(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 388 934 A2

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90105364.5

(51) Int. Cl.5: H01J 29/07

(22) Date of filing: 21.03.90

(30) Priority: 23.03.89 JP 73131/89

(43) Date of publication of application: 26.09.90 Bulletin 90/39

(84) Designated Contracting States: FR NL

(71) Applicant: TOHOKU GAKUIN UNIVERSITY
1-3-1, Tsuchitoi, Aoba-ku
Sendai-shi, Miyagi(JP)

Applicant: MITSUBISHI DENKI KABUSHIKI KAISHA
2-2-3, Marunouchi
Chiyoda-ku Tokyo(JP)

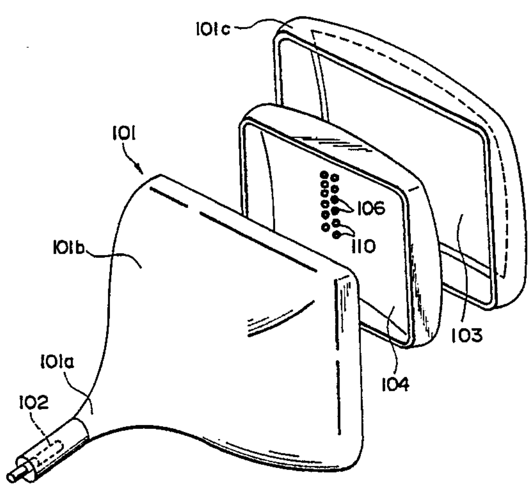
(72) Inventor: Haga, Akira
1-11-19, Tsurugaoka, Izumi-ku
Sendai-shi, Miyagi(JP)
Inventor: Nasuno, Hiroshi
4-2-20, Izu, Tsukidate-cho
Kurihara-gun, Miyagi(JP)
Inventor: Nakanishi, Hisao, c/o Mitsubishi Denki K.K.
Kyoto Seisakuso, 1
Babazusho, Nagaokakyo-shi, kyoto(JP)

(74) Representative: Grupe, Peter, Dipl.-Ing.
Patentanwaltsbüro
Tiedtke-Bühling-Kinne-Grupe-Pellmann-Grams-Struif Bavariaring 4
D-8000 München 2(DE)

(54) **Cathode ray tube.**

(57) A cathode ray tube (101) in which an electron beam discharged from an electron gun (102) passes through holes of a shadow mask (104) and then strikes on a fluorescent substance (103) on the front surface of a tube body. During that time the electron beam is shielded from a magnetic field generated by magnetizing the shadow mask.

FIG. 1



EP 0 388 934 A2

CATHODE RAY TUBE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to a shadow-mask-type color cathode ray tube to be incorporated in a color television receiver.

2. Description of the Related Art:

FIG. 8 of the accompanying drawings schematically shows a shadow-mask-type color cathode ray tube disclosed in Japanese Utility Model Publication No. 29495/1982. As shown in FIG. 8, the Cathode ray tube comprises a tube body 1 composed of a neck portion 1a, a funnel portion 1b and a panel portion 1c. Reference numeral 2 designates an electron gun mounted in the neck portion 1a; and 3, a fluorescent layer coated over the inner surface of the panel portion 1c.

A shadow mask 4 in the form of a thin plate made of iron or its alloy is disposed between the electron gun 2 and the fluorescent layer 3. The shadow mask 4, as shown in FIG. 9, has a plurality of circular holes 6 for passage of electron beams. These holes 6 have a function of controlling the tracks of the electron beams to selectively make any of the fluorescent members and thus the fluorescent layer luminous.

The shadow mask 4 is supported on a frame 5 shown in FIG. 8. The frame 5 is attached to the inner surface of the panel portion 1c via a non-illustrated attachment. Reference numeral 7 designates an interior earth magnetic shielding plate called "magnetic shield" and mounted on the frame 5. It has been a common knowledge that the track of the individual electron beams 8 in the cathode ray tube is deflected due to earth magnetism. The earth magnetic shielding plate 7 serves to eliminate any influence of the earth magnetism.

With this conventional arrangement, the electron beams 8 discharged from the electron gun 2 are deflected by a non-illustrated deflection yoke, pass through the region covered by the interior earth magnetic shielding plate 7, then through the holes 6 of the shadow mask 4, and finally strike on the fluorescent layer 3 to make it luminous. At that time, since earth magnetism is shielded inside the region covered with the interior earth magnetic shielding plate 7, the tracks of the electron beams 8 can hardly be deflected inside this region by earth magnetism. As a result, it is possible to somehow reduce the divergence in incidence position of the electron beams on the fluorescent layer 3.

However, in the conventional cathode ray tube, the shadow mask 4 of a magnetic material is magnetized by earth magnetism, causing a kind of magnetic influence on the electron beams which is hardly be eliminated only by the interior earth magnetic shielding plate 7.

Such an inconvenience caused by the magnetization of the shadow mask 4 will now be described in greater detail.

