Nov. 24, 1959 H. J. EVANS 2,914,691

COMPENSATION OF CATHODE RAY POST ACCELERATION FIELD DISTORTION

Filed Jan. 18, 1956

FIG. 1.

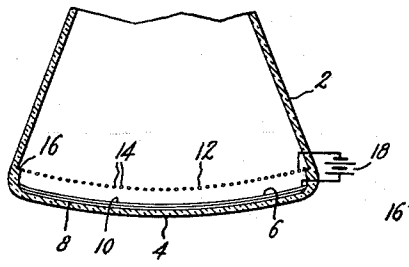


FIG. 3.

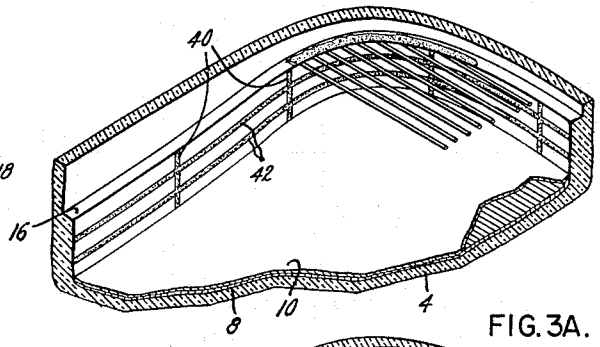


FIG. 3A.

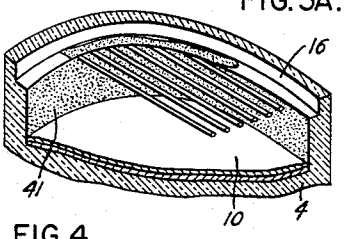


FIG. 2.

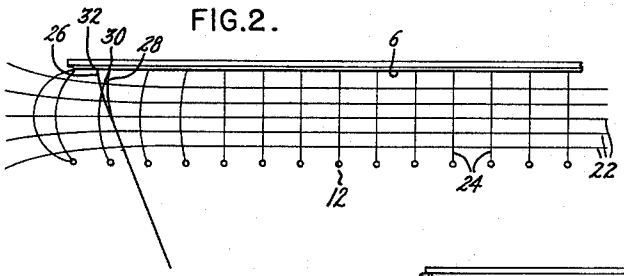


FIG. 4.

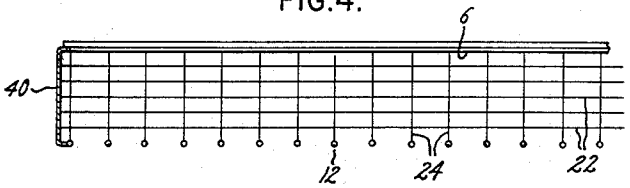


FIG. 5.

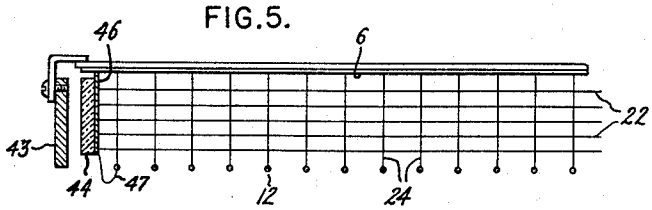


FIG. 6.

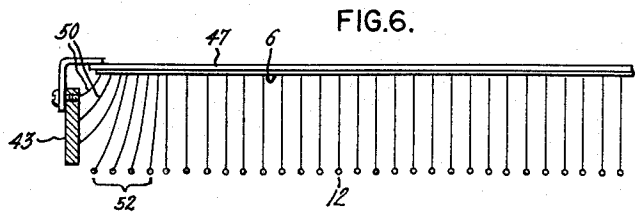
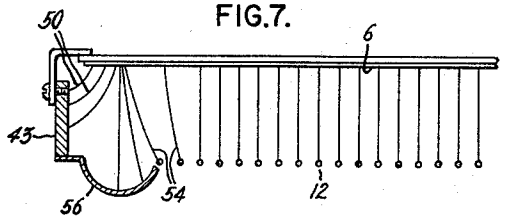


FIG. 7.



