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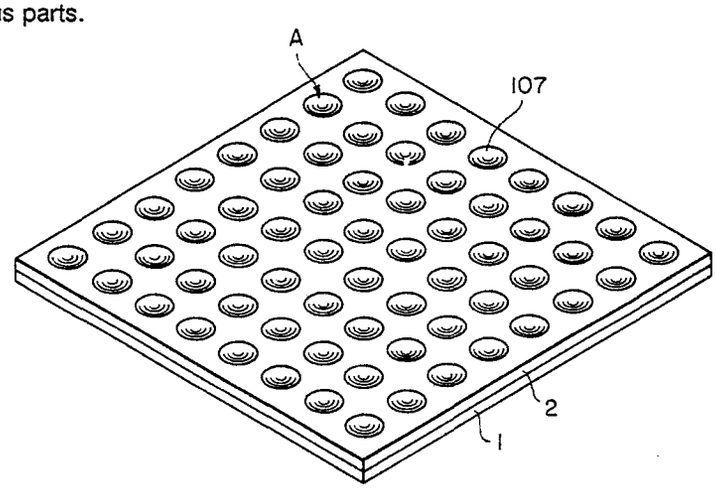
(54) **An optical guide matrix for a dot-matrix luminous display.**

(57) A matrix display board in which linear electrodes are perpendicularly arranged on opposite sides of an insulating board, with luminous elements at each electrical intersection. A masking member which is made of a material having Young's modulus not higher than 100 kg/cm² or not lower than 5×10^5 kg/cm², is joined to the surface having the luminous elements with through-holes corresponding to the luminous elements. The through-holes are shaped and/or filled with a light transmitting material having a concave portion, in order to increase luminous flux density around luminous parts.

FIG. 8



EP 0 206 176 A2

AN OPTICAL GUIDE MATRIX FOR A DOT-MATRIX LUMINOUS DISPLAY

BACKGROUND OF THE INVENTION

The present invention relates to improvements in dot-matrix luminous displays constructed of luminous elements such as light-emitting diodes.

Luminous displays of this type are designed to provide a visible representation of characters, symbols or patterns in the form of a dot pattern by supplying power to and lighting selected luminous elements arranged in a matrix using driving circuits.

The basic structure of such a conventional dot-matrix luminous display includes upper and lower electrodes arranged in a three-dimensional matrix with an insulating layer sandwiched therebetween, and semiconductor chips disposed at intersections between the upper and lower electrodes.

Referring to Figs. 1 and 2, the general structure of such a dot-matrix luminous display will be described. Two sheets of insulating substrates 102 and 103, respectively, bearing parallel rows of upper electrodes 100 and lower electrodes 101 on their surfaces, are fixed together to form a matrix luminous display board (hereinafter referred to as simply a "display board") 1 with the upper electrodes 100 placed perpendicular to the lower electrodes 101 to form a three-dimensional matrix at their intersections. There are provided through-holes 104 in the insulating substrate 102 at portions where the upper and lower electrodes 100 and 101 intersect. A semiconductor chip 105, forming a single luminous element, is placed in each through-hole 104, and, as a final process, the entire surface of the matrix board 1, including the through-holes 104 through which the semiconductor chips 105 are exposed, is coated with a light transmitting thermosetting resin to provide thereby a continuous protective film 107 as shown in Fig. 2. In addition, bonding wires 106 are used to connect the semiconductor chips 105 to the upper electrodes 100, whereas solder or silver paste 108 is used to provide conductive connection between the bottoms of the semiconductor chips 105 and the lower electrodes 101.

However, during the process of manufacturing such display boards, specifically, when the boards are coated with the light transmitting thermosetting resin film 107, there may be produced strain, camber, peeling and cracks (hereinafter collectively referred to as "flaws such as strain") at the joints of the display board 1 and the protective film 107 because of the difference therebetween in the coefficient of thermal expansion. These flaws such as strain result in defective products.

Moreover, the flaws such as strain become more pronounced as the size of the display board 1 is increased. Even finished products are not free from such strain caused by, for instance, the temperature difference between summer and winter or heat generated when power is supplied to the luminous elements.

