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(54) **ANTENNA COIL**

(57) In an antenna coil which includes a core member having an X-axis leg section protruding in the X-axis direction from an intersection of the core member and having a Y-axis leg section protruding in the Y-axis direction from the intersection, X-axis winding wires wound around the outer periphery of the X-axis leg section, and Y-axis winding wires wound around the outer periphery of the Y-axis leg section, at least one of an X-axis winding frame section for the X-axis winding wire, the X-axis winding frame section being provided at the X-axis leg section, and a Y-axis winding frame section for the Y-axis winding wire, the Y-axis winding frame section being provided at the Y-axis leg section, has one of intermediate flange sections for respectively separating the X-axis winding frame section and the Y-axis winding frame section into a pair of winding frame sections and a pair of winding frame sections, the winding frame sections of each of the pairs corresponding to different winding shapes.

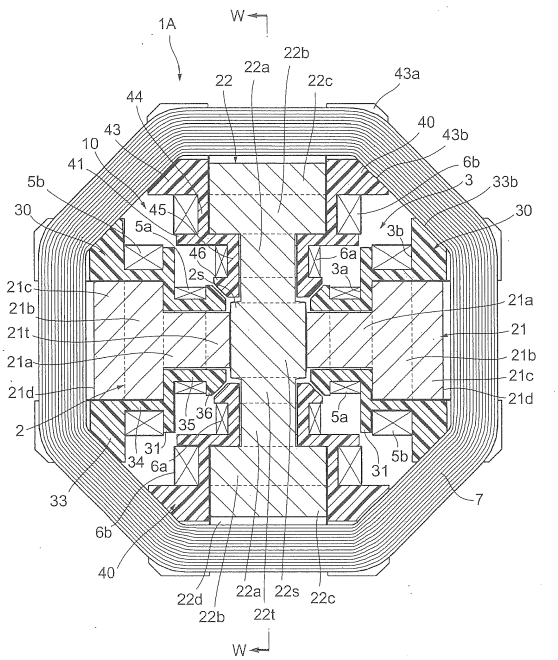

Fig.1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an antenna coil in which coils are wound at least in the X-axis and Y-axis directions crossing each other.

Description of the Prior Art

[0002] As an example of the antenna coil, a type is known which is mounted in a remote controller for unlocking and locking a keyless entry system used in an automobile or a house. In recent years, it has been demanded to improve the sensitivity of the antenna coil in order to enable the information to be more surely exchanged between the controller and the control unit on the side of the automobile or the house. On the other hand, the demand for miniaturization of the antenna coil has also been increased in order to improve portability for the user.

[0003] As for this kind of technique, antenna coils described in Japanese Laid-Open Patent Publication No. 2003-92509 and International Publication No. WO 2007/116797 are known. In Japanese Laid-Open Patent Publication No. 2003-92509, a two-axis antenna coil and a three-axis antenna coil are disclosed. For example, FIG. 1 to FIG. 3 show an antenna coil in which a Y-axis winding wire is superposed and wound around the outer periphery of an X-axis winding wire so as to make the axis lines of the windings orthogonal to each other. Also, FIG. 4 to FIG. 6 show an antenna coil in which an X-axis winding wire and a Y-axis winding wire are wound around a cross-shaped core.

[0004] Further, in International Publication No. WO 2007/116797, FIG. 12 shows an antenna coil in which an X-axis winding wire and a Y-axis winding wire are wound around a cross-shaped core in such an inclined manner that the number of turns of each of the winding wires is increased toward the outer periphery of the cross-shaped core.

[0005] However, the antenna coil, which is disclosed in Japanese Laid-Open Patent Publication No. 2003-92509, and in which the Y-axis winding wire is superposed and wound around the outer periphery of the X-axis winding wire so as to make the axis lines of the windings orthogonal to each other, has a problem that the tension at the time of winding may be intensively applied between the coil wires so as to damage the insulating coating on the coil surface, and that, when the core wire of the coil wire is exposed, a short circuit is caused in the coil so as to deteriorate the antenna characteristics. Further, since the X-axis winding wire and the Y-axis winding wire overlap each other, the height of the antenna coil in the Z-axis direction, that is, the thickness dimension of the antenna coil is increased, which becomes an obstacle when the antenna coil as a whole is miniaturized into a flat shape.

[0006] On the other hand, in the antenna coil which is disclosed in Japanese Laid-Open Patent Publication No. 2003-92509, and in which the X-axis winding wire and the Y-axis winding wire are respectively wound around the cross-shaped core, the space between the X-axis and Y-axis winding wires adjacent to each other is increased from the intersection toward the outer side of the cross core, so that the spaces of the corner portions between the X-axis and Y-axis winding wires are useless.

[0007] In order to improve the reception characteristics, such as the sensitivity, of the antenna coil, it is necessary to increase the length of the legs protruding in the X-axis and Y-axis directions of the cross core. However, as the length of the legs is increased, the useless space is increased, which becomes an obstacle to the miniaturization of the whole shape of the antenna coil.

[0008] Further, in the antenna coil which is disclosed in International Publication No. WO 2007/116797 and in which, around the legs respectively protruding in the X-axis and Y-axis directions of the cross core, the X-axis winding wire and the Y-axis winding wire are respectively wound in such an inclined manner that the number of turns of each of the windings is increased toward the outer side of the cross core, the winding work for successively increasing the number of turns is complicated and difficult, and collapse of winding wire may occur.

[0009] The present invention has been made in view of the above described circumstances. An object of the present invention is to provide an antenna coil which is capable of attaining both the improvement of antenna characteristics and the miniaturization of the antenna coil.

SUMMARY OF THE INVENTION

[0010] To this end, an antenna coil according to the present invention includes a core member having an X-axis leg section and a Y axis leg section which respectively protrude in the X-axis and the Y-axis directions from the intersection of the core member, and an X-axis winding wire and a Y-axis winding wire which are respectively wound around the outer periphery of the X-axis leg section and the Y-axis leg section, and is featured in that at least one of an X-axis winding frame section for the X-axis winding wire, which frame section is provided at the X-axis leg section, and a Y-axis winding frame section for the Y-axis winding wire, which frame section is provided at the Y-axis leg section, includes an intermediate flange section for separating the winding frame section into at least two winding frame sections for different winding shapes.

[0011] In the present invention, the core member can be configured so that the X-axis leg section and the Y-axis leg section are formed into a cross shape in which the X-axis and Y-axis leg sections intersect each other at the midpoint thereof.

[0012] In this case, it is preferred that the X-axis leg section has the X-axis winding frame sections on both sides of the midpoint of the X-axis leg section, and the Y-axis leg section has the Y-axis winding frame sections on both sides of the midpoint of the Y-axis leg section, and that each of the X-axis winding frame section and the Y-axis winding frame section is provided with the intermediate flange section, and each of the winding flange sections is formed into the plurality of winding frame sections separated from each other by the intermediate flange section.

[0013] Further, it is preferred that the core member is formed into a T-shape in which the X-axis leg section and the Y-axis leg section are made to cross each other at the end of one of the X-axis leg section and the Y-axis leg section.

[0014] In addition, in the antenna in accordance with the present invention, the intermediate flange section may be formed into a plate-shaped intermediate flange section made of the core member.

[0015] Still further, in the antenna coil in accordance with the present invention, an outer flange section made of the core member is provided at the outer end of the X-axis leg section and the Y-axis leg section so as to be in parallel with the intermediate flange section.

[0016] Moreover, the inner winding wire wound around the inner winding frame section provided on the inner side of the intermediate flange section is wound with a smaller number of turns, and the outer winding wire wound around the outer winding frame section provided on the outer side of the intermediate flange section is wound with a larger number of turns.

[0017] Further, the width of the X-axis leg section and the Y-axis leg section is made smaller in the inner winding section corresponding to the inner winding frame section provided on the inner side of the intermediate flange section, and is made larger in the outer winding section corresponding to the outer winding frame section provided on the outer side of the intermediate flange section.

[0018] It is also preferred that a Z-axis winding wire is wound around the peripheral portion of the antenna coil in the peripheral direction.

