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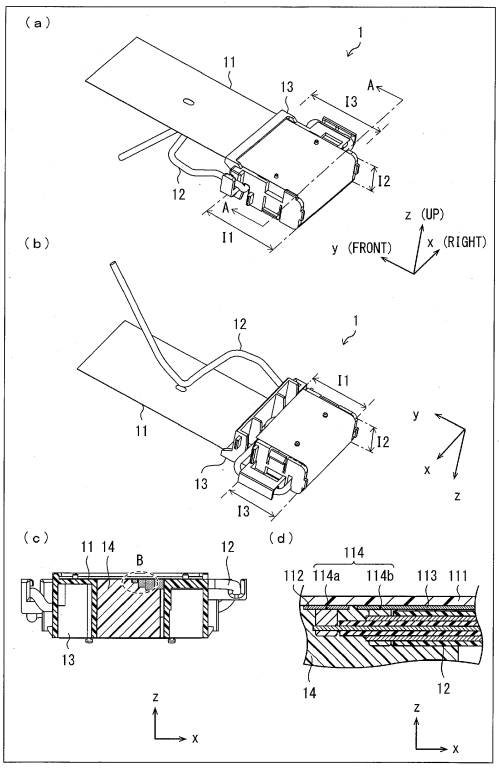
(54) ANTENNA DEVICE AND METHOD FOR MANUFACTURING THE SAME

(57) An antenna device (1) includes: a film antenna (11); a coaxial cable (12); and a support (13). The support (13) has (i) an indentation (13D) provided in a part in which a feed section (114) of the film antenna (11) is arranged, (ii) a holding part for holding the coaxial cable (12), and (iii) a path for drawing a tip part of the coaxial cable (12) into the indentation (13D), and the film antenna (11) is wound around the support (13) so as to surround the indentation (13D).

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an antenna device including a film antenna. The present invention also relates to a method for manufacturing such an antenna device.

Background Art

[0002] Conventionally, in a case where a three-dimensional antenna is formed by use of a flexible film antenna, a three-dimensional structure of an antenna conductor is maintained by attaching/winding the film antenna to/around a highly rigid support. This is because unless the film antenna is attached/wound to/around the highly rigid support, a change in three-dimensional structure of the antenna conductor occurs, and the change results in a change in antenna characteristic.

[0003] Note that a high-frequency current is supplied to/from a film antenna via a cable (e.g., a coaxial cable) that is connected to the film antenna. The film antenna and the cable are normally connected by soldering a hot side conductor and a cold side conductor of the cable (an inner conductor and an outer conductor of the coaxial cable) to respective two feed points provided in an antenna conductor of the film antenna. Thus, in order that the film antenna and the cable are not disconnected from each other even in a case where the cable is pulled, it is important to achieve greater durability (connection reliability) with respect to pulling of the cable.

[0004] Known examples of a technique for achieving greater durability with respect to pulling of the cable include a technique in which by arranging, in a middle of a wiring path for a cable, a holding member providing and holding the cable while bending the cable, a force by which to pull the cable is made difficult to transmit to a connection between an antenna and the cable (see, for example, Patent Literature 1).

Citation List

[Patent Literature]

[0005] [Patent Literature 1]
Specification of European Patent No. 2403327 (Publication Date: January 4, 2012)

Summary of Invention

Technical Problem

[0006] Note, however, that use of two three-dimensional structures, which are (i) a support for maintaining a three-dimensional structure of a flexible film antenna and (ii) a holding member providing and holding a cable while bending the cable, for an antenna device in combination causes a problem of causing the antenna device to have a structure that is more complicated or made larger.

[0007] The present invention has been made in view of the problem, and an object of the present invention is to (i) prevent an antenna device including a flexible film antenna from having a structure that is more complicated or made larger and (ii) allow the antenna device to have a more stable antenna characteristic and greater durability with respect to pulling of a cable.

Solution to Problem

[0008] In order to attain the object, an antenna device in accordance with an aspect of the present invention includes: a film antenna; a cable which has a tip part connected to a feed section of the film antenna; and a support around which the film antenna is wound, the support having (i) an indentation provided in a part in which a connection between the cable and the film antenna is arranged, (ii) a holding part for holding the cable, and (iii) a path for drawing the tip part of the cable into the indentation, and the film antenna being wound around the support so as to surround the indentation.

[0009] In order to attain the object, a method in accordance with an aspect of the present invention for manufacturing an antenna device including: a film antenna; a cable; and a support around which the film antenna is wound and which has a holding part for holding the cable, the support having (i) an indentation provided in a part in which a connection between the cable and the film antenna is arranged and (ii) a path for drawing the tip part of the cable into the indentation, the method includes: a wiring step of causing the holding part to hold the cable and drawing the tip part of the cable into the indentation via the path; a connecting step of, after the wiring step, connecting the tip part of the cable to the feed section which is arranged in the indentation; and a winding step of, after the connecting step, winding the film antenna around the support so as to surround the indentation.

Advantageous Effects of Invention

[0010] The present invention makes it possible to (i) prevent an antenna device including a film antenna from having a structure that is more complicated or made larger and (ii) allow the antenna device to have a more stable antenna characteristic and greater durability with respect to pulling of a cable. Further, according to the present invention, during production of the antenna device, a lighter load can be applied to a connection between the film antenna and the cable, and the connection can have greater connection reliability.

Brief Description of Drawings

[0011]

(a) of Fig. 1 is a perspective view illustrating an upper surface side of an antenna device in accordance with Embodiment 1 of the present invention. (b) of Fig. 1 is a perspective view illustrating a lower surface side of the antenna device. (c) of Fig. 1 is a view along arrows A-A of the antenna device. (d) of Fig. 1 is an enlarged sectional view illustrating a feed section and a vicinity thereof (region B).

Fig. 2 is a development view illustrating a film antenna of the antenna device illustrated in Fig. 1.

(a) of Fig. 3 is a perspective view illustrating an upper surface side of a support of the antenna device illustrated in Fig. 1.(b) of Fig. 3 is a perspective view illustrating a lower surface side of the support.

Fig. 4 is a view along arrows C-C of a right arm part of the support illustrated in Fig. 3.

Fig. 5 is a flowchart of a method for manufacturing the antenna device illustrated in Fig. 1.

Fig. 6 is a perspective view illustrating the antenna device which is being manufactured in accordance with the method shown in Fig. 5.(a) of Fig. 6 illustrates the antenna device which has been subjected to a wiring step. (b) of Fig. 6 illustrates the antenna device which is being subjected to a connecting step. (c) of Fig. 6 illustrates the antenna device which has been subjected to a winding step. (d) of Fig. 6 illustrates the antenna device which has been subjected to an injecting step.

(a) of Fig. 7 is a perspective view illustrating an upper surface side of an antenna device in accordance with Embodiment 2 of the present invention. (b) of Fig. 7 is a perspective view illustrating a lower surface side of the antenna device.

(a) of Fig. 8 is a perspective view illustrating an upper surface side of a support of the antenna device illustrated in Fig. 7.(b) of Fig. 8 is a perspective view illustrating a lower surface side of the support.

Fig. 9 is a view along arrows D-D of a right arm part of the support illustrated in Fig. 8.

Fig. 10 is a flowchart of a method for manufacturing the antenna device illustrated in Fig. 7.

Fig. 11 is a perspective view illustrating the antenna device which is being manufactured in accordance with the method shown in Fig. 10.(a) of Fig. 11 illustrates the antenna device which has been subjected to a wiring step. (b) of Fig. 11 illustrates the antenna device which is being subjected to a connecting step. (c) of Fig. 11 illustrates the antenna device which has been subjected to a first winding step. (d) of Fig. 11 illustrates the antenna device which has been subjected to an injecting step. (e) of Fig. 11 illustrates the antenna device which has been subjected to a second winding step.

Fig. 12 illustrates a method for providing, inside a spoiler, the antenna device illustrated in Fig. 1.

(a) of Fig. 13 is a perspective view illustrating an upper surface side of an antenna device in accordance with Embodiment 3 of the present invention. (b) of Fig. 13 is a perspective view illustrating a lower surface side of the antenna device.

(a) of Fig. 14 is a plan view illustrating a support of the antenna device illustrated in Fig. 13.(b) of Fig. 14 is a bottom view illustrating the support. (c) of Fig. 14 is a rear view illustrating the support.

Fig. 15 is a view along arrows E-E of a right arm part of the support illustrated in Fig. 14.

Fig. 16 shows a modified example of the antenna device in accordance with Embodiment 3. (a) of Fig. 16 is a plan view illustrating a support of the antenna device. (b) of Fig. 16 is a bottom view illustrating the support. (c) of Fig. 16 is a rear view illustrating the support.

Fig. 17 shows a modified example of the antenna device in accordance with Embodiment 3. (a) of Fig. 17 is a plan view illustrating a support of the antenna device. (b) of Fig. 17 is a bottom view illustrating the support. (c) of Fig. 17 is a rear view illustrating the support.

Fig. 18 illustrates a method for providing, inside a spoiler, the antenna device illustrated in Fig. 13.

Description of Embodiments

[Embodiment 1]

(Configuration of antenna device)

[0012] A configuration of an antenna device 1 in accordance with Embodiment 1 of the present invention is described below with reference to Figs. 1 through 6.

[0013] Fig. 1 is a view illustrating the antenna device 1 in accordance with Embodiment 1. (a) of Fig. 1 is a perspective view illustrating an upper surface side of the antenna device 1. (b) of Fig. 1 is a perspective view illustrating a lower surface side of the antenna device 1. (c) of Fig. 1 is a view along arrows A-A of the antenna device 1 illustrated in (a) of Fig. 1.(d) of Fig. 1 is an enlarged sectional view illustrating a feed section and a vicinity thereof (a region B illustrated in (c) of Fig. 1).

[0014] As illustrated in Fig. 1, the antenna device 1 includes a film antenna 11 that is flexible, a coaxial cable 12 connected to the film antenna 11, and a support 13 for supporting the film antenna 11 and holding the coaxial cable 12. Moreover, in the antenna device 1, the film antenna 11 is wound around the support 13 which has outer dimensions of a box shape (i.e., substantially a rectangular parallelepiped shape) and is made of a resin having rigidity so that a three-dimensional structure of the film antenna 11 (antenna conductor) is maintained.

[0015] The antenna device 1 in accordance with Embodiment 1 can be used as, for example, an on-vehicle antenna which is to be incorporated in a resin-made spoiler that is mounted at a rear end of a roof of a vehicle body such as an automobile. In such a case, the antenna device 1 is provided at a rear end of the roof of the vehicle body in a state in which, in Fig. 1, a positive direction of

an x-axis is a rightward direction, a negative direction of the x-axis is a leftward direction, a positive direction of a y-axis is a forward direction, a negative direction of the y-axis is a backward direction, a positive direction of a z-axis is an upward direction, and a negative direction of the z-axis is a downward direction. Note that, in the descriptions below, the positive direction of the x-axis, the negative direction of the x-axis, the positive direction of the y-axis, the negative direction of the y-axis, the positive direction of the z-axis, and the negative direction of the z-axis in the drawings are sometimes expressed as right, left, front, rear, up, and down, respectively.

[0016] Fig. 2 is a development view illustrating the film antenna 11 included in the antenna device 1 illustrated in Fig. 1. As illustrated in Fig. 2, the film antenna 11 is made up of a dielectric film 111 which is flexible and a first antenna conductor 112 and a second antenna conductor 113 which are provided on a surface of the dielectric film 111. The first antenna conductor 112 and the second antenna conductor 113 constitute a dipole antenna in which the first antenna conductor 112 and the second antenna conductor 113 serve as respective antenna elements. Alternatively, the first antenna conductor 112 and the second antenna conductor 113 constitute a monopole antenna in which the first antenna conductor 112 and the second antenna conductor 113 serve as an antenna element and a ground plane, respectively. The film antenna 11 which is flexible is bent along the line V-V and the line W-W in Fig. 2 such that folds come to an inner side and is wound around the support 13. Moreover, the film antenna 11 which is flexible is wound around the support 13 which has a three-dimensional shape such that each of the first antenna conductor 112 and the second antenna conductor 113 has a predetermined three-dimensional structure.

[0017] Specifically, as illustrated in Fig. 1 and Fig. 2, a third section J3 of the film antenna 11 is arranged along a third supporting surface (i.e., section I3 in Fig. 1) of an upper surface of the support 13 so that the second antenna conductor 113 extends from a feed section 114 in the y-axis direction. Moreover, a second section J2 of the film antenna 11 is arranged along a second supporting surface (i.e., section I2 in Fig. 1) which is perpendicular to the third supporting surface, and a first section J1 of the film antenna 11 is arranged along a first supporting surface (i.e., section I1 in Fig. 1) which is perpendicular to the second supporting surface. As such, the first antenna conductor 112 extending from the feed section 114 in the z-axis direction is bent so as to extend in the y-axis direction while facing with the second antenna conductor 113. As such, in the antenna device 1 in accordance with Embodiment 1, the film antenna 11 which is flexible is supported by the support 13 which is rigid so that the three-dimensional structure of the antenna conductor is maintained, and thus an antenna characteristic is stabilized.

[0018] The coaxial cable 12 which is connected to the feed section 114 of the film antenna 11 has at least any of a function to transmit a high-frequency current which has been outputted from the film antenna 11 upon reception and a function to transmit a high-frequency current which is to be inputted to the film antenna 11 for transmission. The coaxial cable 12 is made up of an inner conductor, an insulator covering the inner conductor, an outer conductor covering the insulator, and a jacket covering the outer conductor. A tip part of the coaxial cable 12, from which tip part the jacket has been removed, is connected to the feed section 114 (feed points 114a and 114b) of the film antenna 11 by soldering or the like. Specifically, the inner conductor of the coaxial cable 12 is connected to the feed point 114a of the first antenna conductor 112, and the outer conductor of the coaxial cable 12 is connected to the feed point 114b of the second antenna conductor 113.

[0019] Note that, as illustrated in (b) of Fig. 1, the coaxial cable 12 that is connected to the film antenna 11 is held, in a state of being bent, by a plurality of holding parts provided in the support 13. From this, in the antenna device 1 in accordance with Embodiment 1, even in a case where the coaxial cable 12 is pulled, the pulling force is hardly exerted on a connection between the film antenna 11 and the coaxial cable 12, and it is thus possible to improve durability with respect to pulling of the coaxial cable 12.

[0020] Moreover, as illustrated in (c) of Fig. 1, the antenna device 1 in accordance with Embodiment 1 employs the support 13 which has (i) an indentation 13D in which the connection between the film antenna 11 and the coaxial cable 12 is arranged and (ii) a path for drawing the coaxial cable into the indentation 13D, in order to improve connection reliability of the connection between the film antenna 11 and the coaxial cable 12 by reducing a load on the connection during manufacture of the antenna device 1.

[0021] Moreover, as illustrated in (d) of Fig. 1, the connection between the film antenna 11 1 and the coaxial cable 12 (specifically, the feed section 114 of the film antenna 11, the tip part of the coaxial cable 12, and solder for connecting these) is contained in the indentation 13D of the support 13, and is sealed by a resin 14 that is obtained by curing a fluid resin injected into the indentation 13D. From this, in the antenna device 1 in accordance with Embodiment 1, it is possible to prevent the connection between the film antenna 11 and the coaxial cable 12 from deteriorating due to, for example, moisture.

