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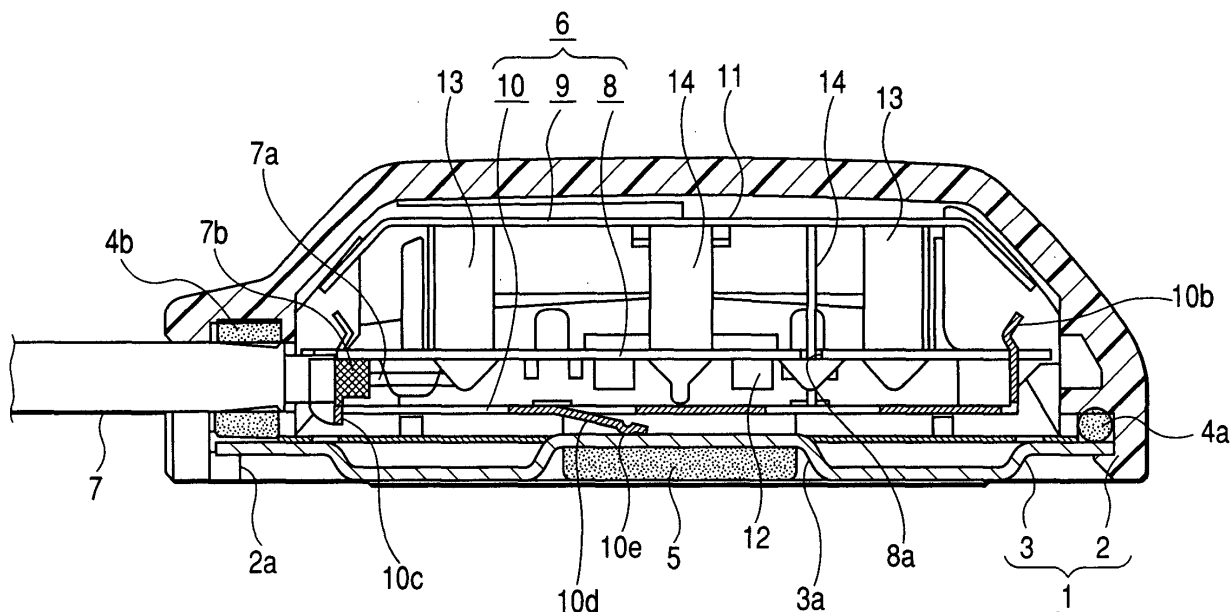
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(54) **Antenna device**

(57) A case has a synthesized resin radome that houses and covers an antenna unit, and a metal cover that covers a bottom opening of the radome. A shield case and the metal cover facing each other are connected to each other by a tongue piece. The antenna unit includes a circuit board that has a wiring pattern and a semiconductor component mounted on a lower surface thereof, the shield case that covers the lower surface of the circuit board and is connected to an outer conductor of a coaxial cable, a radiating conductor plate that is substantially disposed in parallel with an upper surface of the circuit board by a predetermined gap, and feeding pieces that extend from the radiating conductor plate and are connected to the wiring pattern. The antenna unit in the case is connected to an external circuit through the coaxial cable.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a compact antenna device suitable for in-vehicle use and so on, and more particularly, to an antenna device in which an antenna main body having a patch antenna structure and a circuit board with a low noise amplifying circuit and so on mounted thereon are unitized and housed and held in a radome.

2. Description of the Related Art

[0002] In recent years, such an antenna device has been increasingly demanded as an antenna for an ETC (electronic toll collection system) or an antenna for a GPS (global positioning system) to be mounted on a mobile, such as a vehicle or the like.

