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Johanns et al.

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[54] **CATHODE-RAY TUBE HAVING AN ASTIGMATIC LENS ELEMENT IN ITS ELECTRON GUN**

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Related U.S. Application Data

[63] Continuation of Ser. No. 126,425, March 22, 1971, abandoned.

[52] **U.S. Cl.** **313/449,** 313/458, 313/408

[51] **Int. Cl.** **H01j 29/02,** H01j 29/56

[58] **Field of Search** 313/86

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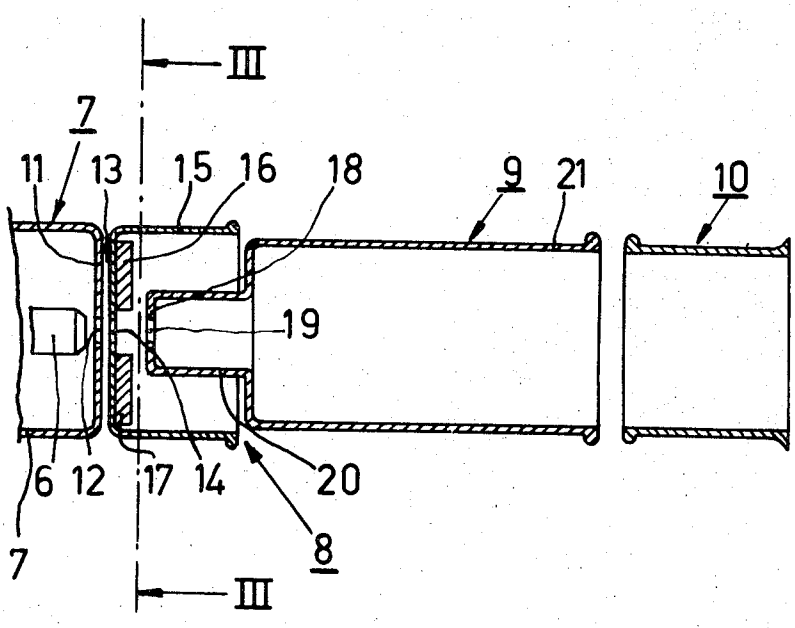
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[57] **ABSTRACT**

A cathode-ray tube, in particular a shadow mask colour tube, having at least one electron gun which comprises at least three grids. The second grid serves as an accelerating electrode. An astigmatic lens element is present in the region of the second and the third grid. As a result of this an elongate spot is formed on the picture display screen of an electron beam in the case of low beam current, while the spot remains substantially unchanged in the case of high beam current. This is of importance, inter alia, for removing moire patterns in a shadow mask colour tube without it being necessary to choose a particular distance of the mask holes.

3 Claims, 10 Drawing Figures



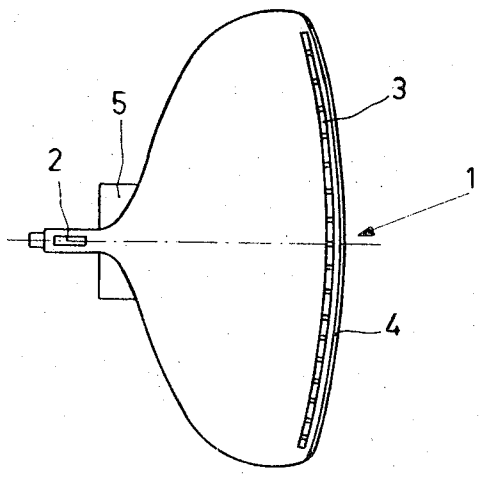


Fig.1

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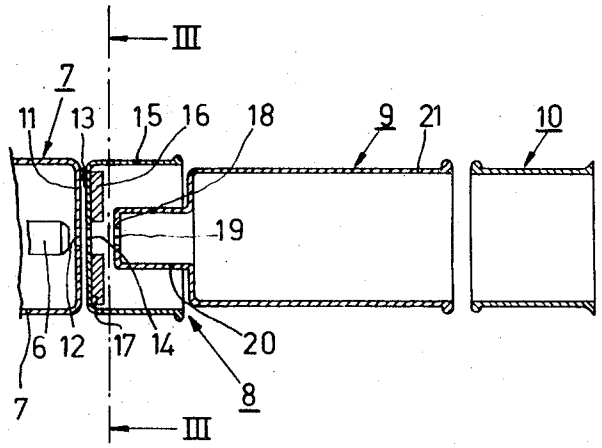


