A signal display tube includes composite strips placed uniformly across a phosphor coating of the screen. Each strip comprises a photoconductive, a conductive and an insulative member. The electron beam sweeps the viewing screen with an intensity insufficient to excite the phosphor coating. The presence of a bright spot is sensed by an adjacent composite strip, which then causes the electron beam to produce a new bright spot. The time involved between sensing existing spots and producing new ones is such that the existing bright spots either move laterally or are refreshed in the same position.
3,790,851

ELECTRON BEAM TUBE WITH MOVING DISPLAY OR MEMORY

This is a Continuation of U.S. Pat. application Ser. No. 25,882, filed on Apr. 6, 1970, now abandoned.

The invention relates generally to the display of a signal and more specifically to the shifting of information laterally on the screen of a CRT while new information is being entered at one of the edges of the screen, or the "freezing" of repetitive or nonrepetitive signals on the screen for an indefinite period of time.

In many cathode ray tubes oscilloscopes, the cathode ray or electron beam is deflected in accordance with the information signal to be displayed. Periodic signals can be observed as standing images on the screen. Non-periodic signals however, can only be observed for as long a time as the persistence of the phosphor allows. After the energy of the electron beam is absorbed by the phosphor, and released in the form of light, the information contained in this energy is lost and is not normally recoverable, per se.

It is an object of this invention to provide an electron beam tube with a means to retain nonrepetitive signals and the information contained therein.

It is another object of this invention to provide an electron beam tube requiring only a single beam to accomplish this retentive feature.

It is still another object of the invention to provide an improved cathode ray tube oscilloscope which utilizes a single beam to propagate or perpetuate the display of repetitive or nonrepetitive signals.

It is an additional object of this invention to provide a means of displaying a plurality of signal sequences during a specific period of time.

It is yet another object of this invention to provide a means for displaying a plurality of nonrepetitive signals continuously with time.

In accomplishing these and other objectives there has been provided, in accordance with the present invention, an improved electron beam display tube which incorporates a unique target screen that includes a luminescent phosphor coating and means selectively responsive to discrete areas of luminescence of the phosphor coating to effect Z axis modulation. In an exemplary operation, a raster is scanned by an electron beam and a bright spot is produced on the left edge of the viewing screen in a position representative of the amplitude of the signal to be displayed. The bright spot causes an activation of the selectively responsive means, which cooperates with the beam producing means whereby, on successive sweeps of the beam thereafter, the spot is either refreshed in place or propagated toward the opposite side of the screen from the side at which it originated, depending on whether the tube is operating in a memory mode or in a propagation mode.

A better understanding of the present invention may be had by reading the following detailed description and associated drawings, in which:

FIG. 1 is a schematic block diagram of the system according to the present invention.

FIG. 2 is an enlarged partial horizontal sectional view of the target screen of the tube face shown schematically in FIG. 1 and at a time T₁.

FIG. 4 is an enlarged partial horizontal sectional view of the target screen of the tube face shown schematically in FIG. 1 and at a time T₂.

FIG. 5 is a schematic diagram of the portion of the system enclosed by dashed lines in FIG. 1, and including additional circuits for multitrace display.

In FIG. 1, the electron beam 38, is understood to be produced in the normal manner which is well known in the art, and therefore its associated circuitry is omitted to avoid unnecessary complication. FIG. 1 shows a glass face 31, an anode 2, a phosphor coating 32, and a gridwork 1, displaced from one another in order to present a clear and distinct representation of these elements. In actuality however, these items are arranged adjacent to and touching each other respectively. Input terminals 40 and 41 are connected to amplifier 14. The output of this amplifier 14 is connected to the output of a zero set circuit 15, and also to one input of a comparator circuit 13. The other input to the comparator circuit 13 comes from the output of a Y axis ramp generator 9. The output of a clock signal generator 10 is connected to the input of the Y axis ramp generator 9 and also to the input of an X axis ramp generator 8. The output of the Y axis ramp generator 9 is also connected to vertical deflection plates 19 of a CRT. One output terminal of the X axis ramp generator 8 is connected to horizontal deflection plates 20 of the CRT. The output terminal of the comparator 13 is connected to one input of a two input AND gate 11. The other input of gate 11 is connected to an output terminal of the X axis ramp generator 8 which supplies a Start X axis Sweep signal. The output terminal of gate 11 is connected to one input terminal of a two input OR gate 12. The output terminal of gate 12 is connected to a write-level drive circuit 16. The output of the write-level drive circuit 16. The output of the write-level drive circuit 16 is connected to the output of a read-level bias supply 17 and also to a control grid 18 of the CRT. A common bus 50 connects conductive members 33 of the grid work 1. A amplifier 3 has its input connected to the common bus 50 and its output connected to the input of a pulse shaper circuit 4. The output of the pulse shaper 4 is connected to one input of an inhibit gate circuit 5. The other input of the inhibit gate circuit 5 is connected to the output of the write-level drive circuit 16. An adjustable delay circuit 6 has its input terminal connected to the output terminal of the inhibit gate 5, and its output terminal is connected to one input of the end of sweep inhibit gate 7. The other input to the end of sweep inhibit gate is connected to the X axis ramp generator circuit 8 which provides an End of X Axis Sweep signal. The output terminal of the end of sweep inhibit gate 7 is connected to one input of the OR gate 12.