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COMPENSATION OF CATHODE RAY POST ACCELERATION FIELD DISTORTION

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Application January 18, 1956, Serial No. 559,884

10 Claims. (Cl. 313—78)

The present invention relates to cathode ray tubes of the type in which, after deflection but before hitting its target, the electron beam passes through an electric field employed to affect the velocity and/or direction of the beam. More specifically, the invention relates to improved means for correcting undesired distortion of the electron beam trajectory due to fringe effects in such an electric field. The invention has particular utility in eliminating spurious color response caused by such field fringing in color television picture tubes of the post acceleration type.

In cathode ray tubes of the type here concerned, a pair of electrodes, one of which may be a target electrode, are disposed in the path of the scanning electron beam and maintained at different potentials so as to create an electric field in the space between the electrodes by which the electron beam is modulated in velocity and/or direction after deflection, and caused to strike the target at desired locations and/or with desired velocities. In certain color television picture tubes of the so-called post acceleration type, for example, the aluminized phosphor target electrode serves as one of the electric field electrodes, and an electron-permeable grid disposed in spaced confronting relation with the target electrode on the side thereof facing the electron beam serves as the other electric field electrode. The grid is maintained at a potential substantially below the potential of the target electrode so as to create a relatively strong electric field between the electrodes by which electrons of the beam are strongly accelerated toward the target electrode, and strike it with high velocity providing the desired degree of brightness.

It will be appreciated that the uniformity of effect of such an electric field upon an electron beam passing through it depends upon the uniformity or homogeneity of the field itself. With electrode arrangements conventionally employed wherein the two electrodes are substantially parallel and of substantially equal area, the electric field throughout the central portion of the interstice between the electrodes is substantially uniform and is characterized by equi-potential surfaces which are planar, equally spaced, and parallel to the electrodes. As a result, the trajectory of electrons passing through this portion of the electric field is affected by the field in a uniform and predictable manner, and the electrons strike the target at desired locations. However, at the periphery of the interstice the equi-potential surfaces and the electric flux lines of the field become distorted in shape and spacing, this condition being commonly known as "fringing" of the field, and the resultant effect on the trajectory of an electron beam passing through this portion

of the field is such as to cause appreciable non-homogeneous displacement of the beam and accompanying distortion of the image or other pattern traced by the beam on the target electrode. Such distortion is in many applications highly undesirable, and may be sufficient in color television picture tubes, for example, to cause a spurious color response or color infidelity about the peripheral portion of the target electrode.

In many prior art cathode ray tubes, this fringe distortion is concealed by covering the distorted portion of the display by masking techniques. For example one means frequently employed is a decorative mask positioned around the periphery of the cathode ray tube faceplate so as to hide the distorted area. This is not a satisfactory solution, however, because it excessively reduces the usable area of the viewing face of the tube.

Accordingly, a principal object of the present invention is to provide means for correcting fringe field distortion of the electron beam trajectory in cathode ray tubes of the type described.

Another object is to substantially increase the usable viewing area in cathode ray tubes of the type described.

Another object is to provide, in cathode ray tubes of the type referred to, fringe field distortion correcting means within the tube itself which is simple, inexpensive, and easy to incorporate in the tube from a manufacturing standpoint.

Another object is to provide, in a post acceleration color television picture tube, improved fidelity of color response.

Briefly stated, in a preferred aspect of the invention I correct such fringe field distortion by providing adjacent to the edge of the field a corrective electrode having a physical arrangement such as to extend across the edge of the field from one field electrode to the other and make electrical contact with each, the said corrective electrode having a high resistance to current flow between the field electrodes such as to limit such current to an amount insufficient to overload the tube bias supply, and having a potential gradient such as to match the desired field potential gradient in the space between the electrodes. With this arrangement the corrective electrode provides a surface adjacent the periphery of the space between the electrodes on which the equi-potential lines of the field can terminate without undesired distortion, and thus the objectionable fringe effects of the field are completely eliminated.

My invention will be better understood from the following description taken in connection with the accompanying drawing, and its scope will be defined in the appended claims.

