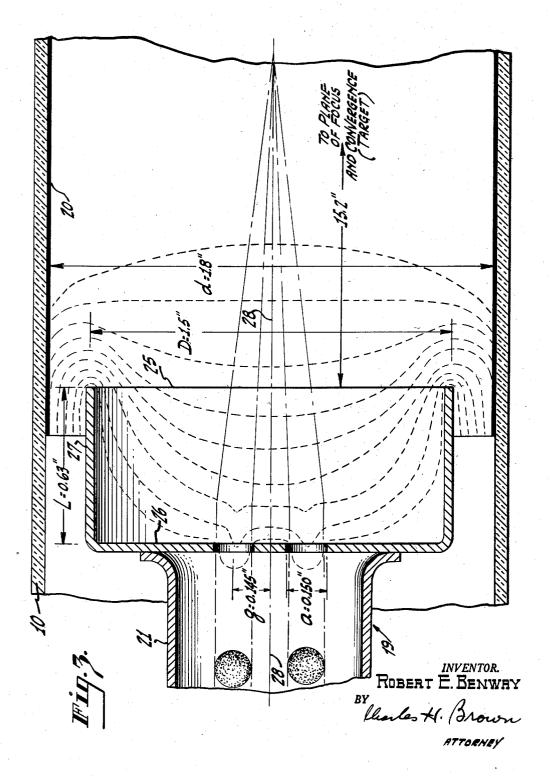


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COMBINATION FOCUSING AND CONVERGING LENS FOR MULTIPLE BEAM TUBES

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This invention relates to means for focusing and converging a plurality of electron beams, and more particularly, to a combination focusing and converging lens for multiple beam tubes.

This invention is especially useful in cathode ray viewing tubes for color television receivers. In such tubes, three electron beams are modulated with three-color signals, respectively, and directed thru apertures in an aperture mask to a three-color phosphor dot screen. The three electron beams, the apertures in the mask and the phosphor dots of the screen are so oriented that electrons of each beam strike only the phosphor dots of one color. It is necessary for the three electron beams to be focused to small spots in the plane of the mask and screen target. It is additionally necessary to converge the three beams so that they merge at the same small spot in the plane of the mask and screen target.

It is an object of this invention to provide an improved and simplified electrode structure for both focusing and converging a plurality of electron beams.

It is another object to provide an improved combination electrostatic focusing and converging lens which is relatively insensitive to power supply voltage variations.

It is a further object to provide an improved multiple beam gun requiring one less direct current biasing potential than has previously been required.

It is a still further object to avoid distortion and arcing caused by charges collecting on the glass mount beading by which the gun electrodes are supported.

In one aspect, the invention comprises a multiple beam 45 gun for use in a color kinescope and including a cupshaped electrode mounted coaxially in the neck of the tube. The end of the cup-shaped electrode is provided with symmetrically arranged apertures thru which the electron beams pass on their way to the target. The 50 inner surface of the tube neck is coated with a conductive substance which is biased with a considerably higher positive potential than is applied to the cup-shaped electrode. The dimensions of the cup-shaped electrode are so chosen that the resulting electric field configuration 55 causes a focusing of the individual beams as they pass thru the respective apertures in the end of the cup-shaped member, and also causes the beams to converge to the same point at the target.

These and other objects and aspects of the invention 60 will be apparent to those skilled in the art from the following more detailed description taken in conjunction with the appended drawings, wherein:

Figure 1 is a broken sectional view of a color kinescope constructed according to the teachings of this in- 65 vention;

Figure 2 is a sectional view taken on the line 2-2 of Figure 1;

Figure 3 is an enlarged sectional view showing the combination focusing and converging lens forming a part 70 of the color kinescope of Figure 1; and

Figure 4 is a chart which will be referred to in de-

scribing how the relative dimensions of the cup-shaped electrode affect the focusing and converging processes.

