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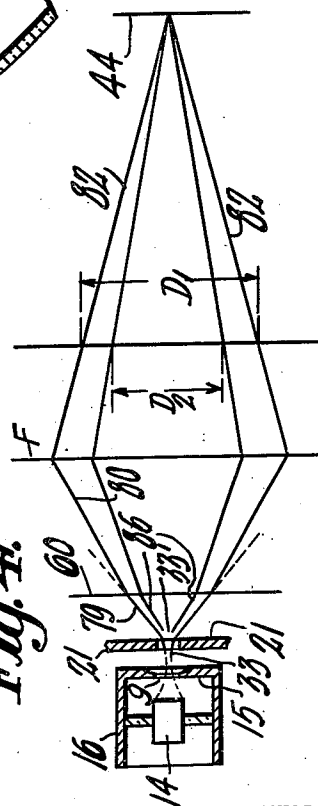
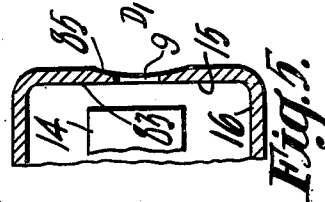
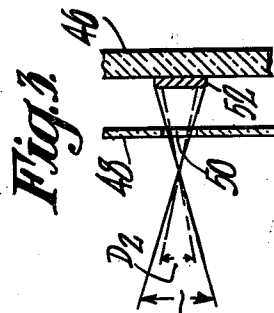
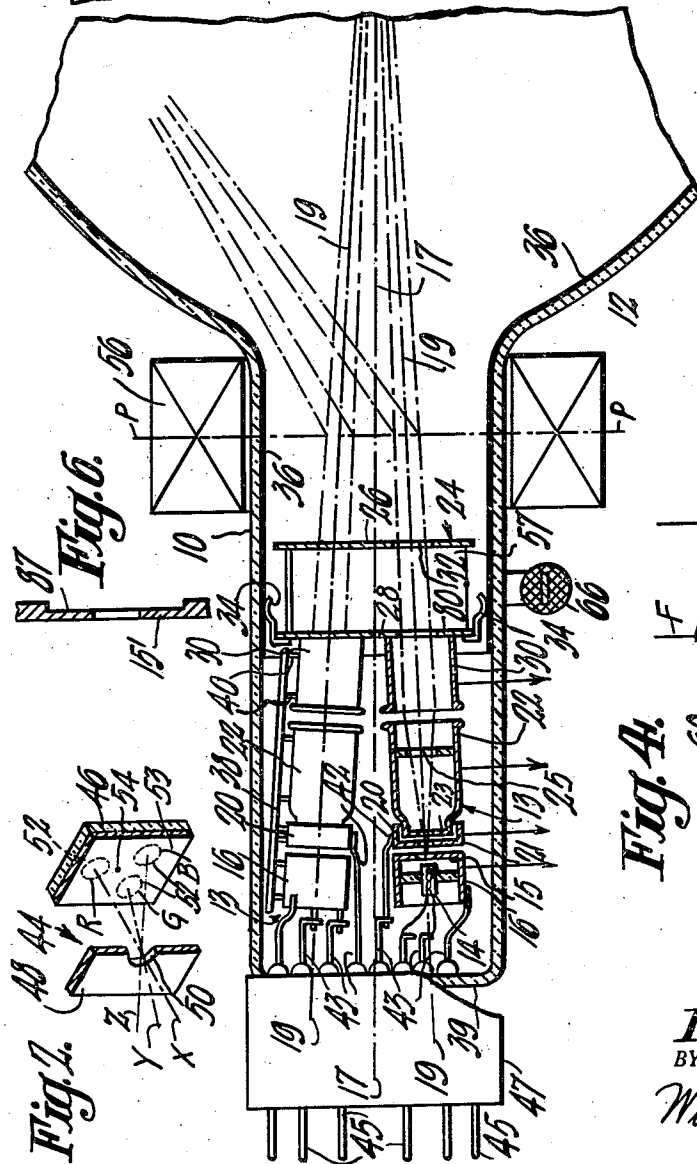
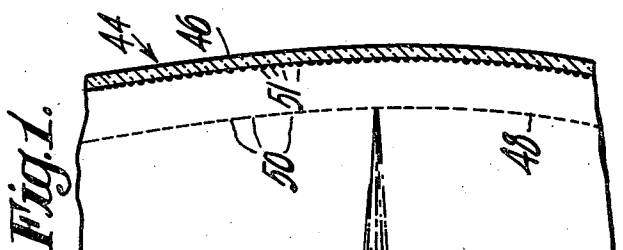
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2,806,163