(Structure of support)

[0022] The following description will discuss a structure of the support 13 included in the antenna device 1, with reference to Fig. 3 and Fig. 4.(a) of Fig. 3 is a perspective view illustrating an upper surface side of the support 13 in which the coaxial cable 12 is provided. (b) of Fig. 3 is a perspective view illustrating a lower surface side of the support 13 in which the coaxial cable 12 is provided. Fig. 4 is a view along arrows C-C of a right arm

part 13R (described later) of the support 13.

[0023] The support 13 is a resin molded product having box-shaped outer dimensions in which the indentation 13D is provided in a middle on a y-axis negative side. The indentation 13D penetrates the support 13 in the up-and-down direction, and thus a shape of the support 13 in a plan view is a U-shape. The feed section 114 of the film antenna 11 which is wound around the support 13 and the tip part of the coaxial cable 12 held by the support 13 are arranged in the indentation 13D. Three sides of the indentation 13D are covered with the film antenna 11 which is wound around the support 13, and thus the indentation 13D is closed.

[0024] Hereinafter, in the support 13, a part located on an x-axis negative side of the indentation 13D is referred to as "left arm part 13L", a part located on an x-axis positive side of the indentation 13D is referred to as "right arm part 13R", and a part located on a y-axis positive side of the indentation 13D is referred to as "main body part 13M". In other words, the support 13 includes (i) the main body part 13M having a rectangular parallelepiped shape and (ii) the left arm part 13L and the right arm part 13R each of which has a rectangular parallelepiped shape and protrudes from the main body part 13M in the negative direction of the y-axis. Further, the indentation 13D is provided between the left arm part 13L and the right arm part 13R which are apart from each other.

[0025] In an upper surface of the right arm part 13R on the y-axis negative side, a recessed groove 13R1 is provided so as to penetrate the right arm part 13R in the x-axis direction (from an outward surface of the support 13 to the indentation 13D) as illustrated in (a) of Fig. 3. The coaxial cable 12 extends from the feed section 114 of the film antenna 11, which feed section 114 is arranged in the indentation 13D, in the positive direction of the x-axis while passing through the recessed groove 13R1 (see Fig. 4). That is, the recessed groove 13R1 serves as a path for drawing out the coaxial cable 12 from the indentation 13D (in other words, for drawing the coaxial cable 12 into the indentation 13D).

[0026] Moreover, a projection part 13R2 which is projecting in the positive direction of the x-axis is provided on the x-axis positive side of the right arm part 13R. In an upper surface of the projection part 13R2, a recessed groove 13R3 is provided which penetrates the projection part 13R2 in the y-axis direction. The coaxial cable 12 drawn out from the recessed groove 13R1 (path) is bent so as to extend in the positive direction of the y-axis, and is fit into the recessed groove 13R3. That is, the recessed groove 13R3 serves as a first holding part for holding the coaxial cable 12.

[0027] Further, in a lower surface of the main body part 13M, a recessed groove 13B is provided which extends in the x-axis direction (see (b) of Fig. 3). The recessed groove 13B has two groove walls 13B1 and 13B2 which extend in the x-axis direction and five standing walls 13B3 through 13B7 which are provided between the groove walls 13B1 and 13B2 and extend in the y-axis direction. Among the five standing walls 13B3 through 13B7, the four standing walls 13B3 through 13B6 are provided with respective slits 13B8 through 13B11 into which the coaxial cable 12 can be pressed and set. By causing the coaxial cable 12 to pass through the recessed groove 13B having the five standing walls 13B3 through 13B7, it is possible to firmly hold the coaxial cable 12 in a meandering state. That is, the recessed groove 13B serves as a second holding part for holding the coaxial cable 12.

[0028] Moreover, in the main body part 13M on the x-axis negative side, a projection part 13T1 projecting in the negative direction of the x-axis is provided. In an upper surface of the projection part 13T1, a recessed groove 13T2 is provided which penetrates the projection part 13T1 in the y-axis direction. The coaxial cable 12 which is held by the recessed groove 13B (second holding part) as above described is bent so as to extend in the positive direction of the y-axis, and is fit into the recessed groove 13T2. That is, the recessed groove 13T2 serves as a third holding part for holding the coaxial cable 12.

[0029] Further, at an end part of the upper surface of the main body part 13M on the y-axis positive side, a guide ring 13G is provided through which the film antenna 11 passes. By the guide ring 13G, the third section J3 of the film antenna 11 is kept contacting with an upper surface (third supporting surface I3) of the support 13.

[0030] As above described, in the support 13 included in the antenna device 1 in accordance with Embodiment 1, (1) the indentation 13D is provided in a part in which the feed section 114 of the film antenna 11 wound around the support 13 is arranged, and (2) the recessed groove 13R1 penetrating the right arm part 13R in the x-axis direction is provided in the upper surface of the right arm part 13R as a path for drawing, into the indentation 13D, the tip part of the coaxial cable 12 which tip part is to be connected to the feed section 114 of the film antenna 11.

[0031] With the arrangement, in the manufacture of the antenna device 1, it is possible to carry out a wiring step of causing the support 13 to hold the coaxial cable 12 and drawing the tip part of the coaxial cable 12 into the indentation 13D via the recessed groove 13R1, and then carry out a connecting step of connecting the tip part of the coaxial cable 12 to the feed section 114 of the film antenna 11 in the indentation 13D. Thus, during arrangement of the cable, a lighter load can be applied to the connection between the film antenna and the cable, and the connection can have greater connection reliability.

[0032] Note that elastic plate pieces 13P1 and 13P2 having respective protrusions 13Q1 and 13Q2 at their ends are provided in respective lateral surfaces of the support 13 on the x-axis positive side and the x-axis negative side, and the elastic plate pieces 13P1 and 13P2 extend in the negative direction of the z-axis. The protrusions 13Q1 and 13Q2 which are provided at the respective ends of the elastic plate pieces 13P1 and 13P2 are used to fix the antenna device 1 to an installation target (e.g., a spoiler of an automobile), as described later.

(Method for manufacturing antenna device)

[0033] The following description will discuss a method for manufacturing the antenna device 1, with reference to Fig. 5 and Fig. 6. Fig. 5 is a flowchart of a method for manufacturing the antenna device 1. Fig. 6 is a perspective view illustrating the antenna device 1 which is being manufactured.

[0034] The antenna device 1 can be manufactured by carrying out steps shown in Fig. 5, that is, a wiring step S11, a connecting step S12, a winding step S13, an injecting step S14, and a curing step S15. Contents of the steps are as follows.

(1) Wiring step S11

[0035] The holding parts (i.e., the recessed groove 13R3, the recessed groove 13B, the recessed groove 13T2) of the support 13 are caused to hold the coaxial cable 12, and the tip part of the coaxial cable 12 is drawn into the indentation 13D via the recessed groove 13R1. As such, the coaxial cable 12 is held by the holding parts in a state of being bent. From this, even in a case where the coaxial cable 12 is pulled in the steps after the wiring step S11, the pulling force is hardly exerted on the connection between the film antenna 11 and the coaxial cable 12, and it is thus possible to reduce a load on the connection, and accordingly connection reliability of the connection can be improved. (a) of Fig. 6 illustrates the antenna device 1 which has been subjected to the wiring step S11.

(2) Connecting step S12

[0036] The support 13, in which the coaxial cable 12 is provided in the wiring step S11, is placed on the film antenna 11 in a state in which the upper surface (third supporting surface I3) of the support 13 faces in the downward direction. In this case, the third section J3 of the film antenna 11 is brought into contact with the third supporting surface I3 of the support 13, and the feed section 114 of the film antenna 11 is arranged in the indentation 13D of the support 13. Further, the tip part of the coaxial cable 12 which has been drawn into the indentation 13D of the support 13 is connected (by soldering in Embodiment 1) to the feed section 114 of the film antenna 11. (b) of Fig. 6 illustrates the antenna device 1 which is being subjected to the connecting step S12. Such connecting work can be carried out because the indentation 13D is provided in the support 13.

(3) Winding step S13

[0037] The film antenna 11 which has been connected to the coaxial cable 12 in the connecting step S12 is wound around the support 13 in which the coaxial cable 12 has been provided in the wiring step S11. In this case, the film antenna 11 is bent along the support 13, the second section J2 of the film antenna 11 is brought into contact with the second supporting surface I2 of the support 13, the film antenna 11 is further bent along the support 13, and the first section J1 of the film antenna 11 is brought into contact with the first supporting surface I1 of the support 13. As such, three sides (in the positive direction of the z-axis, the negative direction of the y-axis, and the negative direction of the z-axis) of the indentation 13D are covered with the film antenna 11 and are thus closed. (c) of Fig. 6 illustrates the antenna device 1 which has been subjected to the winding step S13.

(4) Injecting step S14

[0038] The antenna device 1 is arranged such that the recessed groove 13R1 is arranged above the indentation 13D, and a fluid resin is injected into the indentation 13D through the recessed groove 13R1. The fluid resin is injected until the connection between the film antenna 11 1 and the coaxial cable 12 is embedded in the fluid resin. (d) of Fig. 6 illustrates the antenna device 1 which is being subjected to the injecting step S14.

(5) Curing step S15

[0039] The antenna device 1 is allowed to stand and the fluid resin which has been injected into the indentation 13D in the injecting step S14 is cured. For example, in a case where the fluid resin injected into the indentation 13D in the injecting step S14 is a thermoplastic resin, the fluid resin is cooled (e.g., by natural cooling).

[0040] Note that, by reducing a space in the indentation 13D by putting stuffing (such as electrically insulating solid substance) into the indentation 13D, it is possible to reduce an amount of a resin which needs to be injected in the injecting step S14. This makes it possible to provide the antenna device 1 which is lower in cost and lighter in weight.

[Embodiment 2]

(Configuration of antenna device)

[0041] A configuration of an antenna device 2 in accordance with Embodiment 2 of the present invention is described below with reference to Figs. 7 through 11.

[0042] As with Embodiment 1, in a case where the antenna device 2 in accordance with Embodiment 2 is used as an on-vehicle antenna that is incorporated in a spoiler, the antenna device 2 is provided at a rear end of a roof of a vehicle body in a state in which, in the drawings, a positive direction of an x-axis is a rightward direction, a negative direction of the x-axis is a leftward direction, a positive direction of a y-axis is a forward direction, a negative direction of the y-axis is a backward direction, a positive direction of a z-axis is an upward direction, and a negative direction of the z-axis is a downward direction. Note that, in the descriptions below, the positive direction

of the x-axis, the negative direction of the x-axis, the positive direction of the y-axis, the negative direction of the y-axis, the positive direction of the z-axis, and the negative direction of the z-axis in the drawings are sometimes expressed as right, left, front, rear, up, and down, respectively.

[0043] Fig. 7 is a view illustrating the antenna device 2 in accordance with Embodiment 2. (a) of Fig. 7 is a perspective view illustrating an upper surface side of the antenna device 2. (b) of Fig. 7 is a perspective view illustrating a lower surface side of the antenna device 2.

[0044] As illustrated in Fig. 7, the antenna device 2 includes a film antenna 21, a coaxial cable 22, and a support 23. Functions and structures of the film antenna 21 and the coaxial cable 22 included in the antenna device 2 are similar to those of the film antenna 11 and the coaxial cable 12 included in the antenna device 1 in accordance with Embodiment 1. Therefore, the functions and the structures of the film antenna 21 and the coaxial cable 22 which are included in the antenna device 2 are not described here.

[0045] The support 23 included in the antenna device 2 has functions to maintain a three-dimensional structure of the film antenna 21 and to hold the coaxial cable 22, as with the support 13 which is included in the antenna device 1 in accordance with Embodiment 1. In Embodiment 2 also, a resin molded product is used as the support 23.

[0046] In the antenna device 2 in accordance with Embodiment 2, the film antenna 21 is wound around the support 23, as with in the antenna device 1 in accordance with Embodiment 1. Therefore, an antenna characteristic of the antenna device 2 is highly stable. Moreover, in the antenna device 2 in accordance with Embodiment 2, the coaxial cable 22 is held by the support 23, as with in the antenna device 1 in accordance with Embodiment 1. Therefore, the antenna device 2 can achieve high durability with respect to pulling of the coaxial cable 22.

(Structure of support)

[0047] The following description will discuss a structure of the support 23 included in the antenna device 2, with reference to Fig. 8 and Fig. 9.(a) of Fig. 8 is a perspective view illustrating an upper surface side of the support 23 in which the coaxial cable 22 is provided. (b) of Fig. 8 is a perspective view illustrating a lower surface side of the support 23 in which the coaxial cable 22 is provided. Fig. 9 is a view along arrows D-D of a right arm part 23R (described later) of the support 23.

[0048] The support 23 is a resin molded product having box-shaped outer dimensions in which the indentation 23D is provided in a middle on a y-axis negative side. The support 23 is made up of a main body part 23M, a left arm part 23L, and a right arm part 23R. Structures of the main body part 23M and the left arm part 23L constituting the support 23 are similar to those of the main body part 13M and the left arm part 13L, respectively, which constitute the support 13 in accordance with Embodiment 1. Therefore, the structures of the main body part 23M and the left arm part 23L constituting the support 23 are not described here.

[0049] In the right arm part 23R, a through hole 23R1 is provided so as to penetrate the right arm part 23R in the x-axis direction (from an outward surface of the support 23 to the indentation 23D). The coaxial cable 22 extends from a feed section of the film antenna 21, which feed section is arranged in the indentation 23D, in the positive direction of the x-axis while passing through the through hole 23R1. That is, the through hole 23R1 serves as a path for drawing out the coaxial cable 22 from the indentation 23D (in other words, for drawing the coaxial cable 22 into the indentation 23D).

[0050] In a case where the support 23 is arranged in a state in which an upper surface (third supporting surface I) of the support 23 faces in the downward direction, a part of the right arm part 23R which part is located in a bottom surface of the through hole 23R1 constitutes a blocking wall 23R4 which inclines such that a height on an outer side (x-axis positive side) is greater than a height on an inner side (x-axis negative side) (see Fig. 9). The height of the blocking wall 23R4 (i.e., a height of an end part on the x-axis positive side) is set to be greater than a height of the connection between the film antenna 21 and the coaxial cable 22 (i.e., the feed section of the film antenna 21, the tip part of the coaxial cable 22, and solder for connecting these). The blocking wall 23R4 blocks a resin injected into the indentation 23D during manufacture of the antenna device 2.

[0051] Moreover, a projection part 23R2 which is projecting in the positive direction of the x-axis is provided on the x-axis positive side of the right arm part 23R. In an upper surface of the projection part 23R2, a recessed groove 23R3 is provided which penetrates the projection part 23R2 in the y-axis direction. The coaxial cable 22 drawn out from the through hole 23R1 in the positive direction of the x-axis is bent so as to extend in the positive direction of the y-axis, and is fit into the recessed groove 23R3. That is, the recessed groove 23R3 serves as a first holding part for holding the coaxial cable 22.

