United States Patent

Barten

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[45] **July 18, 1972**

[54] CATHODE RAY TUBE HAVING TRIANGULAR GUN ARRAY AND CURVILINEAR SPACING BETWEEN THE FOURTH AND FIFTH GRIDS

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[22] Filed: **Aug. 21, 1970**

[21] Appl. No.: **66,072**

Related U.S. Application Data

[63] Continuation of Ser. No. 769,612, Oct. 22, 1968, abandoned.

[30] **Foreign Application Priority Data**

Nov. 11, 1967 Netherlands.....6715341

[52] **U.S. Cl.**.....**313/70 C,** 313/82 BF

[51] **Int. Cl.**.....**H01j 29/50,** H01j 31/20, H01j 29/02

[58] **Field of Search**.....313/69 C, 70 C, 82 BF, 82 IT, 313/92 B, 70 R, 86

[56] **References Cited**

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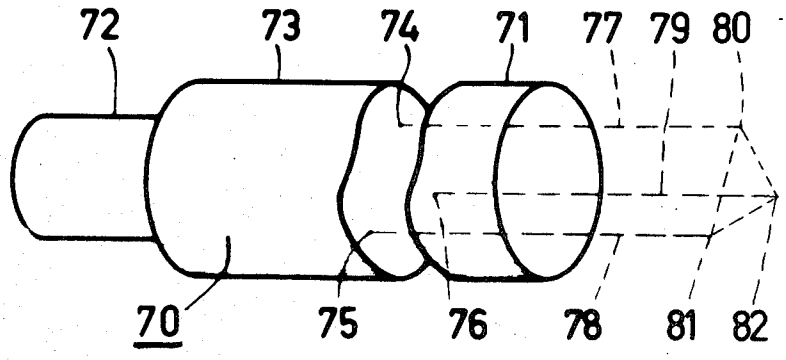
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Primary Examiner—Robert Segal
Attorney—Frank R. Trifari

[57] **ABSTRACT**

A single gun cathode ray tube for the display of colored television images including a separate cathode for each electron beam and common first, second, third, fourth and fifth grids, each having apertures for each beam. The ends of the fourth and fifth grids facing each other define a boundary having a sinusoidal shape.