TRIPLE GUN FOR COLOR TELEVISION

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2,806,163

TRIPLE GUN FOR COLOR TELEVISION

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9 Claims. (Cl. 313—70)

This invention is directed to an electron gun structure utilized for forming a plurality of electron beams in a cathode ray tube and, particularly, in tubes utilizing plural electron beams which have a common deflection over the tube target.

Plural electron beams have been used in cathode ray tubes for various purposes. One application of plural beams is in television picture tubes for color in which each beam forms a different color fluorescent light on the phosphor screen and where each beam is modulated by signals corresponding to the color of the light that the beam initiates. A type of tube for color television is that disclosed in the copending application of Hannah C. Moodey, S. N. 295,225, filed June 24, 1952. This type of color tube utilizes a masking electrode at the phosphor screen in combination with three electron beams. The electron beams are, respectively, modulated by video signals corresponding to red, green and blue portions of the televised picture. The mask at the screen has a large number of small apertures there-through. The phosphor screen is formed with a large number of phosphor dots on an adjacent surface of a supporting glass plate. The phosphor dots are arranged in groups of three in alignment with each aperture of the masking electrode. The dots of each group are of different phosphor material luminescing with either red, green or blue light when struck by high energy electrons. The three beams of the tube, of the type disclosed in the above cited application, approach the masking electrode and the phosphor screen at a small angle to the screen. The arrangement is such that the masking electrode masks each phosphor dot from all but one of the electron beams. Also, the phosphor dots are positioned so that each beam will strike only those phosphor dots formed of the same phosphor material.

In tubes of the type described, however, it has been found to be advantageous to provide a gun structure which provides a beam of minimum cross-sectional area in the deflecting plane of the tube since the picture brightness of the tube is inversely related to the beam size in the deflecting plane. The screen efficiency of the target structures of color tubes of the type described is thus increased with a decrease of beam cross-section in the deflection plane.

It is, therefore, an object of this invention to provide a novel plural gun structure.

It is another object of this invention to provide a novel plural gun structure for a cathode ray tube in which the cross-sectional areas of the electron beams thereof are at a minimum in the deflection plane of the tube.

It is another object of the invention to provide a cathode ray tube having a novel plural electron gun structure to provide electron beams of minimum size in the deflection plane and a target structure of optimum efficiency.

The invention is specifically related to a cathode ray tube for color having a plural gun structure and a target assembly of optimum efficiency. By providing a control

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grid electrode having an aperture which is formed with a thin edge in the order of 4 mils, it is possible to decrease the cross-sectional area of the electron beams in the deflection plane of the tube. This improves the screen efficiency of the tube and provides a brighter picture.

Figure 1 is a sectional view of a cathode ray tube utilizing a plural gun structure in accordance with the invention;

Figure 2 is an enlarged partial view of the target of the tube of Figure 1;

Figure 3 is an enlarged sectional view of a portion of the screen structure of the tube of Figure 1;

Figure 4 is a schematic showing of the operation of the gun structure of Figure 1 in accordance with the invention.

Figure 5 is an enlarged partial view of the structure of Figure 4;

Figure 6 is an enlarged partial view of a modification of the structure shown in Figures 4 and 5.