[0003] In the related art, such an antenna device generally has a configuration in which an antenna unit is housed in a case having a pair of upper and lower radomes, and the antenna unit is connected to an external circuit through a coaxial cable. The antenna unit schematically has a circuit board with a wiring pattern or a semiconductor component mounted on a lower surface thereof, an antenna main body, such as a dielectric patch antenna or the like, that has a radiating conductor and is mounted on the circuit board, and a shield case, formed of a metal plate, that is mounted so as to cover the lower surface of the circuit board. A feeding point of the radiating conductor and the wiring pattern of the circuit board are connected to each other by a feeding pin. Further, the shield case is connected to a ground through an outer conductor of the coaxial cable. The shield case prevents unwanted radiation of a low noise amplifying circuit having a wiring pattern or a semiconductor component from adversely affecting on antenna characteristics and prevents interfering waves coming from the outside from adversely affecting on the low noise amplifying circuit.

[0004] However, since the antenna device having the above-described configuration in which the case of the antenna unit has a pair of synthesized resin radomes (upper and lower radomes) needs to prepare individual dedicated molds for both radomes, case cost is increased and thus it is difficult to reduce manufacturing costs of the entire device.

[0005] For this reason, in the related art, an antenna device has been proposed in which a metal plate cover covers the bottom opening of one radome housing an antenna unit so as to reduce case cost, such that the antenna device can be manufactured at low cost (for example, see JP-A-7-326914 (pages 2 and 3, and FIG. 2)). Further, according to the related art, the antenna device can be easily mounted at an arbitrary place of a metal exposed portion or a metal embedded portion in a vehicle by incorporating a magnet in a recess formed in the metal plate cover.

[0006] As described above, the manufacturing costs of the antenna device can be reduced by combining the metal plate cover with the radome. However, when static electricity charged in a human body is applied to the cover, the semiconductor component mounted on the circuit board may be easily damaged by static electricity. That is, since the metal plate cover and the radiating conductor of the antenna main body are disposed substantially in parallel with each other and function as a parallel plate capacitor, there is a possibility that excessive induced current caused by the static electricity applied to the cover flows from the radiating conductor into the wiring pattern of the circuit board and thus the semiconductor component is destroyed. Moreover, it is conceivable to additionally provide a circuit for preventing electrostatic breakdown in the circuit board, but, in this case, the circuit configuration becomes complicated, costs may be increased. Accordingly, cost reduction using the metal plate cover is lost.

SUMMARY OF THE INVENTION

[0007] The invention has been finalized in view of the drawbacks inherent in the related art, and it is an object of the invention to provide an antenna device that can be manufactured at low cost and can prevent electrostatic breakdown.

[0008] In order to achieve the above-described object, according to an aspect of the invention, an antenna device includes a case, and an antenna unit that is housed in the case. The antenna unit has a circuit board that has a wiring pattern and a semiconductor component mounted on one surface thereof, a shield case that covers one surface of the circuit board and is connected to a ground through an outer conductor of a coaxial cable, a radiating conductor that is disposed on the other surface of the circuit board substantially in parallel with the other surface of the circuit board by a predetermined gap, and a feeding member that is provided between the radiating conductor and the wiring pattern. The antenna unit is connected to an external circuit through the coaxial cable. The case has a synthesized resin radome that houses, holds, and covers the antenna unit, and a metal cover that covers a bottom opening of the radome, through which the shield case is exposed in a projecting manner. The shield case and the metal cover facing each other are connected to each other.

[0009] In the antenna device having the above-described configuration, even though static electricity is applied to the

metal cover, which contributes to reduce the case cost, the static electricity can rapidly escape to the shield case. Therefore, electrostatic breakdown of the semiconductor component mounted on the circuit board can be prevented.

[0010] In the antenna device according to the aspect of the invention, it is preferable that a tongue piece provided in the shield case be brought into elastic contact with the metal cover. By doing so, the connection between the shield case and the metal cover can be very simply implemented. In this case, it is preferable that the tongue piece be provided in a region of the shield case neighboring to the outer conductor of the coaxial cable. By doing so, the electrostatic breakdown to be concerned until the static electricity reaches the outer conductor of the coaxial cable can be reliably prevented. Further, in this case, it is preferable that a convex portion formed at a free end of the tongue piece be brought into elastic contact with the metal cover. According to this configuration, since the tongue piece and the metal cover are stably brought into elastic contact with each other by the convex portion having a small contact area, a change in resistance at the contact portion due to vibration is eliminated, such that noise can be prevented from occurring.