In the magnetized shadow mask 4, as shown in FIG. 10, there exist a multiplicity of magnetic induction lines 11 along the surface of the shadow mask 4. These magnetic induction lines 11 are distributed also inside the holes 6. In FIG. 10, only one of the holes is shown for clarity.

Generally, it is known that as the electron beams incidents a magnetic field perpendicularly thereto, they are deflected along a circular track upon receipt of Lorentz force, as shown in FIG. 11. For an easy understanding of the electron beam tracks and the magnetic field distribution, the tracks of the electron beams 8 are illustrated in FIG. 11; practically, however, the direction in which the electron beams 8 are deflected is perpendicular to this sheet of drawing.

When the electron beams 8 incident on the shadow mask 4 perpendicularly to the magnetic field formed by the magnetized shadow mask 4, the deflection d of the electron beams 8 at the outgoing side of a magnetic field, after they have flied at a velocity v in a length ℓ of space in which the magnetic field is formed, can be obtained from the folliwing equation:

$$d = \frac{e \cdot H}{2 \cdot c \cdot m \cdot v} \times \ell^2 \text{ (C.G.S. unit system) ....(1)}$$

where H stands for magnetic field intensity, c stands for speed of light, e stands for charge of electron, and m stands for mass of electron.

It is understood from the equation (1) that the deflection d of electron beams is proportional to magnetic field intensity H and also to square of length of magnetic field.

As shown in FIG. 10, if there exist many magnetic induction lines 11 in the individual hole 6 of the shadow mask 4, the intensity H is increased. And as shown in FIG. 11, if the inner surface of the hole 6 is a taper surface diverging in the heading direction of the electron beams 8, the length ℓ along which the electron beams fly is extended.

Consequently since the deflection d of the electron beams is increased, as shown in FIG. 12, the electron beams pass through the holes 6 and then are deflected from the original tracks after released from the restraint by magnetic field H so that the electron beams 8 reached the fluorescent layer 3 strike on a fluorescent member 3b located in a position different from the position of the correct fluorescent member 3a on which the electron beams 8 are to strike originally. This causes a color shear, and therefore a clear color image cannot be achieved.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a cathode ray tube in which magnetic influences, such as misdeflection of electron beams passing through holes of a shadow mask, can be reduced by shielding the magnetic field generated by magnetization of the shadow mask, thus preventing any color shear.

According to this invention, there is provided a cathode ray tube comprising:

(a) a tube body having a substantially flat plate-like panel portion, and a tubular neck portion disposed perpendicularly to the panel portion and spaced a predetermined distance therefrom;

(b) an electron gun disposed in the neck portion of the tube body for emitting an electron beam toward the panel of the tube body;

(c) a fluorescent substance coated over an electron-gun-side surface of the panel portion of the tube body;

(d) a shadow mask made of a magnetic material and having a plurality of holes, the shadow mask being disposed between the electron gun and the fluorescent substance in such a manner that the electron beam discharged from the electron gun passes through the holes of the shadow mask to strike the fluorescent substance; and

(e) a magnetic shielding means for magnetically shielding the electron beam from a magnetic field generated by magnetizing the shadow mask.

With this arrangement, because of the magnetic shielding means, even though the shadow mask is magnetized such as due to earth magnetism, it is possible to reduce any misdeflection of the electron beams in the magnetic field generated by this magnetization.

Each of the holes of the shadow mask may have preferably a circular shape. The inner front surface of each hole may be taper surface of a diameter progressively increasing toward the opposite side of the electron gun.

Further, the magnetic shielding means may include a magnetic shield layer formed over the inner front surface of each hole of the shadow mask. The material of the magnetic shield layer should preferably be higher in magnetic permeability than the magnetic material of the shadow mask. This material should preferably consist of an nickel-iron (NiFe) alloy.

The magnetic shielding means may include a layer coated over the inner surface of the individual hole of the shadow mask by plating. The magnetic shield layer should preferably has a uniform thickness; this case is particularly advantageous in preventing any misdeflection of the electron beams.

The above and other advantages, features and additional objects of this invention will be manifest to those versed in the art upon making reference to the following detailed description and the accompanying drawings in which two preferred structural embodiments incorporating the principles of this invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view showing a cathode ray tube according to a first embodiment of this invention;

FIG. 2 is a detail plan view of a featuring part of the cathode ray tube of FIG. 1, showing a magnetic shield layer disposed on the inner surface of each of holes;

FIG. 3 is a cross-sectional view taken along line III-III of FIG. 2, showing that the individual hole has a taper inner front surface;

FIG. 4 is a schematic plan view showing a magnetic field around the individual hole of the first embodiment;

FIG. 5 is a cross-sectional view taken along line V-V of FIG. 4, showing the tracks of electron beams flying in the magnetic field;

FIG. 6 is an enlarged cross-sectional view showing the relation between the individual hole and a refractive index of the magnetic field of the first embodiment;

FIG. 7 is a fragmentary plan view of the shape of an individual hole of a modified cathode ray tube according to a second embodiment, showing that the hole is in the shape of a slot.

