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Sinusas

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[54] **CATHODE RAY TUBE DEFLECTION SYSTEM UTILIZING ELECTROMAGNETIC AND ELECTROSTATIC BEAM DEFLECTION**

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[58] **Field of Search** ....315/17, 23, 24, 25, 27 R, 30, 315/31

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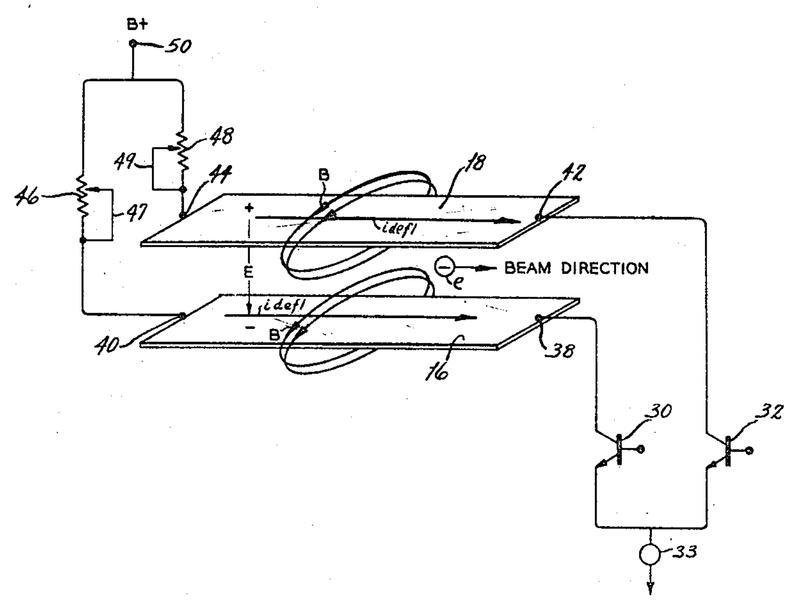
[57] **ABSTRACT**

A deflection system for electrically charged particle beams and having at least first and second deflection plates therein between which the charged particle beam passes. Selected locations on each of the first and second deflection plates are driven by a source of deflection signals, and a load circuit is connected between other selected locations on the first and second deflection plates. The deflection signals applied to the deflection plates establish both an electromagnetic and an electrostatic field between the deflection plates, and the combined force of these fields is utilized to deflect the charged particle beam and thus provide maximum deflection sensitivity for the system. Additionally, the deflection system disclosed herein may be operated either wholly be electromagnetic deflection or wholly by electrostatic deflection. Furthermore, since the deflection plates of the system exhibit a characteristic impedance, these plates may be terminated in their characteristic impedance for optimum system performance; and the latter feature enables deflection plate length to be adjusted without affecting the frequency response of the system.

