

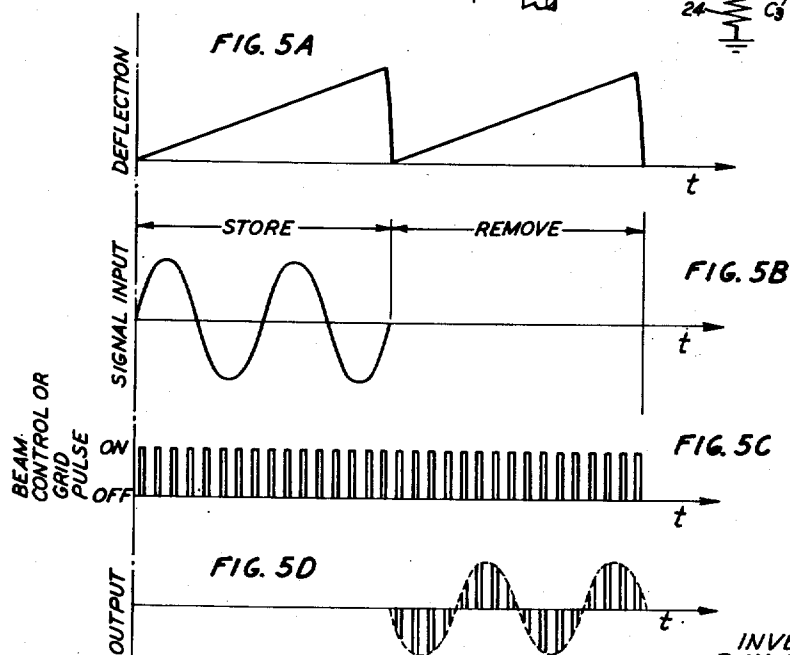
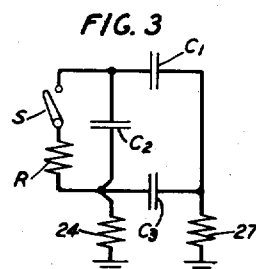
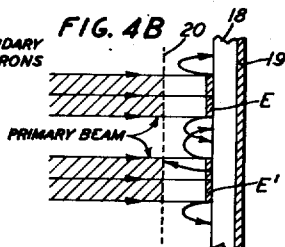
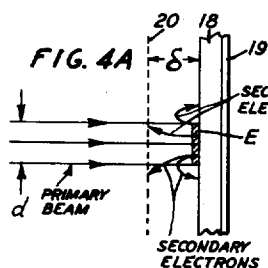
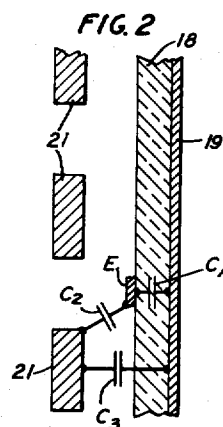
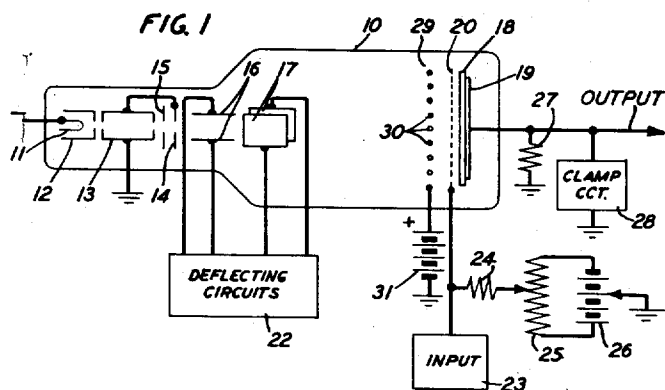
April 13, 1954