[0011] In the antenna device according to the aspect of the invention, it is preferable that the radiating conductor is formed of a metal plate that faces the circuit board with an air layer interposed therebetween, and the feeding member is formed by turning up a metal piece extending from the metal plate toward the circuit board. By doing so, a sheet metal patch antenna in which an antenna main body can be formed one metal plate, and thus the manufacturing costs of the antenna device can be markedly reduced, as compared with an antenna device using a dielectric patch antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a cross-sectional view of an antenna device according to an embodiment of the invention;
FIG. 2 is a perspective view of the antenna device; and
FIG. 3 is a perspective view of a shield case, which is used for the antenna device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] An embodiment of the invention will be described with reference to the drawings. FIG. 1 is a cross-sectional view of an antenna device according to an embodiment of the invention. FIG. 2 is an exploded perspective view of the antenna device. FIG. 3 is a perspective view of a shield case which is used for the antenna device.

[0014] The antenna device shown in the drawings primarily has a case 1 that is formed by fitting a metal cover 3 into a radome 2, a sealing member 4 that is mounted on a fitting portion 1a between the radome 2 and the metal cover 3 or the like, a magnet 5 that is mounted on a lower surface of the metal cover 3, and an antenna unit 6 that is housed in an inner space of the case 1. The antenna unit 6 is connected to an external circuit (not shown), such as a receiving circuit, through a coaxial cable 7. The antenna unit 6 has a circuit board 8 that has an electronic circuit unit, such as a low noise amplifying circuit or the like, an antenna main body 9 that serves a sheet metal patch antenna, and a shield case 10 that is formed of a metal plate. A ground pattern (not shown) provided on an almost entire upper surface of the circuit board 8 faces a radiating conductor plate of the antenna main body 9 by a predetermined gap. Further, on a lower surface of the circuit board 8, a wiring pattern (not shown) is provided and a semiconductor component 12, which is connected to the wiring pattern, is mounted. The semiconductor component 12 and the wiring pattern constitute the electronic circuit unit.

[0015] The radome 2 is a mold product formed of synthetic resin and has a bottom opening 2a, which opens downward. The radome 2 houses and holds the antenna unit 6 and, as shown in FIG. 1, the entire antenna unit 6 is covered with the radome 2. The metal cover 3 is formed by pressing a metal plate and covers the bottom opening 2a of the radome 2. The metal cover 3 is provided with a recess 3a formed at the center of the bottom and the magnet 5 is fixed in the recess 3a. Therefore, the antenna device can be easily mounted at an arbitrary place of a metal exposed portion or a metal embedded portion in a vehicle. Moreover, the metal cover 3 is made larger than the radiating conductor plate 11 of the antenna main body 9 and functions as a reflective plate. As shown in FIG. 1, the case 1 is assembled by fitting the metal cover 3 into the radome 2, and a fitting portion 1a having a substantially square frame shape and a cable lead opening 1b neighboring to the fitting portion 1a are provided between the radome 2 and the metal cover 3. Further, a ring-shaped mounting portion 4a of the sealing member 4 is mounted on the fitting portion 1a, and a cable inserting portion 4b of the sealing member 4 is mounted on the cable lead opening 1b. In such a manner, a gap existing in the fitting portion 1a and the cable lead portion 1b is sealed.

[0016] The sealing member 4 is a mold product formed of an elastic material, such as rubber, in which the ring-shaped mounting portion 4a and the cable inserting portion 4b are integrally molded. The ring-shaped mounting portion 4a is formed to substantially have the same square frame shape as that of the fitting portion 1a. Further, the cable inserting portion 4b is molded such that an inserting hole 4c is provided in a convex body having an external shape to be fitted into the cable drawing opening 1b. An axial direction of the inserting hole 4c is aligned with an axial direction of the ring-

shaped mounting portion 4a under an no-load condition. That is, since one side of the ring-shaped mounting portion 4a is connected to one corner of the cable inserting portion 4b, the cable inserting portion 4b can rotate along a circumferential direction of one side of the ring-shaped mounting portion 4a. Further, the inserting hole 4c of the cable inserting portion 4b is provided to insert the coaxial cable 7 therethrough. When the sealing member 4 is assembled into the case 1, first, the coaxial cable 7 is inserted into the inserting hole 4c, and is assembled into the cable lead opening 1b in a state in which the cable inserting portion 4b is elastically rotated by 90 degrees, and then the ring-shaped mounting portion 4a is mounted on the fitting portion 1a.