In the drawing:

Figure 1 is a fragmentary horizontal sectional view of a cathode ray image producing tube to which the present invention may be applied;

Figure 2 is an enlarged fragmentary sectional view of the electrodes of the tube of Figure 1 between which the electric field is developed, showing diagrammatically an exemplary arrangement of the equi-potential planes and electric flux lines thereof;

Figure 3 is an enlarged fragmentary perspective view of a portion of the structure of Figure 1 and illustrating one form of the present invention;

Figure 3A is a view similar to Figure 3 showing a variation thereof;

Figure 4 is a view similar to Figure 2, showing diagrammatically the manner of correction of the electric field by the arrangement shown in Figure 3;

Figure 5 is a fragmentary sectional view of another form of electrode arrangement, and illustrating another form of the invention;

Figure 6 is a view similar to Figure 5, showing still another form of electrode arrangement and the distortion of the electric field therein; and

Figure 7 is a view similar to Figure 6, showing diagrammatically the correction of the electric field distortion according to another form of the invention.

Referring now to Figure 1, a preferred embodiment of the invention will be described in connection with a cathode ray color television picture tube of the post acceleration type. The tube includes an envelope 2 having a faceplate 4 and containing one or more electron guns (not shown) for generating one or more electron beams. A target electrode 6 includes a phosphor coating 8 deposited on the interior surface of the faceplate substantially coextensive therewith, and overlaid with a conducting coating 10 of aluminum or the like. The phosphor coating consists of a plurality of groups of three discrete incremental areas of different primary color emitting phosphors, which may have any desired configuration such as dots, stripes, and so forth, and are here shown by way of example as vertical stripes. Rearwardly spaced from the target electrode is a second electrode or grid 12 approximately the same size as the target. The grid is permeable to electrons, and is shown by way of example as made up of many parallel spaced fine wires 14 supported from ledges 16 on the wall of the tube envelope 2. The grid 12 has a slight curvature in one direction approximating the curvature of the tube faceplate, and the wires are so spaced and arranged as to provide color selection by permitting the electron beam from any one gun to strike only phosphor increments of the color for which it is intended. Alternatively the grid may be constructed from an integral foraminate sheet, the specific construction of the grid forming no part of the present invention, and requiring only the provision of electron permeable areas of proper size and number for proper color control of the beam from each electron gun. To create the proper accelerating field between the target and grid, the target electrode 6 is maintained at a potential substantially above that of the grid by a suitable power supply shown schematically at 18.

Figure 2 illustrates diagrammatically the electric flux lines and equi-potential planes of the electric field between the grid 12 and the target electrode 6, and one form of fringe distortion of the field. As will be seen in Figure 2, neglecting the region very close to the grid wires, which may be disregarded, the lines 22 denoting the configuration of the equi-potential planes in the field are straight, parallel, and equally spaced, and the lines 24 denoting the electric flux lines are straight and normal to the two field electrodes, at points inwardly displaced from the edge of the interstice between the electrodes. But at the periphery of the interstice the flux lines bow out and the equi-potential lines flare out due to the fringing of the field. As a result of this distortion of the flux lines and equi-potential lines, and because the forces on an electron moving in such a field tend to direct it parallel to the flux lines, a corresponding distortion is produced in the trajectory of the electron beam passing through the field from the grid to the target electrode. The distortion in the situation illustrated is such as to displace the beam trajectory inwardly from path 26 to path 28 and cause the beam to strike the target electrode at a point 30 inwardly displaced from the point 32 at which it should strike for proper fidelity of image reproduction and color response.

In one embodiment of the invention as shown in Figure 3, I correct such fringe distortion of the field by means of a corrective electrode positioned adjacent to the edge of the space between the target and grid and arranged to form a high resistance current path between the target and grid. The corrective electrode may take a variety of physical forms, such as a plurality of individual high resistance wires or ribbons, wire mesh, or a continuous sheet of high resistance material. However, for ease of manufacture the corrective electrode preferably consists of a plurality of individual conductors 40 incorporated in the tube in the form of strips of high resistance coating material, such as chromic or iron oxide paint, applied directly to the interior wall of the tube envelope between the target electrode and the grid. The resistance of each of these conductive strips to current flow between the target and grid is made to vary with length, i.e., measured in a direction parallel to the electric flux lines, such that the variation in potential along each strip matches the variation in potential along the flux lines in the undistorted portion of the field. Because of this matching of potential gradients, the conductors 40 will provide surfaces on which field equi-potential lines will terminate as shown diagrammatically in Figure 4 with substantially the same equally spaced parallel relation as they have in the central portion of the field, and a sufficient proportion of the field equi-potential lines will be so terminated on conductors 40 as to substantially eliminate the fringe distortion of the field.

