



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.01.2005 Bulletin 2005/02

(51) Int Cl.7: **H01J 29/48, H01J 29/56**

(21) Application number: **03077137.2**

(22) Date of filing: **08.07.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT RO SE SI SK TR
 Designated Extension States:
AL LT LV MK

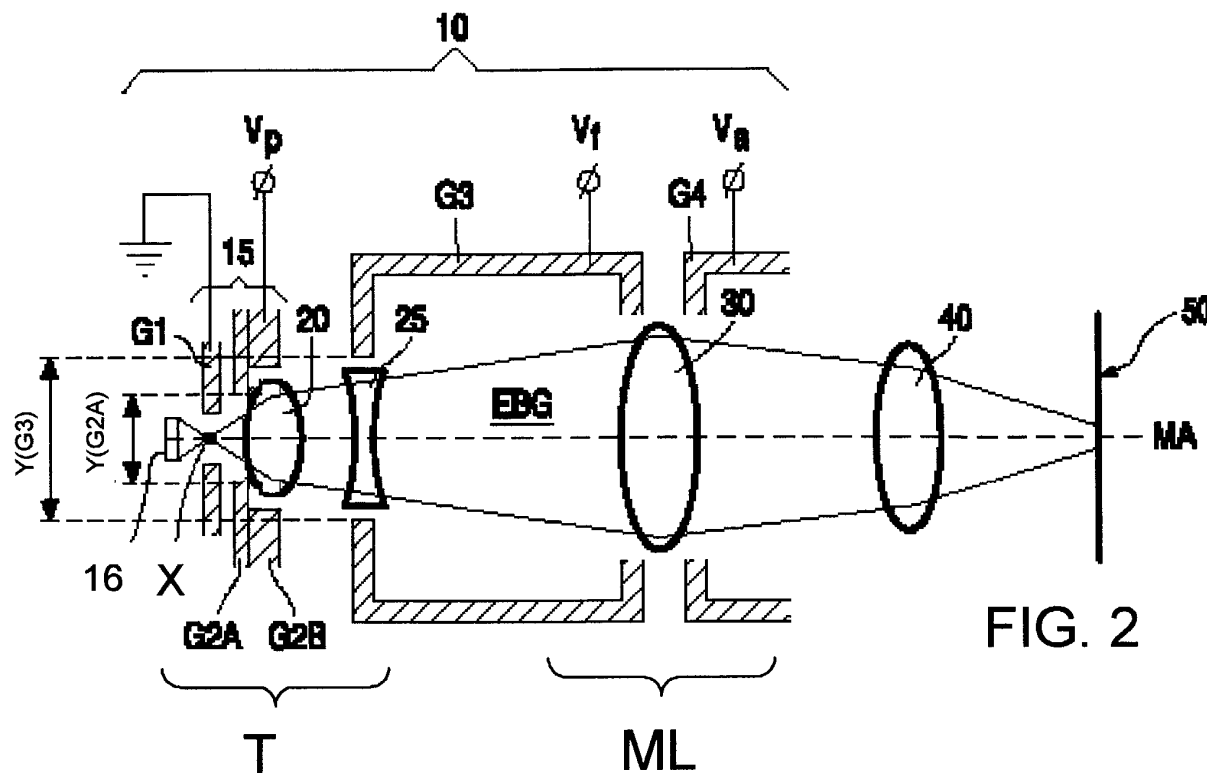
(72) Inventors:
 • **Steinhauser, Heidrun**
NL-5654 CA Eindhoven (NL)
 • **Snel, Jan**
NL-5651 CA Eindhoven (NL)

(71) Applicant: **LG Philips Displays NL**
5651 CA Eindhoven (NL)

(54) **Cathode ray tube and electron gun**

(57) A cathode ray tube comprises an electron gun (10) with a main lens (ML) section and a triode section. The triode section (T) comprises a first (G1), second (G2) and third (G3) electrode, the first electrode facing a cathode. The triode section is arranged such that in operation a cross-over (X) in the electron beam is formed in the frame (y) direction, while no cross-over is formed in the line (x) direction. The first electrode (G1)

has an elongated aperture facing the cathode having an aspect ratio (y/x) between 0.35 and 0.60 ($0.35 \leq y(G1)/x(G1) \leq 0.6$). The second electrode (G2) has an aperture facing the first electrode triode wherein $x(G2A) < x(G1)$ and $y(G2A) > y(G1)$ and the dimension of the electron beam in the main lens portion in the frame (y) direction is less than 1/2 of the dimension of the electron beam in the line (x) direction ($y(ML)/x(ML) \leq 0.5$).



Description

[0001] The invention relates to a cathode ray tube comprising:

a display screen for receiving an electron beam and displaying an image by means of said electron beam, said display screen comprising a plurality of luminescent picture elements in at least two different colors;
 an electron gun having a main lens section for focusing the electron beam onto said display screen and a triode section for generating the electron beam, the triode section comprising a first (G1), second (G2) and third (G3) electrode, the first electrode facing a cathode,
 deflection means for deflecting the electron beam across a number of scan lines on the display screen, so as to display the image, in a line (x) direction and a frame (y) direction and
 color selection means for guiding the electron beam towards one of said at least two different colors of the picture elements and a means for providing voltages to the electron gun.

[0002] The invention also relates to an electron gun for use in such a cathode ray tube.

[0003] An embodiment of such a cathode ray tube is known from US-A-4,620,134. In the triode section, electrons are emitted from a cathode and are accelerated through an extraction grid. Between the extraction grid and the pre-focusing electron lens, the electron beam forms a cross-over which is imaged into a spot at a pre-determined picture element of the display screen by a focusing section of the electron gun, in particular by the main lens.

[0004] Deflection means are provided between the electron gun and the display screen. In operation, the deflection means are addressed in such way that the electron beam formed in the electron gun is deflected across a number of scan lines on the display screen. The angle of deflection is greatest in the corners of the display screen, the greatest value of the deflection angle occurring in the cathode ray tube being referred to as "maximum deflection angle" hereinafter. The electron beams are scanned over the display screen in a first, line, direction and a second, frame, direction. Within the concept of the invention the line direction is the fast direction, i.e. the direction in which the scan frequency is the highest.

[0005] In operation, the electron beam is scanned in such way that successively each of the picture elements receives the electron beam. The beam current of the electron beam is modulated thereby, and an image is formed on said display screen.

[0006] Generally, the cathode ray tube is a color cathode ray tube, wherein three electron beams are formed in the so-called 'in-line plane', which beams are ar-

ranged next to each other in the horizontal direction, each beam corresponding to one of the colors red, green, and blue. The in-line direction, often the horizontal direction, is often also called the x-direction, whereas the other direction, often the vertical direction, is also called the y-direction. A shadow mask being provided with holes is located in proximity of the display screen and guides each of the electron beams to a picture element having the corresponding color.

[0007] The design of the electron gun has in the last decades steadily increased in complexity. The deflection angles have also steadily increased. Increasing the deflection angle allows a flatter tube to be used. However, increasing the angle of deflection also increases the distortion of the beam spot on the screen, since distortions of the beam spot increase with the angle of deflection. To counteract such beam distortions, especially distortions in the corners of the screen, measures which make the electron gun design ever more complicated have been added to the electron gun design. Examples of such measures are the introduction of more and more elements into the electron gun, such as an increased number of main lens electrodes (an example of which is the so-called distributed main lens design in which the main lens comprises not two or three, but a large number of electrodes), the introduction of dynamic voltages in the gun (the so-called DAF, dynamic astigmatism and focusing lens), the introduction of dynamic voltages in the pre-focusing lens part (the so-called DBF, dynamic beam forming, concept). Although such measures to some extent alleviate the problems, they increase the costs of the electron gun, and the complexity of the design itself becomes a problem in that the more elements are introduced, the more alignment and other manufacturing problems may occur.

[0008] Even with said measures disturbing artefacts, especially moiré patterns, may still be visible in parts of the displayed image.

[0009] It is an object of the invention to provide a cathode ray tube of the type described in the opening paragraph, of a relatively simple yet adequate design.