Figure 1 discloses a cathode ray tube having a plurality of electron beams and used as a picture viewing tube for color television. The tube consists of an evacuated envelope having a neck portion 10 of glass and a bulb portion 12 which may be either conical or substantially the frustum of a pyramid, and which may be of metal or glass. Within the neck portion 10 of the envelope are a plurality of electron guns 13 each consisting of a cathode electrode 14 mounted within a tubular control grid electrode 16. Each control grid 16 is closed at one end by a wall 15 having a single aperture 9 at its center (Figure 4). The adjacent end of each cathode tube 14 is closed by a solid wall portion and is coated on its outer surface, facing electrode wall 15, with electron emitting material, such as a mixture of barium and strontium oxides, to provide a source of electron emission.

Closely spaced from the control grid wall 15 of each electron gun and along a common axis 19, there is mounted a short tubular or cup-like accelerating electrode 20 having a centrally disposed aperture in the bottom wall 21 of the cup in line with the aperture 9 in the control grid wall 15. Spaced along the axis 19 of each gun from accelerating electrode 20 is a relatively long tubular accelerating electrode 22, closed at its end facing accelerating electrode 20 by a centrally apertured wall portion 23, whose aperture is aligned with the apertures in electrode portions 21 and 15. Spaced from the other end of electrode 22 of each gun 13 is a common electrode 24, having a plate portion 26 at the far end and having mounted in an oppositely disposed plate portion 28 a plurality of short tubular members 30. One of the tubular members 30 is aligned on the common axis 19 of each electron gun with the other gun electrodes 16, 20 and 22 respectively. Through plate 26 of electrode 24, there is formed an aperture 32 on the axis of each gun in alignment respectively with the apertures of electrode portions 15, 21 and 23. Electrode 24 is electrically connected by spring fingers or spacers 34 to a conductive wall coating 36, which extends over the inner surface of the tubular envelope neck portion 10 from a point adjacent electrode 24 into the conical envelope portion 12.

The several electrodes described are mounted within the neck portion 10 by rigidly fastening them together by means of a plurality of glass mounting rods 38, of which one is shown in Figure 1. Each electrode has studs 40 having one end welded to the electrode and the other end fixed into one of the glass rods 38, a connection is made from each electrode respectively, through supporting base wires 43 sealed through the end wall 39 of the tubular envelope neck portion 10. The base wires 43 are conductively fixed to base pins 45 extending through a base 47 to make electrical contact to external sources of potential. By base wires 43 and the spring spacing

fingers 34, the electron guns are rigidly supported within the envelope neck portion 10.

During the operation of the several electron guns, appropriate potentials are applied to several gun electrodes. The electron emission from each cathode 14 is formed by electrostatic fields respectively between electrode portions 15, 21, and 23 into an electron beam directed through the apertured portions of the gun electrodes. The difference of potential between electrode 22 and the corresponding electrode portion 30 provides a principal focusing lens field in the path of each electron beam, whereby the electrons of each beam are converged to a small focused spot at a target electrode 44 mounted in the large shell portion 12 of the envelope.

Target electrode 44 consists of a glass support plate 46 and a metallic masking electrode 48 closely spaced from the surface of plate 46 facing the electron guns. Support plate 46 may be the end wall or face plate of bulb 12 or an additional plate supported within bulb 12. Masking electrode 48 is a thin copper-nickel sheet having a large number of small apertures 50. Fixed to the adjacent surface of the glass plate 46 is a luminescent screen 51 consisting of groups of phosphor dots 52 (Figure 2), with each group consisting of three dots positioned in a triangular arrangement about a center point 54. The positioning of each group of phosphor dots is such that the center of each aperture 50, in the masking electrode 48, will be aligned with point 54 of the corresponding group of phosphor dots.

