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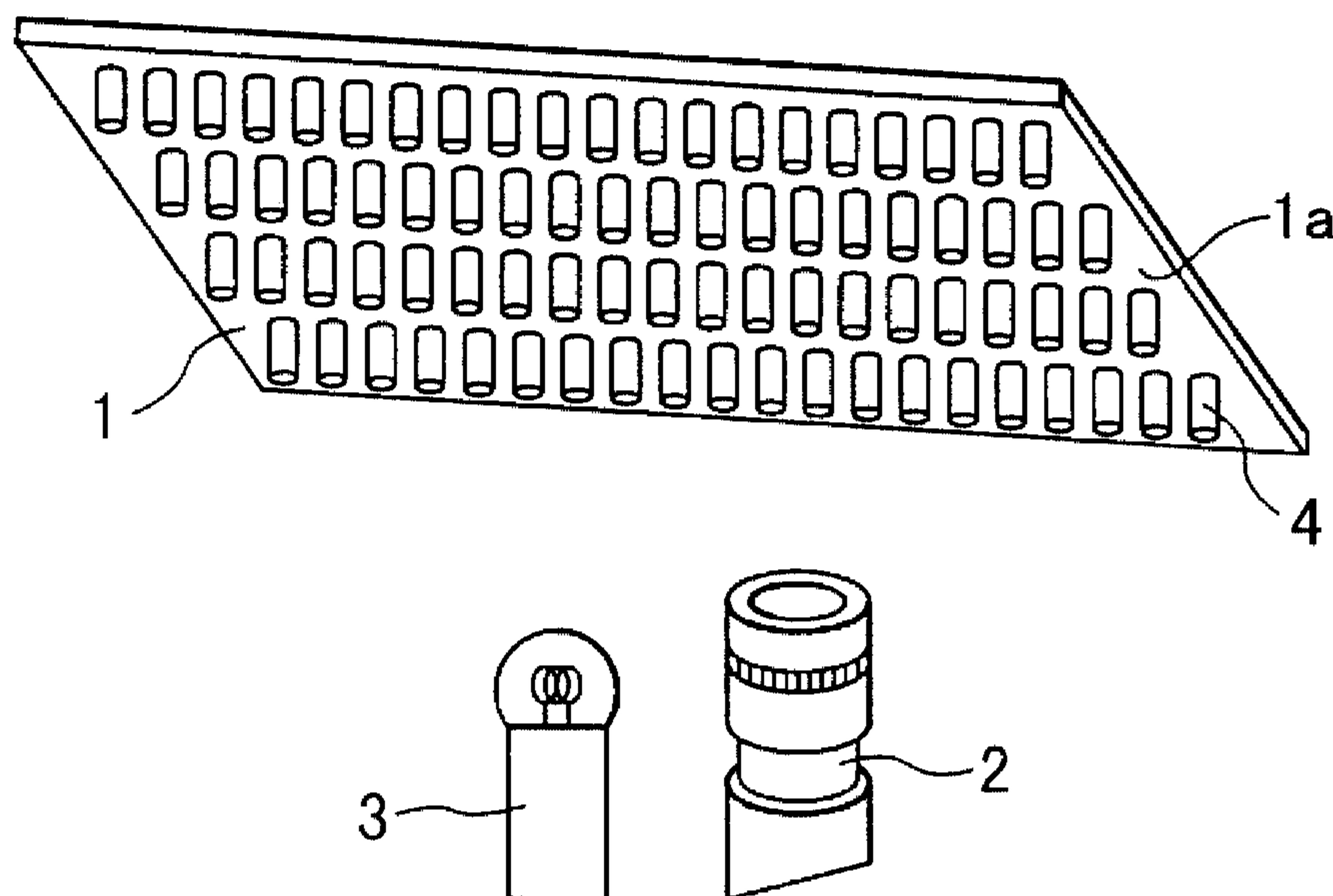
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(54) Titre : CAPTEUR TACTILE

(54) Title: TOUCH SENSOR



(57) **Abrégé/Abstract:**

A touch sensor for detecting three-dimensional features of an object includes a rubber skin and a plurality of pins provided on one surface of the rubber skin. The rubber skin and pins are formed of materials having different colors to facilitate image processing. An image acquisition device is provided facing the one surface with the pins. When an object presses against the outer surface of the rubber skin, the rubber skin is depressed in a way that corresponds to the shape of the object. This spreads the pins, forming a pattern of a different brightness that is detected by the image acquisition device to thereby enable three-dimensional features of the object to be identified.