Fig. 2

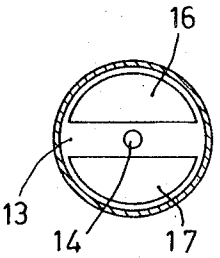


Fig. 3

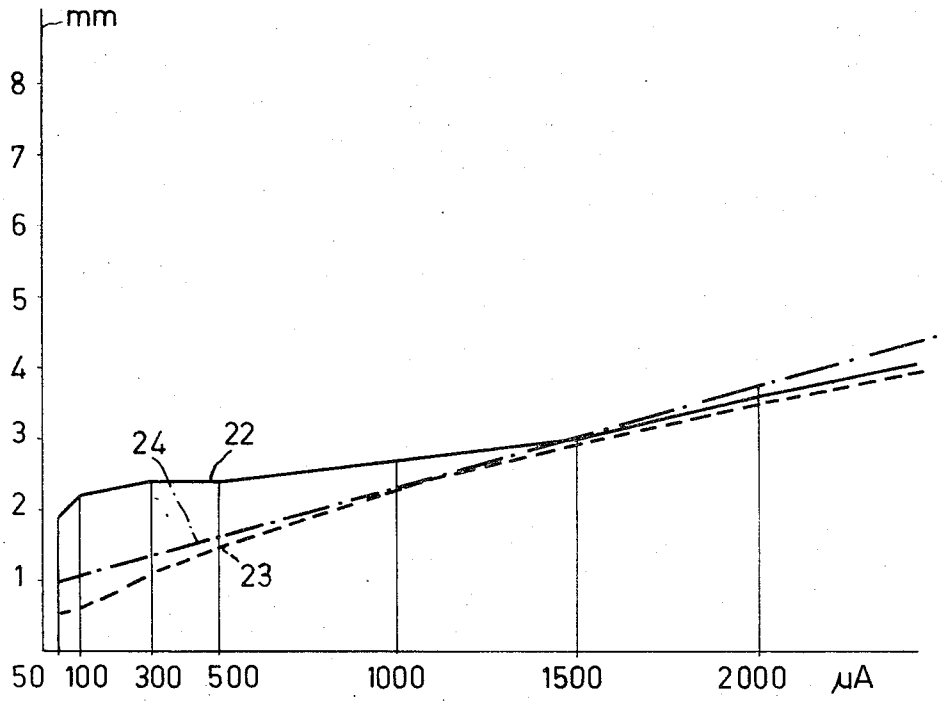


Fig. 4

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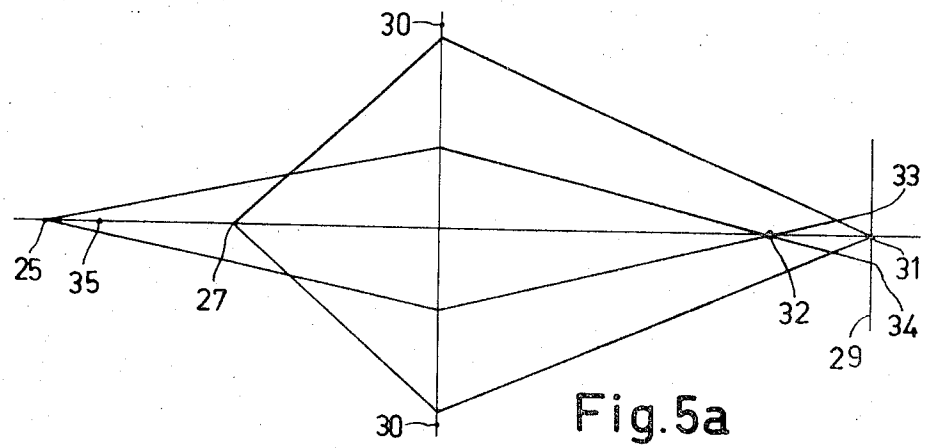


