Oct. 3, 1950

E. E. SHELTON

2,524,606

ELECTRON DISCHARGE DEVICE

Filed Feb. 2, 1948

FIG. 1

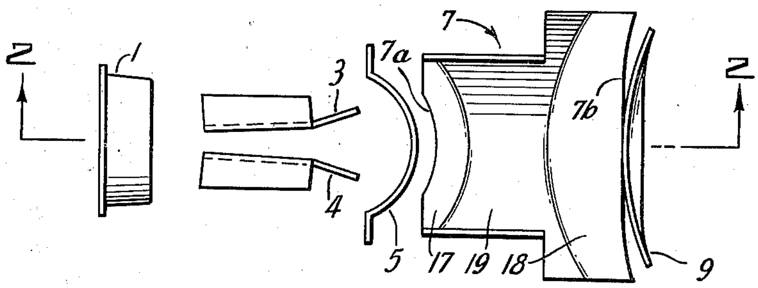
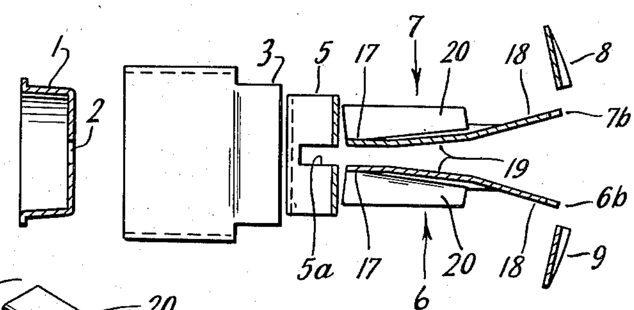


FIG. 2



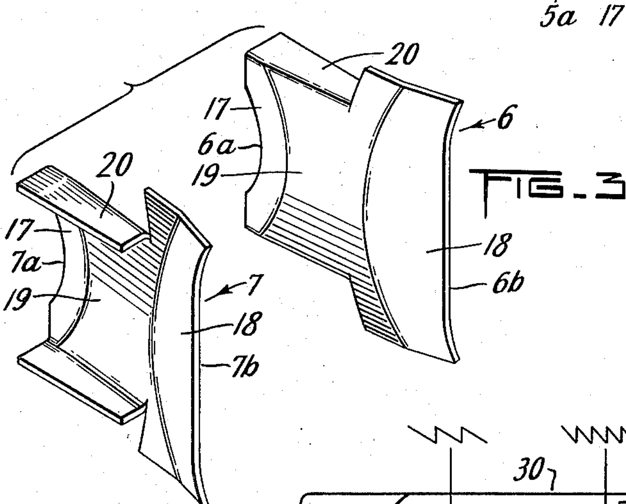


FIG. 3

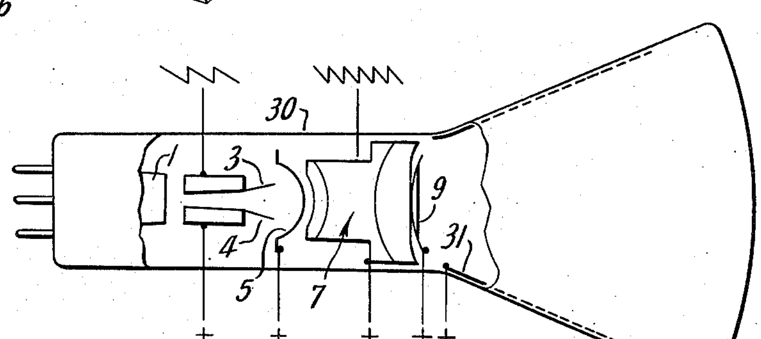


FIG. 4

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Patented Oct. 3, 1950

2,524,606

UNITED STATES PATENT OFFICE

2,524,606

ELECTRON DISCHARGE DEVICE

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Application February 2, 1948, Serial No. 5,847
In Great Britain May 26, 1939

Section 1, Public Law 690, August 8, 1946
Patent expires May 26, 1959

7 Claims. (Cl. 250—158)

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This invention relates to cathode ray tubes of the kind in which the beam is deflected successively in two mutually perpendicular directions, and in which at least the second of these deflections (herein called the "X" deflection) is produced electrostatically. In such cases it is customary, although not essential, for the first deflection (herein called the "Y" deflection) also to be produced electrostatically.

