

PATENT SPECIFICATION

(11)

1231985

DRAWINGS ATTACHED

- (21) Application No. 5807/70 (22) Filed 6 Feb. 1970
 (31) Convention Application No. 6902025 (32) Filed 8 Feb. 1969 in
 (33) Netherlands (NL)
 (45) Complete Specification published 12 May 1971
 (51) International Classification H 01 j 29/62
 (52) Index at acceptance

HID 4A4 4A7 4E1 4E3B2 4E3Y 4G6 4GY 4K4 4K7
 4K8



(54) CATHODE-RAY TUBE INCLUDING AN ELECTRON GUN
 SYSTEM FOR PRODUCING A PLURALITY OF ELECTRON
 BEAMS

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to a cathode-ray tube comprising an electron gun system for producing a plurality of electron beams, at least two common, substantially circular-cylindrical and substantially coaxial electrodes whose axis does not coincide with the axis of the paths of one or more of said beams, and a display screen. The gun system may comprise a separate gun for each beam, each gun having an independent cathode, control grid and accelerating electrodes. As an alternative the system may comprise a single gun having common accelerating electrodes and a common control grid or cathode for all the beams. The display screen may be made up from a plurality of substances which are capable of luminescing in different colours in response to electron bombardment and the tube may include a colour selection electrode arranged adjacent and on the gun side of said screen, the electron gun system producing a number of electron beams corresponding with the number of luminescing substances, and a lens field obtained by means of the common, substantially circular-cylindrical electrodes at least contributing to the convergence of said beams in the plane of the colour selection electrode.

In such a colour-display tube each of the electron beams is focused on the display screen or in a plane located near said screen, for example that of the colour selection electrode. This is performed partly by the lens effect between successive electrodes of the gun or guns, which thus provide a first focusing effect. The lens effect of the common, substantially circular-cylindrical electrodes causes the electron beams to converge substantially in the

plane of the colour selection electrode (which may be a shadow-mask electrode). This lens effect can be obtained by means of a free-standing substantially circular-cylindrical electrode together with conductive coating on the tube envelope, by means of two free-standing substantially circular-cylindrical electrodes (which may have substantially equal diameters) or by means of more than two substantially circular-cylindrical electrodes. This lens effect usually additionally provides the required second focusing action on each electron beam. Such an electro-static converging system is particularly suitable when the beams are close to each other, because there is then little room for the pole pieces which would be required for magnetic convergence. This may be the case in a cathode-ray tube in which the various electron beams are produced by a single gun. If the number of electron beams is three and if the centres of the beams in the gun lie at the corners of an isosceles triangle, dynamic convergence is required. In principle, dynamic convergence may be dispensed with by using a special type of deflection coil, provided that the electron beams in the gun are substantially co-planar.

It has been found that if the adjacent ends of each of said substantially circular-cylindrical electrodes lie in planes at right angles to the cylinder axis, a rotation-symmetrical field is produced but that such a lens field produces an asymmetrical second focusing action on a beam whose axis does not coincide with the axis of the cylinder. As a result the electron spot produced by the beam on the screen assumes an elongate form. The electrons of the beam which move in a plane containing the axis of the beam and the axis of the cylinder are focused more strongly than electrons which move in the plane which contains the axis of the beam and which is perpendicular to the first plane. A plane containing the axis of the cylinder is termed a meridional plane of the lens and electrons which move in such a plane

which also contains the axis of the beam will be termed "meridional electrons". A plane at right angles to a meridional plane of the lens is termed a sagittal plane of the lens and electrons which move in the sagittal plane which contains the axis of the beam and which is perpendicular to the meridional plane of the lens containing the beam axis will be termed "sagittal electrons". When a beam whose axis substantially coincides with the cylinder axis is subjected to the second focussing action said focusing difference between the meridional and sagittal electrons does not occur, since a field which is rotation-symmetrical about the beam axis is present at this position.

The difference in the second focusing action on the meridional and the sagittal electrons of a beam whose axis does not substantially coincide with the cylinder axis may be reduced by disturbing the rotation-symmetry in a particular manner. However, it must not be such as to disturb the focussing of a beam whose axis coincides with the cylinder axis. Thus the difference in post-focusing of the meridional and the sagittal electrons of a beam whose axis does not coincide with the cylinder axis, has to be eliminated while keeping the field substantially rotation-symmetrical at the cylinder axis.