The phosphor dots 52 of each group are formed of phosphor material fluorescing with a different colored light when struck by the high energy electrons from guns 13. The dots of each group have a red, green, or blue fluorescence under electron bombardment as indicated respectively by R, G, and B in Figure 2. Furthermore, the positioning of the phosphor dots 52 is that in which each dot is aligned with its corresponding aperture 50 in electrode 48 along a different directional line X, Y, or Z, respectively. The fluorescent screen may be covered with a thin film 53 of reflective metal to intensify the luminescence of the phosphor by reflecting light from the phosphor screen through plate 46 toward the observer.

The three electron beams leaving the electron guns 13 are caused to converge by mounting each gun 13 at a small angle to envelope axis 17 so that the axes 19 of the three guns will converge to a common point at the masking electrode 48. Thus, each beam, normally following the axis 19 of its gun, will approach the masking electrode 48 at a small angle of incidence and from one of the different directions X, Y, or Z. Electrons from each beam passing through the apertures 50 of electrode 48 along one of the paths extending in the directions X, Y, or Z, will strike one phosphor dot in each group of dots. The arrangement is such that the electrons from each gun can strike only those phosphor dots 52 luminescing with a single color of light. The angle which each gun makes with tube axis 17 is small and is determined by the dimensions of the tube. In tubes of the type described which have been successfully operated, this angle is in the order of $1^\circ 10'$. The Figure 1 exaggerates the angle between the guns and axis 17 for purpose of illustration.

The three beams are simultaneously scanned over the surface of the masking electrode 48 by conventional scanning means indicated as a neck yoke 56, which consists of two pairs of deflecting coils, with the coils of each pair mounted on opposite sides of the envelope neck 10. Each pair of deflecting coils of yoke 56 is connected in series to sources of saw-tooth currents for providing line and frame scanion of the three electron beams simultaneously over the surface of the masking electrode 48. The scanning coils of yoke 56 are conventional and do not constitute a part of this invention and need not be further described. The scanion of

electron beams may be in any desired manner but for color television viewing is normally a rectangular raster. The operation of tubes of the type described are more fully set forth in copending application Serial No. 231,925, filed June 16, 1951, by Harold B. Law, now Patent No. 2,663,821 dated December 22, 1953.

A plurality of magnets, of which one magnet 66 is shown, are mounted on the tube neck 10 with a different magnet adjacent to each beam path. Magnets 66 are used to correct for misconvergence of the three beams at the target 44, during tube operation.

In tubes of the type described, it is desirable to obtain a maximum screen brightness. However, since the masking aperture plate 48 at the target absorbs a large percentage of the beam current, the brightness of the picture obtained is not a maximum. Also, as set forth in the article by H. B. Law, page 479 of the RCA Review, Part II, September 1951, the efficiency of operation of a masked screen of the type shown in Figures 1 and 2 is determined by the beam current striking the screen 46 through mask 48. This screen efficiency can be expressed as the product of a constant K and the quantity $(\sqrt{3}-D/S)^2$, where D is the beam diameter in the deflection plane and S is the beam-to-axis spacing in the deflection plane of the tube.

The deflection plane is determined, as is shown in Figure 1. When each beam is deflected by the fields of yoke 56, the direction of the beam is changed from an undeflected beam path to a new path approaching target 44 from a different direction. Each deflected beam is considered as originating from a deflection plane P substantially at the center of the coils of the yoke 56. The plane P is that determined by projecting each deflected beam path backwards onto its respective undeflected beam path. The points where the projected paths of the deflected beams meet their undeflected paths determine this plane of deflection.