1 Claim, 11 Drawing Figures



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SHEET 1 OF 2

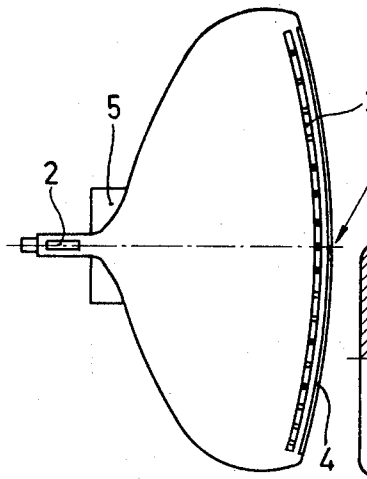


FIG. 1

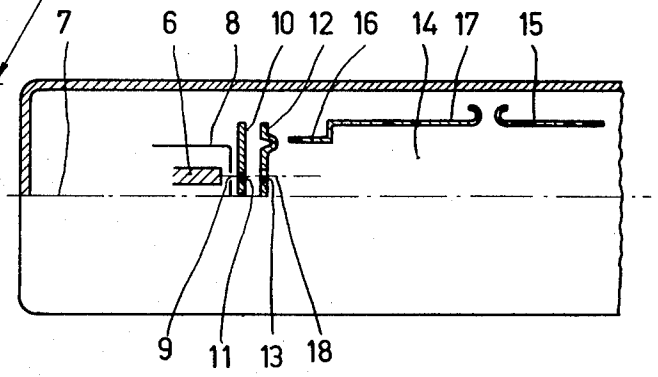


FIG. 2

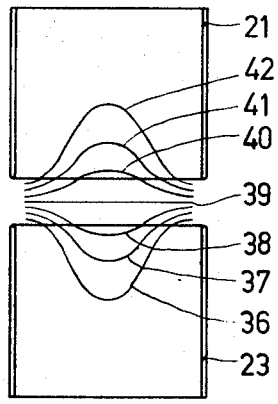


FIG. 5

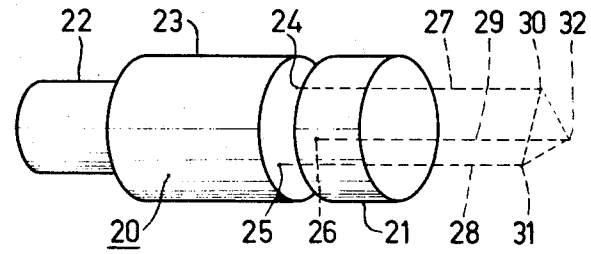


FIG. 3

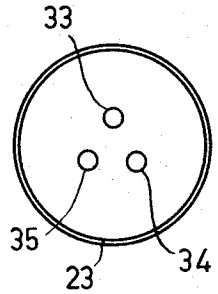


FIG. 4

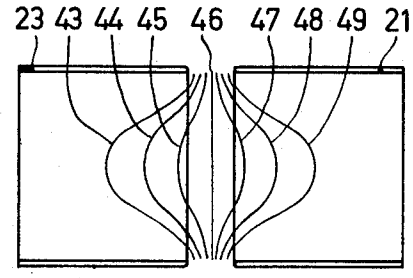


FIG. 6

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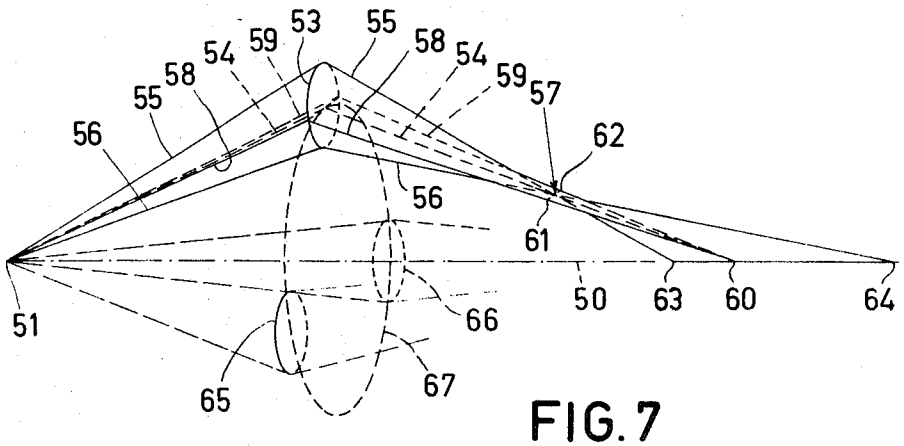


FIG. 7

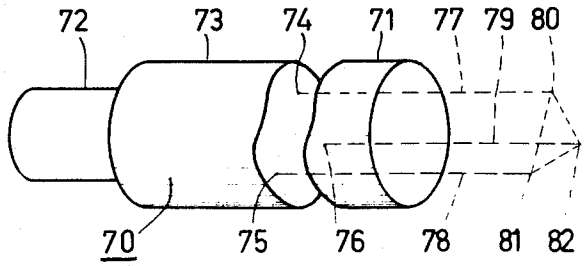


FIG. 8

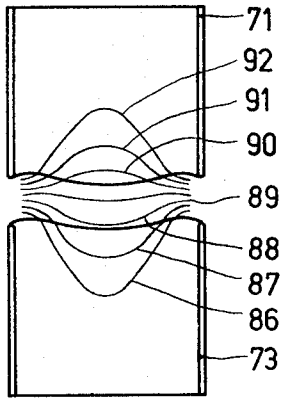


FIG. 10

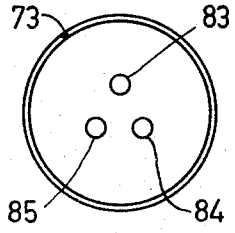


FIG. 9

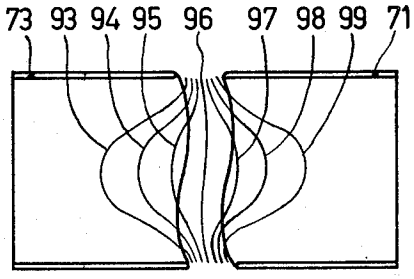


FIG. 11

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CATHODE RAY TUBE HAVING TRIANGULAR GUN ARRAY AND CURVILINEAR SPACING BETWEEN THE FOURTH AND FIFTH GRIDS

This application is a continuation of Ser. No. 769,612, filed Oct. 22, 1968 and now abandoned.

