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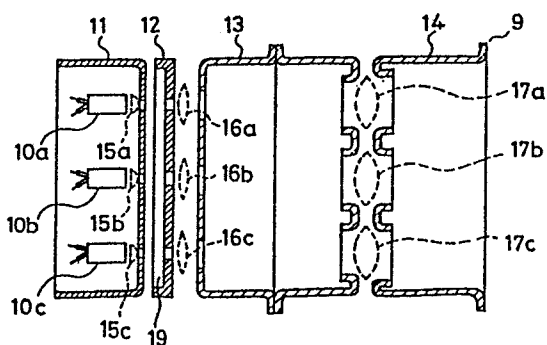
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(54) **Cathode ray tube for color display.**

(57) An electron gun has a G_2 electrode having a horizontally positioned oblong groove thereon and three apertures for passing three electron beams, which are disposed on a bottom of said groove, and intensity of an electric field on the axis of each electron gun between the G_2 electrode (12) and a G_3 electrode, diameters of respective apertures of a G_1 electrode (11), the G_2 electrode (12) and the G_3 electrode (13), distance interval between an emitter and the G_1 electrode (11), between the emitter and the G_2 electrode (12) and between the G_1 electrode (11) and the G_2 electrode (12) are selected in a predetermined relation, and thereby a generation of moire image interference fringes are prevented.

FIG.1



TITLE OF THE INVENTION

Cathode ray tube for color display

FIELD OF THE INVENTION AND RELATED ART STATEMENT

1. FIELD OF THE INVENTION

The present invention relates generally to a cathode ray tube for color display, and more particularly to a cathode ray tube for displaying high resolution color images irrespective of variation of luminance thereof.

2. DESCRIPTION OF THE RELATED ART

Generally, a resolution of a cathode ray tube for color display is influenced by a diameter and shape of a beam spot which lands on a fluorescent screen. Therefore, it is important to form the beam spot as small as possible and to reduce distortion of shape in order to obtain a high resolution image. However, the diameter of the beam spot generally increases with increase of a beam current, and hence, the resolution is apt to be lowered in a high luminance display which is resulted by a large beam current.

The above-mentioned problem is elucidated with reference to FIG.11 showing a prior art. Referring to FIG.11, when a large beam current flows, an electron beam 2a which is emitted from a central portion of an electron emission plane of a cathode 1 and is adjacent to an axis of an electron gun is converged by a cathode lens 4, which is formed between the cathode 1 and a G_1 electrode 3, and

produces a crossover 5a. On the other hand, electron beam 2b which is emitted from a peripheral portion of the electron emission plane of the cathode 1 and is apart from the axis of the electron gun are subject to comparatively strong convergence by the cathode lens 4, and a crossover 5b is formed at a position nearer to the cathode 1 than the crossover 5a of the electron beam adjacent to the axis of the electron gun. Then, a difference of the positions of the crossover 5a and 5b causes the difference of the diameter of the beam spot on a hypothetical object point, and magnifies the diameter of the images produced on the fluorescent screen, and as a result it deteriorates the resolution.

A conventional example of methods for improving the above-mentioned problem in the prior art is that: the intensity of the electric field on the axis of the electron gun between the G_2 electrode 6 and the G_3 electrode 7 is selected within a range of 5×10^4 -- 5×10^5 V/cm, and the intense prefocus lens 8 is formed adjacent to the crossover 5a, then the electron beam component 2b which is apart from the axis of the electron gun in the area of the prefocus lens 8 is converged more than the electron beam component 2a which is near the axis of the electron gun. Hence, the difference of divergence angles of both the electron beam components 2a and 2b after the crossover becomes small, thereby decreasing the diameter

of the hypothetical object point under the large beam current and the resultant diameter of the beam spot.

However, as shown in FIG.12, since an electron beam component 2c, which is emitted from the central portion of the electron beam emission plane of the cathode 1 under a small beam current produces a crossover 5c adjacent to the cathode 1, and the electron beam component 2c receives intense convergence effect from the prefocus lens 8. As a result, the diameter of the beam spot becomes too small since the hypothetical object point is decided by the second crossover 5d, and hence, contrast of moire image interference fringes, which is produced on the fluorescent screen in connection with pitch of the apertures of the shadow mask and the periodic time of the scanning line, becomes high. Thus another problem that fringe images is conspicuous.

OBJECT AND SUMMARY OF THE INVENTION

Object of the present invention is to maintain a small diameter beam spot under a large beam current, and prevent the diameter of the beam spot becoming too small under a small beam current.

The cathode lay tube for color display in accordance with the present invention comprises:

three cathodes each having electron emitter arranged horizontally in-line,

a G_1 electrode having three circular apertures

each having diameter of d_1 and facing the cathodes,

a G_2 electrode facing the G_1 electrode at the side opposite to said cathodes and having a horizontally positioned oblong groove on at least one surface thereof facing the G_1 electrode and three circular apertures facing said three circular apertures of G_1 electrode and having diameter of d_2 on the bottom of the groove,

a G_3 electrode facing the G_2 electrode at the side opposite to said G_2 electrode keeping a distance of g_{23} and having round apertures having diameter of d_3 ,

the three cathode, the G_1 electrode, the G_2 electrode and the G_3 electrode constituting horizontal in-line type three electron guns,

means for providing an electric field of an intensity on the axis of each electron gun between the G_2 electrode and the G_3 electrode is selected in a range of 5×10^4 -- 5×10^5 V/cm, and

when a distance from a surface facing the G_2 electrode of the G_1 electrode to the face of the electron emitter is g_{k1} and a distance from a surface facing the G_3 electrode of the G_2 electrode to the emitter is g_{k2} , the respective values have the following relation:

$$d_1 \geq d_2$$

$$d_2 \leq d_3 \leq 2.3 d_2$$

$$g_{k1} / d_1 \leq 0.35$$

$$1.40 \leq g_{k2} / d_1 \leq 1.75$$

$$0.8 \leq g_{23} / d_1 \leq 1.4.$$

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a cross-sectional side view of an electron gun of a cathode ray tube for color display of a first embodiment in accordance with the present invention.