From the above relationship, expressed for the screen efficiency or screen or picture brightness of a tube of the type described, it can be seen that the reduction of each beam diameter, D, within the deflection plane increases the screen efficiency. This is due to the fact that, an electron beam of smaller diameter in the deflection plane, will cover less area of each phosphor spot 52. This effect is shown more specifically in Figure 3 where D₁ represents a beam of a given diameter. Fringe electrons from the edge of the beam D₁ passing adjacent to the edge of an aperture 50 will strike the edge of a corresponding phosphor dot 52. The paths of these fringe electrons are indicated by the solid lines drawn through aperture 50 to the edge of the spot 52 and determine the spread of the beam D₁ in passing through aperture 50. Aperture 50, then, must be sufficiently small to prevent these fringe electrons from spreading beyond the spot 52 to strike additional neighboring phosphor spots and thus cause color dilution in the picture. However, if the beam diameter is made smaller such as that indicated by D₂, for example, the spread of the beam, is smaller as indicated by the dotted lines representing the beam paths of the fringe electrons. Beam D₂ strikes a smaller surface area of the corresponding spot 52. Because of this, then, the aperture 50 may be opened until the fringe electrons of the beam D₂ strike the edge of spot 52. By opening the aperture 50, more of the beam passes through the aperture to strike the phosphor spot 52 and thus produce a brighter fluorescence from spot 52. This procedure increases the screen efficiency and picture brightness, as described.

During tube operation, the electrons emitted from each cathode 14 pass through the aligned apertures in electrode wall portions 15 and 21. The configuration of the electrostatic field formed between plates 15 and 21, at operating potentials, causes the electrons from each cathode to form a beam having a minimum cross sectional area or "crossover point" 33 adjacent plate 21 and as schemati-

cally shown in Figure 4. From each crossover point 33 the electrons of each beam pass respectively into the tubular electrode 22 of the gun as a diverging beam.

Due to the differences of potential between electrode portions 21 and 23 of each gun 13 there is formed a pre-focusing electron lens field which produces a converging action on the respective beams therebetween.

Between the third accelerating electrode 22 of each gun and the accelerating electrode portion 30, there is established a principal focusing electron lens field which converges or focuses the beam to a minimum spot size at the target 44.

Figure 4 schematically shows the effect of the several electron lenses on each electron beam between the cathode 14 of the respective gun and the target assembly 44. The electron beam, on leaving the cross-over point 33, is widely divergent as indicated by lines 79 forming the envelope of the beam paths in this region. The beam passes first through the plane of the prefocusing field between electrode portions 21 and 23, indicated by the line 60 of Figure 4. The prefocusing field 60 lessens the divergence of the electron beam as indicated by the solid lines 80. The beam next enters the principal focusing field between the tubular electrode portions 22 and 30, the plane of which is indicated in Figure 4 by the line F. In each gun, this principal focusing field converges the electrons of the beam to a minimum point at the target assembly 44, as indicated by the lines 82 forming the envelope of the electron paths of the beam. The effect of the prefocusing field 60 and the focusing field F is to image the cross-over point 33 of the electron beam at the target electrode.

In accordance with the invention, the control grid electrode plate 15 is modified to provide a shaped aperture substantially as shown in Figures 4 and 5. The surface 83 of electrode plate 15 adjacent to the emitting surface of cathode 14 is substantially planar while, as shown in Figures 4 and 5, the surface 85 of plate 15 adjacent to and facing electrode plate 21 and immediately surrounding aperture 9 is substantially spherical. The effect is that of providing a very thin wall thickness at the edge of the aperture 9 through plate 15.

The effect of the spherical surface 85 of plate 15 during tube operation is to move the position of the cross-over point 33 farther away from plate 15 to a point 33'. The beam is also narrowed and there is less divergence of the electrons of the beam leaving the cross-over point 33' than without the shaped aperture.

In Figure 4, the new beam path leaving cross-over point 33' and provided by the shaped aperture of plate 15 is indicated by lines 16 representing the envelope of the electron beam paths. As shown, the electron paths are less divergent than upon leaving the cross-over point 33. Because of this factor, the cross-sectional area of the beam in the principal focusing field F is less and the effect of the principal focusing lens on the beam is to provide a smaller cross-sectional dimension D₂ of the beam in the deflection plane P. This, in turn, and as set forth fully above, may be used to increase the screen efficiency of the color tube or may be used to increase the manufacturing tolerance of the screen unit; or both. This provision of a shaped control grid aperture in the electron gun structure, as described, greatly improves the picture brightness of a color tube using a masking electrode, which intersects a portion of the beam at the target.

