

PATENT SPECIFICATION

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DRAWINGS ATTACHED



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(54) CATHODE-RAY TUBE

(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:—

- 5 This invention relates to a cathode-ray tube comprising an electron gun for producing an electron beam, and a display screen, said electron gun comprising a cathode and, in order therefrom, a first grid, an accelerating second grid, and a third grid.

- 10 In such a cathode-ray tube the electron beam is usually focused to a spot substantially on the display screen, the spot causing the relevant part of the screen to luminesce. The electron beam scans the display screen according to a particular pattern so that the spot moves over the screen. The size of the spot depends, *inter alia*, on the beam current. The brightness of the luminescing part of the screen also depends on the beam current, and thus greater brightness goes hand in hand with a larger spot. The screen is usually scanned along horizontal lines which may be quite prominent, especially with a low beam current, because the spot is then comparatively small. When the spot is larger two successive lines may partly overlap so that the separate lines become less visible and consequently the line structure of the display as a whole becomes less conspicuous.

- 15 The line structure of the display may be a particular nuisance in a shadow-mask cathode-ray tube for displaying colour pictures. In such a cathode-ray tube a plurality of electron beams are produced and each electron beam excites a different luminescent substance on the screen, the apertured shadow-mask preventing the electrons of

each beam from reaching the other luminescent substance. Annoying Moiré patterns may occur during operation of the tube as a result of optical interference between the line structure of the display and the aperture configuration of the mask. It is known that the occurrence of such Moiré patterns can be prevented by choosing the mutual spacing of the apertures in a particular manner in relation to the line separation. The line separation is a function of the dimension of the display at right-angles to the scanning lines (in the case of horizontal scanning lines this will be the height of the display) and of the number of scanning lines per display. The mutual spacing of the mask apertures should hence be chosen in accordance with the height of the display and the number of scanning lines per display.

However, the choice of the mutual spacing of the mask apertures is restricted for other reasons, so that the occurrence of Moiré patterns cannot always be prevented by a suitable choice of the aperture spacing. If a mask is available having a suitable spacing of the mask holes for a given height of the display screen, the spacing of the mask holes in a mask for a smaller display screen should be smaller in comparison with the former mask, since the line separation will be smaller. A smaller spacing of the mask holes cannot be realised without the holes themselves also being made smaller, because otherwise the mask could not fulfil its function of preventing the electrons of a given electron beam from reaching one or more of the other luminescent substances. It is difficult to manufacture a mask having a large number of such small holes. It is also then difficult to lay down the luminescent substances which make up the display screen. Moreover, the distance between the mask and the display screen should also be reduced when the spacing of the mask holes is reduced. A re-

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duction of this distance presents difficulties in connection with the reduced tolerances then imposed on the positioning of the mask.

5 The value of the tube deflection angle also affects the choice of the mask hole spacing. The angle between the direction in which an electron beam passes through a mask hole and the longitudinal axis of the tube increases with increasing deflection angle of the beam. During operation of the tube the mask is heated by the electrons and the mask is usually suspended so that it moves towards the screen when it is so heated. The spot which is formed by an electron beam behind a given mask hole is displaced as a result of the mask displacement and the spot displacement increases with increasing deflection angle. This displacement of the spot on the screen may allow the electrons to impinge upon a luminescent substance other than the one intended, so that so-called "mislanding" will occur. For a given transmission of the mask the extent of the mislanding increases with decreasing spacing of the mask holes. It is therefore desirable that the mask hole spacing is large in tubes in which a large deflection angle, for example 110° , occurs. This does not allow a free choice of the mask hole spacing for stopping the occurrence of Moiré patterns.