[0019] It is preferred that the winding frame sections separated by the intermediate flange section are configured such that at least either the number of turns of the winding or the cross-sectional area of the core member is different between the winding frame sections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a sectional front view of a three-dimensional antenna unit provided with an antenna coil according to a first embodiment of the present invention, the view being taken along the line V-V in FIG. 2;

FIG. 2 is a sectional side view taken along the line W-W in FIG. 1;

FIG. 3A is a longitudinal sectional front view schematically showing the configuration of a three-dimensional antenna unit having an antenna coil according to a second embodiment of the present invention;

FIG. 3B is a central sectional plan view of FIG. 3A;

FIG. 4A is a longitudinal sectional front view schematically showing the configuration of a three-dimensional antenna unit having an antenna coil according to a third embodiment of the present invention;

FIG. 4B is a central sectional plan view of FIG. 4A;

FIG. 5A is a longitudinal sectional front view schematically showing the configuration of a three-dimensional antenna unit having an antenna coil according to a fourth embodiment of the present invention;

FIG. 5B is a central sectional plan view of FIG. 5A;

FIG. 6 is a front view schematically showing the configuration of an antenna coil according to a fifth embodiment of the present invention;

FIG. 7 is a front view schematically showing the configuration of an antenna coil according to a sixth embodiment of the present invention;

FIG. 8 is a partially sectional front view schematically showing the configuration of an antenna coil according to a seventh embodiment of the present invention; and

FIG. 9 is a partially sectional front view schematically showing the configuration of an antenna coil according to an eighth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] In the following, embodiments of an antenna coil according to the present invention and embodiments of a three-dimensional antenna unit having the antenna coil will be described with reference to the accompanying drawings. Note that, in all the drawings, even when some of the components having the same name have different shapes and configurations in the different embodiments, they are denoted by the same reference numerals or characters, and the explanation thereof is suitably omitted.

<First embodiment>

[0022] FIG. 1 and FIG. 2 show a three-dimensional antenna unit 1A having an antenna coil 10 according to a first embodiment of the present invention. Note that the left and right direction in FIG. 1 is the X-axis direction, the vertical direction in FIG. 1 is the Y-axis direction, and the left and right direction (front and rear direction) in FIG. 2 is the Z-axis direction.

[0023] The antenna coil 10 includes: a cross-shaped core member 2 which has an X-axis leg section 21 protruding in the X-axis direction from an intersection 2s located at the center portion (midpoint) of the core member

2, and a Y-axis leg section 22 protruding in the Y-axis direction from the intersection 2s; four X-axis base members 30 which are made of an insulating material and respectively attached to both side ends of the X-axis leg sections 21 of the core member 2; four Y-axis base members 40 which are made of the insulating material and respectively attached to both side ends of the Y-axis leg sections 22 of the core member 2; X-axis winding frame sections 3 which are formed around the outer periphery of the X-axis leg section 21 by the core member 2 and the X-axis base member 30; Y-axis winding frame sections 4 which are formed around the outer periphery of the Y-axis leg section 22 by the core member 2 and the Y-axis base member 40; two X-axis winding wires 5a and 5b which are wound around the X-axis winding frame section 3; and two Y-axis winding wires 6a and 6b which are wound around the Y-axis winding frame section 4.

[0024] Further, a Z-axis winding wire 7 is wound around the peripheral portion of the antenna coil 10 in the peripheral direction, and terminal sections 9 (see FIG. 2) are respectively provided at the X-axis base member 30 and the Y-axis base member 40. Further, as required, the outer periphery is covered with a resin molding or housed in a case, so that the three-dimensional antenna unit 1A is formed.

[0025] Each of the members will be described in detail. First, the core member 2 is formed into the cross shape in such a manner that the X-axis leg section 21 having an I-shape (rod shape) and the Y-axis leg section 22 (see FIG. 2) having the same I-shape (rod shape) are combined together in the front and rear direction at the intersection 2s located at the midpoint of the leg sections. The X-axis leg section 21 and the Y-axis leg section 22 have the same shape, and hence the configuration of the Y-axis leg section 22 will be described with reference to FIG. 2.

[0026] An intersection 22s located at the midpoint of the Y-axis leg section 22 is deviated to the front surface side so as to be formed in a plate shape for connecting the upper and lower Y-axis winding frame sections 4. Inner flange sections 22t and 22t extending in the front and rear direction are successively provided on both sides (upper and lower sides in FIG. 2) of the intersection 22s. A recessed section 22f is formed behind the intersection 22s by the inner flange sections 22t and 22t protruding in the rear direction.

[0027] Inner winding sections 22a and 22a serving as winding shaft portions are successively provided on the outer side of the inner flange sections 22t and 22t. The inner winding sections 22a and 22a are formed to have a width (X-axis direction length) slightly smaller than the width of the intersection 22s. Further, on the outer side of the inner winding sections 22a and 22a, outer winding sections 22b and 22b, each of which has a larger X-axis direction width and a smaller Z-axis direction thickness than the inner winding section 22a, are successively provided so that step sections are formed on both sides of each of the outer winding sections 22b and 22b. On both outer upper and lower ends of the outer winding sections 22b and 22b, outer flanges 22c and 22c are successively provided so as to have the same X-axis direction width as and a larger Z-axis direction thickness than the outer winding section 22b. In the outer end surface of each of the outer flanges 22c and 22c, a recessed core section 22d extending in the X-axis direction for winding the Z-axis winding wire 7 is provided.

[0028] The X-axis leg section 21 has the same shape as the shape of the Y-axis leg section 22. On both sides of an intersection 21s located at the midpoint of the X-axis leg section 21, inner flange sections 21t and 21 t, inner winding sections 21a and 21a, outer winding sections 21 band 21 b, and outer flanges 21 c and 21 c are successively provided in this order, and a recessed section 21 d is provided in each of the outer flanges 21 c and 21 c.

[0029] In the assembled state, the core member 2 is configured in such a way that the X-axis leg section 21, which is inverted front-to-back and rotated by 90 degrees with respect to the Y-axis leg section 22, is combined with the Y-axis leg section 22 by inserting the intersection 21s (see FIG. 2) located at the midpoint of the X-axis leg section 21 into the recessed section 22f provided on the rear surface side of the intersection 22s of the Y-axis leg section 22 from the rear surface side of the intersection 22s.

[0030] After the X-axis base member 30 having an intermediate flange section 31 is attached to both ends of the X-axis leg section 21 from the rear surface side, the X-axis winding wires 5a and 5b are wound, while after the Y-axis base member 40 having an intermediate flange section 41 is attached to both ends of both ends of the Y-axis leg section 22 from the rear surface side, the Y-axis winding wires 6a and 6b are wound. The X-axis base member 30 and the Y-axis base member 40 have approximately the same shape, and hence the configuration of the Y-axis base member 40 will be described with reference to FIG. 1 and FIG. 2.

[0031] The Y-axis base member 40 has, at the outer side end thereof, a substrate section 42 which is brought into contact with the rear surface of the outer flange 22c of the Y-axis leg section 22. Also, outer frame sections 43 located on both sides of the outer flange 22c of the Y-axis leg section 22 are provided on both X-axis direction sides of the substrate section 42. The outer frame section 43 has a recessed section 43a for winding the Z-axis winding wire, which recessed section is formed so as to be connected to the recessed core section 22d of the outer flanges 22c. The side bottom surface of the recessed section 43a is formed into a taper surface 43b which is inclined inward so as to be directed to an adjacent taper surface 33b of the X-axis base member 30. Similarly to the Y-axis base member 40, the X-axis base member 30 is formed to have a substrate section (not shown), an outer frame section 33, an outer winding frame 34 described below, the intermediate flange section 31, an inner winding frame 3S, and an inner flange 36.

[0032] Rod-shaped outer winding frames 44 extending along both sides of the outer winding section 22b of the Y-axis leg section 22 are successively provided on the inner side of the outer frame section 43 of the Y-axis base member 40. The intermediate flange section 41 is successively provided on the inner side of the outer winding frame 44. A rod-shaped inner winding frames 45 extending along both sides of the inner winding section 22a of the Y-axis leg section 22 is successively provided on the inner side of the intermediate flange section 41. Further, an inner flange 46 is successively provided at the inner end portion of the inner winding frame 45.

[0033] The intermediate flange section 41 is a member for separating the inner winding section 22a and the outer winding section 22b of the Y-axis leg section 22, that is, a member for separating the Y-axis winding frame section 4 into an inner winding frame section 4a and an outer winding frame section 4b. The intermediate flange section 41 has an opening on the central front surface side thereof, and the inner winding section 22a of the Y-axis leg section 22 is inserted through the opening. Further, the inner flange 46 is extended in the front and rear direction along both the side surfaces of the inner flange section 22t of the Y-axis leg section 22, so as to form a winding flange on the inner side of the inner winding frame section 4a.

[0034] As shown in FIG. 1, the outer winding frame 44 and the inner winding frame 45 are respectively extended in the axial direction of the Y-axis leg section 22 along the side surfaces of the outer winding section 22b and the inner winding section 22a of the Y-axis leg section 22. The front and rear surfaces of the outer and inner winding sections 22b and 22a of the Y-axis leg section 22 are opened by not providing the outer winding frame 44 and the inner winding frame 45, so that the Y-axis winding wires 6a and 6b described below are respectively wound around the outer and inner winding sections 22b and 22a.

