This invention relates to cathode ray tubes and particularly to the deflection electrodes of the electrostatically deflected polar coordinate cathode ray tubes.

Cathode ray tubes of the type shown in U.S. Patent 2,328,359 intended for use in displaying electrical signals in a polar coordinate presentation are difficult to construct accurately since the center electrode of the radial deflection pair of electrodes is supported from the front face of the tube entirely independently of the electron gun and hence is subject to misalignment through improper positioning while being sealed into the glass envelope or through mechanical shocks received by the completed tube. When the center deflection electrode of polar coordinate tubes having two pairs of mutually perpendicular deflection plates is supported by the electron gun, a gap caused by the support for the center electrode is produced in the circular pattern on the face of the tube. Furthermore, there is an elliptical distortion of the electron beam envelope in electrostatically deflected cathode ray tubes due to the fact that the centers of deflection of the horizontal and vertical pairs of deflection plates are not coincident.

An electrostatically deflected polar coordinate cathode ray tube is described hereinafter in which the pair of radial deflection electrodes are formed as frustums of elliptically cross sectioned cones to minimize the effects of the elliptical distortion in the electron beam envelope. The radial deflection electrodes are rigidly mounted on the electron gun in such a manner as to withstand any reasonable mechanical shock and corrector plates are mounted axially on the radial deflection electrodes to reduce the width of the gap in the pattern on the face of the tube.

It is one object of this invention to produce an improved polar coordinate cathode ray tube.

Other objects are to produce a steadier radial deflection electrode pair for electrostatically deflected polar coordinate cathode ray tubes, to equalize the deflection sensitivity over the entire circle of the radial deflection electrodes, and to reduce the gap in the cathode ray pattern traced on the screen of polar coordinate cathode ray tubes.

Other objects will be apparent after studying the following specification and drawings in which:

Figure 1 illustrates a cathode ray tube embodying this invention;

Figure 2 shows a cross section of the radial deflection electrodes through 2—2 of Figure 1;

Figure 3 shows a top view of the electrodes in Figure 2;

Figures 4 and 5 illustrate the deflection of the electron beam in Figure 1 by the horizontal and vertical pairs of deflection plates respectively;

Figures 6 and 7 illustrate sections through 6—6 and 7—7 respectively of the radial deflection electrodes in Figure 1; and

Figure 8 shows a typical pattern on the fluorescent screen of the tube in Figure 1.

In Figure 1 a polar coordinate cathode ray tube is shown comprising a bulb 11 having a base 12 and an electron gun mounted in the neck 13 of the bulb 11. The electron gun comprises a control grid 14 with a cathode (not shown) located therein, a portion 16 of the second anode, the focussing anode 17, and a section 18 which is electrically connected to the portion 16 to form the complete second anode, all mounted on a pair of insulating rods 19 and 20. A first pair of deflection plates 21 and 22 and a second pair of deflection plates 23 and 24 similar to those shown in U.S. Patent 2,391,273 also are mounted on the ceramic rods 19 and 20. A spring centering device 25 is attached to an insulating disk 27 which may be, for instance, a mica plate. The radial deflection electrode pair comprising an inner electrode 29 and an outer electrode 28 is secured to the ends of the ceramic rods 19 and 20. Electrical connections to the deflection plates 21 and 22 may be made by means of a pair of contact terminals 31 and 32 which may be of the type shown in U.S. Patent 2,448,808.

Figure 2 shows the deflection electrode 28 supported by a pair of wire rods 37 and 38 extending from the ceramic rods 19 and 20. The center electrode 29 is preferably supported by a thin metal ribbon support 39 from one of the ceramic rods 19 and is electrically insulated from the outer electrode 28. Directly above the support 39 and attached to the wall of the outer electrode 28 is a thin metal connector plate 51 which, as is shown in both Figure 2 and Figure 3, extends substantially parallel to the support 39 from the inner wall of the electrode 28 to the proximity of the electrode 29.

