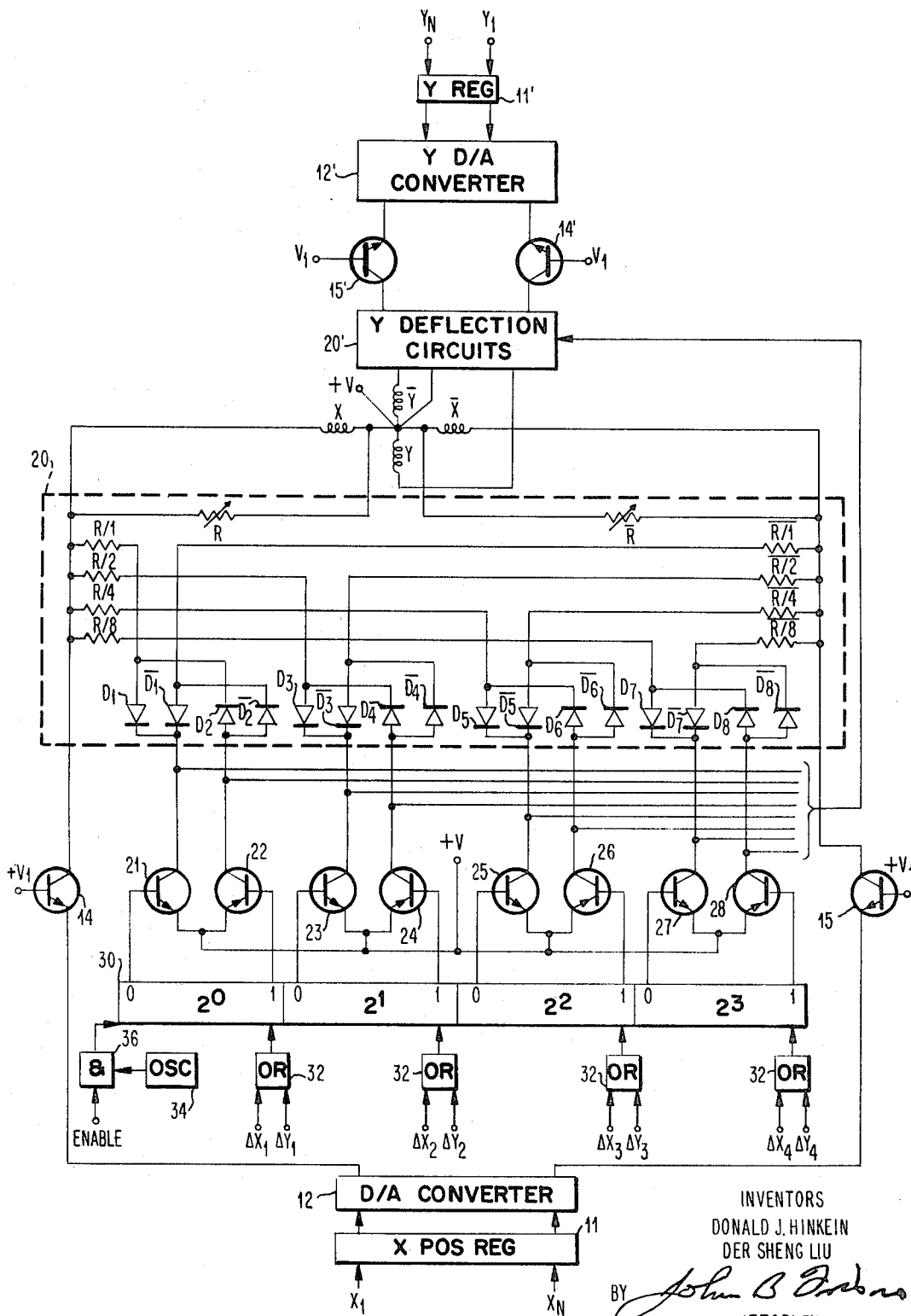


March 4, 1969

D. J. HINKEIN ET AL
GRAPHIC DEFLECTION SYSTEM EMPLOYING VARIABLY DAMPED
DEFLECTION WINDING
Filed Nov. 26, 1965

3,431,457



INVENTORS
DONALD J. HINKEIN
DER SHENG LIU

BY *John B. Anderson*
ATTORNEY

1

2

3,431,457

GRAPHIC DEFLECTION SYSTEM EMPLOYING VARIABLY DAMPED DEFLECTION WINDING

Donald J. Hinkein, Germantown, and Der Sheng Liu,
New Paltz, N.Y., assignors to International Business
Machines Corporation, New York, N.Y., a corporation
of New York

Filed Nov. 26, 1965, Ser. No. 509,717

U.S. Cl. 315—18

Int. Cl. H01j 29/70

7 Claims

ABSTRACT OF THE DISCLOSURE

Display beam deflections of substantially constant velocity are provided upon the application a single step of current corresponding to the desired deflection. The display beam deflection control winding is damped by a plurality of weighted impedances which are connected selectively across the winding by a sequencing control to vary the damping of the winding from an overdamped to a critically damped state during the deflection.