The invention provides a cathode-ray tube comprising an electron gun system for producing a plurality of electron beams, at least two common, substantially circular-cylindrical and substantially coaxial electrodes whose axis does not coincide with the axis of the paths of one or more of said beams, and a display screen, the axes of the electron beam paths and the substantially circular-cylindrical electrodes being located substantially in a plane, the axis of one beam substantially coinciding with the axes of the substantially circular-cylindrical electrode, the distances between the effective boundary line (as herein defined) of the substantially circular-cylindrical electrodes and the display screen at its points of intersection with said plane being relative maxima and greater than the average distance between said line and said screen, and the distances between the points of intersection with a plane perpendicular to said plane and containing the axis of the electrodes also being relative maxima.

The term "effective boundary line of the substantially circular-cylindrical electrodes" means the following: If the first and second substantially circular-cylindrical electrodes are a free-standing electrode and a conductive coating on the tube envelope, respectively, then the diameter of the first electrode will be smaller than that of the second and the conductive coating on the envelope will usually overlap a part of the first electrode. The effective boundary line is then the normal projection of the end of the free-standing first electrode which is enclosed by the second electrode on to said second electrode. If the first and

second electrodes are both free-standing substantially circular-cylindrical electrodes of unequal diameters and if one electrode overlaps the other, the effective boundary line is again the normal projection of the end of the smaller diameter cylinder on to the cylinder having the larger diameter. If the first and second electrodes do not overlap each other (which will certainly be the case when the two electrodes have equal diameters) the effective boundary line will be either the centre-line of the gap between the end of the larger electrode and the projection of the adjacent end of the smaller electrode on an imaginary continuation of the larger electrode or, with two electrodes of equal diameter, the centre-line of the gap between the electrodes.

The desired effect obtained by making the distance of the effective boundary line from the display screen, where it cuts a plane containing the electron beams, a relative maximum and greater than the average distance, is achieved because the intersections of the equipotential surfaces of the lens with a sagittal plane which contains the axis of a beam which does not coincide with the cylinder axis are made curved to that they are concave towards the display screen so that intensified focusing of the sagittal electrons is produced, whereas the intersections of the equipotential planes with a meridional plane which contains the beam axis are made curved so that they are convex towards the display screen so that a reduced focusing of the meridional electrons is produced. The difference between the second-focusing action on the meridional and sagittal electrons of such a beam can thus be reduced. If desired, the sagittal and the meridional electrons can thus be focussed substantially at one point. In order to ensure that the field required for the beam whose axis coincides with the cylinder axis is still obtained, even when this is done, the distances between the effective boundary line and the display screen at the points of intersection of said line with a plane perpendicular to the plane containing the axes of the electron beams and which contains the cylinder axis are also made relative maxima. Said distances are preferably substantially equal to the corresponding distances where the effective boundary line intersects the plane containing the axes of the electron beams. The strengths of the converging lens in two orthogonal planes containing the axis of the cylinders will then be the same so that the field has four planes of symmetry, which is a favourable situation for the beam whose axis coincides with that of the cylinders.

The effective boundary line may have various forms. It may, for example, have a square-wave form but it preferably has no discontinuities because a smoother variation of the equipotential planes will then be obtained. In the particular case in which the distance between the effective boundary line and the

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display screen has four equal maxima, the effective boundary line preferably has a sinusoidal shape, because the variation of the equipotential planes will then be as gradual as possible.

If the effective boundary line coincides with an end on a said electrode, this end should preferably follow its profile. If the effective boundary line is the centre-line of the gap as described above, its required shape may be obtained by profiling only one of the adjacent ends of the electrodes determining the gap, while the other end lies in a plane normal to the axis of the electrodes. Both ends may be profiled, as an alternative, preferably in a complementary manner.

By obviating the astigmatism a more circular electron spot is produced on the display screen and it has been found that this spot can be made smaller.