Figure 1 shows the essential elements of a color television picture tube necessary for an understanding of the 5 present invention including an evacuated envelope having a cylindrical neck portion 10, a flared or enlarged bulb portion 11 and a face plate 12. A phosphor dot screen 13 is laid down on the inner surface of the face plate 12 and consists of phosphor dots of three different colors. 10 An aperture mask 14 is positioned in spaced relationship with the phosphor dot screen, each aperture in the mask 14 being in alignment with a cluster of three phosphor dots of three different colors on the screen 12.

The neck end of the envelope is provided with a base 15 having contact prongs connected within the tube to electrodes of a multiple beam gun. The gun includes three cathodes 16 arranged on the three corners of an equilateral triangle, a first grid assembly 17, a prefocusing second grid assembly 18, and a third grid assem-

20 bly 19. A conductive coating 20 on the inside of the neck 10 of the tube constitutes a fourth or accelerating electrode. The usual deflection yoke 9 surrounds the neck 10.

The third grid assembly 19 includes a cylindrical mem-25 ber 21, an apertured end plate 22 thru which the beams enter from the left as diverging beams, an apertured plate 23 positioned at an intermediate point in the cylinder 21, and an apertured cup-shaped electrode 25. The apertures in the plate 23 are slightly smaller than the size of 30 the beams so that the plate 23 acts as a beam masking diaphragm. The apertures in the cup-shaped electrode 25 are proportioned so that the electrons passing thru the apertures in the plate 23 do not strike the edges of the apertures in the cup-shaped electrode 25. Figure 2

shows the three apertures in the cup-shaped electrode 25 to be equally spaced and equidistant from the longitudinal axis 28 of the tube. The respective apertures in all the grid assemblies and the respective cathode 16 are in alignment. The grid assemblies are mechanically 40 mounted in insulated relationship by means of glass mount beadings 24.

Referring to Figure 3, showing an enlarged portion of Figure 1, the cup-shaped electrode 25 consists of a circular end wall or plate 26 and a cylindrical wall 27. The cylindrical wall 27 has an axial length L and a diameter D. The apertures in the end plate 26 have centers spaced a distance g from the longitudinal axis 28 of the tube. The apertures are round and have a diameter a. The accelerating electrode 20 consisting of a conductive coating on the inner surface of the neck 10 has a diameter d.

The accelerating electrode 20 may, for example, be biased to a potential of 27,000 volts with respect to the first grid 17, and the third grid assembly 19 including cup-shaped electrode 25 may be biased to a potential of 3,000 volts relative to the first grid 17. Because of the potential difference between the accelerating electrode 20 and the cup-shaped electrode 25, and because of the physical geometry of the electrodes, a complex electric field configuration is created which may be illustrated by the dashed equi-potential lines in Figure 3. The electric force exerted upon electrons passing thru the field is exerted at right angles with the equipotential lines.

It will be noted that some of the equi-potential lines in Figure 3 bulge into and thru the apertures in the circular end plate 26 so that the electron beams passing thru the apertures have electric forces exerted upon them which cause the beams to be focused to a small point in the plane of the target at the viewing end of the tube. In order to prevent focusing distortion, it is necessary that the equi-potential lines in the apertures be

perfectly symmetrical. If the lines are to some extent lopsided, the beam becomes distorted as it goes towards the target so that it ceases to have a circular cross-section and does not focus to a small spot at the target. Symmetry of the equi-potential lines in the apertures is accomplished by proportioning the cup-shaped electrode 25 so that the equi-potential lines adjacent to the end plate 26 in the region of the apertures are substantially parallel to the end plate 26. This is accomplished by making length L of the cylindrical wall 27 small com- 10 pared with the diameter D. The length L should be less than one-half the diameter D.

After the electron beams pass thru the apertures in the end plate 26 they reach a region in the cup-shaped electrode 25 where the equi-potential lines are undisturbed 15 by the apertures in the end plate 26 and are symmetrical with relation to the cylindrical wall 27 of the cup-shaped electrode 25. In this region the electric field acts on all three beams to cause them to converge at the same point at the target. All three beams are acted upon equally 20 because of the geometric symmetry about the axis 28 of The converging action is accomplished by the tube. making the length L of the cylindrical wall 27 sufficiently large relative to the diameter D so that the equi-potential lines have sufficient curvature to cause the three beams 25 to converge at the same point at the target.

