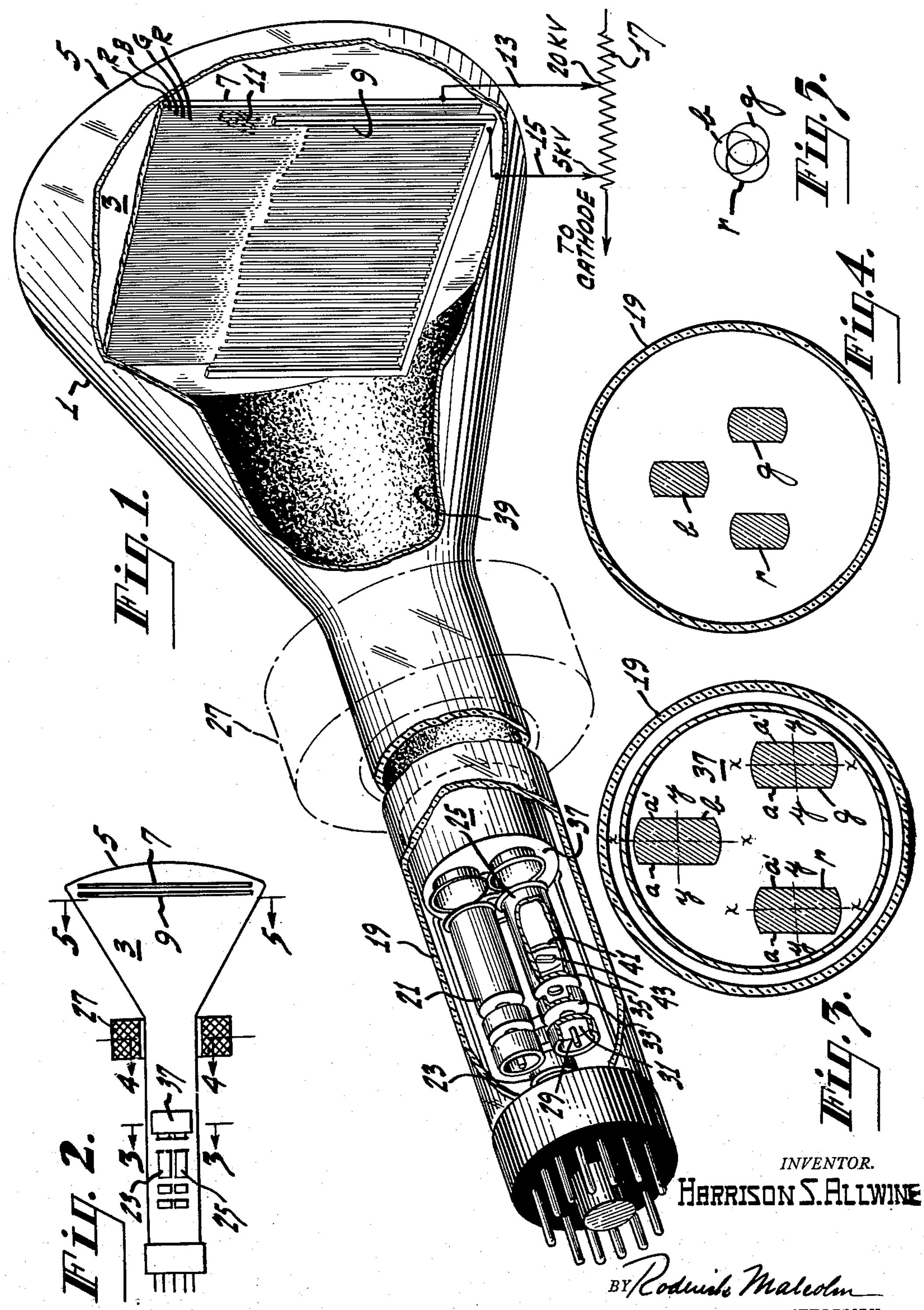
May 22, 1956 | H. S. ALLWINE | 2,747,134

