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Ohgoshi et al.

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[45] **May 13, 1975**

[54] **COLLINEAR ELECTRON GUN SYSTEM INCLUDING ACCELERATING GRID HAVING GREATER EFFECTIVE THICKNESS FOR OFF AXIS BEAMS**

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[21] Appl. No.: **290,985**

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[63] Continuation-in-part of Ser. No. 13,909, Feb. 25, 1970.

[30] **Foreign Application Priority Data**

Mar. 7, 1969 Japan 44-17325

[52] **U.S. Cl.** **313/412;** 313/414

[51] **Int. Cl.** **H01j 29/50;** H01j 31/20

[58] **Field of Search** ..... 313/69 C, 70 K, 70 C

[56] **References Cited**

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[57] **ABSTRACT**

In a cathode ray tube of the single-gun, plural-beam type in which the plurality of beams are made to intersect each other substantially at the optical center of a main focusing lens, a beam generating assembly is provided in which the crossover points of the respective beams are made to occur at suitable distances from the main focusing lens to correct for any disparity in the focusing effects imparted to the respective beams by the main focusing lens and any auxiliary lens and thereby to cause the beams to be precisely focused on the screen.

10 Claims, 9 Drawing Figures

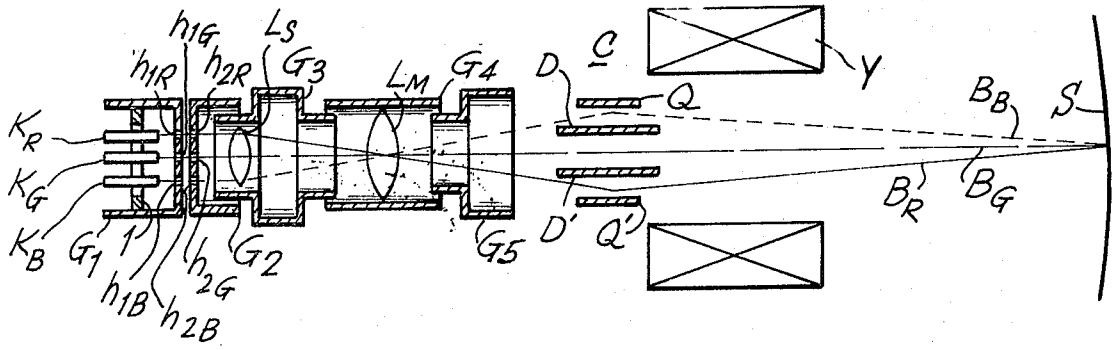


FIG. 1. PRIOR ART

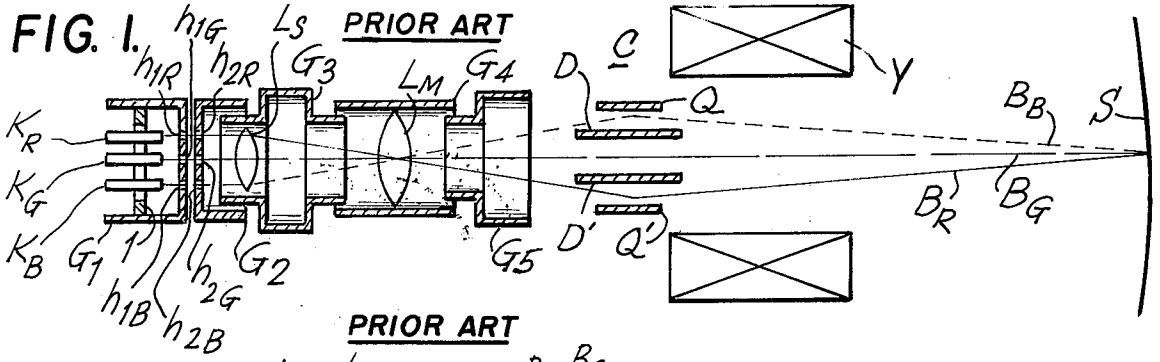


FIG. 2. PRIOR ART

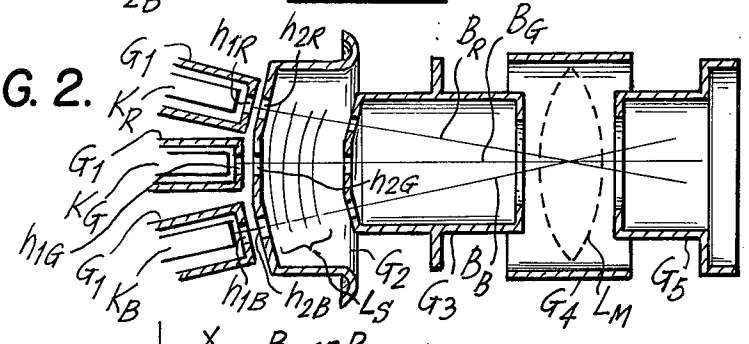


FIG. 3.

