Dec. 5, 1939. H. E. HOLLMANN 2,182,382

CATHODE RAY DEVICE

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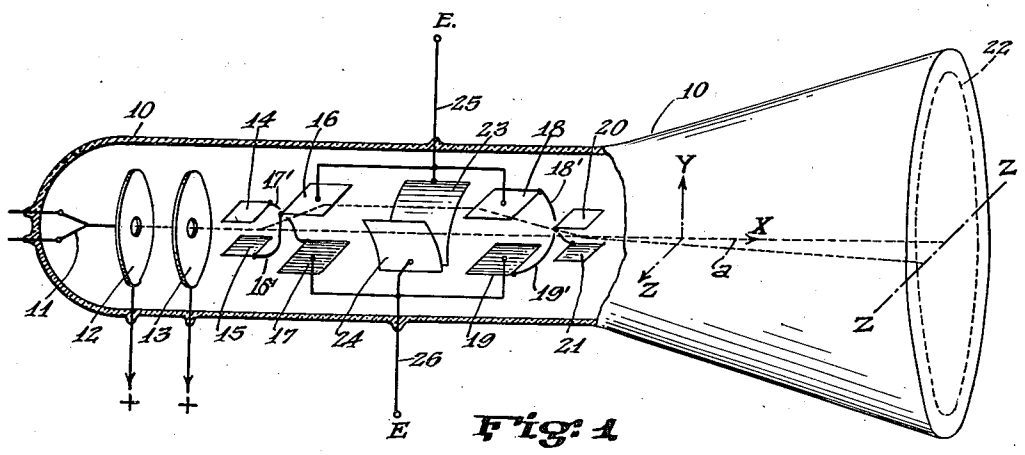


Fig: 1

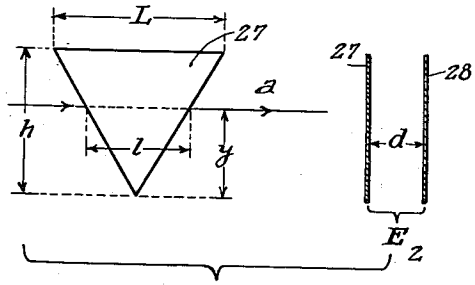


Fig: 2

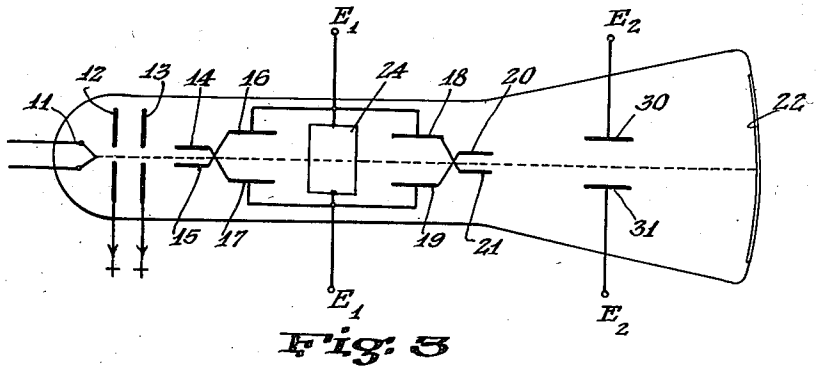


Fig: 3

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CATHODE RAY DEVICE

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4 Claims. (Cl. 250—158)

The present invention relates to cathode ray devices, more particularly to an improved construction for and a method of operating such devices.

The known cathode ray tubes used for indicating, recording, translating or other purposes usually comprise a means known as an electron gun for producing a concentrated beam or pencil of electrons, a screen or target for the electron beam to strike against and a means such as one or more pairs of electrostatic deflecting plates or magnetic field coils for deflecting the electron beam to obtain a curve or pattern on the recording screen or to vary the current flow in a circuit connected to the output or target electrode in accordance with variations of a signal or magnitude to be recorded or translated.

In most cases it is desirable to operate a cathode ray tube in accordance with a linear deflecting law so as to record or translate the deflecting currents or potentials faithfully and without distortion. This requirement is usually fulfilled if the electric or magnetic deflecting field through which the electron beam has to move is of a substantially uniform or homogeneous character.