The total resistance of the conductive path formed by conductors 40 must be sufficiently high to avoid an excessive drain on the power supply 18 providing the voltage differential between the two electrodes. Thus the current flow through conductors 40 should be substantially less than the electron beam current. However, within this limit, it is also desirable to have as large a current flow as possible in the conductors so as to minimize any variaton in their potential gradient which might result from bombardment of the conductors by stray electrons.

The conductors 40 may be suitably spaced and arranged around all or any desired portion of the periphery of the electric field, as necessary to provide the desired correction of fringe field distortion. If the current drain between target and grid through conductors 40 can be kept low enough, in fact, the several conductors 40 may be combined into a single continuous conductive sheet or coating 41 on the envelope wall as shown in Figure 3A, in which case substantially all of the field equi-potential lines will terminate on the continuous sheet with the same directivity and spacing as they have in the central portion of the field, and optimum correction will be obtained. However, if necessary to reduce the current in conductors 40 to acceptable limits, the conductors may be relatively narrow. In such an instance the effective area of the corrective electrode may be increased by connecting equi-potential points on the several conductors 40 by means of additional conductive bands 42. For convenience, conductors 42 may also be painted or otherwise applied directly on the wall of the tube envelope. The conductors 42 thus bridge the spaces between conductors 40, and provide additional areas on which additional equi-potential lines may terminate without distortion. Strips 42 can be varied in spacing or number as necessary to reduce fringe field distortion to an acceptable minimum.

As the electric field fringe distortions are thereby eliminated, distortion of the electron trajectory at the peripheral portions of the target electrode is corrected or eliminated, and the electron beam will strike the target electrode at the proper points to produce an image free of color infidelity or other distortion. The peripheral portion of the target area will thus be reclaimed as a usable viewing area and provides a substantial addition to the total viewing area of the target.

Another embodiment of the invention is shown in Figure 5, in connection with a grid and target electrode arrangement of the "sandwich" type, wherein the grid and target are carried by a supporting frame 43 as distinct from the tube envelope. In this embodiment fringe field distortion is corrected by inserting between the edge of the grid and the target electrode a non-conducting support 44 having a high resistance conductive surface 46 electrically connected at its rear edge to the grid by a conductor 47 and electrically connected at its front edge to the target electrode. As in the embodiment of Figure 3, the resistance of conductor 46 is made to vary with length in a direction parallel to the field flux lines so that the voltage change along the conductor matches the equi-potentials in the undistorted portion of the electric field. Likewise the total resistance of the conductive path formed by conductor 46 is preferably made such as to permit as large a current flow as possible between electrodes 6 and 12, within acceptable limits of drain on the power supply 18, so as to minimize voltage variations due to stray electrons striking conductor 46. One convenient arrangement for forming both the insulating support 44 and a conductive surface thereon is to use lead glass for the support 44 and chemically reduce the surface as necessary to provide a film of pure lead of the proper thinness to provide the necessary resistance for conductor 46.

The electrical effect of the arrangement shown in Figure 5 is substantially the same as that of the arrangement shown in Figure 3, i.e., the conductive surface 46 between the grid and the target electrode provides a voltage gradient across the edge of the interelectrode space which exactly matches the voltage gradient between the equi-potential lines in the undistorted portion of the field. Thus the field equi-potential lines can extend all the way to the edge of the interelectrode space without departing from the equally spaced parallel relation they have in the central portion of the field, and fringe distortion is eliminated.

Figure 6 shows still another embodiment of the invention. This embodiment is particularly suitable with an electrode arrangement of the sandwich type shown in Figure 5, wherein the grid is supported by a frame 43 at grid potential. With such an arrangement fringe field distortion is caused in part by termination of some of the flux lines from the marginal portion of target 6 on frame 43, as shown at 50, this angling of the flux lines producing a corresponding inward deflection of the electron beam. Such fringe field distortion may be corrected according to the invention by eliminating that portion of the grid in the area 52 opposite the edge portion of the target electrode. Figure 7 shows the change in the pattern of the flux lines resulting from such a modification of the grid. Some of the flux lines which previously terminated on the grid wires in the area 52 now follow an inwardly angled path to the periphery of the remaining portion of the grid as shown at 54. This angling of the flux lines 54 produces an outward deflection of an electron beam and thereby compensates for the inward deflection of the beam which the lines 50 tend to produce, the net displacement of the locus of contact of the beam with the target being thus substantially zero. This distortion compensation may be enchanced by minimizing the spacing between the frame 43 and the peripheral portion of the target electrode, so as to concentrate the distorted flux lines 50 into the area at the extreme edge of the target electrode. This may be conveniently done, for example, by extending the conductive coating of the target to close proximity to frame 43.