12 Claims, 4 Drawing Figures



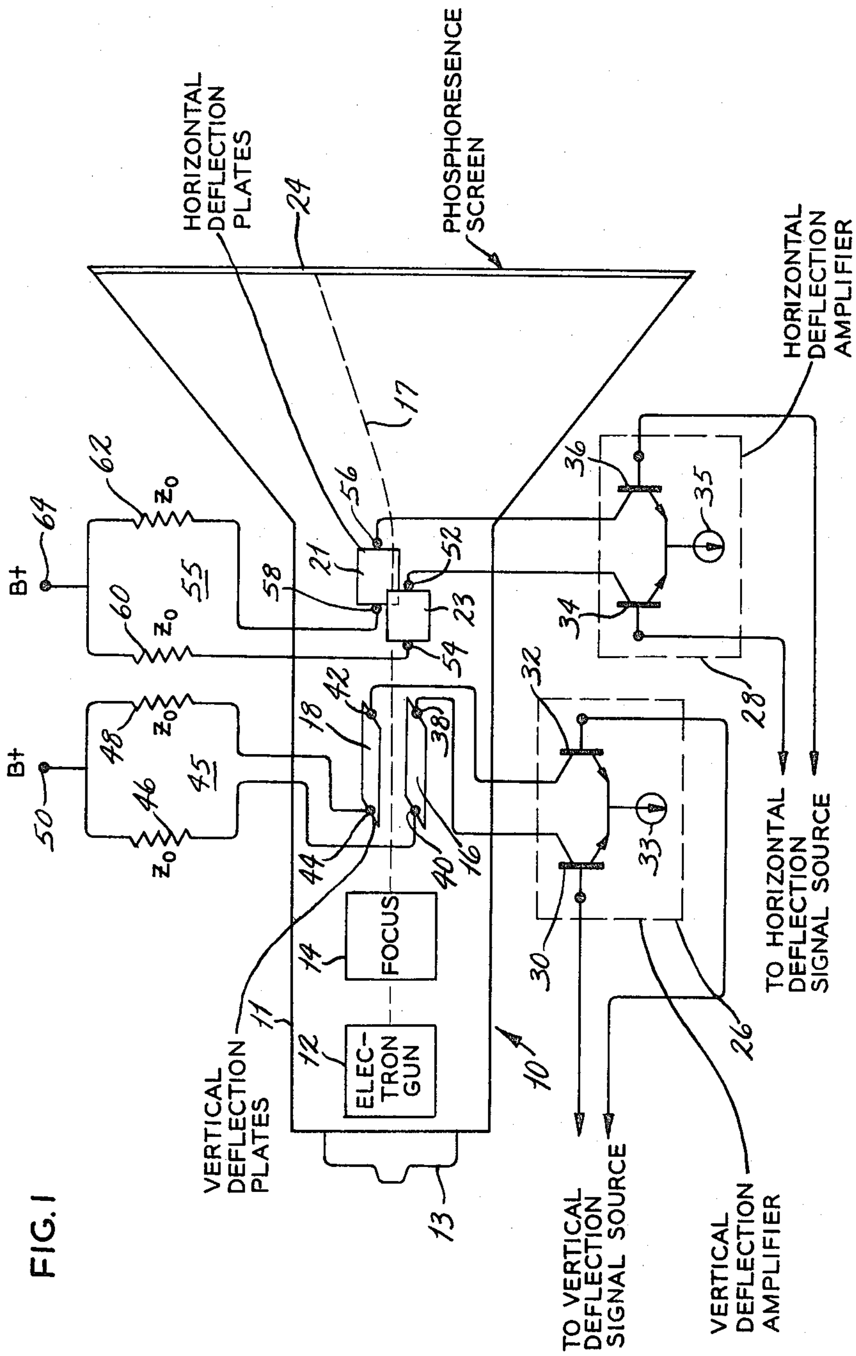


FIG. 1

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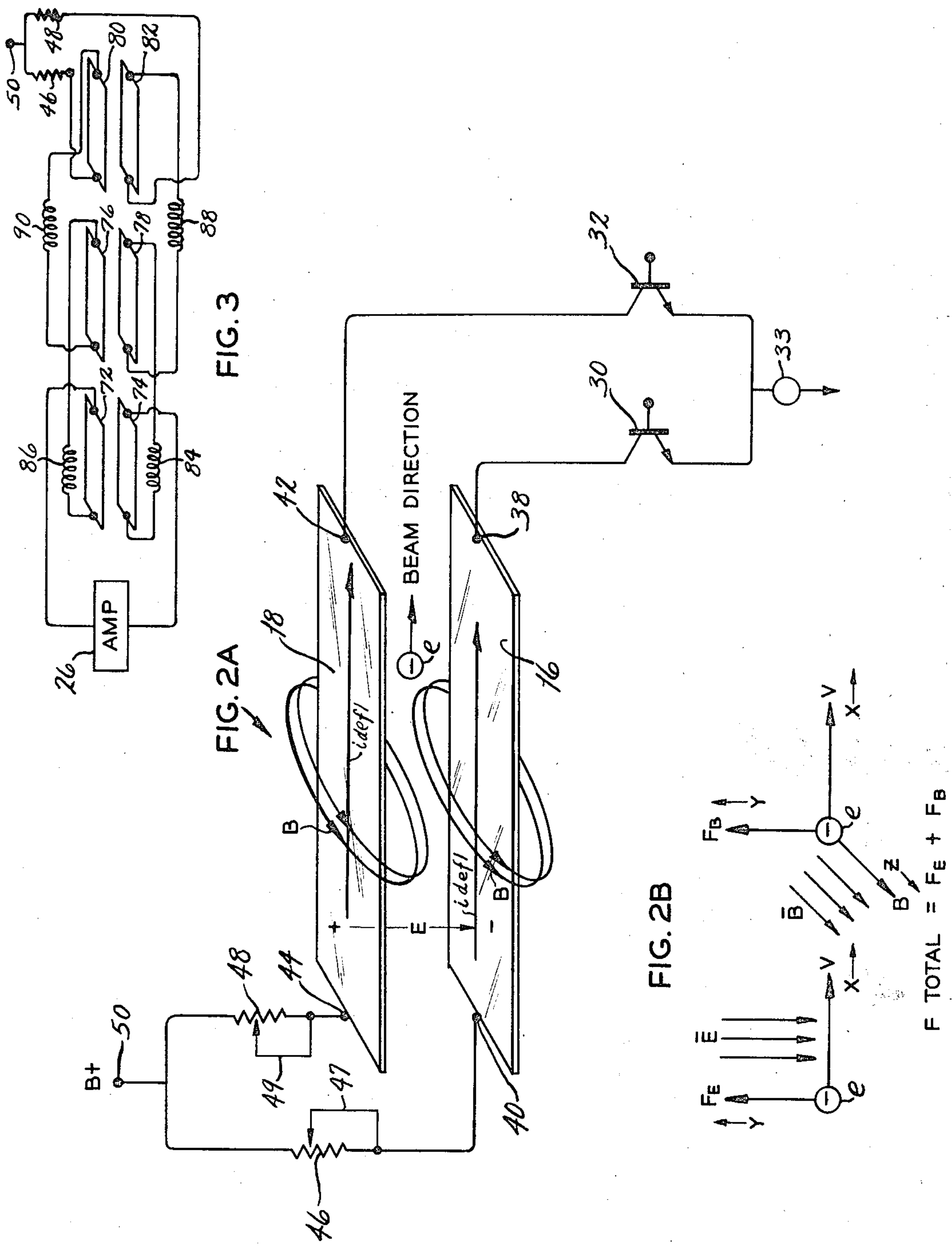