DUAL FOCUS CATHODE-RAY TUBES

Filed April 30, 1953 | 2 Sheets-Sheet 1



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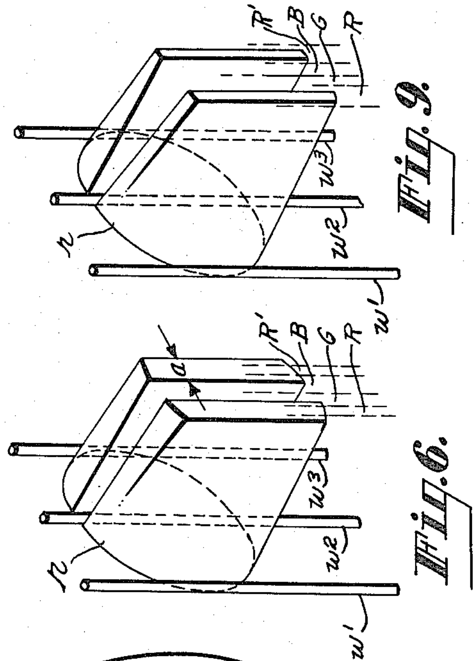

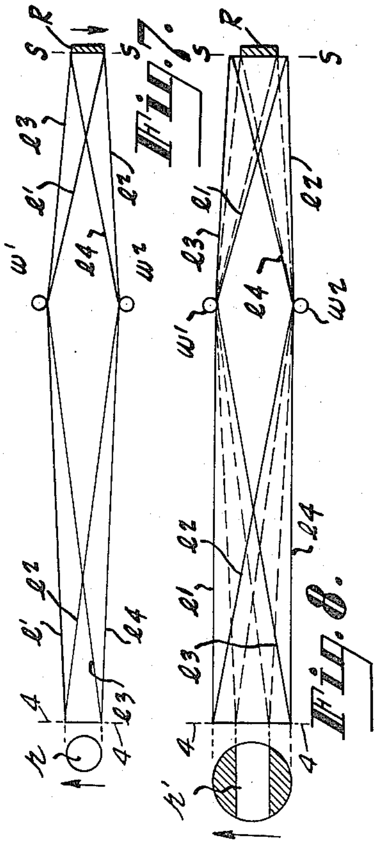

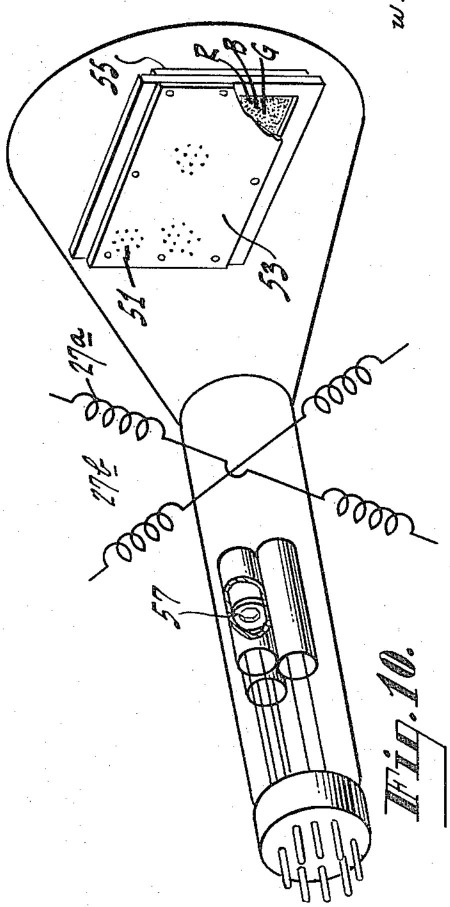

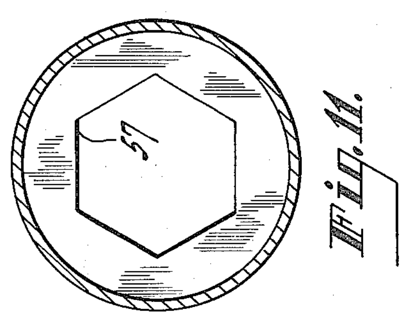

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United States Patent Office

2,747,134

Patented May 22, 1956

2,747,134

DUAL FOCUS CATHODE-RAY TUBES

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Application April 30, 1953, Serial No. 352,239

11 Claims. (Cl. 315—13)

This invention relates to improvements in color-kinescopes and other cathode-ray (C. R.) tubes of the kind wherein electrons are subjected to a first focusing action near their source or virtual source and to one or more independent focusing actions near the screen or "target" of the tube.