Under the influence of normal operating potentials the pattern on the face of the polar coordinate cathode ray tube appears as shown in Figure 8 in which the trace 40 is set to form a circle 41 having a predetermined radius. This circle 41 is called the median circle and signal voltages impressed on the radial deflection electrodes 28 and 29 cause the radius of the trace 40 to become either greater or less than its median value as
shown by the projections from the circular pattern.

At one point in the trace the support 39 deflects the electron beam so as to cause a shadow on the screen of the tube. This shadow is similar to an optical shadow of the support 39 and may be of the order of 1/4 inch radius having a radius of 1 1/2 inches. As is shown by the dotted lines in Figure 6, signal voltages occurring during the time that the beam is in this shadow region would not appear as visible patterns on the cathode ray tube screen. Consequently the information represented by these signals, such as the pulse 42, would be lost.

The corrector plate 51 acts to reduce the angle of this gap in the trace of the cathode ray beam. Since this plate 51 has a voltage impressed on it which is opposite in polarity to the voltage impressed on the support 39, the electron beam which was deflected away from a portion of the screen to create the gap indicated at 42 is deflected back to its original trajectory thus decreasing or eliminating the gap. In practice the voltages of the electron gun and the deflection system are selected so as to narrow the gap for a three inch median circle to 1/4 inch or less.

The line 50 in Figure 4 represents the electron beam deflected the necessary amount by the pair of deflection plates 21 and 22 to produce the median circle. Similarly, in Figure 5 the line 52 represents the electron beam deflected the necessary amount by the upper pair of deflection plates 23 and 24 to produce the median circle. In order to produce the median circle 41 on the screen of the cathode ray tube, the signal voltages applied to the deflection plates 21, 22, 23 and 24 are adjusted to provide equal deflection in both of two mutually perpendicular directions as indicated by points 46 and 57 which are equidistant from the center 58 of the screen 54. Although the deflection of the electron beam does not take place at a single point between the given pair of deflection plates but is distributed over an area, it is well known to represent the deflection as having taken place about a center point which for the pair of deflection plates 21 and 22 is the point 59. The pair of deflection plates 23 and 24 are the center of deflection at the point 61. It is important to note that between the points 59 and 61 the electron beam is being deflected back and forth in only one direction and it is only above the point 61 that the beam is deflected at right angles to this first direction.

In order to create the circular pattern on the screen, the angle of deflection A for the pair of plates 21 and 22, and the angle of deflection B for the pair of plates 23 and 24, must be greater than the angle of deflection B for the pair of plates 21 and 22 which are farther from the screen. Since the polar coordinate tube is designed with certain dimensional relations for a particular accelerating voltage and deflection sensitivity, the path of the electron beam through the deflection area of the electrodes 28 and 29 is predetermined.

In tracing out a circle on the screen 54 the paths of the electron beam form a conical sheet having an elliptical cross section with a continuously varying eccentricity which is shown graphically in Figures 6 and 7. The radii D and F in Figure 6 represent the distance from the center line 53 in Figures 4 and 5 to the rays 51 and 52 respectively in a plane passing through the lower edge of the electrode 28 when these rays are deflected so as to produce the median circle 42. It is a well known exercise in analytic geometry to construct an ellipse based on two concentric circles and this ellipse is indicated in Figure 6 by the reference character 71.

Figure 7 shows an ellipse 72 representing the cross section of the conical sheet at the top edge of the electrode 28 as formed by radii C and E corresponding to D and F in Figure 6. It will be noticed that the ellipse 72 is more nearly circular than the ellipse 71 which is as required, since at the screen 54 the ellipse becomes a circle and at the point 61 in Figure 5 the ellipse degenerates into a straight line.

In order to keep spot distortions at a minimum the electrodes 28 and 29 have cross sections at the bottoms and tops thereof corresponding in shape to the ellipses in Figures 6 and 7 respectively but preferably changed in size so that the conical sheet passes midway between these two electrodes throughout the axial lengths thereof. In order to take best advantage of the minimum spot distortion thus achieved, push-pull deflection should be applied to the two electrodes 28 and 29.