[0052] In the support 23 included in the antenna device 2 in accordance with Embodiment 2 also, (1) the indentation 23D is provided in a part in which the feed section of the film antenna 21 wound around the support 23 is arranged, and (2) the through hole 23R1 penetrating the right arm part 23R in the x-axis direction is provided in the right arm part 23R as a path for drawing, into the indentation 23D, the tip part of the coaxial cable 22 which tip part is to be connected to the feed section of the film antenna 21, as with the support 13 included in the antenna device 1 in accordance with Embodiment 1.

[0053] With the arrangement, in the manufacture of the antenna device 2, it is possible to carry out a wiring step of causing the support 23 to hold the coaxial cable 22 and drawing the tip part of the coaxial cable 22 into the indentation 23D via the through hole 23R1, and then carry

out a connecting step of connecting the tip part of the coaxial cable 22 to the feed section of the film antenna 21 in the indentation 23D. Thus, during arrangement of the cable, a lighter load can be applied to the connection between the film antenna and the cable, and the connection can have greater connection reliability.

[0054] Here, as a path for drawing out the coaxial cable 22 from the indentation 23D, the through hole 23R1 which is provided in the right arm part 23R so as to penetrate the right arm part 23R in the x-axis direction is used. Note, however, that Embodiment 2 is not limited to this. That is, as the path for drawing out the coaxial cable 22 from the indentation 23D, it is possible to use a recessed groove which is provided in a lower surface of the right arm part 23R so as to penetrate the right arm part 23R in the x-axis direction. With the configuration, it is possible to more easily carry out the above described wiring step.

(Method for manufacturing antenna device)

[0055] The following description will discuss a method for manufacturing the antenna device 2, with reference to Fig. 10 and Fig. 11. Fig. 10 is a flowchart of a method for manufacturing the antenna device 2. Fig. 11 is a perspective view illustrating the antenna device 2 which is being manufactured.

[0056] The antenna device 2 can be manufactured by carrying out steps shown in Fig. 10, that is, a wiring step S21, a connecting step S22, a first winding step S23, an injecting step S24, a curing step S25, and a second winding step S26. Contents of the steps are as follows.

(1) Wiring step S21

[0057] The holding parts of the support 23 are caused to hold the coaxial cable 22, and the tip part of the coaxial cable 22 is drawn into the indentation 23D via the through hole 23R1. As such, the coaxial cable 22 is held by the holding parts in a state of being bent. From this, even in a case where the coaxial cable 22 is pulled in the steps after the wiring step S21, the pulling force is hardly exerted on the connection between the film antenna 21 and the coaxial cable 22, and it is thus possible to reduce a load on the connection, and accordingly connection reliability of the connection can be improved. (a) of Fig. 11 illustrates the antenna device 2 which has been subjected to the wiring step S21.

(2) Connecting step S22

[0058] The support 23, in which the coaxial cable 22 is provided in the wiring step S21, is placed on the film antenna 21 in a state in which the upper surface (third supporting surface I3) of the support 23 faces in the downward direction. In this case, the third section J3 of the film antenna 21 is brought into contact with the upper surface (third supporting surface I3) of the support 23, and the feed section of the film antenna 21 is arranged in the indentation 23D of the support 23. Further, the tip part of the coaxial cable 22 which has been drawn into the indentation 23D of the support 23 is connected (by soldering in Embodiment 2) to the feed section of the film antenna 21. (b) of Fig. 11 illustrates the antenna device 2 which is being subjected to the connecting step S22. Such connecting work can be carried out because the indentation 23D is provided in the support 23.

(3) First winding step S23

[0059] A part of the film antenna 21 is wound around the support 23. In this case, the film antenna 21 is bent along the support 23, and the second section J2 of the film antenna 21 is brought into contact with the second supporting surface I2 of the support 23. From this, two of three sides of the indentation 23D is surrounded by the film antenna 21. (c) of Fig. 11 illustrates the antenna device 2 which has been subjected to the first winding step S23. At this stage, one of the three sides of the indentation 23D (on a first supporting surface I1 side facing in the upward direction) is opened.

(4) Injecting step S24

[0060] A fluid resin is injected into the indentation 23D from above while the antenna device 2 is arranged such that the upper surface (third supporting surface I3) of the support 23 faces in the downward direction. The fluid resin is injected until the connection between the film antenna 21 and the coaxial cable 22 is embedded in the fluid resin. At this stage, one of the three sides (on the first supporting surface I1 side facing in the upward direction) of the indentation 23D is not covered with the film antenna 21, and it is therefore possible to easily confirm visually whether or not the connection between the film antenna 21 and the coaxial cable 22 is embedded in the fluid resin. In this case, the through hole 23R1 is located lateral to the indentation 23D and is communicated with the indentation 23D. However, the fluid resin is blocked by the blocking wall 23R4 that is provided in the through hole 23R1, and therefore the fluid resin will not leak from the through hole 23R1. (d) of Fig. 11 illustrates the antenna device 2 which is being subjected to the injecting step S24.

(5) Curing step S25

[0061] The antenna device 2 is allowed to stand and the fluid resin which has been injected into the indentation 23D in the injecting step S24 is cured. For example, in a case where the fluid resin injected into the indentation 23D in the injecting step S24 is a thermoplastic resin, the fluid resin is cooled (e.g., by natural cooling). Alternatively, in a case where the fluid resin injected into the indentation 23D in the injecting step S24 is a photocurable resin (e.g., ultraviolet curing resin), the fluid resin is irradiated with light (e.g., irradiated with an ultraviolet ray).

(6) Second winding step S26

[0062] A rest of the film antenna 21 is wound around the support 23. In this case, the film antenna 21 is bent along the support 23, and the first section J1 of the film antenna 21 is brought into contact with the first supporting surface I1 of the support 23. From this, the three sides of the indentation 23D are surrounded by the film antenna 21, and the indentation 23D is closed. (e) of Fig. 11 illustrates the antenna device 2 which has been subjected to the second winding step S26.

[0063] Note that, by reducing a space in the indentation 23D by putting stuffing (such as electrically insulating solid substance) into the indentation 23D, it is possible to reduce an amount of a resin which needs to be injected in the injecting step S24. This makes it possible to provide the antenna device 2 which is lower in cost and lighter in weight.

[Method for providing each of antenna devices in Embodiments 1 and 2 inside spoiler]

[0064] The following description will discuss a method for providing, inside a spoiler 5, the antenna device 1 in accordance with Embodiment 1, with reference to Fig. 12.

[0065] A spoiler 5 in which the antenna device 1 is to be incorporated has an opening 51 a which is provided in an upper surface of a housing 51 so that the antenna device 1 can be provided inside the housing 51 (see Fig. 12). Note that, in Fig. 12, shapes of the antenna device 1 and the spoiler 5 are schematically drawn in order to simply illustrate the method for providing the antenna device 1 inside the spoiler 5.

[0066] The spoiler 5 in accordance with Embodiment 1 includes (i) the housing 51 having an opening provided in the upper surface and (ii) a lid 52 for closing the opening 51a of the housing 51 (see (a) of Fig. 12). The housing 51 has (i) a first containing space 511 which is arranged in a part protruding from a rear end of a roof of a vehicle body in the backward direction in a case where the spoiler 5 is mounted at the rear end of the roof and (ii) a second containing space 512 which is arranged along the roof. The first containing space 511 and the second containing space 512 are communicated with each other, and the first containing space 511 has a space for containing the support 13. Moreover, the first containing space 511 is provided with two supporting plates 513 and 514 for supporting the support 13 of the antenna device 1.

[0067] In Embodiment 1, as illustrated in (b) of Fig. 12, the antenna device 1 is inserted into the housing 51 via the opening 51 a provided in the upper surface of the housing 51, and the protrusions 13Q1 and 13Q2 provided in the support 13 of the antenna device 1 are engaged with respective engagement holes provided in the respective supporting plates 513 and 514, so that the antenna device 1 is fixed to the supporting plates 513 and 514. Then, as illustrated in (c) of Fig. 12, the opening 51a of the housing 51 is closed with the lid 52, and thus the spoiler 5 in which the antenna device 1 is incorporated is provided. In this manner, the antenna device 1 is attached to the spoiler 5 in a state in which the support 13 is contained in the first containing space 511 and the film antenna 11 wound around the support 13 partially extends in the second containing space 512. Note that the coaxial cable 12 connected to the film antenna 11 is drawn out to an outside of the housing 51 via a through hole (not illustrated) provided in the housing 51.

[0068] Note that the antenna device 2 in accordance with Embodiment 2 can be provided inside the spoiler 5 by a method identical with the method for providing the antenna device 1 in accordance with Embodiment 1 inside the spoiler 5.

[Embodiment 3]

(Configuration of antenna device)

[0069] A configuration of an antenna device 3 in accordance with Embodiment 3 of the present invention is described below with reference to Fig. 13. Fig. 13 is a perspective view illustrating the antenna device 3.

[0070] As illustrated in Fig. 13, the antenna device 3 includes a film antenna 31, a coaxial cable 32, and a support 33. Functions and structures of the film antenna 31 and the coaxial cable 32 included in the antenna device 3 are similar to those of the film antenna 11 and the coaxial cable 12 included in the antenna device 1 in accordance with Embodiment 1. Therefore, the functions and the structures of the film antenna 31 and the coaxial cable 32 which are included in the antenna device 3 are not described here.

[0071] The support 33 included in the antenna device 3 has functions to maintain a three-dimensional structure of the film antenna 31 and to hold the coaxial cable 32, as with the support 13 which is included in the antenna device 1 in accordance with Embodiment 1. In Embodiment 3 also, a resin molded product is used as the support 33.

[0072] In the antenna device 3 in accordance with Embodiment 3, the film antenna 31 is wound around the support 33, as with in the antenna device 1 in accordance with Embodiment 1. Therefore, an antenna characteristic of the antenna device 3 is highly stable. Moreover, in the antenna device 3 in accordance with Embodiment 3, the coaxial cable 32 is held by the support 33, as with in the antenna device 1 in accordance with Embodiment 1. Therefore, the antenna device 3 can achieve high durability with respect to pulling of the coaxial cable 32.

(Structure of support)

[0073] The following description will discuss a structure of the support 33 included in the antenna device 3, with reference to Fig. 14 and Fig. 15.(a) of Fig. 14 is a plan view illustrating the support 33 in which the coaxial cable 32 is provided. (b) of Fig. 14 is a bottom view illus-

trating the support 33 in which the coaxial cable 32 is provided. (c) of Fig. 14 is a rear view illustrating the support 33 in which the coaxial cable 32 is provided. Fig. 15 is a view along arrows E-E of a right arm part 33R (described later) of the support 33.

[0074] The support 33 included in the antenna device 3 in accordance with Embodiment 3 is a resin molded product in which an indentation 33D is provided in a middle on a y-axis negative side. The support 33 is made up of a main body part 33M, a left arm part 33L, a right arm part 33R, and a supporting plate 33S. The main body part 33M, the left arm part 33L, and the right arm part 33R correspond to the main body part 13M, the left arm part 13L, and the right arm part 13R, respectively, which are of the support 13 included in the antenna device 1 in accordance with Embodiment 1. Note, however, that the main body part 33M, the left arm part 33L, and the right arm part 33R are modified in shapes in accordance with a difference of a wiring path of the coaxial cable 32.

[0075] The supporting plate 33S is a plate-like member which extends from the main body part 33M in the positive direction of the y-axis in a plane in which a third supporting surface lies. As such, the supporting plate 33S is unique to Embodiment 3 and is not provided in the support 13 included in the antenna device 1 in accordance with Embodiment 1. In a case where the film antenna 31 is wound around the support 33, a second antenna conductor 313 of the film antenna 31 is arranged along an upper surface (i.e., the third supporting surface I3 and the supporting plate 33S) of the support 33, and a feed section of the film antenna 31 is arranged in the indentation 33D.

[0076] Note that the film antenna 31 is attached to the support 33 with double-sided adhesive tapes 34 through 36. In Fig. 14, outer dimensions of each of the double-sided adhesive tapes 34 through 36 are indicated by dotted lines. As illustrated in (a) of Fig. 14, in a vicinity of a tip part of the coaxial cable 32 which tip part is arranged in the indentation 33D, an opening 351 is provided in the double-sided adhesive tape 35 so that electrically conductive connection between the coaxial cable 32 and the feed section of the film antenna 31 is not disturbed.

[0077] Further, in Embodiment 3, a recessed groove 33R1 is provided in a lower surface of the right arm part 33R of the support 33 so as to hold the coaxial cable 32 which is in a state of being bent. The recessed groove 33R1 holds the coaxial cable 32 which (i) extends from the indentation 33D in the positive direction of the x-axis and (ii) is then bent in the positive direction of the y-axis. That is, the recessed groove 33R1 serves as a path for drawing the tip part of the coaxial cable 32 into the indentation 33D and also as a first holding part for holding the coaxial cable 32.

[0078] In a case where the support 23 is arranged in a state in which an upper surface (i.e., the third supporting surface I3) of the support 23 faces in the downward direction, as illustrated in Fig. 15, a part of the right arm part 33R which part is to be located in the bottom surface of the recessed groove 33R1 constitutes an inclined part 33R3 which is inclined such that a height on an outer side (i.e., the x-axis positive side) becomes greater than a height on an inner side (i.e., the x-axis negative side). The inclined part 33R3 functions to arrange the coaxial cable 32 so that the tip part of the coaxial cable 32 is inclined with respect to the film antenna 31. Therefore, it is possible to connect an inner conductor and an outer conductor of the coaxial cable 32 respectively to two feed points of the film antenna 31.

[0079] Moreover, a blocking wall 33R2 whose height is greater than that of a connection between the film antenna 31 and the coaxial cable 32 is provided in the recessed groove 33R1 between the connection and the main body part 33M. Therefore, in a case where the antenna device 3 is manufactured by a method similar to the manufacturing method for the antenna device 2 in accordance with Embodiment 2, a resin which has been injected into the indentation 33D so as to embed the connection between the film antenna 31 and the coaxial cable 32 is blocked by the blocking wall 33R2 and accordingly will not flow into the main body part 33M.

[0080] Further, a recessed groove 33B which penetrates in the x-axis direction is provided in the lower surface of the main body part 33M (see (b) of Fig. 14). The recessed groove 33B is provided with two groove walls 33B1 and 33B2 which extend in the x-axis direction and a plurality of standing walls 33B5 through 33B7 which are provided between the two groove walls 33B1 and 33B2 and extend in the y-axis direction. The groove wall 33B1 is provided with a notch 33B3 for drawing the coaxial cable 32, which extends from the first holding part, into the recessed groove 33B. The groove wall 33B2 is provided with a notch 33B4 for drawing the coaxial cable 32, which is provided in the recessed groove 33B, out in the positive direction of the y-axis. The three standing walls 33B5 through 33B7 have respective slits 33B8 through 33B10 into which the coaxial cable 12 can be pressed and set. By providing the coaxial cable 32 in the recessed groove 33B having the three standing walls 33B5 through 33B7, it is possible to firmly hold the coaxial cable 32. That is, the recessed groove 33B serves as a second holding part for holding the coaxial cable 32. Note that, instead of providing the notch 33B4 in the groove wall 33B2 and uses the notch 33B4 as a path for drawing the coaxial cable 32 to an outside of the recessed groove 33B, it is possible to provide a through hole in a center of the groove wall 33B2 and use the through hole as a path for drawing the coaxial cable 32 to an outside of the recessed groove 33B.