The invention relates to a cathode-ray tube comprising an electron gun system for producing one or more electron beams and at least two common, substantially circular-cylindrical and substantially coaxial electrodes, the axis of which does not coincide with the axis of one or more electron beams and comprising a picture screen. The invention relates particularly to such a cathode-ray tube which is provided with a picture screen having a number of differently luminescing substances and a color selecting electrode placed at a short distance from the picture screen, the electron gun system producing a number of electron beams corresponding to the number of luminescent substances, which beams are converged in the plane of the color selecting electrode by means of a lens field obtained by means of the common substantially circular-cylindrical electrodes.

In the said color tube each of the electron beams is focused on the luminescent screen or at least on the surface located near said screen, for example, that of the color selecting electrode. This is effected partly by the lens action between successive grids of the gun or of the guns which thus produce a pre-focusing. The lens action obtained by means of the common, substantially circular-cylindrical electrodes converges the electron beams substantially in the plane of the color selecting electrode, for example, a shadow mask electrode. This lens action can be obtained by means of one substantially circular-cylindrical grid and a conductive coating on the envelope, by means of two substantially circular-cylindrical grids which in a particular case have substantially equal diameters, or by means of more than two substantially circular-cylindrical grids. Moreover, said lens action provides the required after-focusing to each electron beam. Such an electrostatic convergence system is used particularly when the beams lie near to each other because in that case there is little space for the pole shoes required in the case of magnetic convergence. This may be the case, for example, in a cathode-ray tube in which the various electron beams are produced by one gun.

It has been found that when the end faces of each of the abOve-mentioned substantially circular-cylindrical electrodes, located on the side of or within the other electrode associated with the convergence system, are flat surfaces at right angles to the axis of the cylinder, a rotational-symmetrical field is produced, it is true, but that such a lens field in the after-focusing of a beam the axis of which lies beyond the axis of the cylinder, produces an aberration which is not rotational-symmetrical with respect to the axis of the beam. As a result of this the spot of electrons formed by the beam has an astigmatic character. The rays of the beam located in the plane through the axis of the beam and the axis of the cylinder are actually focused towards the axis of the beam to a stronger extent as a result of the spherical aberration of the lens, than the rays lying in the plane through the axis of the beam which is perpendicular to the first plane. A plane through the axis of the cylinder is termed a meridional plane of the lens and the said plane through the axis of the beam and the axis of the cylinder thus is the meridional plane of the lens passing through the axis of the beam. The rays of the beam lying in this plane are termed meridional rays. A plane at right angles to the meridional planes of the lens is termed a sagittal plane of the lens and the rays of the beams lying in such a plane are termed sagittal rays. The rays lying in the said plane through the axis of the beam which is perpendicular to the meridional plane of the lens passing through the axis of the beam are to be considered as sagittal rays.