FIG.2 is a perspective view showing a composition of electrodes of the electron gun in the first embodiment.

FIG.3 is a horizontal sectional view showing path of an electron beam in the electrodes under a large beam current.

FIG.4 is a vertical sectional view showing a path of the electron beam in the electrodes under a large beam current.

FIG.5 is a horizontal sectional view showing a path of the electron beam in the electrodes under a small beam current.

FIG.6 is a vertical sectional view showing a path path of the electron beam in the electrodes under the small beam current.

FIG.7 is a graph showing an electric potential distribution on the axis of the electron gun.

FIG.8 is a perspective view showing a constitution of electrodes of an electron gun in a second embodiment in accordance with the present invention.

FIG.9 is a horizontal sectional view showing a

path of an electron beam in the electrodes under a large beam current in the second embodiment.

FIG.10 is a vertical sectional view showing a path of the electron beam in the electrodes under the large beam current in the second embodiment.

FIG.11 is the cross-sectional view showing the path of the electron beam under a large beam current in the cathode ray tube for color display in the prior art.

FIG.12 is the sectional view showing the path of the electron beam under a small beam current of the cathode ray tube for color display in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A sectional view of a cathode ray tube of a first embodiment in accordance with the present invention is shown in FIG.1.

Referring to FIG.1, an electron gun 9 is an in-line type gun wherein cathodes 10a, 10b and 10c are disposed on a horizontal line which is perpendicular to an axis of the electron gun 9, and is provided with a G_1 electrode 11 as a control grid, a G_2 electrode 12 as an accelerating grid, a G_3 electrode 13 as a focusing grid and a G_4 electrode 14 as a final accelerating grid (anode). Cathode lenses 15a, 15b and 15c are formed between the G_1 electrode 11 and the cathodes 10a, 10b and 10c, respectively. Prefocus lenses 16a, 16b and 16c are formed between the G_2 electrode 12 and the G_3 electrode

13. Main lenses 17a, 17b and 17c are formed between the G_3 electrode 13 and the G_4 electrode 14.

As shown in FIG.2, the G_1 electrode 11 has three circular apertures 18 having a diameter of d_1 as electron beam paths. The G_2 electrode 12 has an oblong groove 19 of width W and length L on its surface facing the G_1 electrode 11, and circular apertures 20 for passing the electron beam having a diameter of d_2 are disposed on the bottom of the groove 19. In an actual constitution, the G_2 electrode 12 is composed by combination of an electrode plate 12a having three apertures 20 and an electrode plate 12b having an oblong rectangular opening of width W and length L .

The G_3 electrode 13 is provided with round apertures for passing the electron beams having a diameter of d_3 on a member opposite to the G_2 electrode 12.

When a distance from a surface of the G_1 electrode 11 facing the G_2 electrode to an electron emission surface of the cathode 10 is designated g_{k1} , a distance from a surface of the G_2 electrode 12 facing the G_3 electrode to the electron emission surface of the cathode 10 is designated g_{k2} and a distance between the G_2 electrode 12 and the G_3 electrode 13 is designated g_{23} , the respective values in a cathode ray tube for color display of 90° deflection type of 21 inches are shown as follows:

d_1 0.7 mm ϕ
 d_2 0.7 mm ϕ
 W 0.7 mm
 L 16.0 mm
 d_3 0.9 mm ϕ
 g_{k1} 0.195 mm
 g_{k2} 1.04 mm
 g_{23} 0.8 mm.

In order to maintain an intensity of an electric field on the axes of the electron guns between the G_2 electrode 12 and the G_3 electrode 13 in a range of 5×10^4 -- 5×10^5 V/cm, the voltages which are applied to the respective electrodes are to be selected as follows:

Potential of cathode 20--200 V
 Potential of G_1 electrode 0 V
 Potential of G_2 electrode 300--800 V
 Potential of G_3 electrode 6--8 KV
 Potential of G_4 electrode 20--30 KV.

In the above-mentioned constitution, three electron beams in the electron gun 9 run along the path as shown in FIG.3 and FIG.4 when the large beam current flows. A cross-sectional plan view of the electron gun 9 is shown in FIG.3 and a cross-sectional elevation view thereof is shown in FIG.4. An electron beam 22h and 22v adjacent to the axis of the electron gun which is emitted from a central portion of the electron emission surface of

the cathode 10 form crossovers 23h and 23v in the prefocus lens 16a, 16b and 16c. Consequently, the electron beams adjacent to the axis of the electron guns do not receive lens effect by the prefocus lens, and thus, a total magnification of the lenses including the main lenses 17a, 17b and 17c is comparatively small. Furthermore, since the diameter of the electron beam in the main lens is not so large, an aberration is small.

On the other hand, electron beams 24h and 24v which are emitted from a peripheral portion of the electron emission surface of the cathode 10 and are passing apart from the axis of the electron gun form crossovers 25h and 25v at positions adjacent to the cathode 10. However, since divergence after the crossover is suppressed by intense prefocusing lens effect, aberration in the main lens is suppressed to a small value. As a result in the embodiment, when the beam current is about 4 mA, the beam spot having a diameter as small as 35--45 % of the prior art can be obtained.

