United States Patent [19]

Hughes

[11] **3,873,879**

[45] **Mar. 25, 1975**

[54] **IN-LINE ELECTRON GUN**

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[73] Assignee: **RCA Corporation,** New York, N.Y.

[22] Filed: **Mar. 28, 1973**

[21] Appl. No.: **345,665**

Related U.S. Application Data

[62] Division of Ser. No. 217,758, Jan. 14, 1972, Pat. No. 3,772,554.

[52] **U.S. Cl.** ..... **315/13 C,** 315/13 CG, 313/70 C, 313/92 B

[51] **Int. Cl.** **H01j 29/50**

[58] **Field of Search** .... 315/13 C, 13 CG; 313/70 C, 313/85, 86, 92 B; 250/213

[56] **References Cited**

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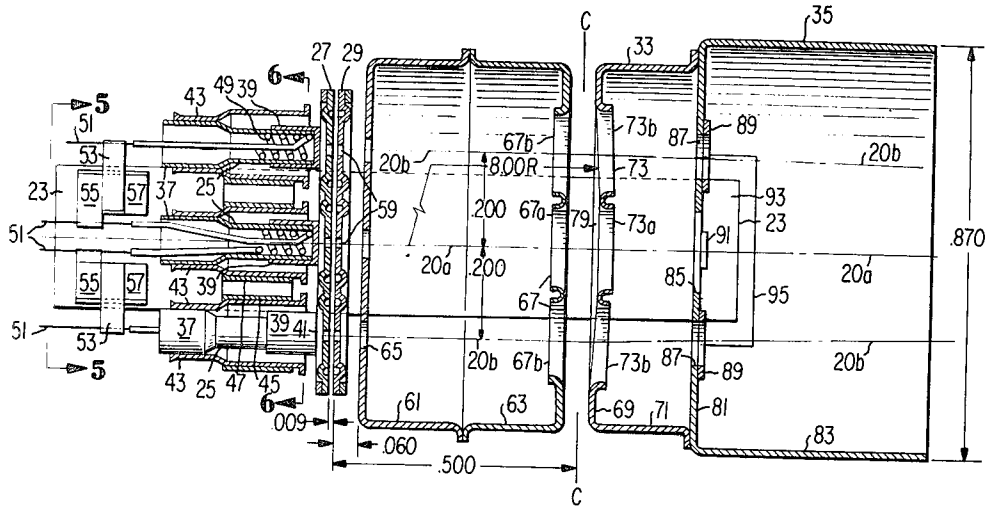
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Primary Examiner—Benjamin R. Padgett
Assistant Examiner—P. A. Nelson
Attorney, Agent, or Firm—Glenn H. Bruestle; Dennis H. Irlbeck

[57] **ABSTRACT**

The three co-planar beams of an in-line gun are converged near the screen of a cathode ray tube by means of two plate-like grids transverse to the beam paths and having corresponding apertures for the three beams. The three beam apertures of the first grid are aligned with the three beam paths. The two outer beam apertures of the second grid are offset outwardly relative to the beam paths to produce the desired convergence. The three sets of apertures also provide separate focusing fields for the three beams. The second plate-like grid is formed with a barrel shape, concave toward the first grid, to minimize elliptical distortion of beam spots on the screen due to crowding of the adjacent focusing fields. Each of the two outer beams is partially shielded from the magnetic flux of the deflecting yoke by means of a magnetic ring surrounding the beam path in the deflection zone, to equalize the size of the rasters scanned on the screen by the middle and outer beams. Other magnetic pieces are positioned on opposite sides of the path of the middle beam, to enhance one deflection field while reducing the transverse deflection field for that beam.