R. W. SEARS
CATHODE-RAY DEVICE

2,675,499

Filed July 10, 1948

2 Sheets-Sheet 1



INVENTOR
R. W. SEARS
BY

Walter C. Kiesel
ATTORNEY

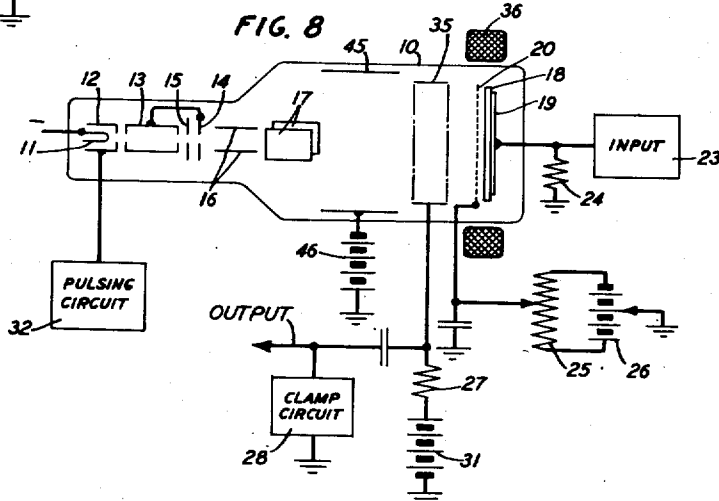
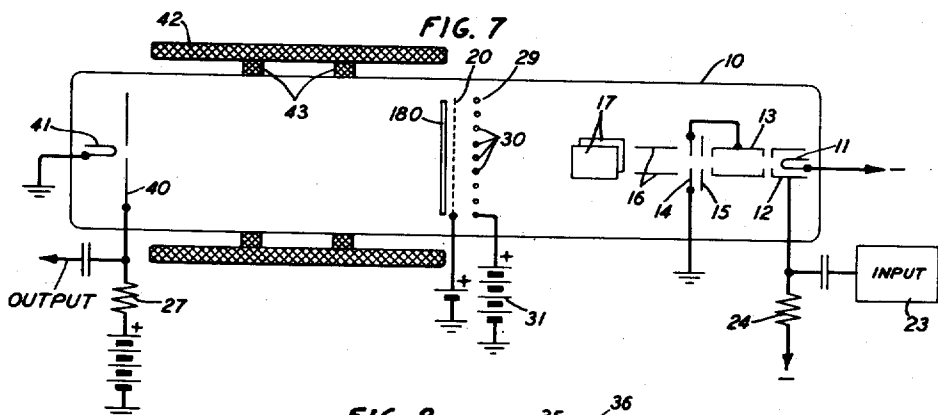
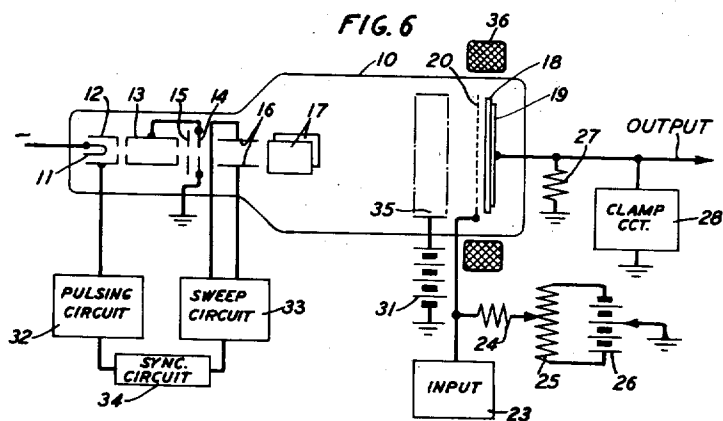
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2 Sheets-Sheet 2



INVENTOR
R. W. SEARS
BY

Halter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

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CATHODE-RAY DEVICE

Raymond W. Sears, West Orange, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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This invention relates to electron discharge apparatus and more particularly to cathode ray devices of the type commonly referred to as storage tubes, wherein an input signal is stored in the form of a charge distribution for a period of time and converted into an output signal at a subsequent period.