Fig.5a

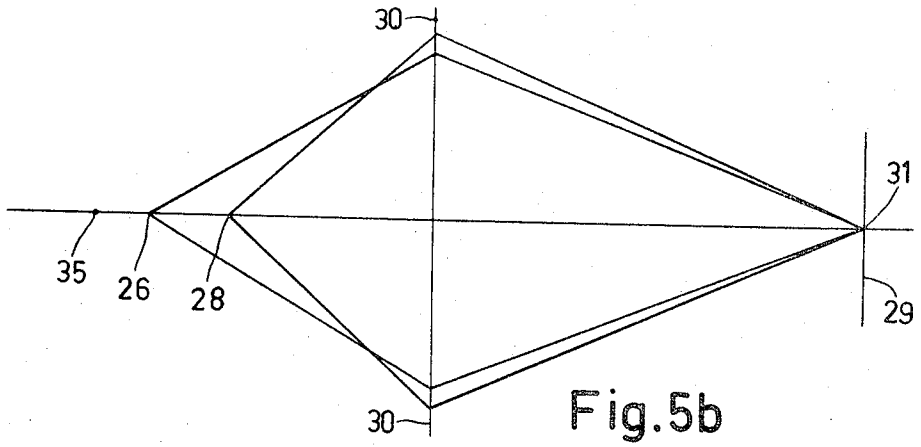


Fig.5b

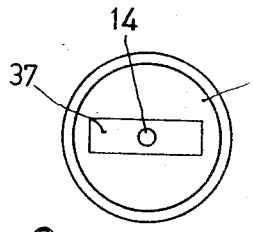


Fig.6

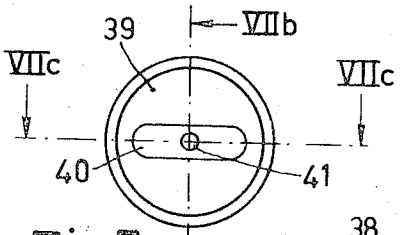


Fig.7a

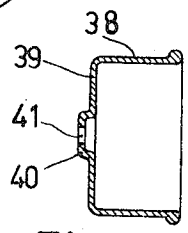


Fig.7b

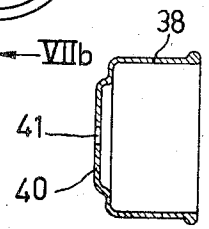


Fig.7c

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CATHODE-RAY TUBE HAVING AN ASTIGMATIC LENS ELEMENT IN ITS ELECTRON GUN

This is a continuation, of application Ser. No. 126,425, filed Mar. 22, 1971, now abandoned.

The invention relates to a cathode-ray tube comprising at least one electron gun for producing at least one electron beam and a picture display screen, each electron gun comprising a cathode and at least three grids, the second grid serving as an accelerating electrode.

In such a cathode-ray tube the electron beam is usually focused substantially on the picture display screen so that a spot is formed at that region which causes the relevant part of the picture display screen to luminesce. The electron beam scans the picture display screen according to a particular pattern so that the spot moves over the picture display screen. The size of the spot depends, inter alia, on the current strength in the beam. In order to obtain a greater brightness of the luminescing part of the picture display screen, a larger beam current is necessary, which goes hand in hand with a larger spot. The picture display screen is usually scanned along lines, namely horizontal lines. It is possible that these lines are visible during scanning of the picture display screen. This will occur in particular with a low beam current because in that case the spot is comparatively small. In the case of an increasing beam current because in that case the spot is comparatively small. In the case of an increasing beam current, the spots of two successive lines may partly overlap each other so that the separate lines become less visible and consequently the line structure of the reproduced picture as a whole is less conspicuous.