In cathode-ray tubes of the kind wherein the beam-electrons approach a viewing screen through the apertures of a nearby grill or "mask" the electrons are subjected to a focusing (and/or "shadowing") action at or near the screen which is independent of the focusing action that takes place at or near the gun of the tube. The influence to which the electrons are subjected at or near the screen differs in different types of screen units. For example, in the "shadow-mask dot-screen" tubes of Goldsmith 2,630,542 (wherein the mask and screen are ordinarily operated at the same potential) the screen-unit subjects the electrons to a focusing action which may be said to be similar to that which takes place in a pin-hole camera. On the other hand, if a "dot" screen and its mask are operated at different potentials, with the screen at the higher potential, the beam electrons are subjected to the converging action of a spherical electron-lens system. Similarly, if a "line" screen is operated at a higher potential than its parallel-wire grill (as in Flechsig, French Patent 866,065 of 1941) the beam electrons are subjected to the converging action of a cylindrical lens system.

If a "line" type screen-unit is provided with more than one grill, the electrons may be subjected to the action of a "compound" cylindrical lens system. If the grill wires are properly oriented (for example, with the wires of one grill at right angles to the color lines on the screen, as disclosed by Edward G. Ramberg in copending application Serial No. 277,182, now U. S. P. 2,728,044) the beam-electrons may be subjected to a converging action in one plane and an independent diverging action in a plane at right-angles to the first.

In color-kinescopes containing plural or multi-element lenticular screen-units the particular screen-color that is illuminated at any given instant is normally a function of the particular angle at which the beam electrons approach the screen. In the case of a tri-color kinescope, three-guns may be employed; i. e., one gun for each screen-color. In such 3-gun C. R. tubes the greater the angular separation of the guns the easier it is to "sort out" the three beams. Stated generally in another way, the greater the "convergence angle" the less the possibility that a given beam will impinge upon a color-area other than the one upon which it should impinge.

In agreement with the above mentioned rule, color-purity was achieved in early directional type color-kinescopes etc. by mounting the three guns 120° apart, each in a separate neck, with separate beam-deflecting coils and keystone-correction means associated with each gun. (As to this see the Goldsmith patent, for example.)

Schroeder (U. S. Patent 2,595,548), by bringing the guns close together, delta (Δ) fashion, in a single neck,

dispensed with separate beam-deflecting coils and eliminated the necessity for keystone correction. In Schroeder's tube, in order to reduce color-dilution occasioned by possible overlap of the three beam spots at the screen, the practice has been to make the three beams, and the apertures in the "mask," of a diameter considerably smaller than the beams and apertures which can be used in a similar tube having widely-spaced guns. Other gun parameters remaining the same, any reduction in either of said diameters results in a decrease in the quantity of electrons available at the screen and a consequent decrease in the brightness of the color-pictures reproduced on said screen.

Accordingly, the principal object of the present invention is to provide a method of and means for producing images of improved brightness in C. R. tubes of the kind wherein the beam electrons are subjected to a first focusing action near their source and to one or more independent focusing actions near the screen or target of the tube.

Another and related object of the invention is to achieve the foregoing object, in a multi-gun color television tube (*a*) without any sacrifice in "color-purity," (*b*) without any increase in the spacing or "convergence angle" of the electron-guns and (*c*) without adversely affecting the limiting resolution.

The present invention teaches that when a dual-focus cathode-ray tube employs a screen unit of the line-screen type (as distinguished from the dot-screen type), it is not necessarily the diameter, but rather the width of the beam at or near its plane-of-deflection that determines color purity. By "beam-width," in the case of a line-screen tube, is meant the dimension, in the plane of the screen that extends approximately at right angles to the direction of extension of color-phosphor lines. The significance of the difference between "beam-diameter" and "beam-width" as a color-purity determinant will be apparent when it is appreciated that a 20% reduction in beam-diameter results in a 36% reduction in the beam's cross-sectional area and an approximately equivalent reduction in beam-current and image-brightness, whereas a 20% reduction in beam width only provides the same increase in color-purity yet reduces the beam's cross-sectional area only 10.5%. Consequently, a substantial reduction in loss of brightness results.