[0081] Further, in a vicinity of the notch 33B4 of the groove wall 33B2, a projection part 33B12 and an L-shaped hook 33B13 are provided. The coaxial cable 32 which has been drawn out through the notch 33B4 to the outside of the recessed groove 33B is drawn out in the positive direction of the y-axis in a state of being fit between the projection part 33B12 and the L-shaped hook 33B13 so that variation in positions of the coaxial cable 32 in the z-axis direction is restricted. That is, the projec-

tion part 33B12 and the L-shaped hook 33B13 serve as a third holding part for holding the coaxial cable 32.

[0082] The main body part 33M is provided with elastic pieces 33P1 and 33P2 which extend from respective right and left lateral surfaces in the positive direction of a y-axis, and protrusions 33Q1 and 33Q2 are provided at respective ends of the elastic pieces 33P1 and 33P2. Further, in an end region of the supporting plate 33S, expanded sections 33S1 and 33S2 which project in the respective leftward and rightward (width) directions are provided. The protrusions 33Q1 and 33Q2 which are provided at the respective ends of the elastic pieces 33P1 and 33P2 and the expanded sections 33S1 and 33S2 in the end region of the supporting plate 33S are used to fix the antenna device 3 to an installation target (e.g., a spoiler of an automobile), as described later.

(Modified example)

[0083] The following description will discuss a modified example of the antenna device 3 in accordance with Embodiment 3, with reference to Fig. 16 and Fig. 17.

[0084] Fig. 16 is a view illustrating Modified Example 1 of the antenna device 3. (a) of Fig. 16 is a plan view illustrating the support 33 included in the antenna device 3 in accordance with Modified Example 1. (b) of Fig. 16 is a bottom view illustrating the support 33. (c) of Fig. 16 is a rear view illustrating the support 33.

[0085] The antenna device 3 in accordance with Modified Example 1 is different from the above described antenna device 3 in that a beam 33F1 is provided at an end part of the support 33 on the y-axis negative side so as to connect the right arm part 33R with the left arm part 33L. With the configuration, after the winding step of winding the film antenna 31 around the support 33 is carried out, it is possible to more stably maintain a shape of the film antenna 31 which is wound around the support 33.

[0086] Fig. 17 is a view illustrating Modified Example 2 of the antenna device 3. (a) of Fig. 17 is a plan view illustrating the support 33 of the antenna device 3 in accordance with Modified Example 2. (b) of Fig. 17 is a bottom view illustrating the support 33. (c) of Fig. 17 is a rear view illustrating the support 33.

[0087] The antenna device 3 in accordance with Modified Example 2 is different from the above described antenna device 3 in that a configuration is employed in which the coaxial cable 32 is drawn out from the indentation 33D via a recessed groove 33R4 which is provided on an upper surface side of the right arm part 33R, instead of the configuration in which the coaxial cable 32 is drawn out from the indentation 33D via the recessed groove 33R1 which is provided on a lower surface side of the right arm part 33R. At a rear end of the right arm part 33R, a through hole 33R5 penetrating the right arm part 33R in the up-and-down direction is provided, and the coaxial cable 32 which has passed through the recessed groove 33R4 is drawn out to the lower surface side of the right arm part 33R via the through hole 33R5. The recessed groove 33R4 serves as a path for drawing out the tip part of the coaxial cable 32 from the indentation 33D, and also as a first holding part for holding the coaxial cable 32. With the arrangement, the coaxial cable 32 which is arranged in the recessed groove 33R4 on the upper surface side of the right arm part 33R and in the recessed groove 33B on the lower surface side of the main body part 33M is thus three-dimensionally held by the support 33, and therefore durability with respect to pulling of the coaxial cable 32 is further improved.

[Method for providing antenna device in Embodiment 3 inside spoiler]

[0088] The following description will discuss a method for providing, inside a spoiler 6, the antenna device 3 in accordance with Embodiment 3, with reference to Fig. 18.

[0089] A spoiler 6 in which the antenna device 3 is to be incorporated has an opening 61 a which is provided in a lateral surface (i.e., a lateral surface in the forward direction) of a housing 61 so that the antenna device 3 can be provided inside the housing 61 (see Fig. 18). Note that, in Fig. 18, shapes of the antenna device 3 and the spoiler 6 are schematically drawn in order to simply illustrate the method for providing the antenna device 3 inside the spoiler 6.

[0090] As illustrated in (a) of Fig. 18, the spoiler 6 in accordance with Embodiment 3 includes (i) a housing 61 which is arranged at a part protruding from a rear end of a roof of a vehicle body in the backward direction in a case where the spoiler 6 is mounted at the rear end of the roof and (ii) a top board 62 which is arranged along the roof. The housing 61 has therein a space for containing the support 33 of the antenna device 3. In the lateral surface (i.e., a lateral surface in the forward direction) of the housing 61, an opening 61a is provided through which the support 33 of the antenna device 3 is to be inserted. The top board 62 is provided with L-shaped protrusions 621 and 622 for holding the supporting plate 33S of the antenna device 3.

[0091] In Embodiment 3, as illustrated in (b) of Fig. 18, the antenna device 3 is arranged along the top board 62 such that the expanded sections 33S1 and 33S2 projecting in the respective leftward and rightward (width) directions in the end region of the supporting plate 33S of the antenna device 3 are supported by the respective L-shaped protrusions 621 and 622 of the top board 62 of the spoiler 6, and then the antenna device 3 is slid along the top board 62 such that the support 33 of the antenna device 3 is inserted into the housing 61 of the spoiler 6 via the opening 61a. In this case, the elastic pieces 33P1 and 33P2 extending from the support 33 of the antenna device 3 is warped to the inner side so that the protrusions 33Q1 and 33Q2 at the respective ends of the elastic pieces 33P1 and 33P2 enter the housing 61, and the protrusions 33Q1 and 33Q2 are engaged with a surrounding wall of the opening 61a. With the arrangement, the sup-

port 33 of the antenna device 3 is fixed inside the housing 61, and it is therefore possible to prevent the antenna device 3 from accidentally falling off from the spoiler 6.

[0092] Note that the support 33 can be taken out from the inside of the housing 61 by warping the elastic pieces 33P1 and 33P2 to the inner side so as to disengage the protrusions 33Q1 and 33Q2 from the surrounding wall of the opening 61a. As such, the antenna device 3 can be detached from the spoiler 6.

<<Conclusion>>

[0093] In order to attain the object, an antenna device in accordance with an embodiment of the present invention includes: a film antenna; a cable which has a tip part connected to a feed section of the film antenna; and a support around which the film antenna is wound, the support having (i) an indentation provided in a part in which a connection between the cable and the film antenna is arranged, (ii) a holding part for holding the cable, and (iii) a path for drawing the tip part of the cable into the indentation, and the film antenna being wound around the support so as to surround the indentation.

[0094] With the configuration, since the film antenna is wound around the support, it is possible to maintain a three-dimensional structure of an antenna conductor of the film antenna. This makes it possible to stabilize a characteristic of the film antenna. Further, with the configuration, since the cable is held by the support, it is possible to increase durability with respect to pulling of the cable.

[0095] In addition, with the configuration, since the support has the indentation and the path, a connecting step of connecting the tip part of the cable to the feed section of the film antenna can be carried out after a wiring step of causing the holding part to hold the cable and drawing the tip part of the cable into the indentation is carried out. Thus, during arrangement of the cable, a lighter load can be applied to the connection between the film antenna and the cable, and the connection can have greater connection reliability.

[0096] The antenna device in accordance with an embodiment of the present invention may be configured such that the connection between the cable and the film antenna is covered with a resin obtained by curing a fluid resin injected into the indentation.

[0097] With the configuration, since the connection between the cable and the film antenna is sealed with the resin, it is possible to prevent the connection from deteriorating due to, for example, moisture.

[0098] The antenna device in accordance with an embodiment of the present invention may be configured such that the path is a recessed groove that extends from an outward surface of the support to the indentation.

[0099] With the configuration, it is possible to easily arrange the tip part of the cable in the indentation.

[0100] The antenna device in accordance with an embodiment of the present invention may be configured such that the path is provided with a blocking wall that lies between (a) the cable which passes through the path and (b) the film antenna which is wound around the support.

[0101] With the configuration, while the connection between the film antenna and the cable is being covered with a resin by injecting the fluid resin into the indentation, the fluid resin injected into the indentation is blocked by the blocking wall, and thus the fluid resin supplied to the indentation can be prevented from leaking out of the path.

[0102] In order to attain the object, a method in accordance with an embodiment of the present invention for manufacturing an antenna device including: a film antenna; a cable; and a support around which the film antenna is wound and which has a holding part for holding the cable, the support having (i) an indentation provided in a part in which a connection between the cable and the film antenna is arranged and (ii) a path for drawing the tip part of the cable into the indentation, the method includes: a wiring step of causing the holding part to hold the cable and drawing the tip part of the cable into the indentation via the path; a connecting step of, after the wiring step, connecting the tip part of the cable to the feed section which is arranged in the indentation; and a winding step of, after the connecting step, winding the film antenna around the support so as to surround the indentation.

[0103] With the method, the wiring step is carried out before the connecting step. Thus, during arrangement of the cable, a lighter load can be applied to the connection between the film antenna and the cable, and the connection can have greater connection reliability.

[0104] The method in accordance with an embodiment of the present invention may be configured such that: the method uses, as the support, a support whose path is a recessed groove that extends from an outward surface of the support to the indentation, the method further including: an injecting step of, after the winding step, injecting a fluid resin into the indentation via the path in a state in which the path is arranged so as to be upper than the indentation; and a step of, after the injecting step, curing the fluid resin.

[0105] With the method, it is possible to easily carry out the wiring step of drawing the tip part of the cable into the indentation via the path.

[0106] The method in accordance with an embodiment of the present invention may be configured such that: the method uses, as the support, a support whose path is provided with a blocking wall that lies between (a) the cable which passes through the path and (b) the film antenna which is wound around the support; and the winding step includes: a first winding step of bending the film antenna along the support and surrounding two of three sides of the indentation; and a second winding step of further bending the film antenna along the support and surrounding all the three sides of the indentation, the first winding step and the second winding step each being carried out in a state in which the connection between

the cable and the film antenna is arranged in the indentation, the method further including: an injecting step of injecting a fluid resin into the indentation; and a curing step of curing the fluid resin, the injecting step and the curing step each being carried out between the first winding step and the second winding step in a state in which the connection is arranged in a lower part of the indentation.

[0107] With the method, since the upper part of the indentation is opened while the injecting step is being carried out, it is possible to easily inject the fluid resin into the indentation during the injecting step. In this case, the fluid resin injected into the indentation is blocked by the blocking wall, and thus the fluid resin does not leak out of the path.

[0108] Further, with the method, since the upper part of the indentation is opened while the injecting step is being carried out, it is possible, during the injecting step, to inject the fluid resin into the indentation while visually confirming whether the connection between the cable and the film antenna has been embedded in the fluid resin. This makes it possible to easily manufacture the antenna device in which the connection between the cable and the film antenna is resin-sealed without fail.

[Additional Remarks]

[0109] The present invention is not limited to the embodiments, but can be altered by a skilled person in the art within the scope of the claims. An embodiment derived from a proper combination of technical means each disclosed in a different embodiment is also encompassed in the technical scope of the present invention.

Reference Signs List

[0110]

1, 2, 3	Antenna device
11, 21, 31	Film antenna
12, 22, 32	Coaxial cable
13, 23, 33	Support
13D, 23D, 33D	Indentation
13R1, 33R1	Recessed groove (path)
23R1	Through hole (path)

Claims

1. An antenna device (1,2,3) comprising:

a film antenna (11,21,31);
a cable (12,22,32) which has a tip part connected to a feed section of the film antenna (11,21,31); and
a support (13,23,33) around which the film antenna (11,21,31) is wound,
the support (13,23,33) having (i) an indentation (13D,23D,33D) provided in a part in which a connection between the cable (12,22,32) and the film antenna (11,21,31) is arranged, (ii) a holding part (13R3,13B,13T2,23R3,23B,33R1,33B) for holding the cable (12,22,32), and (iii) a path (13R1,23R1,33R1) for drawing the tip part of the cable (12,22,32) into the indentation (13D,23D,33D), and
the film antenna (11,21,31) being wound around the support (13,23,33) so as to surround the indentation (13D,23D,33D).

2. The antenna device (1,2,3) as set forth in claim 1, wherein the connection between the cable (12,22,32) and the film antenna (11,21,31) is covered with a resin (14) obtained by curing a fluid resin injected into the indentation (13D,23D,33D).

3. The antenna device (1) as set forth in claim 2, wherein the path (13R1) is a recessed groove that extends from an outward surface of the support (13) to the indentation (13D).

4. The antenna device (2,3) as set forth in claim 2, wherein the path (23R1,33R1) is provided with a blocking wall (23R4) that lies between (a) the cable (22,32) which passes through the path (23R1,33R1) and (b) the film antenna (21,31) which is wound around the support (23,33).

5. An antenna device (1,2,3) manufacturing method for manufacturing an antenna device (1,2,3) including: a film antenna (11,21,31); a cable (12,22,32); and a support (13,23,33) around which the film antenna (11,21,31) is wound and which has a holding part (13R3,13B,13T2,23R3,23B,33R1,33B) for holding the cable (12,22,32), the support (13,23,33) having (i) an indentation (13D,23D,33D) provided in a part in which a connection between the cable (12,22,32) and the film antenna (11,21,31) is arranged and (ii) a path (13R1,23R1,33R1) for drawing the tip part of the cable (12,22,32) into the indentation (13D,23D,33D),
said method comprising:
a wiring step of causing the holding part (13R3,13B,13T2,23R3,23B,33R1,33B) to hold the cable (12,22,32) and drawing the tip part of the cable (12,22,32) into the indentation (13D,23D,33D) via the path (13R1,23R1,33R1);
a connecting step of, after the wiring step, connecting the tip part of the cable (12,22,32) to the feed section which is arranged in the indentation (13D,23D,33D); and
a winding step of, after the connecting step, winding the film antenna (11,21,31) around the support (13,23,33) so as to surround the indentation (13D,23D,33D).

6. The antenna device (1) manufacturing method as set forth in claim 5, wherein:

the method uses, as the support (13), a support (13) whose path (13R1) is a recessed groove that extends from an outward surface of the support (13) to the indentation (13D),
said method further comprising:
an injecting step of, after the winding step, injecting a fluid resin into the indentation (13D) via the path (13R1) in a state in which the path (13R1) is arranged so as to be upper than the indentation (13D); and
a step of, after the injecting step, curing the fluid resin.