Cathode ray devices of the storage type comprise generally, in one form, a target such as a dielectric sheet having a conductive member or electrode in contact with one face thereof, an electron gun for projecting a concentrated electron stream against the other face of the sheet, and a barrier grid, to which the input signal may be applied, adjacent the latter face. In the operation of such a device, the beam is deflected in two coordinate directions, for example, repeatedly swept in one direction and selectively deflected in the other direction. The operation involves, basically, two periods or cycles, one "store" and the other "remove." During the "store" cycle or period, the potential or charge upon elemental areas of the bombarded face of the dielectric is varied in accordance with the amplitude of the input signal, the charge change on each area being proportional to the signal amplitude at the time the beam impinges upon that area. During the "remove" period or cycle, the charges upon these areas are resolved into respective potential changes in an output circuit connected to the conductive member or electrode in contact with the dielectric sheet.

Fundamentally, the charging and discharging of the elemental areas above noted results from emission of secondary electrons from an area when it is struck by the electron beam. For positive input signals during the "store" period, secondary electrons flow from the area to the barrier grid so that the potential of the area increases in the positive sense and approaches that of the barrier grid at that time. During the "remove" period, the barrier grid is at a constant potential, for example zero, and the secondary current from the area is less than the primary current thereto. Consequently the potential of the area decreases and approaches that of the barrier grid. This potential decrease is resolved into the output signal. For negative input signals during the "store" period, the charging and discharging takes place with polarity opposite to that above mentioned.

It has been found that the output signal level in devices of the type described is relatively low and further that the output signals do not conform with high fidelity to the input signals. The

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reasons for this will be analyzed in some detail hereinafter. However, it may be noted for present purposes that the low level and poor resolution may be ascribed to a secondary electron redistribution on the bombarded face of the dielectric due to a space charge or secondary electron spray at this surface, associated with the impinging primary electron beam.

One general object of this invention is to improve the performance of cathode ray devices of the storage type. More specifically, objects of this invention are to increase the output level and to improve the resolution of such devices.

In accordance with one feature of this invention, means are provided for reducing undesired secondary electron redistribution on the bombarded face of the target.

In accordance with a more specific feature of this invention, means are provided for affecting the primary electron beam so that only spaced elemental areas of the dielectric target are struck by the primary beam, these elemental areas being the same for both the "store" and "remove" sweeps of the beam and so spaced that each area is beyond the region of impact of the secondary electron spray resulting from impingement of the beam upon the next adjacent area or areas.

In one illustrative embodiment of the invention, the beam affecting means comprises an auxiliary electrode between the electron gun and the barrier grid and having a plurality of parallel wires opposite the barrier grid and extending at an angle, for example a right angle, to the direction of the beam sweep.

In another illustrative embodiment of this invention, the beam affecting means comprises a control electrode which is energized to repeatedly blank the beam during each "store" and "remove" period or cycle, whereby during both cycles the beam strikes only spaced elemental areas of the target.

In both of the illustrative embodiments above noted, in effect the beam is pulsed at the bombarded face of the target. Because of the spacing of the elemental areas of this face, secondary electrons emanating from any area cannot reach an adjacent area to alter the charge thereon. Inasmuch as the regions between the spaced elemental areas are not struck by the primary beam, these regions do not emit secondary electrons which might affect the bombarded areas. Thus, deleterious secondary electron distribution with consequent altering of the desired charges upon the bombarded areas is prevented.

The invention and the above-noted and other

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features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is in part a diagram of a cathode ray tube and in part a circuit schematic illustrating one embodiment of this invention;

Fig. 2 is a diagram, to an enlarged scale, of a portion of the target and barrier grid structure included in the tube shown in Fig. 1, with various capacitances between elements of this structure indicated;

Fig. 3 is a diagram representative of the equivalent circuit of the structure illustrated in Fig. 2, together with the input and output resistors;

Figs. 4A and 4B are diagrams which will be referred to hereinafter in the discussion of certain phenomena involved in devices of the type to which this invention pertains;

Figs. 5A to 5D are graphs illustrating the operation of a device embodying this invention;

Fig. 6 is in part a diagram of a cathode ray tube and in part a circuit schematic illustrating another embodiment of this invention;

Fig. 7 is a diagram showing a two-sided storage tube embodying features of this invention; and

Fig. 8 is a diagram and schematic, similar to Figs. 1 and 6, showing another illustrative embodiment of this invention.

Referring now to the drawing, the cathode ray tube illustrated in Fig. 1 comprises an evacuated enclosing vessel 10 having at one end thereof an electron gun which includes a cathode 11, a control electrode 12, anodes 13 and 14 and a focussing electrode 15. The electron gun produces a concentrated electron beam which is projected centrally between two pairs of deflector plates 16 and 17 mounted in space quadrature.

The electron beam is projected against a target mounted at the other end of the vessel 10, the target comprising a body or sheet 18 of dielectric material, for example mica, having on its rear surface a conductive member or output electrode 19, for example a metal coating. Closely adjacent the face of the insulating sheet 18 toward the electron gun is a barrier grid 20, which may comprise a mesh of fine wires or strips 21.

The deflector plates 16 and 17 are energized from deflecting circuits 22, for example to sweep the beam in one direction and to deflect it selectively in a coordinate direction. The input signals are applied to the barrier grid 20, from a source or circuit 23, across a low input impedance 24 in circuit with the potentiometer 25, 26. An output voltage is obtained across an output resistor 27 which is associated with a clamp circuit 28.

The device of Fig. 1 as thus far described is generally of known construction and functions to store a signal for one period of time and to reconstruct the signal at a later time. The general operation thereof is as follows: The storage, or removal or reconstruction of a signal is determined by conditions extant in the input circuit, the storage being effected by alteration of the potential of elements of the surface of the dielectric sheet 18 due to impingement of the beam thereon. For purposes of simple analysis, consider that a repeating saw-tooth sweep voltage is applied between one pair of the deflector plates, that input signals are applied to the barrier grid only during the odd-numbered

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time intervals of the sweep and that during the even-numbered time intervals the barrier grid is maintained at a constant potential, for example zero. The clamp circuit is driven in synchronism with the sweep circuit so that the output resistor is effectively short-circuited during the odd-numbered time intervals.

The fundamental signal storage and removal processes will be understood from the following considerations of the phenomenon at an elemental area of the face of the dielectric 18 toward the gun. Assume that initially this element is in equilibrium condition, that is, that no potential difference obtains across the face of the dielectric. At the instant that the beam, in its sweep, impinges upon the elemental area, assume that because of an input signal the barrier grid is at a positive potential relative to the dielectric face. Secondary electrons are emitted from this element when the beam impinges thereupon and these are drawn to the barrier grid. The ratio of secondary electrons leaving the element to primary electrons reaching it is greater than unity. As a result of the emission, the area under consideration will charge positively until it reaches a potential near that of the barrier grid. Thus, as a result of the input signal a charge is placed upon the area.

Now, when the beam impinges upon the area during the next time interval, there is no signal upon the barrier grid, as has been noted heretofore, and the area is at a potential higher than that of the grid because of the charge thereon. Secondary electrons produced by the impingement of the beam upon the area encounter a retarding field so that the ratio of secondary electrons leaving the area to primary electrons impinging upon it is less than unity. Consequently the area charges negatively until its potential approaches that of the barrier grid so that the secondary electron current from the area to barrier grid is substantially equal to the primary electron current to the area. The change in charge of the area results in a voltage across the output resistor 27 by virtue of the capacitance coupling between the front surface of the dielectric 18 and the electrode 19. This voltage, as is evident, is representative of the charge placed upon the area during the storage period and, hence, of the amplitude of the input signal at the time the beam impinged upon the area during the storage period.