Paths of the electron beam under a low beam current are shown in FIG.5 and FIG.6. FIG.5 shows a horizontal cross-sectional view and FIG.6 shows a vertical cross-sectional view of the electron gun. The electron beam 26h as shown in the horizontal cross-sectional view does not receive the effect of the groove 19 which is provided on the G₂ electrode 12, and forms two crossovers

27a and 27b and produces a beam spot of excessively small diameter in horizontal direction on the fluorescent screen. However, since the smallness of the beam spot is in only in the horizontal direction, the moire image interference fringes are not produced.

On the other hand, since the electron beam 26v in vertical cross-sectional view as shown in FIG.6 receives strong effect of a divergence electric field 28 due to the groove 19, a single crossover 27c is formed. Hence, a vertical diameter of the beam spot which is formed on the fluorescent screen under the low beam current of about 50 μ A does not become too small. The vertical diameter of the beam spot can be made as large as 1.0 mm which is twice the size in the prior art, and the moire image interference fringes are prevented to appearance.

In order to realize the above-mentioned effect, it is required that the diameters d_2 and d_3 and a distance between the electrodes g_{k1} and g_{k2} are selected to comparatively short and an intensity of electric field on the axis of the electron gun between the G_2 electrode 12 and the G_3 electrode 13 is selected within the range of 5×10^4 -- 5×10^5 V/cm, and that, the diameter d_2 is made smaller than or equal to the diameter d_1 and the diameter d_3 is made larger than or equal to the diameter d_2 . In case that the diameter d_3 is smaller than the diameter d_2 ,

since a part of the electron beam is liable to be cut, the diameters d_2 and d_3 are selected to be in the following relation:

$$d_2 \leq d_3 \leq 2.3 d_2.$$

Increase of the distance g_{k1} above $0.35 d_1$ spoils matching of cathode lens action with prefocus lens action. Furthermore, as to the distance g_{k2} and g_{23} , the respective distances are required to be within ranges of the below-mentioned relation:

$$1.40 \leq g_{k2} / d_1 \leq 1.75$$

$$0.8 \leq g_{23} / d_1 \leq 1.4.$$

Deviation of the respective distances g_{k2} and g_{23} from the above-mentioned ranges obstructs good arrangement of the crossover location in conjunction with a prefocus lens.

The width W of the groove 19 is recommended to be equal to the diameter d_2 or to be slightly larger than that. In the embodiment, though the groove 19 is made to be a single oblong rectangular groove covering the three apertures 20 for passing the beam, each one independent small groove may be disposed on the respective apertures 20. In such case of providing the independent grooves, the length of the groove are made longer than $1.75 d_2$, and the apertures 20 for passing the electron beam are to be disposed on central portions of the bottom of the respective grooves.

FIG.7 is a graph showing relation of the electric potential (V) on the axis of the electron gun and its second order differential coefficient (V'') in the electron gun in accordance with the present invention, and a distance (Z) from the electron emission surface of the cathode is shown on an abscissa. Referring to the graph, a positive maximum value of the second order differential coefficient (V'') exists at a position of the distance Z_1 , and a negative maximum value (V'') thereof exists at a position of the distance Z_2 . The distances Z_1 and Z_2 are selected in the range as shown by the following relation:

$$1.0 \leq Z_1 / d_1 \leq 2.0$$

$$0.5 \leq (Z_2 - Z_1) / d_1 \leq 1.2.$$

In the above-mentioned embodiment, a constitution of the electrode of the main lens is a bi-potential type, but a uni-potential type or multi-potential type are usable.

A second embodiment in accordance with the present invention is shown in FIG.8 to FIG.10. In the embodiment, the G_2 electrode 12 is has a horizontally long groove 19b on a surface which faces the G_1 electrode 11 of width W and length L, and furthermore, a groove 19c which is similar to the groove 19b is provided on the surface which faces the G_3 electrode 13. The width W' of the groove 19c can be set in a rang shown by the following inequity:

$$d_2 \leq W' \leq 3 d_2;$$

and when the width of W of the groove 19b is 0.7 mm, the width W' of the groove 19c can be made 1.0 mm.

As shown in FIG.9 and FIG.10 , similarly to the afore-mentioned case, the electron beam 24V in the vertical cross-sectional view of FIG.10, which is for the component apart from the axis of the electron gun, forms a crossover at a position adjacent to the prefocus lens, which position is nearer than a crossover of the electron beam 24h in the horizontal cross-sectional view of FIG.9 which is for the component apart from the axis of the electron gun. However, in the cases of FIG.9 and FIG.10 the electron beam 24h is greatly converged in the vertical direction by intense converging electric field of the focusing lens induced by the groove 19c. Therefore, a vertical diameter of the electron beam in the deflection magnetic field after passing the main lens can be kept to be small, and hence a distortion of the beam spot which is focused on a peripheral portion of the fluorescent screen can be minimized.

WHAT IS CLAIMED IS

1. A cathode ray tube for color display comprising:
three cathodes each having electron emitter
arranged horizontally in-line,

a G_1 electrode having three circular apertures
each having diameter of d_1 and facing the cathodes,

a G_2 electrode facing the G_1 electrode at the
side opposite to said cathodes and having a horizontally
positioned oblong groove on at least one surface thereof
facing the G_1 electrode and three circular apertures
facing said three circular apertures of G_1 electrode and
having diameter of d_2 on the bottom of the groove,

a G_3 electrode facing the G_2 electrode at the
side opposite to said G_2 electrode keeping a distance of
 g_{23} and having round apertures having diameter of d_3 ,

said three cathode, said G_1 electrode, said G_2
electrode and said G_3 electrode constituting horizontal
in-line type three electron guns,

means for providing an electric field of an
intensity on the axis of each electron gun between the G_2
electrode and the G_3 electrode is selected in a range of
 5×10^4 -- 5×10^5 V/cm, and

when a distance from a surface facing the G_2
electrode of the G_1 electrode to the face of the electron
emitter is g_{k1} and a distance from a surface facing the G_3
electrode of the G_2 electrode to the emitter is g_{k2} , the

respective values have the following relation:

$$d_1 \geq d_2$$

$$d_2 \leq d_3 \leq 2.3 d_2$$

$$g_{k1} / d_1 \leq 0.35$$

$$1.40 \leq g_{k2} / d_1 \leq 1.75$$

$$0.8 \leq g_{23} / d_1 \leq 1.4.$$

2. A cathode ray tube for color display in accordance with claim 1, wherein

said G_2 electrode has a horizontally positioned long groove on a surface which faces said G_3 electrode.