7. The antenna device (2,3) manufacturing method as set forth in claim 5, wherein:

the method uses, as the support (23,33), a support (23,33) whose path (23R1,33R1) is provided with a blocking wall (23R4) that lies between (a) the cable (22,32) which passes through the path (23R1,33R1) and (b) the film antenna (21,31) which is wound around the support (23,33); and
the winding step includes:

a first winding step of bending the film antenna (21,31) along the support (23,33) and surrounding two of three sides of the indentation (23D,33D); and
a second winding step of further bending the film antenna (21,31) along the support (23,33) and surrounding all the three sides of the indentation (23D,33D),

the first winding step and the second winding step each being carried out in a state in which the connection between the cable (22,32) and the film antenna (21,31) is arranged in the indentation (23D,33D),
said method further comprising:

an injecting step of injecting a fluid resin into the indentation (23D,33D); and
a curing step of curing the fluid resin,

the injecting step and the curing step each being carried out between the first winding step and the second winding step in a state in which the connection is arranged in a lower part of the indentation (23D,33D).

FIG. 1

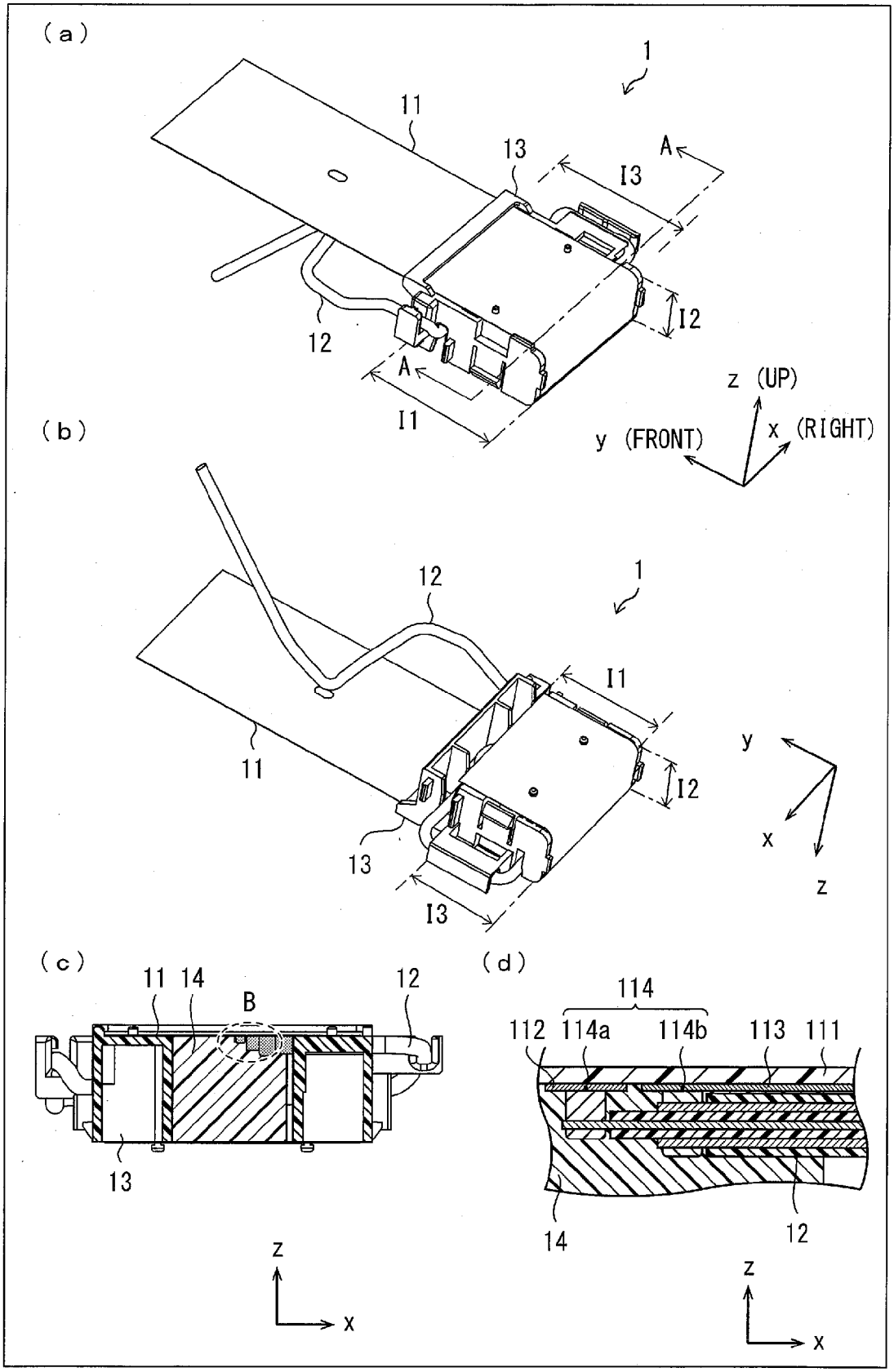

(a)
1
11
13
A
I3
I2
12
A
I1
z (UP)
y (FRONT)
x (RIGHT)
(b)
12
1
I1
11
I2
13
I3
y
x
z
(c)
11 14
B
12
13
z
x
(d)
114
112 114a 114b 113 111
14
12
z
x

FIG. 2

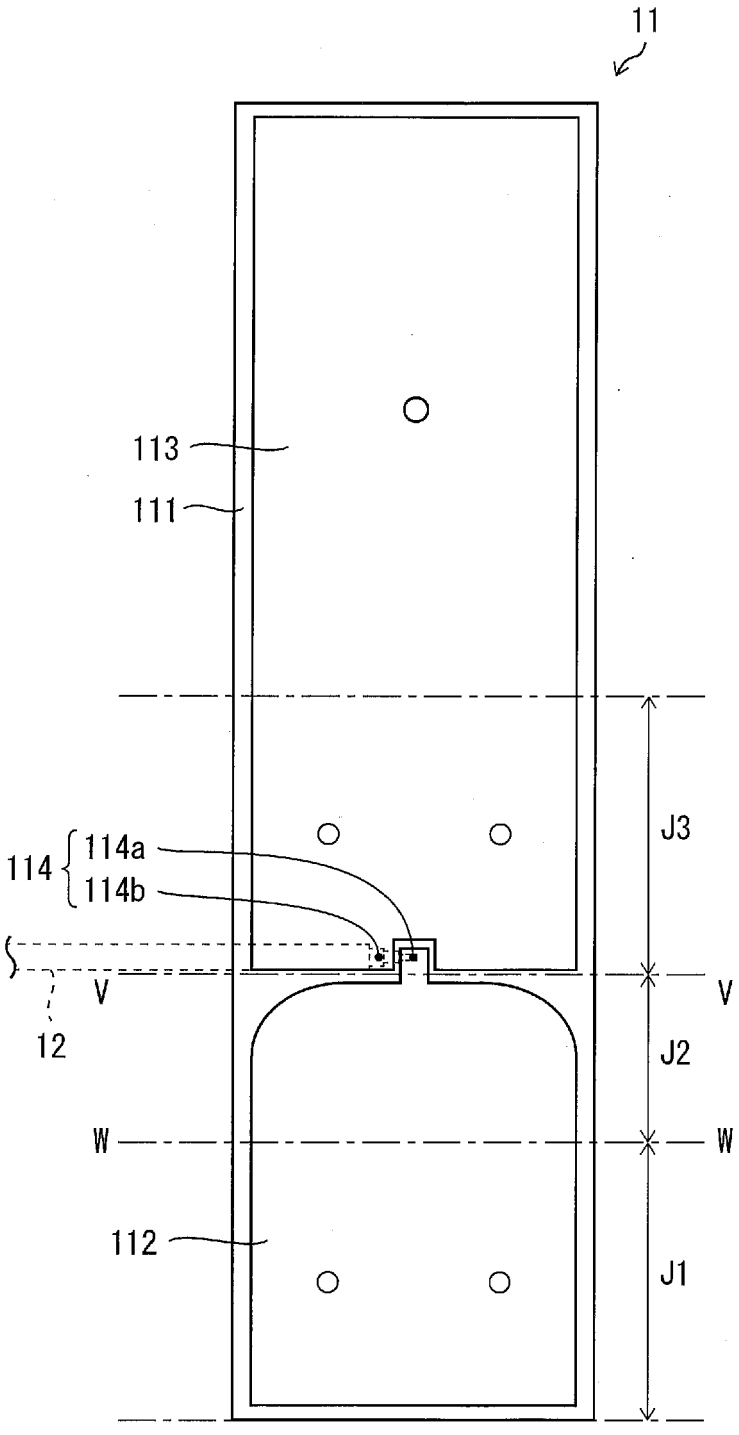


FIG. 3

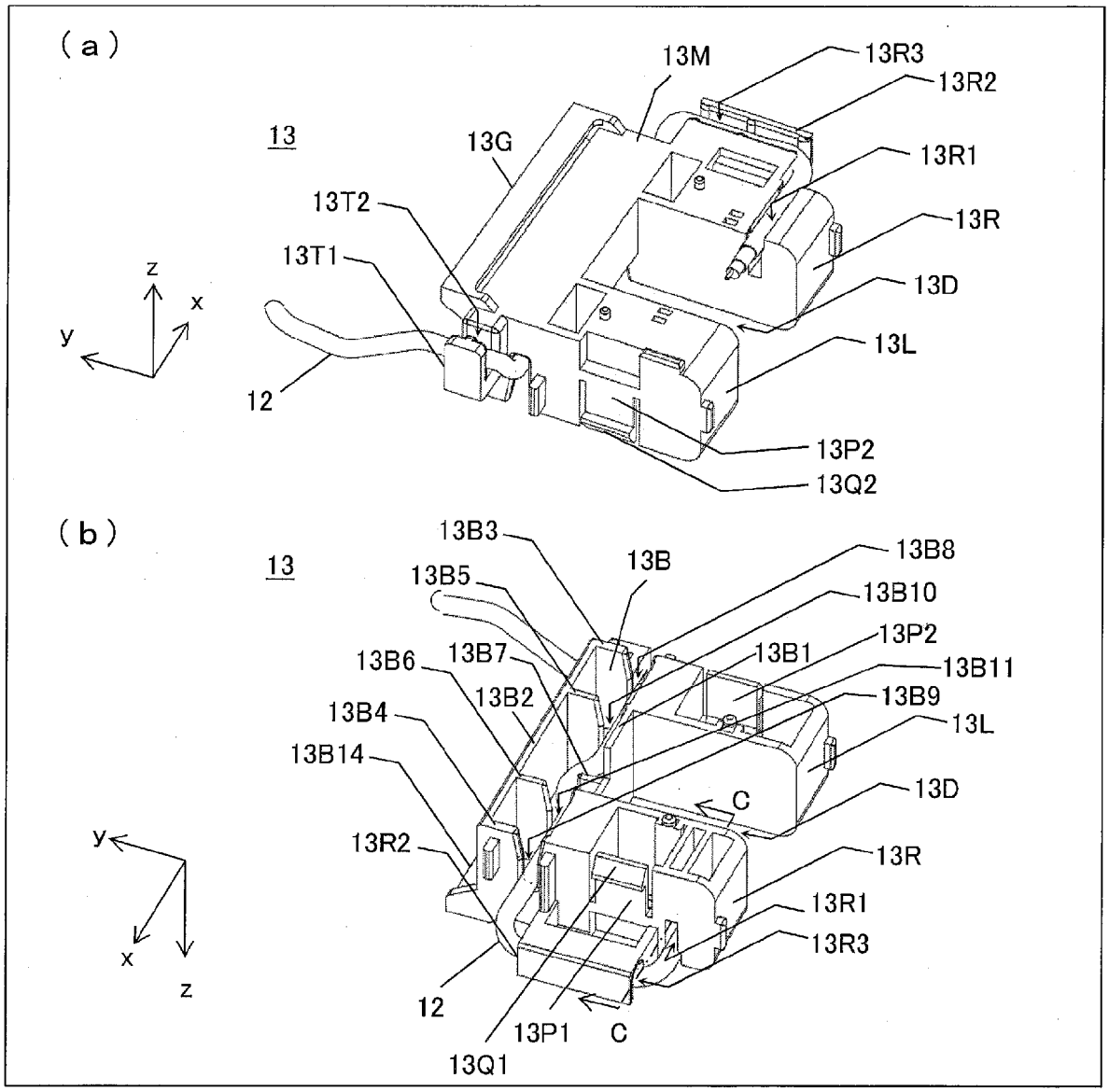

(a)
13
13M
13R3
13R2
13G
13R1
13T2
13R
13T1
13D
13L
12
13P2
13Q2
z
x
y
(b)
13
13B3
13B
13B8
13B5
13B10
13P2
13B6
13B7
13B1
13B11
13B2
13B9
13B4
13L
13B14
C
13D
13R2
13R
13R1
13R3
12
13P1
C
13Q1
y
x
z

