

Colour Display Tube.

The invention relates to a colour display tube comprising in an evacuated envelope which is composed of a neck, a cone and a display window, in said neck an electron beam generating system with which three electron beams
5 situated with their axes in one plane are generated, which beams are focused, by means of a focusing lens field, on a display screen which is provided on the inside of the display window, which focusing lens field is formed between two electrodes of the electron beam generating system situated
10 one behind the other along the axes, which electrodes comprise outermost edges facing each other and within these edges three apertures through which the electron beams pass are provided symmetrically with respect to the said plane in a recessed part extending substantially at right angles
15 to the axes.

Such a colour display tube is known from US-PS-4,370,592. It is also stated in said Patent that the focusing lens field generated in this manner still is astigmatic and the electron beams are focused vertically
20 more strongly than horizontally. As described in said Patent, said astigmatism is corrected by providing the second electrode of the focusing lens with a plate having an elongate slot which is provided on the side of the display screen. Said slot is situated symmetrically with
25 respect to the plane through the beam axes. However, it has been found that said corrections of the horizontal/vertical astigmatism are not sufficient since the quality of the spot on the display screen nevertheless leaves something to be desired. The United Kingdom Patent Application 2,112,564
30 describes also such a colour display tube. The horizontal/vertical astigmatism is eliminated by making the apertures in the recessed part elongate. This is also not sufficient to get smaller spot dimensions.

It is therefore an object of the invention to provide measures to improve the quality of the spot and to obtain smaller dimensions of the spot than with the known tubes with comparable beam currents.

5 For that purpose, according to the invention, a colour display tube of the kind described in the opening paragraph is characterized in that the central aperture in at least one of the electrodes is elongate and is formed in such manner that a quadrupole component and a compensating
10 eight-pole component are generated in the focusing lens field at the area of the central electron beam, and in that the outermost apertures in at least one of the electrodes are formed in such manner that a quadrupole component and a compensating six-pole component are generated in the focusing
15 lens field at the area of the outermost electron beams.

The invention is based on the recognition obtained experimentally and from computations that, because the three electron beams are situated with their axes in one plane and within facing outermost edges, not only a different focusing
20 in a horizontal and a vertical direction takes place, but also in directions situated inbetween. Around the central beam is formed in particular an eight-pole component and around the outer beams is formed in particular a six-pole component in the focusing lens field. These multipole
25 components must be compensated for at least for the greater part. According to the invention this can be achieved by giving the apertures in the electrodes between which the focusing lens field is generated such a shape deviating from a circular aperture that in addition to the quadrupole
30 component for the central beam, a compensating eight-pole component is obtained and for the outermost beams a compensating six-pole component is obtained. The horizontal/vertical astigmatism can be compensated for substantially by the quadrupole component in the lens field. However, it
35 is also possible to allow a horizontal/vertical astigmatism to occur in the focusing lens field to such an extent that the astigmatism of the deflection coils is compensated for.

It has also been found that there is an optimum distance by which the outermost edge projects above the recessed part. Therefore, a first preferred embodiment of a colour display tube in accordance with the invention is characterized in that the outermost edge projects above the recessed part by a distance which is equal to 10 to 25% of the largest diameter of the recessed part within the outermost edge.

When the distance is smaller, the influence of the shape of the apertures on the lens field predominates and reduces the effective lens diameter. When the distance is larger, the influence of the apertures is too small to be able to readily correct the aberrations. The electrodes usually have an oval cross-section at right angles to the longitudinal axis of the electron beam generating system. However, it is also possible for the electrodes to have a circular orthogonal cross-section. A compensating eight-pole component in the focusing lens field can be generated by making the central aperture in the recessed part of the first and/or the second electrode substantially octagonal as well as elongate to generate a quadrupole component. A compensating six-pole component in the focusing lens field can be generated by making the outermost apertures substantially pear-shaped.

A second preferred embodiment of the colour display tube in accordance with the invention is therefore characterized in that, viewed in the direction of propagation of the electron beams, the central aperture in at least the first electrode of the two electrodes between which the focusing lens field is formed is elongate, the long axis of said aperture being at right angles to the said plane and the edge of said aperture forming substantially an octagon and the outermost apertures being pear-shaped, the edges of said apertures, viewed from the central aperture, converging outwards. A focusing lens formed between two electrodes may be considered to be composed of two lens parts, namely a positive lens part (equipotential lines convex in the direction of the electrode of low potential) and a weaker

negative lens part (equipotential lines convex in the direction of the electrode of high potential). The strength of the positive lens part is always greater than that of the negative lens part, so that the two lens parts together have a positive lens action.