[0010] This object is achieved by means of the cathode ray tube according to the present invention, which is characterized

- in that the triode section is arranged such that in operation a cross-over in the electron beam is formed in the frame (y) direction, while no cross-over is formed in the line (x) direction,
- in that the first electrode facing has an elongated aperture facing the cathode having a dimension in the line (x) direction and a dimension in the frame (y) direction, having an aspect ratio (y/x) between 0.35 and 0.60 and
- in that the second electrode has an aperture facing the first electrode of which the dimension in the line (x) direction is smaller than the dimension of the aperture in the first electrode in the line (x) direction,

and a dimension in the frame (y) direction larger than the dimension in the frame (y) direction of the aperture in the first electrode and

- in that the triode and the main lens part of the electron gun are such arranged that the dimension of the electron beam in the main lens portion in the frame (y) direction is less than 1/2 of the dimension of the electron beam in the line (x) direction.

[0011] In standards designs, although there may be some astigmatism in the electron-optical lenses, the triode part and the prefocus part (i.e. the lens formed by grid g2b and g3a) acts in both directions in a similar fashion and a cross-over is made in both directions. Usually the electron beam is substantially round or slightly to moderately deformed.

[0012] In an electron gun in accordance with the invention, this standard concept has been left, the triode and prefocus part of the gun as well as the rest of the gun acts fundamentally differently in the y-direction than in the x-direction. In the y-direction a cross-over is present in the electron beam. A cross-over is a node in the electron beam, where the individual electron trajectories, or the majority of individual electron trajectories cross-over from one side of a plane of symmetry (for the x-direction this is the y-plane, for the y-direction this is the x-plane) to the other side. No cross-over means that the majority of the individual electron trajectories stay at one side of the plane of symmetry, and throughout the whole electron beam. This forms one aspect of the invention. In one direction (the y-direction) there is a strong prefocussing action after the triode part leading to a cross-over, while in the other (x-direction) there is a diverging action, the electron beam paths do not converge in a cross-over point. It is remarked that electron-optically this makes a large difference, since it is usually the cross-over point which is imaged on the screen via the focusing lens in the main lens part.

[0013] Another aspect is that a thin-y-beam concept is used. The aperture in the first electrode is strongly elongated (an aspect ratio (y/x) of between 0.35 and 0.60), i.e. the aperture in the G1 is considerably longer in the x-direction than in the y-direction. It has been found that thin beams (thin in the y-direction) have a good spot behavior in the y-direction as they are scanned over the screen. Too thin a beam (ratio's below 0.35), however, may lead to haze, which is unwanted, and furthermore may lead to very high loads on the cathode, for beam ratio larger than 0.60 the advantage is relatively small.

[0014] Preferably the ratio lies between 0.4 and 0.55, most preferably between 0.45 and 0.50. Many aspect come into designing an electron gun, the inventors have found that within the indicated ranges best performances may be obtained.

[0015] A further aspect is that that the second electrode has an aperture facing the first electrode triode of which the dimension in the line (x) direction is smaller

than the dimension of the aperture in the first electrode in the x-dimension, and a dimension in the frame (y) direction larger than the dimension in the frame direction of the aperture in the first electrode. This enables in a simple manner the triode to be converging in the y-direction and diverging in the x-direction as described above.

[0016] Preferably the dimension in the line (x) direction of the aperture in the second electrode facing the first electrode lies between 0.7 and 0.9 of the x-dimension of the aperture of the first electrode, most preferably between 0.75 and 0.85. Preferably the dimension in the frame (y) direction of the aperture in the second electrode facing the first electrode is between 1.5 and 2 times the y-dimension of the aperture in the first electrode, most preferably between 1.6 and 1.8.

[0017] Such dimensions offer the best compromise between a strong convergent action in the one (y) direction and the diverging action in the other for the indicated range of aspect ratio of the aperture in the first electrode.

[0018] Preferably the aperture in the second electrode facing the first electrode has an aspect ratio of 1, and is preferably round. This is a simple construction.

[0019] A further aspect is that the beam diameter in the main lens is much smaller in the frame (y) direction than in the line (x) direction. The beam is in the y-direction in the main lens much smaller (at least twice as small) than in the x-direction. To establish this the divergence in the y-direction between the triode part and the main lens part is considerably smaller than the divergence in the x-direction. Persons skilled in the art have computer programs to calculate field lines, electron optical lenses and the corresponding beam paths, enabling them to compare beam sizes in different directions and calculate beam sizes. The y-dimension of the beam, increases moderately or stays constant between the triode part and the main lens, whereas the divergence of the beam in the x-direction is much larger, providing for an electron beam in the main lens with a larger (at least twice) x-dimension than y-dimension.

[0020] Depending on the complexity of the design many ways are possible to achieve this feature. One way is to provide a relatively strong Q-pole in the field formed between the second and third electrode.

[0021] In a first embodiment the second electrode is provided with a first sub-electrode having the aperture facing the first electrode, and a second sub-electrode having an elongated aperture with a aspect ratio (x/y) larger than 3 and the third electrode has an aperture facing the second electrode with an aspect ratio of approximately 1 and a dimension smaller than the largest dimension of the aperture in the second sub-electrode and larger than the smallest dimension of the aperture in the second sub-electrode. The quadrupole action is than mainly due to the strongly elongated form of the aperture in the second sub-electrode (the G2B).

[0022] In another, preferred, embodiment the second electrode is provided with a first sub-electrode having

the aperture facing the first electrode, followed by a second sub-electrode having an elongated aperture with an aspect ratio (x/y) between 1.0 and 1.5 and the third electrode (G3 or G3a) has an aperture with an aspect ratio (x/y) of between 0.4 and 0.6, and the dimension in the frame (y) direction of the aperture in the third electrode is between 3.5 and 6.5 times the y -dimension of the aperture in second sub-electrode. The quadruple action is then due to the elongated form of the aperture in the G3 electrode.

[0023] Many electron gun designs apply dynamic voltages to electrodes in particular to electrodes forming part of or positioned close to the main lens part. This is in particular done to prevent a degradation of the beam spot in the y -direction as the beam is scanned over to screen the comers. One can improve the beam spot by choosing the optimal value for the beam size at for instance the corners and the centre. The difference between the optimum values provides an estimate of the dynamic swing one has to use, or the image errors on the screen. If, in a conventional gun, without the use of dynamic voltages, the beam spot in the y -direction at the centre is optimal, the applied focus voltages at the comers is relatively far from optimal, leading to image errors such a haze. This can be counteracted by the introduction of dynamic voltages, however, at the cost of making the device more complex and costly. For a device in accordance with the invention, due to the thin beam concept, and the small divergence in the y -direction, the beam spot size in the y -direction at the centre can be made nearly voltage independent, preferably having a dy/dV_{focus} of less than 10%/kVolt, and in preferred embodiments it is. Typically in prior art devices the change is considerably more, some 25% or more. A small dependence of the beam spot in the y -direction at the centre means that one can choose a value of a focus voltage which provides an optimum value for the comers of the screen i.e. when the beam is deflected to a comer), is also optimal or at nearly optimal for the centre. Thus one can use a static voltage or only a limited dynamic voltage swing. Use of a dynamic voltage swing is for instance advantageous for a cathode ray tube with a very large deflection angle (above 120°). In preferred embodiments, however, the electron gun is a static electron gun.

[0024] "Static electron gun" within the concept of the invention means that no dynamic voltage are applied. It is remarked that this does not just simplify the design of the electron gun, but also the means for providing voltage and even the arrangement of the pins at the other end of the neck portion of the cathode ray tube via which the voltages are supplied to the electrodes within the electron gun.

[0025] These and other aspects of the invention will be apparent from and elucidated with reference to the appended drawings. Herein:

Fig. 1 shows a cathode ray tube;

Fig. 2 is a schematic cross-sectional view along the y -direction of a cathode ray tube in accordance with the invention;

Fig. 3 shows a cross-sectional view along the x -direction of a part including the triode part of a cathode ray of an electron according to the invention.