The composite strips 39, shown in FIG. 2 comprise a conductive member 33, a photoconductive member 34 and an insulative member 35. The conductive member 33 is electrically isolated from the electron beam 38 in part by the insulative member 35 and in part by a normally nonconducting photoconductive member 34. When the photoconductive member 34 is excited by a radiant spot on the viewing screen the normally nonconducting photoconductive member changes states and becomes conducting thereby establishing a conductive path between the electron beam and the conductive member 33 of the composite strip 39.
FIG. 5 shows the amplifier 14, the zero set circuit 15, the comparator 13, and the AND gate 11 of FIG. 1. An AND gate 11A has one input terminal connected to the X axis ramp generator 8 which provides a Start of X axis sweep signal and the other input connected to the output of a comparator 13A. One input of comparator 13A is connected to a point of common connection connecting the output of an input signal amplifier 14A and the output of a zero set circuit 15A. The output terminal of AND gate 11A is connected to one input of a multi-input OR gate 12A. OR gate 12A also has inputs from the end of sweep inhibit gate 7 and the output terminal of AND gate 11. The output of OR gate 12A is connected to the write-level drive circuit 16 which is shown in FIG. 1.

In operation, an electron beam 38 is generated and scans the viewing screen in much the same way as a T.V. raster. The normal reading level intensity of an electron scanning beam is not sufficient to excite the phosphor screen to luminescence and hence no bright spots will appear. The intensity of the beam at the reading level is controlled by the read-level bias supply 17. The signal to be displayed enters the circuit through an amplifier 14, shown in FIG. 1. After amplification, the signal is added to a zero set voltage. The purpose of the zero set voltage is to set the zero voltage reference level on the viewing screen. The signal then is fed into a compare-amplifier 13. When the Y axis ramp voltage is equal to the voltage of the signal to be displayed as modified by the zero set voltage, the compare-amplifier 13 sends a signal to an AND gate 11. Upon receipt of the next X axis sweep signal, the "AND" gate 11, gives an output pulse which goes through an "OR" gate 12 and into a write-level drive circuit 16. The write-level drive 16, in turn, momentarily intensifies the electron beam 38 to the writing level, or the level required to produce a bright spot on the viewing screen. In this manner, samples of new information are at the left edge of the viewing screen in the exemplary embodiment at a rate substantially equal to the Y axis ramp signal frequency.

When more than one signal are to be displayed, the circuit of FIG. 5 is substituted for the circuit enclosed by dashed lines in FIG. 1. One input signal is connected to the input terminals 40 and 41 of the amplifier 14. The second input signal is connected to the input terminals 40A and 41A of a second input signal amplifier 14A and so on. Additional input signals may be displayed by incorporating similar circuitry as that shown in FIG. 5. When the instantaneous magnitude of any input signal is equal to the amplitude of the Y axis ramp signal, the associated comparator 13A will produce an enabling signal which is then fed to the appropriate AND gate 11A. Upon receipt of the next X axis sweep pulse from the X axis ramp generator 8, the AND gate 11A will cause an enabling pulse to be introduced to the OR gate 12A. The OR gate 12A will then pass a signal to the write-level drive circuit which in turn causes a bright spot to be produced on the viewing screen.