If one or more of the beams is not rotation-symmetrical about its axis after having left the first focusing lens, said shape of the effective boundary line allows the astigmatism to be removed so that circular electron spots can be obtained for all beams on the display screen. It is furthermore possible to produce an elongate, for example vertical, electron spot on the display tube from beams which initially have a rotation-symmetrical nature. This could not be done for all beams if they pass through a converging system the circular-cylindrical electrodes of which have end faces located in planes, since the rotation-symmetry is maintained for the beam whose axis coincides with the axes of the electrodes whilst it is difficult to obtain the correct degree of astigmatism for the beams located away from the axis. This elongate electron spot shape can, however, be obtained for all beams by using the shape of the effective boundary line described. In these two cases the distances between the effective boundary line of the substantially circular-cylindrical electrodes and the display screen where it intersects the plane normal to the plane containing the axes of the electron beams and the axis of the electrodes will not be equal to the corresponding distances where it intersects the plane containing the axes of the electron beams. The effective boundary line may then have the form of two superimposed sine curves, two cycles of one and four cycles of the other being included in the boundary line. In this way the boundary line can be made to have a smooth shape.

Embodiments of the invention will now be described more fully, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a longitudinal section of a cathode-ray tube,

Figure 2 shows parts of the section of Figure 1 on an enlarged scale,

Figure 3 shows the shape of some known converging electrodes,

Figure 4 is a radial section of the electrodes of Figure 3,

Figure 5 is a section of the electrodes of Figure 3 taken perpendicular to the plane of the paper,

Figure 6 is a section of the electrodes of Figure 3 taken perpendicular to the plane of Figure 5,

Figure 7 illustrates schematically the paths of electrons of a beam in the lens of Figure 3,

Figure 8 shows the shape of some converging electrodes according to the invention,

Figure 9 is a radial section of the electrodes of Figure 8,

Figure 10 is a section of the electrodes of Figure 8 taken perpendicular to the plane of the paper,

Figure 11 is a section of the electrodes of Figure 8 taken perpendicular to the plane of Figure 10,

Figure 12 is a developed view of part of Figure 8,

Figure 13 is a developed view of another two circular-cylindrical electrodes, and

Figure 14 is a developed view of two other circular-cylindrical electrodes.

The cathode-ray tube 1 of Figure 1 comprises a gun 2 (shown schematically) producing three electron beams, whose centres are located in a plane containing the axis of the gun, the axis of the central electron beam coinciding with the gun axis. These three electron beams are converged on a shadow-mask 3, after which the beams each strike given parts of a luminescent screen 4. The screen is scanned by means of a deflection device 5 shown schematically.

In Figure 2 the gun comprises three cathodes 6, 7 and 8, a common first grid 9 having openings 10, 11 and 12 for the beams from the cathodes 6, 7 and 8, a common second grid 13 having openings 14, 15 and 16 and a common third grid 17 having openings 18, 19 and 20. The centres of the openings 11, 15 and 19 are located on the axis 21 of the gun, whereas the centres of the openings 10, 14 and 18 are located on a line 22 parallel to the axis 21, and the centres of the openings 12, 16 and 20 are located on a line 23 also parallel to the axis 21. The line 22 coincides with the axis of the cathode 6, the axis 21 coincides with the axis of the cathode 7 and the line 23 coincides with the axis of the cathode 8. The tube also includes a common fourth electrode 24 and a common, circular-cylindrical fifth electrode 25. The fourth electrode 24 comprises two interconnected, circular-cylindrical portions 26 and 27. Each of the electron beams is subjected to a first focussing action between the second grid 13 and the fourth electrode 24, and to a second focussing action in the accelerating converging lens comprising the fourth electrode 24 and the fifth

electrode 25, the lens field being produced between the circular-cylindrical portion 27 and the circular-cylindrical electrode 25, which have equal diameters.

5 Figure 3 shows the shape of known fourth and fifth electrodes. The fourth electrode 30 comprises two interconnected, circular-cylindrical portions 32 and 33. The fifth electrode 31 is circular-cylindrical and has the same diameter as the portion 33. The adjacent ends of the electrodes 30 and 31 are located in planes normal to the axis of the cylinders. The axes of the beams at the centres of the gap are indicated by 34, 35 and 36, which points are located on a line 37.

10 The sectional view of Figure 4 (taken at right angles to the axis of the converging lens of Figure 3) shows the circular-cylindrical portion 33 of the electrode 30 together with the three beams 38, 39 and 40 in the gap between the electrodes 30 and 31, the axes of which beams are designated in Figure 3 by 34, 35, 36 respectively, at this position.