Thus, it will be seen that the achievement of the previously mentioned and other objects of the invention is predicated, first, upon an appreciation of the phenomena involved in the independent focusing actions which take place in the C. R. tubes to which the invention is applicable and, second, upon the realization of the fact that optimum performance cannot be achieved in such tubes with a beam (or beams) of conventional circular cross-sectional contour.

The particular shape of the beam (or beams) required to achieve optimum performance in dual-focus tubes involves a consideration not only of the particular type of electron-lens (e. g., "cylindrical" or "spherical") employed in the screen unit, but also of the pattern (e. g., "dot" or "line") of the screen per se. In applying the invention to dual-focus, tri-color, 3-gun tubes of the line-screen variety the invention dictates the use of three beams, each having a long cross-sectional dimension and, preferably, two straight sides which, in their plane-of-deflection, are parallel to the direction of extension of the color-lines on the screen.

Insofar as color-purity is concerned the beam's size and shape near its plane-of-deflection are of considerable importance while its size and shape in sections successively closer to the focusing grill are of successively less importance. (For example, the size and the shape of the beam at the plane of the lens-grill have no effect whatsoever on color purity; the only factor of importance with respect to "color purity" in said plane is the direction of travel of the individual electrons in the beam.) Accordingly, the beams may be endowed with their non-circular shape by an appropriately shaped and positioned stopping aperture which, for convenience, may be placed in each gun. If the electron-guns also contain a conventional lens-system the non-circular pattern of each beam in its plane-of-deflection is converted into a circular pattern by the time the beam reaches the screen-unit. Thus, the present invention may be said to teach a novel method of operating a C. R. tube which involves scanning its screen-unit or "target assembly" with the circular end of a beam which, in its plane-of-deflection, is of non-circular contour.

The invention is described in greater detail in connection with the accompanying two sheets of drawings, wherein:

Fig. 1 is a partly diagrammatic view in perspective of a tri-color kinescope containing a color-screen unit of the so-called "focused line-screen" variety and a battery of three electron-guns capable of projecting electron-beams of non-circular contour;

Fig. 2 is a longitudinal sectional view of the C. R. tube of Fig. 1, on a reduced scale;

Fig. 3 is an enlarged sectional view taken on the line 3—3 of Fig. 2 showing the pattern of the three non-circular beams as they emerge from the battery of electron-guns;

Fig. 4 is an enlarged view of the three beams, taken on the line 4—4 of Fig. 2 in their plane-of-deflection or "center-of-scan";

Fig. 5 is a similar view, taken on the line 5—5 of Fig. 2, showing that the non-circular beams of the earlier views assume a circular contour as they approach the color-screen unit;

Fig. 6, which is included to visualize the problem of "color-purity tolerance" with which the invention is concerned, is a view in perspective, on an enlarged scale, looking through the line-screen of a C. R. tube similar to the one shown in Fig. 1 but employing a conventional (circular) beam;

Figs. 7 and 8 plot the paths of electrons, in dual focus tubes, from emissive surfaces of different areas, through the lens field of a parallel wire grill; these drawings being referred to in explaining the principle of the present invention;

Fig. 9 is a view in perspective, similar to Fig. 6, but showing how the originally non-circular beam of the present invention effects an increase in "color-purity tolerance" at the screen;

Fig. 10 is a partly diagrammatic view in perspective of a color-kinescope of the dot-screen "shadow-mask" variety, embodying the invention; and

Fig. 11 is an elevational view of a hexagonal beam-forming aperture constructed in accordance with the principle of the invention for use in the "shadow-mask" tube of Fig. 10.