3. A cathode ray tube for color display in accordance with claim 1 or 2, wherein

said groove of said G_2 electrode is formed by laminating a metal plate having a horizontally oblong slot on a plate having three apertures disposed horizontally.

4. A cathode ray tube for color display in accordance with claim 1 or 2, wherein

a width of said groove is substantially equal to a diameter of apertures of said G_2 electrode.

FIG.1

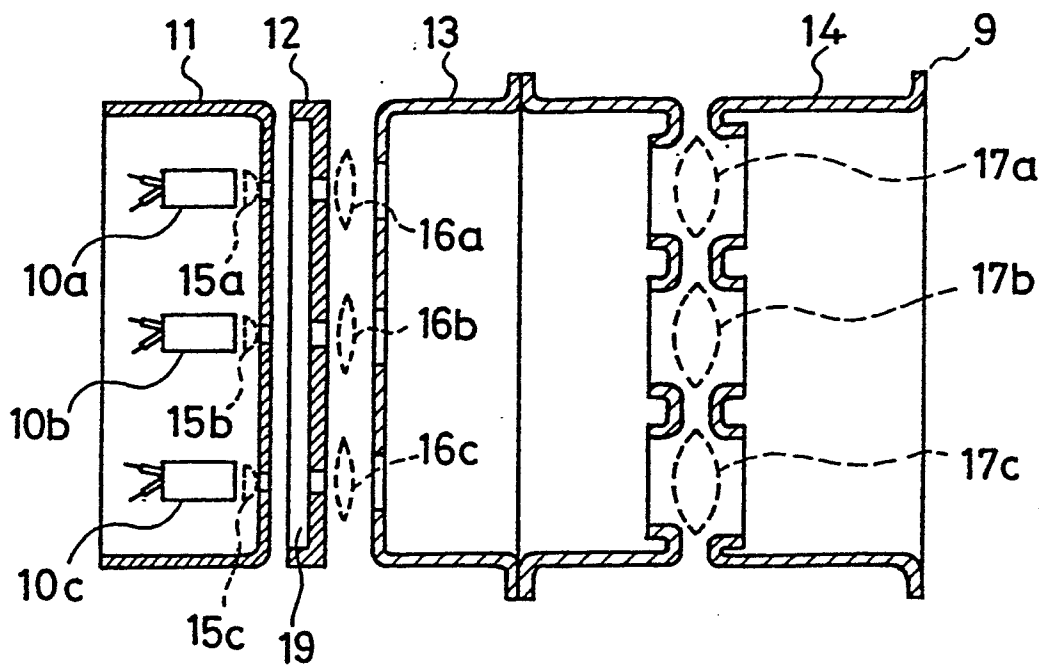


FIG. 2

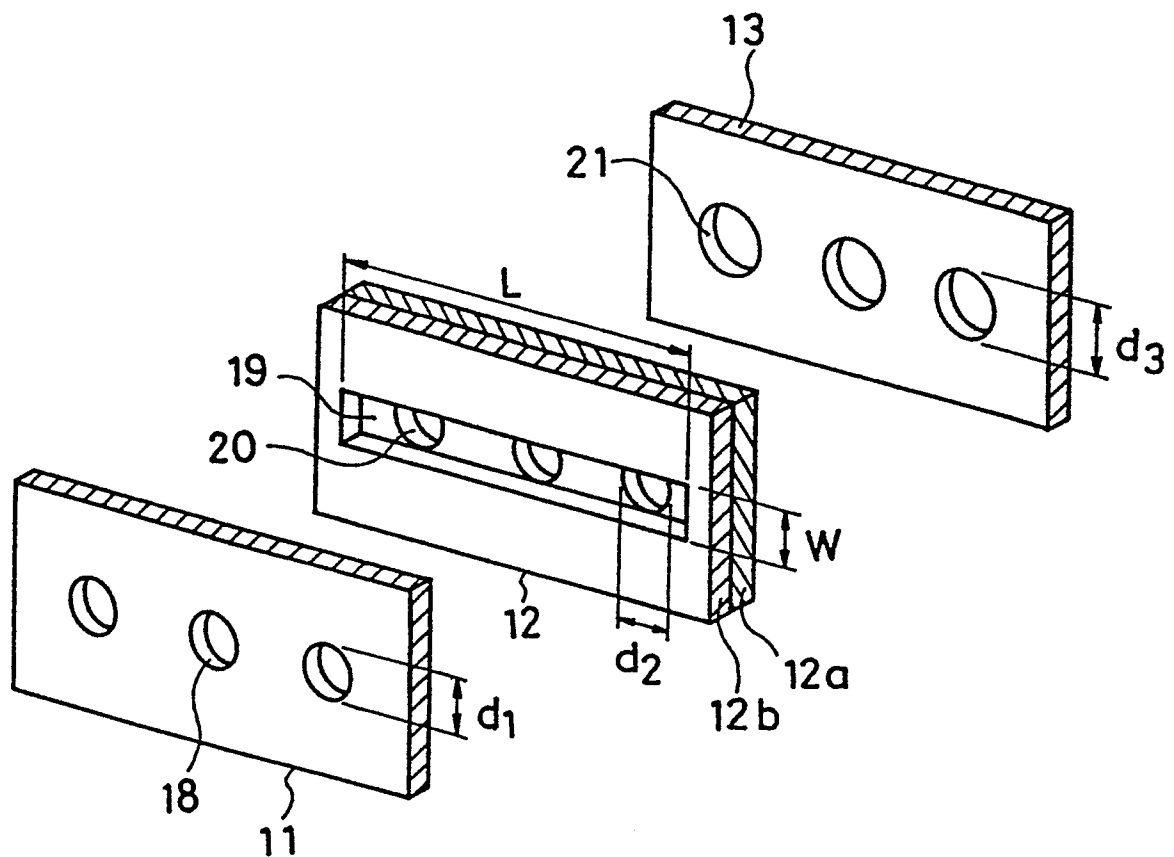


FIG. 3

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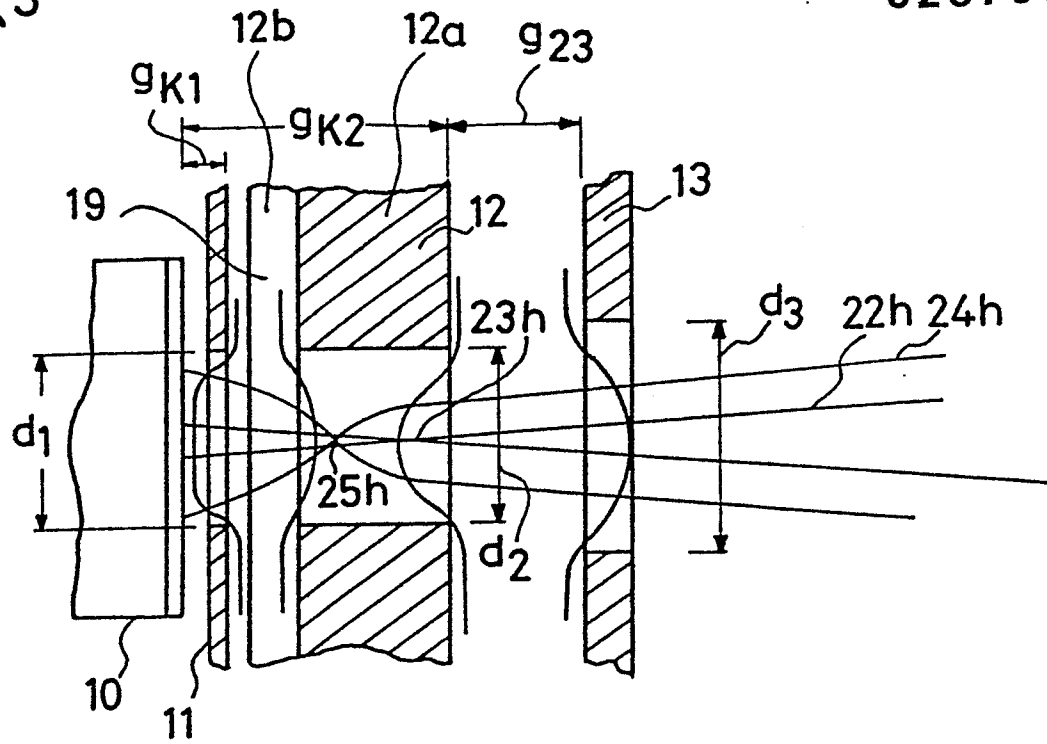