In FIG. 2, a bright spot 36 is shown existing at a time T. Radiation from this bright spot has excited to conductivity the photoconductive member 34 of an adjacent composite strip 39 on the side of the bright spot from which the electron scanning beam 38 approaches during its horizontal sweeps. The horizontal sweep section 30 in the example is from right to left as viewed from inside the tube. This sweep would be seen by an observer as left-to-right on the viewing screen. Since the photoconductive member 34 is excited, and therefore in a conductive state, the conductive member 33 detects the electron beam as a negative going pulse, as the beam 38 passes over the photoconductive member 34. Referring again to FIG. 1, the common bus 40 connecting the conductive members 33, passes the detection pulse to an amplifier 3 from which it is sent through a pulse shaper 4 and then to an inhibit gate 5. The purpose of the inhibit gate 5 is to prevent the action of "writing" a bright spot, to simultaneously cause a spot to be "read." When the write-level drive circuit is caused to intensify the electron beam to the "write" level, it sends a pulse of a predetermined duration to the inhibit gate 5. If this "write" pulse and the detection pulse co-exist at any time at the inhibit gate 5, then the inhibit gate 5 will not allow the detection pulse to pass to the delay circuit. If the detection pulse is passed by the inhibit gate, it is then presented to the input terminal of an adjustable delay circuit 6. After a delay, the detection pulse is then sent to an end of sweep inhibit gate 7. This gate 7 prevents the bright spot from being "rewritten" after it has reached, for example, the right edge of the screen. The end of sweep inhibit gate 7 receives an end of sweep pulse from the X axis ramp generator whenever the electron beam has reached the end of the target screen on each X axis sweep across the screen. If an "end of sweep" pulse is not present at the end of sweep inhibit gate 7 when the delayed detection pulse is, then the delayed detection pulse is passed to the OR gate 12 which in turn sends a signal to the write-level drive circuit 16. The write-level drive circuit 16 then intensifies the beam 38 to the "writing" level, or sufficiently to produce a bright spot on the viewing screen. The time delay circuit is used to produce a predetermined delay between the "reading" of the bright spot pulse and its application to the write-level drive 16. In one such predetermined delay the system will operate in a refresh or memory mode. In this case the time delay is equal to the time required for the electron beam to move from the composite strip sensing radiant spot to the next adjacent phosphor screen area. At this time the beam intensity will be increased to the writing level and a new bright spot will be produced at substantially the same location as that of the faded spot which had originally caused the intensity of the beam to be increased. In a second adjustment of the time delay circuit, the delay between the "read" and "write" operations is such as to cause the bright spot to appear to be shifted laterally on the face of the tube thereby characterizing the propagation mode of the display system. In the latter case the time delay is substantially equal to the time required for the electron beam to travel from the composite strip sensing the radiant spot to the second or subsequent phosphor area encountered thereafter. When the electron beam impinges this second phosphor area, the beam intensity will be increased to the writing level and a new bright spot will be produced which will be displaced by one or more composite strips from the faded radiant spot that originally caused the beam intensity to be increased.

The propagation mode is used to display a continuous signal which varies with time. In this mode, new information in the form of bright spots is introduced, for example, at the left edge of the screen, and existing information is propagated toward the right edge of the screen. FIG. 2 shows the electron reading beam 38 im-
ping on the excited photoconductive member of a composite strip 39. This initiates the sensing function as previously explained. The time delay circuit is set so as to delay the spot-writing pulse a predetermined time after the sensing of an existing spot. This is indicated in FIG. 4 wherein the beam 38 senses an existing spot 37 as time \( T_1 \) and produces a pulse which is then delayed and causes the intensity of the beam to be increased to the writing level \( 21 \) at a later time \( T_2 \). The beam 38 at the writing level then produces a new spot 36 which is
displaced incrementally to the right as the viewer sees it, of the sensed spot 37. The increment is illustrated as being equal to the space between adjacent strips 39.

The memory mode can be used to sustain a portion of a signal on the viewing screen for an indefinite period of time. In this mode, a displayed segment of a signal is "frozen" in place and each bright spot making up the displayed segment is refreshed on every successive screen scan by the electron beam, thereby maintaining the display on the screen indefinitely. FIG. 2 shows the electron reading beam 38 striking the excited photoconductive member of a composite strip 39. This initiates the detection as previously explained. The time delay circuit 6 is set so as to delay the spot writing pulse a predetermined time after the sensing of an existing spot. This is indicated in FIG. 3 wherein the beam 38 senses an existing spot 37 at time \( T \) and produces a pulse which is then delayed and causes the intensity of the beam 38 to be increased to the writing level at a later time \( T_1 \). This produces a new spot 36 at substantially the same position as the sensed spot 37. Mask bars may be added to the screen to prevent the spreading of the bright spots produced by the beam.

Thus there has been provided a moving-trace CRT, with the capability of propagating existing traces to one side of the viewing screen while introducing presently occurring signal values at the other side of the screen, or stopping the moving display on command and refreshing the "frozen" display with every sweep of the electron beam thereafter.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A signal display system including:
   a CRT display tube having a single scanning electron beam, a phosphor screen, and a photosensitive grid work superimposed on said phosphor screen;
said photosensitive gridwork including a plurality of composite bars each formed of a conductive member, a nonconductive member shielding a longitudinal portion said conductive member from said electron beam, and a photosensitive member shielding the residual longitudinal portion of said conductive member from said electron beam;
   means for generating a first sweep signal to effect a sweeping of said beam across the face of said tube in a first direction at a first scanning rate;
   means for generating a second sweep signal to effect a sweeping of said beam in a second direction perpendicularly with respect to said first direction and at a second scanning rate;
   input signal control means;
   beam intensity control means for controlling the intensity level of said electron beam between a first intensity level less than sufficient to excite said phosphor screen to luminosity, and a second intensity level sufficient to excite said phosphor screen to luminosity;
gating means responsive to said input signal control means and coupled to said intensity control means for introducing a luminous spot on said phosphor screen along a first edge thereof and representative of the instantaneous value of the input signal;
said gating means including means for momentarily actuating said intensity control means from said first level to said second level; and
   means for actuating said photosensitive gridwork for actuating said intensity control gating means on subsequent sweeps of said beam in said second direction in response to sensing signals developed in said conductive member incident to luminous spots on said phosphor screen imposed during the previous such sweep of said beam.