The line structure of the picture may give rise to difficulties in particular in a cathode-ray tube for displaying colour pictures which comprises a colour selection electrode having systematically arranged apertures. In such a cathode-ray tube a number of electron beams are produced and each electron beam causes a particular luminescent substance present on the display screen of the tube to luminesce, while the colour selection electrode (usually termed the mask) prevents the electrons of said beam from reaching one of the other luminescent substances. During operation of the tube, annoying moire patterns may occur as a result of interference between the line structure of the picture and the hole structure of the mask. It is known that the occurrence of moire patterns can be reduced by choosing the mutual distance of the mask holes in a particular manner in relation to the line distance. The line distance is a function of the dimension of the picture at right angles to the scanning lines (in the case of horizontal scanning lines this is the height of the picture) and of the number of scanning lines per picture. The mutual distance of the mask holes should hence be chosen in accordance with the height of the picture and the number of scanning lines per picture.

It has now been found, however, that the choice of the mutual distance of the mask holes is subject to certain restrictions for various reasons, so that the occurrence of moire patterns cannot always be reduced by means of the distance of the mask holes. If with a given height of the picture display screen a mask is available in which a desirable distance of the mask holes is present, the distance of the mask holes in a mask for a smaller picture display screen should be smaller in comparison with the former mask, since actually the line distances are smaller. A smaller distance of the

mask holes cannot be realized without the dimension of the mask holes being also made smaller, because otherwise the mask cannot fulfil its function of preventing electrons of a given electron beam from reaching one of the other luminescent substances. A mask having small holes and in addition a large number of such small holes meets with technological problems in manufacturing the mask. Difficulties may present themselves in addition when providing the luminescent substanves of the picture display screen. Moreover, for a ready functioning of the tube, the distance between the mask and the picture display screen should also be reduced when the distance of the mask holes is reduced. In connection with the tolerances occurring upon securing the mask, a reduction of said distance presents difficulties. For quite different considerations the value of the maximum deflection angle has a limiting effect upon the choice of the distance of the mask holes. When the maximum deflection angle of the beam increases, the angle at which the beam impinges on the mask at a particular place increases. During operation of the tube the mask is heated by the electrons and the suspension of the mask usually is such that under the influence of said heating it experiences an axial displacement. Moreover, in places where the brightness in the displayed picture is great, as a result of which the mask can be locally heated comparatively strongly, an axial displacement of the mask may occur locally. As a result of the axial displacement of the mask, the electron spot which is formed by an electron beam behind a certain mask hole is displaced and said displacement is larger according as the deflection angle is larger. This displacement of the spot on the picture display screen presents the possibility for the passed electrons to impinge upon a luminescent substance other than the one intended, so that a so-called mislanding will occur. With a given transmission of the mask the extent of the mislanding is the larger according as the mutual distance of the mask holes is smaller. In tubes in which a large deflection angle, for example 110°, occurs, it is therefore desirable that the mutual distance of the mask holes be large. This impedes a given choice of the mutual distance of the mask holes for checking the occurrence of moire patterns.

It is therefore of importance to check the occurrence of moire patterns in a different manner. This can be done in a simple manner by using an astigmatic beam when it is ensured that the line structure on the picture display screen is less visible. As already noted, the line structure in the case of a large beam current is already less visible than in the case of a small beam current. It should therefore be ensured that the line structure becomes less visible also in the case of a small beam current without a measure taken for that purpose resulting in undesirable effects in another respect. The line structure can be made less visible in the case of a small beam current by increasing the dimension of the spot at right angles to the scanning lines, in which case the spots of two successive lines will start overlapping each other increasingly also in the case of a small beam current. However, the dimension of the spot in the direction of the scanning lines must not be increased in order that the definition of the displayed picture in that direction be not adversely influenced. In the case of a larger beam current the dimension of the spot is already larger and it should be seen that it is not additionally increased in the direction at right angles to the

scanning line, in order that the definition of the displayed picture in the direction at right angles to the scanning lines be not unfavourably influenced. In addition, the dimension of the electron beam at the area of the deflection plane in the case of a large beam current may not be noteworthily increased because otherwise the half-shadow effect of the electron beam occurring behind the mask holes would be inadmissibly increased. On the basis of these considerations the beam in the case of low beam currents should be influenced more than in the case of high beam currents and said influence must mainly result in an increase of the spot at right angles to the scanning lines.