[0035] In this way, the Y-axis base members 40 and 40 are provided respectively on both sides of the Y-axis leg section 22, and the Y-axis winding frame sections 4 and 4 are formed on both sides of the intersection 2s. Further, the intermediate flange sections 41 and 41 are provided, and thereby each of the Y-axis winding frame sections 4 and 4 is formed to be separated into a pair of the inner winding frame sections 4a and 4a and a pair of the outer winding frame sections 4b and 4b. The Y-axis winding wires (inner winding wires) 6a and 6a are respectively wound around the inner winding frame sections 4a and 4a respectively formed around the inner winding sections 22a and 22a, on both sides of which the inner winding frames 45 and 45 are located. Similarly, the Y-axis winding wire (outer winding wires) 6b and 6b are respectively wound around the outer winding frame sections 4b and 4b respectively formed around the outer winding sections 22b and 22b, on both sides of which the outer winding frames 44 and 44 are located.

[0036] The inner winding wire 6a is wound around the inner winding frame section 4a which, in the space formed by the intermediate flange section 41 and the inner flange 46 of the Y-axis base member 40, and by the inner flange section 22t, is formed by the outer periphery of the exposed front and rear surfaces of the inner winding section 22a of the Y-axis leg section 22 and the outer periphery of the inner winding frames 45 formed on both sides of the inner winding section 22a. Similarly, the outer winding wire 5b is wound around the outer winding frame section 4b which, in the space formed by the outer flange 43 of the Y-axis base member 40, the outer flange 22c of the Y-axis leg section 22, and the intermediate flange section 41, is formed by the outer periphery of the exposed front and rear surfaces of the outer winding section 22b of the Y-axis leg section 22 and the outer periphery of the outer winding frames 44 formed on both sides of the outer winding section 22b.

[0037] Similarly to the Y-axis leg section 22, the X-axis base members 30 and 30 are attached respectively on both sides of the X-axis leg section 21, and then the X-axis winding frame sections 3 and 3 are similarly formed on both sides of the intersection 2s. The intermediate flange sections 31 and 31 are provided so that inner winding frame sections 3a and 3a and outer winding frame sections 3b and 3b are respectively formed so as to allow the inner winding frame section 3a to be separated from the outer winding frame section 3b. Then, the X-axis winding wires 5a and 5b (inner winding wire and outer winding wire) are wound around the inner winding frame sections 3a and the outer winding frame sections 3b, respectively.

[0038] The intersection 21s located at the midpoint of the X-axis leg section 21 around which the X-axis winding wires 5a and 5b are wound as described above, and the intersection 22s located at the midpoint of the Y-axis leg section 22 around which the Y-axis winding wires 6a and 6b are wound, are combined with each other in the front and rear direction so that a cross shape is formed so as to allow both the rear surfaces of the X-axis base member 30 and of the Y-axis base member 40 to be located on the same plane. Thereafter, the Z-axis winding wire 7 is wound around the recessed (core) sections 21 d, 22d, 33a and 43a of the outer flanges 21 c, 22c, 33 and 43 formed respectively at the outer periphery of the X-axis leg section 21, the Y-axis leg section 22, the X-axis base member 30, and the Y-axis base member 40. Then, the outer periphery of the Z-axis winding wire 7 is covered with a resin molding or housed in a case as required, so that the three-dimensional antenna unit 1A is formed.

[0039] Note that each of the end portions of the X-axis winding wires 5a and 5b, the Y-axis winding wires 6a and 6b, and the Z-axis winding wire 7 is connected to each of the predetermine terminal sections 9.

[0040] In the X-axis winding wires 5a and 5b and the Y-axis winding wires 6a and 6b which are wound as described above, the inner winding wires 5a and 6a and the outer winding wires 5b and 6b are formed so that any of the winding dimensions of the inner winding wire 5a

and 6a, which dimensions include the inner peripheral dimension, the outer peripheral dimension, and the winding cross-sectional area, is smaller than any of the winding dimensions of the outer winding wire 5b and 6b. That is, by the formation of the intermediate flange sections 31 and 41, the X-axis winding wires 5a and 5b and the Y-axis winding wires 6a and 6b are separated into the inner winding frame sections 3 a and 4a and the outer winding frame sections 3b and 4b so that the winding frame shape (inner and outer peripheral dimensions) of the inner winding frame sections 3a and 4a is different from the winding frame shape of the outer winding frame sections 3b and 4b. Thereby, the X-axis winding wire 5a and 5b and the Y-axis winding wire 6a and 6b are arranged by effectively utilizing the inner space, so that the miniaturization of the three-dimensional antenna unit 1A is realized.

[0041] According to the present embodiment, the antenna characteristics (sensitivity performance, and the like) is improved by increasing the number of turns of the X-axis winding wire 5a and 5b and the Y-axis winding wire 6a and 6b and further by increasing the core cross-sectional area of the X-axis leg section 21 and the Y-axis leg section 22.

<Second to fourth embodiments>

[0042] Second to fourth embodiments shown in FIG. 3A, FIG. 3B to FIG. 5A, and FIG. 5B show typical configuration examples in which the antenna characteristics (sensitivity performance, and the like) of antenna coils 11 to 13 are improved. That is, in order to improve the antenna characteristics, it is effective means to increase the number of turns of the winding or to increase the cross-sectional area of the core, as described above. Accordingly, the second embodiment shown in FIG. 3A and FIG. 3B is an example in which the antenna characteristics are improved by increasing the number of turns of the winding, and the third embodiment shown in FIG. 4A and FIG. 4B is an example in which the antenna characteristics are improved by increasing the core cross-sectional area. Further, the fourth embodiment shown in FIG. 5A and FIG. 5B is an example in which the antenna characteristics are improved by increasing the number of turns of the winding and the core cross-sectional area.

[0043] First, in FIG. 3A and FIG. 3B showing a three-dimensional antenna unit 1B of the second embodiment, a core member 2 is formed into a cross shape having an intersection 2s, a rectangular plate-shaped X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a rectangular plate-shaped Y-axis leg section 22 protruding in the Y-axis (vertical) direction from both sides of the intersection 2s.

[0044] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame section 3b by a plate-shaped intermediate flange section 31 made of an insulating material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by a plate-shaped intermediate flange section 41 made of an insulating material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 31 and 41 are provided so as to extend in the Z-axis direction perpendicular to the respective protruding directions of the X-axis leg section 21 and the Y-axis leg section 22. Further, a rectangular-shaped outer flange 23 made of an insulating material is provided to surround the outer end portions of the X-axis leg section 21 and the Y-axis leg section 22 so as to connect the outer end portions with each other.

[0045] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a and the outer winding wire 5b are respectively wound around the inner winding frame section 3a and the outer winding frame section 3b which are divided from each other by the intermediate flange section 31. Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. The inner winding wire 6a and the outer winding wire 6b are respectively wound around the inner winding frame section 4a and the outer winding frame section 4b which are divided from each other by the intermediate flange section 41.

[0046] Further, in the X-axis winding wires 5a and 5b and the Y-axis winding wires 6a and 6b, the inner winding wires 5a and 6a respectively wound around the inner winding frame sections 3a and 4a, each of which is provided between each of the intermediate flange sections 31 and 41 and the intersection 2s of the core member 2 located on the inner side of the intermediate flange sections 31 and 41, are wound with a small number of turns so as not to interfere with each other. Also, the outer winding wires 5b and 6b respectively wound around the outer winding frame sections 3b and 4b, each of which is provided between each of the intermediate flange sections 31 and 41 and the outer flange 23 located on the outer side of the intermediate flange sections 31 and 41, are wound with a large number of turns in correspondence with the large side space and in the range in which the outer winding wires 5b and 6b do not interfere with each other. Further, a Z-axis winding wire 7 is provided by being wound around the outer periphery of the outer flange 23 in the peripheral direction, so that the three-dimensional antenna unit 1B is formed.

[0047] Thus, since the intermediate flange sections 31 and 41 are provided, the number of turns of the outer winding wires 5b and 6b is increased, and thereby the antenna characteristics are improved. In the second embodiment, as the number of turns of the outer winding

wires 5b and 6b is increased, the Z-axis direction height of the antenna coil 11 tends to be increased as shown in FIG. 3B.

[0048] Next, in FIG. 4A and FIG. 4B showing a three-dimensional antenna unit 1C of the third embodiment, a core member 2 is formed into a cross shape having an intersection 2s, a rectangular plate-shaped X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a rectangular plate-shaped Y-axis leg section 22 protruding in the Y-axis (vertical) direction from both sides of the intersection 2s.

[0049] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame section 3b by a plate-shaped intermediate flange section 31 made of an insulating material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by a plate-shaped intermediate flange section 41 made of the insulating material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 31 and 41 are provided so as to extend in the Z-axis direction perpendicular to the directions in which the X-axis leg section 21 and the Y-axis leg section 22 are made to protrude respectively. Further, an outer flange 23 made of a rectangular-shaped insulating material is provided to surround the outer end portions of the X-axis leg section 21 and the Y-axis leg section 22 so as to connect the outer end portions with each other.