FIG. 4

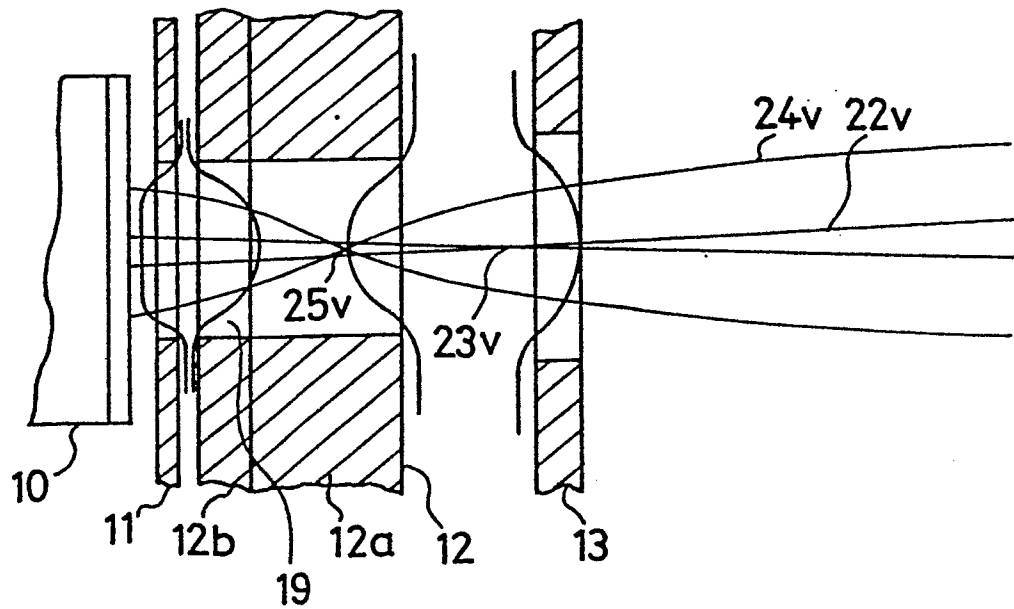


FIG. 5

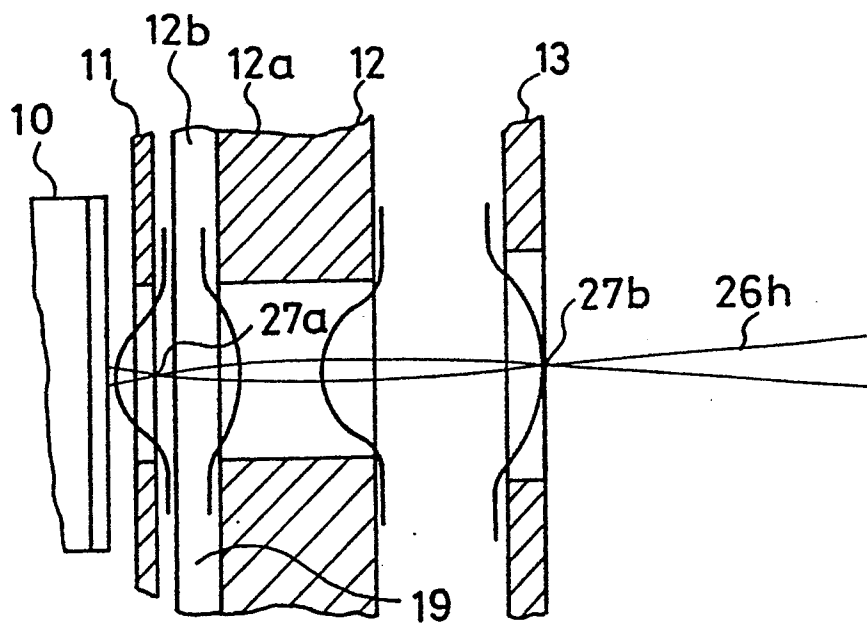


FIG. 6