This invention relates to computer controlled graphic display systems and more particularly to a deflection system for use in graphic display devices which utilizes discrete steps of current for effecting movement of a display element.

Computer controlled displays utilizing cathode ray tubes to display information have proved to be a very useful man machine communication device in the data processing field since the device is capable of providing graphic as well as alpha-numeric information. The display devices are capable of a number of different modes of operation, the most common utilizing a conventional television type raster scan and selective beam blanking to display the desired information. Such systems, however, are not well suited for displaying graphic information which entails, in many instances, the display of long lines, which more often than not, are skewed with respect to the raster.

Graphic display systems are particularly suited to a vectoring system in which the screen, or display area, is divided into a rectangular coordinate system and the beam is vectored from one (X, Y) position to another by specifying successive straight lines in terms of the (X, Y) coordinates of the end points of the successive straight lines. The computer in such a system need only store the end points of the successive straight lines and the beam intensity information for each such line, i.e. blanked or unblanked. Thus, an image may be defined with a minimum amount of storage.

The computer will specify the end points, in most instances, by a binary code which is readily converted into two currents, one for (X) and one for (Y) which when applied to the (X) and (Y) deflection windings of the display device will cause the beam to move to the end point specified by the binary coded signal from the computer. In such a system it is essential that the beam move in a straight line from its origin or then attained point to the specified end point and within a uniform velocity. Any non-linearity will introduce image distortion and a non-uniform velocity will cause image intensity variations corresponding inversely to beam velocity.

One object of this invention is to provide a deflection system for displays employing cathode ray tubes which deflects the beam with substantially uniform velocity.

Another object of the invention is to provide a deflection system for displays employing cathode ray tubes which is capable of producing up to full screen linear de-

flections upon the application of a single step of current corresponding to the desired deflection.

A further object of the invention is to provide a deflection system for a graphic display system utilizing a cathode ray tube which is capable of producing unlimited linear deflections of substantially constant velocity upon the application of a single step of current corresponding to the desired deflection.

The invention contemplates a deflection system for a display comprising winding means for receiving an incremental current corresponding to the desired beam position, a plurality of weighted impedance means, and switch means responsive to a control signal corresponding to the magnitude of the desired beam deflections for selectively and sequentially connecting the weighted impedance means across the winding means to vary the damping of the winding means from an over damped to a critical damped state.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

The single figure is a schematic and block diagram of a novel deflection system for a display device constructed in accordance with the invention.

The novel deflection circuit shown in the drawing is connected to provide push pull deflection. In a push pull deflection system two X and two Y direction windings are provided. In the drawings these are labeled $X, \bar{X}$ and $Y, \bar{Y}$. When the beam is centered the currents through each winding half for each direction are substantially equal and opposite and when a deflection is desired the currents are differentially incremented. Thus increasing the current in X winding and simultaneously decreasing the current in the $\bar{X}$ direction causes the beam to move from the center position horizontally. Alternatively decreasing the current in X and increasing the current in $\bar{X}$ causes the beam to move horizontally in the opposite direction. Movement in the vertical direction, either up or down from center, is effected by a similar complementary current change in the Y and $\bar{Y}$ windings.

The X position of the beam is controlled by an X position register 11 which is provided with n inputs (X_1-X_n) each of which corresponds to one bit of an n bit binary coded digital signal defining the X coordinate of the position of the beam. When register 11 is zero the beam is positioned as far to the left as possible since no current is supplied to the X winding and full current is supplied to $\bar{X}$ winding. Current control is effected by a digital to analog converter 12 responsive to the output of register 11 and may take the form of the digital to analog converter shown in application Ser. No. 505,534, now U.S. Patent No. 3,391,300 filed Oct. 28, 1965, by D. J. Hinkein and A. G. Stritt and assigned to the assignee of this application.