If the apertures in the second electrode of the focusing lens have the same shape as the apertures in the first electrode, the influence of the apertures in the first electrode on the positive lens part is attenuated by the influence of the apertures in the second electrode on the negative lens part. This will be entered into hereinafter.

A third preferred embodiment of the colour display tube in accordance with the invention is characterized in that, viewed in the direction of propagation of the electron beams, the central aperture in the second electrode of the two electrodes between which the focusing lens field is formed is elongate, the long axis of said aperture being situated in the said plane and the edge of the said aperture substantially forming an octagon and the outermost apertures being substantially pear-shaped, the edges of the said apertures, viewed from the central aperture, diverging outwards.

By constructing the apertures in the second electrode in this manner, the desired correction can also be obtained. The desired correction can also be achieved by combination of the first and the second preferred embodiments. It will be obvious that the desired eight-pole and six-pole components can also be obtained by providing, for example, an elongate, substantially octagonal central aperture in the first electrode with the long axis of the aperture at right angles to the said plane and two outwardly diverging, substantially pear-shaped, outermost apertures in the second electrode of the focusing lens. It is also possible to obtain the desired eight-pole and six-pole components, for example, by providing an elongate, substantially octagonal central aperture having its long axis in the said plane in the second electrode and two outwardly converging, substantially pear-shaped outermost apertures in the first

electrode. However, from a technical point of view of production this is less attractive.

The pear-shaped apertures are obtained in a simple manner by composing them, viewed from the central aperture, of outwardly or inwardly converging isosceles trapeziums which are closed by arcs of circles on the outside and/or inside.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawing, in which:

10 Figure 1 is a longitudinal sectional view of a colour display tube according to the invention,

Figure 2 is a longitudinal sectional view of an electron-beam generating system in a colour display tube according to Figure 1,

15 Figure 3 is an elevation of a lens electrode of Figure 2,

Figure 4 shows the diameter of the spot on the display screen as a function of the beam current for three colour display tubes,

20 Figure 5 is another elevation of a lens electrode of Figure 2, and

Figure 6 shows an alternative pear-shaped aperture.

Figure 1 is a longitudinal sectional view of a colour display tube of the so-called "in-line" type.

25 An integrated electron-beam generating system 5 is provided in a glass envelope 1 which is composed of a display window 2, a cone 3, and said neck 4, the electron-beam generating system generating three electron beams 6, 7 and 8 which are situated with their axes in the plane of the drawing.

30 The axis of the central electron beam 7 initially coincides with the tube axis 9. On its inside the display window 2 comprises a large number of triplets of luminescent material. Each triplet comprises a line consisting of a blue-luminescing phosphor, a line consisting of a green-luminescing phosphor and a line consisting of a red-luminescing phosphor. All triplets together constitute the display screen 10. The luminescent material lines are at

right angles to the plane of the drawing. In front of the display screen is positioned a shadow mask 11 in which a large number of elongate apertures 12 are provided through which the electron beams 6, 7 and 8 pass, which beams each
5 impinge only on luminescent material lines of one colour. The three electron beams which are situated in one plane are reflected by the system of deflection coils 13.

Figure 2 is a longitudinal sectional view of the electron-beam generating system in the colour display tube
10 shown in Figure 1. The electron-beam generating system comprises a common cup-shaped control electrode 20 in which three cathodes 21, 22 and 23 are connected, and a common plate-shaped anode 24. The three electron beams situated with their axes in one plane are focused by means of the
15 electrodes 25 and 26 which are common for the three electron beams. Electrode 25 consists of two cup-shaped parts 27 and 28 which are connected together with their open ends. Electrode 26 comprises one cup-shaped part 29 and a centring sleeve 30 the bottom of which has apertures 31 through which
20 the electron beams pass. Electrode 25 has an outer edge 32 extending towards electrode 26 and electrode 26 has an outer edge 33 extending towards electrode 25. Apertures 38, 39 and 40 are provided in the recessed part 34 which extends at right angles to the axes 35, 36 and 37 of the electron beams
25 6, 7 and 8. Apertures 42, 43 and 44 are provided in the recessed part 41 which extends substantially at right angles to the axis 36 of the central electron beam. The recessed parts 34 and 41 can form one assembly with the parts 28 and 29, respectively, just like in the electron-beam generating system described in United States Patent 4,370,592.
30 The apertures in the recessed parts may also comprise collars. Because the edge 33 comprises a larger aperture than edge 32, the electron beams converge after the focussing lens. However, it is also possible to let the electron beams
35 converge already in or after the triode part of the electron-beam generating system which is formed by the cathode and the electrodes 20, 24 and 25; (See, for example,

United States Patent 4,291,251). The wall of the electrodes 25 and 26 is, for example, 0.25 mm thick. The slot between the electrodes 25 and 26 is, for example, 1 mm wide.