10 It is therefore important to find a different way of stopping the occurrence of Moiré patterns. This could be done by making the line structure of the display less prominent. As already noted, the line structure is usually less visible with a large beam current than with a small beam current. It is therefore desirable to also make the line structure less visible with a small beam current without this resulting in undesirable side-effects. The line structure can be made less visible with a small beam current by increasing the dimension of the spot in a direction at right-angles to the scanning lines, so that the spots of two successive lines partly overlap each other even with a small beam current. However, this must not result in the dimension of the spot in a direction parallel to the scanning lines also being materially increased, because that would adversely affect the definition of the display in that direction. In addition any measure taken should not increase the (already larger) spot dimensions present with large beam currents because otherwise the definition of the display in the two orthogonal directions would be reduced. Furthermore, any measure taken should not, in the case of a large beam current, materially increase the dimensions of the electron beam where it passes through the deflection plane because otherwise the penumbra effect of the electron beam occurring behind the mask holes would be

inadmissibly increased.

On the basis of these considerations it will be seen that the beam should be influenced more at low beam currents than at high beam currents, and that this influence should mainly result in an increase of the spot dimension at right-angles to the scanning lines.

The invention provides a cathode-ray tube comprising an electron gun for producing an electron beam and a display screen, said electron gun comprising a cathode and, in order therefrom, a first grid, a second accelerating grid, and a third grid, an astigmatic lens element being present in the electron gun between or at the first grid side of the second grid and the side of the third grid which is furthest from the cathode, said element being provided on or being formed by a said grid.

Said astigmatic lens element can be made to operate as follows. A first cross-over of the beam is formed by the cathode, the first and the second grids. This cross-over usually lies between the first grid and the third grid, its actual position depending upon the beam current and the configuration of the grids. With low beam currents the cross-over can be made to lie between the first and the second grid, while with increasing beam current it moves away from the cathode towards the space between the second and the third grid. As a result of the fact that the cross-over lies between the first and second grid with a low beam current and that an astigmatic lens element is present in the region specified, the beam is then influenced by said astigmatic lens element so that an increase in the dimension of a spot formed by the beam on the screen, which dimension is at right-angles to a scanning line, can be obtained with a correct orientation of the astigmatic element. When the beam current increases, the cross-over moves towards the astigmatic lens element so that the influence thereof on the beam is reduced. When the cross-over coincides with the optical centre of the astigmatic lens element, the beam will not be substantially influenced by the element.

The astigmatic lens element may be constructed in various ways: a non-rotationally-symmetric aperture in the second grid through which the beam passes; a non-rotationally-symmetric aperture in the third grid through which the beam passes; an extra plate having a non-rotationally-symmetric aperture through which the beam passes, this extra plate being present either on the second grid on the first or third grid sides thereof, in which case it will effectively form part of the second grid, or on the third grid on the second grid side thereof, in which case it will effectively form part of the third grid; a non-rotationally-

symmetric profiling of a plate part of the second grid, which part lies at right-angles to the axis of the gun and in which a rotationally-symmetric aperture is present through which the beam passes; a non-rotationally-symmetric profiling of a similar apertured plate part of the third grid; the provision of slots in a tubular part of the third grid, which part extends parallel to the axis of the gun and is encircled by a similar tubular part of the second grid, these slots extending parallel to the gun axis; the provision of similar slots in a tubular part of the second grid, which part extends parallel to the axis of the gun, these slots being covered by plates located farther away from the gun axis, the plates forming an extra electrode. A plate part of a grid can be provided with a non-rotationally-symmetric profile by securing one or more plates to the plate part so that certain parts thereof effectively have a larger thickness, or by giving the plate part itself a non-rotationally-symmetric profile, in which case the material thereof will have a uniform thickness.

Because the astigmatic lens element is provided on or is formed by a said grid, separate extra elements may not have to be provided in the gun. Since it is not easy to provide a small non-rotationally-symmetric aperture in a grid with great precision, a circular aperture is preferred. The astigmatic property is therefore preferably obtained in a way other than by providing a non-rotationally-symmetric aperture.

In order that the invention may be readily carried into effect, embodiments thereof will now be described in greater detail, 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 is a longitudinal section of an electron gun in the tube of Figure 1,

Figure 3 is a cross-sectional view of the electron gun shown in Figure 2,

Figure 4 shows the dimension of the spot on the display screen of the tube of Figure 1 in two mutually perpendicular directions as a function of the beam current in the tube,

Figures 5a and 5b show electron beam paths in part of the cathode-ray tube of Figure 1,

Figure 6 shows a cross-sectional view of an alternative second grid, and

Figures 7a, 7b and 7c show a further alternative second grid.