15 Figure 5 shows the intersections of some equipotential planes, formed at the gap due to the application of a voltage difference between the electrodes 30 and 31, and the meridional plane containing the axes of the beams 38, 39 and 40. These intersections are designated by 41, 42, 43, 44, 45, 46 and 47. From the Figure it is apparent that these intersections are symmetrical on either side of the gap.

20 Figure 6 shows the intersections of some equipotential planes, formed at the gap due to the application of the same voltage difference between the electrodes 30 and 31, and the plane containing the axis of the beams 38 at the centre of the gap and which is normal to the meridional plane containing the axes of the beams 38, 39 and 40. These intersections are designated by 48, 49, 50, 51, 52, 53 and 54. From the Figure it will be apparent that these intersections are again symmetrical on either side of the gap.

25 Because in the case described with reference of Figures 3, 4, 5 and 6 the axes of the beams 38 and 40 in the lens field between the fourth and fifth electrodes do not coincide with the axes of the cylinders, this lens field produces an aberration in the second focussing action to which these beams are subjected. The axis of the gun is designated by 55 in Figure 7. A virtual crossover of each of the beams 38 and 40 is reproduced by the lens effect between the second and fourth electrodes approximately at the point 56 on the axis of the gun. These common cross-overs have to be reproduced at a single point on the screen by the lens effect between the fourth and fifth electrodes. This lens effect has therefore to converge and focus the beams simultaneously. In fact an aberration is produced, which is evident from the electron paths illustrated for the beams. The circle 57 is a section of the beam 38 taken in the main plane of the converging lens. The

meridional electrons of the beam located in the plane containing the axis 58 of the beam and the axis 55 of the gun—the paths 59 and 60 thereof are illustrated in the Figure—are focused approximately at point 61. The electrons located in the sagittal plane containing the axis of the beam—the Figure illustrates the rays 62 and 63—are focused at point 64 which lies on the axis 55 owing to the rotation-symmetry of the lens field about the axis 55. The meridional electrons are thus more strongly focused towards the axis of the beam than the sagittal rays. In this manner two focal lines 65—66 and 67—68 are formed, which give rise to astigmatism of the electron spot obtained at the intended focus position. The same applies to the beam 40, a section 69 of which is shown, taken in the main plane of the converging lens. The centres of the circles 57 and 69 are located on a line 70, which intersects the axis 55 of the gun. The meridional electron paths 71 and 72 and the sagittal electron paths 73 and 74 of the beam 40 are shown in the Figure. The sagittal and meridional electrons of the beam 39 (not shown) whose axis coincides with the axis 55 of the gun are focused at one point.

Figure 8 illustrates a possible shape of the fourth and fifth electrodes according to the invention. The fourth electrode 80 comprises two interconnected, circular-cylindrical portions 82 and 83. The fifth electrode 81 is circular-cylindrical and has the same diameter as the portion 83. The adjacent ends of the electrodes 80 and 81 have a sinusoidal shape in a complementary manner so that the gap between them has a constant width and the centre of the gap follows the same sinusoidal form. The axes of the beams at the centres of the gap are indicated by 84, 85, 86 and these points are located on a line 87.

Figure 9 is a sectional view taken at right angles to the axis of the converging lens of Figure 8 and shows the circular-cylindrical portion 83 of the electrode 80 with the positions of the three beams 88, 89 and 90 at the gap between the electrodes 80 and 81, the axes of which beams at this position are designated in Figure 8 by 84, 85 and 86 respectively.

Figure 10 shows the intersections of some equipotential planes, formed by the gap due to the application of a voltage difference between the electrodes 80 and 81, and the meridional plane containing the axes of the beams 88, 89 and 90. These intersections are designated by 91, 92, 93, 94, 95, 96 and 97. From the Figure it will be apparent that the intersections are still almost symmetrical on either side of the gap. As compared with the intersections 41 to 47 of Figure 5 they are slightly more convex towards the fifth electrode 81, at positions near the axes of the beams 88 and 90. Thus the focusing of the meridional electrons of the beams 88 and 90 is slightly weakened.

Figure 11 shows the intersections of some equipotential planes, formed by the gap due to the application of the same voltage difference between the electrodes 80 and 81, and the plane containing the axis of the beam 88 at the centre of the gap and normal to the meridional plane containing the axes of the beams 88, 89 and 90. These intersections are designated by 98, 99, 100, 101, 102, 103 and 104. From the Figure it will be apparent that the intersections are not symmetrical about the gap. As compared with the intersections 48 to 54 of Figure 6 they are more concave towards the fifth electrode 81, at positions near the axis of the beam 88. Thus the focusing of the sagittal electrons of the beam 88 is strengthened. In this manner focusing of the meridional and sagittal electrons of the beam 88 can be obtained at one point.