Converter 12 may, as shown in the above cited application, include a plurality of binarily weighted current sources which are selectively connected under control of register 11 to the X and $\bar{X}$ windings via transistor buffer amplifiers 14 and 15, respectively, to thus secure the desired positioning in the X or horizontal direction.

Vertical or Y direction deflection is effected by a pair of push pull windings Y and $\bar{Y}$. The Y binary coded digital signal is applied to a Y position register 11' and converted in a digital to analog converter 12' to two differential or complementary currents which are applied to windings Y and $\bar{Y}$ via transistor buffer amplifiers 14' and 15', respectively.

The circuit thus far described will provide limited linear beam deflection if the time constants of the X and Y cir-

cuits are equal. If the change in current through the windings exceeds a predetermined limit the circuit will not produce linear deflections. However, even in the case of linear deflections the velocity will not be uniform and therefore the intensity of the trace will vary from beginning to end. Furthermore, the limitation on the length of linear movement is a severe drawback since it requires that long traces be executed as a series of shorter traces.

The limitation of the deflection stems from the fact that the induced voltage in the windings produces two distinct types of adverse effects. First a decrease in current is sufficiently large will induce a voltage which causes the base-collector voltage of the connected buffer amplifier 14 or 15, as the case may be, to exceed the break down voltage and second the increase in current in the other winding causes the other buffer transistor to saturate. Once saturation takes place the equality of the time constants of the X and Y circuits is destroyed since the ratio of R/L for at least one deflection circuit is changed due to the saturation of the associated buffer and therefore linear deflection is no longer possible.

The current in the X winding changes exponentially according to the expression

$$(1) \quad I_x = I_0(1 - e^{-RT/L})$$

where I_0 is the steady state current supplied by the current source, L is the inductance of the winding X and R is the damping resistance of winding X and includes the resistance of buffer amplifier 14. Due to the exponential change in each of the windings the beam velocity is non linear. The value of R in the above equation may be varied incrementally according to the length of the vector to be drawn such that the current changes substantially linearly (or approximates a linear function) with respect to time. This is accomplished by providing sixteen values of resistance which may be placed in parallel with the winding to incrementally change the damping from an over damped state to a critical damped state to thus linearize the change of current.

Such a solution provides two beneficial results. In the first instance the current change with respect to time approximates the desired linear relationship and thus provides a substantially uniform beam velocity and trace intensity. Secondly, the damping resistors connected in parallel with the windings limit the voltage swings at the collector of transistors 14 and 15 to prevent saturation and/or breakdown. The bias voltage V_1 applied to the base of transistors 14 and 15 is selected to provide equal swings above and below the nominal steady state D.C. voltage at the collector. Thus equal voltage changes above and below the steady state nominal D.C. voltage are provided to breakdown and to saturation, respectively.

Windings X and $\bar{X}$ are provided with adjustable resistors R and $\bar{R}$, respectively. Windings Y and $\bar{Y}$ are also provided with similar adjustable resistors, however, these are not separately shown and are included in block 20' which is identical to the components illustrated within dashed block 20. Resistors R and $\bar{R}$ are initially adjusted to compensate for the differences in the windings X, $\bar{X}$, Y and $\bar{Y}$. The resistance values are selected such that the time constants of the windings and parallel resistors are substantially identical and critically damped.

Four resistors R/1, R/2, R/4 and R/8, which equal R, one half R, one quarter R and one eighth R, respectively, are provided and are selectively connected in parallel with resistor R to provide as much as sixteen discrete values of damping whereby the damping of winding X may be varied in as many as sixteen steps from an over damped to a critically damped condition where resistor R only is in parallel with winding X.

Resistors R/1, R/2, R/4 and R/8 each have one end connected to the common junction of winding X and the collector of buffer amplifier 14. The other end of resistor R/1 is returned to +V via diodes D1 or D2 and transistor

switches 21 or 22, respectively. The other end of resistor R/2 is returned to +V via diodes D3 or D4 and transistor switches 23 or 24, respectively. The other end of resistor R/4 is returned to +V via diodes D5 or D6 and transistor switches 25 or 26, respectively, and resistor R/8 is returned to +V via diodes D7 or D8 and transistor switches 27 or 28, respectively.

The $\bar{X}$ winding and parallel resistor $\bar{R}$ is similarly provided with resistors $\bar{R}/1$, $\bar{R}/2$, $\bar{R}/4$ and $\bar{R}/8$ and diodes $\bar{D}1$ - $\bar{D}8$ which are connected to transistor switches 21-28 as described above.