The color-kinescope shown in Fig. 1 comprises an evacuated envelope **1** having a main chamber **3** in the form of a frustrum which terminates at its large end in a window **5** through which the obverse face of the glass viewing screen **7** of a bi-part target assembly or screen-unit **7, 9** is viewed. The viewing screen **7**, here illustrated, is of the mosaic line-screen variety described in the Flechsig (French Patent 866,065) and Schroeder (U. S. Patent 2,595,548) patents. It is provided on its rear or target surface with a multiplicity (say 1500 or more) of parallely disposed phosphor lines R (red), B (blue) and G (green) of different color-emissive characteristics arranged in a repetitive pattern in groups of three. These parallel lines R, B and G are here shown as extending in the vertical direction, they may, however, extend horizontally across the screen, or at an angle with respect to said directions. An electron-transparent light-reflecting

film **11** constituted, for example, of evaporated aluminum renders the entire target surface of the screen conductive. The other element of the screen or target assembly comprises an electrically conductive mask or grill **9** made up of fine wires (say 0.003″ diameter) disposed parallel to the color-phosphor lines on the screen **7**, there being one opening in the grill **9** for each group (R, B and G) of color lines. Separate external leads **13** and **15** from the conductive surface (**11**) of the screen and from the grill (**9**), respectively, permit the application of appropriate potentials from a source **17**, to these separate electrodes. In the instant embodiment it will be assumed that the metal coating **11** on the screen is maintained at a potential approximately four times that of the grill **9** in order to establish an electron-lens field in the spaces between adjacent wires in said grill. The lines of force of which said fields are comprised are not here illustrated since it is well known that with the described voltage distribution the lens-field adjacent to each pair of wires is that of a cylindrical-lens the generatrices of which, in this embodiment, are substantially parallel to the color lines (R, B and G) on the line-screen or target **7**. As a consequence, the lens action adjacent to the grill wires is such as to converge beam-electrons toward the long central axis of each of said lines, as is described in greater detail in connection with Figs. 7 and 8.

The other or small end of the main chamber **3** terminates in a tubular neck **19** which contains a battery of three electron-guns **21, 23, 25** each one of which is allotted to a particular screen color. The guns as here shown are arranged delta (Δ) fashion about an axis normal to the plane of the viewing screen **7**. They may, however, be arranged "in line"—as in the Flechsig patents. As in Schroeder U. S. Patent 2,595,548, the required horizontal and vertical scanning movements are supplied to each electron-beam by a common deflecting yoke **27** which will be understood to comprise two pairs of electro-magnetic coils (*27a*, *27b*, Fig. 10) disposed at right angles to each other on the neck **19** of the tube.

The guns here shown are of duplicate construction, and with the exception of the "stopping aperture" (**41, 43**, later described), are of the type claimed by Hannah C. Moodey in copending application, Serial No. 295,225. Thus, each gun comprises an indirectly heated cathode **29**, a control grid **31**, a short cup-like screen grid electrode **33**, a first accelerating electrode (or "first anode") in the form of a hollow metal tube **35** and a second accelerating electrode (or "second anode") consisting of a large tubular portion **37** common to the three guns. A conductive coating **39** on the inner surface of the main chamber **3** and neck **19** of the envelope **1** comprises a third accelerating electrode (or "third anode").

As previously indicated, the present invention teaches that in 3-gun dual-focus line-screen C. R. tubes maximum picture-brightness is achieved (without sacrificing color-purity etc.) when a section of each beam (*r*, *b* and *g*) taken in its plane-of-deflection (4—4, Fig. 2) has straight sides *a*, *a′* (see Fig. 3) or at least a long cross-sectional dimension along the axis *x*—*x* (same figure) parallel to the direction of extension of the color-lines (R, B and G) on the screen-plate and a shorter dimension along an axis *y*—*y* at a right angle to said long axis. (The "plane-of-deflection" in three-gun tubes may be defined as the plane in which the axis of each deflected beam, when extended rearwardly, intersects the axis of origin of that beam.) The means shown in Fig. 1 for endowing each beam with a non-circular contour in its plane-of-deflection comprises a diaphragm **41** disposed within the first anode cylinder **35** and having an appropriately shaped beam forming aperture **43** therein. The straight sides *a* and *a′* and the long dimension along the cross-sectional axis *x*—*x* of the beams (*r*, *b* and *g*) are established by the "stopping aperture" **43** in each gun and continue parallel to each other throughout the space between the guns and their plane-of-deflection 4—4 (Fig. 2). As indicated in Fig. 4, the beams *r*, *b* and *g*, retain their above described shape in their plane-of-deflection, but at said plane are reduced in area by the focusing action of the lens-system in each gun. The beams gradually lose their straight sides and acquire a substantially circular contour (see Fig. 5) as they approach the grill **9** of the screen-unit. This is so because the bi-potential electron-lens field in the space between the first and second anode **35—37** of each gun operates to focus, in or near the plane of the grill **7**, an image of the circular emitting surface of the cathode **29** or of the circular cross-section of the "first cross-over" (virtual cathode) in that gun. As in light-optics, this focusing action is, of course, independent of the shape of any aperture near the lens.