The principal object of the invention is to avoid deflection amplitude distortions (namely, trapezium, pin-cushion and barrel distortions) of the raster when the deflection voltages are applied asymmetrically and when large angles of deflection are produced.

According to the principal feature of the invention, there is provided a double electrostatic deflection cathode ray tube having an interplate screen and wherein both of the "X" deflection plates have their entrance and emergent edges curved concavely, and have at least part of their surfaces curved convexly toward each other so that their central parts are closer together than their sides, whereby deflection amplitude distortions are substantially eliminated when the tube is operated with total angles of deflection up to at least about thirty degrees, even though the potentials of one "X" deflection plate and one "Y" deflection plate be held constant and the deflection voltages be applied wholly to the other deflection plates.

By the term "interplate screen" in this specification is meant an electrode placed across the path of the beam, between the region of "Y" deflection and the region of "X" deflection, curved spherically about substantially the apparent centre of "Y" deflection, or cylindrically about an axis passing substantially through that centre and perpendicular to the plane of "Y" deflection, and slotted so as to allow passage of the beam at all required angles of "Y" deflection. This interplate screen is maintained at constant potential when the tube is in operation, usually the potential of the final anode of the electron gun.

In the modified form of the invention wherein the "Y" deflection is produced electromagnetically instead of electrostatically, this screen is still required, although the term "interplate screen" becomes inappropriate.

The effect of the interplate screen is presumed to be the shaping of the equi-potential lines of the field between the entrance edges of the "X" plates so that they are crossed substantially at right angles by the beam under all degrees of "Y" deflection. This prevents the refraction of the elec-

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tron beam towards the axis when entering the space between the "X" plates and trapezium distortion due to this cause is, therefore, eliminated. The curvature of the entrance edges of the "X" plates is for the same purpose.

The emergent edges of the "X" plates are curved concavely for the similar purpose of preventing or compensating for refraction of the beam in the direction of "Y" deflection when emerging from the space between the "X" plates.

When the entrance and emergent edges of the "X" plates are both curved concavely, the length of each plate in its middle is considerably less than its length at its sides. Compensation for the resulting variation with "Y" deflection of "X" deflection sensitivity, known as pin-cushion distortion, is effected by the curving of at least part of the surfaces of the "X" plates convexly toward each other so that their central parts are closer together than their sides.

According to a preferred feature of the invention an additional electrode is provided beyond each "X" deflection plate, or at least beyond the working "X" plate (i. e. that "X" deflection plate which is arranged for its potential to be varied during operation while the potential of the other is kept constant) said additional electrode being situated outside the extreme deflected path of the beam and being arranged to be operated at a constant potential, whereby the collection by the said "X" plate of secondary electrons returning from the screen is substantially prevented. A further effect of this additional electrode is to reduce the defocussing of the beam which tends to occur when the beam is deflected to pass close to the working "X" plate. The conductive coating on the wall of the envelope, or the shield surrounding the deflector plates, provided for the purpose of collecting secondary electrons returning from the screen is preferably maintained at the same constant potential as this additional electrode, which may be the highest potential attained by the working "X" plate during operation.

The present invention will be more fully understood by reference to the following detailed description, which is accompanied by the drawings in which:

Fig. 1 is an elevational view of the deflecting electrode construction of a cathode ray tube embodying the principles of the present invention, while

Fig. 2 is a horizontal sectional view of the electrode structure shown in Fig. 1, taken along the line 2—2 of Fig. 1,

Fig. 3 is an exploded view in perspective of one pair of deflection plates of the deflecting structure shown in Figs. 1 and 2, while

Fig. 4 is a diagrammatic representation of a cathode ray tube embodying the principles of the present invention in which there is generally indicated the arrangement of the various electrodes within the tube and the potentials applied thereto.