[0050] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a and the outer winding wire 5b are respectively wound around the inner winding frame section 3 a and the outer winding frame section 3b which are divided from each other by the intermediate flange section 31. Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. The inner winding wire 6a and the outer winding wire 6b are respectively wound around the inner winding frame section 4a and the outer winding frame section 4b which are divided from each other by the intermediate flange section 41.

[0051] In this case, in the X-axis winding frame section 3 and the Y-axis winding frame section 4, in the range in which the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2 do not interfere with each other, the X-axis leg section 21 and the Y-axis leg section 22 are respectively formed to have a narrow width in the inner winding sections 21a and 22a corresponding to the inner winding frame sections 3a and 4a, and are respectively formed to have a wide width in the outer winding sections 21b and 22b corresponding to the outer winding frame sections 3b and 4b. Further, the number of turns (winding thickness) of the inner winding wire 5a and 6a wound around the inner winding sections 21a and 22a is set to be equal to the number of turns of the outer winding wire 5b and 6b wound around the outer winding sections 21b and 22b. Further, a Z-axis winding wire 7 is provided by being wound around the outer periphery of the outer flange 23 in the peripheral direction, so that the three-dimensional antenna unit 1C is formed.

[0052] Thus, since the intermediate flange sections 31 and 41 are provided, the core cross-sectional area of the outer winding sections 21b and 22b on the outer side of the intermediate flange sections 31 and 41 is increased in the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2, and thereby the antenna characteristics are improved. In the third embodiment, since the number of turns of the outer winding wires 5b and 6b is equal to the number of turns of the inner winding wires 5a and 6a, it is possible to make short the Z-axis direction height of the antenna coil 12 as shown in FIG. 4B.

[0053] Next, in FIG. 5A and FIG. 5B showing a three-dimensional antenna unit 1D of the fourth embodiment, a core member 2 is formed into a cross shape having an intersection 2s, a plate-shaped X-axis leg section 21 which is formed to protrude in the X-axis (right and left) direction from both sides of the intersection 2s and the thickness of which is changed in the interval on both sides of the intersection 2s, and a plate-shaped Y-axis leg section 22 which is formed to protrude in the Y-axis (vertical) direction from both sides of the intersection 2s and the thickness of which is changed in the interval on both sides of the intersection 2s.

[0054] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame section 3b by a plate-shaped intermediate flange section 31 made of an insulating material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by a plate-shaped intermediate flange section 41 made of the insulating material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 31 and 41 are provided so as to extend in the Z-axis direction perpendicular to the directions in which the X-axis leg section 21 and the Y-axis leg section 22 are made to protrude respectively. Further, an outer flange 23 made of a rectangular-shaped insulating material is provided to surround the outer end portions of the X-axis leg section 21 and the Y-axis leg section 22 so as to connect the outer end portions with each other.

[0055] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a and the outer winding wire 5b are respectively wound around the inner winding frame section

3 a and the outer winding frame section 3b which are divided from each other by the intermediate flange section 31. Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. The inner winding wire 6a and the outer winding wire 6b are respectively wound around the inner winding frame section 4a and the outer winding frame section 4b which are divided from each other by the intermediate flange section 41.

[0056] In this case, in the X-axis winding frame section 3 and the Y-axis winding frame section 4, the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2 are respectively formed to have a narrow width in inner winding sections 21a and 22a corresponding to the inner winding frame sections 3a and 4a, and are respectively formed to have a wide width in outer winding sections 21b and 22b corresponding to the outer winding frame sections 3b and 4b. Further, the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2 are respectively formed to have a large thickness in the inner winding sections 21 a and 22a and are respectively formed to have a small thickness in the outer winding sections 21b and 22b. Further, in the X-axis winding wires 5a and 5b and the Y-axis winding wires 6a and 6b, the inner winding wires 5a and 6a respectively wound around the inner winding frame sections 3a and 4a, each of which is provided between each of the intermediate flange sections 31 and 41 and the intersection 2s of the core member 2 located on the inner side of the intermediate flange sections 31 and 41, are wound with a small number of turns so as not to interfere with each other. The outer winding wires 5b and 6b respectively wound around the outer winding frame sections 3b and 4b, each of which is provided between each of the intermediate flange sections 31 and 41 and the outer flange 23 provided on the outer side of the intermediate flange sections 31 and 41, are wound with a large number of turns in correspondence with the large side space and in the range in which the outer winding wires 5b and 6b do not interfere with each other. Further, a Z-axis winding wire 7 is provided by being wound around the outer periphery of the outer flange 23 in the peripheral direction, so that the three-dimensional antenna unit 1D is formed.

[0057] Thus, since the intermediate flange sections 31 and 41 are provided, the number of turns of the outer winding wires 5b and 6b, and the core cross-sectional area of the outer winding sections 21b and 22b on the outer side of the intermediate flange sections 31 and 41 are increased, and thereby the antenna characteristics are improved. In the fourth embodiment, as shown in FIG. 5B, although the Z-axis direction height of the antenna coil 13 is lower than the Z-axis direction height of the antenna coil 11 of the second embodiment, the Z-axis direction height of the antenna coil 13 tends to be increased to be higher than the Z-axis direction height of the antenna coil 12 of the third embodiment, as the number of turns of the outer winding wires 5b and 6b is increased.

<Fifth and sixth embodiments>

[0058] The above described embodiments show configurations in which the intermediate flange sections 31 and 41 formed in the winding frame sections 3 and 4 are formed of an insulating member separately from the core member 2. However, each of fifth and sixth embodiments shown in FIG. 6 and FIG. 7 shows an embodiment in which the intermediate flange sections 31 and 41 are formed by the core member 2. Further, the fifth and sixth embodiments respectively show two typical configuration examples for improving the antenna characteristics (sensitivity performance, and the like) of antenna coils 14 and 15. That is, in order to improve the antenna characteristics, it is effective means to increase the number of turns of the winding or to increase the cross-sectional area of the core, as described above. Accordingly, the fifth embodiment shown in FIG. 6 is an example in which the antenna characteristics are improved by increasing the number of turns of the winding, and the sixth embodiment shown in FIG. 7 is an example in which the antenna characteristics are improved by increasing the core cross-sectional area.

[0059] First, in FIG. 6 showing the antenna coil 14 of the fifth embodiment, a core member 2 is formed into a cross shape having an intersection 2s, a X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a Y-axis leg section 22 protruding in the Y-axis (vertical) direction from both sides of the intersection 2s.

[0060] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame sections 3b by a plate-shaped intermediate flange section 24 made of the core material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by a plate-shaped intermediate flange section 25 made of the core material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 24 and 25 are provided so as to extend in the Z-axis direction perpendicular to the directions in which the X-axis leg section 21 and Y-axis leg section 22 are made to protrude respectively. Further, outer flanges 26 and 27 made of the core material are respectively provided at the outer ends of the X-axis leg section 21 and the Y-axis leg section 22 so as to be in parallel with the intermediate flange sections 24 and 25, respectively.

[0061] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a and the outer winding wire 5b are respectively wound around the inner winding frame section

3a and the outer winding frame section 3b which are divided from each other by the intermediate flange section 24. Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. The inner winding wire 6a and the outer winding wire 6b are respectively wound around the inner winding frame section 4a and the outer winding frame section 4b which are divided from each other by the intermediate flange section 25.

[0062] Further, in the X-axis winding wires 5a and 5b and the Y-axis winding wires 6a and 6b, the inner winding wires 5a and 6a respectively wound around the inner winding frame sections 3a and 4a, each of which is provided between each of the intermediate flange sections 24 and 25 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange sections 24 and 25, are wound with a small number of turns so as not to interfere with each other. Also, the outer winding wires 5b and 6b respectively wound around the outer winding frame sections 3b and 4b, each of which is provided between each of the intermediate flange sections 24 and 25 and each of the outer flanges 26 and 27 respectively provided on the outer side of the intermediate flange sections 24 and 25, are wound with a large number of turns in correspondence with the large side space and in the range in which the outer winding wires 5b and 6b do not interfere with each other. Thereby, the antenna coil 14 is formed.

[0063] In the present embodiment, the intermediate flange sections 24 and 25 and the outer flanges 26 and 27, which are made of the core material, are provided, so that the base members are unnecessary for the winding frame sections 3 and 4. Further, the antenna characteristics are improved as the number of turns of the outer winding wire 5b and 6b is increased. In the fifth embodiment, similarly to the second embodiment, as the number of turns of the outer winding wires 5b and 6b is increased, the Z-axis direction height of the antenna coil 14 tends to be increased.

[0064] Next, in FIG. 7 showing the antenna coil 15 of the sixth embodiment, a core member 2 is formed into a cross shape having an intersection 2s, an X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a Y-axis leg section 22 protruding in the Y-axis (vertical) direction from both sides of the intersection 2s.

