceed to said viewing screen to produce a stored display representative of said second signal that is integrated with said non-stored display.

2. A cathode-ray type tube comprising a target assembly including a metallic sheet having a plurality of uniformly spaced parallel slots which extend throughout its effective area, a layer of dielectric material having secondary electron emission characteristics disposed on one side of said metallic sheet, and a thin layer of conductive material disposed over portions of said dielectric layer along both sides of alternate slots to provide non-storage slots, said thin layer of conductive material extending to a point approximately midway between centers of the adjacent slots whereby the exposed portions of said dielectric material cooperate with said adjacent slots to provide storage slots and the electrically conductive coated portions cooperate with said remaining slots to provide non-storage slots; a viewing screen disposed adjacent the other side of said metallic sheet and coextensive with said target assembly; means for producing first and second high energy electron beams of elemental cross-sectional area; means for individually controlling the intensity of said first and second electron beams with first and second signals; first and second deflecting means disposed about the paths of said first and second electron beams, respectively, the centers of deflection of said deflecting means being equidistant from said target assembly and spaced a predetermined distance apart in a plane normal to the slots in said metallic sheet; a mask electrode disposed coextensive with and at a predetermined distance from said target assembly on said one side of said metallic sheet, said mask electrode having one opening for each adjacent pair of storage and non-storage slots disposed so as to allow said first electron beam to impinge only on said non-storage slots and said second electron beam to impinge only on said storage slots; means for energizing said first deflecting means to scan said first electron beam over said non-storage slots in synchronism with said first signal, whereby a portion of the current of said first electron beam proceeds through said non-storage slots to said viewing screen to produce a non-stored display representative of said signal; means for energizing said second deflecting means to scan said second electron beam over said storage slots in synchronism with said second signal to produce a charge pattern thereon; and means for directing a broad beam of flood electrons uniformly over said target assembly whereby the flood electrons penetrate through the storage slots in proportion to the charge therealong and proceed to said viewing screen to produce a stored display representative of said second signal that is integrated with said non-stored display.

3. The cathode-ray tube as defined in claim 2 wherein said thin layer of conductive material is electrically insulated from said metallic sheet, thereby enabling said thin layer of conductive material to be maintained at a potential different from that applied to said metallic sheet.

4. In a plural beam cathode ray tube having means to store information and to display said stored information as well as non-stored information, the improvement comprising, in combination, a target assembly including an electrically conductive base member having a plurality of apertures therein, storage means cooperatively associated with alternate rows of said apertures to store electrical charges established by a first electron beam corresponding to information to be displayed, the other rows of said apertures permitting a second electron beam to pass therethrough without storage of electrical charges, and a mask electrode having a plurality

of apertures therein and disposed with respect to said target assembly to permit said first electron beam to impinge substantially only on said alternate rows of apertures in said target assembly and to permit said second electron beam to impinge substantially only on said remaining rows of apertures in said target assembly.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,884,558 April 28, 1959

George F. Smith

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 68, for "non-storgae" read -- non-storage --; column 5 line 41, for "manually" read -- mutually --.

Signed and sealed this 25th day of August 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents