

Jan. 5, 1960

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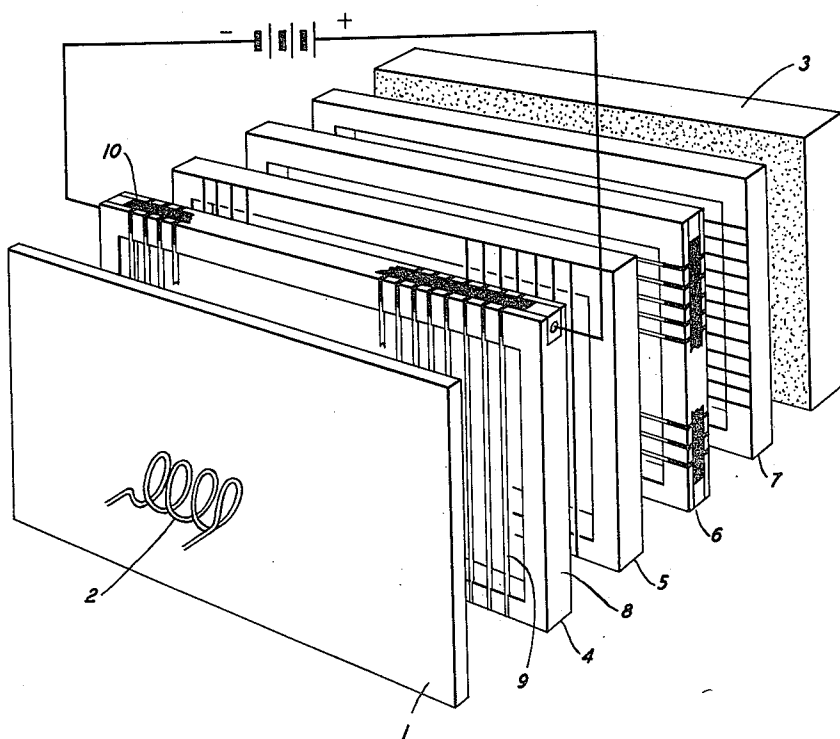
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ELECTRON DISCHARGE DEVICES USING GRID CONTROL SCANNING

Filed Aug. 27, 1956

4 Sheets-Sheet 1

FIG. 1



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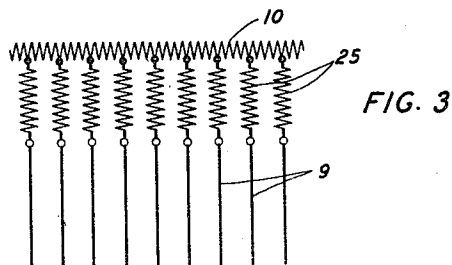
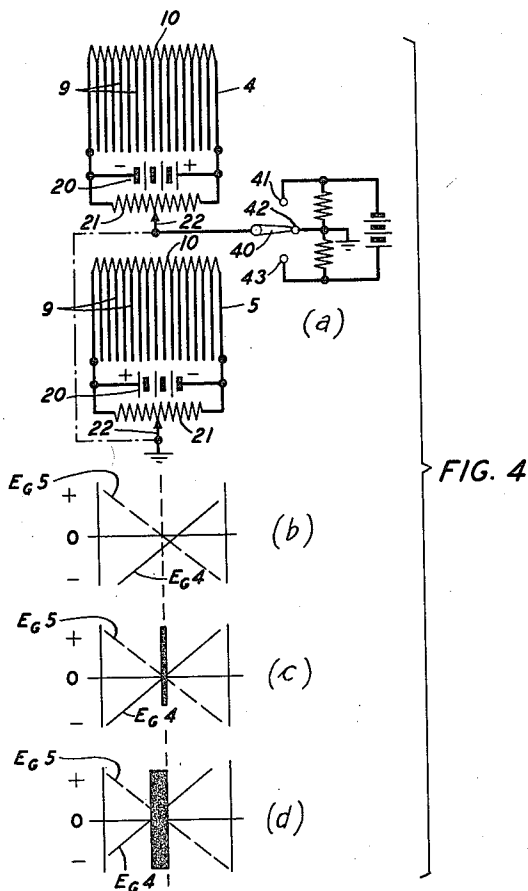
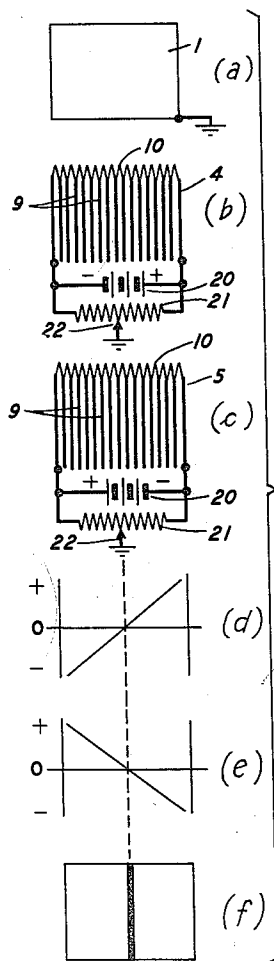
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4 Sheets-Sheet 2