The principal impedances involved in the operation above described are indicated in Figs. 2 and 3. In the former, for purposes of clarity of illustration, an elemental area of the front face of the dielectric 18 has been shown raised from this surface and is designated as E. This is coupled, through the dielectric, to the electrode 19 by a capacitance C₁ and to the barrier grid by a capacitance C₂. A third capacitance, C₃, obtains between the barrier grid and the electrode 19. The action of the electron beam in charging the area to a potential approaching that of the barrier grid with a signal thereon is analogous to connecting a resistance, shown at R in Fig. 3, across the capacitance C₂ through a switch S, the resistance being established through the impinging electron beam and the secondary electrons produced thereby. For practical reasons, C₁ should be large and C₂ and C₃ should be small. Also the output resistor 27 should be smaller than C₂.

In order to obtain a suitably small value for C₃, it has been found advantageous to space the

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barrier grid from the dielectric. It has been found, however, that so spacing this grid results in a relatively low output signal level and relatively poor resolution of the input signal.

The reasons for such observed low level and poor resolution and the principles involved in this invention for increasing this level and improving the resolution will be apparent from the following analysis with reference to Figs. 4A and 4B. In these figures, the primary electron beam is represented by the horizontal arrowed lines and has a diameter d adjacent the barrier grid 20 and the dielectric 18, the grid to dielectric spacing being δ . As in Fig. 2, for purposes of clarity of illustration, in Fig. 4A an elemental area E of the dielectric surface is represented as raised and in Fig. 4B two such areas, E and E', are so represented.

When, as illustrated in Figs. 4A and 4B, the primary beam impinges upon the elemental area E, secondary electrons are produced, as has been noted heretofore. Some of these electrons flow to the barrier grid, as indicated by the arrows extending from E to the grid in Fig. 4A. However, other of the secondary electrons return to the surface of the dielectric beyond the elemental area E, as indicated in Fig. 4A by the arrows extending from E to the dielectric 18. Thus, some secondary electron redistribution occurs outside of the area E whereby the charge upon other areas is altered.

Although such redistribution may occur over only a limited area beyond the area E, that is to a distance to either side of E comparable with or smaller than the distance δ , the effect thereof may well extend over a great area. The secondary electrons returning to the dielectric surface may be viewed as a spray around the periphery of the area or element upon which the primary beam impinges. This spray moves with the beam as the latter sweeps over the surface of the dielectric. Thus, during the "store" period, i. e. when the input signal is applied to the barrier grid, a negative space charge follows the beam and alters, specifically reduces, the charges placed on successive areas or elements of the dielectric surface. Similarly, during the "remove" period, i. e. when no signal is impressed upon the barrier grid, the negative space charge moving with and in front or ahead of the primary beam, produces an alteration in the charge upon successive elemental areas before the charges are translated into potential variations across the output resistor 27. Because of these effects, it will be evident that a low output level and poor signal resolution are to be expected.

Consider now the conditions and relations illustrated in Fig. 4B. The two elemental areas E and E' are spaced a distance such that when the primary electron beam is impinging upon one area, the spray of the resulting secondary electron emission does not reach the other area. Thus, the charge placed upon each area and the translation thereof into an output signal component is unaffected by the secondary electron spray from the other area. If, furthermore, no emission from the dielectric occurs from the regions of the dielectric surface between the areas E and E', deleterious effects of secondary electron distribution heretofore pointed out will be greatly reduced. Hence, a higher output level and better signal resolution will be realized.

In accordance with a feature of this invention, the desirable conditions illustrated in Fig. 4B are produced and a high output level and good signal resolution are obtained. In one embodiment, il-

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lustrated in Fig. 1, an auxiliary electrode 29 is provided opposite the barrier grid, the auxiliary electrode comprising a plurality of parallel wires 30 normal to the direction of the beam sweep and being maintained at a positive potential by a source such as a battery 31 so that all secondary electrons produced by impingement of the beam upon the wires 30 will be returned to and collected by these wires. The wires 30 should be spaced from one another to prevent the secondary electron spray overlap of successive elemental areas of the dielectric surface heretofore noted. For a beam diameter d of 10 mils and a barrier grid-dielectric spacing δ of 10 mils, wires 30 ten mils in diameter and spaced on 20 mil centers may be used. It will be understood that the wires intercept the primary electron beam and, thus, prevent impingement of the beam upon regions intermediate the areas of the dielectric surface aligned with the openings between adjacent wires 30, whereby secondary emission from these intermediate regions is eliminated.