FIG. 4

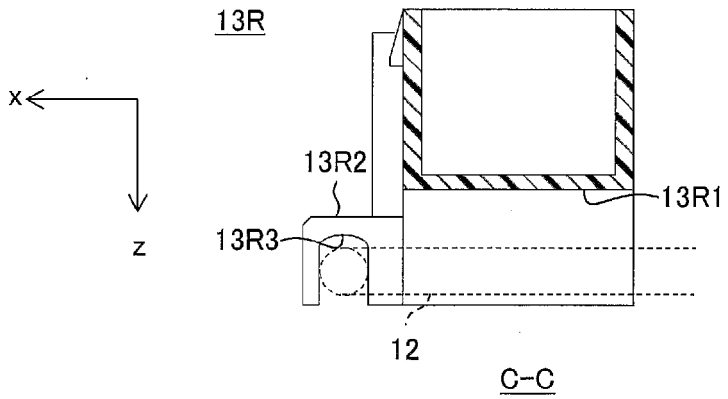

13R
x
z
13R2
13R1
13R3
12
C-C

FIG. 5

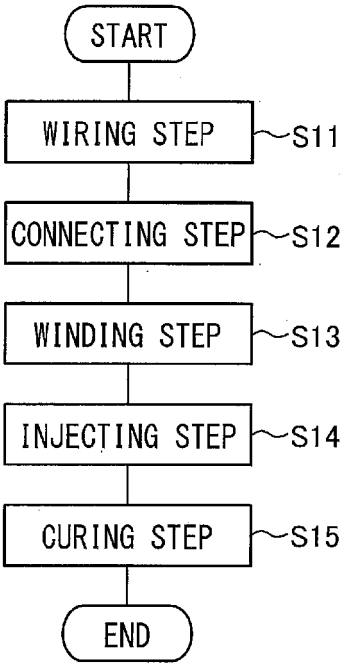

START
WIRING STEP
S11
CONNECTING STEP
S12
WINDING STEP
S13
INJECTING STEP
S14
CURING STEP
S15
END

FIG. 6

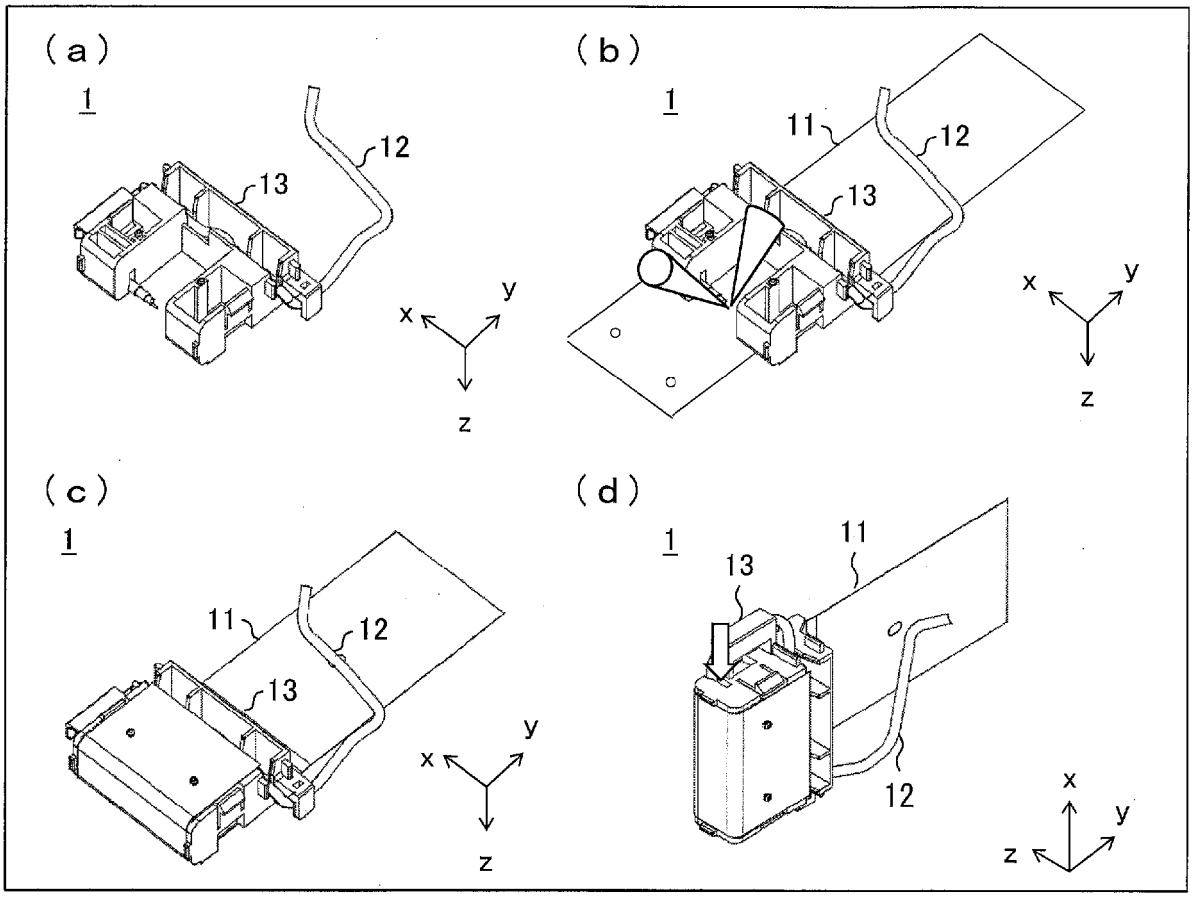

(a)
1
12
13
x
y
z
(b)
1
11
12
13
x
y
z
(c)
1
11
12
13
x
y
z
(d)
1
13
11
12
x
y
z

FIG. 7

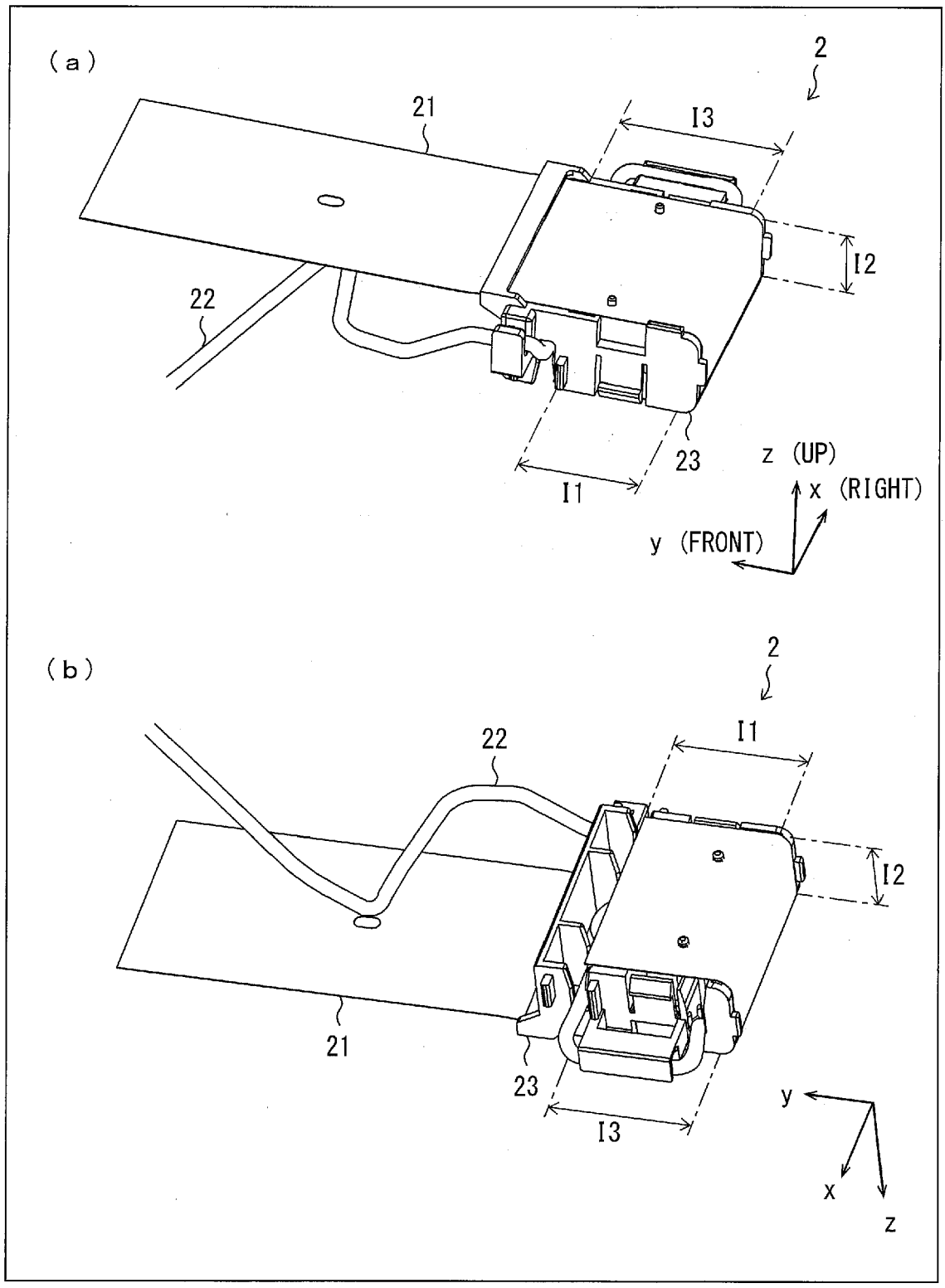


FIG. 8

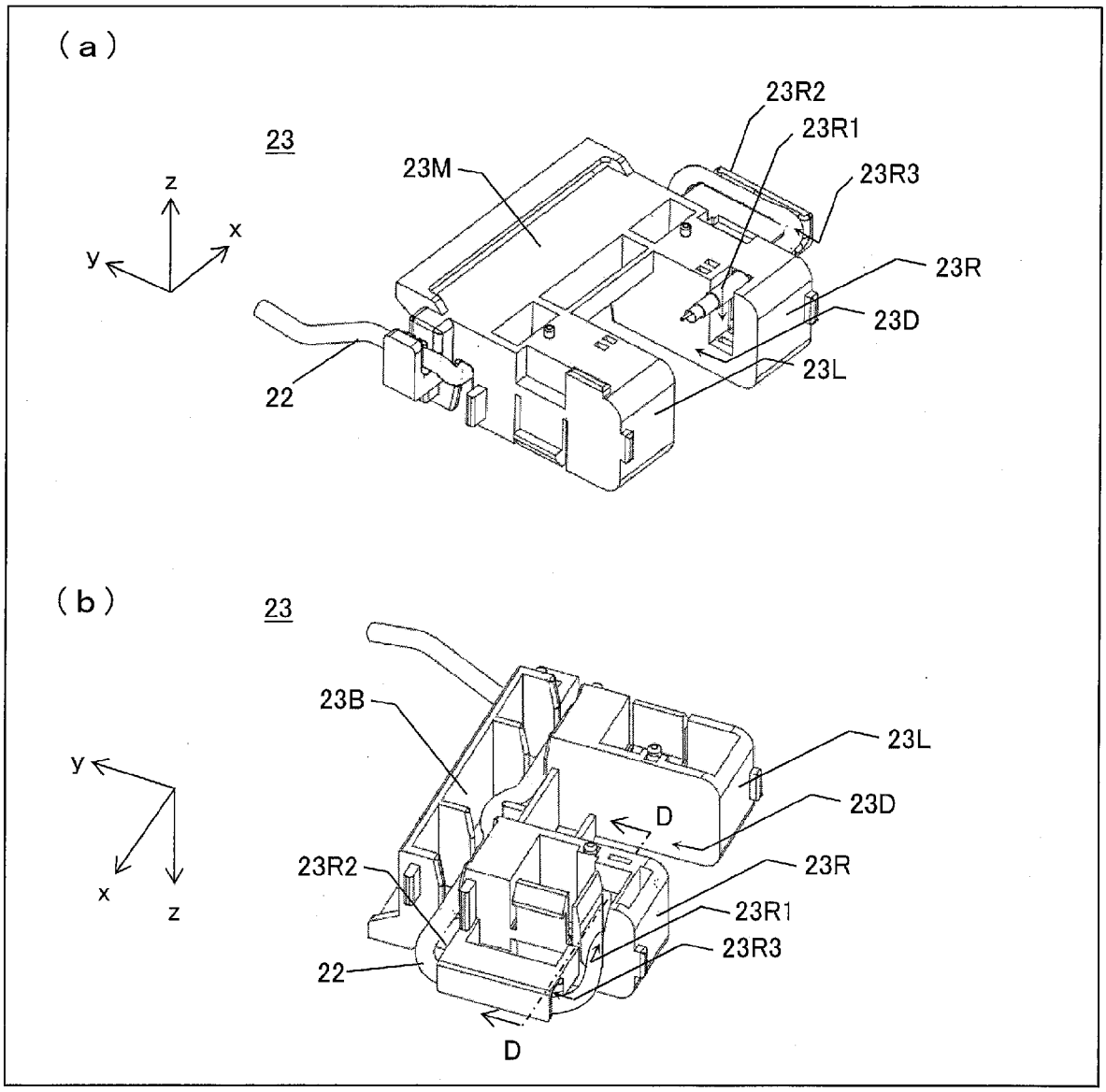

(a)
23
z
x
y
23M
23R2
23R1
23R3
23R
23D
23L
22
(b)
23
y
x
z
23B
23L
23D
D
23R2
23R
23R1
23R3
22
D

FIG. 9

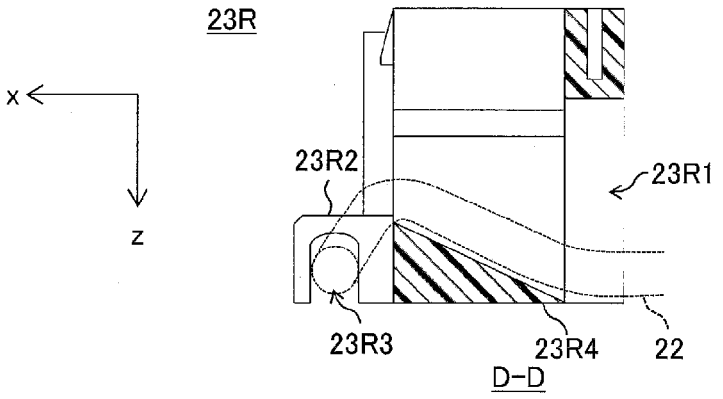

23R
x
z
23R2
23R1
23R3
23R4
22
D-D

FIG. 10

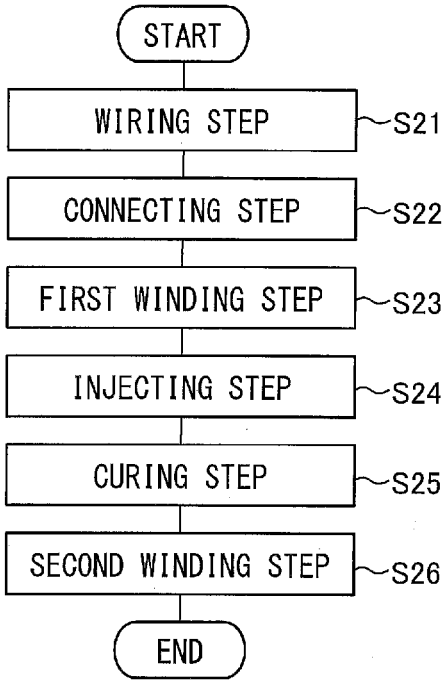

START
WIRING STEP
S21
CONNECTING STEP
S22
FIRST WINDING STEP
S23
INJECTING STEP
S24
CURING STEP
S25
SECOND WINDING STEP
S26
END