Fig. 4 shows a cross-sectional view along the y -direction of a part including the triode part of a cathode ray of an electron according to the invention.

Fig. 5 shows the electron beam shape in the electron gun along the x - and y -direction.

Fig. 6 illustrates schematically an electron gun in accordance with a first embodiment of the invention.

Fig. 7 illustrates schematically an electron gun in accordance with a second embodiment of the invention.

Fig. 8 illustrates the y and x - dimension of the beam spot on the screen for an embodiment of the invention.

[0026] In the color cathode ray tube depicted in Fig. 1, three electron beams EBR, EBG, EBB are generated in the triode section 15 of an electron gun 10. Each of the electron beams EBR, EBG, EBB corresponds to one of the colors red, green, and blue from which a color image is formed. The electron beams EBR, EBG, EBB are aligned in the plane of the drawing, commonly referred to as 'in-line' plane.

[0027] Figure 2 illustrates an electron gun 10 in cross-sectional view along the y -direction. The triode section T comprises a first electrode G1 and a second electrode G2, which electrode comprising two sub-electrodes, G2A and G2B, G2A facing the first electrode G1, the electron gun 10 further comprises a second focusing electrode G3 receiving a focus voltage V_f , and an anode G4 receiving an anode voltage V_a . The main lens (ML) 30 is formed between the second focusing electrode G3 and the anode G4. The focus voltage V_f is, for example, 6 kV and the anode voltage V_a is 30 kV.

[0028] Each electron beam EBR, EBG, EBB is accelerated through the electron gun 10 by the anode voltage V_a and, after exiting from the electron gun 10, passes the deflection means 40 before reaching the display screen 50.

[0029] The deflection means 40 are arranged to deflect the electron beam EBR, EBG, EBB through a predetermined, varying deflection angle, so that the electron beam EBR, EBG, EBB can impinge on any desired picture element of the display screen 50. The shadow mask 45 is arranged near the display screen 50 and is provided with a pattern of electron beam passing holes, which are arranged such that each electron beam EBR, EBG, EBB can only impinge on a picture element of corresponding color.

[0030] The electron beam EBG is shown together with the electron-optical system of the electron gun in fig. 2 in cross-section along the y -direction. The electron

beam EBG was chosen by way of example, and the following is equally valid for the other electron beams EBR, EBB.

[0031] Electrons are emitted from a thermionic cathode 16 which is heated by a filament. The beam EBG of emitted electrons is focused into a cross-over X by a first electrode G1. Afterwards, the electron beam EBG passes a second electrode G2A, the first focusing electrode G2B which forms a pre-focus lens 20, and the second focusing electrode G3 which forms a lens 25. The second electrode G2A and the first focusing electrode G2B are connected together and receive, in operation, a pre-focusing voltage V_p of, for example, about 800 V. The second focusing electrode G3 receives the focus voltage V_f of, for example, 6 kV.

[0032] The electron beam EBG is focused onto the display screen 50 into a beam spot MA, by main lens 30. For completeness of the drawing it is remarked that the deflection means can also have a focusing effect on the beam, which in figure 2 is schematically indicated by lens 40. The triode section and the beam form in the triode section is shown in more detail in Fig. 4.

[0033] Figs. 3 and 4 illustrate the aspects of the invention as far as they relate to the triode section T.

[0034] Fig. 3 illustrate in a cross-sectional view along the x-direction the triode section T, showing the electron beam shape and electron beam paths. The G1 electrode has an aperture with a dimension (size) $x(G1)$, the aperture in the G2A electrode has a dimension $x(G2A)$, the aperture G2B has a dimension $x(G2B)$, the approximate sizes and position and thicknesses are indicated. The G3 electrode is positioned roughly on the indicated position, but the dimension (aperture size) is so large that it falls outside the range of the figure. Examples will be given below of various exemplary sizes. The size of the aperture are such that electron beam does not form a cross-over in the x-direction, but, on the contrary, the majority of the electron emitted do not cross the plane of symmetry. The following relation hold ($x(G2A) < x(G1)$), as can be seen on the figure. Preferably it holds $0.7x(G1) \leq x(G2A) \leq 0.9x(G1)$, even more preferably $0.75x(G1) \leq x(G2A) \leq 0.85x(G1)$.

[0035] Figure 4 shows the triode section in a cross-sectional view along the y-direction. Immediately apparent is that a cross-over X is formed, in contrast to the situation shown in figure 4. Furthermore the y-dimension of the aperture in the G1 electrode is considerably smaller than the x-dimension. It holds $0.35 \leq y(G1)/x(G1) \leq 0.6$. The y-dimension of the aperture in the G2A electrode is larger than the y-dimension in the G1 electrode, i.e. $y(G2A) > y(G1)$. Furthermore preferably the dimension in the frame (y) direction of the aperture in the second electrode facing the first electrode is between 1.5 and 2 times the y-dimension of the aperture in the first electrode facing the cathode

$$(1.5y(G1) \leq y(G2A) \leq 2y(G1)).$$

[0036] Figure 5 shows a further aspect of the invention relating to the size of the electron beam in the main lens. The size of the electron beam is taken at a mid point of the cathode load range, i.e. in between zero cathode load range and the maximum sustainable cathode load range. The electrodes of the triode section and possible further electrode in between the triode section and the main lens section are such arranged and in operation supplied with voltages that aspect ratio of the electron beam in the main lens, i.e. the ratio between the dimension of the electron beam in the y-direction $y_{beam}(ML)$ and the dimension in the x-direction $x_{beam}(ML)$ is less than 0.5, preferably less than 1/3, i.e. the divergence after the triode section is much less in the y-direction than in the x-direction. The combination of a thin y-beam concept, but yet not too thin, since the aspect ratio of the aperture in the G1 electrode is held between $0.35 \leq y(G1)/x(G1) \leq 0.6$, in combination with the concept of providing in the triode section a cross-over in the y-direction without a cross-over in the x-direction provides for the advantageous aspects of the invention.

[0037] Fig. 6 illustrates schematically a first design for an electron gun for a device in accordance with the invention. This exemplifies a very simple, yet successful design, in which, using the concepts of the invention it has proven possible to obtain beam spot characteristics comparable to much more complex designs in which DAF and DBF were used. Below a number of examples of electron gun in accordance with the invention are given. The following abbreviations are used:

s01=distance between cathode and G1

G1=first electrode

G1A= first sub-electrode of G1 (in case the first electrode is a compound electrode, or has an aperture which is differently shaped at one side, than at the other)

G1B= second sub-electrode of G1

$x(G1)$, $x(G1A)$, $x(G1B)$ =x-dimension of aperture in G1, respectively G1A, G1B

$y(G1)$, $y(G1A)$, $y(G1B)$ =y-dimension of aperture in G1, respectively G1A, G1B

d1,d1a,d1b= thickness G1, G1A, G1B

s12=distance between G1 and G2

G2= second electrode

G2A= first sub-electrode of G2 (in case the first electrode is a compound electrode, or has an aperture which is differently shaped at one side, than at the other)

G2B= second sub-electrode of G2

$x(G2)$, $x(G2A)$, $x(G2B)$ =x-dimension of aperture in G2, respectively G2A, G2B

$y(G2)$, $y(G2A)$, $y(G2B)$ =y-dimension of aperture in G2, respectively G2A, G2B

s23=distance between G2 and G3.

G3=third electrode

$x(G3)$ =x-dimension of aperture in G3 facing G2 (G2B) electrode

y(G3)=y-dimension of aperture in G3 facing G2
(G2B) electrode
d3a=thickness of plate in which apertures in G3
electrode facing the G2 electrode are made
L=total length of G3 electrode
R=round aperture

[0038] Various examples of designs for electron guns in accordance with the invention are now exemplified.