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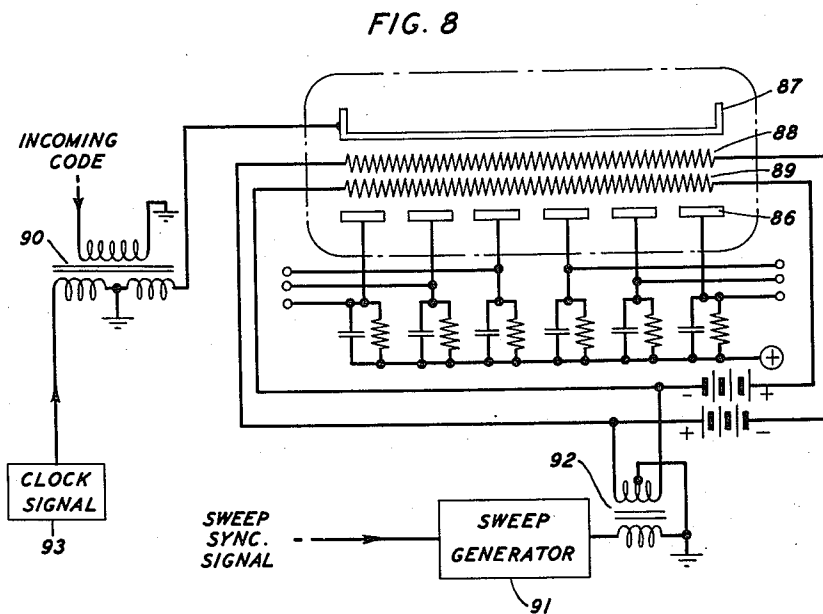
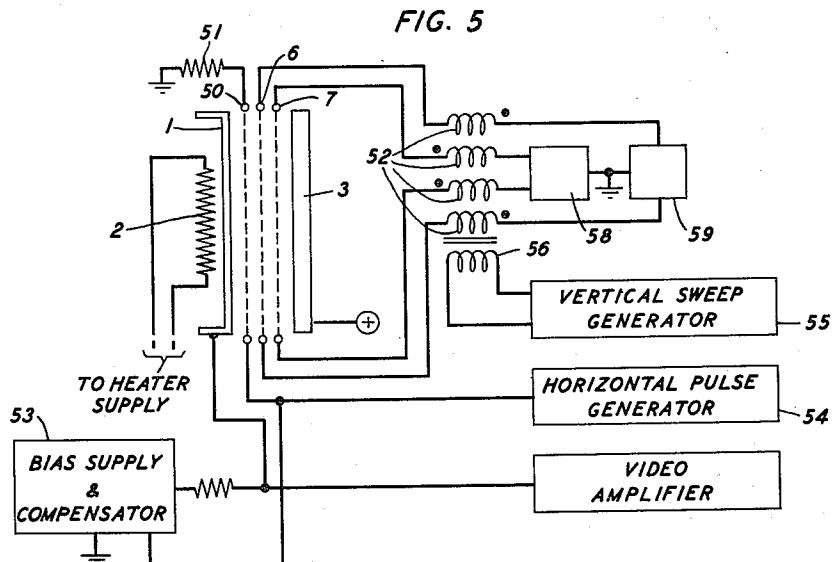
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ELECTRON DISCHARGE DEVICES USING GRID CONTROL SCANNING

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4 Sheets-Sheet 3



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ELECTRON DISCHARGE DEVICES USING GRID CONTROL SCANNING

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FIG. 6

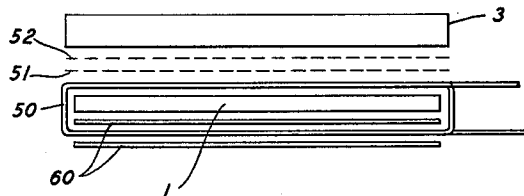
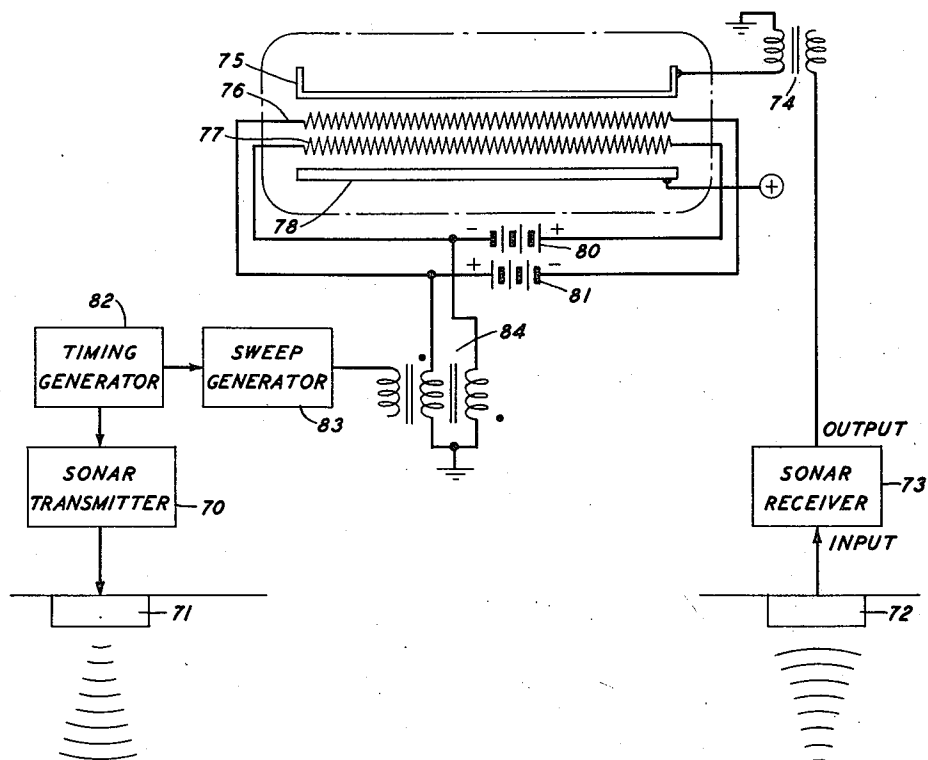


FIG. 7



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1

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ELECTRON DISCHARGE DEVICES USING GRID CONTROL SCANNING

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12 Claims. (Cl. 315—30)

This invention relates to electron discharge devices and particularly to grid controlled scanning of an electron beam in electron discharge devices.

In the conventional type of cathode ray tube as utilized, for example, in television applications, the position of the electron beam and hence the particular area of the target impinged by the beam at any instant, is determined by the intensity of deflecting fields established in electrostatic or electromagnetic deflection systems. The utilization of such deflection systems requires employment of the familiar electron gun with its attendant accelerating and focusing electrodes to form and project a suitable electron beam through the deflecting field. Such elements demand an appreciable tube length for effective operation, thus hindering the use of cathode ray tubes in limited space applications.

The instant invention provides a unique grid control of electrons emitted from the cathode so as to eliminate conventional beam forming and deflecting elements. The entire output of a large cathode surface is received at the grid structure which, in accordance with this invention, directs the passage of electrons through portions of the grid allowing only a controlled portion of the electrons to reach the target screen.

By utilizing a cathode surface substantially as large as the target display surface, the electron emission may be controlled by the grid structure to provide a suitable scanning raster for various applications such as television, sonar and multiplex code conversion.

Accordingly, it is an object of this invention to provide an improved electron discharge device.

It is another object of this invention to provide a compact electron discharge device which contains few components.

It is a further object of this invention to provide grid control of an electron beam in lieu of electrostatic or electromagnetic deflection.

These and other objects of the invention are attained, in accordance with the invention, by the provision of a series of grids in an evacuated chamber between a flooding beam cathode and a target anode display surface, the elements all being of substantially like planar dimensions. The grid structure performs the essential positioning control of the electron beam on the display surface and may be adapted to modulate the beam intensity as well in applications requiring such control.

In conventional cathode ray tube operation, the electron gun normally provides a fine pencil shaped beam which may be deflected in horizontal and vertical coordinates so as to impinge the target anode at any desired discrete area. With a regularly graduated deflection program, as normally employed in television applications, for example, the beam may be scanned over the target surface in a predetermined raster.

I have found, in accordance with one aspect of this invention, that such scanning may be performed by a grid structure comprising a pair of adjacent grids for each deflection coordinate, each including a series of fine paral-

2

lel wires lying in a plane perpendicular to the electron beam path and mutually parallel to a deflection coordinate. The grid wires are attached at one end at equally spaced intervals to a resistance member such that a voltage applied to the resistance member tends to produce a linear potential gradient across the individual grid wires in the plane through which the positioning is to be controlled. By applying voltage of opposite polarity to the resistance members of each of a pair of the grids, oppositely directed linear potential gradients will be established thereacross.

The grid structure will allow electrons from the cathode to pass therethrough to the target anode only in those areas where the grid wires exhibit a positive potential. Thus, by appropriate settings of the potential gradients on the various grids relative to cathode potential, electrons may be channeled through the grid structure to impinge the target anode in a desired discrete area. Also, by varying the potential gradients according to a uniform program, the restricted electron path may be altered in a regulated pattern so as to scan an electron beam about the target anode.

In accordance with another aspect of this invention, the grid structure may constitute a portion of a voltage pulse delay line in which the individual grid wires act as a distributed inductance. By biasing the grid to cut off electron flow and applying a pulse to the delay line of sufficient amplitude to bring the tube out of cutoff, electrons may be scanned across the target anode as the voltage pulse moves down the delay line.

Additionally, a mode of intensity modulation may be performed utilizing the grid structure in accordance with this invention whereby variations in the potential gradients relative to cathode potential applied to pairs of grids will permit consequent variations in the portion of the electron beam reaching the target anode.

It is a feature of this invention to position a pair of coordinate grid structures in the path of electron flow, which grid structures comprise mutually parallel grid wires connected in each individual grid to a common conductive element.

It is another feature of this invention that oppositely directed linear potential gradients be applied to the conductive elements of the pair of coordinate grid structures.

It is another feature of this invention to employ a pair of grid structures for each deflection coordinate.

It is another feature of this invention so to vary relative positions of the potential gradients on each grid structure effectively to confine the electron beam to impinge the target electrode in a discrete area and to scan the impinging portion of the beam over the target electrode.

It is another feature of this invention so to vary the cathode potential relative to the grid structure as to vary the number of electrons impinging the target anode.

It is another feature of this invention to utilize the individual grid wires as a portion of a delay line to provide distributed inductance and to bias the grid to cutoff prior to application of a voltage pulse to the delay line sufficient to bring the voltage above the cutoff level.