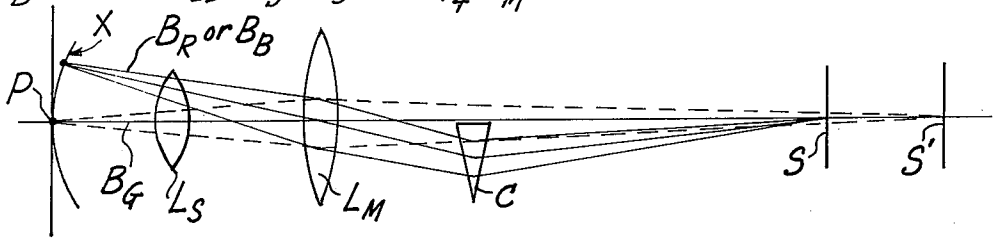
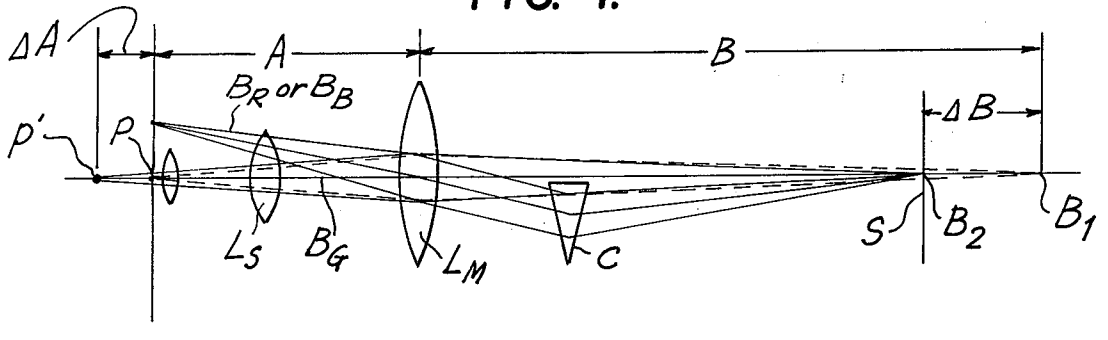


FIG. 4.



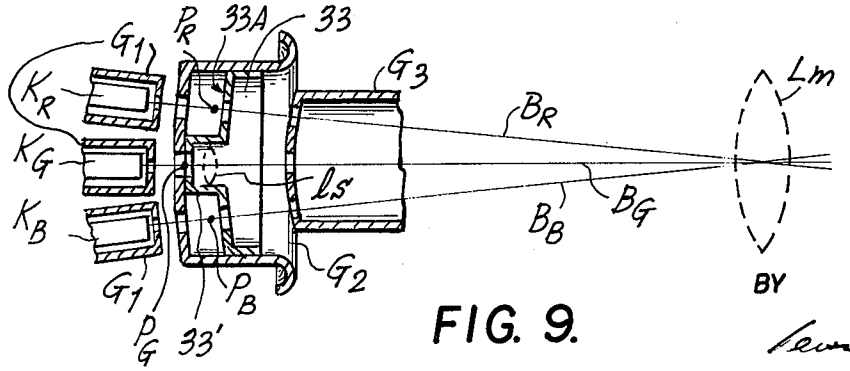


FIG. 9.

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FIG. 6.

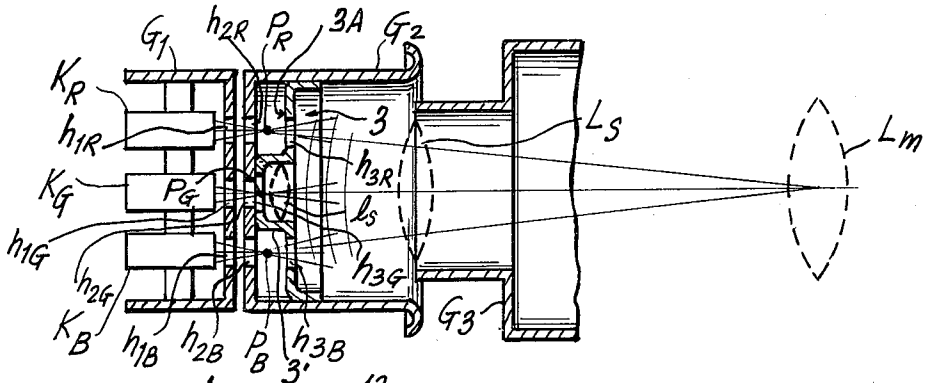


FIG. 7.

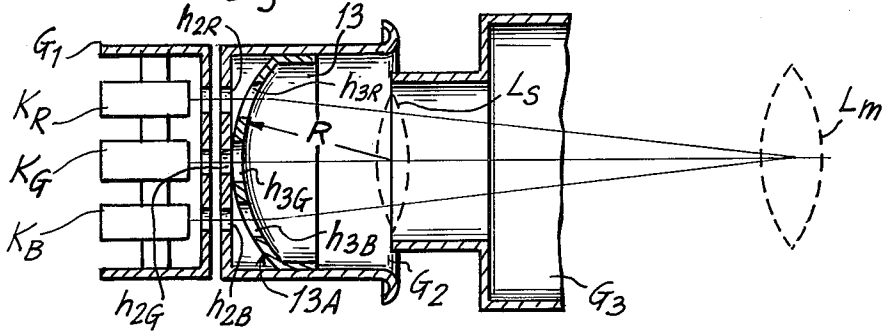


FIG. 8.