Example 1:

[0039]

(all measures in mm)
s01=0.08
x(G1)= 0.69
y(G1)= 0.32
d1=0.09
s12=0.16
x(G2A)=y(G2A)=0.6 (R)
x(G2B)=1.7
y(G2B)=1.6
d2a=0.25
d2b=1
s23=1.2
x(G3)=3.3
y(G3)=6.5
d3a=0.4
L=28.62

[0040] In this example the y/x ratio for the aperture in the G1-electrode is 0.46,

$x(G2A)/x(G1)<1=0.87$
 $y(G2A)/y(G1)>1=1.88$
 $x(G2A)/y(G2A)=1$
 $x(G2B)/y(G2B)=1.06$
 $x(G3)/y(G3)=0.51$
 $y(G3)/y(G2B)=4.06$

[0041] A second example is given by :

(all measures in mm)
s01=0.1
x(G1)= 0.8
y(G1)= 0.4
d1=0.1
s12=0.21
x(G2A)=y(G2A)=0.65 (R)
x(G2B)=1.4
y(G2B)=1.15
d2a=0.25
d2b=0.7
s23=1.2
x(G3)=2.7
y(G3)=5.5
d3a=0.4

L=28.805

[0042] In this second example the y/x ratio for the aperture in the G1-electrode is 0.5,

$x(G2A)/x(G1)<1=0.81$
 $y(G2A)/y(G1)>1=1.63$
 $x(G2A)/y(G2A)=1$
 $x(G2B)/y(G2B)=1.22$
 $x(G3)/y(G3)=0.49$
 $y(G3)/y(G2B)=4.78$

[0043] A third example is given by:

(all measures in mm)
s01=0.1
x(G1)= 0.8
y(G1)= 0.4
d1= 0.1
s12=0.21
x(G2A)=y(G2A)=0.65 (R)
x(G2B)=1.25
y(G2B)=1.08
d2a=0.25
d2b=0.7
s23=1.2
x(G3)=2.7
y(G3)=5.5
d3a=0.4
L=28.805

[0044] In this third example the y/x ratio for the aperture in the G1-electrode is 0.5,

$x(G2A)/x(G1)<1=0.81$
 $y(G2A)/y(G1)>1=1.63$
 $x(G2A)/y(G2A)=1$
 $x(G2B)/y(G2B)=1.16$
 $x(G3)/y(G3)=0.49$
 $y(G3)/y(G2B)=5.09$

[0045] A fourth example is given by :

(all measures in mm)
s01=0.14
x(G1)= 0.8
y(G1)= 0.4
d1= 0.09
s12=0.23
x(G2A)=y(G2A)=0.65 (R)
x(G2B)=2.5
y(G2B)=2.1
d2a=0.25
d2b=1.0
s23=1.2
x(G3)=2.7
y(G3)=5.5
d3a=0.4

L=28.62

[0046] In this fourth example the y/x ratio for the aperture in the G1-electrode is 0.5,

$x(G2A)/x(G1) < 1 = 0.81$
 $y(G2A)/y(G1) > 1 = 1.63$
 $x(G2A)/y(G2A) = 1$
 $x(G2B)/y(G2B) = 1.19$
 $x(G3)/y(G3) = 0.49$
 $y(G3)/y(G2B) = 2.62$

[0047] A fifth example is given by:

s01=0.07
 $x(G1) = 0.75$
 $y(G1) = 0.32$
 $d1 = 0.09$
 $s12 = 0.23$
 $x(G2A) = y(G2A) = 0.65$ (R)
 $x(G2B) = 1.6$
 $y(G2B) = 1.6$
 $d2a = 0.25$
 $d2b = 1.0$
 $s23 = 1.2$
 $x(G3) = 2.7$
 $y(G3) = 5.5$
 $d3a = 0.4$
 $L = 28.62$

[0048] In this fourth example the y/x ratio for the aperture in the G1-electrode is 0.5,

$x(G2A)/x(G1) < 1 = 0.87$
 $y(G2A)/y(G1) > 1 = 2.0$
 $x(G2A)/y(G2A) = 1$
 $x(G2B)/y(G2B) = 1$
 $x(G3)/y(G3) = 0.49$
 $y(G3)/y(G2B) = 3.44$

[0049] In the above examples the aperture in the G3 electrode is strongly elongated, whereas the aperture in the G2B electrode is only moderate elongated.

[0050] Figure 7 exemplifies embodiment in which the aperture in the G2B electrode is strongly elongated while the aperture in the G3 electrode is not or only moderately elongated. It also shows that, although the simple design shown in figure 6 (in which the main lens part is of very simple design, i.e. the G3 electrode forms a single electrode) is a preferred embodiment, more complex designs fall within the scope of the invention. In figure 7 the G3 electrode is a composite electrode (G3A, G3B etc). In this example the G1 electrode is also a composite electrode, i.e. comprising a first sub-electrode G1A and a second sub-electrode G1B.

[0051] For an exemplary, but not limitative embodiments the dimensions are:

(all measures in mm)

s01=0.08
 $x(G1A) = 0.68$
 $y(G1A) = 0.32$
 $d1a = 0.07$
 $x(G1B) = 1.2$
 $y(G1B) = 2.1$
 $d1b = 0.12$
 $s12 = 0.14$
 $x(G2A) = y(G2A) = 0.5$ (R)
 $x(G2B) = 2$
 $y(G2B) = 0.5$
 $d2a = 0.3$
 $d2b = 0.2$
 $s23 = 0.9$
 $x(G3) = 0.75$
 $y(G3) = 0.75$
 $d3a = 0.4$
 $L = 28.98$

[0052] In this fourth example the y/x ratio for the aperture in the G1A-electrode is 0.47,

$x(G2A)/x(G1A) < 1 = 0.74$
 $y(G2A)/y(G1A) > 1 = 1.56$
 $x(G2A)/y(G2A) = 1$
 $x(G2B)/y(G2B) = 4$
 $x(G3)/y(G3) = 1$
 $y(G3)/y(G2B) = 1.5$

As far as the relations between the dimensions in the G1A and G2A electrodes is concerned these design falls within the measures earlier indicated, the difference with the design of figure 6 lies in the G2B and G3 apertures.

[0053] Finally fig. 8 illustrates the behaviour of the beam spot on the screen (MA) see figure 1). Line 81 depicts the spot size in the y-direction in the centre as a function of focus voltage V_{focus}. Line 82 the same in the NE (north-east corner), line 83 depicts the spot size in the centre of the screen in the x-direction as a function of V_{focus}, while line 84 does the same in the north east corner. Evident is that the spot size in the y-direction is in the centre (line 81) nearly constant i.e. independent of the applied focusing voltage. For a device in accordance with the invention, due to the thin beam concept, and the small divergence in the y-direction, the beam spot size in the y-direction at the centre can be made nearly voltage independent, preferably having a dy/dV_{focus} of less than 10%/kVolt, and in preferred embodiments it is. Typically in prior art devices the change is considerably more, some 25% or more. A small dependence of the beam spot in the y-direction at the centre means that one can choose a value a focus voltage which provides an optimum value for the comers of the screen i.e. when the beam is deflected to a corner), is also optimal or at nearly optimal for the centre. Thus one can use a static voltage or only a limited

dynamic voltage swing. Use of a dynamic voltage swing is for instance advantage for cathode ray tube with a very large deflection angle (above 120°). In preferred embodiments, however, the electron gun is a static electron gun.

[0054] "Static electron gun" within the concept of the invention means that no dynamic voltage are applied. It is remarked that this does not just simplify the design of the electron gun, but also the means for providing voltage and even the arrangement of the pins at the other end of the neck portion of the cathode ray tube via which the voltages are supplied to the electrodes within the electron gun.

[0055] The drawings are schematic and not drawn to scale. While the invention has been described in connection with preferred embodiments, it should be understood that the invention should not be construed as being limited to the preferred embodiments. Rather, it includes all variations which could be made thereon by a skilled person, within the scope of the appended claims.

[0056] Particularly, a skilled person would be able to modify physical quantities mentioned in this patent application, such as electrode thickness, aperture diameter, electrode spacings and/or applied voltages, such that an optimum balance is struck.