The invention is based on the discovery of the fact that the difference in intensity of the after-focusing for the meridional rays and the sagittal rays can be removed by a given disturbance of the rotation symmetry of the converging lens. According to the invention, the point of intersection of the line which forms an effective boundary line of the substantially circular-cylindrical electrodes with the planes through the axis of said electrodes and the axis of the beam not coinciding herewith lies farther away from the picture screen than the remaining parts of said line. When the electron gun system produces two or more electron beams, the axis of which does not coincide with the axis of the substantially circular-cylindrical grid, the points of intersection of the said line with the planes through the axis of said grid and the axis of each beam are located farther away from the picture screen than the remaining part of said line. The following serves to explain the expression "effective boundary line" of the substantially circular-cylindrical electrodes. When the lens action is obtained by means of one substantially circular-cylindrical grid and a conductive coating on the envelope, the diameter of the grid is smaller than the diameter of the relative part of the envelope and the conductive coating on the envelope usually overlaps a part of the grid. The effective boundary line in this case is the line which is located within the conductive coating and which the end of the grid describes on the cylinder. When the lens action is obtained by means of two substantially circular-cylindrical grids having unequal diameters and when that one grid overlaps the other, the effective boundary line in this case also is the line which the end of the grid describes on the cylinder with the smallest diameter. When the conductive coating and the grid or the grids do not overlap each other, which is the case in particular with two grids having the same diameters, then the effective boundary line is the line through the centers of the gap which is formed by the end of one electrode and the projection of the end of the other electrode on the plane of the cylinder of one electrode. In the case of two grids having the same diameters, the effective boundary line is the line through the centers of the gap between the grids. The desired action is based on the fact that the cross-sections of the equipotential planes with sagittal planes in the neighborhood of the axis of the beam are curved with the concave side facing the picture screen as a result of which an intensified focusing of the sagittal rays occurs, whereas the cross-sections of the equipotential planes with meridional planes in the neighborhood of the axis of the beam are curved with the convex side facing the picture screen as a result of which a weakened focusing of the meridional rays occurs, so that with a correct proportioning the sagittal rays and the meridional rays are focused substantially in one point. The effective boundary line may have various shapes. For example, it may have the form of a crenel. In particular it has a sinusoidal shape because the variation of the equipotential planes then is as gradual as possible. The number of sines on the circumference is then determined of course by the number of beams the axes of which do not coincide with the axis of the electrodes.

If the effective boundary line coincides with an end of a grid, said end should show the said variation. If the effective boundary line coincides with a line through the centers of a gap as described above, the said variation may be reached by profiling only one of the ends of the electrode which determine the gap while the other end lies in a plane normal to the axis of the electrodes. Alternatively, both ends may be given a profile, namely particularly a complementary profile.

By removing the astigmatism a more circular spot of electrons is formed on the picture screen but it has been found in addition that also a smaller spot of electrons is obtained.

In order that the invention may be readily carried into effect, it will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which FIGS. 1 and 7 show the conventional structure of the prior art and

FIG. 1 is a cross-sectional view of a cathode-ray tube.

FIG. 2 shows certain parts of the cross-sectional view shown in FIG. 1 on an enlarged scale,

FIG. 3 shows the form of the convergence electrodes,

FIG. 4 is a cross-sectional view of FIG. 3.

FIG. 5 is a plan view of FIG. 3,

FIG. 6 is a side-sectional elevation of FIG. 3,

FIG. 7 diagrammatically shows the path of rays of a beam in the case of FIG. 3,

FIG. 8 shows a form of the convergence electrodes according to the invention,

FIG. 9 is a cross-sectional view of FIG. 8,

FIG. 10 is a plan view of FIG. 8,

FIG. 11 is a side-sectional elevation of FIG. 8.

The cathode-ray tube 1 comprises a gun 2, shown diagrammatically, which produces three electron beams enclosing angles of 120° with respect to the axis of the beam and which converges these three electron beams on the shadow mask 3 after which they impinge each upon certain parts of the luminescent screen 4. The scanning of the screen is obtained by the deflection device 5 shown diagrammatically.

FIG. 2 shows the part of the neck of the tube in a partial cross-sectional view. One of the three cathodes 6, of the gun is visible. The two other cathodes are rotated over angles of 120° with respect to the axis of the gun. The gun comprises a common first grid 8 which comprises an aperture 9, for the beam from the cathode 6, a common second grid 10 which comprises an aperture 11 for the said beam, and a common third grid 12 which comprises an aperture 13 for the said beam. The centers of the apertures 9, 11 and 13 lie on a line 18 parallel to the axis of the gun which in this case coincides with the axis of the cathode 6. The gun further comprises a common fourth grid 14 and a common circular-cylindrical fifth grid 15. The fourth grid 14 consists of two interconnected circular-cylindrical parts 16 and 17. Of the grids 14 and 15, only the cross-sectional lines are shown. The pre-focusing for each of the electron beams takes place between the second grid 10 and the fourth grid 14, while an after-focusing takes place in the converging lens which is an accelerator lens and comprises the fourth grid 14 and the fifth grid 15, the lens field being produced between the circular-cylindrical part 17 and the circular-cylindrical grid 15 which have the same diameters.