Although this invention has been described with reference to specific embodiments it is obvious that modifications may be made by those skilled in the art without departing from the scope of the following claims.

What is claimed is:

1. An electrostatically deflected polar coordinate cathode ray tube comprising an evacuated vessel containing a light transiting screen and an electron gun comprising a plurality of electron beam forming electrodes, a plurality of pairs of deflection plates, one of said pairs being supported and adjacent the end of said electron gun nearer said screen, another of said pairs being supported by said gun between said screen and the former of said pairs of deflection plates, a pair of conical deflection electrodes supported by supporting means crossing the area traversed by the electron beam from said electron gun between the latter of said pairs of deflection plates and said screen, and corrector means parallel and adjacent to said supporting means to exert a force on said beam equal and opposite to the force exerted thereon by said supports.

2. A polar coordinate cathode ray tube comprising an evacuated vessel having a light transiting screen and an electron gun, said electron gun comprising a plurality of tubular electrodes, a first pair of deflection plates and said screen electron gun between said screen and said gun, a second pair of deflection plates supported by said electron gun between said screen and said first pair of deflection plates, a pair of radial deflection electrodes comprising a conically shaped outer electrode supported by said electron gun structure and a conically shaped inner deflection electrode coaxial with said outer electrode and suspended by a strap from said electron gun structure, and a corrector plate attached to the inner wall of said outer deflection electrode and extending inwardly toward said inner electrode substantially parallel with said support strap.

3. A polar coordinate cathode ray tube comprising an evacuated vessel having a light transiting screen and an electron gun, said electron gun comprising a plurality of tubular electrodes secured to a plurality of insulating rods, a first pair of deflection plates supported by said rods between said screen and said gun, a second pair of deflection plates substantially perpendicular to said first pair of deflection plates located between said first pair of deflection plates and said screen and supported by said rods, and a pair of radial
deflection electrodes comprising an outer deflection electrode having a frusto-conical shape and supported by said rods and an inner electrode having a corresponding frusto-conical shape and supported from said rods by a conductive support strap, said support strap forming a lead for applying deflection potentials to said inner deflection electrode, and a corrector plate secured to the inner wall of said outer electrode adjacent said support strap and extending substantially parallel thereto from the inner wall of said outer electrode toward, but spaced from, said inner electrode.

4. A polar coordinate cathode ray tube comprising an evacuated vessel containing a light translating screen, an electron gun, a first pair of deflection plates between said electron gun and said screen, a second pair of deflection plates between said first pair of deflection plates and said screen and a pair of radial deflection electrodes between said second named pair of deflection plates and said screen, both said radial deflection electrodes having elliptical cross sections in a plane perpendicular to the axis of said radial deflection electrodes.

5. The device of claim 4 in which the elliptical cross section of said radial deflection electrodes has a different eccentricity at the end of said electrodes proximal to said screen from the eccentricity at the end of said electrodes distal from said screen.

6. A polar coordinate cathode ray tube comprising an evacuated vessel containing a light translating screen, an electron gun, a first pair of deflection plates between said electron gun and said screen, a second pair of deflection plates between said first pair of deflection plates and said screen, and a pair of radial deflection electrodes between said second named pair of deflection plates and said screen, each of said radial deflection electrodes having a frusto-conical shape with the cross section of said electrodes being elliptical with the major axes of the ellipses being perpendicular to said first named pair of deflection electrodes.

7. The device of claim 6 in which the eccentricities of said ellipses varies along the axial length of said radial pair of deflection electrodes.

A polar coordinate cathode ray tube comprising an evacuated vessel containing a light translating screen and an electron gun, said electron gun comprising a polarity of beam forming electrodes, a first pair of deflection plates supported by said gun between said gun and said screen, a second pair of deflection plates supported by said gun between said first pair of deflection plates and said screen, and a pair of frusto-conical radial deflection electrodes, the cross section of said radial deflection electrodes being elliptical with the major axes of the ellipses being perpendicular to said first pair of deflection plates.

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