Claims

1. A cathode ray tube comprising:

a display screen for receiving an electron beam and displaying an image by means of said electron beam, said display screen comprising a plurality of luminescent picture elements in at least two different colors;

an electron gun (10) having a main lens (ML) section for focusing the electron beam onto said display screen and a triode section for generating the electron beam, the triode section (T) comprising a first (G1), second (G2) and third (G3) electrode, the first electrode facing a cathode,

deflection means (40) for deflecting the electron beam across a number of scan lines on the display screen, so as to display the image, in a line (x) direction and a frame (y) direction and color selection means (45) for guiding the electron beam towards one of said at least two different colors of the picture elements wherein

- the triode section is arranged such that in operation a cross-over (X) in the electron beam is formed in the frame (y) direction, while no cross-over is formed in the line (x) direction,
- the first electrode (G1) has an elongated aperture facing the cathode having a di-

mension in the line (x) direction and a dimension in the frame (y) direction, having an aspect ratio (y/x) between 0.35 and 0.60 ($0.35 \leq y(G1)/x(G1) \leq 0.6$) and

- the second electrode (G2) has an aperture facing the first electrode triode of which the dimension in the line (x) direction smaller than the dimension of the aperture in the first electrode in the line (x) direction ($x(G2A) < x(G1)$), and a dimension in the frame (y) direction larger than the dimension in the frame (y) direction of the aperture in the first electrode ($y(G2A) > y(G1)$) and
- the triode and the main lens part of the electron gun are such arranged that the dimension of the electron beam in the main lens portion in the frame (y) direction is less than 1/2 of the dimension of the electron beam in the line (x) direction ($y(ML)/x5(ML) \leq 0.5$).

2. A cathode ray tube as claimed in claim 1, wherein the aspect ratio of the aperture in the first electrode lies between 0.4 and 0.55 ($0.4 \leq y(G1)/x(G1) \leq 0.55$).

3. A cathode ray tube as claimed in claim 2, wherein the aspect ratio of the aperture in the first electrode lies between 0.45 and 0.55 ($0.45 \leq y(G1)/x(G1) \leq 0.5$).

4. A cathode ray tube as claimed in claim 1, wherein the dimension in the line (x) direction of the aperture in the second electrode facing the first electrode lies between 0.7 and 0.9 of the x-dimension of the aperture of the first electrode ($0.7x(G1) \leq x(G2A) \leq 0.9x(G1)$).

5. A cathode ray tube as claimed in claim 4, wherein the dimension in the line (x) direction of the aperture in the second electrode facing the first electrode lies between 0.75 and 0.85 of the x-dimension of the aperture of the first electrode ($0.75x(G1) \leq x(G2A) \leq 0.85x(G1)$).

6. A cathode ray tube as claimed in claim 1 or 4, wherein the dimension in the frame (y) direction of the aperture in the second electrode facing the first electrode is between 1.5 and 2 times the y-dimension of the aperture in the first electrode facing the cathode ($1.5y(G1) \leq y(G2A) \leq 2y(G1)$).

7. A cathode ray tube as claimed in claim 6, wherein the dimension in the frame (y) direction of the aperture in the second electrode facing the first electrode is between 1.6 and 1.8 times the y-dimension of the aperture in the first electrode facing the cathode ($1.6y(G1) \leq y(G2A) \leq 1.8y(G1)$).

8. A cathode ray tube as claimed in claim 1, wherein the aperture in the second electrode facing the first electrode has an aspect ratio of approximately 1 ($x(G2A)/y(G2A) \approx 1$).
9. A cathode ray tube as claimed in claim 8 wherein the aperture in the second electrode facing the first electrode is round.
10. A cathode ray tube as claimed in claim 1, wherein the second electrode is provided with a first sub-electrode having the aperture facing the first electrode, and a second sub-electrode having an elongated aperture with a aspect ratio (x/y) larger than 3 and the third electrode has an aperture facing the second electrode with an aspect ratio of approximately 1 and a dimension smaller than the largest dimension of the aperture in the second sub-electrode and larger than the smallest dimension of the aperture in the second sub-electrode.
11. A cathode ray tube as claimed in claim 1, wherein the second electrode is provided with a first sub-electrode having the aperture facing the first electrode, followed by a second sub-electrode having an elongated aperture with a aspect ratio (x/y) between 1.0 and 1.5 ($1.0 < x(G2B)/y(G2B) < 1.5$) and the third electrode (G3 or G3a) has an aperture with an aspect ratio (x/y) of between 0.4 and 0.6 ($0.4 < x(G3)/y(G3) < 0.6$), and the dimension in the frame (y) direction of the aperture in the third electrode is between 3.5 and 5.5 times the y-dimension of the aperture in second sub-electrode (G2B) ($3.5 < y(G3)/y(G2B) < 5.5$).
12. A cathode ray tube as claimed in claim 1, wherein the electron gun is a static electron gun.
13. An electron gun (1) for a cathode ray tube having a main lens section (ML) for focusing the electron beam onto said display screen and a triode section (T) for generating the electron beam, the triode section comprising a first (G1), second (G2) and third (G3) electrode, the first electrode (G1) facing a cathode, wherein the first electrode has an elongated aperture facing the cathode having a dimension in the line (x) direction and a dimension in the frame (y) direction, having an aspect ratio (y/x) between 0.35 and 0.60 ($0.35 \leq y(G1)/x(G1) \leq 0.6$) and the second electrode has an aperture facing the first electrode triode of which the dimension in the line (x) direction smaller than the dimension of the aperture in the first electrode in the line (x) direction ($x(G2A) < x(G1)$), and a dimension in the frame (y) direction larger than the dimension in the frame (y) direction of the aperture in the first electrode ($y(G2A) > y(G1)$).
14. An electron gun as claimed in claim 13, wherein the aspect ratio of the aperture in the first electrode lies between 0.4 and 0.55 ($0.4 \leq y(G1)/x(G1) \leq 0.55$).
15. An electron gun as claimed in claim 13, wherein the dimension in the line (x) direction of the aperture in the second electrode facing the first electrode lies between 0.7 and 0.9 of the x-dimension of the aperture of the first electrode ($0.7x(G1) \leq x(G2A) \leq 0.9x(G1)$).
16. An electron gun as claimed in claim 13, wherein the dimension in the frame (y) direction of the aperture in the second electrode facing the first electrode is between 1.5 and 2 times the y-dimension of the aperture in the first electrode facing the cathode ($1.5y(G1) \leq y(G2A) \leq 2y(G1)$).
17. An electron gun as claimed in claim 13, wherein the second electrode is provided with a first sub-electrode having the aperture facing the first electrode, and a second sub-electrode having an elongated aperture with a aspect ratio (x/y) larger than 3 and the third electrode has an aperture facing the second electrode with an aspect ratio of approximately 1 and a dimension smaller than the largest dimension of the aperture in the second sub-electrode and larger than the smallest dimension of the aperture in the second sub-electrode.
18. An electron gun as claimed in claim 13, wherein the second electrode is provided with a first sub-electrode having the aperture facing the first electrode, followed by a second sub-electrode having an elongated aperture with a aspect ratio (x/y) between 1.0 and 1.5 ($1.0 < x(G2B)/y(G2B) < 1.5$) and the third electrode (G3 or G3a) has an aperture with an aspect ratio (x/y) of between 0.4 and 0.6 ($0.4 < x(G3)/y(G3) < 0.6$), and the dimension in the frame (y) direction of the aperture in the third electrode is between 3.5 and 6.5 times the y-dimension of the aperture in second sub-electrode (G2B) ($3.5 < y(G3)/y(G2B) < 6.5$).