2. The invention as set forth in claim 1 wherein said gridwork is comprised of strips of elements positioned in closely spaced juxtaposition and perpendicular to said first direction of said scanning beam.

3. The invention as set forth in claim 1 and further including means responsive to a plurality of input signals and operative to cause the substantially simultaneous presentation of said plurality of input signals on said target screen.

4. A signal display system comprising a cathode ray display tube having means forming a single scanning electron beam, a phosphor screen, and a photosensitive gridwork superimposed on said phosphor screen;
said photosensitive gridwork including a plurality of composite bars each formed of a conductive member, a nonconductive member and a photosensitive member,
said composite bars being positioned in closely spaced parallel relation across the face of said tube in a position to be sequentially scanned by said beam, said nonconductive member being positioned to shield said conductive member along one longitudinal portion from the effect of said scanning beam, said photosensitive member being positioned to shield said conductive member along the residual longitudinal portion, said photosensitive members being excitable to a conductive state by a luminous spot on said phosphor screen adjacent to individual ones of said photosensitive members,
means for generating a first sweep signal to effect a sweeping of said beam across the face of said tube in a first direction substantially perpendicular to the longitudinal dimension of said bars and at a first relatively high scanning rate;
means for generating a second sweep signal to effect a sweeping of said beam in a second direction substantially perpendicular to said first direction and at a second substantially lower scanning rate;
input signal control means;
beam intensity control means for controlling the intensity level of said electron beam between a first intensity level less than sufficient to excite said phosphor screen level sufficient to excite said phosphor screen to luminosity;
gating means responsive to said input signal control means and coupled to said intensity control means for introducing a luminous spot on said phosphor screen along a first edge thereof and representative of the instantaneous value of the input signal,
said gating means including means for momentarily actuating said intensity control means from said first level to said second level; 
acting means including said photosensitive grid-work for actuating said intensity control means through said gating means on subsequent sweeps of said beam in said second direction in response to detection signals developed in said conductive member incident to luminous spots on said phosphor imposed on said screen adjacent to one of said photoconductive members during the previous such sweep of said beam; and 
said actuating means further including time delay means connected between said photosensitive grid-work and said gating means for controlling a delay in the application of said sensing signal to said gating means whereby to control the mode of operation of said display system. 
5. The invention as set forth in claim 4 wherein said time delay means includes means defining a relatively short time delay such that said intensity control means is actuated to reexcite to luminosity the same portions of said phosphor screen as were excited on the previous scan of said electron beam, whereby a luminous trace on said phosphor screen appears to remain stationary. 25

6. The invention as set forth in claim 4 wherein said time delay means includes means defining a relatively long time delay such that said intensity control means is actuated to excite to luminosity a portion of said phosphor screen at least one space later, in the direction of the movement of said beam, than the portions which were excited to luminosity on the previous scan of said beam, whereby a luminous trace on said phosphor screen appears to move relatively slowly across the face of said display tube.

7. The invention as set forth in claim 4 wherein said actuating means further includes a first inhibit gating means responsive to said detection signals and signals from said beam intensity control means and operative to preclude the passing of said detection signals to said delay means when said detection signal occurs within a predetermined time period after the switching of said intensity control means to said second level.

8. The invention as set forth in claim 7 wherein said actuating means further includes a second inhibit gating means responsive to signals from said delay means and signals from said first sweep signal generating means and operative to preclude the passing of said detection signals from said delay means to said gating means when said detection signals occur within a predetermined time period immediately preceeding the terminal portion of each electron beam sweep in said first direction.

9. A signal display system including input terminal means for receiving a time varying analog input signal, single gun CRT display means, and digital electronic solid state control means connecting said input terminal means and said single gun CRT display means, said digital electronic solid state control means being operative to effect a presentation of said time varying analog input signal on said single gun CRT display means wherein instantaneous values of said time varying analog input signal are periodically entered at one side of said single gun CRT display means, and previously entered values of said time varying analog input signal are periodically shifted incrementally toward the opposite side of said single gun CRT display means.

10. The signal display system as set forth in claim 9 wherein said digital electronic solid state control means includes means operative to arrest the propagation of said previously entered values, thereafter maintaining an existing image on said single gun CRT display means for an indefinite period of time.

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