4 Claims, 10 Drawing Figures



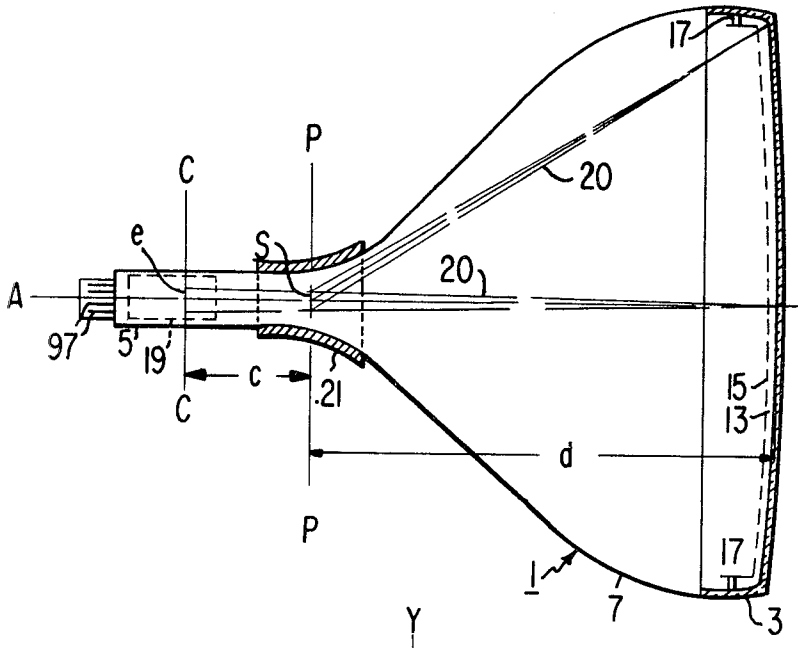


Fig. 1

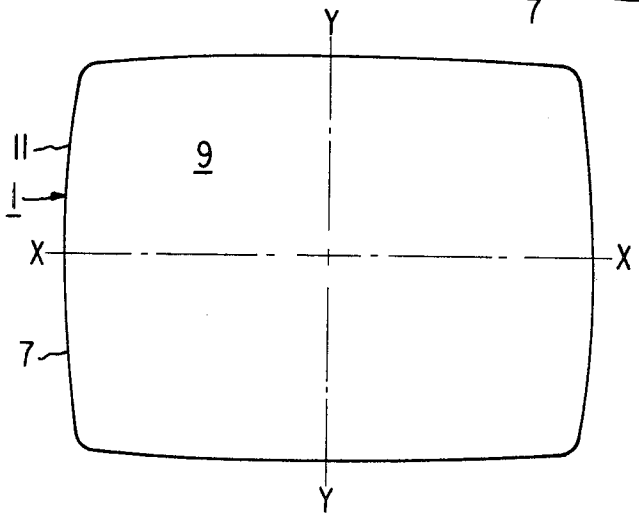


Fig. 2

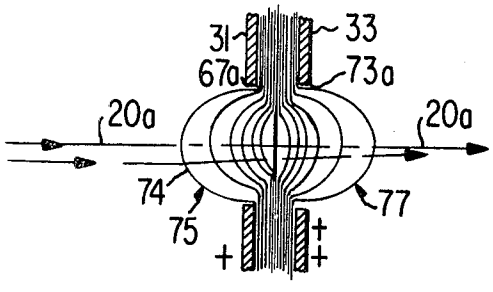


Fig. 9

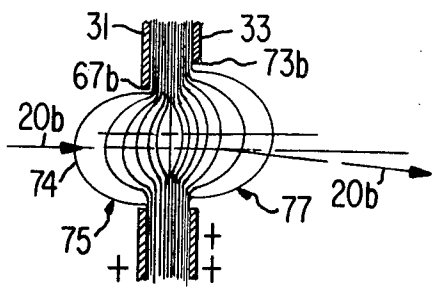


Fig. 10

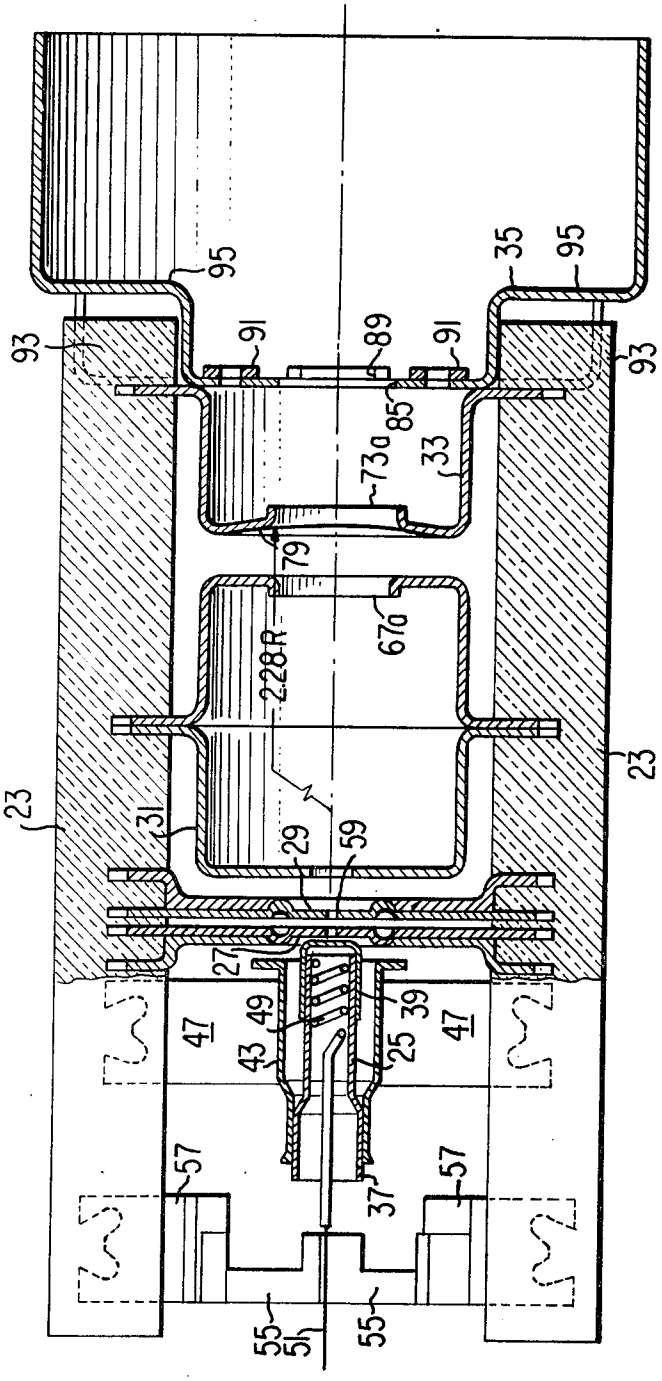

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Fig. 3

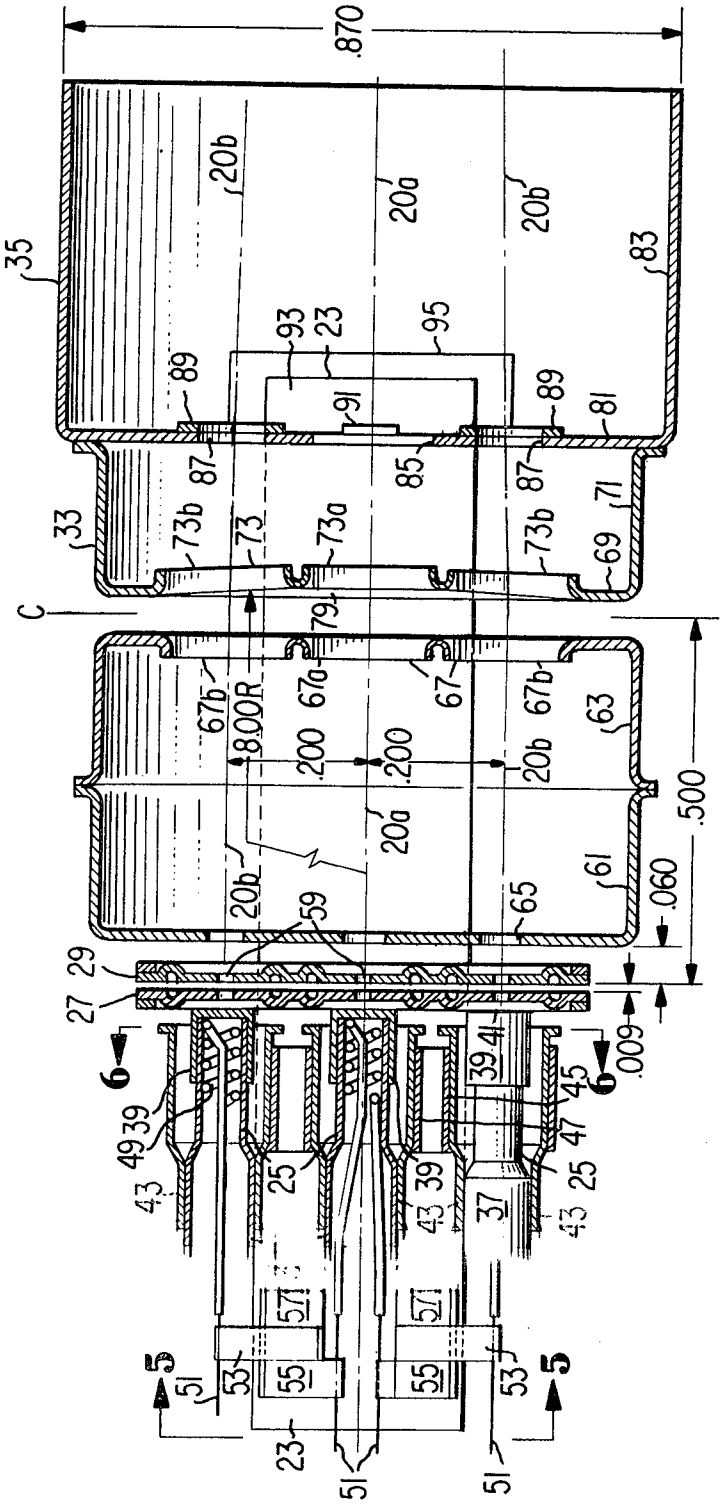


Fig. 4

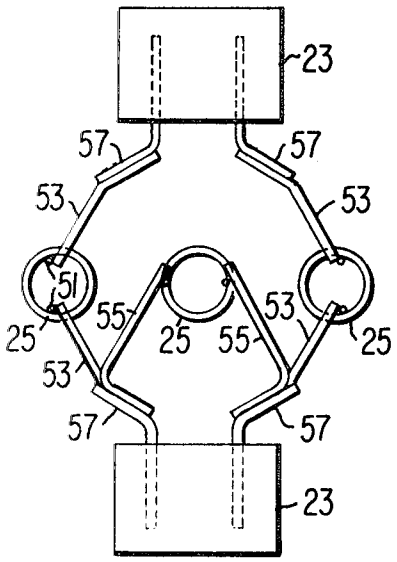