Figure 12 is a developed view of part of the circular-cylindrical portion 83 of the electrode 80 and of part of the circular-cylindrical electrode 81. The intersections thereof with the plane containing the beams are designated by 110 and 112. These intersections cross the edge of the portion 83 at points 106 and 108 as indicated in Figure 9. The intersections of the portion 83 with the plane normal to the plane of the beams and which passes through the axes of the electrodes are designated by 109 and 111. These intersections cross the edge of the portion 83 at points 105 and 107, as shown in Figure 9. The effective boundary line of the circular-cylindrical electrodes is the line 113 which crosses the intersections 109, 110, 111 and 112 at points 114, 115, 116 and 117 respectively. The distances of the points 115 and 117 from the display screen (not shown) are relative maxima and greater than the average distance of the line 113 from the display screen. It is thus ensured that in the beams 88 and 90 the meridional electrons are focused to a lesser extent and the sagittal electrons to a greater extent so that the sagittal electrons and the meridional electrons are focused substantially at one point. Since the distances of the points 114 and 116 from the display screen are also relative maxima and are equal to those of the points 115 and 117 from the display screen the disturbance of the rotation-symmetry, caused by the configuration at 115 and 117, about the beam 89 located on the axes of the electrons is substantially neutralised. In this case the field of the converging lens has four planes of symmetry and is quasi-symmetrical about the axis.

In one example the circular openings 10, 11 and 12 in the first grid 9 had a diameter of 0.75 mm, the circular openings 14, 15 and 16 in the second grid 13 had a diameter of 0.75 mm and the circular openings 18, 19 and 20 in the third grid 17 had a diameter of 2.0 mm. The distance of the line 22 through the centres of the openings 10, 14 and 18 from the axis 21 of the gun was 3.5 mm and the

distance of the line 23 through the centres of the openings 12, 16 and 20 from the axis 21 of the gun was also 3.5 mm. The inner diameter of the portion 82 of the fourth electrode 80 was 14 mm and that of the portion 83 was 20 mm. The inner diameter of the fifth electrode 81 was also 20 mm. The length of the portion 82 in the direction of the gun axis was 7 mm, the average length of the portion 83 in said direction was 18 mm and the average length of the fifth electrode 81 in said direction was 10 mm. The distance between the portion 83 and the fifth electrode 81 was 2 mm. The sinusoidal form of the ends of the portion 83 and the electrode 81 had an amplitude of 0.18 mm. This gun may be supplied by the following voltages:

cathode	0 to 140 V
first grid	0 V
second grid	1,700 V
third grid	350 V
fourth electrode	4,300 V
fifth electrode	25,000 V

The variable cathode voltage serves for controlling the beam current.

In this example, the beams were initially circular-symmetrical and the gap shape described gives circular-symmetrical resultant electron spots. However, an electron spot of astigmatic nature may be desired. For example, the three beams may be located in a horizontal plane and may scan the display screen along horizontal lines. In order to avoid Moiré effects it may then be desirable for the electron spots to have the form of vertical lines. With initially circular-symmetrical beams the electrodes of the converging lens may then have the form shown in Figure 13.

In Figure 13 circular-cylindrical electrodes 120 and 121 are again located one on each side of a gap and have equal diameters, the electrode 121 being nearest the display screen. The intersections thereof with the horizontal plane containing the beams are designated by 123 and 125. The intersections thereof with the vertical plane containing the axes of the electrodes are denoted by 122 and 124. The effective boundary line of the circular-cylindrical electrodes is the line 126 which cuts the intersections 122, 123, 124 and 125 at points 127, 128, 129 and 130 respectively. The distances of the points 128 and 130 from the display screen (not shown) are equal, are relative maxima and are greater than the average distance of the line 126 from the display screen. The distances of the points 127 and 129 from the display screen are equal and are greater than the distances of the points 128 and 130 from the display screen and are also relative maxima. If the electrodes had straight edges the meridional electrons of the beams located away from the axes of the electrodes would be focused more strongly towards the