However the use of a formed aperture changes the cut-off voltage of the control grid electrode since the following relationship exists:

$$E_{co} = K \frac{(A_{G1})^{3/2}}{(T_{G1})(S_{G1-K})(S_{G1-G2})}$$

where E_{co} is the cut-off voltage of the control grid 16; K is a constant; A_{G1} is the diameter of the aperture in the control grid plate 15; T_{G1} is the thickness of the metal at the control grid aperture; S_{G1-K} is the spacing between

the cathode and the control grid; and S_{G1-G2} is the spacing between the control grid plate 15 and the accelerating electrode portion 21.

The above relationship indicates that as the value of T_{G1} is decreased by forming as described, the cut-off voltage is increased. It is desirable to maintain the cut-off voltage of the control grid the same so as to avoid changing the gun operating characteristics. As the above relationship indicates the cathode control grid spacing (S_{G1-K}) can be increased and or the size of the aperture in the control grid portion 15 (A_{G1}) can be decreased. Increasing the cathode to control grid spacing and decreasing the aperture size of the control grid both reduce the divergence of the beam from cross-over point 33 with the resultant advantages set forth above.

In an electron gun structure utilizing a control grid plate 15, as shown in Figure 5, successful operation has been obtained in which the aperture 9 in plate 15 has a diameter of substantially 31 mils. The thickness of plate 15 is in the order of 10 mils, while the spherical surface formed adjacent to the apertured plate 15 has a radius in the order of 100 mils. This provides a thickness of metal in the order of 4 mils at the edge of the aperture of plate 15 and which defines the aperture.

The configuration of the shaped aperture of plate 15 is described above as that formed by a spherical surface extending toward the plane surface of the opposite side of plate 15. This particular configuration provides the optimum effect on the electron beam described above. However, this design of grid structure is not limiting as the same effect can be produced by various designs of the grid plate to provide a thin wall portion defining the aperture through plate 15. For example, in place of the spherical surface shown, it is possible that a stepped wall configuration 87 can be utilized in a control grid plate 15', as indicated in Figure 6.

The advantage of using a shaped aperture not only provides a smaller beam in the deflection plane P but also the shaped aperture provides less aberration of the electron focusing lens, since more of the beam is directed through the more uniform central portion of the focusing lens and less of beam passes through the less uniform peripheral portions of the focusing lens. The shaped aperture furthermore provides a cleaner first cross-over point at 33. That is, the region 33 of the beam is much better defined than without a shaped control grid aperture. This provides a less distorted image of the cross-over point 33 at the target electrode. This also increases picture definition.

The advantage of a small beam diameter in the deflection plane of the tube is that the screen efficiency of the tube may be increased as described above by opening the apertures of the mask 48. Also, a small beam diameter in the focus plane reduces the area of each color dot upon which the respective beam is projected as shown in Figure 3. This permits less critical alignment tolerances of the aperture mask 48 with respect to the phosphor plate 46 and thus results in better color purity with less chance of each beam striking adjacent phosphor spots. This permits the designer to either increase the screen efficiency of the tube or to take advantage of the less critical alignment tolerances, or both.

Although the invention is disclosed as being incorporated in a triple gun structure with the guns in a delta arrangement, the invention need not be limited to this arrangement. The electron guns 13 of Figure 1 can be mounted in-line with all their axes in one plane, or in any other desired arrangement. Neither is the design of the mask and phosphor plate limiting to this invention.