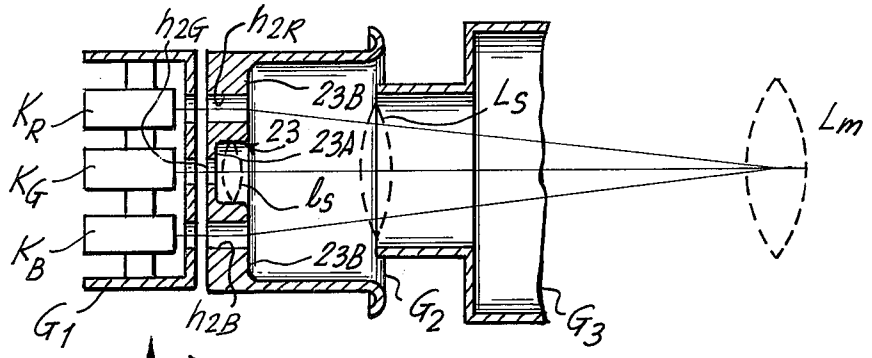
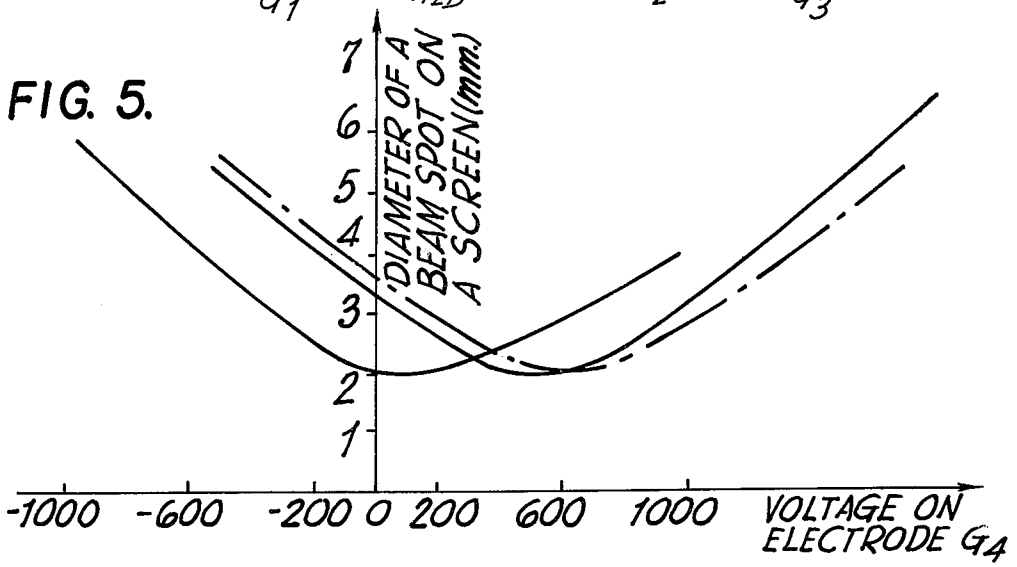


FIG. 5.



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COLLINEAR ELECTRON GUN SYSTEM INCLUDING ACCELERATING GRID HAVING GREATER EFFECTIVE THICKNESS FOR OFF AXIS BEAMS

This application is a continuation-in-part of the pending prior U.S. patent application Ser. No. 13,909, filed Feb. 25, 1970.

This invention relates generally to cathode ray or color picture tubes of the single-gun, plural-beam type, and particularly to tubes of that type in which the plural beams are passed substantially through the optical center of a common electron lens by which the beams are intended to be focused on the color phosphor screen.

In single-gun, plural-beam color picture tubes of the type to which this invention relates, for example, as specifically disclosed in U.S. Pat. No. 3,448,316, issued June 3, 1969, and having a common assignee herewith, a plurality of electron beams are emitted or originated by a beam generating cathode assembly and converged to cross or intersect each other at a location between the cathode assembly and the color screen upon which the beams impinge, and a single main focusing lens for focusing all of the beams on the screen is positioned to dispose its optical center substantially at the location where the beams intersect, whereby the imparting of coma and spherical aberrations to the beams by the main focusing lens is substantially diminished. When the beams are thus converged to intersect each other substantially at the optical center of the main focusing lens, at least certain of the beams emerge from the lens along divergent paths, and pairs of convergence deflecting plates may be arranged along such divergent paths and have voltages applied thereacross to deflect the divergent beams in directions for causing all of the beams to converge at a common point on the apertures beam selecting grill or mask associated with the color screen, or the divergent beams may be allowed to land on the beam selecting grill or mask at spaced locations with suitable time delays being applied to the color signals by which the respective beams are modulated so as to obtain correspondence of the pictures produced on the screen. In either case, the beams are acted upon by the magnetic fields resulting from the application of horizontal and vertical sweep signals to the corresponding coils of a deflection yoke, whereby the beams are made to scan the screen in the desired raster.

In single-gun, plural-beam color picture tubes as described above, the beams pass through the main focusing lens at different respective angles to the axis of the lens, causing the beams to receive different respective focusing effects and thereby causing the beams to be focused at different respective distances from the main focusing lens.