axis of the corresponding beam than the sagittal electrons so that the resulting electron spot would have an astigmatic shape. Since the beams are located in a horizontal plane containing the axes of the cylinders, these beams would form a vertical line focus for the meridional electrons and a horizontal line focus in a plane further away from the gun for the sagittal electrons. With the shape of the gap shown at 128 and 130 the difference in the second focusing action on the meridional and sagittal electrons of these beams is reduced. However a vertical line is still produced in the plane in which the meridional electrons are focused, and this plane is made that of the display screen. Owing to the shape of the gap at 128 and 130 the field on the axes of the electrodes is no longer rotation-symmetrical so that the electron spot formed by the central beam is astigmatic giving a horizontal line in a plane in which the sagittal electrons are focused and a vertical line in a plane further away from the gun where the meridional electrons are focused. Since the distances of the points 127 and 129 from the display screen are also relative maxima, the difference in the second focusing action on the meridional and sagittal electrons of this beam is reduced and, since the distances of 127 and 129 from the display screen are greater than those of the points 128 and 130, this difference becomes so great that the position is reversed and the beam has an astigmatic nature such that the plane in which the meridional electrons are focused to give a vertical line becomes nearer the gun than the plane in which the sagittal electrons are focused to give a horizontal line. In this way the three beams can each be made to give a vertical line in the same plane.

Figure 14 illustrates another configuration in accordance with the invention. This Figure is a developed view of part of circular-cylindrical electrodes 140 and 141 of equal diameters located one on each side of a gap, the electrode 141 being located nearest the display screen. The intersections thereof with the horizontal plane containing the beam axes are designated by 143 and 145. The intersections thereof with the vertical plane going through the cylinder axes are denoted by 142 and 144. The effective boundary line of the circular-cylindrical electrodes is the line 146, which intersects the lines 142, 143, 144 and 145 at 147, 148, 149 and 150 respectively. The distances of the points 148 and 150 from the display screen (not shown) are equal, are relative maxima and are greater than the average distance of the line 146 from the display screen. The distances of the points 147 and 149 from the display screen are equal, are less than the distances of the points 148 and 150 from the display screen and are also relative maxima. This con-

figuration of the electrodes may be used for producing circular-symmetrical electron spots when the beams have such an astigmatic nature prior to their passage through the lens formed by said electrodes that their extension in a vertical direction exceeds that in the horizontal direction. This may be due to the presence of vertical, elliptic apertures in the first focusing grid so that excessive first focusing of the meridional electrons is produced.

WHAT WE CLAIM IS:—

1. A cathode-ray tube comprising an electron gun system for producing a plurality of electron beams, at least two common, substantially circular-cylindrical and substantially coaxial electrodes whose axis does not coincide with the axis of the paths of one or more of said beams, and a display screen, the axes of the electron beam paths and the substantially circular-cylindrical electrodes being located substantially in a plane, the axis of one beam substantially coinciding with the axes of the substantially circular-cylindrical electrodes, the distances between the effective boundary line (as herein defined) of the substantially circular-cylindrical electrodes and the display screen at its points of intersection with said plane being relative maxima and greater than the average distance between said line and said screen, and the distances between the points of intersection with a plane perpendicular to said plane and containing the axis of the electrodes also being relative maxima.
2. A tube as claimed in Claim 1, wherein the display screen comprises a plurality of substances which are capable of luminescing in different colours in response to electron bombardment and the tube includes a colour selection electrode arranged adjacent and on the gun side of said screen, the electron gun system being constructed and arranged for producing a number of electron beams corresponding with the number of luminescent substances, said circular-cylindrical electrodes being capable of producing a lens field at least contributing to converging said beams in the plane of the colour selection electrode when energised.
3. A tube as claimed in Claim 1 or 2 wherein said distances between the points of intersection with the plane normal to the plane containing the axes of the electron beams and said screen are substantially equal to said distances between the points of intersection with the plane containing the axes of the electron beams and said screen.
4. A tube as claimed in Claim 3 wherein the effective boundary line as a sinusoidal form.
5. A tube as claimed in Claim 1 or 2, wherein the effective boundary line has the form