Fig. 5

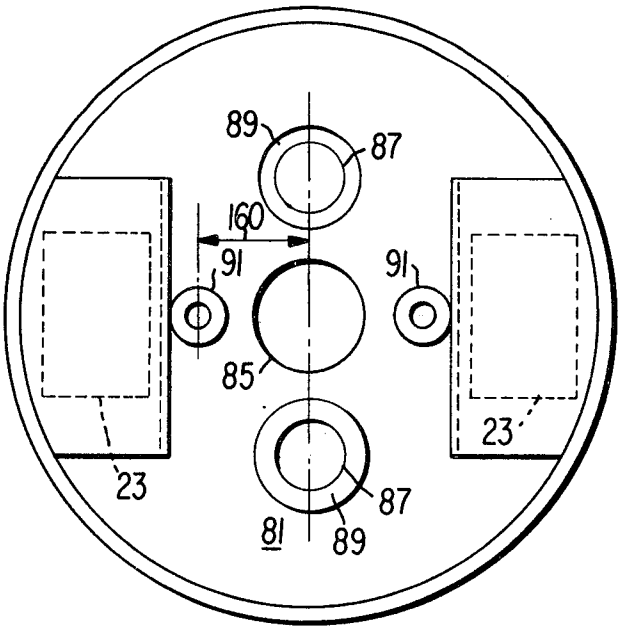


Fig. 7

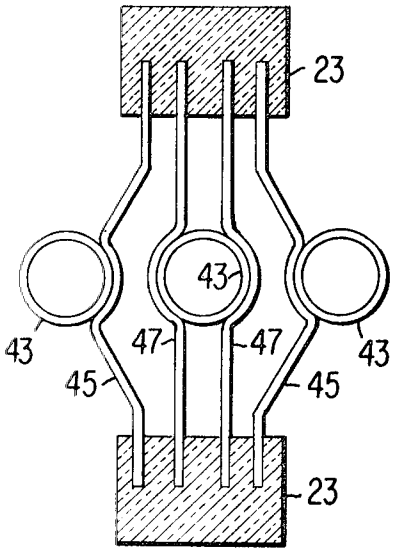


Fig. 6

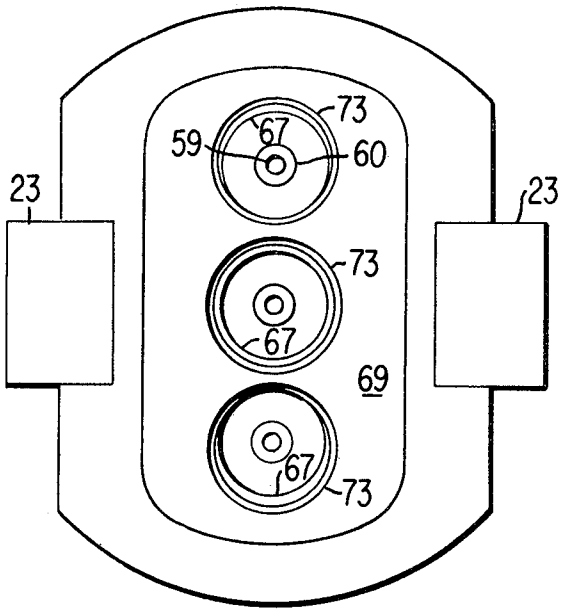


Fig. 8

IN-LINE ELECTRON GUN

This is a division of application Ser. No. 217,758, filed 1/14/72, now U.S. Pat. No. 3,772,554.

BACKGROUND OF THE INVENTION

The present invention relates to an improved in-line electron gun for a cathode ray tube, particularly a shadow mask type color picture tube. The new gun is primarily intended for use in a color tube having a line type color phosphor screen, with or without light absorbing guard bands between the color phosphor lines, and a mask having elongated apertures or slits. However, the gun could be used in the well known dot-type color tube having a screen of substantially circular color phosphor dots and a mask with substantially circular apertures.