In Figure 1, a cathode-ray tube 1 includes a system 2 of three electron guns for generating three electron beams spaced at angles of 120° around the axis of the tube. The electron beams are converged onto a shadow mask 3 by means of a convergence device

(not shown) which is partly inside and partly outside the tube, after which they each impinge on different parts of a picture display screen 4. Scanning of the screen is carried out by means of a deflection device 5.

Figure 2 is a longitudinal section of one of the three electron guns. The gun comprises a cathode 6, a first grid 7, a second grid 8, a third grid 9 and a fourth grid 10. The first grid 7 comprises a plate part 11 having a circular aperture 12. The second grid 8 comprises a plate part 13 having a circular aperture 14 and a circular-cylindrical part 15. Two plates 16 and 17 each in the form of a segment of a circle are provided on the side of the plate part 13 which faces the third grid 9. The third grid 9 comprises a plate part 18 having a circular aperture 19 and two circular-cylindrical parts 20 and 21. The fourth grid 10 is a circular-cylindrical sleeve.

Figure 3 is a cross-sectional view of the gun shown in Figure 2 taken on the line III-III of Figure 2. The two plates 16 and 17 are fixed to the plate part 13 of the second grid. Figure 3 also shows the circular aperture 14. The plates 16 and 17 constitute an astigmatic lens element.

The distance between the cathode 6 and the first grid 7 may be 0.12 mm, between the first grid 7 and the second grid 8 at the area of the apertures 0.47 mm, between the second grid 8 and the third grid 9 at the area of the apertures 2.25 mm, and between the third grid 9 and the fourth grid 10 1.5 mm. The first grid 7 may be 0.13 mm thick at the area of the aperture, the second grid 8 0.25 mm thick at the area of the aperture, the thickness of the plates 16 and 17 may be 1 mm, and the third grid 9 may be 0.25 mm thick at the area of the aperture. The length of the circular-cylindrical part 20 may be 6 mm, that of the circular-cylindrical part 21 16.5 mm, and that of the circular-cylindrical sleeve 10, 10.0 mm. The inside diameter of the part 20 may be 5.5 mm, and that of the part 21 9.5 mm. The diameter of the aperture 12 may be 0.75 mm, that of the aperture 14 0.75 mm and that of the aperture 19 1.5 mm. The distance between the plates 16 and 17 may be 2 mm. The distance in the cathode-ray tube from the cathode to the display screen along the tube axis may be 467 mm. This gun can be operated with the following voltages:

cathode	0 V
first grid	between 0 V and -165 V
second grid	+ 500 V
third grid	between + 4400 V and + 4600 V
fourth grid	+ 25,000 V

The voltage at the first grid can be varied between the limits quoted to control the

beam current and that at the third grid can be varied between the limits quoted to focus the beam for a given beam current.

The astigmatic lens element constituted by the plates 16 and 17 influences the shape of the beam cross-section when a low beam current is used, so that the spot formed thereby on the display screen is then elongated in a vertical direction. This can be seen from the graph of Figure 4 in which the beam current in μA is plotted on the horizontal axis against the horizontal and vertical dimensions of the spot in millimetres in the centre of the display screen on the vertical axis. The solid line 22 relates to the vertical dimension of the spot and the broken line 23 relates to the horizontal dimension of the spot. For comparison a dotted and dashed line 24 is also shown, which depicts the corresponding vertical and horizontal dimensions of a spot formed by a gun which is the same as that described but in which the plates 16 and 17 are omitted so that no astigmatic lens element is present. Since the lines 22 and 23 substantially coincide at high beam currents, a substantially circular spot is then obtained; with low beam currents a spot which is elongate in the vertical direction is obtained. It can be seen from the position of the line 23 relative to the line 24 that the horizontal dimension of the spot has remained approximately the same or has been reduced compared with the case in which no astigmatic lens element is present. Thus the horizontal definition is the same or has improved. This result can be explained as follows. With a given beam current in the tube shown, a real cross-over is formed by the cathode 6, the first grid 7, and the second grid 8. Two virtual cross-overs of this real cross-over are formed by the lens effect of the second grid 8 and the third grid 9, namely one cross-over for the beam components situated in a horizontal plane and one cross-over for the beam components situated in a vertical plane. With a low beam current said virtual cross-overs lie at some distance from each other, but their spacing decreases with increasing beam current until they substantially coincide. This is a result of the fact that the real cross-over which is formed between the first and the second grid with a low beam current moves in the direction of the second grid when the beam current is increased, and hence towards the centre of the astigmatic lens element formed by the plates 16 and 17. One of the virtual cross-overs formed with a low beam current is focused onto the display screen by the main lens of the gun constituted by the third grid 9 and the fourth grid 10, while the other virtual cross-over is focused somewhere between the gun and the screen. Because the gap formed by