Elimination of the marginal portion 52 of the grid does not of course diminish the ability of the grid to control electron flow to the whole of the target, because electrons which might pass through this marginal

portion 52 of the grid at the usual deflection angle would not normally hit the target anyway. In fact an electron shield 56 is normally provided to intercept such electrons, so as to prevent them from hitting the frame 43 and releasing undesired secondary electrons. Such a shield 56 may be attached to frame 43 as shown in Figure 7, in which event the portion of the shield adjacent the area 52 from which the grid wires are removed should preferably be curved or bent well to the rear of the grid, according to the invention, so as to increase the shield spacing from target electrode 6. This increase in shield spacing from the target minimizes the number of flux lines from the target which terminate on the shield and prevents the presence of the shield from disturbing the angled disposition of the flux lines at 54. This embodiment of the invention has the advantage that it corrects for fringe field distortion without requiring additional parts or elements of any kind to be added to the tube structure.

Thus there have been shown and described various arrangements for effectively compensating or correcting fringe distortions of the electric field between a pair of electron beam accelerating electrodes in a cathode ray tube. While the techniques here disclosed have been described only in connection with the correction of unwanted field distortions, it will be readily appreciated by those skilled in the art that these same techniques may also be employed to introduce or create arbitrary distortions in the electric field for various special purposes, such as for example to deflect a scanning electron beam in such a manner as to compensate for curvature, surface irregularities, or peculiarities in the shape of the target electrode or grid. Moreover, it will be understood that the present invention is not limited to application in color television picture tubes, but is useful in any cathode ray tube employing electric field control of direction and/or velocity of the electron beam, wherein fringe field distortion of beam trajectory is a problem. All of the arrangements described have the advantage of being structurally simple, inexpensive, and relatively easy to incorporate in the tube structure, and thereby provide effective and practical means of controlling fringe field effects.

It will be appreciated by those skilled in the art that the invention may of course be carried out in various ways and may take various forms and embodiments other than those illustrative embodiments heretofore described. It is to be understood therefore that the scope of the invention is not limited by the details of the foregoing description, but will be defined in the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes adapted to have different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and a field corrective electrode extending across the edge of the space between said spaced electrodes, said field corrective electrode having at points adjacent the respective spaced electrodes respective potentials substantially equal to the respective potentials of the respective spaced electrodes, and said field corrective electrode having a resistance such as to provide therein a potential gradient across the space between said spaced electrodes which matches the potential gradient of the flux lines of said field between the central portions of said electrodes.

2. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes adapted to have different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and a field corrective electrode extending across the edge of the space between said spaced electrodes, said field corrective electrode including at least one electrical

conductor extending between and connected at its opposite extremities to the peripheral edges of said pair of spaced electrodes said field corrective electrode having a resistance such as to provide a potential gradient across the space between said spaced electrodes which matches the potential gradient desired in the flux lines of said field at the periphery of said field.

3. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes having different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and means for correcting fringe distortions in said field including a plurality of electrical conductors forming current carrying paths between the electrodes at points spaced around the edges thereof, said conductors comprising strips of high resistance conductive paint on the interior wall of the tube envelope and each having a resistance varying as a function of its length such as to provide a potential gradient across the space between the spaced electrodes which matches the potential gradient desired in said field.

4. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes adapted to have different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and a field corrective electrode extending across the edge of the space between said spaced electrodes, said corrective electrode including a plurality of strips of a conductive coating on the interior wall of the tube envelope extending between the edges of said pair of spaced electrodes and having a resistance such as to provide a potential gradient across the space between said spaced electrodes which matches the potential gradient desired in the flux lines of said field at the periphery of said field, and bands of a conductive coating on the wall of said envelope connecting equi-potential points on said strips.

5. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes having different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and means for correcting fringe distortions in said field including a plurality of electrical conductors forming current carrying paths between the electrodes at points spaced around the edges thereof, said conductors having a total resistance such that the total current therein is substantially smaller than said electron beam current and having each a resistance which varies with length such that the potential at any point along each conductor substantially equals the potential at a corresponding point between said spaced electrodes in the central portion of said field.