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CATHODE RAY TUBE DEFLECTION SYSTEM UTILIZING ELECTROMAGNETIC AND ELECTROSTATIC BEAM DEFLECTION

FIELD OF THE INVENTION

This invention relates generally to the directional control of electrically charged particle beams and more particularly to an improved deflection system for a cathode ray tube. Additionally, this invention pertains to cathode ray tubes having an enhanced deflection sensitivity. While the description of the invention makes frequent reference to electron beams, other electrically charged particle beams, such as ion beams, may be deflected in practicing the present invention.

BACKGROUND

Known prior art charged particle deflection systems are either of the electrostatic type as exemplified by cathode ray tubes used in oscilloscopes, or of the magnetic type as exemplified by cathode ray tubes used in television sets. Electrostatic deflection systems normally comprise a pair of conductive plates which are located inside the cathode ray tube envelope and between which an electrical potential is applied to deflect an electron beam passing between and adjacent the conductive plates. The magnetic deflection systems normally employ magnets and associated coils through which a current is passed in order to generate a magnetic field for deflecting an electron beam.

In the conventional prior art electrostatic cathode ray tube deflection system, the deflection current generated to develop the CRT voltage swings for electrostatic deflection did not directly contribute to the force exerted on the electron beam within the cathode ray tube structure. Typically, each of the deflection plates of the prior art electrostatic deflection system were connected at a single point or circuit node between the deflection amplifier load resistance and an active device of the deflection amplifier. The deflection current would normally flow through this load resistance and into the active device, such as a transistor, and thereby develop a deflection voltage (and electric field intensity E) at the CRT deflection plates. This electric field E electrostatically controlled the amount (on angle) of deflection of an electron beam passing between these plates. But the electromagnetic field (and magnetic flux density B) produced by the deflection current flowing through the deflection amplifier load resistance and through the deflection amplifier's active devices did not directly contribute to the electron beam deflection and the deflection sensitivity of the above prior art CRT deflection system. Thus, to the extent that this electromagnetic field B is "wasted," the prior art CRT electrostatic deflection system is inefficient in its operation.

Additionally, and as will become more apparent in the following description of the present invention, the deflection sensitivity of the above-described prior art electrostatic CRT deflection system is limited by the maximum acceptable value of capacitance of the CRT deflection plates. That is, for a given prior art CRT application and its requisite frequency response, the size of the CRT deflection plate is limited to an area which will not unacceptably degrade this frequency response characteristic of the system at high frequencies. As will become apparent hereinafter, the area of the CRT deflection plates of the present invention are not so limited in one embodiment of the invention.

In a completely magnetic CRT deflection system, the potentials generated by the current flowing in the deflection coils did not contribute to the deflection of the electron beam passing between the deflection coils. To the extent that these electrostatic potentials are not used to deflect the electron beam, the prior art CRT magnetic deflection system is inefficient in its operation.

SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a new and improved CRT deflection system which possesses all of

the advantages of similarly employed CRT deflection systems and yet exhibits an overall deflection sensitivity higher than known prior art CRT deflection systems. To attain this, the CRT deflection system according to the present invention utilizes the electromagnetic field, B, produced by the deflection current flowing in the CRT deflection plates in combination with an electrostatic field, E, also produced by said deflection current to generate a total deflection force which is exerted on an electron beam passing between the CRT deflection plates. By fully utilizing the electromagnetic field B and the electrostatic field E produced by a single, predirectioned deflection current flowing in the CRT deflection system, the deflection sensitivity and the overall operating efficiency of the CRT deflection system is increased over that of the prior art, purely electrostatic or purely electromagnetic deflection systems previously described.

Therefore, an object of the present invention is to provide a new and improved deflection system for a cathode ray tube.

Another object of this invention is to provide, in combination, a novel cathode ray tube and associated deflection circuitry exhibiting an improved deflection sensitivity and an improved operating efficiency.

Another object of this invention is to provide an improved cathode ray tube and deflection system therefor having an improved frequency response.

A further object of this invention is to provide an improved CRT deflection system having an improved deflection plate design flexibility.

Still another object of this invention is to provide a CRT deflection system which is more sensitive to high velocity electron beams than either of the above-described electrostatic or magnetic prior art CRT deflection systems.

A feature of this invention is a CRT deflection system wherein the deflection current is caused to flow between two selected points on a CRT deflection plate and thereby develops a predirectioned electromagnetic force between CRT deflection plates. This predirectioned electromagnetic force adds to an electrostatic force between the CRT deflection plates to thereby enhance the total deflection force which is exerted on an electron beam passing between CRT deflection plates.

Another feature of this invention is the provision of a novel deflection system for a cathode ray tube which is capable of operating either entirely by the use of electromagnetic deflection, or by the use of electromagnetic deflection in combination with electrostatic deflection, or entirely by the use of electrostatic deflection with the proper selection of load impedances.

Another feature of this invention resides in the termination of the deflection plates of a cathode ray tube in their characteristic impedances to thereby prevent transmission line reflections in the CRT deflection system. Such characteristic impedance termination permits the length of the CRT deflection plates to be increased to enhance deflection sensitivity and deflection plate design flexibility without decreasing the high frequency performance of the deflection system.

These and other objects and features of the invention will become more fully apparent in the following description of the accompanying drawings.

DRAWINGS

FIG. 1 is a cross-sectional view, partially functional and partially schematic, of the cathode ray tube and associated deflection system according to the present invention;

FIG. 2A is an enlarged view of the vertical deflection plates and the portion of the associated CRT vertical deflection system shown in FIG. 1;

FIG. 2B is a force vector diagram of the combined electrostatic and electromagnetic forces developed by the present CRT deflection system; and

FIG. 3 illustrates an alternative embodiment of the invention utilizing a plurality of deflection plates arranged as a lumped or artificial transmission line. Like reference numerals have been used in the above figures to designate corresponding circuit components therein.

Referring to FIG. 1, there is shown a cathode ray tube (CRT) generally designated **10**. The cathode ray tube **10** includes an evacuated glass envelope **11** having a conventional socket **13** at one end thereof and a target **24**, such as a phosphorescent screen, at the other end. Within the cathode ray tube **10** there is an electron gun assembly **12**, focusing electrodes **14**, and vertical and horizontal deflection plates, which will be described in more detail below with reference to the combined electrostatic and electromagnetic deflection system according to the present invention. All of the above-identified elements of the cathode ray tube **10** are of conventional design and therefore are not shown or described in detail.

First and second vertical deflection plates **16** and **18** are supported and positioned within the CRT assembly **10** so that an electron beam **17** passes between these deflection plates. Input circuitry for the vertical deflection plates **16** and **18** includes a differential (push-pull) deflection amplifier **26** which may, for example, be embodied by differentially coupled NPN transistors **30** and **32** therein. The bases of these emitter coupled NPN transistors **30** and **32** are differentially coupled to a preceding driver stage (not shown) for receiving therefrom vertical deflection signals. The emitter coupled transistors **30** and **32** may be connected to a conventional constant current source **33**, such as a transistor and resistor (not shown).