Furthermore, single-gun, plural-beam color picture tubes as described above generally include an auxiliary lens positioned between the beam generating means and the main focusing lens. Such auxiliary lens is employed to prefocus the beams and sometimes also to converge the beams so that they cross or intersect each other substantially at the optical center of the main focusing lens. In such color picture tubes, the beams pass through the auxiliary lens at different respective distances from the optical axis of the lens, causing the beams to receive different prefocusing effects and thereby also causing a difference between the focusing distances for the respective beams. This disparity in

beam focusing distances causes certain of the beams to impinge upon the screen in a slightly unfocused condition, resulting in unequal beam spot sizes and thus producing pictures having less than perfect resolution.

Accordingly, it is generally an object of this invention to provide a cathode ray or color picture tube of the described type having high resolution of the picture on the screen.

More specifically, it is an object of this invention to provide a cathode ray or color picture tube of the described type in which the beams are focused at substantially the same distance from the main focusing lens, so that such beams will impinge on the screen at sharply defined spots of substantially uniform size.

In accordance with an aspect of this invention, a cathode ray or color picture tube of the single-gun, plural-beam type is provided with a grid-electrode assembly by which the cross-over points of a plurality of electron beams originated by a beam generating cathode assembly are made to occur at locations which are spaced suitable respective distances from the main focusing lens to correct for the different focusing effects imparted to the beams by the lens, so that the beams are focused at substantially the same distance from the main focusing lens.

In accordance with another aspect of this invention, a cathode ray or color picture tube of the single-gun, plural-beam type having an auxiliary lens is provided with a grid-electrode assembly by which the cross-over points of a plurality of beams originated by a beam generating cathode assembly are made to occur at locations which are spaced suitable respective distances from the main focusing lens to correct for the different focusing effects imparted to the beams by the main focusing lens and the different prefocusing effects imparted to the beams by the auxiliary lens, so that the beams are focused at substantially the same distance from the main focusing lens.

The above, and other objects, features and advantages of the invention, will be apparent in the following detailed description of illustrative embodiments thereof which is to be read in connection with the accompanying drawings, in which like or corresponding parts are designated by the same reference designation in the various views, and wherein:

FIG. **1** is a schematic, horizontal sectional view of an existing single-gun, plural-beam color picture tube;

FIG. **2** is a schematic, horizontal sectional view of a portion of another existing single-gun, plural-beam color picture tube;

FIG. **3** is a diagrammatic view illustrating the optical equivalent or analogy of the single-gun, plural-beam color picture tube shown in FIG. **2**;

FIG. **4** is a diagrammatic view illustrating the optical equivalent or analogy of a single-gun, plural-beam color picture tube according to an embodiment of this invention;

FIG. **5** is a graph comparing the beam spot sizes of a prior art, single-gun, plural-beam color picture tube and one according to an embodiment of this invention; and

FIGS. **6**, **7**, **8** and **9** are views similar to portions of FIGS. **1** and **2**, but showing single-gun, plural-beam color picture tubes according to various embodiments of this invention.

In order that the single-gun, plural-beam color picture tubes according to the present invention may be

better understood, the principles and features of prior single-gun, plural-beam color picture tubes will first be described in detail with reference to FIGS. 1 to 3.

Referring initially to FIG. 1, it will be seen that a prior art single-gun, plural-beam color picture tube comprises a glass envelope (not shown) having a neck and a cone extending from the neck to a color screen S provided with the usual arrays of color phosphors. Disposed within the neck is a single electron gun including three cathodes K_R, K_G and K_B, having their respective beam-generating surfaces disposed as shown so that the respective beams B_R, B_G and B_B emitted therefrom are directed in a substantially horizontal plane containing the axis of the gun, with the central beam B_G being coincident with such axis and the side beams B_R and R_B being parallel thereto. A first or control grid G_1 is spaced from the beamgenerating surfaces of cathodes K_R, K_G and K_B and has apertures h_{1R}, h_{1G} and h_{1B} formed therein in alignment with the respective cathode beam-generating surfaces. A common second grid G_2 acting as an accentuating grid is spaced from the first grid and has apertures h_{2R}, h_{2G} and h_{2B} formed therein in alignment with the respective apertures of the first grid. Cathodes K_R, K_G and K_B and grids G_1 and G_2 cooperate to form beam-generating means. Successively arranged in the axial direction away from the common accelerating grid G_2 are open-ended, tubular grids or electrodes G_3, G_4 and G_5, respectively, with cathodes K_R, K_G and K_B, grids G_1 and G_2, and electrodes G_3, G_4 and G_5 being maintained in the depicted assembled positions thereof, by suitable, nonillustrated support means of an insulating material.