In order to eliminate the aforementioned drawbacks accompanying the prior art shown in Figs. 1 and 2, it has been proposed in the copending U.S. Patent Application Serial No. 796,829, filed November 12, 1985, that the dot matrix luminous display be composed, as shown in Figs. 3 and 4, of a dot matrix luminous display board having luminous elements 105 arranged at intersections between upper and lower electrodes 100 and 101 arranged in a three-dimensional matrix on opposite sides of an insulating layer 110 as a preferred embodiment. The lower electrodes 101 are electrically connected to the upper side of the insulating layer 110 through a through-hole. Additionally, a flexible plate 2 having a plurality of through-holes formed therein at locations corresponding to the luminous elements 105 is joined to the surface of the dot matrix luminous display board. Fig. 3 is a schematic exploded view of a matrix display board 1 and a flexible plate 2 illustrating a dot-matrix luminous display proposed in the copending U.S. patent application wherein through-holes 200 are formed in the flexible plate 2. Fig. 4 is an enlarged cross-sectional view illustrating the dot-matrix luminous display of Fig. 3, in which the same or corresponding members as shown in Figs. 1 and 2 bear the same reference numerals, respectively. The flexible plate 2 is made from a material such as silicon rubber, neoprene rubber and flexible epoxy resin. Further, the through-holes 200 of the flexible plate 2 are filled with a light transmitting resin 107 to increase a visual angle of recognition and to enlarge the apparent luminous parts.

It has been also proposed in the above mentioned U.S. Patent Application to apply white or silver paint to the inner peripheral surface of each through-hole 200 to improve the luminous flux radiated from the luminous element 105 and to obtain clearer light emission by preventing light from leaking to neighboring portions. Particularly, it is preferred to form the flexible plate 2 itself of a white material having an excellent light reflection efficiency.

SUMMARY OF THE INVENTION

In view of the above described drawbacks accompanying the prior art, an object of the present invention is to provide a dot-matrix luminous display capable of increasing an apparent diameter of luminous parts and of making the contour thereof more clear to thereby improve the visual recognizability.

Another object of the present invention is to provide a dot-matrix luminous display capable of preventing the diffusion of light into an undesired area and of concentrating the light radiated from luminous parts in a desired given area.

These and other objects of the present invention are met by the provision of a dot-matrix luminous display which comprises a dot-matrix luminous display board having luminous elements arranged at electrical intersections between upper and lower electrodes arranged in a three-dimensional matrix with an insulating layer sandwiched therebetween. A flexible plate having a plurality of through-holes formed therein at locations corresponding to the luminous elements is joined to the surface of the display board. Each of the through-holes has a trapezoidal cross-section so that top cross-section of the aperture is larger than a bottom cross-section which is in contact with the display board and each of the through-holes is filled with a light transmitting resin.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a perspective view illustrating the basic construction of a dot-matrix luminous display;

Fig. 2 is a partially enlarged vertical sectional view of the display of Fig. 1;

Fig. 3 is a schematic exploded view of a matrix board and flexible plate illustrating a dot-matrix luminous display proposed in a copending U.S. Patent Application;

Fig. 4 is an enlarged cross-sectional view illustrating the dot-matrix luminous display of Fig. 3;

Fig. 5 is an enlarged cross-sectional view illustrating a first example of a luminous part of a dot-matrix luminous display embodying the present invention;

Fig. 6 is an enlarged cross-sectional view illustrating a second example of the luminous part of a dot-matrix luminous display embodying the present invention;

Fig. 7 is an enlarged cross-sectional view illustrating a third example of the luminous part of the dot-matrix luminous display embodying the present invention;

Fig. 8 is a schematic perspective view of the dot-matrix luminous display whose partial cross-section is shown in Fig. 7;

Figs. 9 to 11 are enlarged cross-sectional views illustrating respective fourth, fifth and sixth examples of a luminous part of the dot-matrix luminous display of the present invention; and

Fig. 12 is a schematic diagram illustrating a dot-matrix luminous display which is installed at an elevated position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, an embodiment of the present invention will be described.

Fig. 5 is an enlarged cross-sectional view illustrating a first example of a luminous part of a dot-matrix luminous display embodying the present invention.

As is clear from Fig. 4 and 5, the first example of the present invention, which is shown in Fig. 5, is substantially the same as that shown in Fig. 4 but there is a difference therebetween in that a light transmitting resin seal 107 has a concave surface and a light dispersing agent may be also added thereto, if necessary. The flexible member 2 having a plurality of through-holes 200 is jointed onto the display board 1 with an adhesive, and then a light transmitting resin is injected into the through-holes 200 to seal the luminous elements 105 and the like and to form a seal 107 in each of the through-holes 200. In this first example shown in Fig. 5, as mentioned above, the surface is shaped to have a concave portion so as to fully provide the seal 107 with the so-called concave lens function and a light dispersing agent may be added to the light transmitting resin in order to improve the visual recognizability (a visual angle of recognition). The resin may be, for example, a resin such as epoxy or polyester. Further, in this case, the thickness of the seal 107 in its central thin portion should preferably be in the range of about 1/2 to 2/3 of the thickness dm of the flexible plate 2 and the thickness dm of the flexible palte 2 should be about 1/5 to 1/2 of the diameter 2R of the top cross-section (i.e., diameter of the luminous part A), more preferably, about 1/3 of the diameter 2R of the top cross-section.