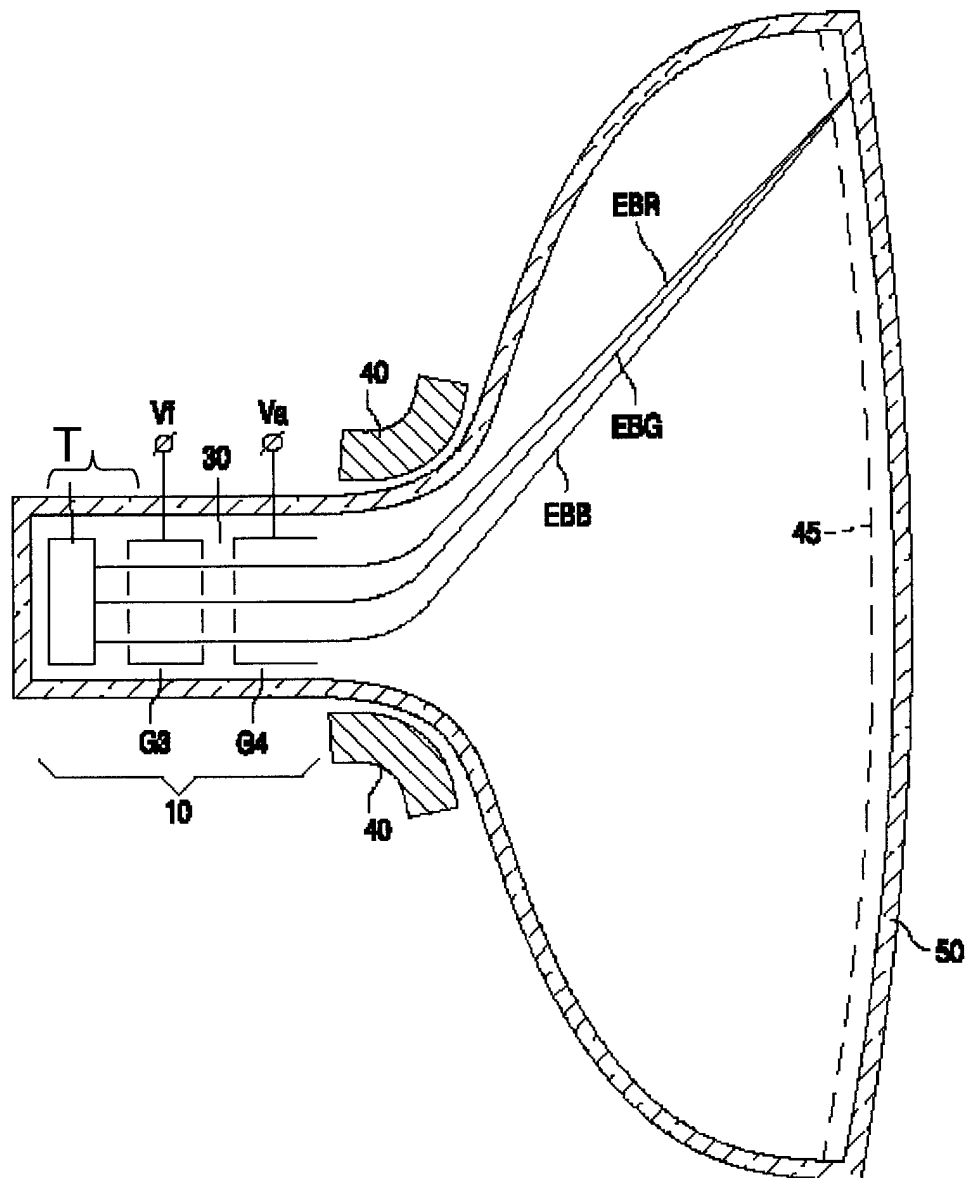
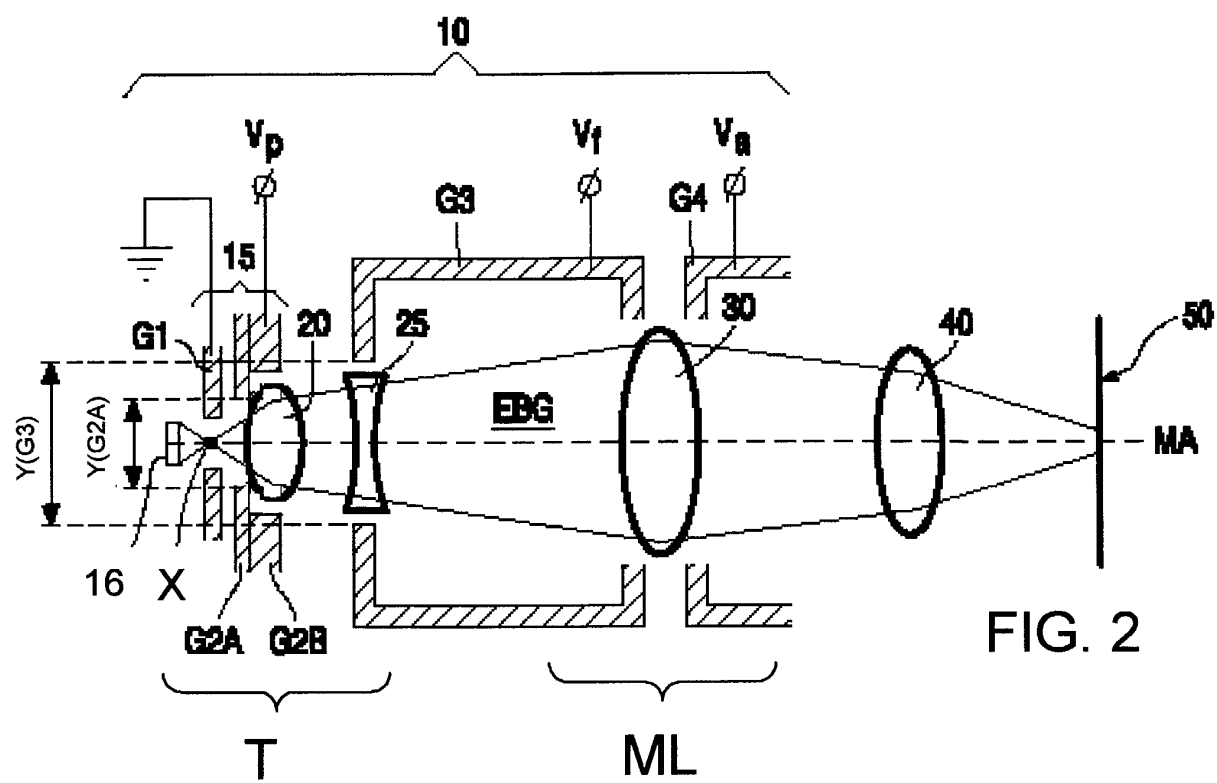
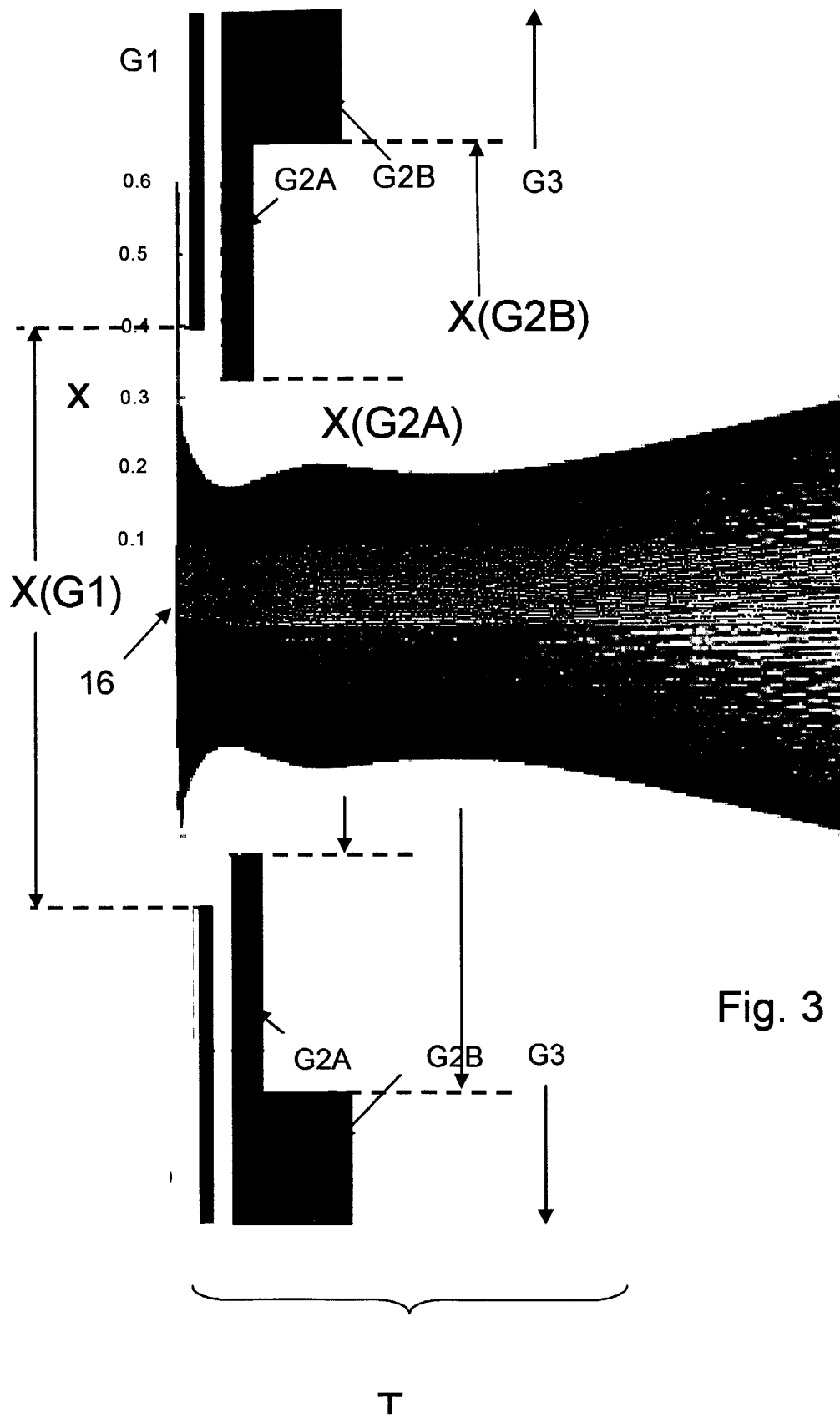


