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(54) Display device and cathode-ray tube.

(57) A display device (20) comprising emission means (23) for generating a row of electron beams (24, 25, 26). The display device (20) further comprises a deflection space (27) which extends between two parallel electrodes (28, 29). The electron beams are deflected in the deflection space according to parabolic paths. The influence of magnetic fields is small. Consequently, magnetic screening of the electron beams is either not necessary or a magnetic screen of a lighter and simpler construction is sufficient.

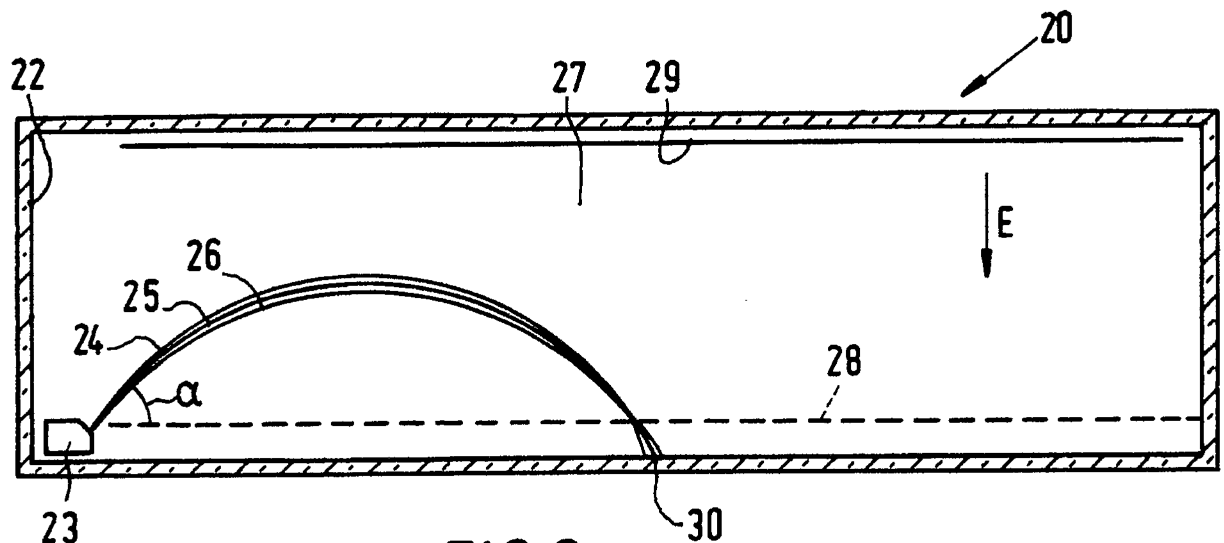

FIG.2

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DISPLAY DEVICE AND CATHODE-RAY TUBE

The invention relates to a display device comprising a cathode-ray tube having a display screen, emission means for generating a row of electron beams which are arranged at one side of said display screen, the emission means having an emitting element for each electron beam and each electron beam scanning a column of picture elements of the display screen, and deflection means for deflecting the electron beams towards the display screen.

The invention also relates to a cathode-ray tube which is suitable for use in a display device.

A display device of the type described in the first paragraph is known from European Patent Application 0 288 095. In said application, a description is given of a colour-display device in which emission means for generating a row of electron beams are arranged at one side of the screen. The emission means comprise one (semiconductor) cathode for each electron beam. In operation, the electron beams are emitted at least substantially parallel to the display screen. A colour selection electrode is located in front of the display screen. A series of deflection strips is provided on a wall which extends parallel to the colour selection electrode. When the device is in operation, the electron beams are located between the deflection strips and the colour selection electrode. By applying potentials to the deflection strips, the electron beams can be selectively deflected towards the display screen, so that the electron beams scan the display screen in a direction transversely to the row of electron beams.

A problem which occurs in such types of tubes is that magnetic fields may influence the paths of the electron beams. In the above-described European Patent Application the space between the deflection strips and the colour selection electrode is surrounded by a magnetic screen which incorporates the colour selection electrode.

One of the objects of the invention is to provide a display device of the type mentioned in the opening paragraph, in which the influence of magnetic fields on the paths of the electron beams is reduced. This enables an omission, a reduction in size or a simpler or lighter construction of the magnetic screen.

For this purpose, the display device according to the invention is characterized in that the deflection means comprise a first and a second electrode which are arranged so as to extend at least substantially parallel to each other and between which there is a deflection space, the display device having means to apply a potential difference to these electrodes, and the emission means being suitable for making the electron beams enter the deflection space at an acute angle with the parallel electrodes.

As will be explained hereinbelow, the influence of magnetic fields on the paths of the electron beams is reduced substantially, and can be readily compensated in some cases, by virtue of the symmetry of the parabolic paths travelled by the electron beams in the deflection space.

An embodiment of a display device according to the invention, in which the display device comprises a colour selection electrode extending in front of the display screen, is characterized in that one of the said electrodes comprises the colour selection electrode, the emission means are suitable for emitting a row of fans of electron beams, and the said angle is approximately 45°.

In the case of an angle of approximately 45°, electron beams having the same kinetic energy and being subject to an equal electric field in the deflection space intersect each other after they have passed through said deflection space, in a first order approximation, at the location of the colour selection electrode. Second order deviations from this can be corrected in a simple manner, either by a small difference between the kinetic energy levels of the electron beams or by a small difference between the electric fields to which the electron beams are subjected, or by a combination of these measures. This enables a simplification of the display device and reduces the influence of magnetic fields.

A further embodiment of the display device according to the invention is characterized in that emission means are constructed such that the angles at which the electron beams in the fans enter the deflection space are symmetrical relative to an angle of 45°.

By virtue hereof, a further simplification of the display device is possible.