A complete understanding of this invention and of these and various other features thereof may be gained from consideration of the following detailed description and the accompanying drawing in which:

Fig. 1 is a perspective view, partially in schematic form, of one illustrative embodiment of this invention;

Fig. 2 is a series of schematic and graphical representations demonstrating the effect of potential gradients present across the various grids of the embodiment of Fig. 1;

Fig. 3 is a portion of the grid structure of Fig. 1 in schematic form;

Fig. 4 is a series of schematic and graphical representations demonstrating grid modulation in the embodiment of Fig. 1;

Fig. 5 is a schematic representation of an electron discharge device incorporating one illustrative embodiment of this invention;

Fig. 6 is a grid structure in accordance with the embodiment of Fig. 5;

Fig. 7 is a schematic representation of a depth measuring system incorporating one illustrative embodiment of this invention; and

Fig. 8 is a schematic representation of a code conversion system incorporating one illustrative embodiment of this invention.

Referring now to the drawing, Fig. 1 is a perspective view of the basic components of one illustrative embodiment of this invention. As there depicted, an electron discharge device comprises a flat cathode member 1 of sufficient size to provide a flooding beam, when energized by heater element 2, which will blanket substantially the entire surface of anode member 3. Positioned between the cathode 1 and anode 3 is a series of grid members 4, 5, 6 and 7, arranged to provide coordinate positioning and, if desired, intensity modulation of the flooding beam. Each grid advantageously comprises a frame 8 and a series of fine conductive wires 9 fastened to the frame 8 so as to maintain the wires 9 mutually parallel to one of two control coordinates. Thus, in this illustrative embodiment the wires 9 in the grids 4 and 5 are parallel to the vertical coordinate so as to control the flooding beam incident on the anode 3 in the horizontal direction while the wires 9 in the grids 6 and 7 are parallel to the horizontal coordinate so as to control movement of the flooding beam in the vertical direction. The wires 9 in each of grid members 4-7 are fastened in insulating material at one side of the frame 8 and at regular intervals to a conductive element 10 which provides a graduated resistance across the opposite side of frame 8. The ends of each of the conductive elements 10 are connected to voltage sources so as to establish a potential gradient across the conductive element 10.

The grids 4 and 5 have their respective conductive elements 10 oppositely connected to a source of potential, such that the potential gradients established across these grids are oppositely directed. Similarly, grids 6 and 7 are oppositely connected to a potential source to provide oppositely directed potential gradients thereacross.

The anode member 3 advantageously may serve as the viewing screen for this device and thus would comprise a transparent material such as glass having a transparent conducting film on the inner surface thereof adjacent grid 7 and having a luminescent material deposited on the transparent conducting film. In this fashion electrons of the flooding beam impinging upon the inner surface of anode 3 will activate the luminescent material so as to provide a visual recording of the desired pattern.

Fig. 2 provides a pictorial representation of a simple method for establishing potential gradients across the grids 4 and 5. As depicted therein, each of the grids 4 and 5 is provided with a source of potential indicated by battery 20. As shown, the negative side of battery 20 is connected to the extreme left side of the grid 4 and to the extreme right side of the grid 5. In this manner oppositely directed potential gradients may be established on these grids.

A simple means for varying the potential gradient position with respect to cathode potential is indicated in Figs. 2b and 2c by the resistance elements 21 and the moving contacts 22 connected to cathode potential, ground in this instance. Each resistance element 21 is connected in parallel with the battery 20 and a conductive element 10 so that varying the positions of the contacts 22 will vary the positions relative to ground of the potential gradients

established across the conductive elements 10 and thus across the grid wires 9.

The means indicated in Fig. 2 for varying the potential gradient position is merely illustrative and may take any number of forms well known in the art including electronic means for extremely rapid variations.