As previously mentioned, the size and shape of the beam's cross-section in its plane-of-deflection are of greater importance in determining color-purity than the size and shape of other cross-sections on the screen side of said plane. Why this is so will the more readily be apparent upon inspection of Fig. 6 which visualizes the problem with which the invention is concerned, and Figs. 7, 8 and 9 which illustrate the phenomena involved in the past and the present solutions of the problem.

Referring now particularly to Fig. 6 which is a greatly enlarged view of a "red" electron-beam *r* as it passes through the apertures of a grill, indicated by the wires w^1, w^2, w^3, and is focused upon two of the red lines R and R′ of a tri-color screen. Here the problem is indicated by showing the focused split-ends of the beam to be of width-dimension *d* slightly larger than that of the red color-lines R, R′ so that the sides of the beam overlap the adjacent green (G) and blue (B) lines on the screen and, consequently, produce color-dilution. The prior art solution of this problem is to reduce the diameter of the beam. This is visualized in Figs. 7 and 8 which trace the paths of two beams *r* and *r′* of different size (here disregard the cross-hatching on the large beam *r′*, Fig. 8) from the plane-of-deflection **4—4**, and thence through the space between the grill-wires w^1, w^2 to a red line R on the screen. (In Figs. 7 and 8, in order to simplify the drawing, the diameter of the beam at the grill corresponds to the spacing of the grill wires. As indicated in Figs. 6 and 9 it may actually span the spaces between three or more adjacent wires.) In Fig. 7 the dimensions of the beam in its plane-of-deflection **4—4** and at the screen S are smaller than the beam Fig. 8 at the corresponding planes (**4—4** and S). As a consequence, the beam in Fig. 7 is confined to the red-phosphor line R. If, as previously mentioned, it is assumed that a 20% reduction in beam diameter is required to achieve the desired "color-purity" tolerance, the resulting reduction in beam-current and image-brightness is the order of 36%.

Referring still to Figs. 7 and 8 it will be observed that both drawings are marked with lines e^1, e^2, e^3 and e^4 which mark the paths traversed by electrons from various parts of the beam in their transit from the plane-of-deflection **4—4** to the screen. It will also be observed that, in agreement with laws of electron-optics, the beam spot on the screen is an inverted image, of the beam in its plane-of-deflection. Now, having in mind that the color-line R on the screen is perpendicular to the plane of the drawing, it will be seen that the electrons that extend beyond the red line R (Fig. 8) onto the blue and green lines (not shown) can be traced back to the "top" and "bottom" sides of the beam in its plane-of-deflection, as is indicated by the shading on the beam in its plane-of-deflection **4—4**. It follows that if the electrons that make up only said (shaded) sides of the beam are eliminated from the beam by the time it reaches its plane-of-deflection, they will likewise be missing from the beam spot (or spots) on the screen, irrespective of the shape of the beam as it approaches the grill. Accordingly, in contrast to the prior art which dictates a uniform decrease in the diameter of the beam, the present invention by the use of the non-circular shape beam-forming aperture **43** (Fig. 1) eliminates only those electrons that cause the trouble. As a consequence, as shown in Fig. 9, the beam is confined to its own particular color-areas on the screen and color-dilution or other "cross-talk" is eliminated. In the instant case the number of electrons available at the screen, instead of being decreased 36% (as in the cited example) is decreased by but 10.5%. Thus the present invention, as applied to a line-screen tube, effects a net gain of approximately 25% in image brightness as compared with a similar tube wherein the beam or beams are of conventionally circular contour in their plane-of-deflection. This advantage holds for a beam having uniform current distribution. A comparable advantage is achieved with beams wherein the current density is greatest at the center of the beam.

