

COLOR PICTURE TUBE HAVING AN INLINE ELECTRON GUN

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5 The present invention relates to color picture tubes having inline electron guns.

10 An inline electron gun is one designed to generate or initiate preferably three electron beams in a common plane and direct those beams along convergent paths in that plane to a point or small area of convergence near the tube screen. In one type of inline electron gun, such as that shown in U. S. Patent 3,873,879, issued to R. H. Hughes on March 25, 1975, the main electrostatic
15 focusing lenses for focusing the electron beams are formed between two electrodes referred to as the first and second accelerating and focusing electrodes. These electrodes include two cup-shaped members having the bottoms of the members facing each other. Three apertures are included
20 in each cup bottom to permit passage of three electron beams and to form three separate main focus lenses, one for each electron beam. In a preferred embodiment, the overall diameter of the electron gun is such that the gun will fit into a 29 mm tube neck. Because of this size
25 requirement, the three focusing lenses are very closely spaced relative to each other, thereby providing a severe limitation on focus lens design. It is known in the art that, the larger the focus lens diameter, the less will be the spherical aberration which restricts the focus quality.

30 In addition to the focus lens diameter, the spacing between focus lens electrode surfaces is important because greater spacing provides a more gentle voltage gradient in the lens, which also reduces spherical aberration. Unfortunately, greater spacing between
35 electrodes beyond a particular limit (typically 1.27 mm) is not permissible because of beam bending from electrostatic charges on the neck glass penetrating into the space between the electrodes, which causes electron beam misconvergence. Therefore, there is a need for

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further development in design of the main focusing lens electrodes which will provide improved focus lenses having reduced spherical aberration.

5 In an electron gun of a tube in accordance with the invention, the main focus lens is formed by two spaced electrodes. Each electrode includes a plurality of apertures therein equal to the number of electron beams. Each electrode also includes a peripheral rim, with the
10 peripheral rims of the two electrodes facing each other. The apertured portion of each electrode is located within a recess set back from the rim. The recess has substantially straight wall sections parallel to the coplanar paths of the electron beams.

In the drawings:

15 FIGURE 1 (Sheet 1) is a planview, partly in axial section, of a shadow mask color picture tube embodying the invention.

FIGURE 2 (Sheet 2) is a partial axial section view of the electron gun shown in dashed lines in FIGURE 1.

20 FIGURE 3 (Sheet 3) is an axial sectional view of the G3 and G4 electrodes of the electron gun of FIGURE 2.

FIGURE 4 (Sheet 3) is a front view of the electron gun of FIGURE 2 taken along line 4-4 of FIGURE 3.

25 FIGURES 5 and 6 (Sheet 4) are axial sectional top and side views, respectively, of the focusing lens electrodes of a prior electron gun showing some equipotential lines of the electrostatic focusing lens fields. The view of FIGURE 6 is taken at line 6-6 of FIGURE 5.

30 FIGURES 7 and 8 (Sheet 5) are axial sectional top and side views, respectively, of the focusing lens electrodes of the electron gun of FIGURE 2 showing some equipotential lines of electrostatic focusing lens fields. The view of FIGURE 8 is taken at line 8-8 of FIGURE 7.

35 FIGURE 9 (Sheet 3) is a plan view of the G4 electrode of the electron gun of FIGURE 2 taken along line 9-9 of FIGURE 2.

FIGURE 1 is a plan view of a rectangular color picture tube having a glass envelope 10 comprising a
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1 rectangular faceplate panel or cap 12 and a tubular neck
14 connected by a rectangular funnel 16. The panel
comprises a viewing faceplate 18 and a peripheral flange
5 or sidewall 20 which is sealed to the funnel 16. A mosaic
three-color phosphor screen 22 is carried by the inner
surface of the faceplate 18. The screen is preferably a
line screen with the phosphor lines extending
substantially perpendicular to the high frequency raster
10 line scan of the tube (normal to the plane of FIGURE 1).
A multi-apertured color selection electrode or shadow mask
24 is removably mounted, by conventional means, in
predetermined spaced relation to the screen 22. An
improved inline electron gun 26, shown schematically by
15 dotted lines in FIGURE 1, is centrally mounted within the
neck 14 to generate and direct three electron beams 28
along coplanar convergent paths through the mask 24 to the
screen 22.

The tube of FIGURE 1 is designed to be used with
20 an external magnetic deflection yoke, such as the yoke 30
schematically shown surrounding the neck 14 and funnel 12
in the neighborhood of their junction. When activated,
the yoke 30 subjects the three beams 28 to vertical and
horizontal magnetic flux which cause the beams to scan
25 horizontally and vertically, respectively, in a
rectangular raster over the screen 22. The initial plane
of deflection (at zero deflection) is shown by the line
P-P in FIGURE 1 at about the middle of the yoke 30.
Because of fringe fields, the zone of deflection of the
30 tube extends axially, from the yoke 30 into the region of
the gun 26. For simplicity, the actual curvature of the
deflected beam paths in the deflection zone is not shown
in FIGURE 1.