For operation of the color picture tube of FIG. 1, appropriate voltages are applied to the grids G_1 and G_2 and to the electrodes G_3, G_4 and G_5. For example, a voltage of 0 to −400 V. is applied to grid G_1, a voltage of 0 to 500 V. is applied to grid G_2, a voltage of 13 to 20 KV is applied to electrodes G_3 and G_5, and a voltage of 0 to 400 V. is applied to electrode G_4, with the voltage of the cathodes as a reference. With such voltage distribution, an electron lens field is established around the axis of electrode G_3 which forms an auxiliary electrons lens L_s, indicated by its optical equivalent, and further, an electron lens field is established around the axis of electrode G_4 which forms a main focusing electron lens L_m, indicated by its optical equivalent. Auxiliary lens L_s prefocuses beams B_G , B_B and B_R and causes side beams B_R and B_B to converge so that they cross or intersect with beam B_G substantially at the optical center of main focusing lens L_m. Further the electrical field of auxiliary lens L_s permeates apertures h_{2R}, h_{2G} and h_{2B} of grid G_2 to reduce the cross-sections of the respective beams to minimums, that is, to cross-over points substantially located at the exits of such apertures.

Also included in the color picture tube of FIG. 1 are electron beam convergence deflecting means C which comprise shielding plates D and D′ disposed in the depicted spaced, relationship at opposite sides of the tube axis, and axially extending, deflector plates Q and Q′ which are disposed, as shown, in outwardly spaced, opposed relationship to shielding plates D and D′, respectively. Although depicted as substantially straight, it is to be understood that the deflector plates Q and Q′ may, alternatively, be somewhat curved or outwardly bowed, as is well known in the art.

The shielding plates D and D′ are equally charged and disposed so that the central electron beam B_G will pass substantially undeflected between the shielding plates, while the deflector plates Q and Q′ have negative charges with respect to the plates D and D′ so that electron beams B_B and B_R will be convergently deflected, as shown by the respective passages thereof between the plates D and Q and the plates D′ and Q′. The screen S is located so that it substantially coincides with the intersection of beams B_G, B_B and B_R, whereby the beams impinge upon screen S at a common area.

In operation, electron beams B_R, B_G and B_B which emanate from the beam generating surfaces of cathodes K_R, K_G and K_B will pass through the respective grid apertures h_{1R}, h_{1G} and h_{1B}, to be intensity modulated with what may be termed the "red," "green" and "blue" intensity modulation signals applied between the said cathodes and the first grid G_1. The beams are brought to image or cross-over points in the apertures of grid G_2. The electron beams will then be converged by the auxiliary lens L_s to cross each other substantially at the optical center of the main lens L and to emerge from the latter with beams B_R and B_B diverging from beam B_G. Thereafter, the central electron beam B_G will pass substantially undeflected between shielding plates D and D′ while beams B_B and B_R will be convergently deflected in passing through deflection means C, as described above, so that the electron beams B_B, B_G and B_R will desirably converge at a common area on screen S.

Electron beam scanning of the face of the color phosphor screen is effected by deflection yoke Y, which receives horizontal and vertical sweep signals whereby the beams are made to scan the screens in the desired raster.

FIG. 2 shows a portion of the electron gun of another prior art, single-gun, plural-beam color picture tube which operates in substantially the same manner as that of FIG. 1, with the exception that the cathodes K_R, K_G and K_B are arranged as shown on an arcuate surface whose center substantially corresponds with the optical center of main lens L_m so that the respective beams B_R, B_G and B_B emitted therefrom are directed in a substantially horizontal plane containing the axis of the gun, with the central beam B_G being coincident with such axis and the side beams B_R and B_B converging toward the axis so that they intersect substantially at the optical center of main lens L_m. While this eliminates the need for the converging function of auxiliary lens L_s, an auxiliary lens L_s may still be employed to prefocus beams B_G, B_B and B_R. Further, in the gun of FIG. 2, the first or central grid is constituted by an assembly of three individual grids G_1 suitably arranged about cathodes K_R, K_G and K_B to provide uniform spacing between the cathodes and apertures h_{1R}, h_{1G} and h_{1B}, respectively.

For operation of the color picture tube of FIG. 2, appropriate voltages are applied to the grids G_1 and G_2 and the electrodes G_3, G_4 and G_5, so as to establish an electron lens field in grid G_2 to form the auxiliary lens L_s, which is indicated by the equipotential lines in grid G_2, and an electron lens field around the axis of electrode G_4 to form a main focusing lens L_m, which is indicated by its optical equivalent. The end surfaces of accelerating grid G_2 and electrode G_3 may be suitably shaped so that they are substantially perpendicular to the beams B_R, B_G and B_B, whereby the electron lens field forming auxiliary lens L_s will be shaped to prefocus the beams and to avoid further convergence of the beams.

Referring to FIG. 3, which is a diagrammatic view illustrating the optical equivalent or analogy of the prior art, single-gun, plural-beam color picture tube shown in FIG. 2, the focusing characteristics of that tube will now be explained. Note that for simplicity, only one of the side beams B_R and B_B is shown, as the other would appear symmetrically identical about the axis of the tube.