FIG. 3 shows the form of the fourth and fifth grids of the prior art. The fourth grid 20 consists of two interconnected circular-cylindrical parts 22 and 23. The fifth grid 21 is circular-cylindrical and has the same diameter as the part 23. The ends of the grids 20 and 21 facing each other lie in flat planes perpendicular to the axis of the cylinders. The axes of the beams at the area of the centers of the gap are denoted by 24, 25 and 26. In order to illustrate the mutual positions of the beams, lines 27, 28 and 29 are drawn parallel to the axis of the cylinders through the points 24, 25 and 26. A plane perpendicular to the axis of the cylinders, intersects these lines in the points 30, 31 and 32 which form the corners of an equilateral triangle.

FIG. 4 is a cross-sectional view at right angles to the axis of the converging lens of FIG. 3; FIG. 5 is a plan view of the converging lens of FIG. 3; FIG. 6 is a front elevation of the converging lens of FIG. 3.

FIG. 4 shows the circular-cylindrical part 23 of the grid 20 within which the three beams 33, 34 and 35 are located at the area of the gap between the grids 20 and 21, of which beams the axes at that area in FIG. 3 are denoted by 24, 25 and 26, respectively.

FIG. 5 shows the plan view. The cross-sections of a few equipotential planes constituted by the gap as a result of the application of a voltage difference between the grids 20 and 21 and the plane which passes through the axis of the beam 33 at the area of the center of the gap, is parallel to the axis of the cylinders and is perpendicular to the meridional plane through the axis of the beam 33 are denoted by 36, 37, 38, 39, 40, 41 and 42. As shown in the Figure, these cross-sections are symmetrical on either side of the gap.

FIG. 6 shows the side-sectional elevation. The cross-sections of a few equipotential planes constituted by the gap as a result of the application of the same voltage difference between the grids 20 and 21 and the meridional plane through the axis of the beam 33 are denoted by 43, 44, 45, 46, 47, 48 and 49. As shown in the Figure these cross-sections are symmetrical on either side of the gap.

Since in the case described with reference to FIGS. 3, 4, 5 and 6 the axis of each beam in the lens field lies between the fourth and fifth grid, outside the axis of the cylinders, said lens field, in the after-focusing of each beam, produces an aberration. In FIG. 7, reference numeral 50 denotes the axis of the gun. The cross-over of each beam is reproduced virtually to an approximation in point 51 on the axis of the gun by the lens action between the second grid and the fourth grid. These common cross-overs should be reproduced in one point on the screen by the lens action between the fourth and fifth grid. Hence said lens action should simultaneously converge and focus the beams. Actually the said aberration occurs, which appears from the path of rays shown for one beam. The circle 53 is the cross-section of the beam with the main plane of the converging lens. The meridional rays of the beam lying in the plane through the axis 54 of the beam and the axis 50 of the gun—the beams 55 and 56 are shown in the figure—are focused to an approximation in the point 57. The rays lying in the sagittal plane through the axis of the beam of which the rays 58 and 59 are shown in the figure, are focused due to the rotational symmetry of the lens field around the axis 50 in point 60 on said axis. So the meridional rays are focused to a stronger extent to the axis of the beam than the sagittal rays. In this manner two focal lines 61, 62 and 63, 64 are formed which give rise to astigmatism of the spot of electrons obtained in the picture space. Of the other two beams the cross-sections 65 and 66 with the main plane of the converging lens are shown and the circle 67 through the centers of the beams in said plane, as well as a part of a few paths of rays all emerging from point 51.

FIG. 8 shows a form of the fourth and fifth grids according to the invention. The fourth grid 70 consists of two interconnected circular-cylindrical parts 72 and 73. The fifth grid 71 is circular-cylindrical and has the same diameter as the part 73. The ends of the grids 70 and 71 facing each other vary sinusoidally and that in a complementary manner so that the gap has a constant width and the center of the gap varies sinusoidally in the same manner. The axes of the beams at the area of the center of the gap are denoted by 74, 75 and 76. In order to illustrate the mutual position of the beams, lines 77, 78 and 79 are drawn through the points 74, 75 and 76 parallel to the axis of the cylinders. A plane perpendicular to the axis of the cylinders intersects said lines in the points 80, 81 and 82 which form the corners of an equilateral triangle. The variation of the said ends of the grids 70 and 71 is such that sinuses are described on the circumference in an axial direction, namely three in connection with the fact that there are three beams, while the largest deviations in the direction of the cathode lie at the area of the beams.