The collector or output electrode of NPN transistor **30** is connected to a first selected location **38** on the first vertical deflection plate **16**, and the collector or output electrode of NPN transistor **32** is connected to a first selected location **42** on the second vertical deflection plate **18**. Thus, the deflection amplifier **26** is connected to differentially drive the first and second vertical deflection plates **16** and **18** with a chosen deflection signal.

The load circuit **45** for the vertical deflection system according to the present invention includes first and second load impedances **46** and **48**, respectively, which are connected to a common voltage supply terminal **50**. The first load impedance **46** is connected to a second selected location **40** on the first vertical deflection plate **16**, and the second load impedance **48** is connected to a second selected location **44** on the second vertical deflection plate **18**.

A pair of horizontal deflection plates **21** and **23** are positioned on opposite sides of the path of the electron beam **17**, and these deflection plates **21** and **23** are connected to a differential deflection amplifier **28**, including emitter coupled NPN transistors **34** and **36**. The collectors or output electrodes of transistors **34** and **36** are connected, respectively, to first selected locations **52** and **56** on the horizontal deflection plates **23** and **21**, and first and second load impedances **60** and **62** within the horizontal deflection load circuit **55** are connected to second selected locations **54** and **58**, respectively, on the first and second horizontal deflection plates **21** and **23**. The first and second load impedances **60** and **62** are further connected to a common supply terminal **64**.

OPERATION

The electron beam **17** passing between the previously identified vertical and horizontal deflection plates is electrostatically deflected in accordance with the magnitude of the electric field intensity E developed between these deflection plates as is well known. Such electrostatic potential is developed by the equal and directionally opposite vertical deflection currents flowing in the first and second impedances **46** and **48**, and these currents generate the differential deflection voltage across plates **16** and **18** as will be apparent by inspection of FIG. 1.

In addition to producing the electrostatic deflection of the electron beam **17** as previously described, the deflection current is caused to flow in a predetermined direction in each of the previously described deflection plates and thereby electromagnetically deflects the electron beam **17**. The amount of electromagnetic deflection in proportional to the flux density B generated by the deflection current flowing in the deflection plates. For example, viewing FIG. 1 from left to right in the drawing, the deflection current flows from the common supply at terminal **50**, through the first load impedance **46** and into the second selected location **40** on the first vertical deflection plate **16**. This deflection current flows directionally from the second selected location or circuit node **40**, through the vertical deflection plate **16**, out of the first selected location or circuit node **38** and into the amplifier **26**. A deflection current of equal magnitude and opposite direction to the above vertical deflection current flows through the load impedance **48**, terminal **44**, the vertical deflection plate **18**, node **42** and the amplifier **26**. These deflection currents flowing in the deflection plates **16** and **18** produce an electromagnetic field between the deflection plates **16** and **18** measured in electromagnetic flux density B. This electromagnetic field B thus contributes to the total deflection force exerted on an electron passing between the vertical deflection plates **16** and **18**. Therefore, the total deflection force exerted on electrons passing between these deflection plates **16** and **18** consists of the electrostatic force produced by the voltage swings at the deflection plates as previously described plus the electromagnetic force produced by current flowing through these deflection plates.

The principle of electromagnetic deflection as employed in the present invention will be better understood by referring to FIG. 2A which is an enlarged view of the vertical deflection plates **16** and **18** and associated vertical deflection circuitry previously identified in FIG. 1. The deflection currents i_{defl}, which flow from the second selected location or point **40** on the left hand end of the first deflection plate **16** to the first selected location or point **38** on the right hand end of the first deflection plate **16** (and from node **42** to node **44** in the second deflection plate **18**) produce an electromagnetic field B which encircles the deflection plates **16** and **18** as shown. An electron with a charge *e* passing through this electromagnetic field B in the direction shown and with a given velocity, *v*, will undergo an electromagnetic force F_B in the direction shown in FIG. 2B equal to the product of Bev. In the three dimensional XYZ coordinate system as illustrated in FIG. 2B, an electron e moving at a velocity *v* in the X direction and passing through an electromagnetic field with a B vector in the Z direction will undergo a deflection force F_B. This deflection force F_B is in the Y direction or toward and perpendicular to the underside of the second vertical deflection plate **18**.

The magnetic deflection force F_B will be proportional to the difference in deflection currents flowing in the pairs of deflection plates **16**, **18** and **21**,**23** respectively, and the direction of this force can be determined in accordance with the well-known right hand rule. If the deflection signal level applied to the base of the NPN transistor **30** exceeds that applied to the base of NPN transistor **32**, then the collector current for NPN transistor **30** flowing horizontally through the vertical deflection plate **16** will be the dominating current for establishing the magnetic deflection force F_B. Conversely, if the deflection current flowing through the vertical deflection plate **18** exceeds the deflection current flowing through vertical deflection plate **16**, then the former deflection current will dominate and control the magnetic deflection force F_B.