FIG. 8 is a cross-sectional view showing a conventional cathode ray tube;

FIG. 9 is a fragmentary plan view showing holes and portions therearound in the conventional cathode ray tube of FIG. 8;

FIG. 10 is a schematic plan view showing a magnetic field around the individual hole in the conventional cathode ray tube;

FIG. 11 is a cross sectional view taken along line X-X of FIG. 10, showing the tracks of electron beams flying in the magnetic field; and

FIG. 12 shows a misdeflection of the electron beams which is caused due to the magnetic field in the conventional cathode ray tube of FIGS. 10 and 11.

DETAILED DESCRIPTION

FIG. 1 shows a cathode ray tube according to an embodiment of this invention. In FIG. 1, reference numeral 101 designates a tube body including a neck portion 101a in which an electron gun 102 is mounted, a funnel portion 101b, and a panel portion 101c to which a fluorescent layer 103 is attached. A shadow mask 104 of a magnetic material, such as iron or iron alloy is disposed between the electron gun 102 and the fluorescent layer 103.

The shadow mask 104, as shown in FIG. 2, has a plurality of circular holes 106 for passage of electron beams. The individual hole 106, as shown in FIG. 3, has a cross-sectional shape diverging toward the fluorescent layer 103. As shown in FIG. 2, a doughnut-shaped magnetic shield layer 110 is formed around the individual hole 106.

The magnetic shield layer 110 consists of a magnetic material, e.g. a nickel-iron alloy (tradename: Permalloy), having a magnetic permeability $\mu 2$ higher than the permeability $\mu 1$ of the magnetic material of the shadow mask 104. The magnetic shield layer 110 is coated over the inner peripheral surface of the individual hole 106 by plating, having a uniform thick ness. This magnetic shield layer 110 minimizes the magnetic flux density of the individual hole 106 to weaken the magnetic field intensity H inside the hole 106, and serves to reduce the deflection d of electron beams flying in the magnetic field by utilizing refraction of magnetic field.

The magnetic shield layer 110 functions as follows. For its first function, as shown in FIG. 4, the magnetic shield layer 111 weakens the magnetic field intensity H in the hole. Specifically, since the magnetic permeability $\mu 2$ of the magnetic shield layer 110 is higher than the magnetic permeability $\mu 1$ of the shadow mask 104, the magnetic induction lines 111 near the hole 106 more concentrate by the magnetic shield layer 110 of the high magnetic permeability, while the magnetic induction lines 111 distributed over the hole 106 are considerably reduced, compared to the conventional art of FIG. 10. Consequently, as is understood from the equation (1), since the deflection d of the electron beam 108 is proportional to the magnetic field intensity H, it is possible to minimize the deflection d of the electron beam

108, as shown in FIG. 5, by weakening the magnetic field intensity H.

For an easy understanding of the electron beam tracks and the magnetic field distribution, the tracks of the electron beams 108 are illustrated in FIG. 5; practically, however, the direction in which the electron beams 108 are deflected is perpendicular to this sheet of drawing.

The second function of the magnetic shield layer 110 is to minimize the length ℓ of space in which the magnetic field of FIG. 5 exists. In other words, assuming that the magnetic permeability (magnetic permeability in vacuum) of the hole 106 is $\mu 0$, the relation between the magnetic permeability $\mu 1$ of the shadow mask 104 and the magnetic permeability $\mu 2$ of the magnetic shield layer 110 is $\mu 2 > \mu 1 > \mu 0$. In this case, the following law of refraction is established.

$$\frac{\tan \theta 1}{\tan \theta 2} = \frac{\mu 1}{\mu 2} \quad \cdots\cdots\cdots\cdots\cdots (2)$$

Namely, as shown in FIG. 6, when the magnetic induction lines 111 passing inside the shadow mask 104 enter the material 110 of the permeability $\mu 2$ from the material 104 of the permeability $\mu 1$, $\mu 2 > \mu 1$ and therefore $\theta 2 > \theta 1$. Similarly, when the magnetic induction lines 111 come from the material of the material 110 of the permeability $\mu 2$ into vacuum (hole 106), $\mu 2 > \mu 0$ and therefore $\theta 2 > \theta 0$. Due to such refraction of magnetic field, the length ℓ along which the electron beams 108 of FIG. 5 flying in the magnetic field would be shortened, compared to the conventional art of FIG. 11.

Consequently, as is understood from the equation (1), since the deflection d of electron beam is proportional to square of length ℓ of the magnetic field, it is particularly effective to shorten the length ℓ of the magnetic field when minimizing the deflection d of the electron beam.

With this arrangement, since the magnetic shield layer 110 of a magnetic permeability higher than that of the shadow mask 104 is formed around the hole 106 of the shadow mask 104, the magnetic induction lines 111 near the hole 106 concentrate in the magnetic shield layer 110 even when the shadow mask 104 has been magnetized, thus weakening the magnetic field intensity H inside the hole 106. Further, as the magnetic field is refracted between the shadow mask 104 and the magnetic shield layer 110, the length ℓ along which the electron beams 108 flying in the magnetic field will be shortened.