FIG. 9 is a cross-sectional view at right angles to the axis of the converging lens of FIG. 8; FIG. 10 is a plan view of the converging lens of FIG. 8; FIG. 11 is a front elevation of the converging lens of FIG. 8.

FIG. 9 shows the circular-cylindrical part 73 of the grid 70 within which the three beams 83, 84 and 85 are located at the area of the gap between the grids 70 and 71, of said beams the axes at that area in FIG. 8 are denoted by 74, 75 and 76, respectively.

FIG. 10 is the plan view. The cross-sections of a few equipotential planes constituted by the gap as a result of the application of a voltage difference between the grids 70 and 71 and the plane which passes through the axis of the beam 83 at the area of the center of the gap, is parallel to the axis of the cylinders and is perpendicular to the meridional plane through the axis of the beam 83, are denoted by 86, 87, 88, 89, 90, 91 and 92. As shown in the figure these cross-sections are not symmetrical on either side of the gap. Compared with the cross-section 36 to 42 from FIG. 5, they are curved at the area of the axis of the beam with the concave side in the direction of the fifth grid 71. As a result of this a stronger focusing of the sagittal rays of the beam is obtained.

FIG. 11 shows the side-sectional elevation. The cross-sections of a few equipotential planes formed by the gap as a result of the application of the same voltage difference between the grids 70 and 71 and the meridional plane through the axis of the beam 81 are denoted by 93, 94, 95, 96, 97, 98

and **99**. As shown in the figure these cross-sections are not symmetrical on either side of the gap. Compared with the cross-sections **43** to **49** of FIG. **6**, they are curved at the area of the axis of the beam with the convex side in the direction of the fifth grid **71**. As a result of this a weaker focusing of the meridional rays of the beam is obtained.

In a particular case the circular aperture **9** has a diameter of 0.75 mm, the circular aperture **11** has a diameter of 0.75 mm and the circular aperture **13** has a diameter of 2.0 mm. The distance between the line **18** through the centers of the apertures **9**, **11** and **13** and the axis **7** of the gun is 2.5 mm. The inside diameter of the part **72** of the fourth grid **70** is 14 mm and that of the part **73** is 22 mm. The inside diameter of the fifth grid **71** is also 22 mm. The dimension of the part **72** in the direction of the axis of the gun is 7 mm, the average dimension of the part **73** in that direction is 22 mm and the average dimension of the fifth grid **71** in said direction is 10 mm. The distance between the part **73** and the fifth grid is 2 mm. The sinusoidal variation of the ends of the part **73** and the grid **71** has an amplitude of 0.25 mm. The gun may be operated at the following voltages:

Cathode between 0 volt and 80 volt
First grid 0 volt.
Second grid 750 volt.
Third grid 350 volt.
Fourth grid between 3,400 volt and 4,200 volt.
Fifth grid 25,000 volt.

The variable voltage at the cathode serves for controlling the beam and that at the fourth grid for the convergence of the beams as a function of their impact areas on the screen. With a maximum current of 2,500 μA per beam it has been found that the form of the gap of the convergence lens according to the invention provides a reduction of the spot of electrons of approximately 15 percent.

I claim:

1. A cathode ray tube comprising an evacuated envelope, a plurality of electron guns within said envelope each gun of said plurality being at the vertex of a triangle for producing a plurality of electron beams having a triangular configuration, at least two cylindrical electrodes arranged in consecutive order and surrounding the path of said beams, the ends of said electrodes confronting each other and defining an effective boundary line providing an aberration reducing electrostatic field for said electron beams, said effective boundary line having a shape resulting from the combination of two sine curves, the period of one being twice the period of the other, a luminescent screen positioned within said envelope to intercept said electron beams, a shadow mask electrode within said envelope between said electron gun and said screen, said shadow mask electrode being proximately spaced from and parallel to said screen, said cylindrical electrodes substantially converging said beams in the plane of the shadow mask electrode, said screen comprising a plurality of different luminescing substances, said electron gun producing a plurality of beams corresponding to the number of different luminescing substances, the distance between said effective boundary line and said screen having maximum values at areas of points of intersections of the line which forms said effective boundary with the axes of said electron beams.

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