FIG. 11

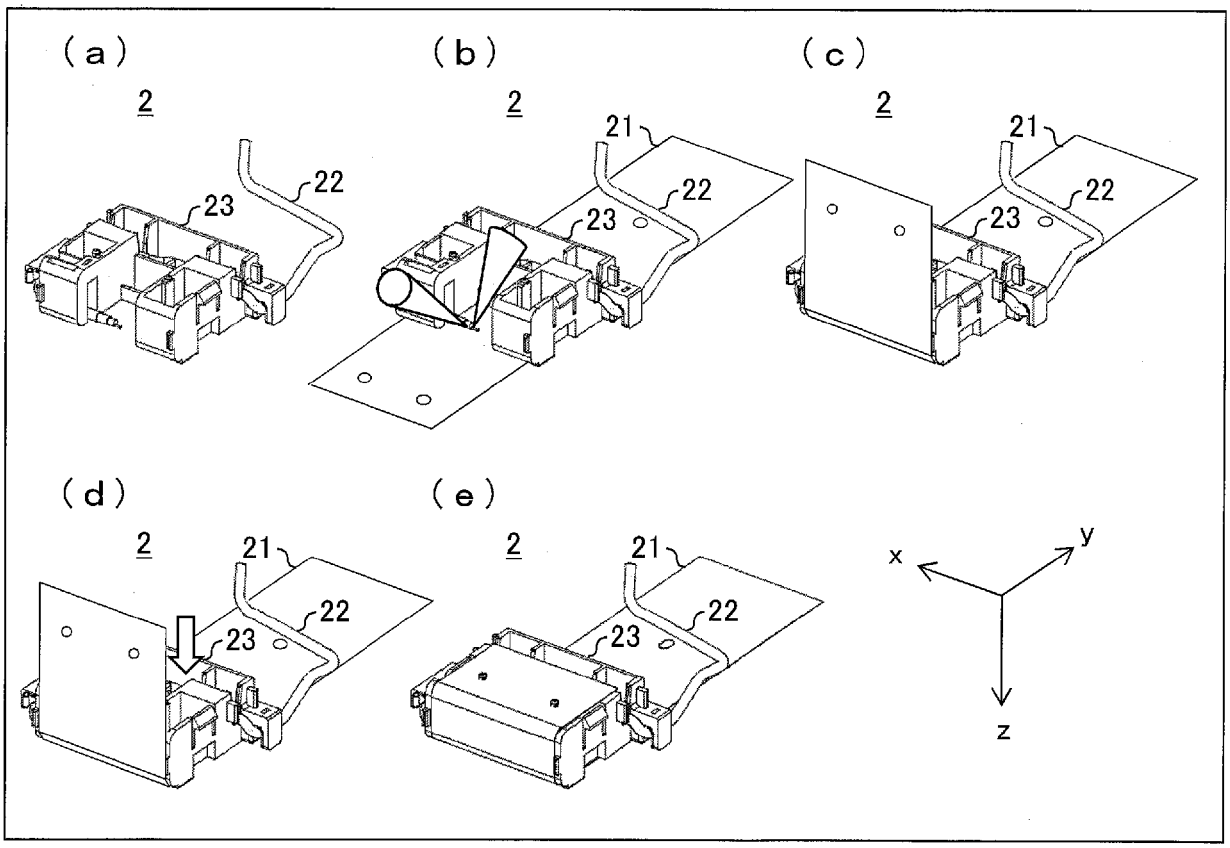

(a)
2
22
23
(b)
2
21
22
23
(c)
2
21
22
23
(d)
2
21
22
23
(e)
2
21
22
23
x
y
z

FIG. 12

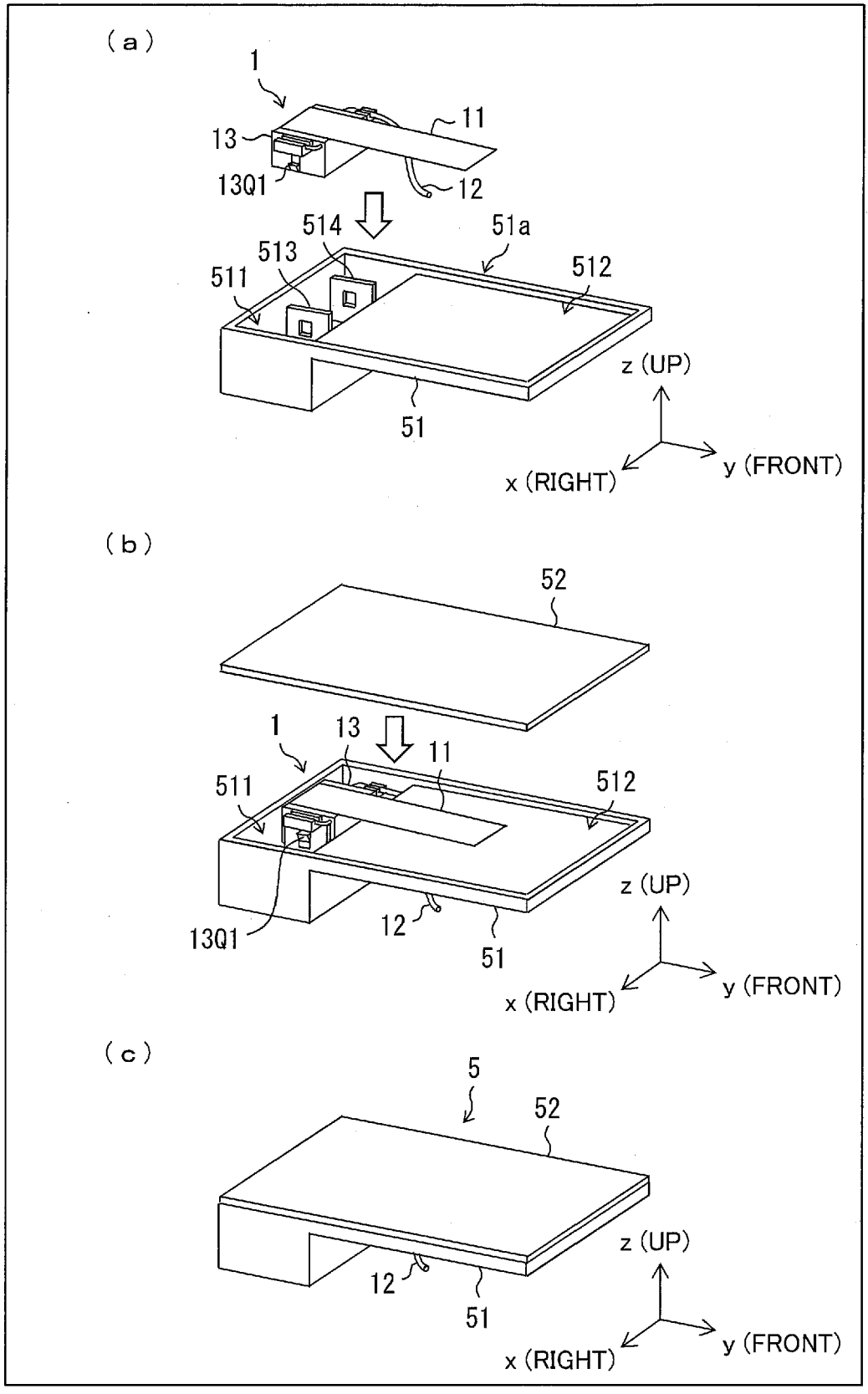

(a)
1
11
13
13Q1
12
514
51a
513
512
511
51
z (UP)
x (RIGHT)
y (FRONT)
(b)
52
1
13
11
511
512
13Q1
12
51
z (UP)
x (RIGHT)
y (FRONT)
(c)
5
52
12
51
z (UP)
x (RIGHT)
y (FRONT)

FIG. 13

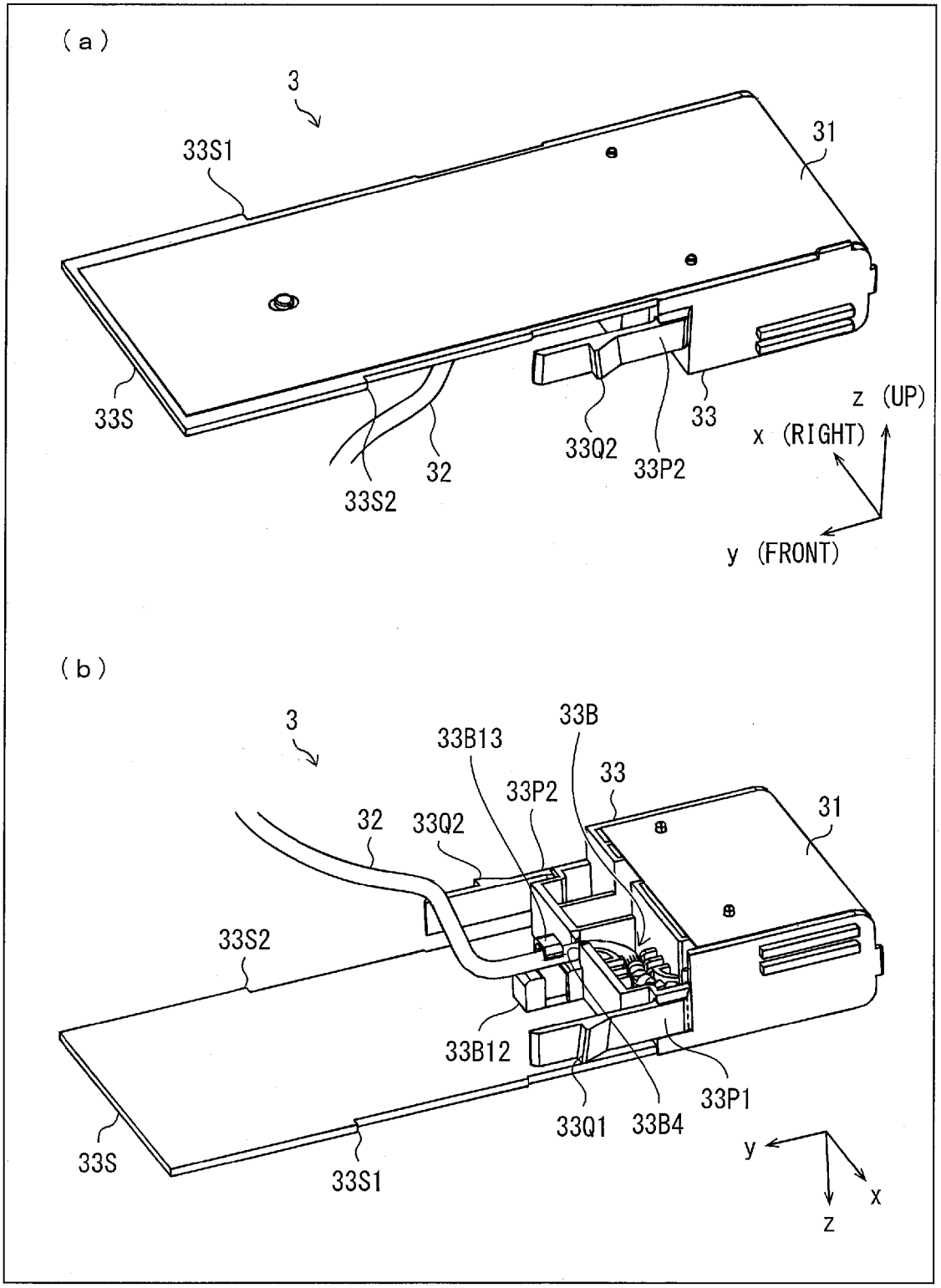

(a)
3
33S1
31
33S
33S2
32
33Q2
33P2
33
z (UP)
x (RIGHT)
y (FRONT)
(b)
3
33B
33B13
33P2
33
32
33Q2
31
33S2
33B12
33P1
33Q1
33B4
33S
33S1
y
x
z

FIG. 14

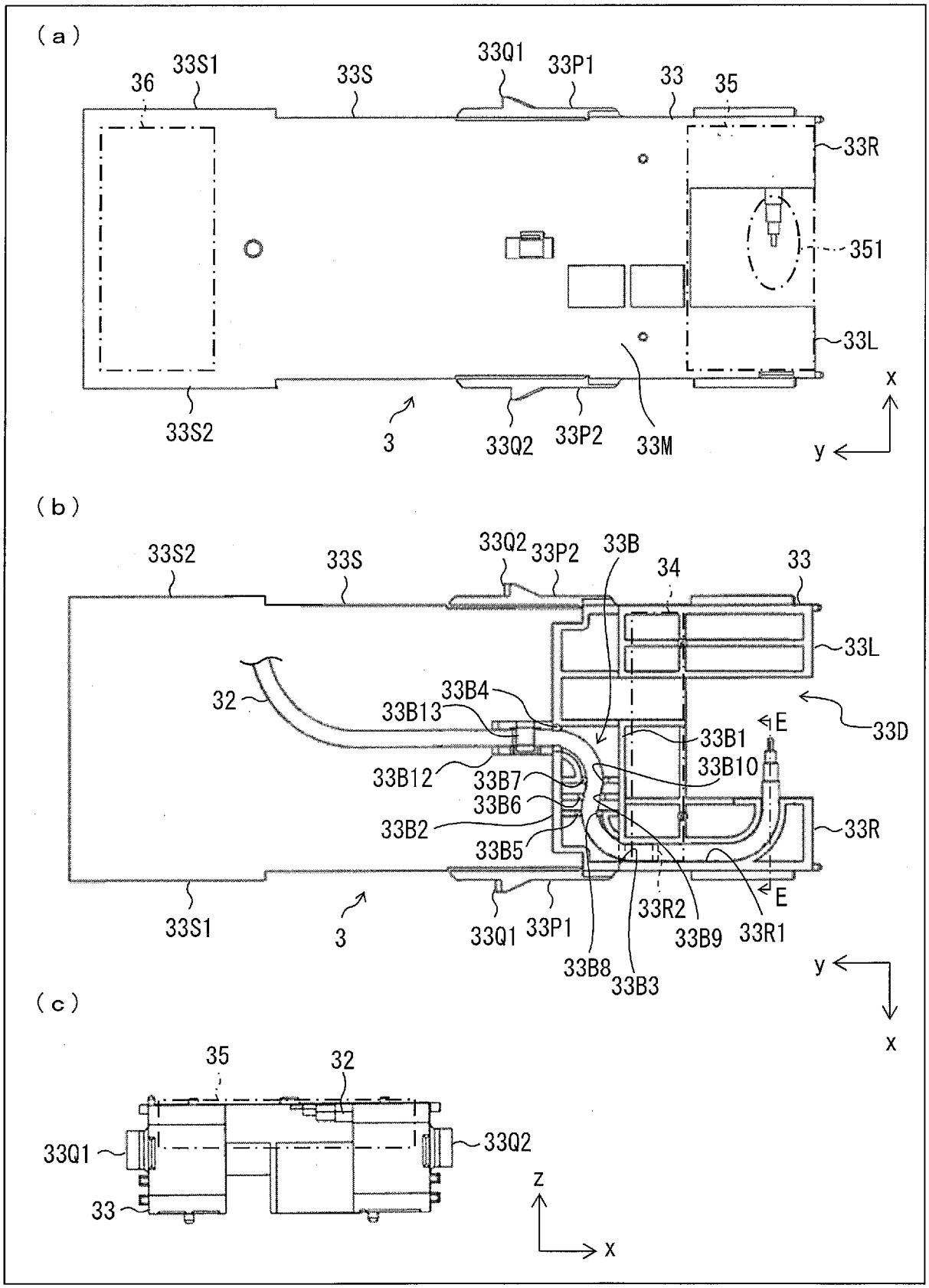

(a)
36
33S1
33S
33Q1
33P1
33
35
33R
351
33L
x
y
33S2
3
33Q2
33P2
33M
(b)
33S2
33S
33Q2
33P2
33B
34
33
33L
32
33B4
33B13
33D
E
33B1
33B10
33B12
33B7
33B6
33B2
33B5
33R
33S1
3
33Q1
33P1
33R2
33B9
33R1
33B8
33B3
y
x
(c)
35
32
33Q1
33Q2
33
z
x