Central beam B_G and side beam B_R or B_B are shown as originating from their respective optical image or cross-over points P located on an arcuate line X concentric with the optical center of main focusing lens L_m and are shown to converge substantially at the optical center of main focusing lens L_m. The image or cross-over points P, in the tube of FIG. 2, are also located approximately at the exit sides of the respective apertures h_{2R}, h_{2G} and h_{2B} provided in second grid G_2. Side beam B_R or B_B passes through auxiliary lens L_s at a distance from its optical axis while central beam B_G passes through lens L_s substantially along the optical axis. This causes a different prefocusing effect to be imparted to side beam B_R or B_B than to central beam B_G. Specifically, side beam B_R or B_B is prefocused to a greater degree than central beam B_G. Furthermore, side beam B_R or B_B passes through main focusing lens L_m at an angle to the optical axis of the latter while central beam B_G passes through it substantially along the optical axis. This causes a different focusing effect to be imparted to side beam B_R or B_B than to central beam B_G. Once again, side beam B_R or B_B is focused to a greater degree than central beam B_G. This results in side beam B_R or B_B being focused closer to main lens L_m than central beam B_G.

If a screen S is located at the focus point of side beam B_R or B_B, central beam B_G would impinge upon screen S in a slightly unfocused condition and would thus produce a larger spot than that produced by side beam B_R or B_B. Similarly, if screen S was moved to location S', corresponding to the focus point of central beam B_G, side beam B_R or B_B would impinge on screen S' in a slightly unfocused condition and would thus produce a larger spot than that produced by central beam B_G. Thus the disparity in beam focusing distances would produce a picture having less than perfect resolution.

Of course, a similar analysis of the tube shown in FIG. 1 would produce a similar result, with the only difference being that side beam B_R or B_B would appear parallel to central beam B_G between its image or cross-over point P and auxiliary lens L_s.

FIG. 4 shows in solid lines the optical equivalent or analogy of a single-gun, plural-beam color picture tube according to this invention, superimposed upon the optical equivalent or analogy of the prior art tube as shown in FIG. 3, indicated in dashed lines. Screen S is shown located at the focusing point B_2 of side beam B_R or B_B, and, in the representation of the prior art tube central beam B_G is shown focused at focusing point B_1, which is located on the tube axis a distance Δ B beyond screen S. According to the present invention, the optical image or cross-over point P' of central beam B_G is located a distance from main focusing lens L_m that is greater by Δ A than the distance A from the optical image or cross-over point P of the central beam B_G to the lens L_m in the prior art tube, in order to increase the focusing effects imparted to central beam B_G. Selection of a suitable distance Δ A results in the coincident focusing of side beam B_R or B_B and central beam B_G at focus point B_2, and thus produces minimum beam spot sizes upon screen S, thereby improving the resolution of the picture produced by the tube.

Referring to FIG. 4, a mathematical analysis of the focusing effects imparted to central beam B_G of the prior art tube results in the following equation:

$$1/A + 1/B = 1/f \quad (1)$$

in which

A = distance between optical image or cross-over point P and main focusing lens L_m.

B = distance between main focusing lens L_m and focusing point B_1, and

f = effective focal length of lens L_m and L_s.

A similar mathematical analysis of the focusing effects imparted to central beam B_G of the tube according to the present invention results in the following equation:

$$1/A + \Delta A + 1/B - \Delta B = 1/f \quad (2)$$

in which A, B and f represent the same quantities as in equation (1) and

ΔB = distance between focusing point B_2 and focusing point B_1, and

ΔA = distance between optical image or cross-over point P' and optical image or cross-over point P.

In accordance with equations (1) and (2), it can be demonstrated that locating the cross-over point of central beam B_G a farther distance from main lens L_m than the cross-over points of side beams B_R and B_B will produce coindident focusing upon screen S.

Referring to FIG. 5, which is a graph comparing the beam spot sizes of a prior art, single-gun, plural-beam color picture tube and one according to an embodiment of this invention, the beneficial results of the present invention will become apparent. The ordinates of the graph of FIG. 5 represent the diameter of the beam spot on the screen, and the abscissas indicate the voltage applied to electrode G_4 which is related to the power of main focusing lens L_m. Curve 1 represents the beam spot size of central beam B_G in a prior art tube as hereinbefore described. Curve 2 represents the beam spot of side beams B_R and B_B of both the prior art tube and the tube according to this invention. Since curves 1 and 2 reach minimums at different locations, it is clearly shown that there is no voltage which may be applied to electrode G_4 to simultaneously produce minimum, identical beam spot sizes for the respective beams.

Curve 1' represents the beam spot size of central beam B_G in a tube according to this invention. Since curve 1' is substantially similar to curve 2, the tube according to this invention substantially attains the optimal focusing condition since curves 2 and 1' reach minimums at substantially identical electrode G_4 voltages. The voltage applied to electrode G_4 may therefore be readily adjusted to simultaneously produce identical, minimum beam spot sizes for the respective beams, thereby producing a picture having higher resolution than that of the prior art tube.

Generally, in accordance with this invention, the cathodes K_R, K_G and K_B are substantially equidistant from the location in the main focusing lens L_m at which the beams B_R, B_g and B_B are made to intersect each

other and also substantially equidistant from the grid or grids G_1, and the difference ΔA between the distance from the cross-over point of central beam B_G to lens L_m and the distance from the cross-over point of each of the side beams B_R and B_B to the lens L_m is achieved by relatively increasing the effective thickness of accelerating grid G_2 at the portions thereof containing apertures h_{2R} and h_{2B} as compared with the effective thickness of grid G_2 at the portion thereof containing aperture h_{2G}, while maintaining uniform the spacing between grid or grids G_1 and grid G_2 at all of the apertures. By reason of the foregoing, the electric field established by the high voltage applied to electrode G_3 permeates the control apertures h_{2G} to a greater extent than the side apertures h_{2R} and h_{2B} and thus has a greater affect on central beam B_G than on side beams B_R and B_B, whereby the crossover points of the side beams are located closer to main lens L_m as compared with the location of the cross-over point of the central beam.