Switches 21-28 are under the control of a four bit counter 30 which is set by the larger of two four bit codes ΔX or ΔY supplied by the computer. The ΔX code corresponds to the magnitude of the horizontal component of the deflection and the ΔY code corresponds to the magnitude of the vertical component of the deflection. Each bit position of this code is supplied via an OR gate 32 to the corresponding bit position of counter 30 and sets counter 30 to a value corresponding to the magnitude of the greater of ΔX or ΔY . Thus, if a full screen deflection is to be executed in any direction the counter will be set to all "ones." The four bits utilized are the four high order bits of the difference between the current position in X or Y and the new position, thus with a ten bit code the screen is divided into 16 identifiable magnitudes.

A ten bit code provides 1024 addressable points and utilizing the four high order bits only in counter 30 provides 16 identifiable magnitudes with 63 points or raster units therebetween. Thus, the deflection circuit, and buffer amplifier 14 in particular, must be able to handle the current required to deflect 63 raster units without saturation to provide linear deflection. If this requirement cannot be met then a five or larger position counter will be necessary to handle the deflection. The larger the counter and the more resistances connected in parallel, the more nearly linear the increase in current through winding X will be, however, it is not believed that more than four or five bits providing 16 or 32 divisions would be required since the human eye is incapable of detecting intensity variations at that level. Furthermore, equipment limitations, primarily buffer amplifier 14, do not present a problem with four or more bit positions providing a sixteenth uncorrected deflection.

The counter 30 is initially set by the larger of ΔX or ΔY and must be reduced to zero at a fixed rate. This is accomplished by an oscillator 34 gated by an AND gate 36 which is conditioned at appropriate time by an enable signal from the computer. The output of AND gate 36 is applied to counter 30 and decrements the counter at a rate determined by oscillator 34.

When the counter reaches zero the deflection is within 63 raster units of completion and terminates a fixed time thereafter. With this arrangement asynchronous operation is possible since only the actual time required to complete a vector need be taken. This factor represents a substantial time savings because, in any graphic system, short vectors are far more numerous than long vectors and therefore synchronous operation is costly from the point of view of time.

In operation the X and Y position registers contain some value and the beam is at a position determined thereby. When deflection to a new point is desired the new X and Y coordinate of that point along with ΔX and ΔY are supplied by the computer. The ΔX and ΔY values are the four high order bits of the difference, regardless of sign, between the old values of X and Y and the new values of X and Y, respectively.

Counter 30 is set and the new values of X and Y are inserted in the X and Y position registers. At this point gate 36 is enabled and the counter 30 reduced to zero. As the counter decrements to zero the resistances in parallel with the associated yoke windings change by steps, up to sixteen determined by the magnitude of the vector, to thus

March 4, 1969

D. J. CHRISTOPHER

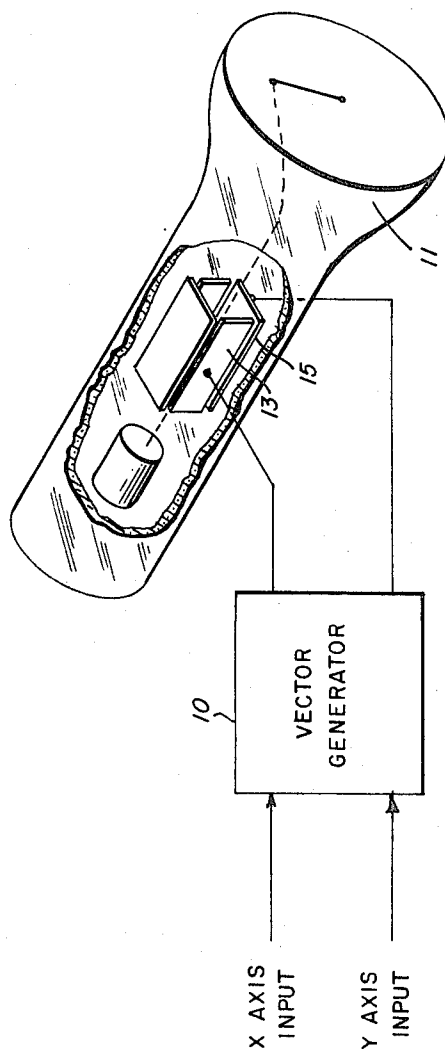
3,431,458

VECTOR GENERATOR

Filed Sept. 1, 1967

Sheet 1 of 2

FIG. 1



INVENTOR

DARYL J. CHRISTOPHER

BY *Irving S. Rappaport*
ATTORNEY