It is thus far apparent that the cup-shaped electrode 25 must have a cylindrical wall 27 of length L sufficiently small relative to the diameter D to provide undistorted focusing, and the length L must be sufficiently large rela- 30 tive to the diameter D to provide sufficient convergence. By properly proportioning the cup-shaped electrode 25, both focus and convergence can be obtained at the target. As an example of a tube actually constructed and successfully operated, the cup-shaped electrode 25 had 35 the dimensions shown on Figure 3 of the drawings.

The focusing lenses formed in the apertures in the end plate 26 should be shielded from electric fields which may be set up by other electrodes in the tube. This shielding is performed by the cylindrical member 21 40 forming a part of the third grid assembly 19. All parts of the third grid assembly 19, including the cup-shaped electrode 25, are in electrical contact with each other and are biased to the same potential. The cylindrical member 21 provides a field-free path for the beams so 45 that no disturbing electric field can exist on the lefthand side of the end plate 26 and symmetrical lenses are established in the apertures in end 26.

The proper length L of the cylindrical wall 27 relative to the diameter D is influenced by the diameter a 50 and the spacing g of the apertures in the end plate 26. The larger the diameter a and spacing g, the shorter should be the length L and/or the larger should be the diameter D, in order to avoid focus distortion due to lack of parallelism between equi-potential lines and the 55 portions of end 26 near the apertures therein. Focus distortion can also result from insufficient spacing between the apertures. The ratio of the aperture spacing g to the aperture diameter a should be greater than 0.9 in order to prevent interaction between the three focus- 60 ing lenses in the apertures in end 26. If the apertures are too close together, the field in one aperture distorts the fields in the other apertures.

A chart of Figure 4 illustrates how the proper length L for the cylindrical wall 27 was experimentally determined. Starting with a cup-shaped electrode having a diameter D of 1.5 inches, and having apertures with a diameter a of 0.150 inch with centers spaced from the axis 28 at a distance g of 0.145 inch, the axial length L of the cylindrical wall 27 was varied to determine the 70 length providing both focus and convergence at the target which was positioned 15.2 inches from the cupshaped electrode 25: With each different length L the potential applied to the cup-shaped electrode 25 was ad-

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the degree of convergence was noted. It will be seen from Figure 4 that when the length L of the cylindrical wall 27 was greater than 0.63 inch, the three beams were over-converged so that they crossed before reaching the target. Similarly, when the length L was less than 0.63, the beams were under-converged. With a length L of 0.63 inch both focus and convergence was achieved.

In practicing the invention, the apertures in the end plate 26 should be designed so that the ratio of g to dis greater than 0.9, where g is the distance of the aperture centers from the axis 28, and a is the aperture diame In this way, interaction between the focusing eter. lenses in the apertures is avoided. With given values of g and a, the dimensions L and D of the cup-shaped electrode 25 must be selected so that the equi-potential lines adjacent to the end plate 26 in the region of the apertures are substantially parallel to the end plate 26. Under this condition, the equi-potential lines extending into the apertures are substantially symmetrical with the apertures so that there is no focus distortion. This is accome plished by making L relatively small compared with D, and more specifically, by making L less than onehalf D.

It will be apparent to those skilled in the art that ther objects of the invention can be achieved with structures having different dimensions than those shown in Figure For example, if the spacing g of the apertures is, greater than that shown, it will be necessary to increased the diameter D and/or reduce the length L of the cup shaped electrode 25 in order to maintain parallelism. between the equi-potential lines adjacent to the end plate 26 in the region of the apertures. Similarly, if the spacing g of the apertures is less than that shown, inverse, changes should be made in the dimensions D and L. At the same time, the diameter D must be kept small enough, and/or the length L must be kept large enough to simultaneously provide the necessary degree of convergence

According to this invention, a single grid assembly 19 in combination with the accelerating electrode 20, serves to both focus and converge the beams. Heretofore, it has been necessary to provide one grid assembly for. focusing and a separate grid assembly for converging. It has been necessary to apply different biasing potentials. to the two grid assemblies. According to this invention, a single grid assembly is employed for both purposes, and only one source of biasing potential is used compared with the two previously necessary. As a result, there are savings in the power supply as well as savings in the number of electrodes in the tube and a reduction in the number of bias potentials which must be applied. thru the prongs in the base of the tube.