When a dot-matrix luminous display with a dot pitch of 8.0 mm (the distance between the centers of adjacent dots) and a side length of the display board of about 64 mm is employed for the present invention, for instance, it is possible to set the diameter 2R of the luminous part at 6.5 mm, the thickness dm of the flexible plate at 2.0 mm and the thickness ds of the display board 1 at 1.6 mm.

The flexible plate 2 used for the dot-matrix luminous display is primarily intended to prevent the leakage of light received from the luminous elements 105, to increase the apparent diameter of the luminous part A and to make clear the contour thereof in order to improve the visual recognizability of the dot-matrix luminous display. At the same time, it is used to protect the electrode patterns 100 and 101 on the surface of the display board 1 and to prevent the leakage of resin (for instance, thermosetting or ultraviolet-curing liquid resin) used for sealing the luminous element 105.

As also set forth in the copending application, the flexible plate 2 should preferably be made of flexible materials such as neoprene rubber and silicon rubber to prevent crack, deformation and the like caused by cure shrinkage when the light transmitting material is used to form the seal 107 and to prevent bending and deformation as a result of temperature changes. Such flexible materials have Young's modulus not higher than 100 kg/cm^2. Moreover, a light reflecting face formed on the inner peripheral wall of the throuh-holes 200 should be formed directly with a light reflecting material - (for instance, a white material) or by coating the wall with a light reflecting material such as a silver paint. It is also preferred to apply a light absorbing dark paint to the top exposed surface of the flexible plate 2 to prevent light from unnecessarily reflecting from it.

The results of experiments made by the present inventors have proved that the seal 107 formed in the luminous part for sealing the luminous element and the like should have specific characteristics. In particular, the seal 107 should be composed of a light transmitting material with a relatively high refractive index of 1.3 or higher. It should have a light reflecting face formed on the inner peripheral wall of the through-hole 200 of the flexible plate 2. These properties are useful in that the contour of the luminous part is made clear and visual recognizability is improved.

Fig. 6 is an enlarged cross-sectional view illustrating a second example of the luminous part A of a dot-matrix luminous display embodying the present invention, in which the inner peripheral wall of each of the through-holes 200 is shaped with an outwardly opening slope so that a top cross-section of the through-hole has a diameter larger than that of a bottom.

Fig. 7 is an enlarged cross-sectional view illustrating a third example of the luminous part A of the present invention. As is similar to the first example of the present invention shown in Fig. 5, the seal 107 has a concave surface and a light dispersing agent may be also added thereto, if necessary.

Fig. 8 is a schematic perspective view of the dot-matrix luminous display whose partial cross-section is shown in Fig. 7.

Figs. 9 to 11 are enlarged cross-sectional views illustrating fourth, fifth and sixth examples of the luminous part A of the dot-matrix luminous display of the present invention, respectively. The fourth to sixth examples of the luminous parts A are designed so as to concentrate the light emission from the luminous part A in a given direction, thereby improving the luminance in this direction and improving the visual recognizability.

In Figs. 9 to 11, centers RO, rO of the top and bottom cross-sections 200a and 200b of each through-hole 200 of the flexible plate 2 are displaced from each other by a certain value $\underline{s}$ and all of the through-holes 200 are shaped in the same manner so that the upper and lower cross-sections are displaced in the same direction to direct the light radiated from the luminous part A in the same direction.

The inner peripheral wall of the through-hole 200 allowing its top opening 200a to communicate with the bottom opening 200b, is preferably coated with paint with a high light reflectance to provide a light reflecting face.

The eccentric distance between the cross-section centers in accordance with the present invention can be set at any value depending on the direction of radiation. However, it is preferable that the eccentric distance $\underline{s}$ between the center RO of the top cross-section 200a and the center r0 of the bottom cross-section 200b be set so as to satisfy the relation $R/5 \leq s \leq R/2$ where R and r designate radii of the top cross-section 200a and the bottom cross-section 200b.

As to the relationship between the two cross-sectional radii, that is, R and r, it is normal to set the values to satisfy the relations that $R \geq r$ and preferably that $R/3 \leq r < R$.