Therefore, since the deflection d of the electron beam 108 at the outgoing side of the magnetic field is minimized, the electron beam 108 can strikes precisely on the correct fluorescent member 3a as indicated by phantom lines in FIG. 12, without any misdeflection or deviation indicated by solid lines in FIG. 12. As a result, a clear color image can be ob tained without causing any color shear due to influence by earth magnetism.

In the foregoing embodiment, a doughnut-shaped magnetic shield layer 110 is formed around the individual circular hole 106. This invention should by no means be limited to this specific form; for example, the individual hole of the shadow mask may be a substantially rectangular slot as shown in FIG. 7. Further, the cross-sectional shape of the hole 106 should not be limited to a trumpet shape.

According to this invention, since the deflection of the individual electron beam can be minimized as it passes through the corresponding hole of a shadow mask, it is possible to reduce the influence by magnetization of the shadow mask itself. Therefore a clear color image can be obtained without causing any color shear.

A cathode ray tube in which an electron beam discharged from an electron gun passes through holes of a shadow mask and then strikes on a fluorescent substance on the front surface of a tube body. During that time the electron beam is shield from a magnetic field generated by magnetizing the shadow mask.

Claims

1. A cathode ray tube comprising:

(a) a tube body having a substantially flat plate-like panel portion, and a tubular neck portion disposed perpendicularly to said panel portion and spaced a predetermined distance therefrom;

(b) an electron gun disposed in said neck portion of said tube body for emitting an electron beam toward said panel portion of said tube body;

(c) a fluorescent substance coated over an electron-gun-side surface of said panel portion of said tube body;

(d) a shadow mask made of a magnetic material and having a plurality of holes, said shadow mask being disposed between said electron gun and said fluorescent substance in such a manner that the electron beam discharged from said electron gun passes through said holes of said shadow mask to strike said fluorescent substance; and

(e) a magnetic shielding means for magnetically shielding the electron beam from a magnetic field generated by magnetizing said shadow mask.

2. A cathode ray tube according to claim 1, wherein each of said holes of said shadow mask has a circular shape.

3. A cathode ray tube according to claim 2, wherein an inner front surface of each said hole is a taper surface of a diameter progressively increasing toward the opposite side of said electron gun.

4. A cathode ray tube according to claim 1, wherein each of said holes of said shadow mask is in the form of a substantially rectangular slot.

5. A cathode ray tube according to claim 4, wherein an inner front surface of each said hole is a taper surface of a diameter progressively increasing toward the opposite side of said electron gun.

6. A cathode ray tube according to claim 1, wherein said magnetic shielding means includes a magnetic shield layer formed over the inner front surface of each said hole of said shadow mask, said magnetic shielding means consisting of a material higher in magnetic permeability than said magnetic material of said shadow mask.

7. A cathode ray tube according to claim 6, wherein said magnetic shielding means consists of an nickel-iron alloy.

8. A cathode ray tube according to claim 6, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

9. A cathode ray tube according to claim 7, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

10. A cathode ray tube according to claim 9, wherein said magnetic shielding means has a uniform thickness.

11. A cathode ray tube according to claim 2, wherein said magnetic shielding means includes a magnetic shield layer formed over the inner front surface of each said hole of said shadow mask, said magnetic shielding means consisting of a material higher in magnetic permeability than said magnetic material of said shadow mask.

12. A cathode ray tube according to claim 11, wherein said magnetic shielding means consists of an nickel-iron alloy.

13. A cathode ray tube according to claim 11, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

14. A cathode ray tube according to claim 12, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

15. A cathode ray tube according to claim 14, wherein said magnetic shielding means consists of an nickel-iron alloy.

16. A cathode ray tube according to claim 11, wherein an inner front surface of each said hole is a taper surface of a diameter progressively increasing toward the opposite side of said electron gun.

17. A cathode ray tube according to claim 16, wherein said magnetic shielding means consists of an nickel-iron alloy.

18. A cathode ray tube according to claim 16, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

19. A cathode ray tube according to claim 18, wherein said magnetic shielding means includes a layer coated over the inner surface of each said hole of said shadow mask by plating.