A still further embodiment of the display device according to the invention is characterized in that the emission means are suitable for simultaneously generating at least two of the electron beams which form a fan.

A colour image may be composed of successive images in the primary colours or of simultaneous images. For this purpose, the electron beams forming the fan can be generated successively or simultaneously. The simultaneous display of images in the primary colours has the advantage that lower frequencies can be used for driving the emission means and/or applying the potential difference to the electrodes. The display device according to the invention is very suitable for this purpose because the differences between the kinetic energy levels need only be small. Preferably, the emission means are suitable for the simultaneous emission of all the electron beams forming a fan.

A still further embodiment of the display device according to the invention is characterized in that the emission means are suitable for generating electron beams, the energy levels of which differ so much from each other that at a specific potential difference between the said electrodes the electron beams intersect in the plane of the colour selection electrode.

Yet another embodiment of the display device according to the invention, is characterized in that the emission means comprise deflection electrodes.

The deflection electrodes permit the angle at which an electron beam enters the deflection space and the energy of the electron beam to be influenced in a simple manner.

A further embodiment of the display device according to the invention is characterized in that the electrodes are approximately rectangularly shaped and the interspace between the electrodes is more than 1/4 times the length of the electrodes viewed in the direction of travel of the electron beams.

When the above-mentioned length ratio is smaller than 1/4, it is impossible to use the deflection space between the electrodes to the full extent without an electron beam contacting an electrode.

Preferably, the distance between the electrodes is less than 0.40 times the length of the electrodes viewed in the direction of travel of the electron beams.

A further increase of this distance leads to a larger potential difference between the electrodes being required.

In a preferred embodiment of the display device according to the invention, the length of the electrodes viewed in the direction of travel of the electron beams is smaller than the length viewed in a direction transversely to the said direction.

This enables a relatively superficial construction of the display device, thereby reducing the influence of magnetic fields.

A still further preferred embodiment of the display device according to the invention is characterized in that the quotient of the length of the electrodes in the direction of travel of the electron beams and the length of the electrodes in a direction transversely to the said direction is smaller than 3 : 4.

Yet another embodiment of the display device according to the invention is characterized in that the said quotient is approximately 9 : 16.

The invention will be explained in greater detail by means of a few exemplary embodiments of the display device and with reference to the accompanying drawings, in which

Fig. 1 is a sectional view of the known colour display device;

Fig. 2 is a sectional view of a colour display device according to the invention;

Fig. 3 shows a detail of the colour display device depicted in Fig. 2;

Figs. 4a and 4b show a further detail of the colour display device depicted in Fig. 2;

Fig.5 shows a further detail of the colour display device according to the invention;

Fig. 6 shows a deflection space.

The Figures are diagrammatic and not drawn to scale, in general, corresponding parts in the various embodiments bearing the same reference numerals.

Fig. 1 is a sectional view of the known display device. A colour display device 1 comprises a cathode-ray tube 2 containing an emission means 3 for emitting a row of electron beams 4 in a deflection space 5 between deflection strips 6 and a colour selection electrode 7. For each column of picture elements at least one electron beam is emitted. When in operation, voltages are applied to the deflection strips, in such a manner that after the electron beams have entered the deflection space 5 they initially trace a straight path which extends parallel to the deflection strips 6 and the colour selection electrode 7. By applying a high voltage to one or several of the deflection strips, the electron beams are forced to deflect through an angle of 90° towards the colour selection electrode.

Magnetic fields cause deviations in the paths of the electron beams. Said deviations can be reduced at least partly by accommodating the deflection space in a magnetic screen. The colour selection electrode in Fig. 1 forms part of said magnetic screen. A reduction of the influence of the magnetic fields on the paths of the electron beams may permit a simpler or lighter construction of the magnetic screen or even its omission. The present invention provides a display device in which the influence of magnetic fields on the paths of the electron beams is reduced.

Fig. 2 is a sectional view of a display device, in the present example a colour display device 20, according to the invention. Said colour display device 20 comprises emission means 23 in an evacuated envelope 22, said emission means being used to generate a row of fans of, in the present example three, electron beams 24, 25 and 26. It is to be noted that said emission means 23 may comprise three different sources for the three electron beams or one common source for the three electron beams. The colour display device 20 further comprises a deflection space 27 between a colour selection electrode 28 and a flat electrode 29. In operation, an electric field E is applied in the deflection space 27 by means of a potential difference between the colour selection electrode 28 and the flat electrode 29. The electron beams 24, 25 and 26 enter the deflection space 27 at an angle with the plane of the colour selection electrode, i.e. at an angle x with the field lines of the electric field E. In the deflection space, the electron beams describe parabolic paths. After having passed through the deflection space, the electron beams 24, 25 and 26 pass through apertures in the colour selection electrode 28, diverge in the space between the colour selection electrode 28 and a display screen 30 and are incident on said display screen 30.

The influence of the magnetic fields on the paths of the electron beams is represented by the force F_B exerted by the magnetic fields on the electrons in the electron beams. Said force is represented by the eqation

F_B = BXv, where B is the magnetic field, v is the velocity of the electrons and X is the vector product of B and v.

The electrons move in the plane of the drawing. Consequently, the z-component of the velocity of the electrons, z being the direction perpendicularly to the plane of the drawing, is 0. The x-component of the velocity of the electrons, x being the horizontal direction, is a constant v_x. The y-component of the velocity of the electrons varies between an initial value v_{y0} on entering the deflection space, and a final value $-v_{yo}$. The magnetic field in the deflection space has the components B_x, B_y and B_z in the x, y and z-direction, respectively. The resulting forces on the electrons in the x, y and z-directions, being F_x, F_y and F_z, are:

$F_x = -v_yB_z$

$F_y = -v_xB_z$

$F_z = B_xv_y-v_xB_y$.