[0017] The antenna unit 6 has the circuit board 8, the antenna main body 9, and the shield case 10, all of which are unitized. The wiring pattern provided on the lower surface of the circuit board 8 is soldered to an inner conductor (core) 7a of the coaxial cable 7. In the circuit board 8, through-holes 8a (see FIG. 1) are formed at positions corresponding to mounting legs 13 or feeding pieces 14 to be described below, and concave notches 8b are formed at plural positions of an outer circumference.

[0018] The antenna main body 9 includes the radiating conductor plate 11 that faces the ground pattern with an air layer of a predetermined thickness interposed therebetween, the mounting legs 13 that are formed by turning up four corners of the radiating conductor plate 11 toward the circuit board 8, and feeding pieces 14 that are formed by turning up two parts neighboring to a middle portion of the radiating conductor plate 11 toward the circuit board 8. The four mounting legs 13 and the two feeding pieces 14 are inserted into the corresponding through-holes 8a and then are soldered to the lower surface of the circuit board 8. In such a manner, the feeding pieces 14 are connected to the wiring pattern, such that the radiating conductor plate 11 and the electronic circuit unit are electrically connected to each other. Further, the mounting legs 13 are mechanically connected to solder lands, which are electrically isolated from the wiring pattern. Therefore, the antenna main body 9 is reliably held on the circuit board 8.

[0019] The shield case 10 covers the low noise amplifying circuit having the semiconductor component 12 on the lower surface of the circuit board 8. Therefore, a possibility that antenna characteristics are deteriorated by unwanted electrical waves to be radiated from the low noise amplifying circuit or interfering waves from the outside adversely affects on the low noise amplifying circuit is markedly reduced. As a result, high reliability is easily achieved. In the shield case 10, clearance holes are formed in plural places that face the solder portions of the lower surface of the circuit board 8, respectively. Further, elastic anchoring pieces 10b extend upward at plural places of the outer circumference of the shield case 10. The elastic anchoring pieces 10b are correspondingly snapped into the notches 8b of the circuit board 8 and then are soldered to the ground pattern on the upper surface of the circuit board 8. Further, in the shield case 10, a cable holding portion 10c is formed upright in a substantially U shape for positioning and holding an outer conductor 7b of the coaxial cable 7 by press-fitting an exposed tip thereof, and a tongue piece 10d protrudes by cutting and bending down a part between the middle portion and the cable holding portion 10c. A convex portion 10e is formed on a tip (free end) of the tongue piece 10d and is brought into contact with the metal cover 3 due to elastic repulsive force of the tongue piece 10d, as shown in FIG. 1. As a result, the shield case 10 is connected to the ground through the outer conductor 7b of the coaxial cable 7, and the metal cover 3 is connected to the shield case 10 through the tongue piece 10d.

[0020] The antenna device having such a configuration can operate as a circularly polarized antenna by performing two-point feeding to the radiating conductor plate 11 through the two feeding pieces 14 connected to the wiring pattern of the circuit board 8. That is, if a predetermined high-frequency signal is supplied to the radiating conductor plate 11 through the low noise amplifying circuit, circularly polarized waves are radiated from the radiating conductor plate 11. Further, if signal waves are received by the radiating conductor plate 11, electrical signals thereof are outputted to an external receiving circuit through the low noise amplifying circuit or the coaxial cable 7.