20. A cathode ray tube according to claim 19, wherein said magnetic shielding means has a uniform thickness.

FIG. 1

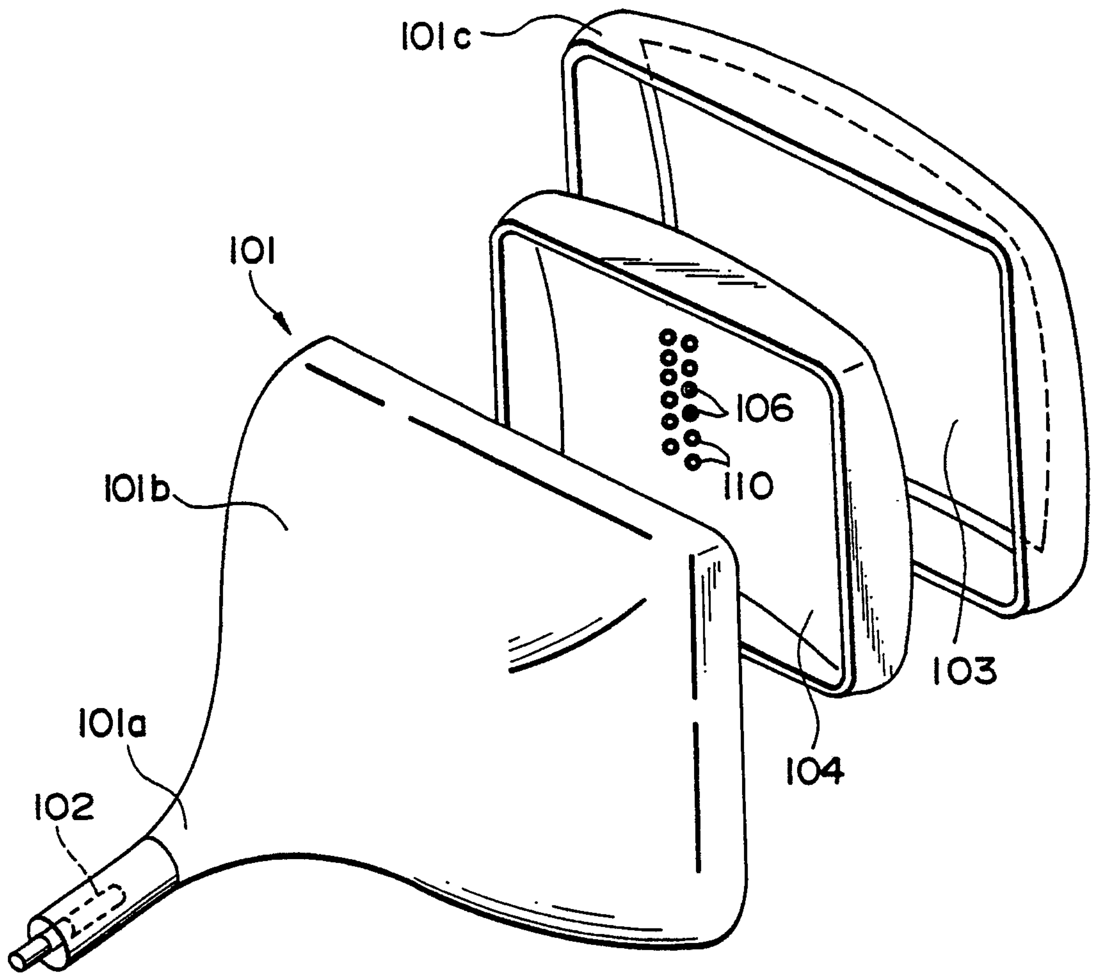


FIG.3