The influence of forces or components of forces in relation to the velocity in the y-direction (F_x and B_xv_y) on the location where the electron beams impinge on the colour selection electrode and on the angle at which the electron beams impinge on the colour selection electrode is zero, because any effect of such a force on the first part of the electron path, i.e. up to the extremum of the electron path is compensated by an opposite effect on the second part of the electron paths. F_y, the force in the y-direction, is a constant and can be readily compensated by an additional constant potential difference between the electrodes 28 and 29. As the effect of F_x is zero, and F_y can be compensated, so that the effect of F_y is zero, the angle at which the electron beams impinge on the colour selection electrode remains uninfluenced. Consequently, only one component of the force in the z-direction, F_z, is important and this component also has a constant value and, hence, can be compensated in a relatively simple manner. Consequently, a magnetic screen, if any, only has to shield one component of the magnetic field, if this is desirable. In the known display device, the influence of F_x and B_xv_y is not zero because in the deflection space v_y varies between zero and a maximum value, and v_x is not constant but varies at the location where the electron beams are deflected towards the screen. Consequently, F_x and F_y influence the angle at which the electron beams impinge on the colour selection electrode. This leads to colour errors. Further, it is important that in the known display device the electron beam is deflected towards the display screen in a very small area in which large gradients in the deflection field occur. Calculations have shown that small deviations, caused by the influence of the magnetic field, at the location where the electron beam enters the area where the electron beam is deflected towards the display screen bring about large deviations at the location where the electron beam impinges on the display screen. As the deflection field exhibits no gradients, the display device according to the invention is much less sensitive to this effect. It is to be noted that the use of the deflection space in combination with emission means emitting a row of electron beams forms part of the present invention. The electron beams enter the deflection space substantially directly after issuing from the emission means. They do not first pass through another deflection space in order to be deflected in a transverse direction (z-direction). Such an arrangement would largely annihilate the intended effect.

In Fig. 2, which shows a preferred embodiment of the display device according to the invention, the angle at which the electron beams enter the deflection space is approximately 45°. For electron beam 5 this angle α is 45°. For the electron beams 4 and 6, the angle is 45° - δ and 45° + δ, respectively. After the electron beams have described parabolic paths, they pass through a colour selection electrode 8 and impinge on a display screen 10. The angle δ which the electron beams 4 and 6 form with the electron beam 5 is generally small, in the order of magnitude of a few tenths to a few degrees.

Fig. 3 shows a detail of the colour display device of Fig.2. Of the electron beams 24, 25 and 26, only electron beam 25 is shown in Fig. 3. Electron beam 25 has a velocity v_0, with v^2_0 is proportional to the kinetic energy E_{kin} of the electrons. The velocity in a direction perpendicularly to the plane of the colour selection electrode is $vy_0 = v_0\cos(\alpha)$; the velocity in a direction parallel to the plane of the colour selection electrode is v_{xo} =

$v_0\sin(\alpha)$. In the deflection space the electron-beams are subject to an acceleration $\underline{a}$ which is directed from the flat electrode 29 to the colour selection electrode 28. Said acceleration is directly proportional to the field strength of the electric field E.

The distance covered by an electron beam in the deflection space 27 in the direction parallel to the plane of the colour selection S_x is:

$S_x = 2{*}v_0^2/a{*}\sin(\alpha)\cos(\alpha) = \text{constant}{*}\sin(2\alpha)$

S_y, being the distance covered by the electron beam in a direction transversely to the electrodes, is represented by:

$S_y = 1/2{*}v_0^2/a{*}\sin^2(\alpha)$

Developing $\sin(2\alpha)$ about 45° (= $\pi/4$ radials) gives (α expressed in radials):

$\sin(2\alpha) = 1-2{*}(\pi/4 - \alpha)^2$ + higher order terms

This formula shows that for an angle of 45°, in a first-order approximation, the distance S_x is equal for all three electron beams 24, 25 and 26 when the electron beams 24, 25 and 26 are equally energized and subject to an equal electric field in the deflection space.

In a second order approximation, there is a small difference Δ between the location where beam 25 passes through the colour selection electrode and the location where beams 24 and 26 pass through the colour selection electrode.

For beam 25 it holds that:

S_{x25} = constant

For beams 24 and 26 it holds that:

$S_{x24,26} = \text{constant}{*}(1 - 2\delta^2)$

It follows that:

$\Delta = S_{x25} - S_{x24,26} = S_{x25}{*}2{*}\delta^2$

An estimation of δ and, hence, of Δ can be made for a specific type of tube by means of Fig. 4a. The electron beams 24, 25 and 26 intersect at the location of colour selection electrode 28. Subsequently, the electron beams diverge, in the present example, along straight lines. The distance D between the target spots of the electron beams on the display screen is

$D = 2{*}D_1{*}\delta$

where D_1 is the distance between the colour selection electrode and the display screen.

For example, if D_1 is 1 cm and the distance D is equal to the distance between phosphors on the display screen (≅ 250 µm), δ is 1/80 radial (≅ 0.7°) and Δ is $S_{x5}{*}3.124{*}10^{-4}$. Δ is small and not shown in Fig. 4a, yet under certain conditions it is recommendedable to correct this difference. In the case of a colour display device having a display screen with a dimension of approximately 50 cm, Δ varies from approximately 0 µm at one edge of the display screen to approximately 156 µm at an opposite edge, which is approximately equal to half the distance between phosphors on the display screen. Δ increases according as the dimensions of the display screen increase.

The difference Δ is smaller if, for example, the electron beams are located at a distance from each other at the location where they enter the deflection space. When, in the above example, the electron beams 24 and 26 are spaced 78 µm from electron beam 25 when they enter the deflection space, Δ varies across the display screen between approximately -78 µm and +78 µm, which leads to an improved image display.