As shown in Fig. 9, each luminous element 105 in the luminous part A is sealed with a hardening light transmitting resin (for instance, thermosetting and ultraviolet-curing resin) to form the seal 107, just as in the first to third examples. In that case, if necessary, the concave surface 107a of the seal 107 shown in Fig. 10 may be provided to increase the luminous flux density around the luminous part A due to the function of the concave lens, thus increasing the clarity of the contour of the luminous part A, so that a brighter easy-to-see dot matrix luminous display unit is obtainable.

In view of the object of the present invention, the dot matrix luminous display unit according to the invention can use not only a dynamic driving circuit is used to light each luminous element but also a driving circuit which capable of lighting luminous elements at the same time.

Fig. 12 shows an example of the dot matrix luminous display device used as a display panel and arranged in a high place. An embodiment of the present invention thus arranged brought about good results with an angle of elevation ϴ in the range from 45 to 60 degrees.

Use of the dot matrix luminous display unit according to the present invention provides the following effects in view of the construction:

(1) Due to the multiplied effects of the concave lens function of the sealing layer and the light reflecting face formed on the inner peripheral wall of the through-hole of the flexible plate, the flux of light from the luminous element is made to concentrate upon the contour of the luminous part and the density of the flux of light in the coutour is increased. As a result, the clear contour of the luminous part results in an easy-to-see dot matrix luminous display unit.

(2) In comparison with what has a flat or convex surface of the sealing layer, the contour of the luminous part becomes clear. Accordingly, it becomes possible to decrease the thickness of the flexible plate, increase the visual angle of recognition and besides reduce material and production costs. When the similar luminous elements are used as a light source, the dot matrix luminous display unit obtainable has a thinner flexible plate and a large diameter dots without damaging visual recognizability.

When no light dispersing agent is added to the sealing layer according to the present invention, there is anticipated the multiplied effects of the concave lens function and the light reflecting face formed on the inner peripheral wall of the through-hole of the flexible plate and, further it can provide a light transmittance greater (higher than about 90%) than that which is available when the dispersing agent is added. Consequently, a dot matrix luminous display unit offering higher luminance is obtainable.

(3) According to the present invention, the centers of the upper and lower openings of each through-hole of the flexible plate are displaced from each other and a light reflecting face is formed on the inner peripheral face of the through-hole allowing the upper opening to communicate with the lower opening. Consequently, the light radiated from the luminous elements is concentrately emitted onto a given irradiation area defined by the eccentricity between the upper and lower openings of the through-hole.

For that reason, the increased luminous flux in the given irradiation area will improve the luminance in that area and thus visual recognizability to a greater extent. Thus, when the dot matrix luminous display unit is used as a luminous display panel for installation in a high place, it is not only of high commercial value but also very useful.

While the above described examples of the present invention employs a flexible plate having Young's modulus not higher than 100 kg/cm² as a masking member, modifications are possible without departing from the basic concept of the present invention. That is, rigid materials having Young's modulus higher than 5×10^5 kg/cm² may be employed as a masking member. Concrete examples of such a rigid material are an iron, an aluminum and a stainless steel. In this case, such rigid masking members have rigidity sufficiently high against stress caused by contraction upon setting of the thermosetting resin, and therefore it is also possible to eliminate an occurrence of flaws such as strain of the masking members.

Claims

1. A dot-matrix luminous display comprising:

a dot-matrix luminous display board having luminous elements arranged at electrical intersections between upper and lower electrodes arranged in a three-dimensional matrix with an insulating layer sandwiched therebetween; and

a masking member which is made of a material having Young's modulus not higher than 100 kg/cm² or not lower than 5×10^5 kg/cm², and said masking member having a plurality of through-holes formed therein at locations corresponding to the luminous elements and joined to a surface of the display board.

2. A display as recited in Claim 1, further comprising a light transmitting resin filling said through-holes.

3. A display as recited in Claim 2, wherein an upper surface of said light transmitting resin filling said through-holes has a concave shape, for increasing luminous flux density around said luminous elements.

4. A display as recited in Claim 3, wherein said resin has a refractive index of 1.3 or higher.

5. A display as recited in Claim 1, wherein said through-holes have an upper cross-section larger than a lower cross-section.

6. A display as recited in Claim 1, wherein said through-holes have a circular upper cross-section and a circular lower cross-section, the center of said upper cross-section being displaced in a plane of said masking member from the center of said lower cross-section.

7. A display as recited in Claim 6, wherein said upper cross-section is larger than said lower cross-section.

8. A display as recited in Claim 1, wherein a side wall of each through-hole is light reflective.

9. A display as recited in Claim 8, wherein said masking member comprises a substantially white material, thereby making said side wall light reflective.