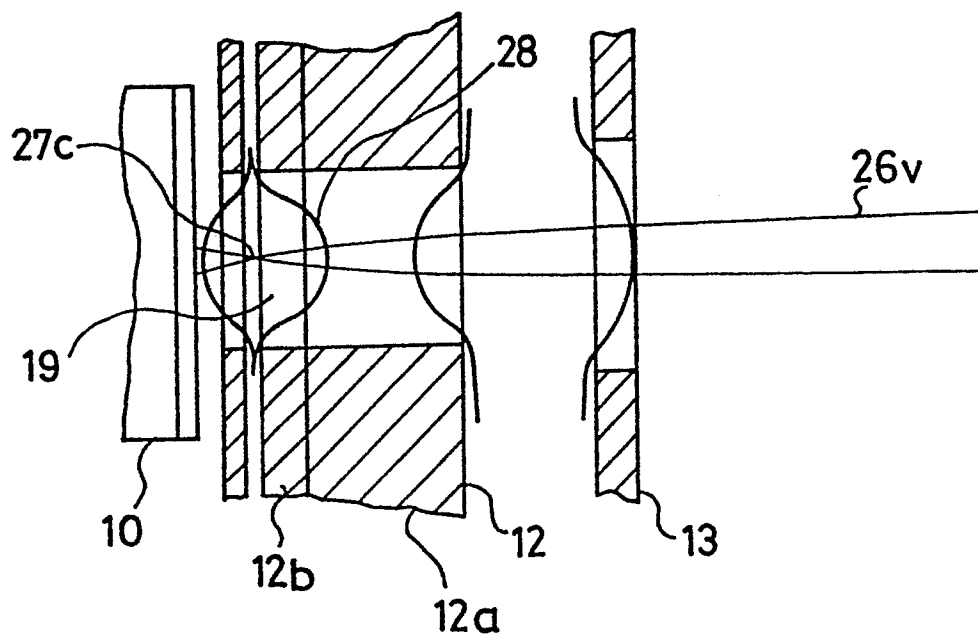


FIG. 7

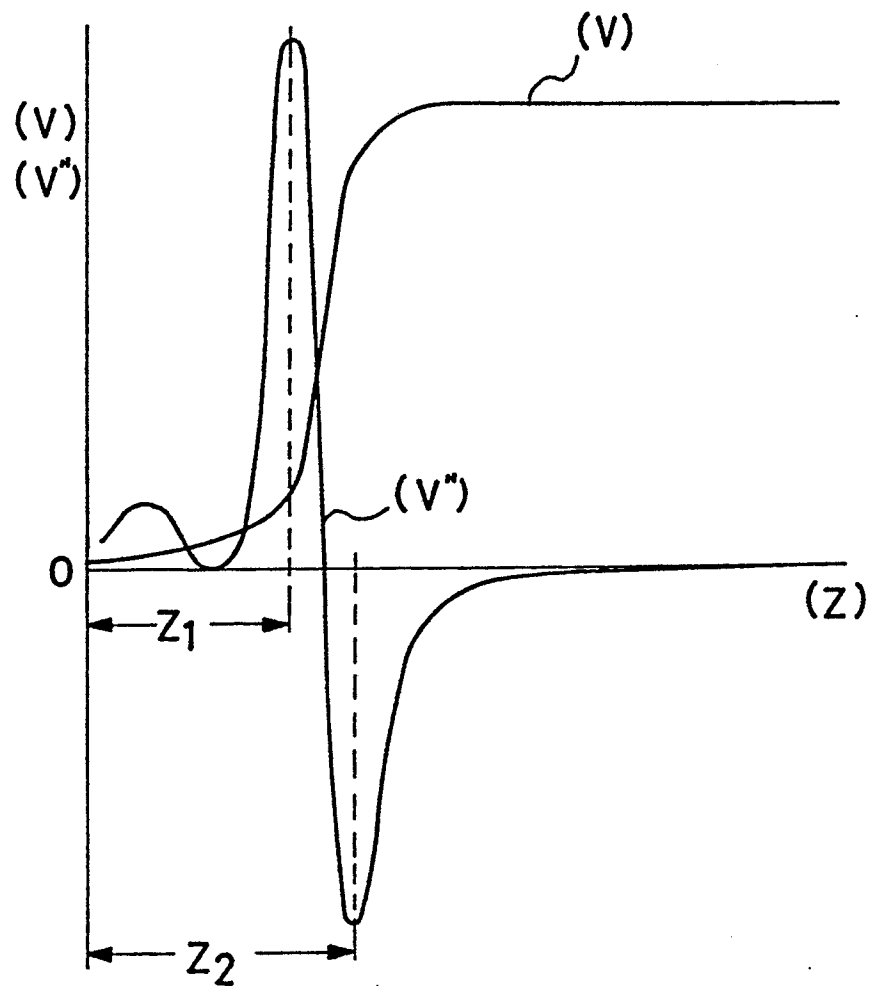
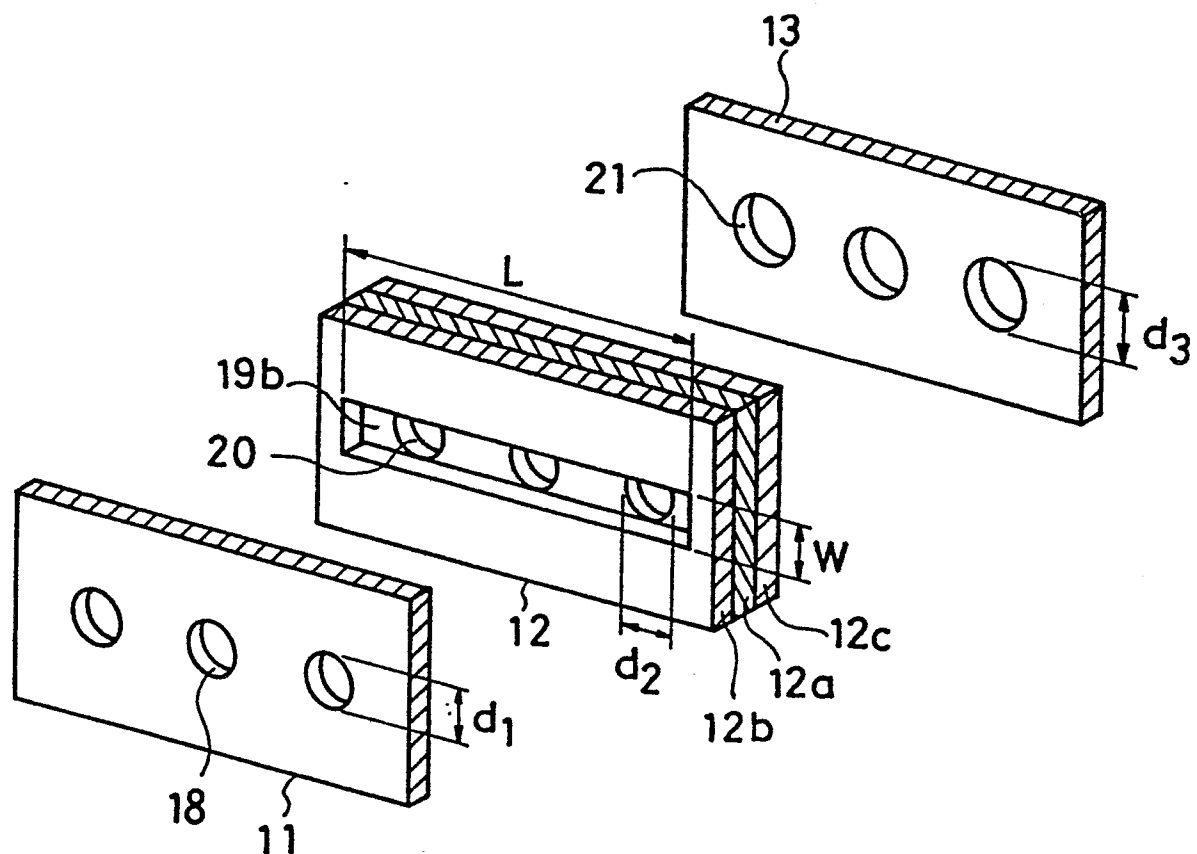