According to the invention, an astigmatic lens element is present in the electron gun in the region of the second and the third grid. The region of the second and the third grid is to be understood to mean herein the part of the electron beam between on the one hand the part of the second grid located on the side of the first grid and on the other hand the part of the third grid which is farthest remote from the cathode. The operation of said astigmatic lens element is as follows. A cross-over of the beam is formed by the cathode. the first and the second grid which serves as an accelerating electrode. The location of the cross-over usually lies in the region from the first grid to the third grid dependent upon the current strength of the beam and the configuration of the grids. In the case of low beam currents the cross-over lies between the first and the second grid, while with increasing beam current it moves in the direction away from the cathode towards the space between the second and the third grid. As a result of the fact that the cross-over in the case of low beam current lies between the first and the second grid and as astigmatic lens element is present in the region of the second and the third grid, the beam, in the case of a low beam current, is influenced by said astigmatic lens element so that an increase of a spot at right angles to this scanning line is obtained. When the beam current increases, the cross-over moves in the direction of the astigmatic lens element so that the influence hereof on the beam is reduced. When the cross-over coincides with the optical centre of the astigmatic lens element, the beam is substantially not influenced by this. So, in general, the location where the astigmatic element is provided will depend on the location of the cross-over and the extent of cross-over displacement upon variation of the beam current in the absence of said element.

The astigmatic lens element may be constructed in various mannners: 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 is present either between the first and the second grid, namely on the side of the second grid, or between the second and the third grid; a non-rotationally symmetric profile of the plate-shaped part of the second grid at right angles to the axis of the gun in which a rotationally symmetric aperture is present through which the beam passes; a non-rotationally symmetric profile of the plate-shaped part of the third grid at right angles to the axis of the gun in which a rotationally symmetric aperture is present through which the beam passes; in the case of a third grid having a tubular part parallel to the axis of the gun and a second grid having likewise a tubular part parallel to the axis of the gun, which part is present around the tubular part of the third grid, the presence of axial apertures in said part of the third grid; in the case of a second grid having a tubular part parallel to the axis of theggun, the presence of axial apertures in said part which are covered by plates located farther away from the axis of the gun and which form an extra electrode. A non-rotationally symmetric profile of a plate-shaped part of a grid can be realised by securing one or more plates to the plate-shaped part so that actually certain parts have a larger thickness or, when the thickness remains the same, giving the plate itself a non-rotationally symmetric profile.

The astigmatic lens element is present in particular in one of the grids. This has the advantage that no separate extra elements need be provided in the gun and/or extra voltages be applied. Since it is not so easy to realize with great precision a small non-rotationally symmetric aperture in a grid, it is to be preferred to use a circular aperture. The grid therefore comprises preferably an astigmatic lens element and a circular aperture.

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:

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

FIG. **2** is a cross-sectional view of an electron gun,

FIG. **3** is a cross-sectional view of the electron gun shown in FIG. **2**,

FIG. **4** shows the dimension of the spot on the picture display screen in two mutually perpendicular directions as a function of the beam current,

FIGS. **5***a* and **5***b* show diagramatically the path of rays in a part of the cathode-ray tube,

FIG. **6** shows another embodiment of the second grid, and

FIGS. **7***a*, **7***b* and **7***c* show another embodiment of the second grid.

Referring now to FIG. **1**, the cathode-ray tube **1** comprises a system **2** which is shown diagrammatically and comprises three electron guns for generating three electron beams. The electron beams are converged onto a shadow mask **3** by means of a convergence device (not shown) present partly inside and partly outside the tube, after which they each impinge on certain parts of a picture display screen **4**. The scanning of the picture display screen is carried out by a deflection device **5** which is shown diagrammatically.