FIG. 1
PRIOR ART

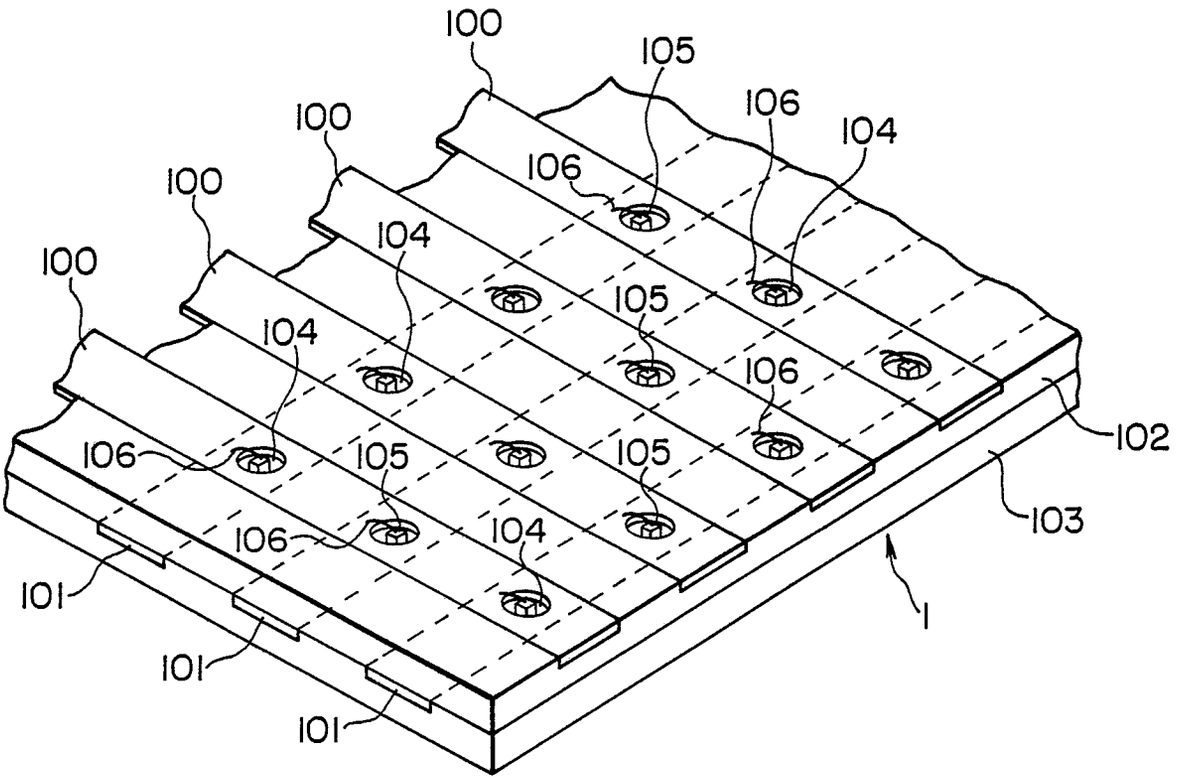


FIG. 2
PRIOR ART

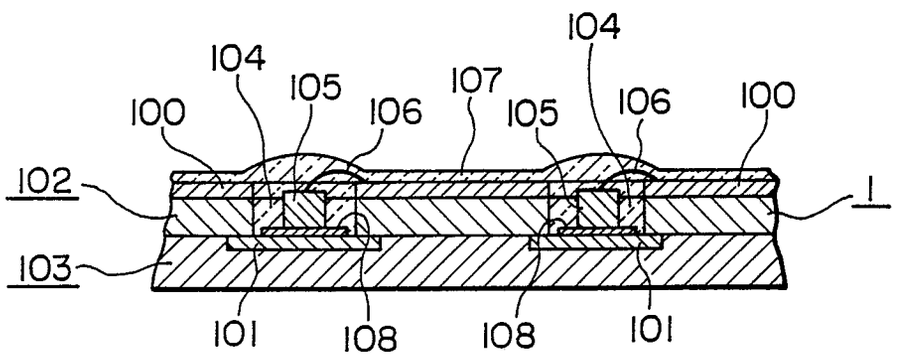


FIG. 3