The difference Δ is smaller, and can even be compensated completely, when the above constant of the electron beams 24 and 26 is a factor of $1+2\delta^2$ larger than the constant of the electron beam 25, for example when the kinetic energy E_{kin} of the electron beams 24 and 26 is a factor of $1+2\delta^2$ larger or the electric field strength is a factor of $1+2\delta^2$ smaller than for electron beam 25.

Fig. 4a shows an arrangement in which the electrons follow a straight path between the electrode 28 and the display screen 30. It is alternatively possible to apply a potential difference between the electrode and the display screen, so that the electrons are post-accelerated after they have passed through the colour selection electrode 28. The advantages of a so-called post-acceleration tube are that only a relatively small voltage has to be applied between the electrodes 28 and 29 and that the heat supply by the electrons to the colour selection electrode is smaller. Consequently deformations of the colour selection electrode caused by temperature difference are less frequent. Fig. 4b shows a detail of such a colour display device. As the electron beams are accelerated they diverge less in the space between the colour selection electrode 28 and the display screen 30 for a given angle δ. The distance between the electron beams on the display screen should, however, be equal to D which is the distance between the phosphors. For this reason, the angle δ between the electron beams is larger, approximately a factor of 3 to 5. As a consequence hereof Δ increases by a factor of 10 to 20. These factors and the values for D_1, D, δ and Δ are only given by way of example and should not be regarded as limitative

Fig. 5 shows an arrangement which enables the energy of the electron beams 24 and 26 to be increased and the angle at which electron beams enter the deflection space to be influenced in a simple manner. An electron gun 40 comprises an electron-emitting element 41, for example a p-n emitter, a system of electrodes 42, 43, 44, 45 and 46 which accelerate, deflect and focus an electron beam 47 emitted by the element 41. When an electron beam 47 emerges from an aperture 48 it has a velocity of v_0, i.e. an energy E_0. Beyond aperture 48 there are deflection electrodes 49 and 50 which are at the same voltage as aperture 48 for a specific period of time. During this time, the electron beam is not deflected by the deflection electrodes. After electron beam 47 has left electron gun 40 it enters the deflection space which is not shown in Fig. 5. In a subsequent period of time a potential difference is applied between the electrodes 49 and 50. The electric field thus generated accelerates the electrons in a direction transversely to the direction of travel of the electron beam. The electrons of electron beam 47a which are deflected through an angle δ have a kinetic energy $E_0*(1+\delta^2)$ when the electrons are not accelerated between aperture 48 and electrodes 49, 50. By applying a small potential difference of approximately $E_0*(1+\delta^2)$ between aperture 48 and electrodes 49, 50 the kinetic energy can be readily increased by again a factor of $1 + \delta^2$. The following example shows that this can be achieved by small potential differences between the electrodes:

The acceleration $\underline{a}$ of the electrons in a direction transversely to the direction of travel between the electrodes 49 and 50 is:

$\underline{a} = F/m = eE/m = eV/md$ (1)

where F is the force exerted on the electrons, E is the field strength between the electrodes, $\underline{d}$ is the distance between the electrodes, $\underline{m}$ is the mass of one electron and V is the potential difference between the electrodes 49 and 50;

The velocity transversely to the direction of travel (defined as the T (transversal) direction) v_T on leaving the electrodes 49 and 50 is:

$v_T = at = al/v_0$ (2)

where $\underline{t}$ is the time during which the electrons are present between the electrodes 49 and 50, l is the length of the electrodes 49 and 50 in the direction of electron beam 47 and v_0 is the velocity of the electrons in the direction of electron beam 47. It further holds that:

$v_T = \delta v_0$ (3)

and

$1/2 m v_0^2 = eV_{electron}$ (4)

with $V_{electron}$ is equal to the potential difference between the source emitting the electrons, in the present example element 41, and the average potential of the electrodes 49 and 50. A combination of the formulae 1, 2, 3 and 4 gives:

$V/V_{electron} = \delta d/l$

Consequently it has been found that for a $V_{electron}$ of approximately 2 KeV, a δ of approximately 1/80 radial (0.7 degrees) and a d:l ratio of approximately 1:1 a potential difference between the electrodes 49 and 50 of approximately 25 V is sufficient. For a post-acceleration tube in which δ may have a value of approximately 3 to 5 degrees, a potential difference in the order of magnitude of 100 to 200 V is sufficient. In addition, for the deflected electron beam 47a, a potential difference of approximately 0.3 V (or several V in the case of a post-acceleration tube) can be applied between aperture 48 and the electrodes 49 and 50. By virtue hereof, the energy of the electrons in the deflected electron beams is again a factor of $1+\delta^2$ larger than the energy of the undeflected electron beam, and the electron beams intersect at the location of the colour selection electrode.

It is alternatively possible to apply a slightly weaker electric field (reduced by a factor of $1+\delta^2$) in the deflection space to the deflected electron beams whose energy is increased by a factor $1+\delta^2$. For example, when for the electron beam 47 the potential difference between the flat electrode and the colour selection electrode is 1 KV, the potential difference for the deflected electron beam 47a is approximately 0.15 V (and for a post-acceleration tube approximately 3 to 9 V) lower. It is to be noted that in all the above cases the velocity of the electrons in the x direction is equal or substantially equal for the electron beams 47 and 47a. As a consequence hereof, the influence of magnetic fields on the electron beams is at least substantially equal. In the present example, the electron beams 47 and 47a are generated in succession. Consequently, the images in the various primary colours are displayed successively. In an embodiment of the display device according to the invention, the emission means are suitable for the simultaneous generation of at least two of the electron beams of the fan. The emission means may comprise, for example, three sources for a fan of three electron beams, for example electron beams 24 and 26 of Fig. 2 being generated simultaneously. Said electron beams intersect at the location of the colour selection electrode 28. This enables at least two of the images in the primary colours to be displayed simultaneously without an energy difference between the electron beams 24 and 26 being necessary. This leads to a reduction of the frequency or frequencies at which the emission means or the electrodes 28 and 29 are driven. Preferably, all electron beams are generated simultaneously, so that they all pass through the deflection space at the same time.