the plates 16 and 17 is horizontal, with the voltages stated and with low beam current, the virtual cross-over which is focused between the gun and screen is that of the beam components situated in a vertical plane.

Figures 5a and 5b show the path of electrons in the tube from each virtual cross-over to the display screen. Figure 5a shows the path of beam components lying in a vertical plane and Figure 5b that of components lying in a horizontal plane. In Figure 5a, 25 is the location of the corresponding virtual cross-over with a low beam current and 27 is its location with a high beam current. In Figure 5b, 26 is the location of the other virtual cross-over with a low beam current and 28 is its location with a high beam current. The locations 27 and 28 substantially coincide, i.e. they are at substantially the same distance from the picture display screen 29. The centre of the lens constituted by the third and fourth grids is denoted by 30. The virtual cross-over 26 is focused by the lens on the display screen at 31. The virtual cross-over 25 is focused at a point 32 which is situated nearer to 30 so that the corresponding impact area on the display screen is a vertical line 33-34. With a high beam current beam components lying both in the horizontal plane and in the vertical plane are focused on the display screen at 31.

If the tube did not include the plates 16 and 17, the same electrode voltages would cause a single virtual cross-over to be formed by the lens effect of the second and the third grid, which cross-over would lie at 35 (between 25 and 26) with a low beam current and at 27, 28 with a high beam current. If focusing in a horizontal plane (Figure 5b) is considered, it is obvious that, in the absence of the plates 16 and 17, variation of the beam current would cause the cross-over to move over a larger distance than if said plates were provided. Thus, in the latter case, only a small variation of the third grid voltage is required to achieve a focus.

Figure 6 shows an alternative astigmatic lens element for the second grid. In Figure 6 a plate 36 having a rectangular aperture 37 is provided on the third grid 9 side of the plate part 13 of the second grid 8 which again has a circular aperture 14.

Figures 7a, 7b and 7c show a further alternative astigmatic lens element for the second grid. Figure 7a is a cross-sectional view; Figure 7b is a longitudinal section taken on the line VIIb-VIIb of Figure 7a; Figure 7c is a longitudinal section taken on the line VIIc-VIIc of Figure 7a. The second grid consists of a circular-cylindrical part 38 and a plate part 39 in which an elongate bulge 40 is provided on its side which

faces the first grid. A circular aperture 41 is provided in the centre of the plate part 39. This construction has the advantage that the astigmatic lens element can be realised by means of a simple mechanical operation.

As an alternative a similar astigmatic lens element may instead be provided on or be formed by the third grid 9.

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WHAT WE CLAIM IS:—

1. A cathode-ray tube comprising an electron gun for producing an electron beam and a display screen, said electron gun comprising a cathode and, in order therefrom, a first grid, a second accelerating grid, and a third grid, an astigmatic lens element being present in the electron gun between or at the first grid side of the second 20 grid and the side of the third grid which is

furthest from the cathode, said element being provided on or being formed by a said grid.

2. A tube as claimed in Claim 1 for displaying colour pictures, which includes a colour selection electrode have systematically arranged apertures. 25

3. A tube as claimed in Claim 1 or 2, wherein the corresponding grid has a circular aperture. 30

4. A cathode-ray tube, substantially as herein described with reference to Figures 1, 2 and 3, Figures 1, 2 and 6, or to Figures 1 and 7 of the accompanying drawings.

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