In Fig. 2b the contact 22 has been set at a particular point on the resistance element 21, which setting establishes a potential gradient across grid 4, shown graphically in Fig. 2d. Similarly, the setting on grid 5, as shown in Fig. 2c, establishes the potential shown in Fig. 2e. Thus it is seen that a portion of the conductive grid wires 9 is at a negative potential and a portion is at a positive potential with respect to the cathode, and at a discrete area, the potential is zero with respect to the cathode, or ground potential in this instance. With the potential gradients oppositely directed, as shown in Figs. 2d and 2e, the cathode potential is established in the same discrete area on each of the grids 4 and 5. The flooding beam, in attempting to pass through the grids 4 and 5, will encounter a negative potential on a portion of grid 4 which will prevent its passage therethrough. However, the positive portion of the grid will pass a portion of the flooding beam to grid 5. As indicated in Fig. 2e, the portion of the beam passing through grid 4 will encounter that portion of grid 5 which is at a negative potential, so that only that portion of the flooding beam directed at the discrete area of each of grids 4 and 5 at cathode potential will be permitted to pass through to grid 6.

At this point it is evident that only a line or ribbon beam will be available beyond grid 5, as shown in Fig. 2f. The grids 6 and 7, Fig. 1, have potential gradients established thereacross in a manner so as to control the vertical coordinate. These gradients are also oppositely directed such that the portion of the original flooding beam passing through grids 6 and 7, Fig. 2f, will be further confined so as to impinge anode 3 at a discrete point. By varying the potential gradients on the grids 4-7 in accordance with a preestablished scanning pattern, it is seen that the original flooding beam may be scanned over the anode 3 as a fine pencil beam in accordance with any desired pattern.

In order to avoid the detrimental effects of drawing excessive grid current when a large area of any one of the grids 4-7 is positive, series limiting resistances advantageously may be added to the grid conductors, such as resistance 25 on the grid wires 9 in Fig. 3.

Fig. 4 illustrates the application of the grid control of this invention for varying the intensity of the beam incident on the anode 3. The grid 4 has its moving contact 22 connected to ground through the switching mechanism 40, Fig. 4a, which advantageously may vary the reference level of grid 4. Grid 5 has its moving contact 22 connected directly to cathode potential, ground in this instance, as its reference level. By varying the relative reference levels, the size of the transmitted portion of the beam may be varied. Thus, with the switch in position 41, Fig. 4a, the potential gradients E_{G4} and E_{G5} formed by the grids 4 and 5, respectively, in effect will cross at a point at which the grid potential is more negative than the cathode potential, as shown in Fig. 4b. As is evident from this graphical representation, the flooding beam will be completely cut off at this setting of the potential gradients. Movement of the switch control to contact 42 connects the grid 4 to the cathode potential which is at ground in this instance, establishing the potential gradient positions shown in Fig. 4c. With the setting at contact 42 in Fig. 4a, the beam will pass through the discrete area of grids 4 and 5 at the cathode potential, providing the line or ribbon beam output illustrated in Fig. 2f. Again, moving the switch to contact 43 in Fig. 4a, in effect, will cause the potential gradients of the grids 4 and 5 to cross at a potential more positive than that on the cathode, as shown in Fig. 2d, so as to permit a wider ribbon beam, as shown by the shaded

5

area, to pass through the grids; i.e., electrons passing through portions of each grid 4 and 5 at or above cathode potential. In this fashion the proportion of the beam incident on the anode 3 may be varied in accordance with any desired pattern. Similarly, variations conducted in this fashion on the grids 6 and 7 will provide variations in the size of a pencil beam incident on the anode 3.

Fig. 5 is one illustrative embodiment of this invention utilizing a delay line as an integral part of the novel grid control arrangement. As there depicted, only three grids 50, 6 and 7 are employed such that the flooding beam is controlled in only one of the horizontal and vertical coordinates in the manner described hereinbefore. Thus, the grids 6 and 7 in this example will control the vertical coordinate and will pass, in the absence of grid 50, a ribbon beam to the anode 3 and sweep this ribbon beam thereacross. The control for this vertical sweep is provided by source 55 through transformer primary coil 56 and the various secondary coils 52. The coils 52 also pass steady state potential to the grids 6 and 7 from sources 58 and 59 to form the requisite potential gradients. The secondary coils 52 are so arranged as to provide the same instantaneous induced voltage to each end of the grid to which they are connected, thus raising or lowering the potential gradient position on the grid in relation to the cathode potential.