There are however many cases where a deviation from a linear deflecting law is desirable or required, such as if it is desired to compress or reduce the intensity range of the variations of an input signal or magnitude to be recorded or translated, or if a quadratic, or a logarithmic scale or a scale graduated in accordance with any other law is desired for the recorded curve or pattern. Another example of a non-linear deflecting law is the case where the tube is to be used as a compensating device for neutralizing the effect of distortion caused by other elements through which the deflecting currents or potentials had to pass prior to their impression upon the deflecting plates or coils of the cathode ray device. Alternatively the tube itself may serve to produce an artificial distortion of current or potential variation which may or may not be compensated in accordance with any existing requirements.

In order to obtain non-linear deflection for the above or similar purposes, it has been suggested to provide a deflecting field which varies locally for different deflecting angles by using a suitable shape and construction of the deflecting plates or the pole pieces of the deflecting magnets. This expedient however involves great difficulties in practice due to the fact that the shape or pattern of the deflecting field is of a three dimensional character and that the deflection of the electron beam increases the farther the beam penetrates into the deflecting field. This would make it necessary to vary the field strength for each plane at right angle to the axis of the electron beam. A further difficulty is due to the fact that the local variations of the field strength have to be kept within narrow limits compared with the diameter of the electron beam in order to prevent different deflections for different cross-sectional zones of the beam to avoid distortions and impairment of the sharpness or concentration of the beam. These and other causes greatly limit the use of a non-uniform deflecting field in the constructions heretofore known in the prior art for securing another than a linear deflecting law.

The present invention describes a cathode ray tube construction by which the above difficulties are substantially eliminated. With this object in view, the cathode ray tube according to the invention, which may be either an oscillograph tube or a relay tube known as a deflector or beam discharge tube, makes use of different deflecting fields which are partly perpendicular and partly parallel and are controlled in accordance with the same input or deflecting potential or current. These different fields have the effect that the electron beam is not only deflected angularly by the non-uniform deflecting field in accordance with an input deflecting potential or current, but is simultaneously displaced at right angle to the deflecting field by an amount depending on the same deflecting current or potential. In this manner the non-uniform deflecting field acts in two planes in such a manner that the desired deflecting law or function may be obtained in a more simple and efficient manner and for a greater useful operating range than has been possible in the arrangements known in the prior art.

The invention will become more apparent from the following description taken with reference to the accompanying drawing forming part of this specification and wherein

Figure 1 illustrates schematically a cathode ray tube constructed according to the invention.

Figure 2 shows a deflecting plate construction for a tube according to Figure 1 to obtain a deflection according to a quadratic relation.

Figure 3 is a modification of a tube according to the invention.

Like reference numerals relate to like parts in the different views of the drawing.

Referring to Figure 1, there is shown at 10 a vessel or envelope including a cathode 11 which may be a thermionic cathode of either the direct or indirectly heated type of well known construction. The electrons emitted from the cathode are concentrated or focused into a sharp beam *a* by means of any of the known electric or magnetic focusing means or electron lens arrangements such as a pair of positively charged annular accelerating electrodes 12 and 13 shown in the example illustrated. The beam then passes passes four deflecting devices in succession, each

comprising in the example shown a pair of deflecting plates, 14—15, 16—17, 18—19 and 20—21. All the deflecting plates are arranged parallel to each other in a manner so as to deflect the electron ray in the vertical or x—y plane in the example illustrated. The plates 16 and 18 are connected to a lead 25 and plates 17 and 19 are connected to a lead 26. The leads 25 and 26 serve as terminals for impressing the deflecting voltage E to be recorded or translated. The plates 14—15 are controlled in an opposite phase relative to the plates 16—17. For the latter purpose the plate 15 is connected to the plate 16 through a lead 16' and the plate 14 is connected to the plate 17 through a lead 17'. Similarly the plates 20 and 21 are controlled in opposite phase relative to plates 18 and 19. For the latter purpose the plate 19 is connected to plate 20 through lead 19' and the plate 18 is connected to the plate 21 through lead 18'. The purpose of the plates 14—15 and 16—17 is to displace the electron beam a parallel to itself in the vertical or x—y plane within the deflecting zone proper and by an amount proportional to the input or deflecting potential. This parallel displacement is nullified and the beam returned to its initial position by the second pair of deflecting plates 18—19 and 20—21 acting in an opposite manner to the plates 14—15 and 16—17 whereby the beam after passing the plates 20—21 assumes its original position coincident with the tube axis assuming the further deflecting plates 23 and 24 to be described presently are omitted. The parallel displacement of the electron beam can be easily obtained by the proper design and spacing of the electrode systems 14—15, 16—17 and 18—19 and 20—21 as is understood.