Referring now to Figs. 1 and 2 of the drawing, reference character 1 indicates the final anode of an electron gun which projects an electron beam generated at a cathode (not shown) along the axis of the electrode structure. The beam, after passing through the central aperture 2 in anode 1, passes between the "Y" deflecting plates 3 and 4 and through the slot 5*a* in inter-plate screen 5. Its path continues between the "X" deflecting plates 6 and 7 and between the secondary electron collector electrodes 8 and 9 and is directed toward a screen at the end of envelope 30 (Fig. 4). It will be noted that each of the "Y" deflecting plates 3 and 4 are so bent intermediate their ends so as to form a gradually increasing space between them toward the exit. After emerging from the region between the "Y" deflecting plates 3 and 4, the electron beam passes through aperture 5*a* in the inter-plate screen 5. Inter-plate screen 5 is an electrode placed across the path of the beam and curved symmetrically about an axis passing substantially through the apparent center of "Y" deflection and slotted so as to allow passage of the beam through aperture 5*a* at all required angles of "Y" deflection.

As indicated by the + mark in Fig. 4, the inter-plate screen 5 is maintained at a constant potential when the tube is in operation, usually that of the final anode of the electron gun. The effect of the inter-plate screen 5 is presumed to be a shaping of the equi-potential lines of the field between the entrance edges of the "X" plates 6 and 7, so that they are crossed substantially at right angles by the beam under all degrees of "Y" deflection. This prevents the refraction of the electron beam towards the axis when entering the space between the "X" plates 6 and 7. Trapezium distortion due to this cause is therefore eliminated. The final deflection plates 6 and 7 are identical with each other. The entrance edges of each are curved concavely as indicated at 6*a* and 7*a* and the emergent edges are also curved concavely as indicated at 6*b* and 7*b*. The curvature of the emergent edges 6*b* and 7*b* is not constant. There is a straight portion in the middle of each, which was found necessary to avoid over-correction of the trapezium distortion for angles of deflection smaller than about 15°. Each of the plates 6 and 7 is made up of two plane sections 17 and 18 and a curved middle section 19. Plane sections 17 are parallel one to the other while the curved sections and exit sections 18 form a divergent angle along the undeflected path of the beam. The curvature of the middle section 19 is such that all sections thereof cut by planes parallel to the plane of Fig. 2 are rectilinear. The curvature is convex inwardly so that the central part 19 of plate 6 is closer to the central part 19 of plate 7, than are the upper and lower edge portions of plate 6, where lips 20 are provided, with regard to the corresponding sides of plate 7. Plates 6 and 7 are reinforced by the turned-over lip portions 20 at their upper and lower edges.

The various curvatures of plates 6 and 7 and the relationship of one plate with respect to the other is shown more clearly in Fig. 3 wherein a perspective view of these two plates is shown, the spacing between the plates being somewhat increased so that one plate does not lie over the other in the figure. It will be appreciated that for any particular tube, the necessary curvatures for the inter-plate screen 5 and for the entrance and emergent edges of the "X" deflecting plates 6 and 7 may require empirical determination, but the electrode system shown in the accompanying drawing has been found to eliminate deflection amplitude distortion satisfactorily for total angles of deflection up to 30°, that is 15° to each side of the central axis occupied by the undeflected beam.

In Fig. 4 is shown a schematic representation of a cathode ray tube having an evacuated envelope 30 having a funnel-shaped configuration. The fluorescent screen (not shown) occupies the large end wall of the envelope while the electron gun structure and deflecting electrode system occupies the neck of the envelope. One of the "Y" deflecting plates 3 may have a saw tooth deflecting wave of low frequency applied to it as indicated by the saw tooth figure at the end of the connection lead connected to plate 3, while the other, 4, is held at a constant positive potential as indicated by the + mark. The inter-plate screen 5 may be directly connected to plate 4 or it may be separately energized from a fixed potential power equal to that of plate 4 as indicated in the figure. Similarly, plate 7 is held at a fixed potential while plate 6 has a high frequency saw tooth wave applied thereto.

When the driving circuit connected to the working "X" plate in Fig. 4 shows a high impedance, there is a tendency to deflection amplitude distortion which varies with the intensity of the electron beam. This is believed to be due to the collection, by the working "X" plate, of secondary electrons returning from the screen on the end of the tube. This may be substantially prevented by the provision of an additional electrode such as those shown at 8 and 9, beyond the working "X" plate and operated at a constant potential preferably about as high as the maximum potential attained by the working "X" plate during operation.