FIG. **2** is a cross-sectional view 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-shaped part **11** having a circular aperture **12**. The second grid **8** comprises a plate-shaped part **13** having a circular aperture **14** and furthermore a circular cylindrical part **15**. On the side of the plate-shaped part **13** facing the third grid **9** two plates **16** and **17** in the form of a segment of a circle are present. The third grid **9** comprises a plate-shaped part **18** having a circular aperture **19** and furthermore two circular cylindrical parts **20** and **21**. The fourth grid **10** is in the form of a circular cylindrical sleeve.

FIG. **3** is a cross-sectional view of the gun shown in FIG. **2** taken on the line III — III of FIG. **2**. The two

plates **16** and **17** in the form of segments of a circle are present on the plate-shaped part **13** of the second grid which comprises a circular aperture **14.** The plates **16** and **17** constitute an astigmatic lens element.

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

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

The variable voltage at the first grid serves to control the beam. The ratio of the voltages at the third and the fourth grid is chosen to be so that the beam is focused as readily as possible in the spot on the screen.

Due to the presence of the astigmatic lens element constituted by the plates **16** and **17,** the shape of the beam in the case of low beam current is influenced and that in such manner that an increase is obtained in a vertical direction of the spot on the picture display screen. This is shown in the graph of FIG. **4** where the beam current expressed in μA is plotted on the horizontal axis and the dimensions of the spot expressed in millimetres in the centre of the picture display screen is plotted on the vertical axis. A solid line **22** relates to the vertical dimension of the spot and a broken line **23** relates to the horizontal dimension of the spot. For comparison a dot-and-dash line **24** is shown in addition which relates to a gun which is the same as the above-described gun with the only difference that the plates **16** and **17** are lacking so that no astigmatic lens element is pressed. Since the lines **22** and **23** substantially coincide in the case of high currents, a substantially circular spot is obtained; in the case of low currents a vertical spot is obtained. It appears from the position of the line **23** relative to the line **24** that, compared with the case in which no astigmatic lens element is present, the horizontal dimension of the spot has remained approximately the same or has been reduced so that the horizontal definition has remained the same or has improved. This result can be explained as follows. With a low beam current, a real cross-over is formed in the space between the first and the second grid by the cathode **6,** the first grid **7,** and the second grid **8.** Not counting aberrations, space charge and transverse speeds upon emission, this real cross-over is substantially punctiform. As a result of the astigmatic element on the second grid, the beam in the space between the second and the third grid becomes astigmatic. Viewed from the equipotential space within the cylindrical part of the third grid, this gives rise to two virtual cross-overs, one in a vertical line and one in a horizontal line. With low beam current, said virtual cross-overs lie at some distance from each other and whent the beam current increases, said distance decreases until the virtual cross-overs substantially coincide. Then they are again substantially punctiform. This is a result of the fact that the real cross-over which, in the case of low beam current, is formed between the first and the second grid, moves in the direction of the second grid when the beam current increases and hence towards the optic centre of the astigmatic lens element. The vertical virtual line cross-over is focused onto the picture display screen by the main lens of the gun constituted by the third grid **9** and the fourth grid **10,** while the horizontal virtual cross-over is focused in the area between the gun and the picture display screen. The gap formed by the plates **16** and **17** is horizontal. As a result of this, with the voltages stated and with low beam current, a virtual cross-over of the rays of the beam situated in a vertical plane is formed (horizontal line cross-over) which is situated farther away from the picture display screen than the virtual cross-over formed of the rays of the beam situated in a horizontal plane (vertical line cross-over).