The two positioning grids 4 and 5 shown for the horizontal coordinate in Fig. 1 are replaced in Fig. 5 by a single grid 50 connected to or forming a portion of a delay line. By applying a fixed linear horizontal time base from a horizontal pulse generator 54 to this delay line grid 50, which is biased so as to place the tube in a normal cut off condition, the grid 50 may be pulsed so as to permit conduction only in a discrete linear area, which pulse would then move down the delay line grid 50 toward its termination 51, continually changing the conducting area and thereby providing a linear scan. The delay advantageously may be distributed along the line, which delay will be made equal to the time for one sweep of the input signal.

One possible delay line grid structure is illustrated in Fig. 6. In this instance there is shown a grid structure 50, the frame of which surrounds the cathode 1 and its heater. The front face of the grid frame has attached thereto the grid wires which in this instance form inductance for the delay line. The rear face of the grid frame is spaced intermediate metal plates 60 which form the necessary capacitance for the delay line. In this fashion the grid 50 itself forms a distributed delay line. Impulses from a pulse generator will travel down this line so as to increase the potential on each grid wire in turn to cause conduction through the discrete area about the grid wire affected. The delay of the line illustrated in Fig. 6 is set equal to the time for one sweep of the input signal and is terminated in its characteristic impedance in order to prevent reflections.

To compensate for attenuation of the signal pulse traveling through the delay line of grid 50, a saw-tooth voltage wave form advantageously may be applied to the delay line or to the cathode 1 from the source 53, Fig. 5, to assure that each signal pulse, though of declining amplitude, will produce conduction. The source 53 may also be utilized to compensate for the change in cathode potential resulting from the change in area of conduction during the vertical sweep. Thus it may be seen that the circuit of Fig. 5 may have scanning application utilizing a combination of the delay line grid 50 and the two grid vertical positioning system.

In Fig. 7 is shown an adaptation of this grid control structure for depth measurement. The circuit includes the usual components of sonar equipment including a transmitter 70, transducers 71 and 72 for transmitting the signals from the transmitter 70 and receiving the echoes of these signals from an object beneath the surface of

6

the water, and a receiver 73 which provides the echo signals from transducer 72 to transformer 74. The output of transformer 74 varies the signal on cathode 75 of an indicator tube. The cathode 75 is elongated and preferably in cylindrical form surrounded by slotted cylindrical grid support structures. The wires of grids 76 and 77 are stretched across the windows formed by the grid support structures arranged in a concentric form, such that a portion of the electrons emanating from cathode 75 passes through grids 76 and 77 in turn. A tubular glass envelope surrounds the entire structure of the indicator tube and the portion of this envelope adjacent the grid 77 has its inner surface coated with a luminescent material and forms the anode 78 which is placed at a high positive potential with respect to the cathode potential. The ends of grids 76 and 77 are connected to steady state potential sources shown as batteries 80 and 81 in Fig. 7 so as to provide oppositely directed potential gradients across the grids 76 and 77 in the manner described hereinbefore. A timing-generator 82 synchronizes the action of transmitter 70 and a sweep generator 83 which, through transformer 84, varies the position of the potential gradients across the grids 76 and 77 in relation to the cathode potential. By providing a graduated scale adjacent the viewing screen anode 78 of the indicator tube, a direct indication of the distance to the object sounded is available.

The versatility of this novel grid structure is further demonstrated by the application disclosed in Fig. 8. In this circuit a structure similar to that shown in the sonar application of Fig. 7 is provided, but the anode structure is divided into discrete sections 86. With this alteration the circuit may have application in various code conversion systems such as required for time division multiplex operations. In this instance a video signal in time multiplex form is received in transformer 90 and is fed therefrom to the cathode 87 of the converter tube. A saw-tooth voltage applied by sweep generator 91 to grids 88 and 89 through transformer 92 serves to move the conducting area to be coincident with a proper one of the anodes 86 during each time slot. A converter tube thus may be arranged to be nonconducting unless a pulse, present in the incoming code, coincides with signal pulses received at transformer 90 from a clock signal source 93. The incoming encoded signal in pulse time multiplex form thus is readily converted to parallel form by the converter tube utilizing the novel grid structure of this invention.