Abstract of the Disclosure

A touch sensor for detecting three-dimensional features of an object includes a rubber skin and a plurality of pins provided on one surface of the rubber skin. The rubber skin and pins are formed of materials having different colors to facilitate image processing. An image acquisition device is provided facing the one surface with the pins. When an object presses against the outer surface of the rubber skin, the rubber skin is depressed in a way that corresponds to the shape of the object. This spreads the pins, forming a pattern of a different brightness that is detected by the image acquisition device to thereby enable three-dimensional features of the object to be identified.

Title of the Invention:

Touch Sensor

BACKGROUND OF THE INVENTION

Field of the Invention:

This invention relates to a touch sensor that detects three-dimensional features of a touched object.

Description of the Prior Art:

Conventional touch sensors include those using microswitches to detect simply whether an object is or is not being touched, those comprising pressure-sensitive conductive rubber or conductive ink sheets disposed between comb-shaped electrodes that use changes in resistance values to detect a pressure distribution, and those comprising silicone rubber on an optical waveguide substrate that detects a pressure contact distribution based on a light leakage pattern arising from the contact between the waveguide and the silicone rubber produced during contact with an object.

When a robotic hand is operated to grasp an object, the algorithm that is used differs depending on the three-dimensional features of the object in the area of contact between the robot fingers and the object. That is, in using an algorithm to estimate the posture of a grasped object, the algorithm used when the fingers are touching a surface plane of the object, the algorithm used when the fingers are touching a vertex portion, and the algorithm used when the fingers are touching an edge are all different. This has generated a need for a sensor to be developed as a robot touch sensor that is able to detect three-dimensional features of an object being touched.

The prior art pressure-sensitive conductive

rubber sheet or conductive ink sheet type pressure distribution touch sensors and optical waveguide type touch sensor described above each have hard surfaces, and detect one- or two-dimensional features of a touched object, therefore cannot be used to obtain information in the direction in which pressure is applied. Thus, a problem has been that when the grasped object has three-dimensional curved surfaces, or when the sensor is provided on something having a curved shape like the fingertips of a multi-finger hand, the area of contact between the sensor and the object becomes small because of their hard surfaces, and makes it impossible to detect the features of the object.

The present invention was accomplished to resolve the above problems and has as an object to provide a touch sensor capable of readily and accurately detecting three-dimensional features of an object such as vertices and edges.

SUMMARY OF THE INVENTION

To achieve this object, the invention provides a touch sensor for detecting three-dimensional features of an object, the touch sensor comprising: a rubber skin and a plurality of pins provided on an inner surface of the rubber skin, the rubber skin and the pins being constituted of materials of mutually different colors that facilitate image processing, and an imaging device provided facing the inner surface on which the plurality of pins are provided, wherein deformation of the rubber skin by pressure of contact against an outer surface of the rubber skin corresponding to a shape of the object changes an orientation of the plurality of pins on the inner surface, forming a pattern of different brightnesses that is

detected by the imaging device to thereby detect three-dimensional features of the object.

The rubber skin is disposed at the window of a space formed in the fingertip portion of a robotic hand. To enable detection of the three-dimensional features of the object, an endoscope incorporating an image transmission fiber that is optically connected to a camera, and a fiber to provide illumination, is disposed with the tip of the endoscope in the fingertip space, facing the inner surface of the rubber skin.

The above and other features of the present invention will become apparent from the following description made with reference to the drawings.

BRIEF EXPLANATION OF THE DRAWINGS

Figure 1 is a diagram for explaining the basic configuration of the touch sensor according to the invention.

Figure 2 is a diagram for explaining the detection of the shape of an object using the touch sensor of Figure 1.

Figure 3 is a diagram showing an embodiment of the touch sensor of the invention applied to the fingertip of a robotic hand.

Figure 4 is a diagram for explaining the detection of the shape of an object using the touch sensor of Figure 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The touch sensor of the invention will now be explained with reference to the drawings. Figure 1 shows the basic configuration of a touch sensor according to the invention, comprising a rubber skin 1 and a small camera 2 as the image acquisition device. The inside surface 1a of

the rubber skin 1 facing the camera 2 has a plurality of small, densely-arrayed pins 4 extending therefrom. The rubber skin 1 is formed of a flexible rubber of a color that readily reflects light, such as white, for example, while the pins 4 are made of a hard rubber of a color that does not readily reflect light, such as black, for example. The rubber skin 1 and the pins 4 may be formed integrally, or they may be formed separately then bonded together.