At the same time, the deflection currents i_{defl} flowing through the load impedances (Z_o) set up a potential difference equal to $2 Z_o \cdot i_{defl}$ with the polarity indicated and this potential difference produces the electrostatic field E directed from plate **18** to plate **16**. The direction of this electrostatic force E on an electron with a negative charge e is toward the upper vertical plate **18** as will be understood.

Therefore, as shown in FIG. 2B, if the electrostatic force exerted on an electron *e* is F_E, then the total force F_{total} exerted on an electron *e* passing from left to right between the vertical deflection plates **16** and **18** will be equal to $F_E + F_B$. It should be remembered here that the electromagnetic force F_B is only exerted on moving electrons in accordance with the well-known relation F = Bev, whereas the electrostatic force F_E is independent of electron velocity. For this reason, the deflection currents i_{defl} and the electromagnetic field B generated thereby must be predirectioned with respect to the direction of electron velocity v. Thus, in contrast to the prior art CRT deflection systems wherein the electromagnetic field B produced by the deflection current was effectively "wasted," the electromagnetic field B surrounding the deflection current i_{defl} in the present invention is utilized most efficiently as described above. This electromagnetic field B contributes to the total force F_{total} on the electron beam passing between the horizontal and vertical deflection plates and thus enhances the deflection sensitivity of the system.

As will be understood by those skilled in the art, the principals of combined electrostatic and electromagnetic deflection discussed above with reference to the vertical deflection plates **16** and **18** also apply to the operation of the horizontal deflection plates **21** and **23** which are displaced 90° with respect to the vertical deflection plates **16** and **18**. The horizontal deflection in a cathode ray tube is well-known and understood in the art, and therefore, will not be described in detail.

In order to further appreciate and understand the significant advancement in CRT deflection systems provided by the present invention, consider a prior art deflection system wherein the deflection plates are connected at a single terminal or node thereon to the deflection amplifier. In this system, no deflection current passes lengthwise through the plates, and the pairs of deflection plates act as capacitors in parallel with the load resistors and have a frequency dependent capacitive reactance, X_C. One prior art technique used to increase deflection sensitivity of such a deflection system was to increase the length of the deflection plates. In this manner, the electron beam would spend more time between the deflection plates as compared to shorter plates and thus be deflected at an angle greater than that for shorter deflection plates. However, when the length of the deflection plates is increased, the deflection plate capacitance C is also increased. Since the frequency response of the prior art CRT deflection system is proportional to 1/RC, where R is the deflection plate load resistance and C is plate capacitance, then there was a limit to which the deflection sensitivity can be increased at the expense of degrading the frequency response of this prior art CRT system.

The disadvantage of the above limitation imposed on deflection plate area has been overcome in accordance with the present invention. The deflection plates **16** and **18** may be considered a transmission line and as such may be terminated in their characteristic impedance Z_o. A typical characteristic impedance Z_o for commercially available CRT deflection plates is around 300 ohms, and this is a convenient value for the required frequency response of high frequency deflection amplifiers. In accordance with known transmission line physics, the transmission line exhibits a constant resistive input impedance at all frequencies if it is terminated in its characteristic impedance. Thus, an increase in the length of the deflection plates does not change the input impedance or frequency response of the deflection system. The frequency response of the system is no longer proportional to 1/RC up to the point where the time the electron spends between deflection plates approaches a significant fraction of the period of the applied signal frequency.

Therefore, in addition to increasing the overall deflection sensitivity of the CRT deflection system by using both electrostatic and electromagnetic deflection as previously described, the length of the CRT deflection plates **16** and **18** may also be increased to further increase the total deflection sensitivity. If this transmission line is terminated in its characteristic impedance Z_o and if Z_o initially satisfies the amplifier requirements of a particular CRT application, then any further increase in deflection plate length will not affect the frequency response characteristic of the system. That is, a constant Z_o makes the deflection system frequency independent.