FIG. 8



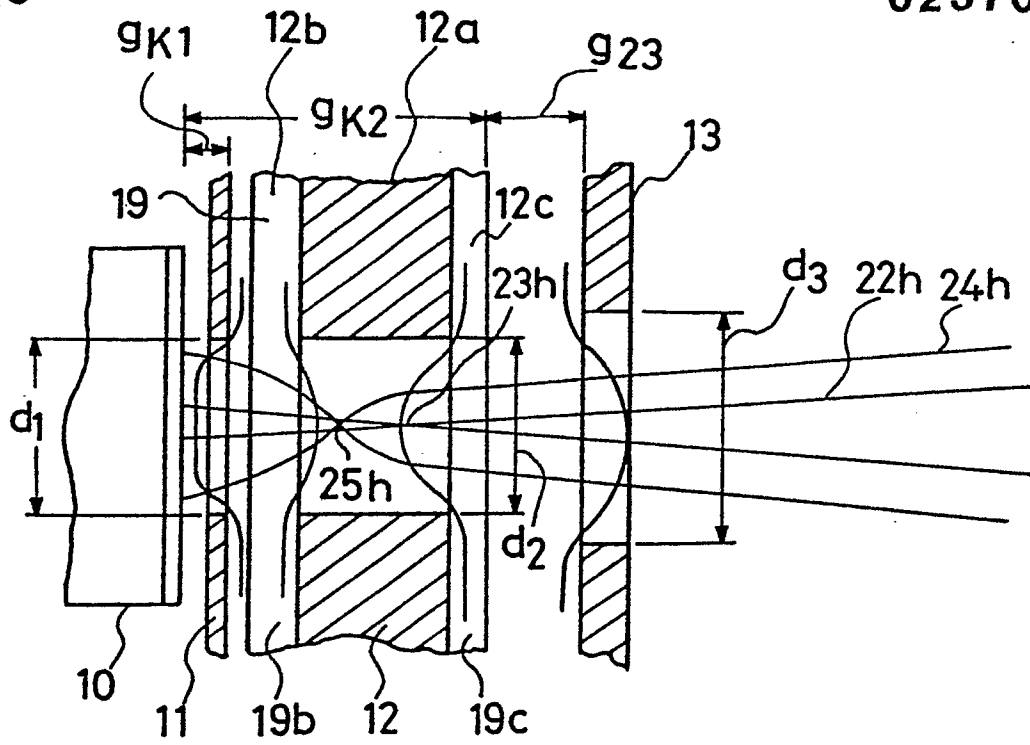


FIG.10

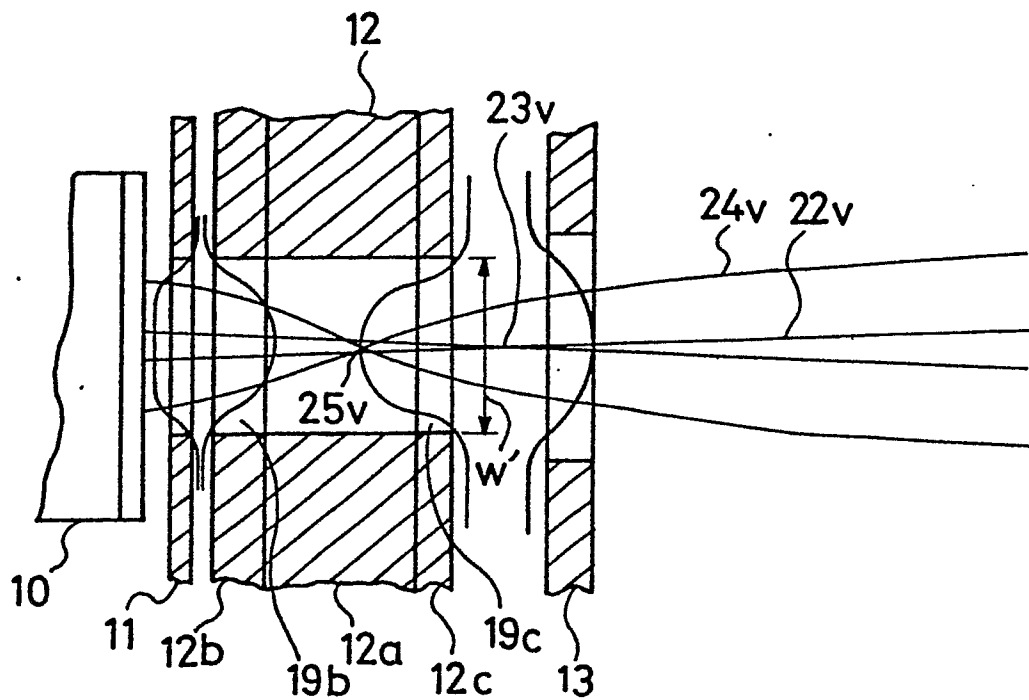


FIG.11 (Prior Art)

0237005

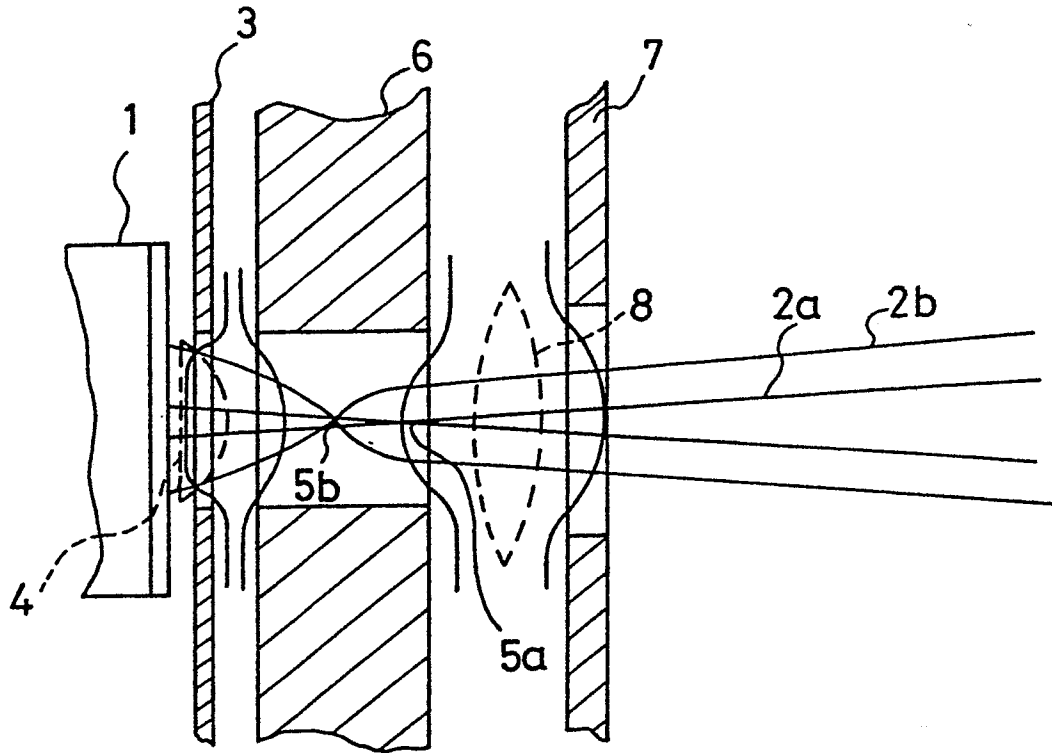


FIG.12 (Prior Art)