The operation of the touch sensor will now be explained with reference to Figure 2. Contact of a target object 5 with the outer surface 1b of the rubber skin 1 of the touch sensor presses the rubber skin 1 inward, toward the camera 2, producing a deformation corresponding to the shape of the object 5. Where a three-dimensional aspect of the object 5 is involved, such as a vertex 6 formed by the meeting of three planes of the object 5 or an edge 7 formed by two planes, the rubber skin 1 will have a correspondingly higher curvature. Because the pins 4 are oriented normal to the rubber skin 1, formation of a highly-curved region 8 in the rubber skin 1 by the above contact with the object 5 causes mutually adjacent pins 4 along the highly-curved region 8 to be splayed outward along the highly-curved region 8, thereby exposing the inner surface 1a of the rubber skin 1. That is, the brightness pattern of the rubber skin 1 undergoes change along the highly-curved region 8.

By using the camera 2 to acquire images of these changes in the brightness pattern, it is possible to detect three-dimensional features of the object 5 such as vertex 6 and edge 7. Moreover, the fact that the pins 4 are splayed outwards along the highly-curved region 8 means that the orientation pattern of the pins 4 also changes.

Thus, the features of the object 5 can also be detected based on images of the pin pattern acquired by means of the camera 2. The smaller the pins 4 and the higher the areal pin density, the more accurate the image of the object shape that is obtained will be. If the camera 2 does not have enough light to obtain images, a lamp 3 can be used to provide illumination. Moreover, when the object 5 has come into contact with the outer surface 1b of the rubber skin 1, a region of the rubber skin 1 that when viewed from the camera 2 all has the same inclination (such as, in Figure 2, the right side of the rubber skin 1, for example) will have the same brightness pattern and pin orientation pattern. This enables a region belonging to one part of the object to be separated from a region belonging to another part of the object.

Figure 3 shows an embodiment of the touch sensor of the invention applied to the fingertip of a multi-fingered robotic hand. The end of a fingertip 10 has a finger base portion 12 that defines a space 11. An endoscope 13 is disposed with the tip of the endoscope 13 projecting into the space 11. The endoscope 13 is a conventional type of endoscope having an optical connection to an imaging apparatus such as a camera or the like situated on the base side of the robotic hand, and incorporates fibers to provide illumination and for transmitting images. A window 14 is formed in the finger base portion 12. The rubber skin 1 is provided over the window 14 with the inner surface 1a having the pins 4 facing the space 11, facing the tip of the endoscope 13. The space 11 thus formed by the finger base portion 12 and the rubber skin 1 is filled with a clear liquid such as silicone oil to keep the rubber skin 1 stretched outwards.

When the fingertip having a touch sensor according to this embodiment presses against an object 5 as part of an operation to grasp the object 5, as shown in Figure 4, the part (edge or vertex) of the object 5 pressing against the rubber skin 1 depresses the rubber skin 1 into the space 11. By pushing the pins 4 apart to expose the inner surface 1a, this changes the brightness pattern along the portion of contact with the object 5. This change is detected by the endoscope 13, thereby enabling three-dimensional feature detection of the object 5. The rubber skin 1 and the pins 4 may be formed by overlaying two sheets of rubber, one being an inner layer and the other an outer layer, with just the inside surface of the inner sheet being of a color that does not readily reflect light, such as black, for example, and the outer sheet and the interior portion of the inner sheet being of a color that does readily reflect light, such as white, for example, with the inner sheet being formed with cuts in the form of a lattice.

While the basic structure of the touch sensor according to the present invention was described in the foregoing with respect to the rubber skin 1 being constituted of a flexible rubber and having a color that readily reflects light, such as for example white, and the pins 4 being constituted of a hard rubber and having a color that does not readily reflect light, such as for example black, the rubber skin 1 can instead be of a color that does not readily reflect light and the pins 4 of a color that does readily reflect light.

It is to be understood that the touch sensor of the invention may be practiced otherwise than as specifically described herein and changes and modifications

freely made so long as these do not depart from the defined gist of the invention.