Examples of the structure of the electron gun portions of color picture tubes in accordance with this invention will now be described with reference to FIGS. **6, 7, 8** and **9.**

FIG. **6** illustrates the application of this invention to a single-gun, plural-beam color picture tube of the type shown on FIG. **1,** but from which all of the structure to the right of the electrode G_3 has been omitted for ease of illustration. In the tube of FIG. **6,** the cathodes K_R, K_G and K_B are arranged parallel to each other so that the beams generated therefrom will be substantially parallel. Further, as in the prior art tube of FIG. **1,** the cathodes of the tube shown on FIG. **6** have their electron emitting surfaces in a common flat plane normal to the tube axis, that is, equidistant from the main lens L_m, and the distances from such electron emitting surfaces to control grid G_1 and from the latter to accelerating grid G_2 are uniform at the apertures provided in grids G_1 and G_2 for the passage of all of the beams.

In order to relatively increase the effective thickness of grid G_2 at the portions thereof through which side beams B_R and B_B are made to pass as compared with the portion of grid G_2 through which center beam B_G passes, the embodiment of FIG. **6** includes an auxiliary electrode **3** disposed within cup-shaped grid G_2 and maintained at the same potential as the latter so as to become an effective part thereof. The auxiliary electrode **3** has an end wall or face plate **3A** which is formed with a central projecting portion **3'** abutting the central portion of the end wall or face plate of grid G_2. The central portion **3'** and the side portions of auxiliary electrode **3** are formed with an aperture h_{3G} and with apertures h_{3R} and h_{3B}, respectively, aligned with apertures h_{2G}, h_{2R} and h_{2B} of grid G_2. Thus, the effective thickness of the combined grid G_2 and auxiliary electrode **3** is greater at apertures h_{2R} and h_{3R} and at apertures h_{2B} and h_{3B} than at apertures h_{2G} and h_{3G}. Thus, the electric field 1_s which forms the auxiliary lens is able to penetrate apertures h_{2G} more readily than it can penetrate to apertures h_{2R} and h_{2B}, with the result that the cross-over point P_G for the central beam B_G is disposed close to the end wall or face plate of grid G_2, whereas the cross-over points P_R and P_B of the side beams B_R and B_B are spaced from the face plate of grid G_2 in the direction toward the main lens L_m.

In the embodiment of FIG. **7,** an effect similar to that described above with respect to FIG. **6** is achieved by providing an auxiliary electrode **13** within accelerating grid G_2 which electrode **13** has an arcuate end wall or face plate **13A** so that, when the central portion of the latter abuts the face plate of grid G_2, the side portions of face plate **13A** are spaced from the face plate of grid G_2. Thus, the effective thickness at apertures h_{2R} and h_{3R} and at apertures h_{2B} and h_{3B} is greater than the effective thickness at apertures h_{2G} and h_{3G} to obtain the desired displacement of the cross-over points of beams B_R and B_B with respect to the cross-over point of beam B_G.

In the embodiment of FIG. **8,** the necessity for the auxiliary electrodes **3** or **13** of FIGS. **6** and **7** is dispensed with by providing the grid G_2 with an end wall or face plate **23** having a thin central portion **23A** and thick side portions **23B** and which is uniformly spaced from grid G_1. Thus, here again the electric field from electrode G_3 penetrates through central aperture h_{2G} and only penetrates to a limited extent into apertures h_{2R} and h_{2B}, whereby the cross-over points of side beams B_R and B_B are located at greater distances from the respective cathodes K_R and K_B than is the cross-over point of center beam B_G with respect to its cathode K_G.

FIG. **9** illustrates the application of this invention to a single-gun, plural beam color picture tube of the type shown on FIG. **2.** In such tube according to the invention, the effective thickness of the grid G_2 at the side portions thereof through which beams B_R and B_B is made greater than the effective thickness at the center portion through which beam B_G passes by providing an auxiliary electrode **33** within grid G_2. The auxiliary electrode **33** is similar to the electrode **3** of FIG. **6** and has a central portion **33'** protruding relative to the side portions of its face plate **33A.** Thus, the cross-over points P_R and P_B of the side beams are displaced in the direction toward main lens L_m relative to the cross-over point P_G of the center beam.