[0065] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame sections. 3b by a plate-shaped intermediate flange section 24 made of the core material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame sections 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by a plate-shaped intermediate flange section 25 made of the core material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 24 and 25 are provided so as to extend in the Z-axis direction perpendicular to the directions in which the X-axis leg section 21 and Y-axis leg section 22 are made to protrude respectively. Further, outer flanges 26 and 27 made of the core material are respectively provided at the outer ends of the X-axis leg section 21 and the Y-axis leg section 22 so as to be in parallel with the intermediate sections 24 and 25, respectively.

[0066] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a is wound around the inner winding frame section 3a which is divided by the intermediate flange section 24 so as to be provided between the intermediate flange section 24 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange section 24, while the outer winding wire 5b is wound around the outer winding frame section 3b which is divided by the intermediate flange section 24 so as to be provided between the intermediate flange section 24 and the outer flange 26. Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. Similarly, the inner winding wire 6a is wound around the inner winding frame section 4a which is divided by the intermediate flange section 25 so as to be provided between the intermediate flange section 25 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange section 25, while the outer winding wire 6b is wound around the outer winding frame section 4b which is divided by the intermediate flange section 25 so as to be provided between the intermediate flange section 25 and the outer flange 27.

[0067] In this case, in the X-axis winding frame section 3 and the Y-axis winding frame section 4, in the range in which the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2 do not interfere with each other, the width of inner winding sections 21a and 22a corresponding to the inner winding frame sections 3a and 4a is narrowed, and the width of outer winding sections 21b and 22b corresponding to the outer winding frame sections 3b and 4b is increased. Further, the number of turns (winding thickness) of the inner winding wires 5a and 6a respectively wound around the inner winding sections 21a and 22a is set to be equal to the number of turns of the outer winding wires 5b and 6b respectively wound around the outer winding sections 21b and 22b, so that the antenna coil 15 is formed.

[0068] In the present embodiment, since the intermediate flange sections 24 and 25 and the outer flanges 26 and 27, which are made of the core material, are provided, the base members are unnecessary for the winding frame sections 3 and 4. Further, in the X-axis leg section 21 and the Y-axis leg section 22 of the core member 2, the antenna characteristics are improved as the cross-sectional area of the outer winding sections 21b and 22b

respectively provided on the outer sides of the intermediate flange sections 24 and 25 is increased. In the sixth embodiment, similarly to the third embodiment, since the number of turns of the outer winding wires 5b and 6b is equal to the number of turns of the inner winding wires 5a and 6a, the Z-axis direction height of the antenna coil 15 is made short.

<Seventh and eighth embodiments>

[0069] In the above described embodiments, the core member 2 is formed into the cross shape in which the X-axis leg section 21 and the Y-axis leg section 22 are made to cross at the midpoint thereof. However, seventh and eighth embodiments shown in FIG. 8 and FIG. 9 respectively show embodiments in which the core member 2 is formed into a T-shape. Further, the seventh embodiment shown in FIG. 8 is an example in which only the Y-axis winding frame section 4 is divided by the intermediate flange section 41. The eighth embodiment shown in FIG. 9 is an example in which the X-axis winding frame section 3 is also divided by the intermediate flange section 31.

[0070] First, in FIG. 8 showing an antenna coil 16 of the seventh embodiment, a core member 2 is formed into a T-shape having an intersection 2s, an X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a Y-axis leg section 22 protruding in the Y-axis direction (downward) from the intersection 2s.

[0071] Outer flanges 26 and 26 made of the core material are formed at both the side end portions of the X-axis leg sections 21, and X-axis winding wires 5 and 5 are respectively wound around X-axis winding frame sections 3 and 3 which are respectively formed around the outer periphery of the X-axis leg sections 21 and between the outer flange 26 and the side surface of the intersection 2s of the core member 2.

[0072] Further, a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by the plate-shaped intermediate flange section 41 made of an insulating material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange section 41 is provided so as to extend in the Z-axis direction perpendicular to the protruding direction of the Y-axis leg section 22. Further, an outer flange 27 made of the core material is provided at the outer end of the Y-axis leg section 22 so as to be in parallel with the intermediate flange section 41.

[0073] Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. The inner winding wire 6a is wound around the inner winding frame section 4a which is divided by the intermediate flange section 41 so as to be provided between the intermediate flange section 41 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange section 41, while the outer winding wire 6b is wound around the outer winding frame section 4b which is divided by the intermediate flange section 41 so as to be provided between the intermediate flange section 41 and the outer flange 27.

[0074] In this case, in the Y-axis winding frame section 4, the Y-axis leg section 22 of the core member 2 is formed to have a narrow width in an inner winding section 22a corresponding to the inner winding frame sections 4a and is formed to have a wide width in an outer winding section 22b corresponding to the outer winding frame section 4b. Further, the number of turns (winding thickness) of the inner winding wire wound around the inner winding section 22a is set to be equal to the number of turns of the outer winding wire of the outer winding section 22b, so that the antenna coil 16 is formed.

[0075] Next, in FIG. 9 showing an antenna coil 17 of the eighth embodiment, a core member 2 is formed into a T-shape having an intersection 2s, an X-axis leg section 21 protruding in the X-axis (right and left) direction from both sides of the intersection 2s, and a Y-axis leg section 22 protruding in the Y-axis direction (downward) from the intersection 2s.

[0076] An X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21 is divided into an inner winding frame section 3a and an outer winding frame sections 3b by the plate-shaped intermediate flange section 31 made of an insulating material and provided in an intermediate portion of the X-axis leg section 21, while a Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22 is divided into an inner winding frame section 4a and an outer winding frame section 4b by the plate-shaped intermediate flange section 41 made of the insulating material and provided in an intermediate portion of the Y-axis winding frame section 4. The intermediate flange sections 31 and 41 are provided so as to extend in the Z-axis direction perpendicular to the directions in which the X-axis leg section 21 and Y-axis leg section 22 are made to protrude respectively. Further, outer flanges 26 and 27 made of the core material are respectively provided at the outer ends of the X-axis leg section 21 and the Y-axis leg section 22 so as to be in parallel with the intermediate flange sections 31 and 41, respectively.

[0077] X-axis winding wires 5a and 5b are wound around the X-axis winding frame section 3 formed around the outer periphery of the X-axis leg section 21. The inner winding wire 5a is wound around the inner winding frame section 3 a which is divided by the intermediate flange section 31 so as to be provided between the intermediate flange section 31 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange section 31, while the outer winding wire 5b is wound around the outer winding frame section 3b which is divided by the intermediate flange section 31 so as to be provided between the intermediate flange section 31 and

the outer flange 26. In this case, in the X-axis winding frame section 3, the X-axis leg section 21 of the core member 2 is formed to have a narrow width in an inner winding section 21 a corresponding to the inner winding frame section 3 a and to have a wide width in an outer winding section 21b corresponding to the outer winding frame section 3b. Further, the number of turns (winding thickness) of the inner winding wire 5a wound around the inner winding section 21 a is set to be equal to the number of turns of the outer winding wire 5b wound around the outer winding section 21b. Further, the inner winding section 21a is formed to be eccentric to the outer winding section 21b. The intersection 2s, the inner winding wire 5a, the intermediate flange section 31, the outer winding wire 5b, and the outer flange 26 are configured so that the upper edge portions thereof in FIG. 9 are arranged on the same straight line.

[0078] Further, Y-axis winding wires 6a and 6b are wound around the Y-axis winding frame section 4 formed around the outer periphery of the Y-axis leg section 22. Similarly, the inner winding wire 6a is wound around the inner winding frame section 4a which is divided by the intermediate flange section 41 so as to be provided between the intermediate flange section 41 and the intersection 2s of the core member 2 provided on the inner side of the intermediate flange section 41, and the outer winding wire 6b is wound around the outer winding frame section 4b which is divided by the intermediate flange section 41 so as to be provided between the intermediate flange section 41 and the outer flange 27. In this case, in the Y-axis winding frame section 4, the Y-axis leg section 22 of the core member 2 is formed to have a narrow width in an inner winding section 22a corresponding to the inner winding frame sections 4a and is formed to have a wide width in an outer winding section 22b corresponding to the outer winding frame section 4b. Further, in the Y-axis winding wires 6a and 6b, the number of turns (winding thickness) of the inner winding wire 6a wound around the inner winding section 22a is made small, and the number of turns of the outer winding wire 6b wound around the outer winding section 22b is increased in correspondence with the large side space. Thereby, the antenna coil 17 is formed.

[0079] As described above, the embodiments of the antenna coils 10 to 17 according to the present invention and the three-dimensional antenna units 1A to 1D provided with the antenna coils are described, but the present invention is not limited to the above described embodiments. The embodiments of the present invention may be modified into various other forms.

[0080] For example, the above described embodiments show the examples in which the X-axis winding frame section 3 or the Y-axis winding frame section 4 is divided into the two winding frame sections 3a and 3b or the two winding frame sections 4a and 4b by providing the intermediate flange section. However, the X-axis winding frame section 3 or the Y-axis winding frame section 4 may be divided into more than two winding frame sections.