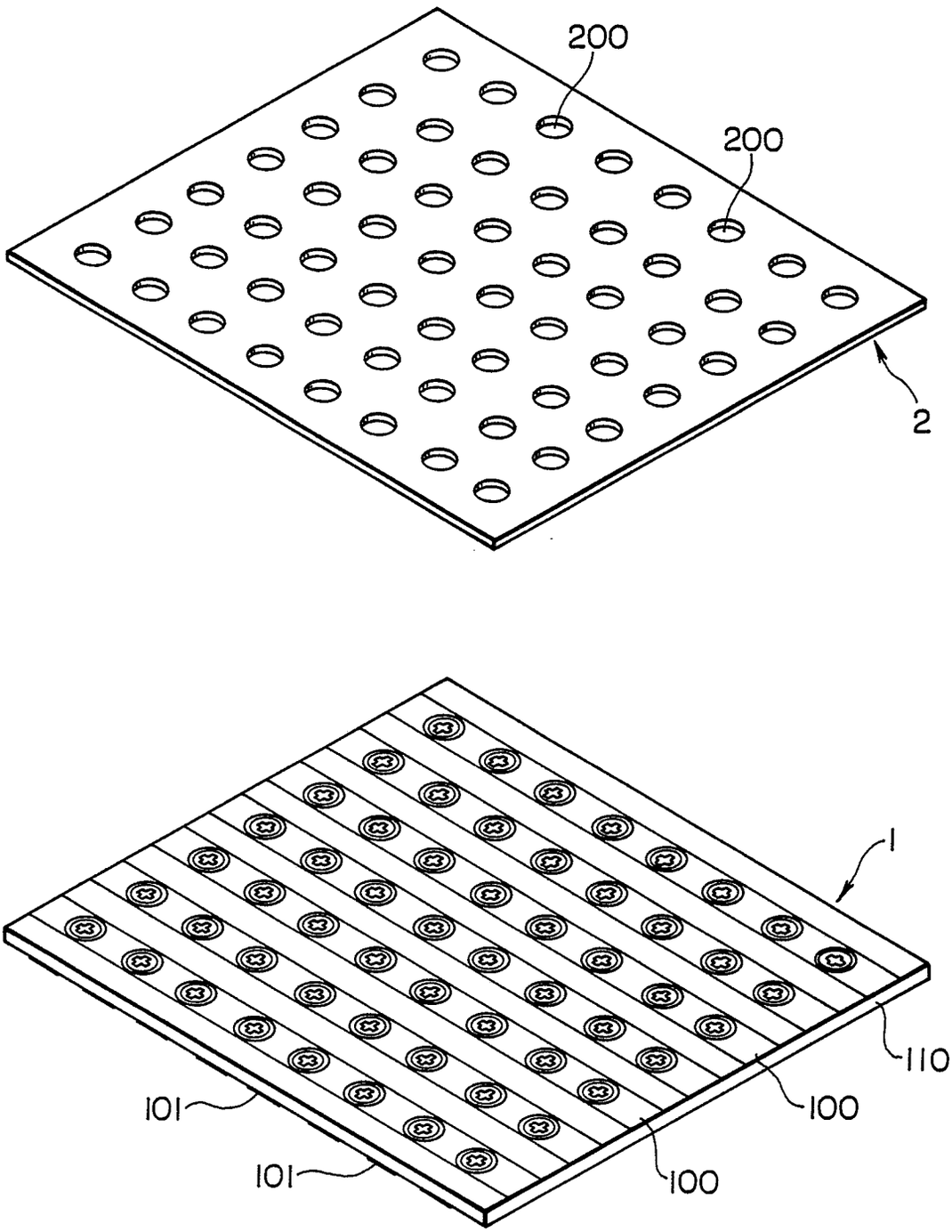


FIG. 4

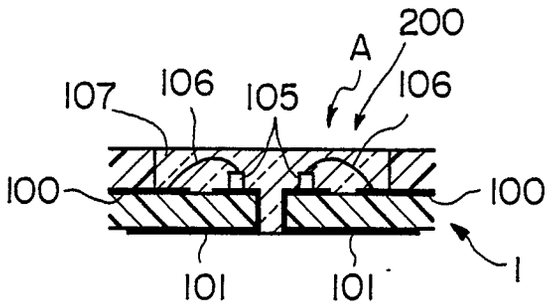


FIG. 5

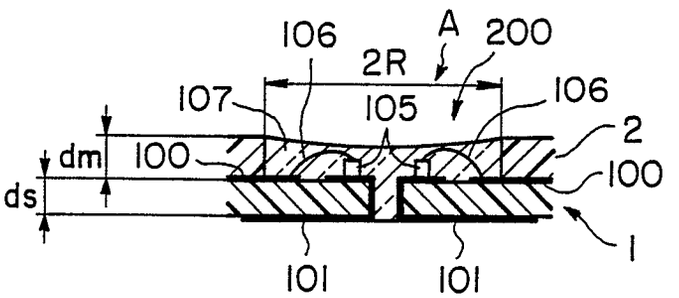


FIG. 6