The distance between the axes of the electron beams 35, 36 and 36, 37 is, for example, 4.45 mm.

Figure 3 is an elevation of lens electrode 25 of Figure 2. By making the aperture 39 to be substantially octagonal and elongate, the long axis being at right angles to the plane through the beam axes 35, 36 and 37, the line of intersection 45 of which with the plane of the drawing being shown, the eight-pole component which is formed in the focusing lens field by the edges 32 and 33 is substantially compensated for, in addition to the horizontal/vertical astigmatism.

The corners of the octagon may be rounded off with which also higher-order multipoles are compensated for. It is also possible to construct the sides 46 and 47 which are parts of a circle in the drawing, to be straight. By making the apertures 38 and 40 to be substantially pear-shaped, the edge of the apertures, viewed from the central aperture 39, converging outwardly, the six-pole component which is formed in the focusing lens field by the edges 32 and 33, is substantially compensated for.

Such pear-shaped and octagonal apertures can easily be realized by starting from a circle (broken lines), parts (48, 49) of the circle being replaced by their chords (50, 51).

A pear-shaped aperture realized in this manner has an edge having the shape of an isosceles trapezium, the base and the top line being replaced by arcs of a circle. A part of the arc 52 may be replaced by its chord 53 (shown in broken lines).

The outermost broken-line circles have a radius of, for example, 2.15 mm and the central circle has a radius of 1.9 mm. The beam axes 35 and 36 and the beam axes 36 and 37 are, for example, 4.45 mm apart. In a system of axes X-Y with the point of intersection in the plane of the drawing, with axis 36 being the centre, the corner points A, B, C and D are situated in the locations indicated in the Table.

	X (mm)	Y (mm)
A	0.8	1.72
B	1.56	0.65
C	3.96	2.09
D	5.46	1.90

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The edge 32 extends 2 mm above the recessed part 34. The apertures 38 and 40 are identical and symmetrical with respect to the X-axis. Aperture 39 is situated symmetrically with respect to the X-axis and the Y-axis.

Figure 4 shows the spot diameter $\bar{d}$ (in mm) on the display screen as a function of the electron beam current i (in mA) for the central electron beam of three electron-beam generating systems. Line A is the variation of the spot diameter as a function of the beam current in an electron-beam generating system of the conventional type without an edge and recessed part. Line B is the variation of the spot diameter as a function of the beam current in an electron-beam generating system according to United States Patent 4,370,592. Line C denotes the variation of the spot diameter as a function of the beam current in an electron-beam generating system for a colour display tube according to the invention. The electrodes 25 and 26 are constructed in accordance with Figures 2 and 3. From this comparison it follows that, by using the invention, the spot diameter is smaller both at high and at low beam currents, as a result of which a sharper picture can be obtained. In tubes according to the invention a 10 to 20% smaller spot was established than in tubes in which the invention was not used. By using apertures as shown in Figure 3 in electrode 25, the desired eight-pole and six-pole component corrections can be obtained in addition to the four-pole component correction. By making the apertures shown to be more or less elongate, the four-pole component in the focusing lens field at the

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area of the beams can also be compensated as desired or be adjusted at a given value. By using the same shape for the aperture as in Figure 3 in electrode 26, the six-pole correction and the eight-pole correction are attenuated.

- 5 The use of identical lens components, however, has advantages to which will be referred hereinafter.

Figure 5 shows another embodiment of the lens electrode 26 of Figure 2. Aperture 43, as aperture 39 in Figure 3 is substantially octagonal and elongate. The long
10 axis of the said aperture, however, now lies in the plane through the electron beam axes of which the line of intersection 54 with the plane of the drawing is shown. By such a shape of the aperture, the eight-pole component which is formed in the focusing lens field by the edges 32 and 33 is
15 substantially compensated in addition to the four-pole component. The apertures 42 and 44 are substantially pear-shaped. The edge of the apertures now diverges outwards. The six-pole component which is formed in the focusing lens field by the edges 32 and 33 is compensated substantially
20 by the said apertures. The different location of the apertures in electrode 26 as compared with the location in electrode 25 is the result of the fact that the focusing lens may be considered to be composed of a positive lens part followed by a weaker negative lens part. By reducing the
25 diameter of the aperture in a given direction in electrode 25, the lens becomes stronger in that direction because the positive lens part is situated near electrode 25. By reducing the diameter of the aperture in electrode 26 in a given direction, the lens becomes weaker in that direction, because
30 the negative lens part is situated near electrode 26. From this it follows that the diameters of the apertures in the electrodes 25 and 26 must be varied oppositely to each other to produce the same effect.