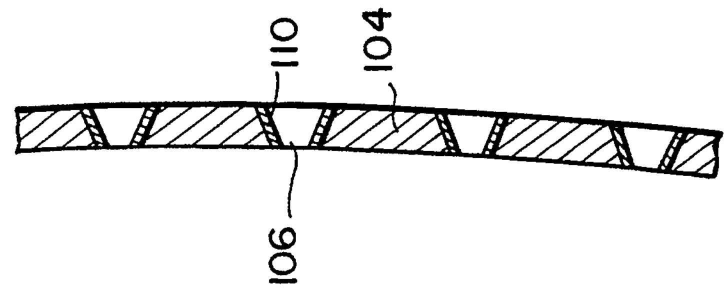


FIG. 2

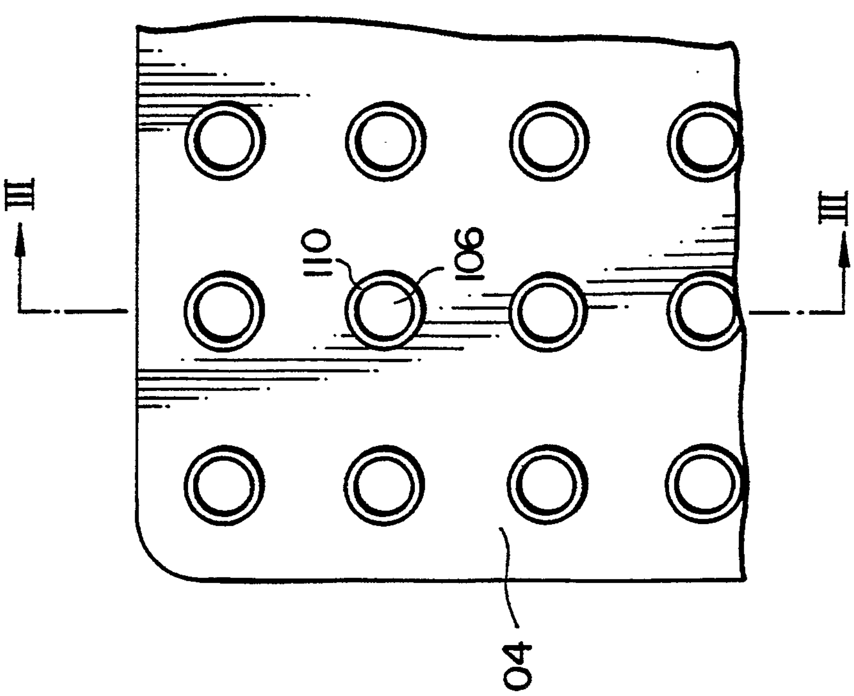


FIG. 5

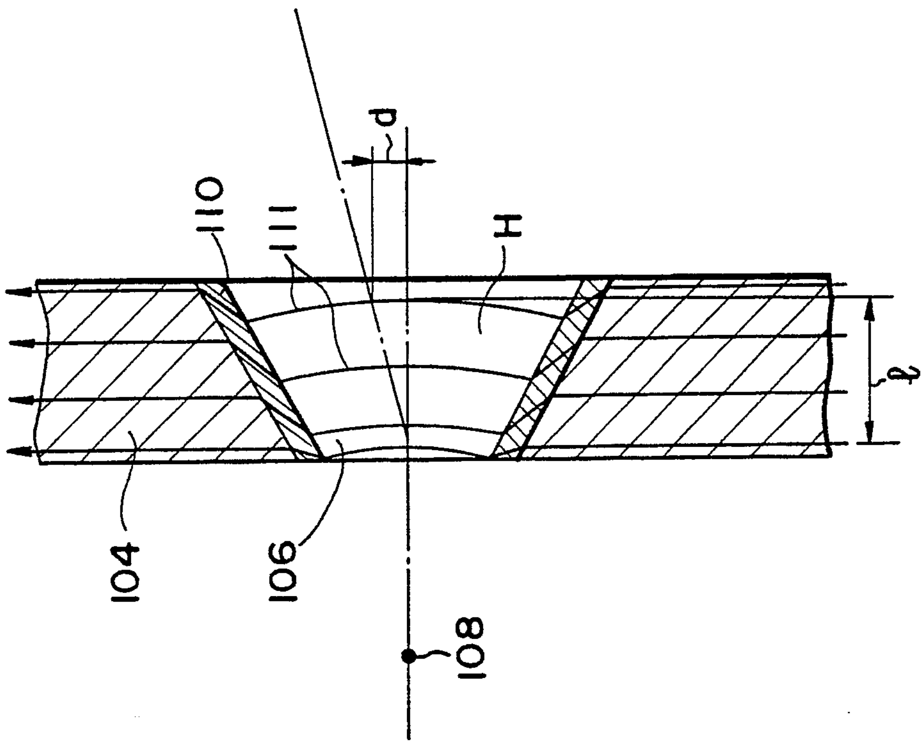


FIG. 4

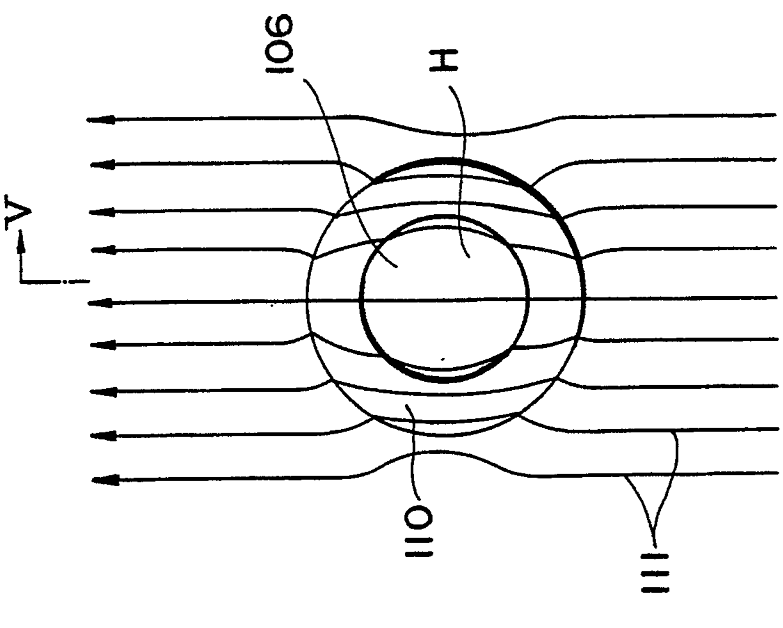


FIG. 6