[0081] Further, a division example in which the.winding shapes of the X-axis winding wire 5a and 5b and the Y-axis winding wire 6a and 6b are enlarged toward the outer side is shown, but the present invention is not limited to this. However, the winding wires may also be divided and formed so that the winding shapes of the winding wires are made small toward the outer side. As an example of such configuration, in an antenna unit which has a rectangular shape as a whole, and in which an X-axis leg section 21 and a Y-axis leg section 22 are provided so as to extend toward the corner portions of the rectangular shape so that the side space of each of the leg sections is narrowed at the outer peripheral portion, the inner space of the antenna unit may be effectively used in such a manner that the winding frame section on each side of the midpoint of the leg section is divided into three sections, and that the winding shape of the intermediate section is enlarged and the winding shape of the inner and outer side sections is made small.

[0082] Further, the position, at which the intermediate flange section is provided, is not limited to the middle position of the X-axis winding frame section 3 and the Y-axis winding frame section 4, and may be a position deviated to the inner side or the outer side in correspondence with the required antenna characteristics.

[0083] Further, an antenna coil may also be configured in such a manner that the intermediate flange section is formed in a bobbin and the winding wire is wound around the bobbin beforehand, and that the bobbin is then attached to the outer periphery of the X-axis leg section 21 or the Y-axis leg section 22 of the core member 2.

[0084] The antenna coil according to the present invention includes the core member having the X-axis and Y-axis leg sections respectively protruding in the X-axis and Y-axis directions from the intersection of the core member, and the X-axis and Y-axis winding wires respectively wound around the outer periphery of the X-axis and Y-axis leg sections, and is featured in that at least one of the X-axis winding frame section for the X-axis winding wire, which frame section is provided at the X-axis leg section, and the Y-axis winding frame section for the Y-axis winding wire, which frame section is provided at the Y-axis leg section, has the intermediate flange section for separating the winding frame section into at least two winding frame sections for different winding shapes.

[0085] Therefore, since the intermediate flange section is provided, the number of turns of the winding wound around the winding frame section provided at the outer periphery of the X-axis and Y-axis leg sections or the cross sectional area of the core member can be increased without collapse of the winding wires. Thereby, the sensitivity of the antenna can be improved, and the antenna coil can be compactly configured by effectively using the outer space between the X-axis and the Y-axis leg sections.

[0086] Further, when the core member is formed into

a cross shape in which the X-axis leg section and the Y-axis leg section intersect each other at the midpoint thereof, and particularly when the X-axis leg section and the Y-axis leg section are configured to respectively include, on both sides of the midpoint of thereof, the X-axis and Y-axis winding frame sections respectively having the intermediate flange section so that each of the winding frame sections is separated into a plurality of winding frame sections by the intermediate flange section, the outer space between the X-axis leg section and the Y-axis leg section can be more effectively used, and hence an antenna coil having excellent characteristics can be obtained while securing miniaturization.

[0087] In an antenna coil which includes a core member having an X-axis leg section protruding in the X-axis direction from an intersection of the core member and having a Y-axis leg section protruding in the Y-axis direction from the intersection, X-axis winding wires wound around the outer periphery of the X-axis leg section, and Y-axis winding wires wound around the outer periphery of the Y-axis leg section, at least one of an X-axis winding frame section for the X-axis winding wire, the X-axis winding frame section being provided at the X-axis leg section, and a Y-axis winding frame section for the Y-axis winding wire, the Y-axis winding frame section being provided at the Y-axis leg section, has one of intermediate flange sections for respectively separating the X-axis winding frame section and the Y-axis winding frame section into a pair of winding frame sections and a pair of winding frame sections, the winding frame sections of each of the pairs corresponding to different winding shapes.

Claims

1. An antenna coil including a core member having an X-axis leg section protruding in the X-axis direction from an intersection of the core member and having a Y-axis leg section protruding in the Y-axis direction from the intersection, and an X-axis winding wire wound around the outer periphery of the X-axis leg section, and a Y-axis winding wire wound around the outer periphery of the Y-axis leg section.

2. The antenna coil according to claim 1, wherein the antenna coil further includes an X-axis winding frame section for the X-axis winding wire, the X-axis winding frame section being provided at the X-axis leg section, a Y-axis winding frame section (4) for the Y-axis winding wire, the Y-axis winding frame section being provided at the Y-axis leg section (22),
a substrate section (42) at the outer side end of the Y-axis leg section (22), and
outer frame sections (43) being provided on both X-axis direction sides of the substrate section,
the outer frame sections having a recessed section (43a) for winding Z-axis winding wire, wherein
side bottom surface of the recessed section is formed into a taper surface (43b) which is inclined inward so as to be directed to an adjacent taper surface (33b) of an X-axis winding shaft portion.

3. The antenna coil according to claim 1 or 2, wherein at least one of an X-axis winding frame section for the X-axis winding wire, the X-axis winding frame section being provided at the X-axis leg section, and a Y-axis winding frame section for the Y-axis winding wire, the Y-axis winding frame section being provided at the Y-axis leg section, comprises an intermediate flange section for separating the winding frame section into at least two winding frame sections for different winding shapes.

4. The antenna coil according to any one of claims 1 to 3, wherein the core member is formed into a cross shape in which the X-axis leg section and the Y-axis leg section are made to cross each other at the midpoint of the X-axis leg section and the Y-axis leg section.

5. The antenna coil according to claim 4, wherein
the X-axis leg section comprises the X-axis winding frame sections provided on both sides of the midpoint of the X-axis leg section;
the Y-axis leg section (22) comprises the Y-axis winding frame sections (4) provided on both sides of the midpoint of the Y-axis leg section (22); and
each of the X-axis winding frame section and the Y-axis winding frame section comprises the intermediate flange section so that each of the winding frame sections is divided by the intermediate flange section into a plurality of winding frame sections.

6. The antenna coil according to claim 5, wherein the core member is formed into a T-shape in which the X-axis leg section and the Y-axis leg section are made to cross each other at the end of one of the X-axis leg section and the Y-axis leg section.

7. The antenna coil according to any one of claims 3 to 6, wherein the intermediate flange section is formed into a plate-shaped intermediate flange section made of the core member.

8. The antenna coil according to any one of claims 3 to 7, wherein an outer flange section made of the core member is provided at the outer end of the X-axis leg section and the Y-axis leg section so as to be in parallel with the intermediate flange section.

9. The antenna coil according to claim 7 or 8, wherein the inner winding wire wound around the inner winding frame section provided on the inner side of the intermediate flange section is wound with a smaller number of turns, and the outer winding wire wound around the outer winding frame section provided on

the outer side of the intermediate flange section is wound with a larger number of turns.

10. The antenna coil according to claim 7 or 8, wherein the width of the X-axis leg section and the Y-axis leg section is made smaller in an inner winding section corresponding to the inner winding frame section provided on the inner side of the intermediate flange section, and is made larger in the outer winding section corresponding to the outer winding frame section provided on the outer side of the intermediate flange section.

11. The antenna coil according to any one of claims 1 to 10, wherein a Z-axis winding wire is wound around the peripheral portion of the antenna coil in the peripheral direction.

12. The antenna coil according to any one of claims 3 to 11, wherein the winding frame sections separated by the intermediate flange section are configured such that at least either the number of turns of the winding or the cross-sectional area of the core member is different between the winding frame sections.

13. The antenna coil according to claim 4, wherein the core member comprises at least two portions, each of which being in a rod shape and the intersection (22s) crossing thereof is deviated to the front surface side so as to be formed in a plate shape for connecting the Y-axis winding frame sections provided on both sides of the midpoint of the Y-axis leg section.

14. The antenna coil according to claim 13, wherein inner flange sections (22t, 22t) extending in the front and rear direction are successively provided on both sides of the intersection, and a recessed section (22f) is formed behind the intersection so that the inner flange sections protrude in the rear direction.

15. The antenna coil according to claim 14, wherein the inner winding sections (22a, 22a) serving as winding shaft portions are successively provided on the outer side of the inner flange sections.

16. The antenna coil according to claim 15, wherein the inner winding sections are formed to have a width slightly smaller than the width of the intersection.

17. The antenna coil according to claim 15, wherein on the outer side of the inner winding sections, outer winding sections (22b, 22b), each of which has a larger X-axis direction width and a smaller Z-axis direction thickness than the inner winding section, are successively provided so that step sections are formed on both sides of each of the outer winding sections.

18. The antenna coil according to claim 17, wherein on both outer ends of the outer winding sections, outer flanges (22c, 22c) are successively provided so as to have the same X-axis direction width as and a larger Z-axis direction thickness than the outer winding section, and in the outer end surface of each of the outer flanges, a recessed core section (22d) extending in the X-axis direction for winding the Z-axis winding wire is provided.