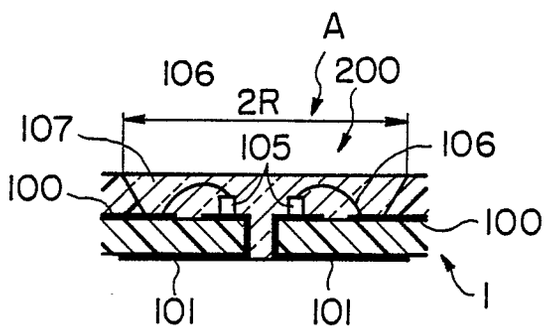


FIG. 7

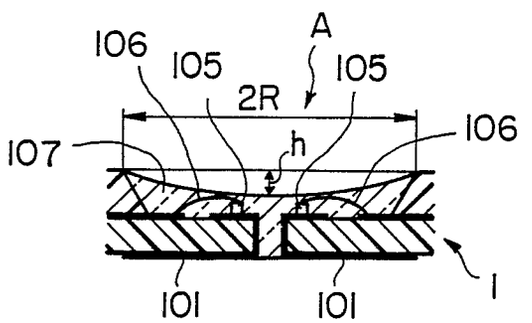


FIG. 8

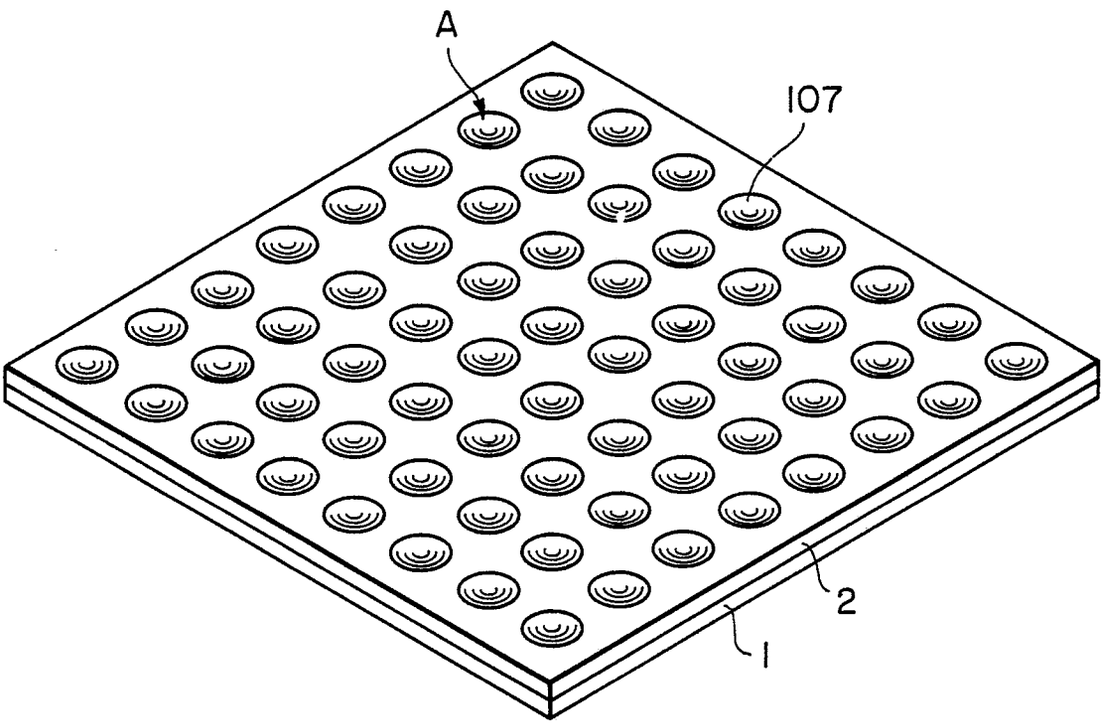


FIG. 9