In accordance with the invention constituted as described above, when a detection object is pressed into contact with the rubber skin, the pressure of the contact deforms the rubber skin. Where the deforming pressure gives rise to highly-curved regions, the inner surface of the rubber skin is exposed between rows of pins, changing the brightness pattern. The detection of these changes in brightness pattern by means of a camera enables the detection of three-dimensional features of the object such as vertices and edges. Also, since the pins are spread out to each side along a highly-curved region, the pattern of pin orientation, as acquired by the camera, can be used to detect three-dimensional features of the object such as vertices and edges.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A touch sensor for detecting three-dimensional features of an object, said touch sensor comprising:

a rubber skin,

a plurality of pins provided on an inner surface of the rubber skin,

said rubber skin and said pins being constituted of materials of mutually different colors that facilitate image processing, and

an imaging device provided facing the inner surface on which the plurality of pins are provided,

wherein deformation of the rubber skin by pressure of contact against an outer surface of the rubber skin corresponding to a shape of the object changes an orientation of the plurality of pins on the inner surface, forming a pattern of different brightnesses that is detected by said imaging device to thereby detect three-dimensional features of the object; and

wherein the rubber skin is disposed at a window of a space formed in a fingertip portion of a robotic hand, and an endoscope incorporating an image transmission fiber that is optically connected to said imaging device and a fiber to provide illumination is disposed in said space formed in the fingertip portion with a tip of the endoscope facing the inner surface of the rubber skin.