Where, as is preferable, the spacing between grill wires is less than the diameter of the beam at the grill (that is, less than the "spot size"), the focusing action of the lens-field in the grill-screen space upon each beam is much the same as it is upon the conventional beam of Fig. 6. That is to say, the grill wires w^1, w^2, w^3 divide the beam into two (or more) segments which are each subjected to the cylindrical lens action of the electric field in the grid-screen space and this lens action focuses said beam-segments upon the phosphor lines of the particular color to which that beam is allotted. However, since the non-circular shape beam-focusing aperture in each gun has deprived the beam of the electrons which have been shown (in Fig. 8) to produce color-dilution the beam is concentrated on said lines (as shown in Fig. 9) and no part of it impinges upon the adjacent lines of different colors.

The invention is not limited in its useful application to "focused-beam line-screen" tubes of either the single or plural grill varieties but may likewise be employed to advantage in so-called "shadow-mask" tubes of both the line-screen and dot-screen varieties.

In Figs. 10 and 11 the invention is shown as applied to "shadow-mask dot-screen" tube. See Goldsmith 2,630,542 and Schroeder 2,595,548.) Here the apertures **51** in the masking plate **53** and the circular phosphor color-dots R, B and G on the screen **55** are each arranged in a hexagonal mosaic pattern. That is to say, each mask-aperture and each color-dot is surrounded by six others; there being one group of red (R), blue (B) and green (G) phosphor dots for each mask-aperture. In this case, the beam-forming aperture **57** in the first anode of each of the three electron-guns is stopped down from six sides (instead of two) to a shape approaching that of a hexagon (see Fig. 11) and the size of the circular holes in the mask may be increased a similar amount, without causing color-dilution, to permit the passage of a greater number of electrons. In this case, assuming a beam of uniform density the maximum possible advantages obtainable is only about 10% increase in brightness. The approximately 10% increase in brightness is due to the fact that the hexagon's area is roughly 10% greater than that of circular beam that would have to be used to achieve the same freedom from "color-dilution" or "cross-talk."

In applying the invention to plural-grill C. R. tubes of the kind wherein two parallel-wire grills are disposed at right-angles to each other, the long-axis of the non-circular beam-forming aperture should be disposed parallel to the wires of the "focusing grill." That is to say, as in Fig. 1, the long dimension of the non-circular beam-forming aperture **43** should extend parallel to the color-lines R, B and G on the screen.

From the foregoing description it should now be apparent that the present invention provides a novel method of and means for producing images of enhanced brightness in dual-focus C. R. tubes, and this too without (*a*) any sacrifice in color-purity or other cross-talk, (*b*) without any increase in the spacing or "convergence angle" of the electron-guns, where a plurality of guns are employed, and (*c*) without adversely affecting the limiting resolution.

What is claimed is:

1. Method of operating a C. R. tube of the kind containing a plane-of-deflection and an apertured electrode through which beam electrons successively pass in their transit from an electron-gun to the ray-sensitive target surface of a mosaic screen, said method comprising, deriving an electron-beam of non-circular cross-section from said electron-gun, projecting said non-circular beam upon said plane-of-deflection, and scanning said target-surface with said beam as modified in its cross-sectional contour by the presence in its path of said apertured electrode.

2. Method of operating a C. R. tube of the kind containing a plane-of-deflection through which beam-electrons pass in their transit from an electron-gun to the target surface of a screen electrode, said method comprising; deriving an electron-beam of non-circular cross-section from said electron-gun, projecting said non-circular beam upon said plane-of-deflection, establishing a beam-focusing field adjacent to said target-surface, and scanning said target surface with said beam as modified in its cross-sectional contour by the presence in its path of said focusing field.

3. Method of operating a C. R. tube having a plane-of-deflection through which beam-electrons pass in their transit from an electron-gun to a screen-unit of the kind comprising spaced-apart field and screen electrodes, said method comprising; deriving an electron-beam of non-circular cross-section from said electron-gun, projecting said non-circular beam upon said plane-of-deflection, establishing a beam-focusing field in the space between said field and screen electrodes, and scanning said screen-electrode with said beam as modified in its cross-sectional contour by the presence in its path of said field electrode and said focusing field.