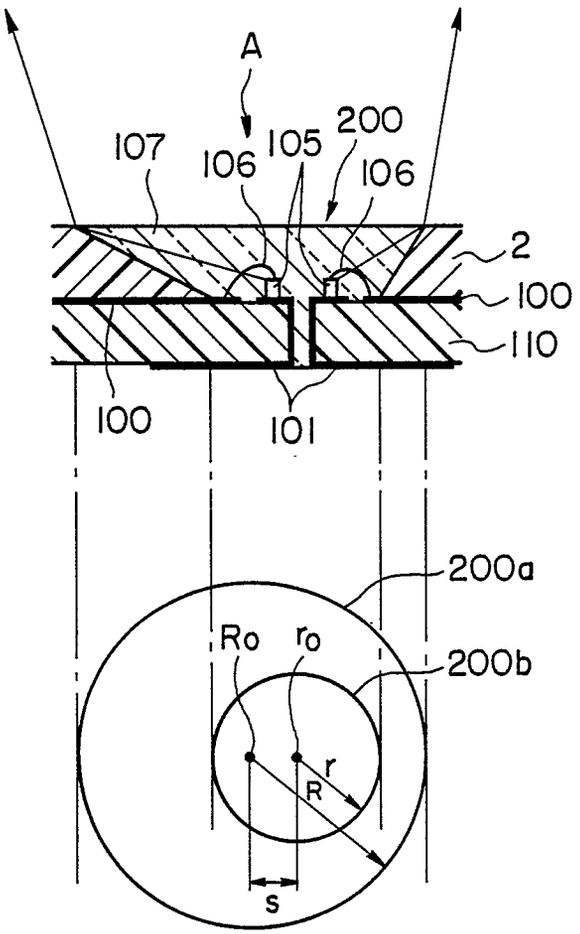


FIG. 10

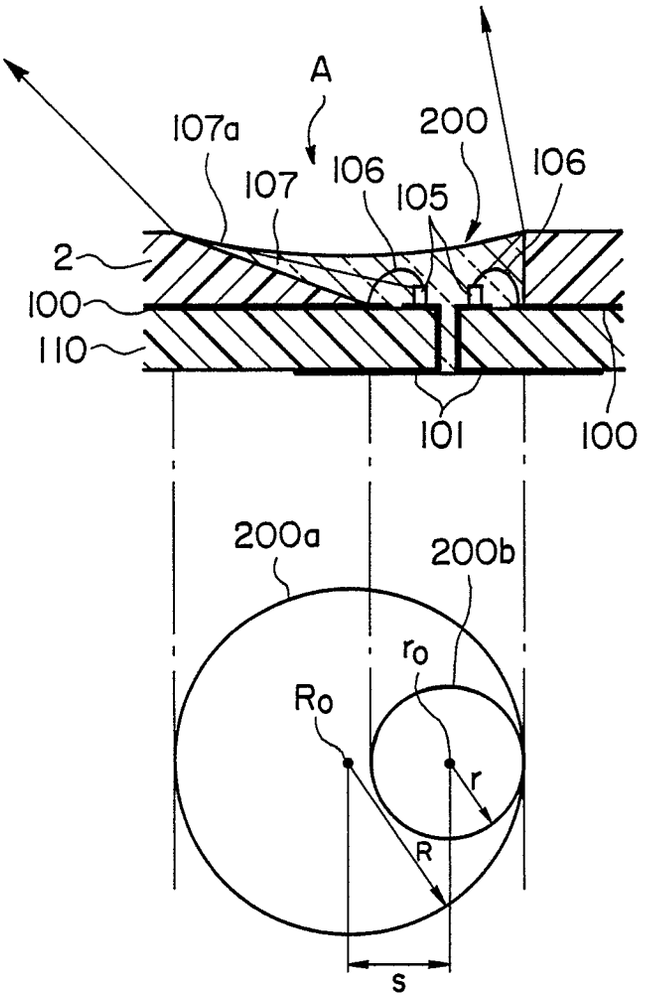


FIG. 11

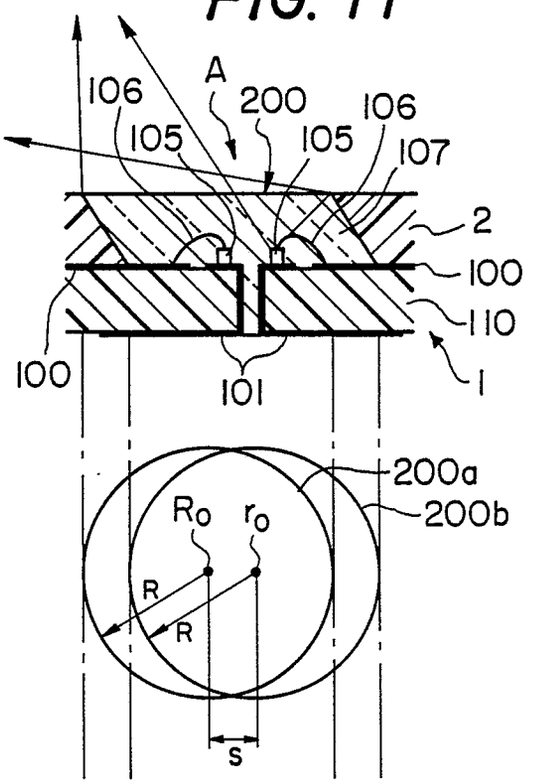


FIG. 12