FIG. 1

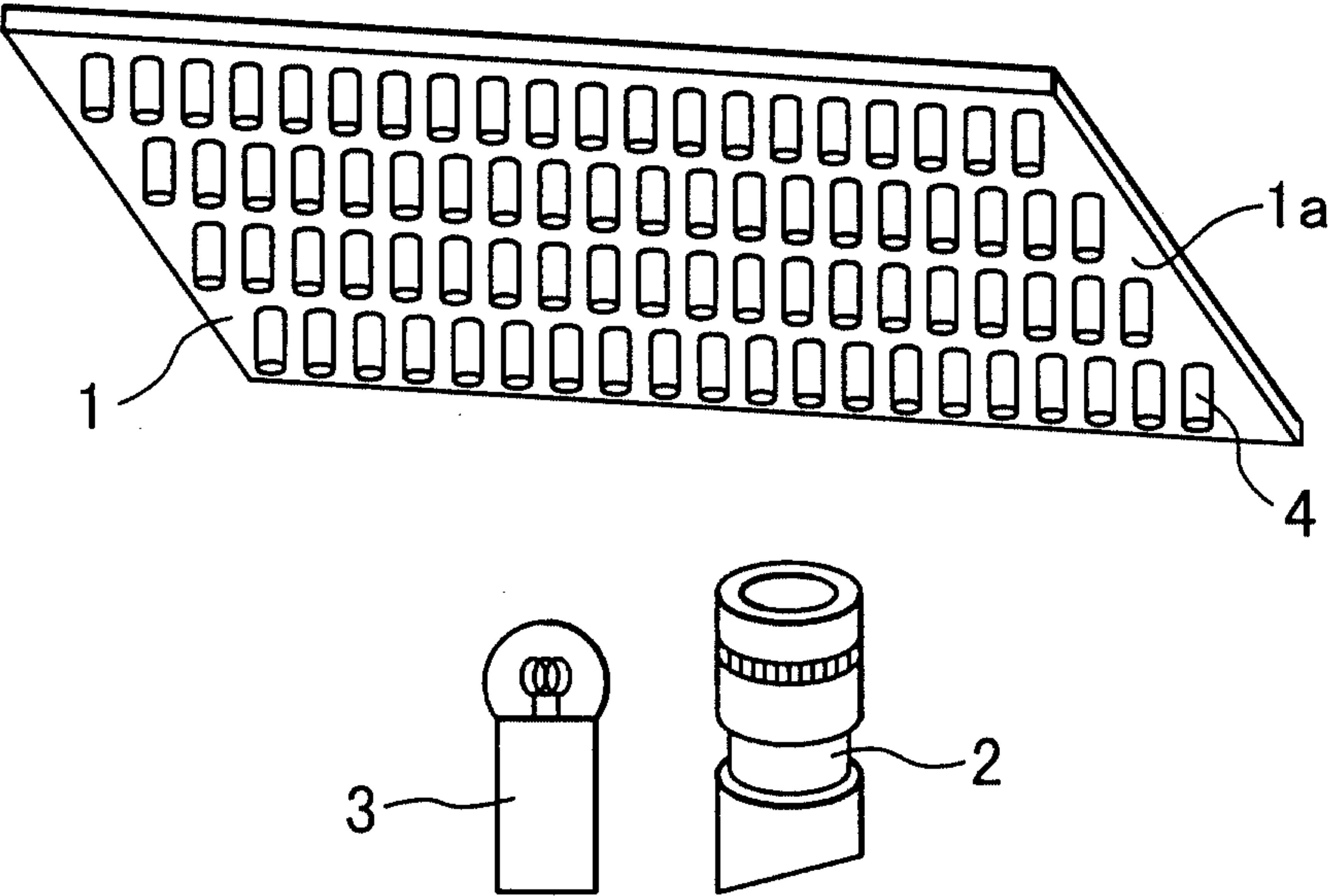


FIG. 2

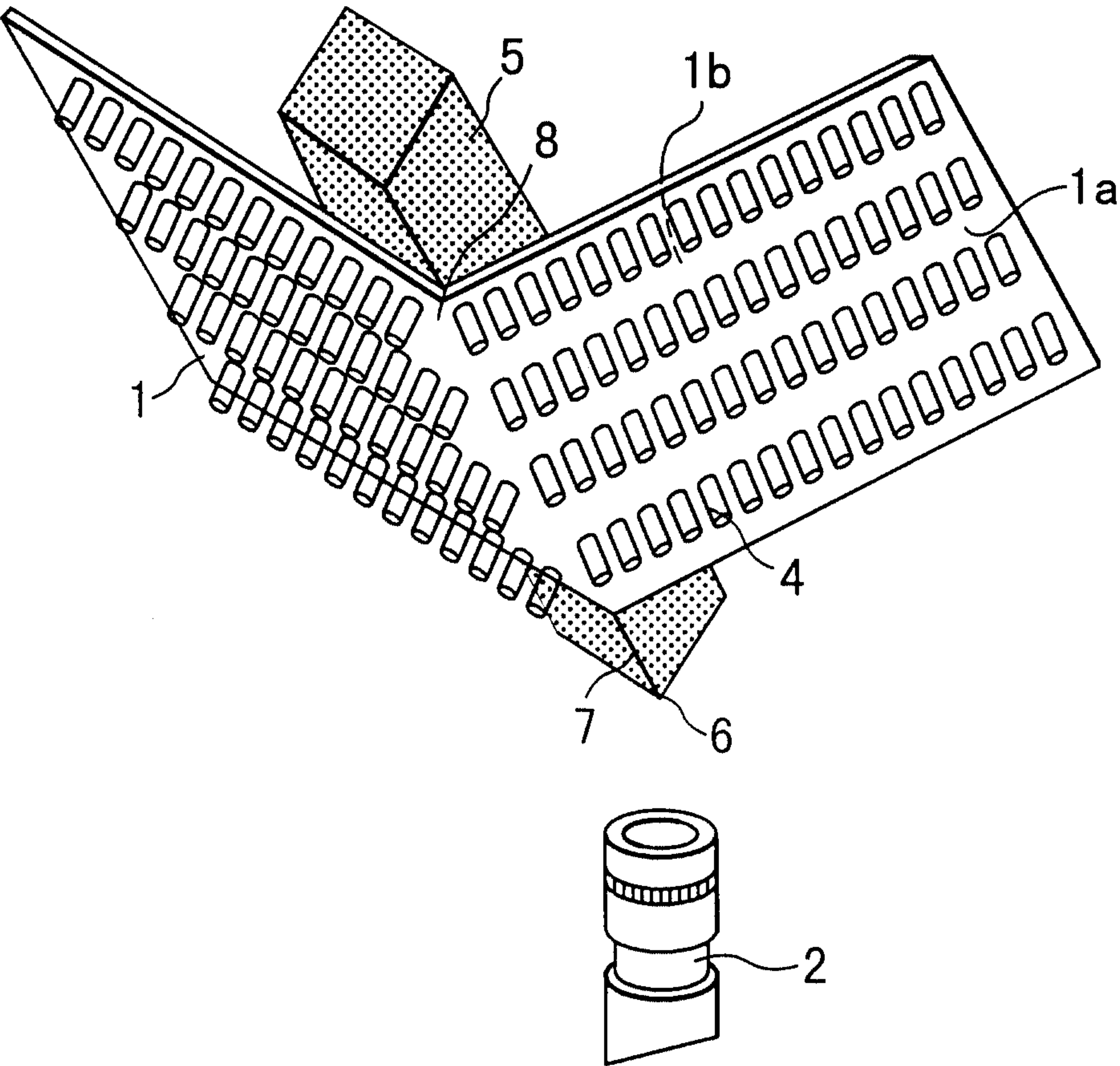