There is furthermore provided between the plates 16—17 and 18—19 means for producing the deflecting field proper consisting in the example illustrated of a pair of deflecting plates 23—24 of curved shape connected to the input leads 25 and 26 and adapted to deflect the electron beam at an angle preferably a right angle to the deflection effected by the remaining deflecting arrangement previously described. As is seen, in this manner a non-linear deflecting law may be obtained in accordance with any desired function by a variation of the shape or curvature of the deflecting plates 23 and 24. Since the deflection is not only inversely proportional to the distance between the deflecting plates, but depends also on the length of the deflecting field or plates in the direction of the electron beam, it is furthermore possible to vary the function or law of the deflection by a proper design of the marginal edge or contour of the deflecting plates.

The exact calculation of the shape and curvature of the deflecting plates depends on the desired sensitivity or deflecting law which may be a simple or a complex function. There is shown with reference to Figure 2 a practical example of the invention as applied to deflecting plates 27 and 28 in place of the curved plates 23 and 24 shown in Figure 1 of triangular shape disposed parallel to each other. The sensitivity or response curve for this shape is found by the following calculation.

If e_z represents the electric field strength between the plates 27 and 28 (see Figure 2) and l the length of the plates or the deflecting field, then the deflecting angle α_z in the horizontal or x—z plane may be expressed by the following equation:

$$\alpha_z = Ke_z l \qquad (I)$$

wherein K is a constant including the volt velocity and length of the electron beam and other tube constants.

Furthermore, the field strength e_z is equal to the voltage E impressed upon the plates divided by the distance therebetween; that is,

$$e_z = \frac{E}{d} \qquad (II)$$

By combining Equations I and II the following equation is obtained for the deflecting angle

$$\alpha_z = KE\frac{l}{d} \qquad (III)$$

In addition to this deflection in the x—z plane, it has further to be considered that the electron beam is simultaneously displaced in parallel in the x—y plane by an amount equal to $y=kE$ wherein k is a constant determined by the deflecting fields produced by the plates 14—15 and 16—17 and the distance therebetween.

If the electron beam is displaced in the y-direction through the triangular deflecting field produced by plates 27 and 28, the effective length l of the deflecting field varies in direct proportion to this displacement. As is seen from Figure 2

$$l = \frac{L}{h}y \qquad (IV)$$

wherein L represents the base and h the height of the triangular plates. By combination of the above formulas, the deflection is obtained as follows:

$$\alpha_z = \frac{KkL}{dh}E^2 \qquad (V)$$

From this it is seen that a tube of the type described having triangular deflecting plates arranged in parallel has a quadratic sensitivity or deflection curve the parameter of which may be varied by varying the constants of the tube.

If it is desired to vary the parameter of the deflecting curve, this can be obtained according to a further feature of the invention by applying to the deflecting plates 23—24 a portion of the total deflecting voltage E by the aid of a suitable voltage divider or drop resistance inserted in the supply lead in a manner well understood. In this case the deflecting field strength has the following value:

$$e_z = \frac{E}{Vd}$$

wherein

$$\frac{l}{Vd}$$

represents the fraction of the total controlling potential applied to the deflecting plates. In the latter case, the deflecting angle is obtained as follows:

$$\alpha = \frac{l}{Vd}\frac{KkL}{dh}E^2$$

It is seen from this that the voltage division enters into the parameter for the parabola or quadratic sensitivity curve which latter can be varied by means of a potentiometer or drop resistance to suit any desired conditions. As is further understood, it is also possible to decrease the potential applied to the deflecting plates 14—15, 16—17, 18—19, 20—21 to secure a further variation of the deflecting law. If an inverse sensitivity law is desired, that is if a deflection is desired varying in accordance with the square root of the deflecting potential, the shape of the

plates is determined by the following formula obtained by a calculation similar to the above

$$\frac{l^2}{d^2}=K\frac{l}{y}$$

In this expression

$$\frac{l}{d}$$

is the so-called "field factor" which should decrease with increasing y. This can be obtained either by varying l or d or both.

As will be understood from the above, it is possible by the employment of the invention to obtain any desired deflecting law such a logarithmic or exponential law by using a suitable shape and/or curvature of the deflecting plates **23** and **24**.