6. In a cathode ray tube, means for generating at least one electron beam, a pair of spaced electrodes having different potentials forming an electric field therebetween through which the electron beam is adapted to pass, and means for correcting fringe distortions in said field including a continuous sheet of electrically conductive material extending around said electrodes adjacent the periphery of the space therebetween and forming a current carrying path between the electrodes, said sheet having a total resistance such that the current therein is substantially smaller than said electron beam current and having a resistance which varies with distance across the interelectrode space such that the potential at any point on the sheet substantially equals the potential at a corresponding point between said spaced electrodes in the undistorted portion of the electric field.

7. In a cathode ray tube, means for generating at least one electron beam, a first electrode adapted to be impinged by the electron beam, a second electrode spaced opposite the first electrode and having an electric potential different from that of the first electrode so as to create an electric field between the electrodes through which the electron beam impinging on the first electrode is adapted to pass, said electric field normally comprising a substantially uniform central portion having a uniform effect on the electron beam trajectory and a normally non-uniform edge portion having a non-uniform effect on the electron beam trajectory, and means for modifying the electric field adjacent the edge of said first and second electrodes comprising a corrective electrode extending between the edges of first and second electrodes, said corrective electrode having a total resistance to flow of current between said first and second electrodes such that such current is substantially smaller than said electron beam current and having a resistance which varies with length such that the electric potentials at all points across the corrective electrode match the electric potentials at corresponding points across the uniform portion of the electric field.

8. In a cathode ray tube, an evacuated envelope having a face plate interiorly coated to form a target electrode substantially coextensive with said face plate, means forming an electron beam in said envelope adapted to illuminate the target electrode, an accelerator electrode substantially equal in area to the target electrode and secured at its edges to the wall of said envelope in spaced generally parallel relation to the target electrode, a bias supply for maintaining the accelerator electrode and target electrode at different potentials to form an electric field therebetween through which said electron beam is adapted to pass to reach said target electrode, said electric field having a substantially uniform central portion and a non-uniform edge portion, and means for restoring uniformity to said non-uniform edge portion comprising a plurality of electrical conductors extending between the edges of said target and accelerator electrodes, said conductors having a total resistance to current flow between said electrodes such as to avoid overloading said bias supply and having a resistance which varies with length such that the variation in potential along said conductors approximately equals the variation in potential along the flux lines of said electric field in the uniform portion thereof.

9. In a cathode ray tube, an evacuated envelope, a target within said envelope having edges adjacent the side walls of said envelope, means forming an electron beam in said envelope adapted to illuminate the target electrode, an accelerator electrode substantially equal in area to the target electrode and mounted in spaced generally parallel relation to the target electrode and with its edges adjacent the side wall of said envelope, said accelerator electrode being adapted to be maintained at a different potential than the target electrode to form an electric field therebetween through which said electron beam is adapted to pass to reach said target electrode, and means for shaping said electric field comprising a plurality of electrically conductive elements extending between the edges of said target and accelerator electrodes, said conductive elements having a total resistance such as to limit current flow between said electrodes to a small fraction of said electron beam current and having a resistance which varies with length such that the variation in potential along said conductive elements corresponds to the desired variation in potential along the flux lines of said electric field at the edge thereof, and spaced conductors connecting equi-potential points on said conductive elements.

10. In a cathode ray tube having an evacuated envelope, a frame of conductive material mounted within the envelope, a target electrode supported by the frame but insulated therefrom, means forming an electron beam adapted to illuminate the target electrode, an accelerator electrode electrically equi-potential with and mounted on said frame in spaced generally parallel relation to said target electrode and between which and the target an electric field is maintained through which said electron

beam is adapted to pass to reach said target electrode, said accelerator electrode being dimensioned so that its peripheral edges are inwardly spaced from the edges of said target, whereby the electric flux lines from the periphery of said accelerator electrode extend outwardly to the marginal portion of said target and provide a corrective field causing outward electron beam deflection compensatory of the inward beam deflection resulting from the inwardly extending flux lines between said frame and the marginal portion of said target, and an electron opaque shield of conductive material on said frame extending around the periphery of said grid in a position such as to prevent the electron beams from striking the frame and having its major portion sufficiently spaced on the opposite side of said grid from said target as to avoid nullifying said corrective field.

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