An in-line electron gun is one designed to generate or initiate at least two, and preferably three, electron beams in a common plane, for example, by at least two cathodes, and direct those beams along convergent paths in that plane to a point or small area of convergence near the tube screen. Various ways have been proposed for causing the beams to converge near the screen. For example, the gun may be designed to initially aim the beams, from the cathodes, towards convergence at the screen, as shown in FIG. 4 of Moodey U.S. Pat. No. 2,957,106, wherein the beam apertures in the gun electrodes are aligned along convergent paths.

In order to avoid wide spacings between the cathodes, which are undesirable in a small neck tube designed for high deflection angles, it is preferable to initiate the beams along substantially parallel (or even divergent) paths and provide some means, either internally or externally of the tube, for converging the beams near the screen. Magnet poles and/or electrostatic deflecting plates for converging in-line beams are disclosed in Francken U.S. Pat. No. 2,849,647, Gundert et al. U.S. Pat. No. 2,859,378 and Benway U.S. Pat No. 2,887,598.

The Moodey patent referred to above also includes an embodiment, shown in FIG. 2 and described in lines 4 to 23 of column 5, wherein an in-line gun for two coplanar beams comprises two spaced cathodes, a control grid plate and an accelerating grid plate each having two apertures aligned respectively with the two cathodes (as in FIG. 2) to initiate two parallel co-planar beam paths, and two spaced-apart beam focusing and accelerating electrodes of cylindrical form. The focusing electrode nearest to the first accelerating grid plate is described as having two beam apertures that are offset toward the axis of the gun from the corresponding apertures of the adjacent accelerating grid plate, to provide an asymmetric electrostatic field in the path of each beam for deflecting the beam from its initial path into a second beam path directed toward the tube axis.

Netherlands U.S. Pat. application No. 6902025, published Aug. 11, 1970 teaches that astigmatic aberration resulting in elliptical distortion of the focused screen spots of the two off-axis beams from an in-line gun, caused by the eccentricity of the in-line beams in a common focusing field between two hollow cylindrical focusing electrodes, can be partially corrected by forming the adjacent edges of the cylindrical electrodes with a sinusoidal contour including four sine waves. A similar problem is solved in a different manner in applicant's in-line gun.

Another problem that exists in a cathode ray tube having an in-line gun is a coma distortion wherein the sizes of the rasters scanned on the screen by a conventional external magnetic deflection yoke are different, because of the eccentricity of the two outer beams with respect to the center of the yoke. Messineo et al. U.S. Pat. No. 3,164,737 teaches that a similar coma distortion caused by using different beam velocities can be corrected by use of a magnetic shield around the path of one or more beams in a delta type gun. Barkow U.S. Pat. No. 3,196,305 teaches the use of magnetic enhancers adjacent to the path of one or more beams in a delta gun, for the same purpose. Krackhardt et al. U.S. Pat. No. 3,534,208 teaches the use of a magnetic shield around the middle one of three in-line beams for coma correction.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, at least two electron beams are generated along co-planar paths toward the screen of a cathode ray tube, e.g., a shadow mask type color picture tube, and the beams are converged near the screen by asymmetric electric fields established in the paths of two beams by two plate-like grids positioned between the beam generating means and the screen and having corresponding apertures suitably related to the beam paths. The apertures in the first grid (nearest the cathodes) are aligned with the beam paths. Two apertures in the second grid (nearest the screen) are offset outwardly with respect to the beam paths to produce the desired asymmetric fields. In the case of three in-line beams, the two outer apertures are offset, and the middle apertures of the two grids are aligned with each other. The pairs of corresponding apertures also provide separate focusing fields for the beams. In order to minimize elliptical distortion of one or more of the focused beam spots on the screen due to crowding of adjacent beam focusing fields, at least a portion of the second grid may be substantially cylindrically curved in a direction transverse to the common plane of the beams, and concave to the first grid. Each of the two outer beam paths of a three beam gun may be partially shielded from the magnetic flux of the deflection yoke by means of a magnetic ring surrounding each beam in the deflection zone of the tube, to minimize differences in the size of the rasters scanned on the screen by the middle and outer beams. Further correction for coma distortion may be made by positioning magnetic pieces on opposite sides of the middle beam path for enhancing one field and reducing the field transverse thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view, partly in axial section, of a shadow mask color picture tube in which the present invention is incorporated;

FIG. 2 is a front end view of the tube of FIG. 1 showing the rectangular shape;

FIG. 3 is an axial section view of the electron gun shown in dotted lines in FIG. 1, taken along the line 3—3 of that figure;