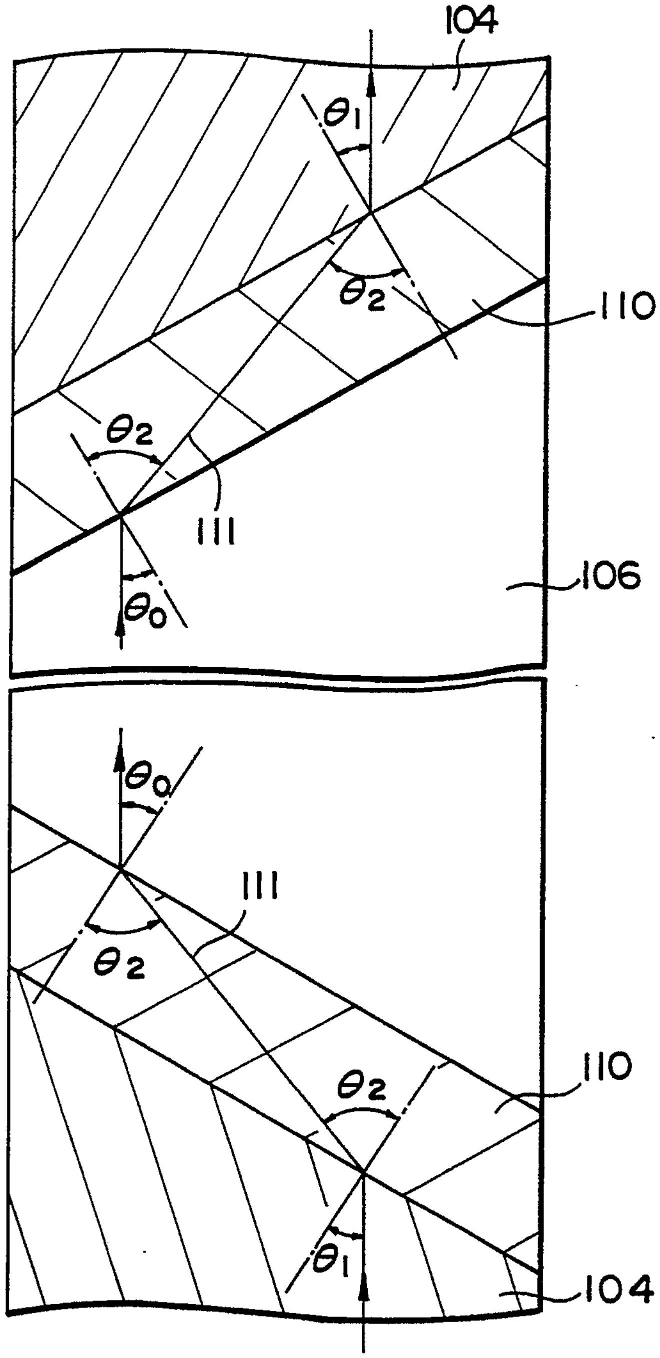

104
θ_1
θ_2
110
θ_2
111
106
θ_0
θ_0
111
θ_2
θ_2
110
θ_1
104

FIG. 7

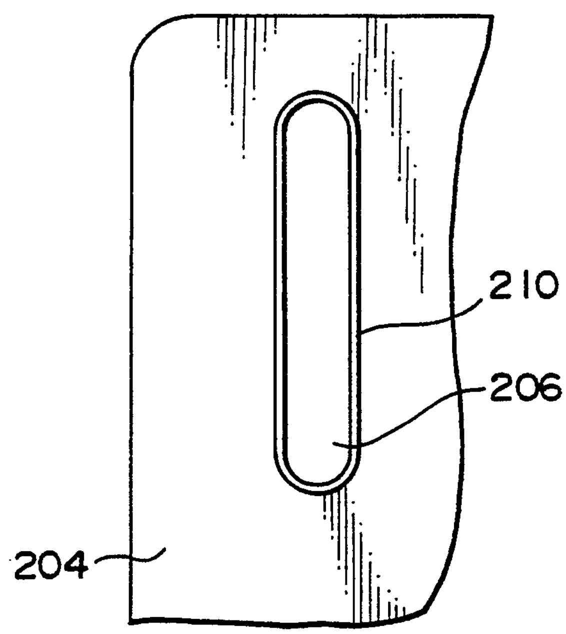


FIG. 8