19. Method for manufacturing an antenna coil including a core member having an X-axis leg section protruding in the X-axis direction from an intersection of the core member and a Y-axis leg section protruding in the Y-axis direction from the intersection, an X-axis winding wire wound around the outer periphery of the X-axis leg section, and a Y-axis winding wire wound around the outer periphery of the Y-axis leg section comprises the steps of:

winding X-axis winding wires (5a, 5b) and Y-axis winding wires (6a, 6b) around outer peripheries of the X-axis leg section and the Y-axis leg section respectively; and

assembling a core member having the X-axis leg section protruding in the X-axis direction and a core member having the Y-axis leg section protruding in the Y-axis direction at an intersection.

20. The method for manufacturing the antenna coil according to claim 19, wherein in the winding step of X-axis winding wires and Y-axis winding wires around outer peripheries of the X-axis leg section and the Y-axis leg section respectively, after an X-axis base member and a Y-axis base member having intermediate flange sections are attached to both ends of the X-axis leg section and the Y-axis leg section from the rear surface side, the X-axis winding wires and the Y-axis winding wires are wound.

21. The method for manufacturing the antenna coil according to claim 19, wherein in the assembling step of the core member having the X-axis leg section protruding in the X-axis direction and the core member having the Y-axis leg section protruding in the Y-axis direction at the intersection, the core member having the X-axis leg section protruding in the X-axis direction and the core member having the Y-axis leg section protruding in the Y-axis direction are combined with each other such that both the rear surfaces of the X-axis base member and of the Y-axis base member are to be located on the same plane.

22. The method for manufacturing the antenna coil according to claim 20 or 21, further comprising the step of winding Z-axis winding wire around the outer periphery of the X-axis leg section, the Y-axis leg sec-

tion, the X-axis base member, and the Y-axis base member after the assembling step of the core member having the X-axis leg section protruding in the X-axis direction and the core member having the Y-axis leg section protruding in the Y-axis direction at the intersection.

23. The method for manufacturing the antenna coil according to any one of claims 19 to 22, further comprising the step of covering the outer periphery of the Z-axis winding wire with a resin mold or a case.

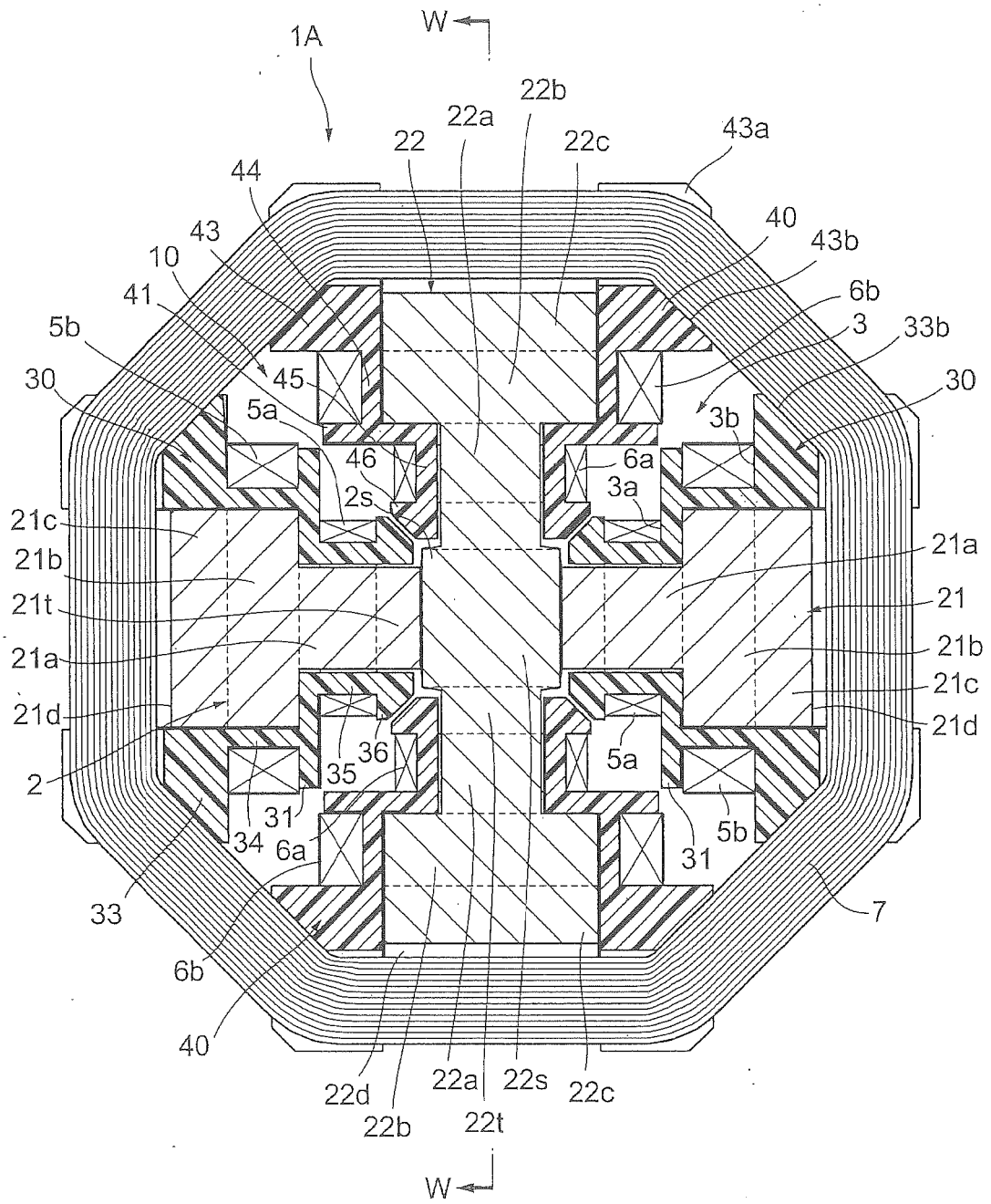

1A
W
22
22a
22b
22c
43a
44
43
40
43b
10
41
6b
5b
3
33b
45
30
30
5a
3b
46
6a
2s
3a
21c
21a
21b
21
21t
21b
21a
21c
21d
21d
36
35
5a
2
31
34
6a
5b
31
33
7
6b
40
22d
22a
22s
22c
22b
22t
W

Fig.1

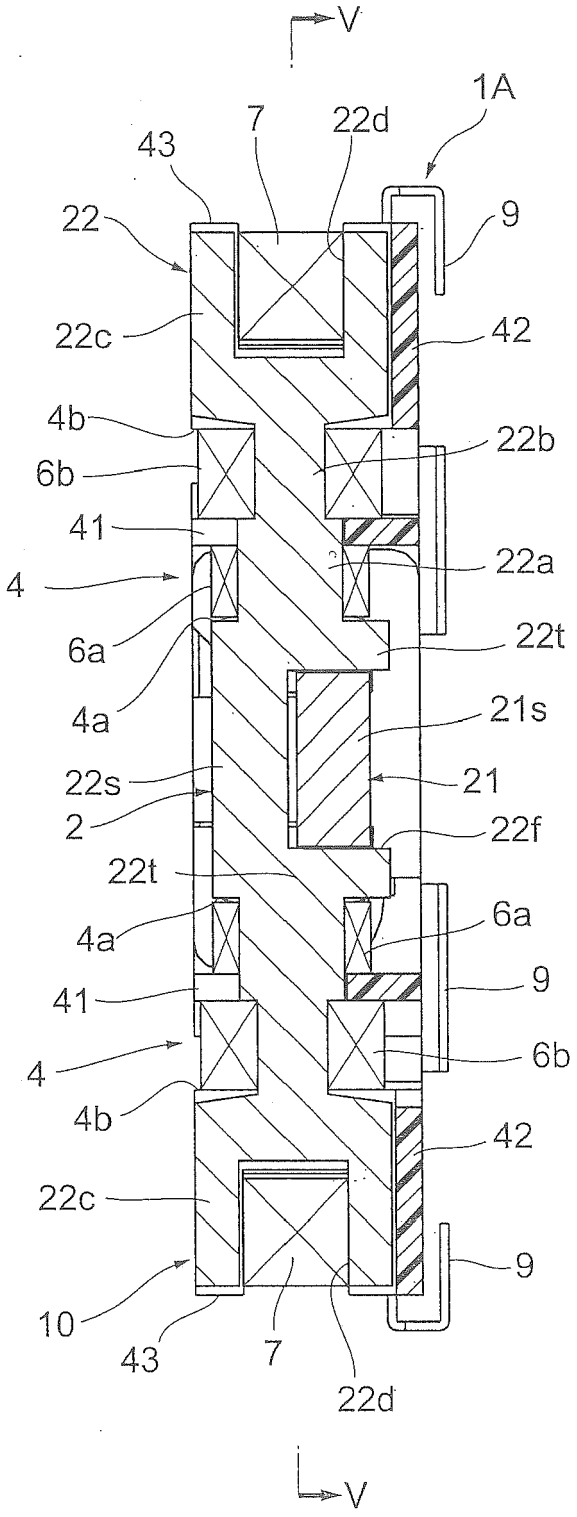

V
1A
7
22d
43
22
9
22c
42
4b
22b
6b
41
22a
4
6a
22t
4a
21s
22s
21
2
22f
22t
6a
4a
9
41
6b
4
4b
42
22c
9
10
43
7
22d
V