The details of the gun 26 are shown in FIGURES 2
35 through 4. The gun comprises two glass support rods 32 on
which the various electrodes are mounted. These
electrodes include three equally spaced coplanar cathodes
34 (one for each beam), a control grid electrode 36 (G1),
a screen grid electrode 38 (G2), a first accelerating and
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5 focusing electrode 40 (G3), and a second accelerating and
focusing electrode 42 (G4), spaced along the glass rods 32
in the order named. All of the electrodes following the
cathodes have three inline apertures in them to permit
passage of three coplanar electron beams. The main
electrostatic focusing lens in the gun 26 is formed
between the G3 electrode 40 and the G4 electrode 42. The
G3 electrode 40 is formed with four cup-shaped elements
10 44, 46, 48 and 50. The mouth or open ends of two of these
elements, 44 and 46, are attached to each other, and the mouth or
open ends of the other two elements, 48 and 50, are also
attached to each other. The apertured base of the third cup shaped
element 48 is attached to the apertured base of the second
15 element 46. Although the G3 electrode 40 is shown as a
four-piece structure, it could be fabricated from any
number of elements, including a single element of the same
length. The G4 electrode 42 is also cup-shaped, but has
an apertured plate 52 over its mouth or open end.

20 The facing base of the G3 electrode 40 bases
and the G4 electrode 42 have large recesses 54 and 56,
respectively, therein. The recesses 54 and 56 set back
the portion of the base of the G3 electrode 40 that
contains three apertures 58, 60 and 62 from the portion of
25 the base of the G4 electrode 42 that contains three
apertures 64, 66 and 68. The remaining portions of the
bases of the G3 electrode 40 and the G4 electrode 42
form rims 70 and 72, respectively, that extend
peripherally around the recesses 54 and 56. The rims 70
30 and 72 are the closest portions of the two electrodes 40
and 42 to each other.

FIGURES 5 and 6 show top and side sectional
views, respectively, of two electrodes 74 and 76 that form
the main focusing lens of a prior electron gun of the
unitized type. The electrode 74 is the G3, and the
35 electrode 76 is the G4. The electrode 74 is cup-shaped and
has three separate apertures 78, 80 and 82 in its bottom.
Similarly, the electrode 76 is cup-shaped and has three
separate apertures 84, 86 and 88 in its bottom. During
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1 tube operation, a potential of 7 kV is applied to the G3
electrode 74 and a potential of 25 kV is applied to the G4
electrode 76. Because of these potentials, an
5 electrostatic field is established in the vicinity of the
G3 electrode apertures 78, 80 and 82 and the G4 electrode
apertures 84, 86 and 88. The shape of the equipotential
lines of this electrostatic field determines the main
focusing lens of the prior art gun. Some of these
10 equipotential lines 90 are shown in FIGURES 5 and 6. A
comparison of these equipotential lines 90 indicates that
the curvature of the outer lines 90 in the top view of
FIGURE 5 is substantially less than the curvature of the
outer lines 90' of the side view of FIGURE 6. Such
15 difference of curvature is especially noted in the
equipotential lines of 8, 9.5, 22 and 24 kV. Because of
this difference of curvature, referred to as astigmatism,
an electron beam 92 passing through the center apertures
80 and 86 will be focused more vertically, as shown in
20 FIGURE 6, than horizontally, as shown in FIGURE 5.
However, as can be seen in FIGURE 5, the two outer
electron beams will encounter greater electrostatic line
curvatures than the center beam and therefore will be
horizontally focused slightly more than the center beam,
25 resulting in slightly less astigmatism for the outer
beams.

As better shown in FIGURES 7 and 8, the improved
electron gun 26 of FIGURE 2 provides a main focusing lens
having substantially reduced spherical aberration compared
30 to that described with respect to the prior gun of FIGURES
5 and 6. The reduction in spherical aberration is caused
by the increase in the size of the main focus lens. This
increase in size results from recessing the electrode
apertures. In the prior gun of FIGURES 5 and 6, the
35 strongest equipotential lines of the electrostatic field
are concentrated at each opposing pair of apertures.
However, in the gun 26 of FIGURE 2, the strongest
equipotential lines extend continuously from between the
rims 70 and 72, so that the predominant portion of the

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main focus lens appears to be a single large lens extending through the three electron beam paths. The remaining portion of the main focus lens is formed by weaker equipotential lines located at the apertures in the electrodes. Some of the equipotential lines 94 of the main focusing field of the improved electron gun 26 are shown in the top and side views of FIGURES 7 and 8, respectively. As can be seen, the vertical curvature of the equipotential lines, shown in FIGURE 8, is more similar to the horizontal curvature, shown in FIGURE 7, than as shown in the similar views for the prior gun. Because of this similarity of curvatures, an electron beam passing along one of the electron beam paths will be focused more equally in the vertical and horizontal planes. Therefore, the type of astigmatism previously noted with respect to the prior gun of FIGURES 5 and 6 is greatly reduced.