An alternative embodiment of the present invention is illustrated in FIG. **2A**, with particular reference to load impedances **46** and **48**. This embodiment involves completely shorting the terminating load impedances, such as impedances **46** and **48**, by moving variable taps **47** and **49** thereon to their uppermost position. This adjustment will convert the deflection system previously described to a wholly electromagnetic deflection system. For such alternative embodiment of the invention, the second selected locations **44** and **40** on the deflection plates **16** and **18**, respectively, will be connected directly to the power supply terminal **50**; and there will be no voltage swings at deflection plates **16** and **18** and no electrostatic deflection of an electron beam **17** passing therebetween. As the deflection amplifier is driven by a differential signal applied thereto, deflection current will flow through the deflection plates **16** and **18** from one end thereof to the other, and the total deflection of said beam will be the result of the F_B force exerted on the beam by the Bev product previously described. In utilizing the purely electromagnetic deflection system described above, care should be taken that the deflection current-supply voltage power product does not exceed the power rating of the CRT deflection system including deflection plates and the deflection amplifiers. For this embodiment of the invention, it may be necessary to select deflection plates **16** and **18** having a sufficiently low resistance to limit the power dissipation to a minimum value. Of course, the position of the taps **47** and **49** may be varied to in turn vary the percentage of the total deflection force contributed by electrostatic and electromagnetic forces on the electron as is shown in the above example illustration.

Referring now to FIG. **3**, there is shown a "slow wave" type of transmission line embodying the invention, and this artificial or lumped type of transmission line is adapted for use with high frequency deflection signals. For example, if the length of the deflection plates **16** and **18** in FIG. **2** is such that the period of the applied deflection signal frequency exceeds the time that it takes an electron to traverse the length of the deflection plates **16** and **18**, then the deflection force between these plates will reverse on an electron during its travel between the deflection plates. This deflection force reversal will obviously result in spurious electron beam deflection, and the artificial or slow wave transmission line structure shown in FIG. **3** is utilized to avoid this difficulty. This transmission line consists of a plurality of deflection plate pairs **72** and **74**, **76** and **78** and **80** and **82**. These deflection plate pairs are serially interconnected as shown via a plurality of deflection signal propagation delay elements which take the form of inductors **84**, **86** and **88** and **90**. The deflection amplifier **26** is connected to drive the input nodes on the left hand pair of deflection plates **72** and **74**, and load circuit characteristic impedances **46** and **48** interconnect the output nodes on deflection plates **80** and **82** to the voltage supply terminal **50**. The inductors **84**, **86**, **88** and **90** are selected so that the deflection signal propagation velocity down the transmission line consisting of the above pairs of deflection plates and the deflection force produced thereby may be synchronized or otherwise properly phased with respect to the beam velocity of electrons travelling between these pairs of plates. In this manner, the above undesirable deflection force reversal during the time an electron is travelling between these plates is avoided.

The present invention is not limited to the specific preferred embodiment thereof described hereinabove. For example, the selected locations on the horizontal and vertical deflection plates to which the external deflection circuitry is connected have been shown on the extreme ends of these deflection plates. These extreme end locations are preferred for maximum electromagnetic beam deflection as previously described. However, for various sizes of horizontal and vertical deflection plates it may be desired to pass deflection current only through a portion of these deflection plates in order to provide a desired amount of electromagnetic beam deflection. In the latter case, the selected locations may be moved in toward the center of the deflection plates so that the deflection current i_{defl} passes through only a portion of these plates.

In addition, it is not necessary that the deflection current i_{defl} flows exactly in parallel with the direction of the velocity of the electron beam **17** as it passes between these plates. The electromagnetic force vector F_B will be most effectively utilized in its contribution to the total deflection force F_{total} if the deflection current i_{defl} flows as shown parallel to the direction of electron beam velocity. However, the selected location **40** in FIG. **2** may be moved inwardly and the selected location **38** may be moved outwardly so that the deflection current i_{defl} is skewed with respect to the direction of beam velocity, and there will still be a force vector of the electromagnetic flux density B which contributes to the deflection force on the electron beam **17**.

I claim:

1. A deflection system for a charged particle beam including, in combination:

a. deflection plate means for controlling the direction of a charged particle beam passing adjacent thereto,

b. input circuit means connected to one selected location on said deflection plate means and operative to receive deflection signals, and

c. load circuit means connected between another selected location on said deflection plate means and a voltage supply terminal, whereby directional deflection current flowing between said input and said load circuit means passes between said first and second selected locations on said deflection plate means to produce an electromagnetic field which exerts a deflection force on said charged particle beam for electromagnetically controlling the deflection of said beam.