In a tube constructed according to this invention, the convergence is much less affected by power supply voltage variations than has been the case with prior electrostatic tubes. It has been found that a one percent power supply voltage change results in only a four mil (0.004, inch) separation of each spot from the axis 28 at the target of the tube. This convergence sensitivity is about. one-half the best which has heretofore been obtained with an electrostatic converging lens.

A further advantage of the gun structure of this invention is that the glass beading 24 used to mount the electrodes of the gun in insulated relationship is so arranged that there is no possibility of the beading becoming charged and thereby distorting the focusing and converging fields.

According to the teachings of this invention there is provided an improved multiple beam cathode ray tube including a simplified third grid assembly which simultaneously focuses and converges the beams.

What is claimed is:

1. In a triple beam gun, means to focus and converge the electron beams comprising, a cup-shaped electrode having a cylindrical wall and an end wall provided with justed to provide perfect focus at the target and then 75 three circular apertures equally spaced from each other

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and from the center of said end wall, a coaxial cylindrical accelerating electrode of larger diameter than said cupshaped electrode and surrounding at least the open end of said cup-shaped electrode, and means spacing and insulating said cup-shaped electrode from said cylindrical accelerating electrode whereby said accelerating electrode may be maintained at a higher positive potential than said cup-shaped electrode, the ratio of the axial length of said cup-shaped electrode to the diameter thereof being less than 0.5 to provide undistorted focusing and to provide convergence.

2. In a multiple beam gun, means to focus and converge the electron beams comprising, a cylindrical accelerating electrode, a cup-shaped electrode mounted coaxially with said accelerating electrode, said cup-shaped 15 electrode having a circular end wall provided with circular apertures for said beams and a cylindrical wall with the open edge thereof extending at least partially within said accelerating electrode, and means spacing and insulating said cup-shaped electrode from said cylindrical 20 accelerating electrode whereby a potential difference may be maintained between said electrodes, the axial length of said cylindrical wall being less than one-half the diameter thereof.

3. In a multiple beam cathode ray tube having a tubular envelope, a plurality of beam-forming electrodes in one end of said envelope, a target at the other end of said envelope, and an accelerating electrode on the inner surface of said envelope, a combination focusing and converging electrode positioned between said beam-forming 30 electrodes and said target, said focusing and converging electrode comprising a cylindrical member and a coaxial cup-shaped member fixed thereto and having an end wall closing said cylindrical member, said end wall of said cup-shaped member having a plurality of beam aper- ³⁵

tures, the open edge of said cup-shaped member being coaxially positioned within and spaced from said accelerating electrode, the axial length of the cylindrical walls of said cup-shaped member being less than one-half the diameter thereof.

4. In a multiple beam cathode ray tube having a tubular envelope, a plurality of beam-forming electrodes in one end of said envelope, a target at the other end of said envelope, and an accelerating electrode on the inner sur-10 face of said envelope, a combination focusing and converging electrode positioned between said beam-forming electrodes and said target, said focusing and converging electrode comprising a cylindrical member and a coaxial cup-shaped member fixed thereto having an end wall closing said cylindrical member, said end wall having a plurality of beam apertures symmetrically arranged around the longitudinal axis of said focusing and converging electrode, the open edge of said cup-shaped member being coaxially positioned within and spaced from said accelerating electrode, the axial length of the cylindrical walls of said cup-shaped member being less than one-half the diameter thereof, the spacing of the centers of said apertures from the longitudinal axis of the tube divided by the diameter of the apertures being greater than 0.9.

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