FIG. 3

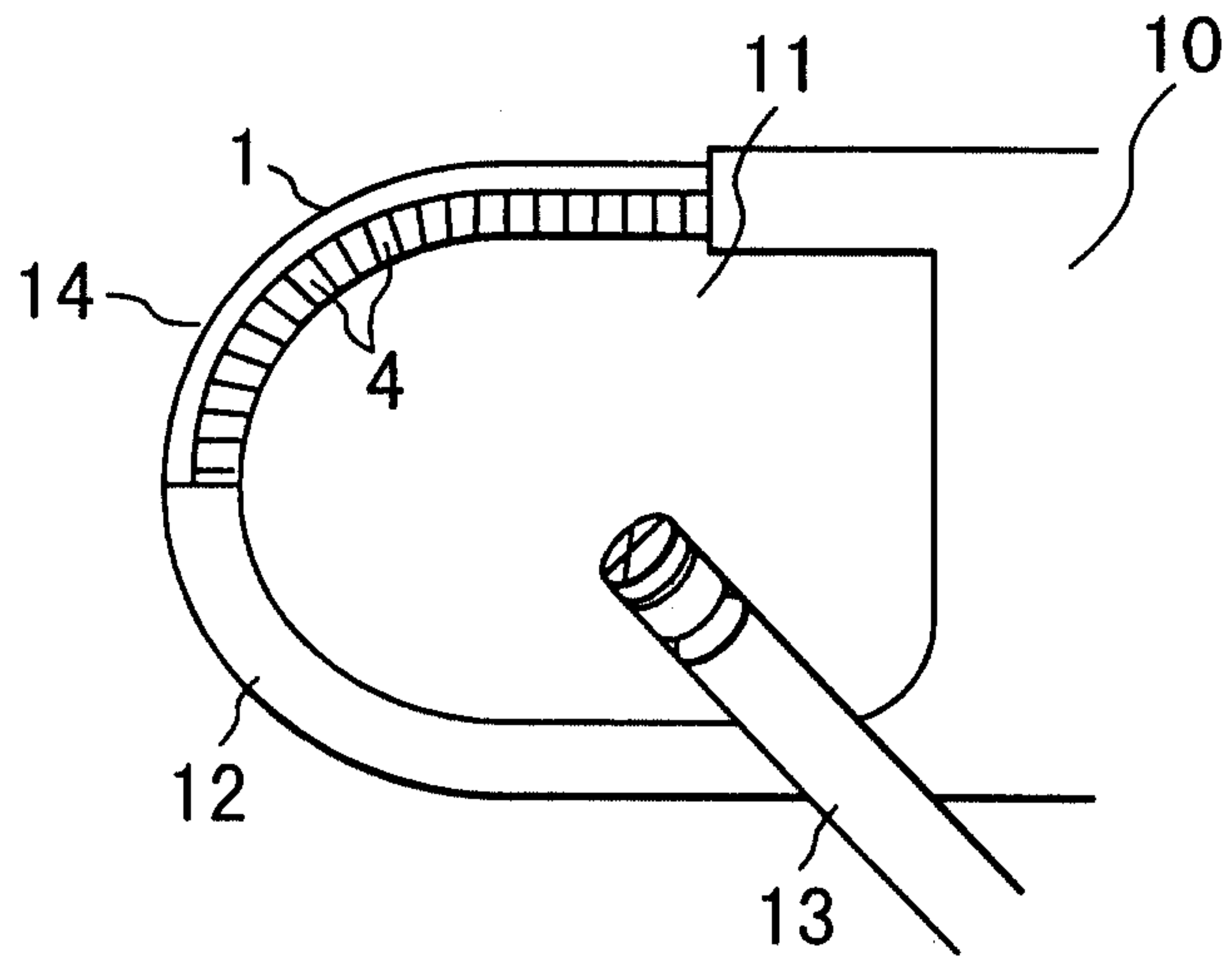


FIG. 4