axis of the corresponding beam than the sagittal electrons so that the resulting electron spot would have an astigmatic shape. Since the beams are located in a horizontal plane containing the axes of the cylinders, these beams would form a vertical line focus for the meridional electrons and a horizontal line focus in a plane further away from the gun for the sagittal electrons. With the shape of the gap shown at 128 and 130 the difference in the second focusing action on the meridional and sagittal electrons of these beams is reduced. However a vertical line is still produced in the plane in which the meridional electrons are focused, and this plane is made that of the display screen. Owing to the shape of the gap at 128 and 130 the field on the axes of the electrodes is no longer rotation-symmetrical so that the electron spot formed by the central beam is astigmatic giving a horizontal line in a plane in which the sagittal electrons are focused and a vertical line in a plane further away from the gun where the meridional electrons are focused. Since the distances of the points 127 and 129 from the display screen are also relative maxima, the difference in the second focusing action on the meridional and sagittal electrons of this beam is reduced and, since the distances of 127 and 129 from the display screen are greater than those of the points 128 and 130, this difference becomes so great that the position is reversed and the beam has an astigmatic nature such that the plane in which the meridional electrons are focused to give a vertical line becomes nearer the gun than the plane in which the sagittal electrons are focused to give a horizontal line. In this way the three beams can each be made to give a vertical line in the same plane.

Figure 14 illustrates another configuration in accordance with the invention. This Figure is a developed view of part of circular-cylindrical electrodes 140 and 141 of equal diameters located one on each side of a gap, the electrode 141 being located nearest the display screen. The intersections thereof with the horizontal plane containing the beam axes are designated by 143 and 145. The intersections thereof with the vertical plane going through the cylinder axes are denoted by 142 and 144. The effective boundary line of the circular-cylindrical electrodes is the line 146, which intersects the lines 142, 143, 144 and 145 at 147, 148, 149 and 150 respectively. The distances of the points 148 and 150 from the display screen (not shown) are equal, are relative maxima and are greater than the average distance of the line 146 from the display screen. The distances of the points 147 and 149 from the display screen are equal, are less than the distances of the points 148 and 150 from the display screen and are also relative maxima. This con-

figuration of the electrodes may be used for producing circular-symmetrical electron spots when the beams have such an astigmatic nature prior to their passage through the lens formed by said electrodes that their extension in a vertical direction exceeds that in the horizontal direction. This may be due to the presence of vertical, elliptic apertures in the first focusing grid so that excessive first focusing of the meridional electrons is produced.

WHAT WE CLAIM IS:—

1. A cathode-ray tube comprising an electron gun system for producing a plurality of electron beams, at least two common, substantially circular-cylindrical and substantially coaxial electrodes whose axis does not coincide with the axis of the paths of one or more of said beams, and a display screen, the axes of the electron beam paths and the substantially circular-cylindrical electrodes being located substantially in a plane, the axis of one beam substantially coinciding with the axes of the substantially circular-cylindrical electrodes, the distances between the effective boundary line (as herein defined) of the substantially circular-cylindrical electrodes and the display screen at its points of intersection with said plane being relative maxima and greater than the average distance between said line and said screen, and the distances between the points of intersection with a plane perpendicular to said plane and containing the axis of the electrodes also being relative maxima.

2. A tube as claimed in Claim 1, wherein the display screen comprises a plurality of substances which are capable of luminescing in different colours in response to electron bombardment and the tube includes a colour selection electrode arranged adjacent and on the gun side of said screen, the electron gun system being constructed and arranged for producing a number of electron beams corresponding with the number of luminescent substances, said circular-cylindrical electrodes being capable of producing a lens field at least contributing to converging said beams in the plane of the colour selection electrode when energised.

3. A tube as claimed in Claim 1 or 2 wherein said distances between the points of intersection with the plane normal to the plane containing the axes of the electron beams and said screen are substantially equal to said distances between the points of intersection with the plane containing the axes of the electron beams and said screen.

4. A tube as claimed in Claim 3 wherein the effective boundary line as a sinusoidal form.

5. A tube as claimed in Claim 1 or 2, wherein the effective boundary line has the form

of two superimposed sine curves, two cycles of one and four cycles of the other being included in the boundary line.

6. A cathode-ray tube substantially as described herein with reference to Figures 8 to 11 and Figures 12, 13 or 14 of the drawings.

C. A. CLARK,
Chartered Patent Agent,
Century House,
Shaftesbury Avenue,
London, W.C.2.
Agent for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1971.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.