When appropriate voltages, similar to those applied to the tube of FIG. **1,** are applied to grid G_1, grid G_2 (or grid G_2 and electrode **3** or **33**) and electrodes G_3, G_4 and G_5 of the tubes illustrated by FIGS. **6, 8** and **9,** the recess defined by the protuberant or projecting central portion of electrode **3** or **33,** or the equivalent recess defined at the central portion of grid G_2 on FIG. **8,** so distorts the electron lens field produced between grid G_2 and electrode G_3 as to provide, in effect, a sub-focusing lens 1_s, indicated by its optical equivalent, located within protuberant portion **3'** or **33',** or within the central recess, to act only on central beam B_G. The effect of such sub-focusing lens 1_s is to enhance the focusing effect on central beam B_G and thereby relatively reduce the distance ΔA by which the distance from the cross-over point of the central beam to the main lens L_m has to be greater than the distance from the cross-over points of the side beams to the main lens in order to achieve precise focusing of all of the beams on the tube screen. Thus, the distance ΔA may be made less than that calculated from equation (2) above when the grid G_2 is shaped as shown on FIG. **8,** or is provided with auxiliary electron **3** or **33** as shown on FIGS. **6** and **9,** for increasing the focusing effect of the lens field between grid G_2 and electrode G_3 on central beam B_G as compared with it focusing effect on side beams B_R and B_B.

In the embodiment of FIG. **9,** the cathodes K_R, K_G and K_B are again equidistant from the main focusing

lens L_m, but arranged so that the beams generated therefrom cross or intersect substantially at the optical center of main lens L_m, thus eliminating the need for the converging function of auxiliary lens L_s. In that case, the relative displacement of crossover points P_R and P_B with respect to cross-over point P_G and the focusing effect of sub-focusing lens 1_s operating only on center beam B_G combine to compensate for different focusing effects resulting from the fact that beams B_B and B_R pass through the field established between grid G_2 and electrode G_3 and through the main focusing lens L_m at angles to the optical axis whereas beam B_G passes therethrough along the axis.

Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention.

What is claimed is:

1. A cathode ray tube comprising: a screen; and electron gun means comprising beam producing means including a first set of cathode and control grid means providing a central beam source located on the axis of the tube for directing a central electron beam along said axis toward said screen and second and third sets of cathode and control grid means providing said beam sources spaced from said central beam source at opposite sides of the latter for directing respective side beams toward said screen in a common plane containing said axis of the tube, accelerating grid means spaced from said control grid means in the direction toward said screen and having a central aperture and two side apertures respectively aligned with said central and side beams, and a main focusing lens comprising a plurality of electrode means arranged in sequence along said axis between said accelerating grid means and said screen, said accelerating grid means cooperating with said beam producing means to establish electric fields for narrowing said beams to minimum cross-sections at respective crossover points adjacent said accelerating grid means, means for directing said side beams to intersect said central beam at a location in the main focusing lens whereby said side beams pass through the main focusing lens at angles to said axis and the focusing effect thereon is different from that on said central beam, said cathode and control grid means being substantially equidistant from each other in said first, second and third sets thereof and said control grid means of said first, second and third sets being substantially equidistant from said location in said main focusing lens where said side beams intersect said central beam, said accelerating grid means having greater effective thickness at said portions thereof containing said side apertures than at the portion thereof containing said central aperture, whereby an electric field established between said accelerating grid means and said electrode means of said main focusing lens panetrates said central and side apertures of the accelerating grid means to different extents and thereby disposes said crossover points of said side beams and said central beam, respectively, at different distances from said main focusing lens to compensate for said different focusing effects.

2. A cathode ray tube according to claim **1**, in which said electric field established between said accelerating grid means and said electrode means forms an auxiliary lens means.

3. A cathode ray tube according to claim **2**, in which said side beams pass through said auxiliary lens means at distances from said axis so that prefocusing effects imparted to said side beams and said central beam, respectively, by said auxiliary lens means are different.

4. A cathode ray tube according to claim **2**, in which said central and side beam sources are aligned in parallel so that said beams issue therefrom substantially parallel to said axis and said auxiliary lens means causes said side beams to converge relative to said central beam so that they intersect each other substantially at said center of said field defining the main focusing lens.

5. A cathode ray tube according to claim **2**, in which said central and side beam sources are arranged so that the said beams issue therefrom in a convergent manner to intersect each other substantially at said location in the main focusing lens.

6. A cathode ray tube according to claim **2**, in which said accelerating grid means has a central recess opening in the axial direction away from said control grid means around said central aperture of said accelerating grid means so that said electric field established between said accelerating grid means and said electrode means is distorted to form a prefocusing lens means within said recess which acts selectively on said central beam.

7. A cathode ray tube according to claim **1**, in which said accelerating grid means includes a one-piece face plate having the respective apertures therein, and the thickness of said face plate is different at the portion thereof having said central and side apertures, respectively, therein.

8. A cathode ray tube according to claim **1**, in which said accelerating grid means includes a cup-shaped grid member having a face plate portion with openings therein corresponding to said central and side apertures, respectively, said cup-shaped grid member opening in the direction away from said control grid means, and an auxiliary electrode at the same potential as said cup-shaped grid member and being disposed within the latter, said auxiliary electrode having openings therein aligned with said openings in said face plate portion, and portions of said auxiliary electrode containing the openings for said central and side beams, respectively, are disposed at different distances from said face plate portion to provide said different effective thicknesses.

9. A cathode ray tube according to claim **8**, in which said face plate portion is substantially flat and said auxiliary electrode has a protuberance directed toward said face plate portion at the location of the opening thereof for the passage of said central beam.

10. A cathode ray tube according to claim **8**, in which said face plate portion is substantially flat and said auxiliary electrode is arcuate.

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