[0021] Further, in the antenna device according to the present embodiment, since the antenna unit 6 having the circuit board 8, the radiating conductor plate 11, and the like is housed in the case 1 and the sealing member 4 is mounted on the fitting portion 1a of the case 1 or the cable lead opening 1b, dust resistance and waterproofing property can be achieved. Further, since the case 1 has the synthesized resin radome 2 and the metal cover 3, the antenna device can be manufactured at low cost, as compared to an antenna device that has a case formed by fitting a pair of upper and lower radomes into each other. Further, since the metal cover 3 serves as a reflective plate suppresses radiation in unwanted directions, a gain can be improved.

[0022] Further, in the antenna device according to the present embodiment, the shield case 10 and the metal cover 3 is connected to each other by coming the tongue piece 10d provided in the shield case 10 into elastic contact with the metal cover 3. Accordingly, even though static electricity charged in a human body is applied to the metal cover 3, static electricity can rapidly escape to the shield case 10. Therefore, there is a low possibility that contingency of excessive induced current caused by the static electricity applied to the metal cover 3 flowing from the radiating conductor plate 11 into the wiring pattern of the circuit board 8 occurs, and electrostatic breakdown of the semiconductor component 12 can be prevented, thereby improving reliability. In addition, since the convex portion 10e is formed on the tip of the tongue piece 10d and is brought into elastic contact with the metal cover 3, such that the tongue piece 10d and the metal cover 3 are stably brought into elastic contact with each other by the convex portion 10e having the small contact area, the change in resistance at the contact portion due to vibration is eliminated, such that noise can be prevented from

occurring. Moreover, like the present embodiment, when the tongue piece 10d is provided in a region of the shield case 10 neighboring to the outer conductor 7b of the coaxial cable 7, electrostatic breakdown to be concerned until the static electricity reaches the outer conductor 7b of the coaxial cable 7 can be reliably prevented, such that reliability is further improved.

[0023] In addition, in the antenna device according to the present embodiment, a sheet metal patch antenna is adopted in which the radiating conductor plate 11 is formed of a metal plate that faces the circuit board 8 with the air layer interposed therebetween, and the feeding pieces 14 are formed by turning up the metal pieces extending from the metal plate toward the circuit board 8. In this case, the antenna main body 9 can be formed of one metal plate. Therefore, manufacturing costs of the antenna device can be reduced, as compared with an antenna device using a dielectric patch antenna.

[0024] In addition, the shape of the antenna main body 9, the feeding method, and the like can be suitably selected. For example, the invention can be applied to a linearly polarized antenna device that is a single point feeding system.

[0025] In the antenna device according to the aspect of the invention, since the case of the antenna unit has of the synthesized resin radome and the metal cover, the case cost is reduced. Further, since the shield case is connected to the metal over through the tongue piece or the like, even though static electricity is applied to the metal cover, electrostatic breakdown of the semiconductor component can be prevented. Therefore, an antenna device with high reliability can be obtained at low cost.

Claims

1. An antenna device comprising:

a case 1; and

an antenna unit 6 that is housed in the case 1, the antenna unit 6 having:

a circuit board 8 that has a wiring pattern and a semiconductor component 12 mounted on one surface thereof;

a shield case 10 that covers one surface of the circuit board 8 and is connected to a ground through an outer conductor 7b of a coaxial cable 7;

a radiating conductor 11 that is disposed on the other surface of the circuit board 8 substantially in parallel with the other surface of the circuit board 8 by a predetermined gap; and

a feeding member 14 that is provided between the radiating conductor 11 and the wiring pattern,

characterized in that the antenna unit 6 is connected to an external circuit through the coaxial cable 7, the case 1 has a synthesized resin radome 2 that houses, holds, and covers the antenna unit 6, and a metal cover 3 that covers a bottom opening 2a of the radome 2, through which the shield case 10 is exposed in a projecting manner, and the shield case 10 and the metal cover 3 facing each other are connected to each other.

2. The antenna device according to claim 1,

characterized in that a tongue piece 10d provided in the shield case 10 is brought into elastic contact with the metal cover 3.

3. The antenna device according to claim 2,

characterized in that the tongue piece 10d is provided in a region of the shield case 10 neighboring to the outer conductor 7b of the coaxial cable 7.