4. Method of operating a C. R. tube having a plane-of-deflection through which beam-electrons pass in their transit from an electron-gun to a screen-unit of the kind comprising a parallel-wire grill arranged with its wires parallel to the elemental ray-sensitive areas on the nearby target surface of a mosaic "line-screen," said method comprising; deriving from said gun a non-circular electron-beam having a long cross-sectional dimension which is parallel to the line-like elemental areas of said screen, projecting said non-circular beam upon said plane-of-deflection, establishing a cylindrical lens-field in the space between said grill and said screen, and scanning the line-like target surface of said mosaic screen with said beam as modified in its cross-sectional contour by the presence in its path of said grill-wires and said cylindrical lens-field.

5. Method of operating a C. R. tube having a plane-of-deflection through which beam-electrons pass in their transit from an electron-gun to a screen-unit of the kind comprising a punctate-aperture mask disposed with its apertures in register with the circular dot-like ray-sensitive areas on the target surface of a nearby mosaic "dot-screen," said method comprising; deriving from said gun an electron-beam of hexagonal cross-section, projecting said hexagonal electron-beam upon said plane-of-deflection, and scanning the dot-like target surface of said mosaic screen with said beam as modified in its cross-sectional contour by the presence in its path of said punctate-aperture mask.

6. A cathode-ray tube comprising a screen-electrode having a mosaic target surface, an electrode mounted adjacent to said screen-electrode and containing a pattern of apertures corresponding to the pattern of elemental areas of said mosaic, an electron-gun mounted in a position to scan said apertured electrode and said screen-electrode, said electron-gun comprising a source of electrons, a diaphragm containing a non-circular beam-forming aperture and an electron-lens system for converting said non-circular beam into a beam of substantially circular cross-section prior to impinging upon said apertured electrode.

7. In a cathode-ray tube of the kind containing a plane-of-deflection through which beam-electrons pass in their transit from an electron-gun to the screen of a lenticular screen-unit, said electron-gun comprising a source of electrons, a diaphragm having a non-circular beam-forming aperture operatively associated with said source and an electron-lens system effective in the region between said plane-of-deflection and said screen-unit for converting said non-circular beam into a beam of circular cross-sectional contour.

8. The invention as set forth in claim 7 and wherein the screen of said lenticular screen-unit is of the "line-screen" variety, and said non-circular beam-forming aperture has a long dimension extending in a direction substantially parallel to the direction of the lines on said "line screen."

9. The invention as set forth in claim 7 and wherein the screen of said lenticular screen-unit is of the "dot-screen" variety, and said non-circular beam-forming aperture is of hexagonal contour.

10. In a 3-gun tri-color kinescope of the kind containing a plane-of-deflection through which electrons from the three guns pass in their transit to a screen-unit of the kind comprising a parallel-wire grill disposed with its wires parallel to phosphor lines of three different color-response characteristics on the nearby target-surface of a mosaic line-screen, the improvement which comprises: a diaphragm, in each of said guns, containing a non-circular beam-forming aperture having a long cross-sectional dimension substantially parallel to said color-phosphor lines, electron-optical means operatively associated with each diaphragm for projecting the non-circular beam resulting from the passage of electrons through the aperture in that diaphragm upon said plane-of-deflection and adapted to convert each non-circular beam into a beam of substantially circular cross-section during its transit through the space between said plane-of-deflection and said parallel-wire grill, means for establishing a cylindrical lens-field in the space between said grill and the target surface of said screen, and means for scanning the color-phosphor lines on said target surface with said beams as modified in their cross-sectional contour by the presence in their paths of said grill-wires and said cylindrical lens-field.

11. In a 3-gun tri-color kinescope of the kind containing a plane-of-deflection through which the three beams from said guns pass along different angularly related converging paths in their transit to a screen-unit of the kind comprising a target-surface made up of a multiplicity of groups of substantially circular phosphor covered dots of different color-emissive characteristics and an electrode containing a multiplicity of substantially circular apertures disposed in a pattern corresponding to the pattern of the groups of color-phosphor dots on said target surface; the improvement which comprises: means operatively associated with each of said guns for imparting a hexagonal cross-sectional shape to each beam prior to its passage through said plane-of-deflection and for converting each of said hexagonally shaped beams into a beam of substantially circular cross-sectional shape as it approaches said screen-unit.

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