A further simplification of the colour display device can then be achieved. Corrections at the location where the electron beams pass through the colour selection electrode can be achieved, for example, by applying slightly less energy to electron beam 25 relative to the electron beams 24 and 26 or by shifting the location where the electron beam 25 enters the deflection space relative to the location where the electron beams 24 and 26 enter said deflection space. The above described example can be compared to a display device according to the invention in which the angle x is 20°.

In the case of electron beam 25 the distance S_x covered is:

$S_x = \text{constant}*\sin(2*20°) = \text{constant}*\sin(40°)$

and in the case of electron beam 24:

S_x = constant*sin(40° + 2δ)

≅ constant*(sin(40°) + 2*cos(40°)*δ) and in the case of electron beam 26:

S_x = constant*(sin(40°)-2*cos(40°)*δ)

Provided that the electron beams have the same energy and are subject to an equal electric field in the deflection space, they will not intersect at the location of the colour selection electrode, the distance between the outer electron beams 24 and 26 being approximately 2*2*cot(40°)*δ*S_x. When S_x is 50 cm and δ is approximately 1/80 radial, as in the above numeric example, this distance is approximately 2 cm. This is approximately a factor of 100 more than 156 μm which resulted from the above-described example. In order to correct these deviations there should be an approximately 100 times larger potential difference between the aperture 48 and the electrodes 49 and 50 or there should be a variation in the potential difference between the flat electrode 29 and the colour selection electrode 28 which is approximately 100 times larger than indicated hereinabove. However, such large potential differences have a number of disadvantages. A large potential difference between aperture 48 and the electrodes 49 and 50 will lead to the formation of a varying lens field between these electrodes, thereby bringing about differences in the shape of the electron beams, which is undesirable. Moreover, there is a relatively large difference between the energy levels of the electron beams entering the deflection space. Deviations occurring as a consequence of magnetic fields are dependent on the velocity of the electron beams. When the angle is 45° these deviations are approximately equal for all electron beams because the differences in velocity are small. When the differences in energy levels are increased, magnetic fields bring about differences in the deviations between the various beams. Obviously, this is also undesirable.

It is to be noted, that the idea of making the fans of electron beams enter the deflection space at an angle of 45° and the resulting advantages are independent of the manner in which the electron beams are generated or of the shape of the emission means and, consequently, it applies in general to display devices in which a fan of electron beams is deflected in a deflection space between two flat electrodes. Nor does the idea of influencing energy levels of the electron beams forming the fan in such a manner that they intersect at the location of the colour selection electrode, and the resulting advantages, depend on the manner in which the electron beams are generated on the shape of the emission means and, consequently, it can be applied in general to display devices in which a fan of electron beams enters the deflection space at an angle and is deflected therein.

Fig. 6 diagrammatically shows the deflection space. Said deflection space is an approximately box-shaped space 60 which is defined by ribs a, b and c. The ribs a and b approximately correspond to the sides of the electrodes 28 and 29 (Fig. 2), rib c corresponds to the distance between the electrodes 28 and 29. When in operation, electron beams 61 enter the deflection space approximately at the location of rib b and at least substantially parallel to rib a . The lengths of the ribs a and c are in a ratio of 1: x , x being selected so that the length of rib c is somewhat larger than the maximum distance between the base 62 of the box-shaped space 60 and the extremum 63 of an electron path (denoted S_y in Fig. 6). In the case of an entrance angle α of 45 degrees, the above-mentioned distance S_y is approximately equal to 1/4 times the distance covered in a direction parallel to the base 62 (indicated by Sx in Fig. 6). When x is smaller than 1/4 it is impossible to make a maximum use of the deflection space. In this case, the maximum value of S_x should be smaller than the length of rib a . Preferably, x is not larger than 0.40. A larger value of x means that the display device becomes larger and that a larger potential difference has to be applied to the electrodes 28 and 29. In order to obtain a display device which is as flat as possible, the length of rib a is preferably smaller than the length of rib b. In an embodiment, the ratio of the length of ribs a and b is smaller than 1:1.333, for example 9:16. In the case of a display device having an image surface area of, for example, 45 x 80 cm (and, consequently, a diagonal of approximately 1 meter) the length of rib c is approximately 12 cm. The "depth" of the display device can then be limited to 15 to 20 cm. A further advantage is that the influence of disturbing magnetic fields is small. The influence of magnetic fields on the paths of the electron beams is smaller according as the distance covered in the deflection space is smaller.

It is to be noted that the ideas concerning the dimensions of the deflection space and the resulting advantages are not dependent upon the manner in which the electron beams are formed or the number of electron beams or the shape of the emission means and, hence, also apply to other types of display devices in which an electron beam enters the deflection space at an angle of approximately 45° and is deflected in said deflection space.

It will be obvious that within the scope of the invention many variations are possible to those skilled in the art. For example, the invention is not limited to the shape of the envelope shown herein, nor by the number of electron beams, nor by a specific embodiment of the emission means, the only characteristic being that the emission means are suitable for emitting a row of electron beams, it additionally being stated that some of the embodiments are based on ideas which, as described hereinabove, can also be used for other types of display devices, nor is the invention limited to an entrance angle of 45°, unless stated otherwise, and for the embodiments in which the entrance angle is approximately 45° the invention is not limited to an embodiment in which the entrance angles are located symmetrically relative to an angle of 45°. The number of electron beams may be for example two, one electron beam forming an angle of $45° - \delta$, and one electron beam forming an angle of $45° + \delta$ with the plane of the colour selection electrode. When three electron beams are emitted, the angles which the electron beams form with the plane of the colour selection electrode may be $45° - \delta$, $45° + \delta$ and $45° + 3\delta$. Four electron beams may be emitted at angles of $45° - 2\delta$, $45° - \delta$, $45° + \delta$ and $45° + 2\delta$. As described hereinabove, the electron beams may enter the deflection space at a small distance from each other or at the same point. The emission means may have one source for each electron beam or a common source for a fan of electron beams.