In another embodiment, illustrated in Fig. 6, secondary electron distribution is reduced by controlling the electron beam. Specifically, the beam is repeatedly blanked during each sweep cycle by applying a blocking bias to the control electrode 12 from a pulsing circuit 32 coupled to the sweep circuit 33 by a synchronizing circuit 34 so that the elemental areas of the dielectric surface bombarded by the primary electron beam are the same for both the "store" and "remove" periods. The frequency of the application of the blocking bias is a multiple of the sweep frequency, is greater than twice the signal frequency and such that the spacing between adjacent elemental areas bombarded is sufficient to prevent the spray overlap heretofore pointed out.

In the embodiment illustrated in Fig. 6, a cylindrical collector electrode 35, maintained positive by the source 31, is provided to receive any secondary electrons, as from the dielectric or the barrier grid, which pass to the left of the barrier grid in the figure.

In both the embodiments illustrated in Figs. 1 and 6, the beam is interrupted, directly or in effect, so that it impinges upon only prescribed, spaced elemental areas of the surface of the dielectric 18 toward the electron gun. The operation of both embodiments is illustrated graphically in Figs. 5A to 5D, wherein the abscissae are time, of the same units and with a common zero axis. Fig. 5A shows two successive sweep cycles, one store and one remove; Fig. 5B shows the signal to be stored or translated, which, as illustrated and heretofore described, is applied to the barrier grid only during the store cycle; Fig. 5C shows the pulsing of the beam, either by blanking of the beam as in the embodiment illustrated in Fig. 6 or by interception by the grid wires 30 in the embodiment illustrated in Fig. 1; and Fig. 5D shows the output signal, composed of pulses, the envelope for which conforms to the input signal.

The signal resolution also may be improved and the output level increased by the creation, adjacent the bombarded surface of the dielectric 18, of a small magnetic field, for example of about 200 gauss, normal to this surface. Such a field restricts the area of the surface to which the secondary electrons constituting the spray, return. The magnetic field may be produced by a cylindrical coil 36 encircling the envelope 10, adjacent the dielectric sheet or body 18. It may

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be used alone or in combination with beam pulsing, effected either by blanking of the beam as in Fig. 6 or by the grid wires 30 as in Fig. 1.

The invention may be embodied also in a two-sided storage device such as shown in Fig. 7. In the device illustrated in Fig. 7, the target 180 is a thin plate of semiconductive material, for example lead glass, and the gun, deflecting system, barrier grid 20 and auxiliary electrode 29 are as in the device shown in Fig. 1 and described hereinabove. The input signal to be stored or translated is applied from the source 23 to the control electrode 12 of the gun. The positive charges produced upon the front or right-hand surface of the plate 180 as a result of the action of the beam from the gun leak through the plate to produce corresponding charges on the rear or left-hand surface of the plate. The charges are removed, to produce a replica of the input signal in the output resistor 27 associated with the output electrode 40, by scanning the back surface with a low velocity beam produced by a cathode 41, focussed magnetically by a coil 42 and deflected in coordinate directions by other coils 43.

The device illustrated in Fig. 8 is a modification of those shown in Figs. 1 and 6 and heretofore described. In this embodiment, the input signal is applied to the back electrode 19 and the output is taken from the collector electrode 35. A secondary current to the collector electrode, proportional to the stored signal, is produced during the "remove" cycles because of the fact that in the discharge process of the bombarded surface of the dielectric, some of the discharge secondary electrons reach points beyond the barrier grid 20, that is to the left in Fig. 8, and are drawn to the collector electrode. An auxiliary electrode 45 maintained negative by a source 46 may be provided between the gun and the collector electrode 35 to prevent secondary electrons from reaching deflection plates 17. An advantage of this arrangement is that the output resistor 27 is not shunted by the capacitance C_3 between the barrier grid and the back electrode.