FIG. 1





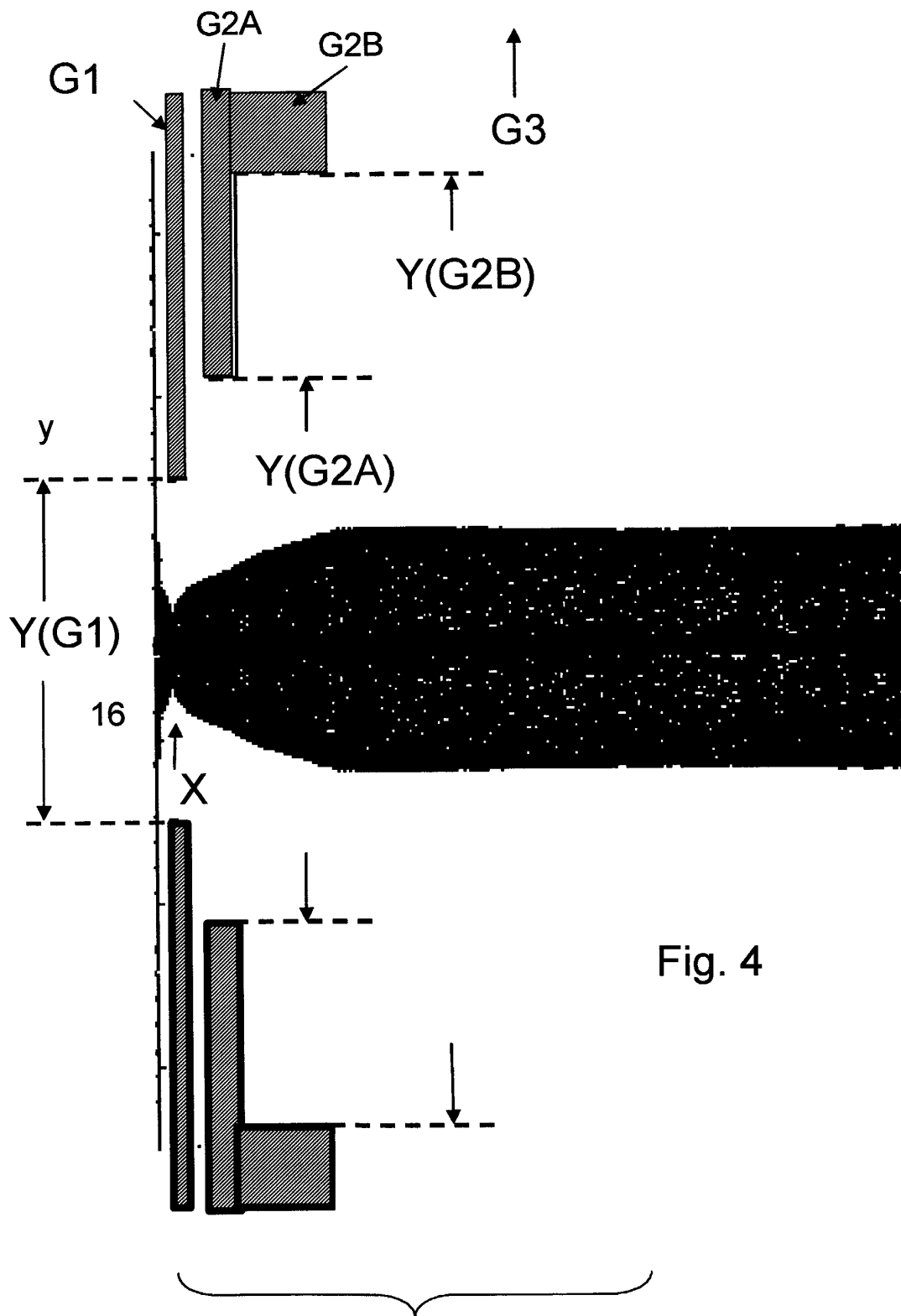


Fig. 4

T

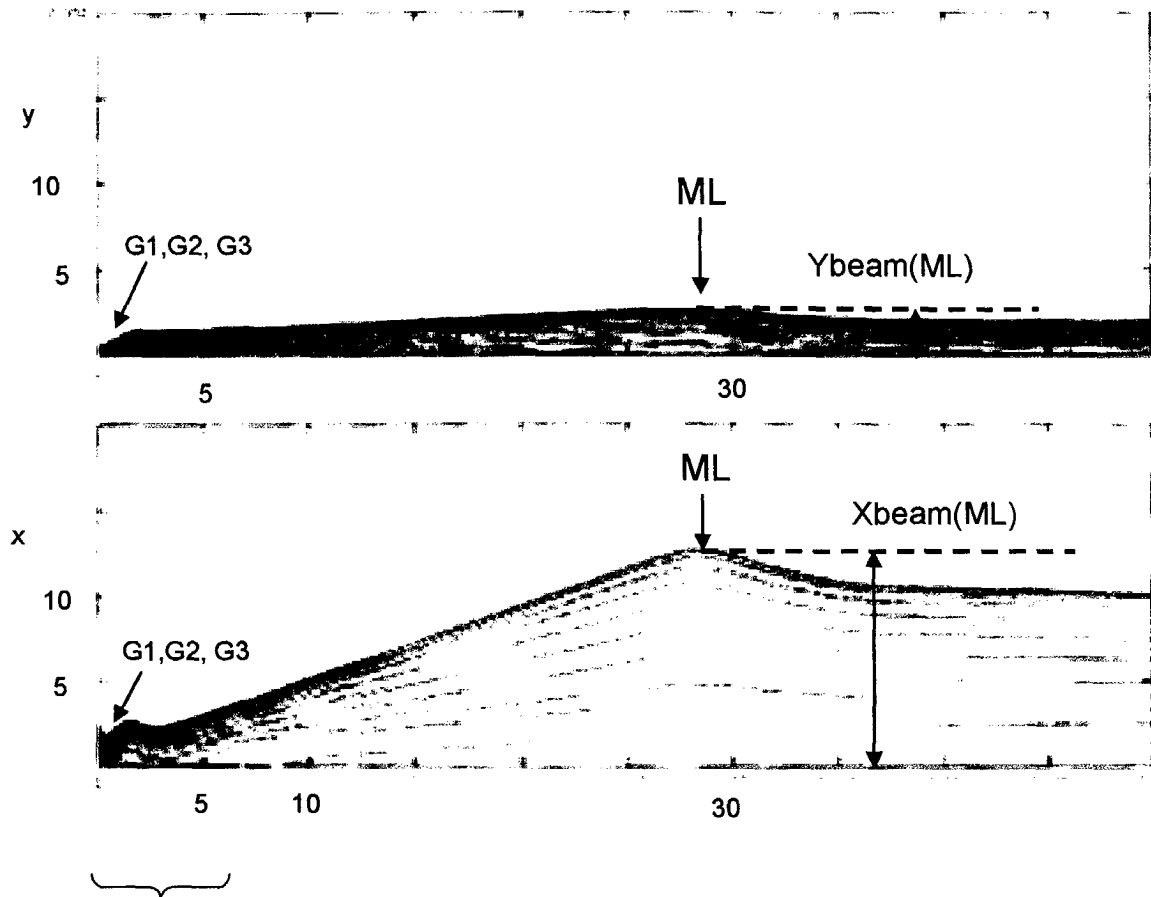


Fig. 5

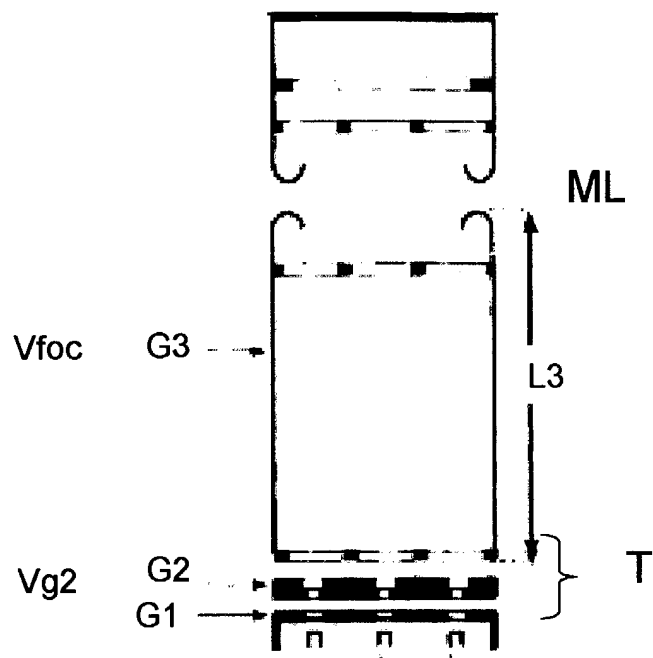


Fig. 6

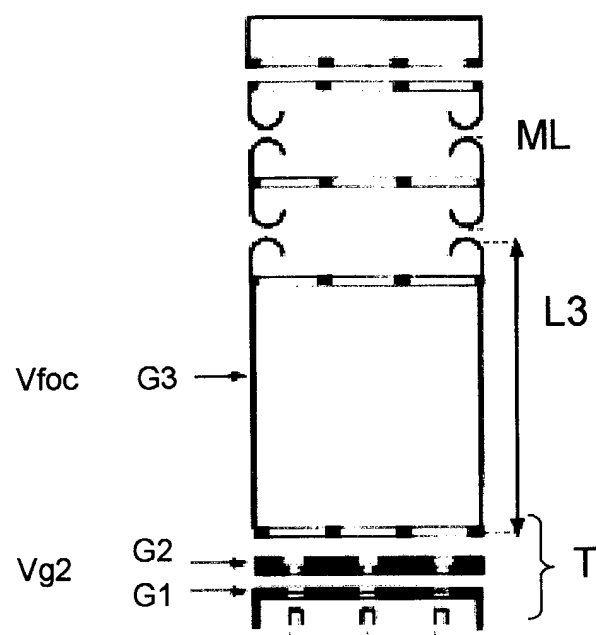


Fig. 7

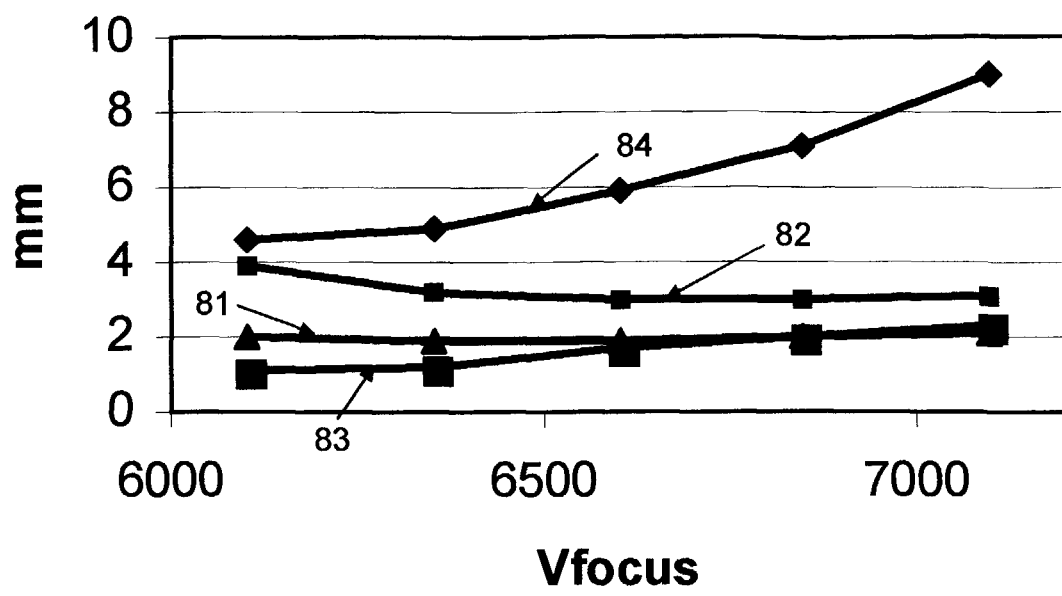


Fig. 8



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 07 7137

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.7)
A,D	US 4 620 134 A (VAN DEN BELD ANTONIUS J M ET AL) 28 October 1986 (1986-10-28) * the whole document *	1-18	H01J29/48 H01J29/56
A	--- PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) & JP 07 006707 A (MATSUSHITA ELECTRON CORP), 10 January 1995 (1995-01-10) * abstract; figures 1-4 *	1-18	
A	--- EP 0 899 768 A (SONY CORP) 3 March 1999 (1999-03-03) * paragraphs [0006]-[0013],[0066]; figure 9B *	1-18	
A	--- US 6 608 435 B1 (OOKUBO SYUNJI ET AL) 19 August 2003 (2003-08-19) * column 1 - column 4; figures 6A-D * & JP 2001 084922 A (TOSHIBA CORP) 30 March 2001 (2001-03-30) -----	1-18	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01J
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 4 November 2003	Examiner Oestreich, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 07 7137

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-11-2003

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 4620134	A	28-10-1986	NL	8204185 A	16-05-1984
			CA	1200835 A1	18-02-1986
			DD	212355 A5	08-08-1984
			DE	3336948 A1	03-05-1984
			ES	8406793 A1	01-11-1984
			FR	2535522 A1	04-05-1984
			GB	2130004 A ,B	23-05-1984
			HK	29288 A	29-04-1988
			IT	1171782 B	10-06-1987
			JP	59096635 A	04-06-1984
			KR	9004260 B1	18-06-1990
			SG	3988 G	17-06-1988

JP 07006707	A	10-01-1995	NONE		

EP 0899768	A	03-03-1999	JP	11067120 A	09-03-1999
			EP	0899768 A2	03-03-1999
			US	6172450 B1	09-01-2001

US 6608435	B1	19-08-2003	JP	2001084922 A	30-03-2001
			CN	1280379 A	17-01-2001
			TW	473763 B	21-01-2002