In the examples described herein, the display device comprises a colour selection electrode. In other embodiments said colour selection electrode may be absent, in which case the display screen may be provided with a conducting layer and the deflection space may be formed between said conducting layer and the flat electrode 29.

Claims

1. A display device comprising a cathode-ray tube having a display screen, emission means for generating a row of electron beams which are arranged at one side of said display screen, the emission means having an emitting element for each electron beam and each electron beam scanning one column of picture elements of the display screen, and deflection means for deflecting the electron beams towards the display screen, characterized in that said deflection means comprise a first and a second electrode which are arranged so as to extend at least substantially parallel to each other and between which there is a deflection space, the display device having means to apply a potential difference to these electrodes, and the emission means being suitable for making the electron beams enter the deflection space at an acute angle with the parallel electrodes.

2. A display device as claimed in Claim 1, in which the display device comprises a colour selection electrode which extends in front of the display screen, characterized in that one of the said electrodes comprises the colour selection electrode, the emission means are suitable for emitting a row of fans of electron beams, and the said angle is approximately 45°.

3. A display device as claimed in Claim 2, characterized in that the emission means are constructed so that the angles at which the electron beams in the fans enter the deflection space are located symmetrically relative to an angle of 45°.

4. A display device as claimed in Claim 2 or 3, characterized in that the emission means are suitable for the simultaneous generation of at least two of the electron beams forming a fan.

5. A display device as claimed in Claim 4, characterized in that the emission means are suitable for the simultaneous emission of all the electron beams forming a fan.

6. A display device as claimed in Claim 2, 3, 4 or 5, characterized in that the emission means are suitable for generating electron beams, the energy levels of the electron beams differing so much that said electron beams intersect in the plane of the colour selection electrode at a specific potential difference between the said electrodes.

7. A display device as claimed in Claim 2, 3, 4, 5 or 6, characterized in that the emission means comprise deflection electrodes.

8. A display device as claimed in any one of the preceding Claims, characterized in that the electrodes are substantially rectangularly shaped and the interspace between the electrodes is more than 1/4 times the length of the electrodes viewed in the direction of travel of the electron beams.

9. A display device as claimed in Claim 8, characterized in that the distance between the electrodes is less than 0.40 times the length of the electrodes viewed in the direction of travel of the electron beams.

10. A display device as claimed in any one of the preceding Claims, characterized in that the length of the electrodes viewed in the direction of travel of the electron beams is smaller than the length viewed in a direction transversely to the said direction.

11. A display device as claimed in Claim 10, characterized in that the quotient of the length of the electrodes in the direction of travel of the electron beams and the length of the electrodes in a direction transversely to the said direction is smaller than 3:4.