Accordingly, it is to be understood that the described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be made by those skilled in the art without departing from the spirit and scope of this invention.

What is claimed is:

1. An electron discharge device comprising a cathode, grid means and a target anode arranged in that order within an evacuated envelope, said grid means comprising a plurality of mutually parallel wires, a distinct resistance member connected at discrete intervals to one end of each of said wires and means applying a potential to said resistance member to control the potential on adjacent ones of said grid wires whereby a portion of the electrons emitted by said cathode is intercepted by certain of said grid wires and the balance impinges a discrete area of said target.

2. An electron discharge device comprising in an evacuated envelope a cathode, a target and grid means for controlling the flow of electrons from said cathode to said target, said grid means comprising a plurality of parallel wires mutually interconnected at one end of each wire through an electrically conductive path, means applying a potential to said grid means through said electrically conductive path, and means in said path including impedance means effective to control the potential on

adjacent ones of said grid wires so as to intercept a portion of the electrons emitted by said cathode at certain of said grid wires and to pass the balance of emitted electrons to a discrete area of said target.

3. An electron discharge device comprising an electron source, a target and grid means positioned between said source and said target, said grid means comprising a plurality of wires connected at one end of each wire to an electrically conductive path, impedance means in said path distributed equally between the connecting ends of said wires, means applying potential to said grid means through said path, and means in said path including said impedance means to control the potential on adjacent ones of said grid wires so as to intercept electrons from said source to said target and passing adjacent a portion of said grid wires.

4. An electron discharge device comprising a source of electrons, a target and control means positioned in the path of electrons traveling from said source to said target, said control means comprising first and second grids each having a resistive member and a plurality of distinct mutually parallel grid wires connected to adjacent grid wires at one end through equal portions of said resistive member and insulated from adjacent grid wires at the other end, and means applying a potential of one polarity to said first grid resistive member and of opposite polarity to said second grid resistive member whereby electrons from said source impinge said target at a discrete area thereof.

5. An electron discharge device in accordance with claim 4 further comprising means for varying the potential of said cathode with respect to the potential on each of said grid wires whereby said target is scanned by impinging electrons.

6. An electron discharge device in accordance with claim 5 further comprising means for varying the potential of said cathode with respect to the potential applied to said resistive members whereby the number of electrons impinging said target may be varied.

7. An electron discharge device in accordance with claim 6 wherein said control means further comprises third and fourth grids each having a resistive member and a plurality of distinct mutually parallel grid wires connected to adjacent grid wires at one end through equal portions of said resistive member, said third and fourth grid wires being angularly displaced with respect to said first and second grid wires, and means applying a potential of one polarity to said third grid and of opposite polarity to said fourth grid.

8. An electron discharge device in accordance with claim 7 wherein said grids are arranged in mutually parallel planes, the wires of said first and second grids being displaced 90 degrees with respect to the wires of said third and fourth grids.

9. An electron discharge device comprising a source of electrons, a target electrode and means for controlling the impingement of electrons from said source at consecutive discrete areas of said target electrode, said control means comprising delay line inductive elements arrayed as a grid of parallel conductors between one side of said source and said target and delay line capacitive means connected to said inductive elements on the opposite side of said source, and means for applying a voltage pulse to each of said inductive elements.

10. An electron discharge device in accordance with claim 6 wherein said control means further comprises pulse delay means including a third grid of parallel grid wires angularly disposed with respect to said first and second grid wires, means biasing said delay means to cutoff, and means for applying a voltage pulse consecutively to each of said third grid wires.

11. An electron discharge device comprising a source of electrons, a target and control means comprising delay line means having interconnected inductive and capacitive means, said inductive means comprising parallel conductive elements arrayed as a grid between one side of said source and said target and said capacitive means comprising a pair of parallel plates positioned on the opposite side of said source, and means for applying a voltage pulse to each of said conductive elements in succession.

12. An electron discharge device in accordance with claim 11 and further comprising means applying a sawtooth voltage wave form to said delay line means to compensate for attenuation of said voltage pulse along said delay line means.

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