What is claimed is:

1. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along spaced paths having a common general direction, each of said electron guns including a cathode electrode and a plurality of electrodes

spaced along said respective beam path for providing an electron lens system for focusing the electron beam to a small point, each of said electron guns including a control electrode between said cathode electrode and said focusing electrodes of each gun, said control electrode having an aperture in said respective beam path, the portion of said control electrode surrounding said aperture having a concave surface, said control electrode portion having a varying thickness with the thinnest portion thereof defining said aperture, a target electrode spaced along said beam paths from said electron guns, said target including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen and between said phosphor screen and said plurality of guns, and means between said plurality of guns and said target electrode for simultaneously scanning said electron beams over said target electrode.

2. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along paths having a common general direction, each of said electron guns including a cathode electrode having an electron emitting surface and a plurality of electrodes spaced along a respective one of said beam paths for providing an electron lens system for focusing the respective electron beam to a small point, and a control electron in each gun between said cathode electrode and said focusing electrodes, each of said control electrodes including a plate portion having an aperture therethrough in said respective beam path, said plate portion having a varying thickness with the thinnest portion thereof defining said aperture, and a target electrode spaced along said beam paths from said electron guns, said target electrode including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen between said screen and said plurality of guns.

3. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along paths having a common general direction, each of said electron guns including a cathode electrode having an electron emitting surface and an accelerating electrode spaced from said cathode electrode along a respective one of said beam paths, a control electrode in each gun between said cathode electrode and said accelerating electrode, each of said control electrodes including a plate portion having an aperture therethrough in said respective beam path and having a varying thickness with the thinnest portion thereof defining said aperture, a target electrode spaced along said beam paths from said electron guns, said target electrode including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen between said screen and said plurality of guns, and means between said guns and said target electrode for focusing said electron beams each to a small spot on said target electrode.

4. The invention of claim 3 wherein each of said control electrode plate portions has a spherical surface facing the respective accelerating electrode.

5. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along paths having a common general direction, each of said electron guns including a cathode electrode having an electron emitting surface and an accelerating electrode spaced from said cathode electrode along a respective one of said beam paths, a control electrode in each gun between said

cathode electrode and said accelerating electrode, each of said control electrodes including a plate portion having an aperture therethrough in said respective beam path and having a varying thickness with the thinnest portion thereof defining said aperture, a target electrode spaced along said beam paths from said electron guns, said target electrode including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen between said screen and said plurality of guns, means between said guns and said target electrode for focusing said electron beams each to a small spot on said target electrode, and means between said focusing means and said target electrode for simultaneously scanning said electron beams over said target electrode.

6. The invention of claim 5 wherein each of said control electrode plate portions are formed with a concave surface facing said respective accelerating electrode.

7. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along spaced paths having a common general direction, each of said electron guns including a cathode electrode and a plurality of electrodes spaced along a respective beam path for providing an electron lens system for focusing the respective electron beam to a small point, a control electrode portion in each gun between said cathode electrode and said focusing electrodes and having an aperture in the respective beam path, the portion of each of said control electrodes surrounding said aperture having a concave surface having a varying thickness facing said focusing electrodes with the thinnest part thereof defining said aperture and being in the order of four mils thick, a target electrode spaced along said beam paths from said electron guns, said target electrode including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen between said screen and said plurality of guns.

8. A cathode ray tube for color television comprising a plurality of electron guns for forming and directing a plurality of electron beams along paths having a common general direction, each of said electron guns including a cathode electrode having an electron emitting surface and an accelerating electrode spaced from said cathode electrode along a respective one of said beam paths, a control electrode in each gun between said cathode electrode and said accelerating electrode, each of said control electrodes including a plate portion having an aperture therethrough in said respective beam path and having a varying thickness with the thinnest portion thereof defining said aperture, a target electrode spaced along said beam paths from said electron guns, said target electrode including a phosphor screen and an apertured masking electrode closely spaced from said phosphor screen between said screen and said plurality of guns.

9. The invention of claim 8 wherein each of said control electrode plate portions are formed with a concave surface facing said respective accelerating electrode.

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