4. The antenna device according to claim 2 or 3,

characterized in that a convex portion 10e is formed at a free end of the tongue piece 10d and is brought into elastic contact with the metal cover 3.

5. The antenna device according to any of claims 1 to 4,

characterized in that the radiating conductor 11 is formed of a metal plate that faces the circuit board 8 with an air layer interposed therebetween, and

the feeding member 14 is formed by turning up a metal piece extending from the metal plate toward the circuit board 8.

FIG. 1

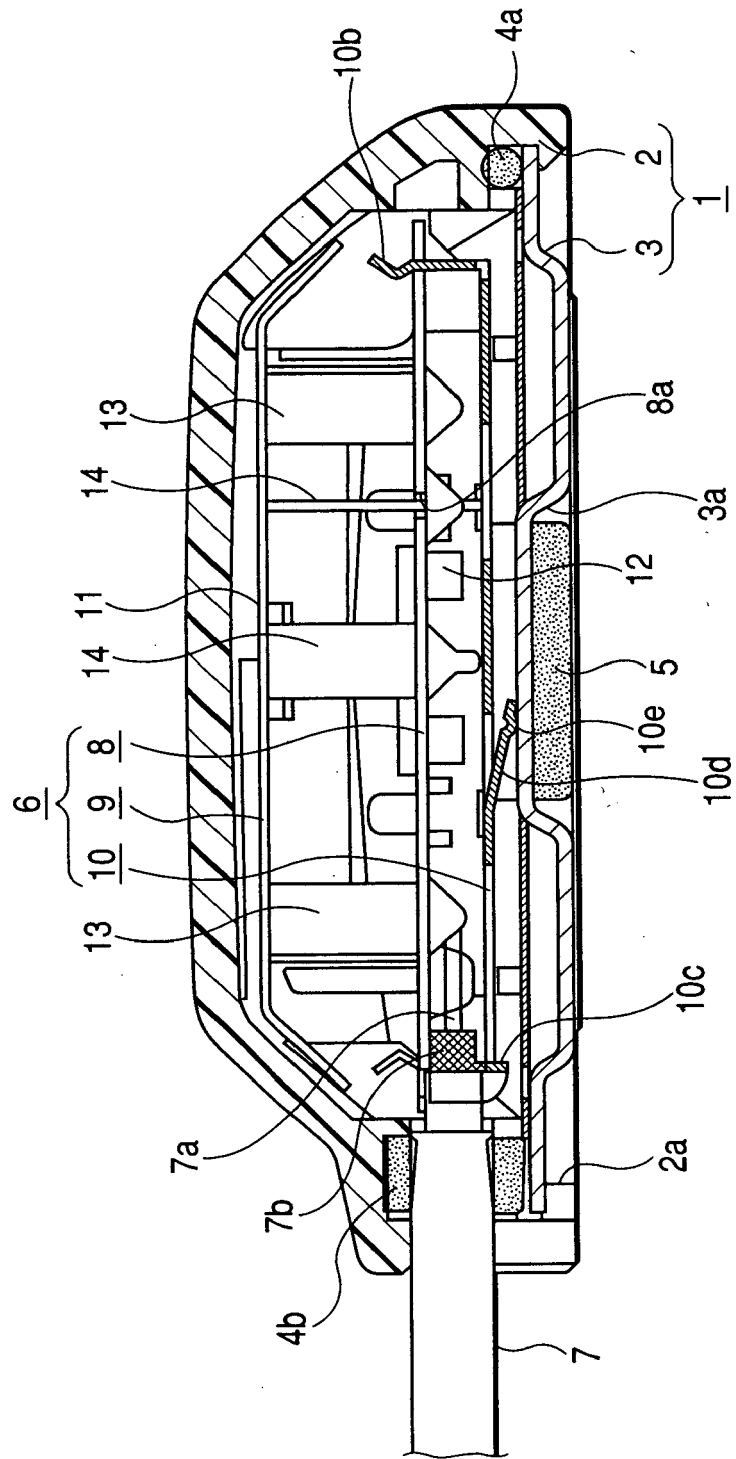


FIG. 2

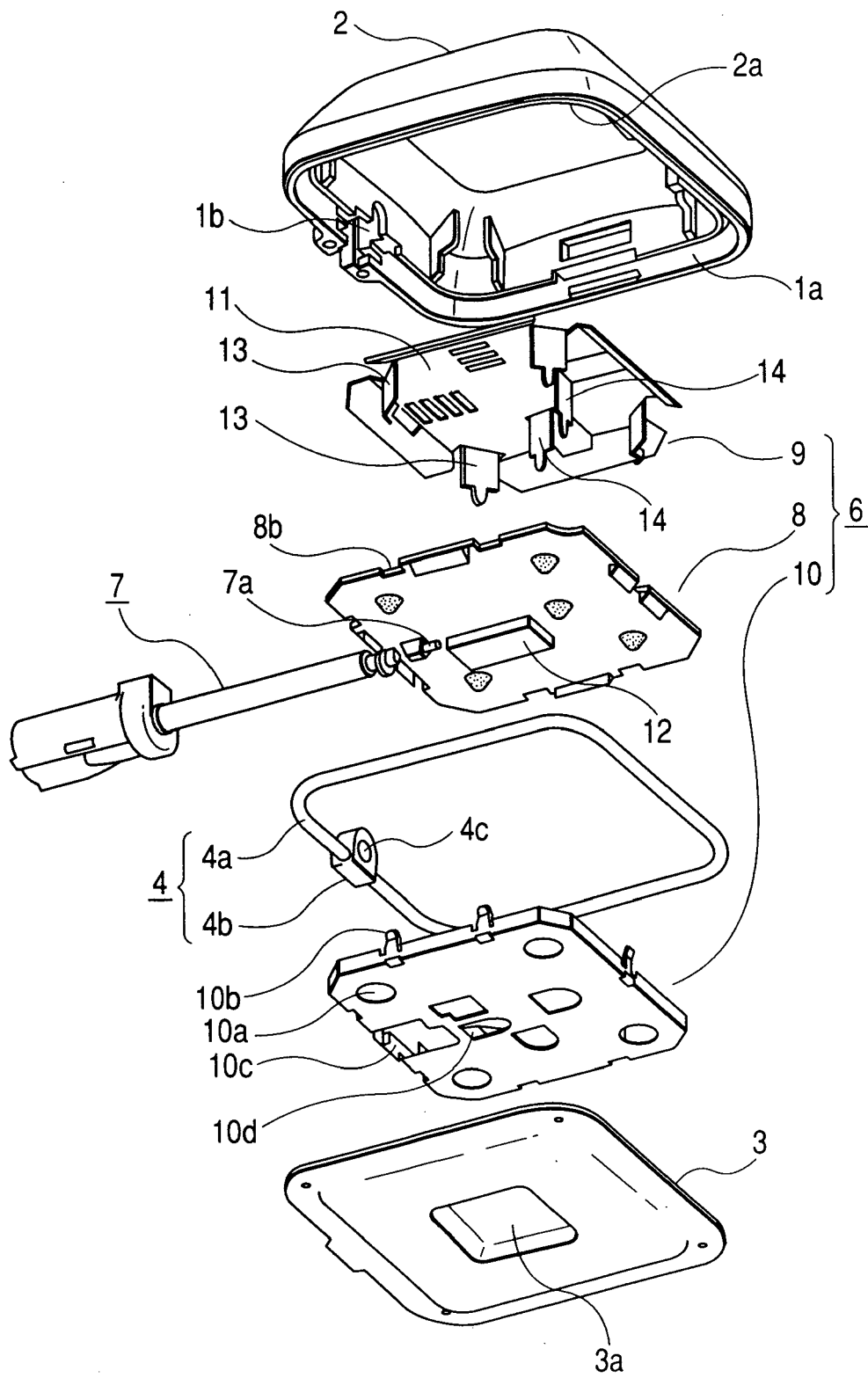


FIG. 3