In place of electrostatic deflection the invention may equally be used with magnetic deflection or combined electrostatic and magnetic deflection in which latter case the curvature and shape of the pole pieces of the deflecting magnets can be determined and designed in a manner similar as described.

A cathode ray tube of the type described is further suited for producing a linear time axis whereby a separate saw-tooth or sweep oscillator usually required for this purpose may be dispensed with. This object is obtained by providing a symmetrical or uniform deflecting field by the provision of a pair of parallel deflecting plates **23** and **24** and applying thereto a sinusoidal sweep potential E1 as illustrated in Figure 3 of the drawing. In this manner a deflection of the recording spot on the luminescent screen **22** of the tube is obtained in the z direction which is proportional to time similar as is obtained by a saw-tooth deflecting potential in an ordinary cathode ray tube. In order to obtain a deflection in a direction at right angle in accordance with variation of a deflecting voltage E2 to be recorded a pair of further deflecting plates or the like may be provided such as shown at **30** and **31** to which the input potentials to be recorded are applied in a manner well known.

It will be apparent from the above, that the invention is not limited to the specific embodiments and constructions shown and described for illustration, but that the novel inventive thought is susceptible of numerous modifications and variations coming within the broad scope and spirit of the invention as defined in the appended claims.

Thus, the novel construction and method applies equally to any type of cathode ray tube whether used for recording variations of electric currents or potentials upon a fluorescent screen or for varying a current in an associate circuit connected to an output or target electrode impinged upon by the electron beam.

It is intended therefore that the specification and drawing be regarded in an illustrative rather than in a limited sense.

I claim:

1. In a cathode ray device, means for producing a concentrated electron beam, a first deflecting arrangement comprising two pairs of deflecting plates arranged adjacent to each other and adapted to deflect said beam in a predetermined plane in opposite directions by an applied deflecting potential, whereby said beam is displaced substantially parallel to its original position, a second similar deflecting arrangement spaced from said first deflecting arrangement and comprising two pairs of deflecting plates adjacent to each other to return said beam to its normal position, and a third deflecting arrangement for exercising a further deflecting field upon the portion of said beam intermediate said first and second deflecting arrangements to deflect said beam in a plane substantially normal to said first plane, and means for impressing the same deflecting potential upon said first, second and third deflecting arrangements.

2. In a cathode ray device, means for producing a concentrated electron beam, a first deflecting arrangement comprising two pairs of deflecting plates adjacent to each other, means for controlling each of said pairs of deflecting plates in opposite sense by an applied deflecting potential to displace said beam in parallel to its original position in a predetermined plane, a second similar deflecting arrangement spaced from said first deflecting arrangement and comprising two pairs of deflecting plates also arranged to be controlled in opposite sense by an applied deflecting potential to return said beam to its original position, and a third deflecting arrangement for exercising a non-uniform deflecting field upon the displaced portion of said beam intermediate said first and second deflecting arrangements for deflecting said beam in a plane substantially normal to said first plane, and means for impressing the same deflecting potential upon said first, second and third deflecting arrangement.

3. In a cathode ray device, means for producing a concentrated electron beam, a first deflecting arrangement comprising two pairs of deflecting plates adjacent to each other, means for controlling said pairs of deflecting plates in opposite sense by an applied deflecting potential for displacing said beam parallel to its original position in a predetermined plane, a second similar deflecting arrangement comprising two pairs of deflecting plates adjacent to each other also arranged to be controlled in opposite sense by an applied deflecting potential to return said beam to its original position, and a third deflecting arrangement comprising a pair of further deflecting plates shaped to produce a non-homogeneous deflecting field exercised upon the displaced portion of said electron beam intermediate said first and second deflecting arrangements to deflect said beam according to a desired non-linear law in a plane substantially normal to said first plane, and means for simultaneously impressing the same deflecting potential upon said first, second and third deflecting arrangements.

4. The combination with a cathode ray device comprising an evacuated vessel, electron gun means therein for producing a concentrated electron ray and a target arranged to be impinged by said electron ray, of an arrangement for deflecting said electron ray in a predetermined direction according to a variable control potential, said deflecting arrangement comprising means for variably displacing a part of said electron ray disposed between said electron gun and said target parallel to itself in proportion to said control potential and in a direction normal to said predetermined direction, and further means for simultaneously exercising a deflecting field in accordance with the same control potential upon the displaced part of the electron ray to deflect the same in said predetermined direction.

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