FIG. 4 is an axial section view of the electron gun taken along the line 4—4 of FIG. 3;

FIG. 5 is a rear end view of the electron gun of FIG. 4, taken in the direction of the arrows 5—5 thereof;

FIG. 6 is a transverse view, partly in section, taken along the line 6—6 of FIG. 4;

FIG. 7 is a front end view of the electron gun of FIGS. 1 and 4;

FIG. 8 is a similar end view with the final element (shield cup) removed; and

FIGS. 9 and 10 are schematic views showing the focusing and converging electric fields associated with two pairs of beam apertures in FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a plan view of a 17V-90° rectangular color picture tube, for example, having a glass envelope 1 made up of a rectangular (FIG. 2) faceplate panel or cap 3 and a tubular neck 5 connected by a rectangular funnel 7. The panel 3 comprises a viewing faceplate 9 and a peripheral flange or side wall 11 which is sealed to the funnel 7. A mosaic three-color phosphor screen 13 is carried by the inner surface of the faceplate 9. The screen is preferably a line screen with the phosphor lines extending substantially parallel to the minor axis Y-Y of the tube (normal to the plane of FIG. 1). A multi-apertured color selection electrode or shadow mask 15 is removably mounted, by conventional means, in predetermined spaced relation to the screen 13. An improved in-line electron gun 19, shown schematically by dotted lines in FIG. 1, is centrally mounted within the neck 5 to generate and direct three electron beams 20 along co-planar convergent paths through the mask 15 to the screen 13.

The tube of FIG. 1 is designed to be used with an external magnetic deflection yoke, such as the yoke 21 schematically shown, surrounding the neck 5 and funnel 7, in the neighborhood of their junction, for subjecting the three beams 20 to vertical and horizontal magnetic flux, to scan the beams horizontally and vertically in a rectangular raster over the screen 13. The initial plane of deflection (at zero deflection) is shown by the line P—P in FIG. 1 at about the middle of the yoke 21. Because of fringe fields, the zone of deflection of the tube extends axially, from the yoke 21, into the region of the gun 19. For simplicity, the actual curvature of the deflected beam paths 20 in the deflection zone is not shown in FIG. 1.

The in-line gun 19 of the present invention is designed to generate and direct three equally-spaced coplanar beams along initially-parallel paths to a convergence plane C—C, and then along convergent paths through the deflection plane to the screen 13. In order to use the tube with a line-focus yoke 21 specially designed to maintain the three in-line beams substantially converged at the screen without the application of the usual dynamic convergence forces, which causes degrouping misregister of the beam spots with the phosphor elements of the screen, the gun is preferably designed with samll spacings between the beam paths at the convergence plane C—C to produce a still smaller spacing, usually called the S value, between the outer beam paths and the central axis A—A of the tube, in the deflection plane P—P. The convergence angle of the outer beams with the central axis is arc tan $e/c+d$, where c is the axial distance between the convergence plane C—C and the deflection plane P—P, d is the distance between the deflection plane and the screen 13, and e is the spacing between the outer beam paths and the central axis A—A in the convergence plane C—C. The approximate dimensions in FIG. 1 are $c = 2.7$ inches, $d = 9.8$ inches, $e = 0.200$ inch (200 mils), and hence, the convergence angle is 55 minutes and $s = 157$ mils.

The details of the improved gun 19 are shown in FIGS. 3 through 8. The gun comprises two glass support rods 23 on which the various electrodes are mounted. These electrodes include three equally-spaced co-planar cathodes 25, one for each beam, a control grid electrode 27, a screen grid electrode 29, a first accelerating and focusing electrode 31, a second accelerating and focusing electrode 33, and a shield cup 35, spaced along the glass rods 23 in the order named.

Each cathode 25 comprises a cathode sleeve 37, closed at the forward end by a cap 39 having an end coating 41 of electron emissive material and a cathode support tube 43. The tubes 43 are supported on the rods 23 by four straps 45 and 47 (FIG. 6). Each cathode 25 is indirectly heated by a heater coil 49 positioned within the sleeve 37 and having legs 51 welded to heater straps 53 and 55 mounted by studs 57 on the rods 23 (FIG. 5). The control and screen grid electrodes 27 and 29 are two closely-spaced (about 9 mils) flat plates having three pairs of small (about 25 mils) aligned apertures 59 centered with the cathode coatings 41 to initiate three equally-spaced coplanar beam paths 20 extending toward the screen 13. Preferably, the initial paths 20*a* and 20*b* are substantially parallel and about 200 mils apart, with the middle path 20a coincident with the central axis A—A.