12. A display device as claimed in Claim 11, characterized in that the said quotient is approximately 9:16.

13. A cathode ray tube suitable for use in a display device as claimed in any one of the preceding Claims.

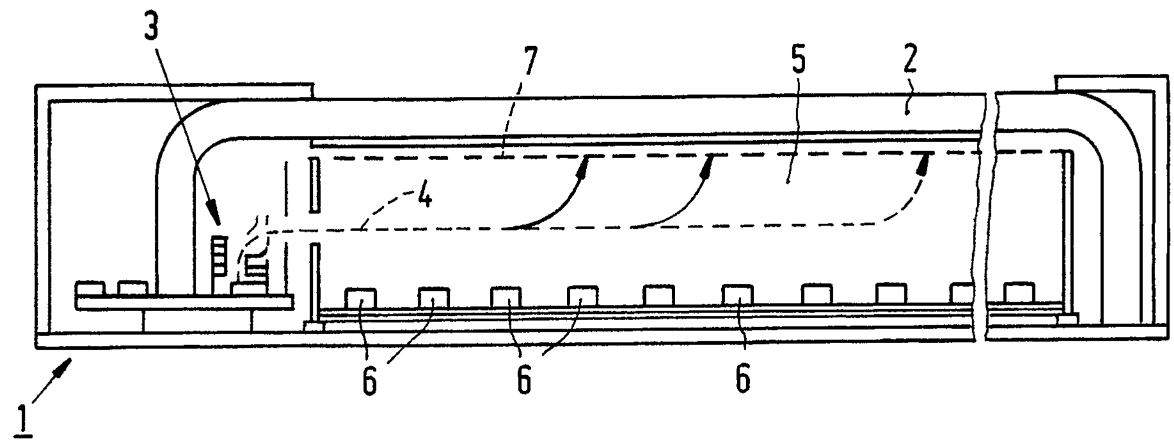

FIG.1

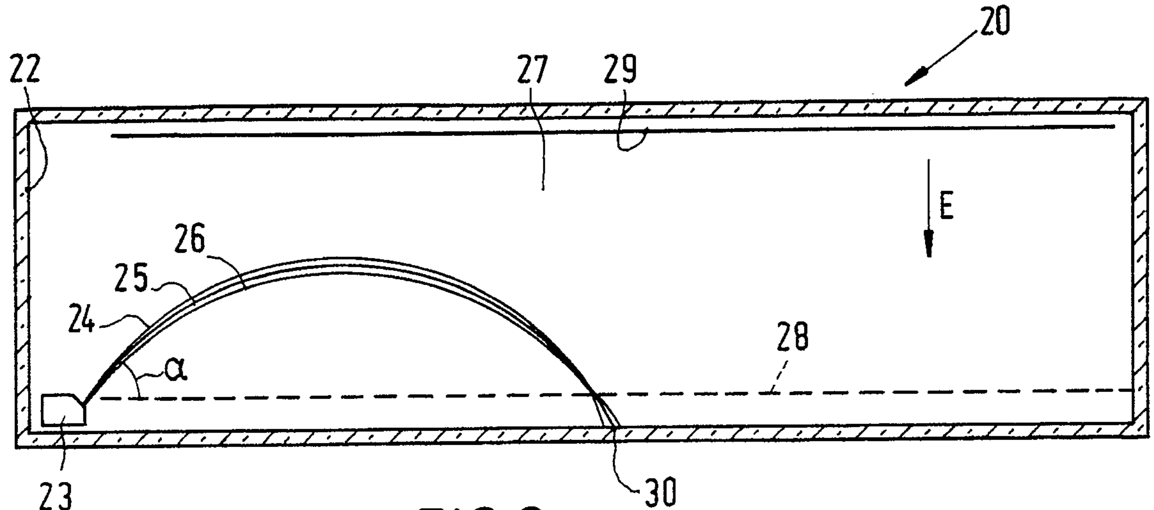

FIG.2

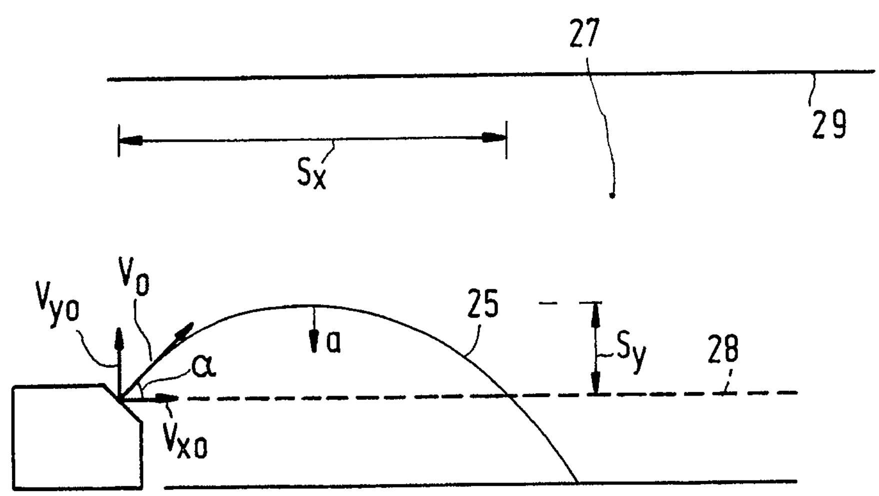

FIG.3

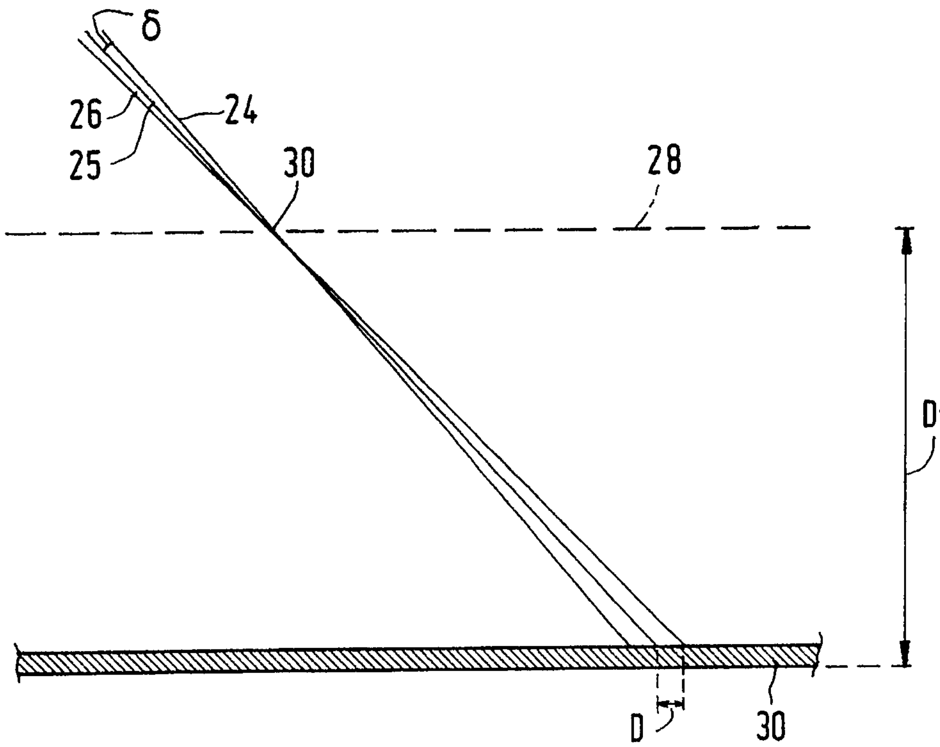

FIG. 4A

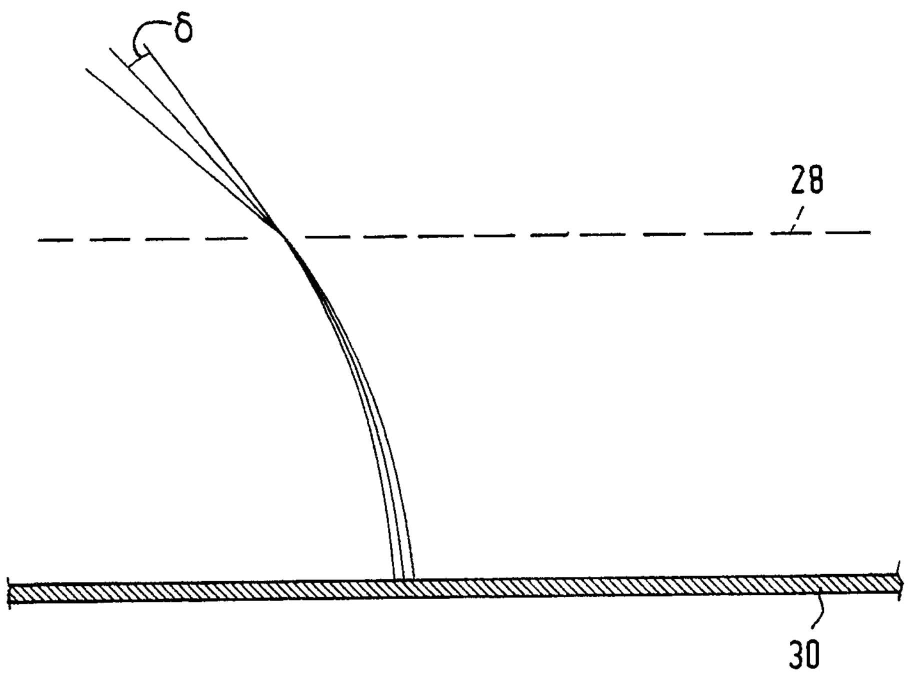

FIG. 4B

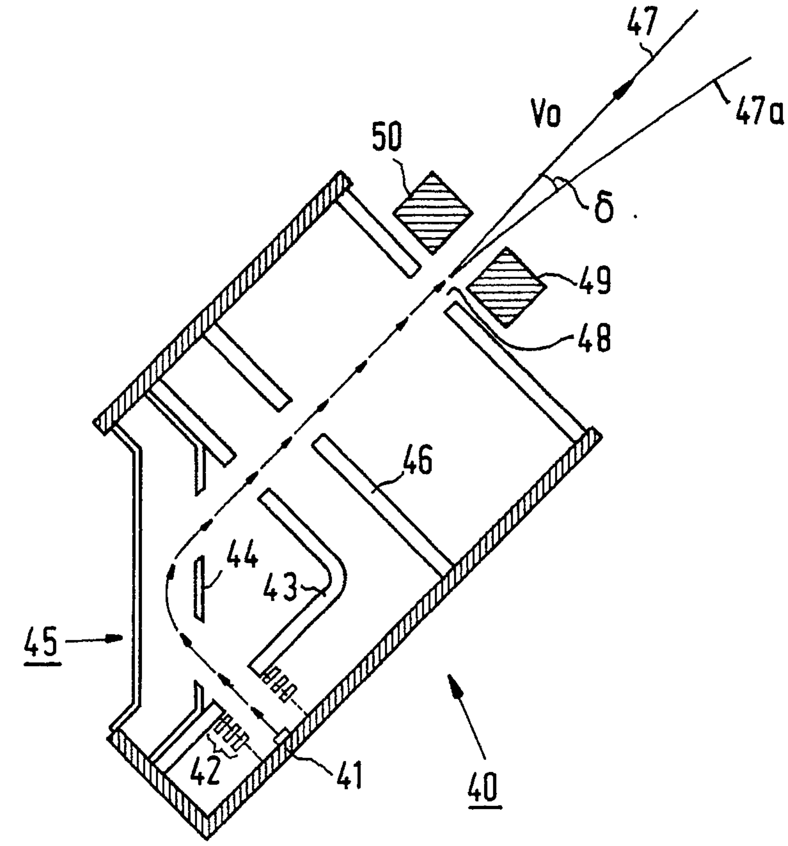

FIG.5

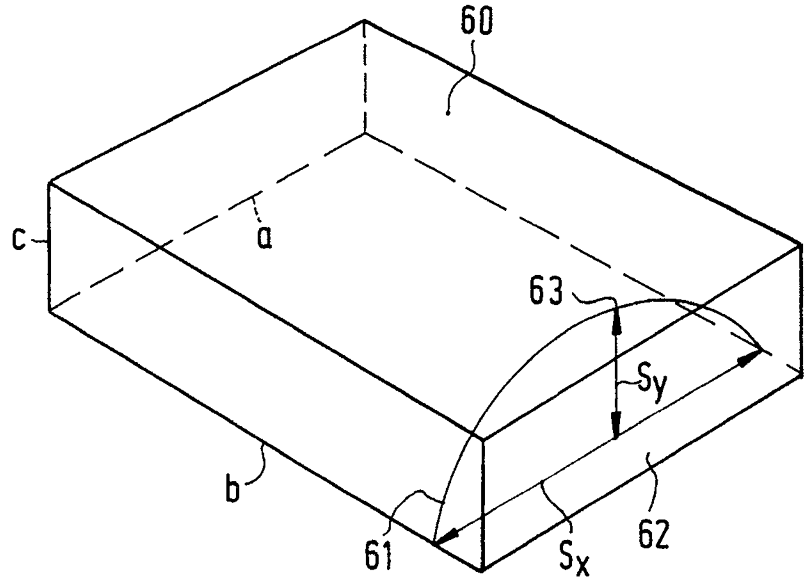

FIG.6

European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 20 2446

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 598 233 (PHILIPS) * Column 3, lines 47-65; column 4, line 49; column 5, lines 2,59-61; column 6, line 51 - column 7, line 2; figures 1,1A,3,4 * – – –	1,8-11,13	H 01 J 31/12
A		4-7	
D,A	EP-A-0 288 095 (PHILIPS) * Column 2, lines 34-37; figure 2 * – – – – –	1,13	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 01 J 31/00
H 01 J 29/00

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	06 December 90	ROWLES K.E.G.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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A: technological background
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D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document