Although specific embodiments of this invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A cathode ray device comprising a dielectric target, an electrode upon one face of said target, an electron gun including a control electrode opposite the opposite face of said target for projecting an electron beam thereagainst, electrode means in secondary electron receiving relation with said opposite face, deflection means for sweeping said beam across said opposite face, means for energizing said deflection means, and means for controlling the potential of said control electrode in synchronism with said energizing means to repeatedly blank said beam during each sweep cycle.

2. A cathode ray device comprising a dielectric sheet, a first electrode upon one face of said sheet, a barrier grid adjacent the opposite face of said sheet and parallel thereto, means for projecting an electron beam against said opposite face, means for sweeping said beam over said opposite face, means operative upon said beam for restricting impingement of said beam during each sweep of said beam over said opposite face

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to the same and prescribed elemental areas of said opposite face, said elemental areas being spaced from each other a preassigned distance, said last-mentioned means including a second electrode positioned within said device in the path of said electron beam, a collector electrode adjacent said barrier grid, an input circuit connected to said first electrode and an output circuit connected to said second electrode.

3. A cathode ray device comprising a target, one face of which is secondary electron emissive, an electrode overlying, spaced from, and in secondary electron receiving relation to said face, means opposite said face for projecting an electron beam thereagainst, means for deflecting said beam to sweep it across said face, and means for reducing undesired secondary electron redistribution over said face as a result of impingement of said beam on said face, said last-mentioned means including an electrode positioned within said device in the path of said beam for repeatedly interrupting said beam during the sweep thereof across said face.

4. A cathode ray device comprising a dielectric body, a conductive member in contact with one face of said body, electrode means adjacent the opposite face of said body for receiving secondary electrons emanating therefrom, means for projecting an electron beam against said opposite face, means for sweeping said beam over said opposite face, and means for repeatedly interrupting said beam during the sweep thereof across said opposite face, said interrupting means comprising an auxiliary electrode having a plurality of beam intercepting parts extending at an angle to the direction of the beam sweep and positioned opposite said opposite face, said beam impinging on only the area of said opposite face between two adjacent beam intercepting parts at any one time.

5. A cathode ray device comprising a dielectric body, a conductive member in contact with one face of said body, electrode means adjacent the opposite face of said body for receiving secondary electrons emanating therefrom, means for projecting an electron beam against said opposite face, means for sweeping said beam over said opposite face, and means for repeatedly interrupting said beam during the sweep thereof across said opposite face, said interrupting means comprising circuit means associated with said projecting means for repeatedly blanking said beam during the sweep thereof.

6. A cathode ray device comprising dielectric target means, electrode means on one face of said target means, an electron gun for projecting an electron beam against the opposite face of said target means, electrode means adjacent said opposite face and in secondary electron receiving relation therewith, means for repeatedly sweeping said beam over said opposite face, and means operative upon said beam for restricting impingement of said beam during each sweep of said beam over said opposite face to the same and prescribed elemental areas of said opposite face, said elemental areas being spaced from each other a preassigned distance, and said beam impinging on only one of said elemental areas at a time.

7. A cathode ray device in accordance with claim 6 comprising a collector electrode spaced from said opposite face of said target means.

8. A cathode ray device in accordance with claim 6 wherein said means operative upon said beam consists of an electrode positioned within

said device in the path of said electron beam and having electron impervious portions between said electron gun and said target means and each aligned with the region between two respective adjacent ones of said elemental areas.

9. A cathode ray device in accordance with claim 6 wherein said means operative upon said beam comprises an electrode positioned within said device in the path of said electron beam and means for applying beam blanking pulses to said electrode positioned in the path of said electron beam.

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