Preferably, in the improved gun 26 (FIGURES 3 and 4), the depths "F" of the recesses 54 and 56 are roughly one-quarter the spacings "C" between the two straight sides of the recesses. The diameter of the apertures in the G3 electrode 40 is such as to just touch an equipotential line within 4% of the electrode voltage that would exist if the apertured portion of the electrode were not present. In the embodiment shown, this 4% line is approximately a semicircle. Spacing of the two electrodes 40 and 42 should be close enough to exclude neck charging from bending the electron beams.

There is a slot-effect astigmatism formed by the main focusing lens because of penetration of the focusing field through the open area of the recesses. This effect can be noted by comparing the compression of the equipotential lines 94 at the sides of the FIGURE 7 embodiment with the compression of the same lines at the two areas near the center of the focus lens. This field penetration causes the focus lens to have greater vertical lens strength than horizontal lens strength. A correction is made for this astigmatism in the electron gun 26 of

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FIGURE 2 by the inclusion of a horizontal slot opening at the exit of the G4 electrode 42. The slot is optimum at one-half the lens diameter in width and is preferably spaced at 86% of the lens diameter from the opposite surface of the G4 electrode. This slot is formed by two strips 96 and 98, shown in FIGURES 2 and 9, welded to the apertured plate 52 of the G4 electrode 42 so as to extend across the three apertures in the plate 52.

To statically converge the two outer beams with the center beam, the width "E" of the recess 56 in the G4 electrode 42 is slightly greater than the width "D" of the recess 54 in the G3 electrode 40 (FIGURE 3). The effect of the greater recess width in the G4 electrode 42 is the same as that discussed with respect to the off-set apertures in U. S. Patent 3,772,554, issued to R. H. Hughes on November 13, 1973.

Some typical dimensions for the electron gun 26 of FIGURE 2 are presented in the following table.

TABLE

External diameter of tube neck- - - - -	29.00mm
Internal diameter of tube neck- - - - -	24.00mm
Spacing between G3 and G4 electrodes 40 and 42-	1.27mm
Center-to-center spacing between adjacent apertures in G3 electrode 40 (A in FIG. 3)- - - - -	6.60mm
Inner diameter of apertures 58, 60 and 62 in G3 electrode 40 (B in FIG. 3) - - - - -	5.44mm
Spacing between two straight sides of recesses in the electrodes 40 and 42 (C in FIG. 4)-	6.99mm
Width of recess in the G3 electrodes 40 (D in FIG. 3)- - - - -	20.19mm
Width of recess in the G4 electrode 42 (E in FIG. 3)- - - - -	20.80mm
Depth of recesses in the electrodes 40 and 42 (F in FIG. 3)- - - - -	1.65mm

In various other inline electron gun embodiments, the depth of the recess in the electrodes 40 and 42 may vary from 1.30 mm to 2.80 mm.

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CLAIMS

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1. A color picture tube having an inline electron gun for generating and directing a plurality of electron beams along coplanar paths toward a screen of said tube, said gun including a main focus lens for focusing said electron beams,

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the main focus lens being formed by two spaced electrodes, each electrode including a portion having a plurality of apertures therein equal to the number of electron beams, each electrode also including a peripheral rim, the peripheral rims of the two electrodes facing each other, and
15 the apertured portion of each electrode being within a recess set back from the rim the said recess having substantially straight wall sections parallel to the coplanar paths of the electron beams.

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2. A tube as defined in claim 2, wherein the recess width in the plane of the electron beams is greater in the main focus lens electrode closest to the
25 screen than in the other main focus lens electrode.

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3. A tube as defined in claim 1 or 2 further comprising means on said gun for correcting for astigmatism formed by the main focus lens.

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4. A tube as defined in claim 3 wherein said means for correcting for astigmatism comprises a slot on said gun located between the main focus lens and said screen.

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5. A tube as defined in claim 4 wherein said slot is formed by two strips.

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6. A tube as defined in any preceding claim wherein said number of electron beams is three.

10 7. A color picture tube having an inline electron gun substantially as hereinbefore described with reference to Figures 1, 2, 3, 4, 7, 8 and 9.

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