FIGS. **5***a* and **5***b* show diagrammatically the path of rays in the tube from said virtual cross-over to the picture display screen. FIG. **5***a* shows the path of rays in a vertical plane and FIG. **5***b* in a horizontal plane. In FIG. **5***a*, **25** is the location of the virtual cross-over in the case of low beam current of the rays of the beam situated in a vertical plane and **27** is the location thereof in the case of a high beam current. In FIG. **5***b*, **26** is the location of the virtual cross-over in the case of a low beam current of the rays of the beam situated in a horizontal plane and **28** is the location thereof in the case of a high beam current. Since the locations **27** and **28** substantially coincide, they are shown at the same distance from the picture display screen **29.** The centre of the lens constituted by the third and the fourth grid is denoted by **30.** The virtual cross-over **26** is focused on the picture display screen at **31** by the lens. The virtual cross-over **25** is focused in a point **32** which is situated nearer so that a vertical extension **33–34** is formed of this on the picture display screen. In the case of high beam current focusing on the display screen in **31** takes place both in the horizontal plane and in the vertical plane. In a cathode-ray tube in which the gun does not comprise the plates **16** and **17,** a virtual cross-over is formed with the same voltages by the lens effect of the second and the third grid, of which cross-over in the case of low beam current the location **35** is situated between **25** and **26** and in the case of high beam current the location is situated in **27** and **28.** When the focusing is considered in a horizontal plane (FIG. **5***b*) it is obvious that in the absence of the plates **16** and **17** the cross-over, in the case of variation of the beam current, moves over a larger distance than in the presence of said plates so that in the latter case a smaller variation of the voltage of the third grid will be sufficient for optimum focusing. This is a favourable property, because in practice the voltage of the third grid is adjusted at a constant value.

FIG. 6 shows another embodiment of the astigmatic lens element of the second grid. In this case a plate **36** having an elongate aperture, namely a rectangular aperture **37**, is present on the side of the third grid **9** on the plate-shaped part **13** comprising a circular aperture **14** of the second grid **8.**

FIGs. *7a*, *7b* and *7c* show another embodiment of the astigmatic lens element of the second grid. Figure *7a* is a plan view; FIG. *7b* is a cross-sectional view taken on the line VII*b* — VII*b* of FIG. *7a*; FIG. *7c* is a cross-sectional view taken on the line VII*c* — VII*c* of FIG. *7a*. The second grid consists of a circular cylindrical part **38** and a plate-shaped part **39** in which an elongate bulge **40** is provided on the side of the first grid. A circular aperture **41** is present in the centre of the plate-shaped part **39.** This embodiment has the advantage that the astigmatic lens element can be realized with a simple mechanical operation.

What is claimed is:

1. A cathode ray tube for color television, comprising:

a. an evacuated envelope having a window at one end thereof;

b. a screen disposed at said window and comprising electron-responsive luminescent areas emitting light of various colors;

c. means for scanning an electron beam across said luminescent screen in the direction from a first side thereof toward an opposite side;

d. electron gun means within said envelope for producing an electron beam, said electron gun comprising a cathode and at least a first, second, and third grids, said first and second grids respectively controlling and accelerating said electron beam, said second grid having a surface portion facing said first grid and said third grid having a first surface portion remote from said cathode and facing toward said luminescent screen, said electron gun further comprising plate means comprising an astigmatic lens element located between said surface portion of said second grid and said first surface portion of said third grid, said astigmatic lens element being a rotationally non-symmetric passage through which said electron beam passes and which has two main axes which are orthogonal with respect to each other and with respect to the axis of said electron gun, the dimension of said passage along one of said main axes significantly exceeding that along the other said axis and said one axis being substantially parallel to said scanning direction of said electron beam; and

e. a shadow mask having a plurality of apertures extending therethrough located between said luminescent screen and said electron gun, and having said apertures disposed at said electron-responsive areas that are accessible to said electron beam via said apertures, said shadow mask being substantially parallel to and proximate with said luminescent screen, whereby there is a reduced incidence of visible moire fringes resulting from interference between a pattern of lines on said luminescent screen scanned by said electron beam and a pattern of said apertures arranged along lines on said color selection electrode.

2. A cathode ray tube as claimed in claim **1** wherein said second grid comprises said astigmatic lens element and a circular aperture.

3. A cathode ray tube as claimed in claim **1** wherein said third grid comprises said astigmatic lens element and a circular aperture.

* * * * *