Electrode 31 comprises first and second cup-shaped members 61 and 63, respectively, joined together at their open ends. The first cup-shaped member 61 has three medium-sized (about 60 mils) apertures 75 close to grid electrode 29 and aligned respectively with the three beam paths 20, as shown in FIG. 4. The second cup-shaped member 63 has three large (about 160 mils) apertures 65 also aligned with the three beam paths. Electrode 33 is also cup-shaped and comprises a base plate portion 60 positioned close (about 60 mils) to electrode 31 and a side wall or flange 71 extending forward toward the tube screen. The base portion 69 is formed with three apertures 73, which are preferably slightly larger (about 172 mils) than the adjacent apertures 67 of electrode 31. The middle aperture 73*a* is aligned with the adjacent middle aperture 67*a* (and middle beam path 20*a*) to provide a substantially symmetrical beam focusing electric field between apertures 67*a* and 73*a* when electrodes 31 and 33 are energized at different voltages. The two outer apertures 73*b* are slightly offset outwardly with respect to the corresponding outer apertures 67*b*, to provide an asymmetrical electric field between each pair of outer apertures when electrodes 31 and 33 are energized, to individually focus each outer beam 20*b* near the screen, and also to deflect each beam, toward the middle beam, to a common point of convergence with the middle beam near the screen. In the example shown, the offset of each beam aperture 73*b* may be about 6 mils.

The approximate configuration of the electric fields associated with the middle and outer apertures are shown in FIGS. 9 and 10, respectively, which show the equipotential lines 74 rather than the lines of force. Assuming an accelerating field, as shown by the + signs, the left half 75 (on the left side of the central midplane) of each field is converging and the right half 77

is diverging. Since the electrons are being accelerated, they spend more time in the converging field than in the diverging field, and hence, the beam experiences a net converging or focusing force in each of FIGS. **9** and **10.** Since the middle beam **20***a* passes centrally through a symmetrical field in FIG. **9,** it continues in the same direction without deflection. In FIG. **10,** the outer beam **20***b* traverses the left half **75** of the field centrally, but enters the right half **77** off-axis. Since this is the diverging part of the field, and the electrons are subjected to field forces perpendicular to the equipotential lines or surfaces **74,** the beam **20***b* is deflected toward the central axis (downward in FIG. **10**) as it traverses the right half **77,** in addition to being focused. The angle of deflection, or convergence, of the beam **20***b* can be determined by the choice of the offset of the apertures **73** *b* and the voltages applied to the two electrodes **31** and **33.** For the example given, with an offset of **6** mils, electrode **33** would be connected to the ultor or screen voltage, about 25 K.V., and electrode **31** would be operated at about 17 to 20 percent of the ultor voltage, adjusted for best focus. The object distance of each focus lens, that is, the distance between the first cross-over of the beams near the screen grid **29** and the lens, is about 0.500 inch; and the image distance from the lens to the screen is about 12.5. inches.

The above-described outward offset of the beam apertures to produce beam convergence is contrary to the teaching of FIG. **3** of the Moodey patent described above, and hence, is not suggested by the Moodey patent.

The focusing apertures **67** and **73** are made as large as possible, to minimize spherical aberration, and as close together as possible, to obtain a desirable small spacing between beam paths. As a result, the fringe portions of adjacent fields interact to produce some astigmatic distortion of the focusing fields, which produces some ellipticity of the normally-circular focused beam spots on the screen. In a three-beam in-line gun, this distortion is greater for the middle beam than for the two outer beams, because both sides of the middle beam field are affected. In order to compensate for this effect, and minimize the elliptical distortion of the beam spots, the wall **69,** or at least the surface thereof facing the electrode **31,** is curved substantially cylindrically, concave to electrode **31,** in the direction normal or transverse to the plane of the three beams, as shown at **79** in FIG. **3.** Preferably, this curvature is greater for the middle beam path than for the outer beam paths, hence, the wall **69** may be made barrel-shaped. In the example given, the barrel shape may have a stave radius of 8 inches (FIG. **4**) and a hoop radius of 2.28 inches (FIG. **3**), with the curvature **79** terminating at the outer edges of the outer apertures **73***b*.

The shield cup **35** comprises a base portion **81,** attached to the open end of the flange **71** of electrode **33,** and a tubular wall **83** surrounding the three beam paths **20.** The base portion **81** is formed with a large middle beam aperture **85** (about 172 mils) and two smaller outer beam apertures **87** (about 100 mils) aligned, respectively, with the three initial beam paths **20***a* and **20***b*.