However, if the apertures in the electrodes 25 and
35 26 have the same shape, a correction nevertheless takes place because the positive lens part is always stronger than the negative lens part. The choice of the same shape of the

apertures in the electrodes 25 and 26 may be attractive for technical reasons in the production. As described in Netherlands Patent Application 8203320 which is not yet laid open to public inspection, the astigmatism of the electron beams can also still be reduced by making the lens electrode components between which the lens field is formed in an electron-beam generating system to be identical. The lens electrode components should be provided so that the corresponding sides are facing each other and the corresponding apertures are opposite to each other. By providing identical components for the lens electrodes opposite to each other in the manner described it is achieved that the deviations from the desired shape of the oppositely located apertures, which deviations have arisen during the manufacture of the apertures, are approximately equally large. As a result of this the disturbing influence on the electron beams for the two lens electrodes is also approximately equally large, but of opposite sign, as a result of which the astigmatism resulting from said deviations becomes smaller.

The pear-shaped apertures may also be constructed as is shown in Figure 6. The straight lines 60, 61, 62, 63 and 64 again are chords of a circle of which the arcs 65, 66 and 67 are still left.

It is also possible to obtain the four-, six- and eight-pole components in the focusing lens field by making the apertures in the recessed parts circular and providing them with collars of which the height, proceeding along the circumference, varies in height (corrugated collars). However, these collars are difficult to manufacture by means of polygonal drawing dies, for example, a hexagonal or octagonal drawing die in a plate having round apertures. It is also possible to use a circular drawing die in a plate having hexagonal or octagonal apertures. The collars may also be made oblique so as to produce convergence.

Claims:

1. A colour display tube comprising in an evacuated envelope which is composed of a neck, a cone and a display window, in said neck an electron beam generating system with which three electron beams situated with their axes in one plane are generated, which beams are focused, by means of a focusing lens field, on a display screen which is provided on the inside of the display window, which focusing lens field is formed between two electrodes of the electron beam generating system situated one behind the other along the axes, which electrodes comprise outermost edges facing each other and within these edges three apertures through which the electron beams pass are provided symmetrically with respect to the said plane in a recessed part extending substantially at right angles to the axes, characterized in that the central aperture in at least one of the electrodes is elongate and is formed in such manner that a quadrupole component and a compensating eight-pole component are generated in the focusing lens field at the area of the central electron beam, and in that the outermost apertures in at least one of the electrodes are formed in such manner that a quadrupole component and a compensating six-pole component are generated in the focusing lens field at the area of the outermost electron beams.
2. A colour display tube as claimed in Claim 1, characterized in that the outermost edge projects over the recessed part by a distance which is equal to 10 to 25% of the largest diameter of the recessed part within the outermost edge.
3. A colour display tube as claimed in Claim 1 or 2, characterized in that, viewed in the direction of propagation of the electron beams, the central aperture in the first electrode of the two electrodes between which the focusing



lens field is formed, is elongate, the long axis of said aperture being at right angles to the said plane and the edge of the said aperture forming substantially an octagon and the outermost apertures being pear-shaped, the edges
5 of the said apertures, viewed from the central aperture, converging outwardly.

4. A colour display tube as claimed in Claim 1, 2 or 3, characterized in that, viewed in the direction of propagation of the electron beams, the central aperture in the second
10 electrode of the two electrodes between which the focusing lens field is formed is elongate, the long axis of said aperture being situated in the said plane and the edge of the said aperture forming substantially an octagon and the outermost apertures being substantially pear-shaped, the
15 edges of the said apertures, viewed from the central aperture, diverging outwardly.

5. A colour display tube as claimed in Claim 1 or 2, characterized in that, viewed in the direction of propagation of the electron beams, the central aperture in the two
20 electrodes between which the focusing lens field is formed is elongate, the long axis of said aperture being at right angles to the said plane and the edge of the said aperture forming substantially an octagon and the outermost apertures being pear-shaped, the edges of the said apertures, viewed
25 from the central aperture, converging outwardly.

6. A colour display tube as claimed in Claim 3, 4 or 5, characterized in that the pear-shaped apertures are formed by isosceles trapeziums converging outwardly or inwardly
viewed from the central aperture and being closed on the
30 inside and/or the outside by arcs of a circle.