FIG. 15

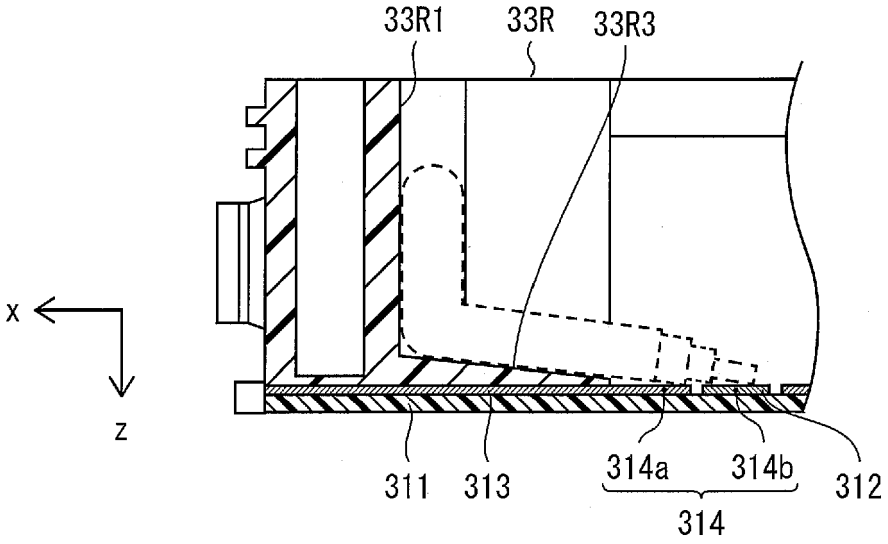


FIG. 16

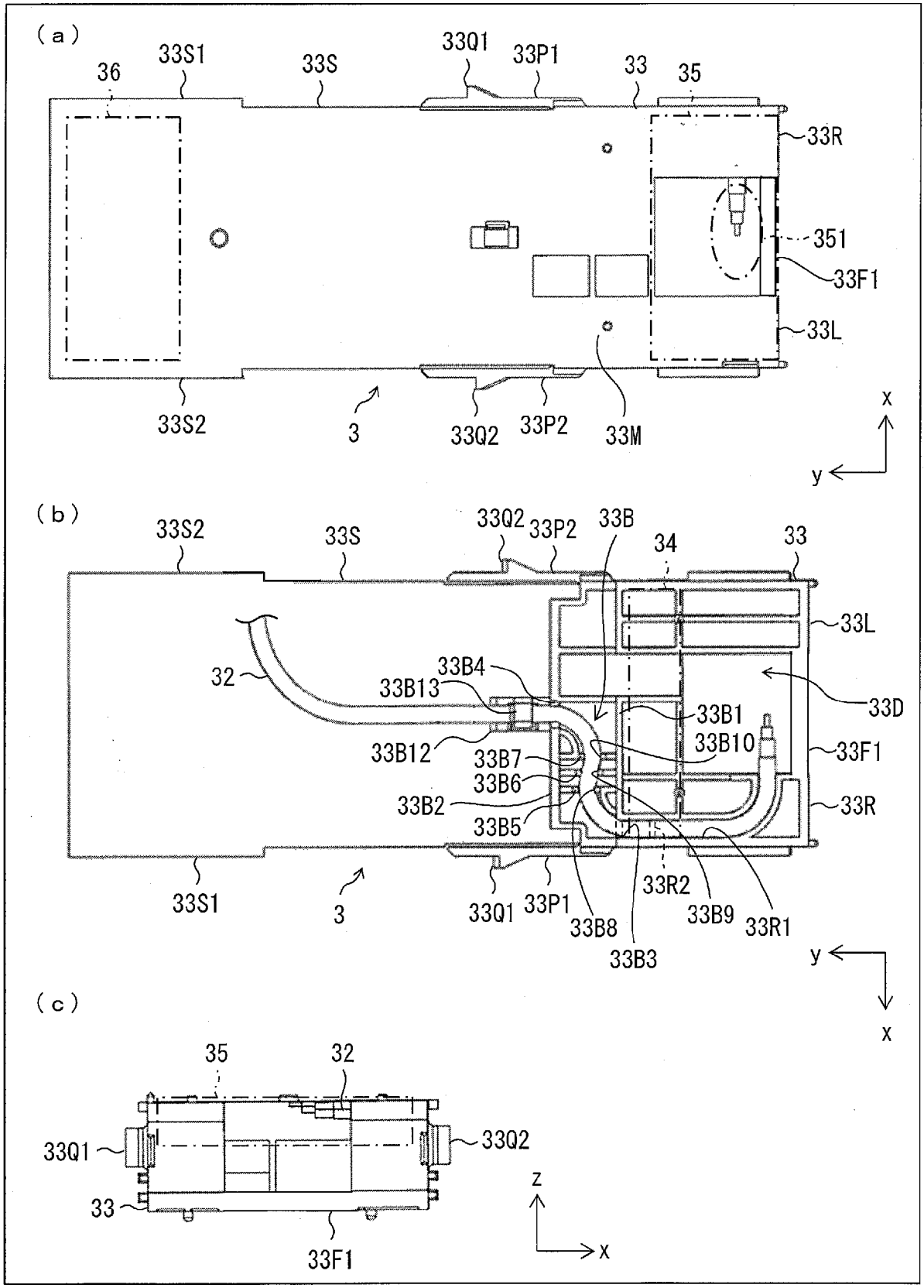

(a)
36
33S1
33S
33Q1
33P1
33
35
33R
351
33F1
33L
33S2
3
33Q2
33P2
33M
x
y
(b)
33S2
33S
33Q2
33P2
33B
34
33
33L
32
33B4
33B13
33D
33B1
33B12
33B10
33F1
33B7
33B6
33B2
33R
33B5
33S1
3
33Q1
33P1
33R2
33B8
33B9
33R1
33B3
y
x
(c)
35
32
33Q1
33Q2
33
33F1
z
x

FIG. 17

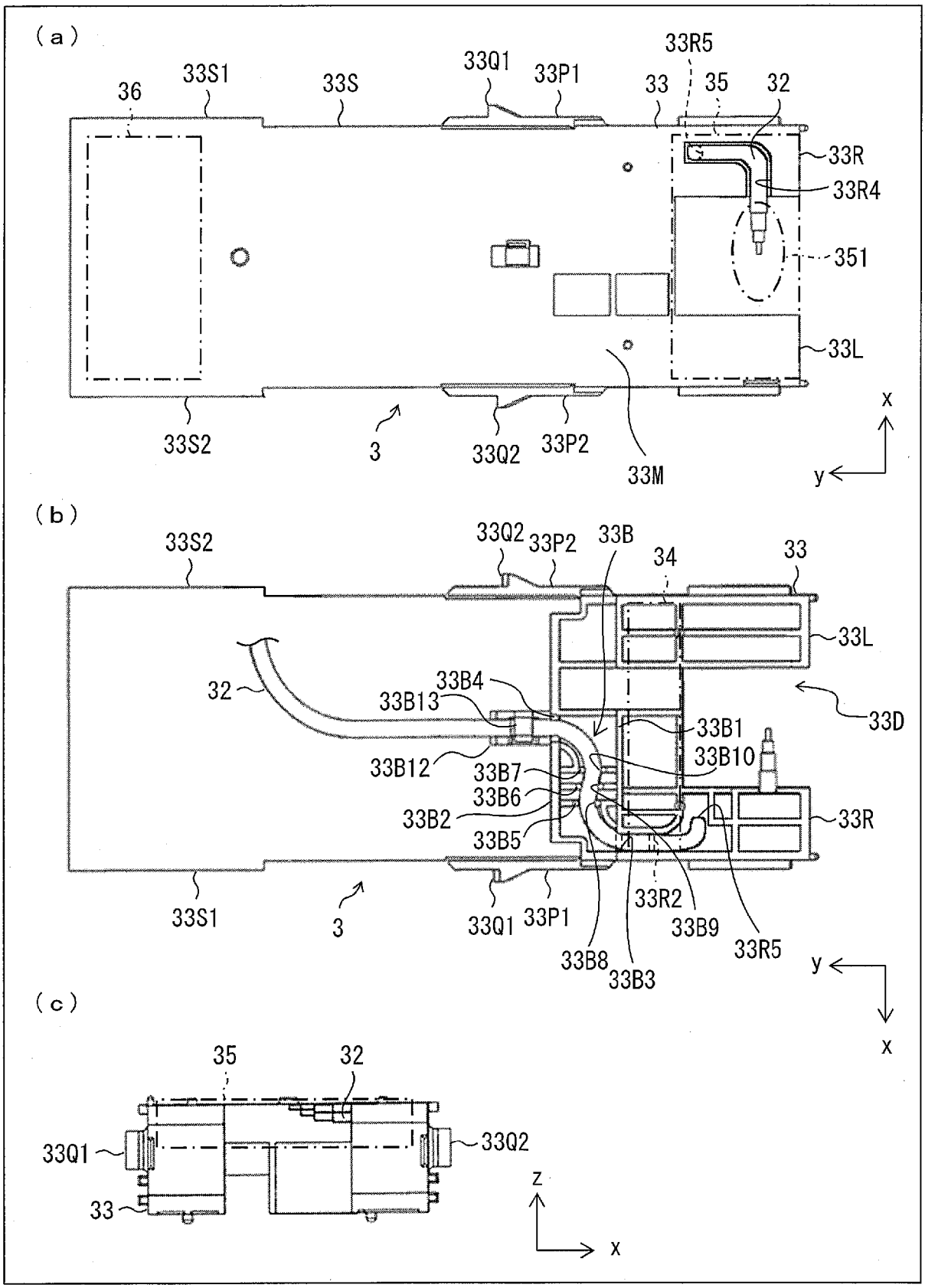
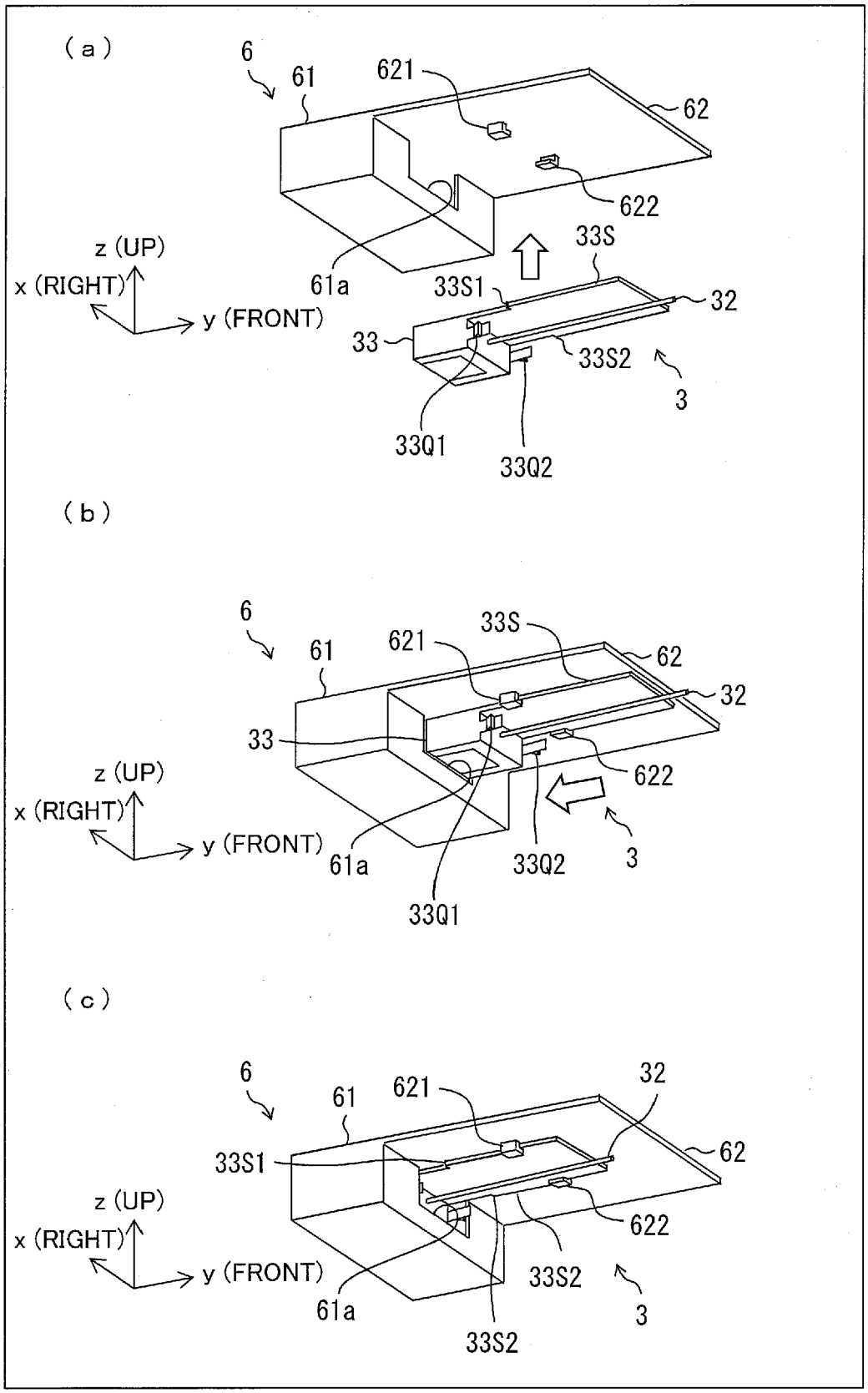

(a)
36
33S1
33S
33Q1
33P1
33
33R5
35
32
33R
33R4
351
33L
33S2
3
33Q2
33P2
33M
x
y
(b)
33S2
33Q2
33P2
33B
34
33
33L
32
33B4
33B13
33D
33B1
33B12
33B10
33B7
33B6
33B2
33B5
33R
33S1
3
33Q1
33P1
33R2
33B9
33R5
33B8
33B3
y
x
(c)
35
32
33Q1
33Q2
33
z
x

FIG. 18


(a)
6
61
621
62
622
33S
z (UP)
x (RIGHT)
y (FRONT)
61a
33S1
32
33
33S2
3
33Q1
33Q2
(b)
6
61
621
33S
62
32
33
622
z (UP)
x (RIGHT)
y (FRONT)
61a
33Q2
3
33Q1
(c)
6
61
621
32
62
33S1
z (UP)
x (RIGHT)
622
y (FRONT)
33S2
61a
3
33S2

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EUROPEAN SEARCH REPORT

Application Number
EP 17 15 9154

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2012/162022 A1 (WEI CHENG-FAN [TW]) 28 June 2012 (2012-06-28) * figures 1-3 * * paragraph [0014] * * paragraph [0018] - paragraph [0019] *	1,5 2-4,6,7	INV. H01Q1/08 H01Q1/10 H01Q1/38 H01Q9/40 H01Q9/42
X A	US 2007/040758 A1 (DWYER BRADLEY L [AU] ET AL) 22 February 2007 (2007-02-22) * figures 1A, 1B * * paragraph [0049] * * paragraph [0053] * * paragraph [0060] *	1,5 2-4,6,7	
A	JP 2010 258544 A (MITSUMI ELECTRIC CO) 11 November 2010 (2010-11-11) * abstract * * figures 1-3 *	1-7	

TECHNICAL FIELDS SEARCHED (IPC)
H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 September 2017	Yvonnet, Yannick

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12-09-2017

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US 2012162022 A1	28-06-2012	TW 201228108 A	01-07-2012
		US 2012162022 A1	28-06-2012
US 2007040758 A1	22-02-2007	EP 1755192 A1	21-02-2007
		US 2007040758 A1	22-02-2007
JP 2010258544 A	11-11-2010	NONE	

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Patent documents cited in the description

- EP 2403327 A **[0005]**