In order to compensate for the coma distortion wherein the sizes of the rasters scanned on the screen by the external magnetic deflection yoke are different for the middle and outer beams of the three-beam gun, due to the eccentricity of the outer beams in the yoke field, the electron gun is provided with two shield rings **89** of high magnetic permeability, e.g., an alloy of 52 percent nickel and 48 percent iron, known as 52 metal, are attached to the base **81,** with each ring concentrically surrounding one of the outer apertures **87,** as shown in FIGS. **4** and **7.** These magnetic shields **89** bypass a small portion of the fringe deflection fields in the path of the outer beams, thereby making a slight reduction in the rasters scanned by the outer beams on the screen. The shield rings **89** may have an outer diameter of 150 mils, an inner diameter of 100 mils, and a thickness of 10 mils.

A further correction for this coma distortion is made by mounting two small discs **91** of magnetic material, e.g., that referred to above, on each side of the middle beam path **20***a*. These discs **91** enhance the magnetic flux on the middle beam transverse to the plane of the three beams and decrease the flux in that plane, in the manner described in the Barkow patent referred to above. The discs **91** may be rings having an outer diameter of 80 mils, an inner diameter of 30 mils, and a thickness of 10 mils.

Each of the electrodes **27, 29, 31** and **33** are mounted on the two glass rods **23** by edge portions embedded in the glass. The two rods **23** extend forwardly beyond the mounting portion of electrode **33,** as shown in FIG. **3.** In order to shield the exposed ends **93** of the glass rods **23** from the electron beams, the shield cup **35** is formed with inwardly-extending recess portions **95** into which the rod ends **93** extend. The electron gun **19** is mounted in the neck **5** at one end by the leads (not shown) from the various electrodes to the stem terminals **97,** and at the other end by conventional metal bulb spacers (not shown) which also connect the final electrode **33** to the usual conducting coating on the inner wall of the funnel **7.**

I claim:

1. In a color picture tube including an evacuated envelope comprising a faceplate and a neck connected by a funnel, a mosaic color phosphor screen on the inner surface of said faceplate, a multiapertured color selection electrode spaced from said screen, an in-line electron gun mounted in said neck for generating and directing three electron beams along co-planar paths through said electrode to said screen, and a deflection zone, located in the vicinity of the junction between said neck and said funnel, wherein said beams are subjected to vertical and horizontal magnetic deflection fields during operation of said tube for scanning said beams horizontally and vertically over said screen; said electron gun comprising:

a. means for generating and directing three electron beams along three co-planar paths towards said screen;

b. means interposed between said first-named means and said deflection zone for focusing each beam near said screen and for converging the three beams near said screen; and

c. a shielding member of magnetic material surrounding each of the outer ones only of said beam paths in siad deflection zone, for partially shielding only the two outer beams from said magnetic deflecting fields, thereby reducing the size of the rasters scanned by the outer beams without reducing the size of the raster scanned by the middle beam.

2. The structure of claim **1,** wherein said electron gun further comprises a pair of magnetic elements posi-

tioned in said deflection zone on opposite sides of the middle beam path and in a plane transverse to the common plane of said paths for enhancing the magnetic deflection field in said middle beam path transverse to said common plane and for reducing the magnetic deflection field in said middle beam path along said common plane, thereby increasing the dimension of the raster scanned by the middle beam in said common plane while reducing the dimension of said raster in said transverse plane.

3. In a color picture tube including an evacuated envelope comprising a faceplate and a neck connected by a funnel, a mosaic color phosphor screen on the inner surface of said faceplate, a multi-apertured color selection electrode spaced from said screen, an in-line electron gun mounted in said neck for generating and directing three electron beams along co-planar paths through said electrode to said screen, and a deflection zone, located in the vicinity of the junction between said neck and said funnel, wherein said beams are subjected to vertical and horizontal magnetic deflection fields during operation of said tube for scanning said beams horizontally and vertically over said screen, and wherein the eccentrity of the outer ones of said beams in the deflection fields causes the sizes of the rasters scanned by the outer beams to tend to be larger than the size of the raster scanned by a middle beam, said electron gun comprising;

a. means for generating and directing three electron beams along three co-planar paths towards said screen;

b. means interposed between said first-named means and said deflection zone for focusing each beam near said screen and for converging the three beams near said screen; and

c. two shield rings of high magnetic permeability material located at the fringe of the deflection zone, each ring concentrically surrounding one of the outer beams, whereby small portions of the fringe deflection field are bypassed around the outer beams thereby reducing the size of the rasters scanned by the outer beams without reducing the size of the raster scanned by the middle beam.

4. The tube as defined in claim **3,** including two small discs of magnetic material located at the fringe of the deflection zone on opposite sides of the middle beam transverse to the plane of the three beams, whereby the magnetic flux on the middle beam transverse to the plane of the three beams is enhanced and the flux in the plane of the three beams is decreased thereby increasing the middle beam dimension in the plane of the three beams while reducing the middle beam dimension in the plane of the three beams.

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