The envelope 30 of the cathode ray tube is preferably provided with a conductive coating 31 on the inside of the envelope which is maintained at the same potential and may be directly connected to the additional electrodes 8 and 9 as indicated in Fig. 4. The tube illustrated in the drawing is entirely symmetrical, and an additional electrode 8 or 9 is provided for each "X" deflecting plate 6 or 7. It is, therefore, immaterial which of the "X" plates 6 and 7 is held at fixed potential, and which is used as the working plate in Fig. 4. Merely for the sake of illustration, plate 7 is indicated as being held at a fixed potential.

The present invention will principally be applied to cathode ray tubes having fluorescent screens, but it is evident that the precise nature of the screen is irrelevant to the invention, and the invention may be used in all cases where asymmetric distortion voltages are employed, and wide angles of deflection are required. Also, the invention is applicable to cathode ray tubes of the gas filled type, as well as to those in which the focusing of the beam is mainly affected by electro-static fields. As, however, the beam current of gas filled tubes is not modulated during operation, the secondary electron collecter electrodes **8** and **9** do not serve the same total purpose, though they still act to increase the apparent plate to plate impedance presented to the driving circuit.

I claim:

1. A cathode ray tube of the kind in which an electron beam from a cathode is deflected successively in two mutually perpendicular directions, the first of these deflections being termed the "Y" deflection and the second of these deflections being termed the "X" deflection and is produced electrostatically by a pair of deflecting plates, said tube comprising Y-deflecting means for producing the said "Y" deflection, and an interplate screen interposed between the said Y-deflecting means and the said pair of deflecting plates, said interplate screen being in the form of an electrode curved concavely towards said Y-deflecting means and being slotted to allow passage of the beam over a range of "Y" deflections, both of said "X" deflection plates having entrant and emergent edges curved concavely, and said "X" deflecting plates having at least part of their facing surfaces curved convexly towards each other so that their central parts are closer together than their side portions.

2. A cathode ray tube according to claim 1, wherein an additional electrode is provided beyond that "X" deflection plate which is arranged for its potential to be varied during operation, said additional electrode being arranged outside the extreme deflected path of the beam and being arranged to be operated at a constant potential whereby the collection by the said "X" plate of secondary electrons returning from the screen is substantially prevented.

3. A cathode ray tube according to claim 1, wherein said X-plates are symmetrically constructed for operation with either of the "X" deflection plates held at constant potential and with the deflection voltages applied to the other of such "X" deflection plates, and including an additional electrode is provided beyond the "X" deflection plate which is arranged to receive a variable potential during operation, said additional electrode being arranged outside the extreme deflected path of the electron beam and being arranged to be operated at a constant potential whereby the collection by the said "X" plate of secondary electrons returning from the screen is substantially prevented.

4. A cathode ray tube of the kind in which an electron beam from a cathode is deflected successively in two mutually perpendicular directions, the second of these deflections being termed the "X" deflection and being produced electrostatically by a pair of deflecting plates, both of the "X" deflection plates having entrance and emergent edges curved concavely, said plates having at least part of their facing surfaces curved convexly toward each other so that their central parts are closed together than their sides.

5. A cathode ray tube according to claim 4 wherein the potential of one of said "X" deflection plates is held constant and the other of said "X" deflection plates has deflection voltages applied thereto and wherein an additional electrode is provided beyond the latter of said "X" deflection plates, said additional electrode being operated at a constant potential whereby the collection of secondary electrons by said latter plate is substantially prevented.

6. A cathode ray tube, having within an evacuated envelope a source for a beam of electrons, a first pair of opposing deflection plates and a second pair of opposing deflection plates arranged in planes perpendicular to said first pair of plates, said second pair of plates having entrance and emergent edges curved concavely and at least part of their facing surfaces curved convexly toward each other, so that their central parts are closer together than the side parts whereby deflection amplitude distortions are substantially eliminated, the potential of one of said first pair of deflection plates and one of said second pair of deflection plates being held constant and the other of each of said pairs of plates having deflection voltages applied thereto.

7. A cathode ray tube according to claim 6, wherein an additional electrode is provided beyond that one of said second pair of deflection plates which is arranged for its potential to be varied during operation and outside the path of said beam when grazing the said one of said second pair of deflection plates, said additional electrode being operated at a constant potential whereby the collection by said plate of secondary electrons is substantially prevented.

EDWARD ERIC SHELTON.

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