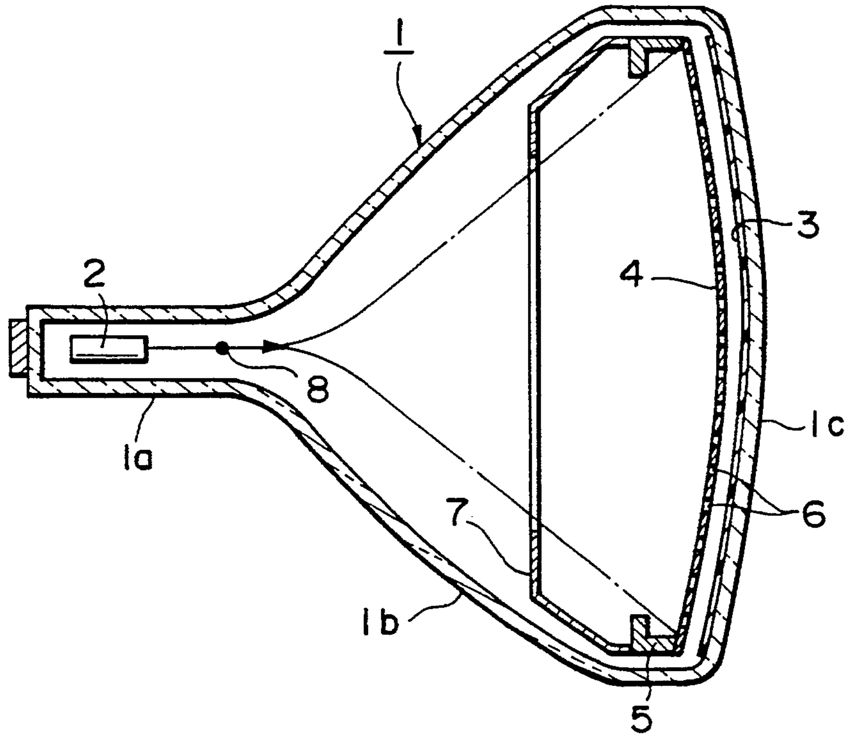


FIG. 9

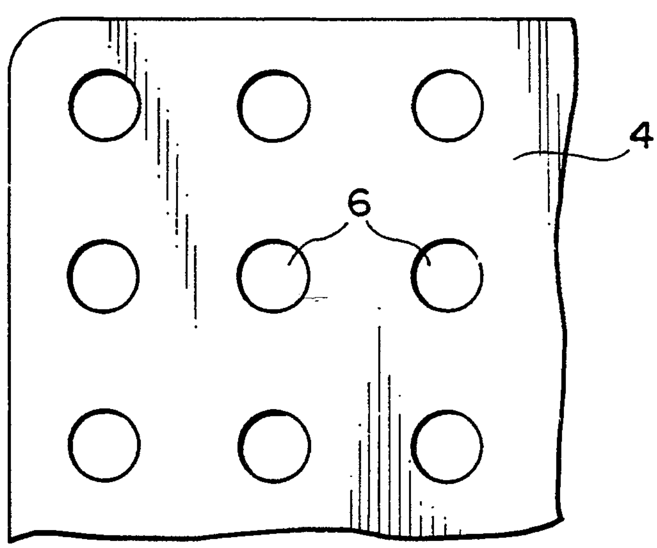


FIG. 11

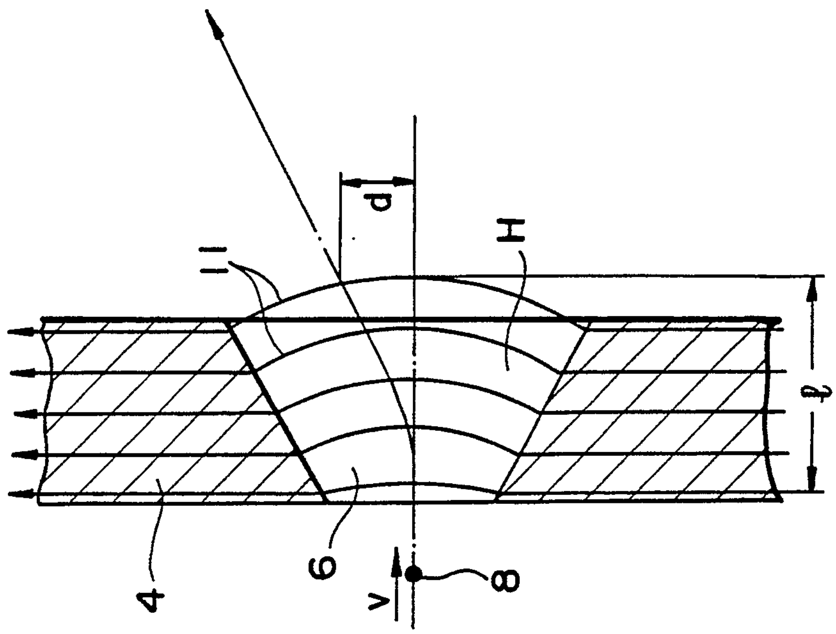


FIG. 10

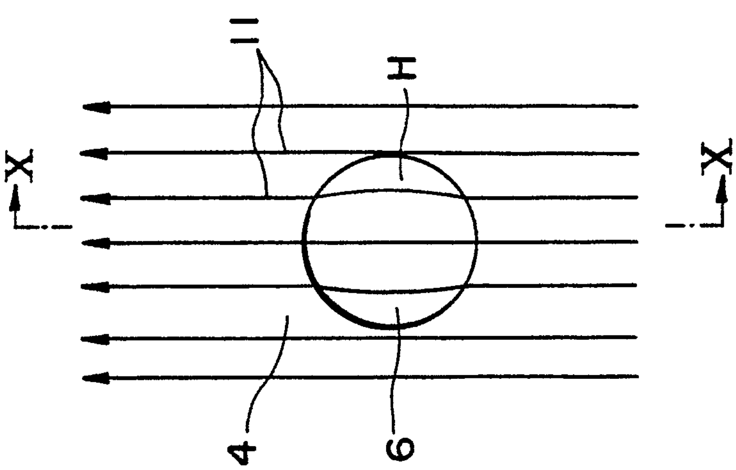


FIG. 12