2. The deflection system defined in claim **1** wherein said load circuit means includes a direct conductive connection between said voltage supply terminal and said another selected location on said deflection plate means so there is no voltage swing at said another selected location and said charged particle beam is controlled wholly by the electromagnetic force exerted thereon and produced by the predirectioned current flowing between said selected location on said deflection plate means.

3. The deflection system defined in claim **1** wherein said load circuit means includes a load impedance connected between said voltage supply terminal and said another selected location on said deflection plate means, the ohmic value of said load impedance and the supply voltage selected to provide a desired deflection voltage at said deflection plate.

4. The deflection system defined in claim **1** wherein said load circuit means includes a selected load impedance connected between said voltage supply terminal and said another selected location on said deflection plate means, said load impedance being the characteristic impedance of the transmission line formed by said deflection plate means to thereby minimize reflections in said deflection system and permit the length of said deflection plate means to be varied without degrading the frequency response of the system.

5. A deflection system for an electron beam tube including, in combination:

a. first and second deflection plates, each having first and second selected locations thereon for connection to circuitry for driving said deflection plates at a chosen deflection frequency,

b. input circuit means connected between said first selected locations on said first and second deflection plates, respectively, and a point of reference potential, said input circuit means adapted to be driven by a source of deflection signals, and

c. load circuit means connected, respectively, between said second selected locations on said first and second deflection plates and a voltage supply terminal, whereby deflection current flowing in a predetermined direction through said first and second deflection plates in response to deflection signals applied to said input circuit means produces a predirectioned electromagnetic force on an electron beam passing between said first and second deflection plates.

6. The deflection system defined in claim **5** wherein said load circuit means includes a direct conductive connection between said voltage supply terminal and said another selected locations on said deflection plates, so there is no voltage swing at said another selected locations and said electron beam is controlled wholly by an electromagnetic force exerted thereon and produced by the predirectioned current flowing between said selected locations on said deflection plates.

7. The deflection system defined in claim **5** wherein said load circuit means includes first and second load impedances connected between said another selected locations on said deflection plates, respectively, and said voltage supply terminal, the ohmic values of said first and second load impedances and the level of the supply voltage selected to provide a desired deflection voltage swing and electrostatic field potential at said deflection plates.

8. The deflection system defined in claim **5** wherein said load circuit means includes first and second selected load impedances connected between said another selected locations on said first and second deflection plates, respectively, and said voltage supply terminal, said load impedances being the characteristic impedances of the transmission lines formed by said first and second deflection plates, respectively, to thereby minimize reflections in said deflection system and permit the deflection plate length to be varied without degrading the frequency response of the system.

9. The deflection system defined in claim **5** which further includes:

a. third and fourth deflection plates, each having first selected locations thereon connected to input circuitry for driving said third and fourth deflection plates at a chosen deflection frequency, and

b. load circuit means connected between second selected locations on said third and fourth deflection plates and a voltage supply terminal, whereby deflection current flowing in a predetermined direction through said third and fourth deflection plates in response to deflection signals applied to said input circuitry produces a predirectioned electromagnetic force on an electron beam passing between said third and fourth deflection plates.

10. The deflection system defined in claim **9** wherein:

a. said first and second deflection plates comprise the vertical deflection plates of said system, and said third and fourth deflection plates comprise the horizontal deflection plates of said system, and

b. said input circuit means connected to said vertical deflection plates includes a differential vertical deflection amplifier for receiving vertical deflection signals and said input circuitry for driving said third and fourth deflection plates includes a differential horizontal deflection amplifier for receiving horizontal deflection signals.

11. A deflection system for a charged particle beam including, in combination:

a. a plurality of pairs of deflection plates between which a charged particle beam passes and is deflected and

b. a plurality of deflection signal delay elements serially connecting said pairs of deflection plates between selected input nodes to which a deflection signal is applied and selected output nodes, whereby deflection current flowing serially through said pairs of deflection plates develops an electromagnetic deflection force on said charged particle beam, and said delay elements may be utilized to properly phase the deflection signal and forces produced thereby with the velocity of the charged particle beam passing between said deflection plates.

12. The system defined in claim **11** wherein:

a. said delay elements are inductors connected between adjacent pairs of deflection plates for delaying the deflection signal passing therethrough, and said system further includes

b. a pair of load impedances connected, respectively, between said pair of output nodes and a power supply terminal for developing electrostatic deflection force between said pairs of deflection plates simultaneously with the production of an electromagnetic force on said charged particle beam by current flowing through said deflection plates.

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