Fig.2

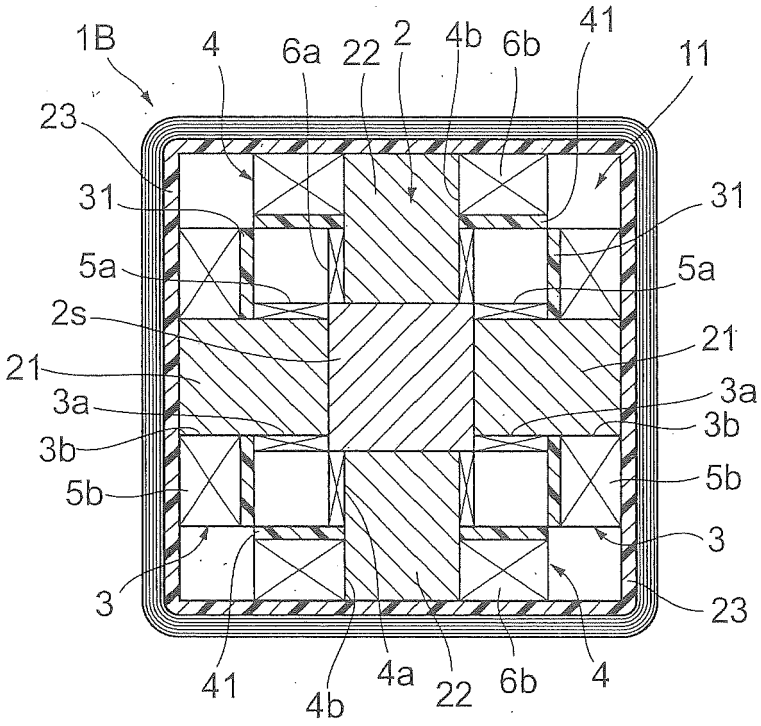

1B
4
6a
22
2
4b
6b
41
11
23
31
31
5a
5a
2s
21
21
3a
3a
3b
3b
5b
5b
3
3
23
41
4b
4a
22
6b
4

Fig.3A

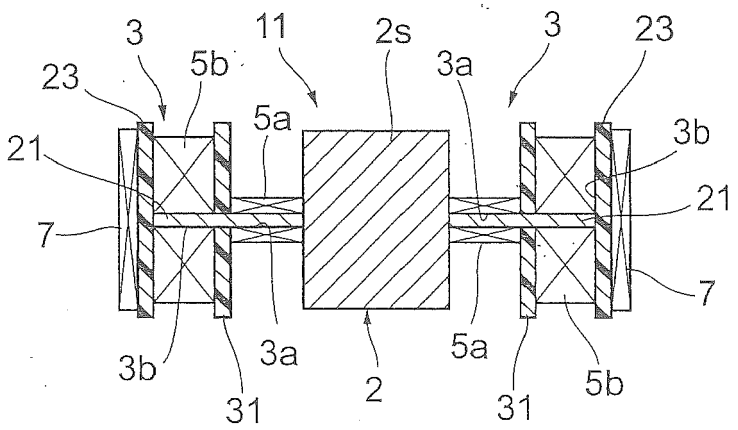
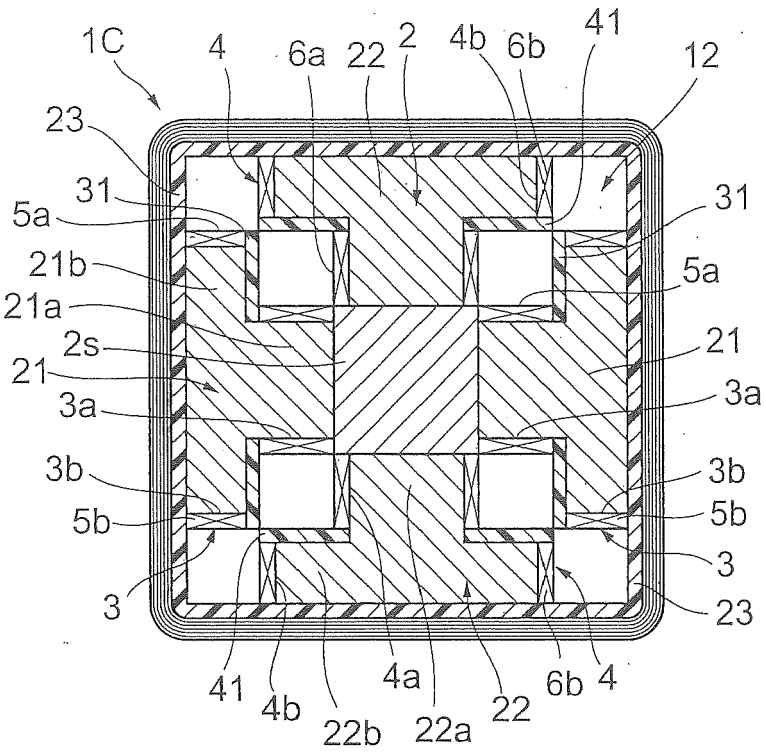

3
11
2s
3
23
23
5b
3a
5a
3b
21
21
7
7
3b
3a
5a
5b
31
2
31

Fig.3B


1C
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6a
22
2
4b
6b
41
12
23
31
5a
21b
21a
2s
21
3a
3b
5b
3
41
4b
22b
4a
22a
22
6b
4

Fig.4A

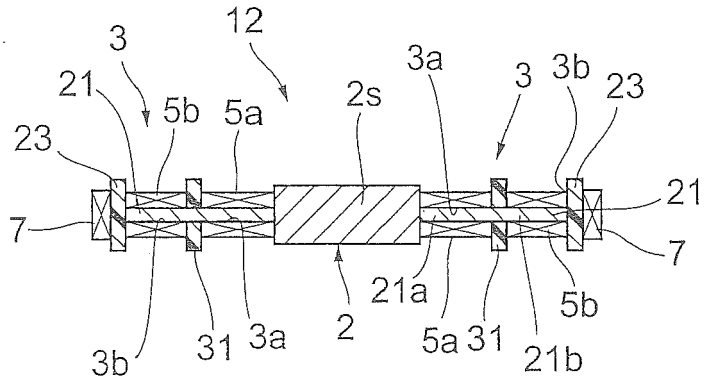
12
3
21
5b
5a
2s
3a
3
3b
23
23
7
21
21a
5b
2
3b
31
3a
5a
31
21b

Fig.4B

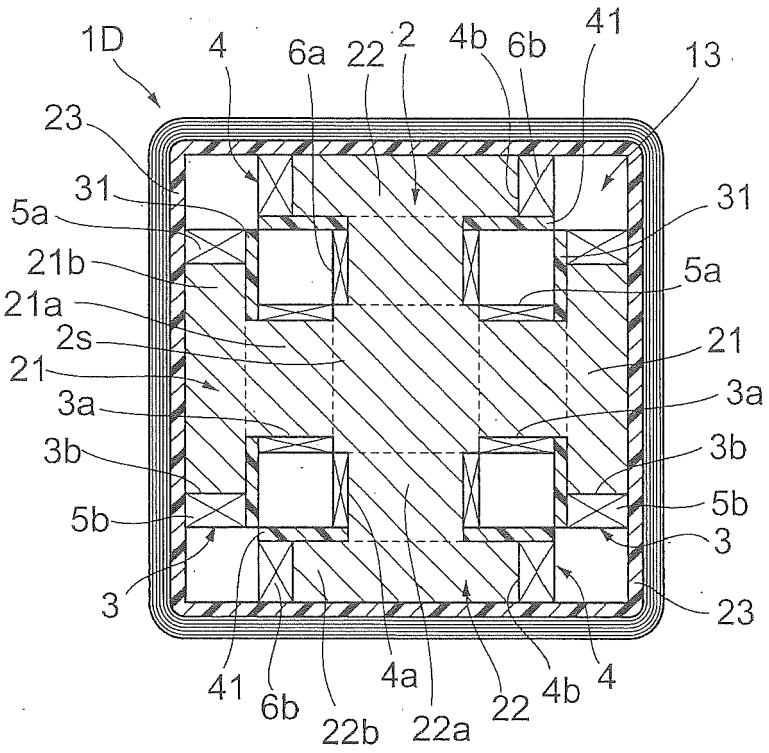
1D
4
6a
22
2
4b
6b
41
13
23
31
5a
21b
21a
2s
21
3a
3b
5b
3
41
6b
22b
22a
4a
22
4b
4
23
3
5b
5a
21
3a
3b
5b
3
31

Fig.5A

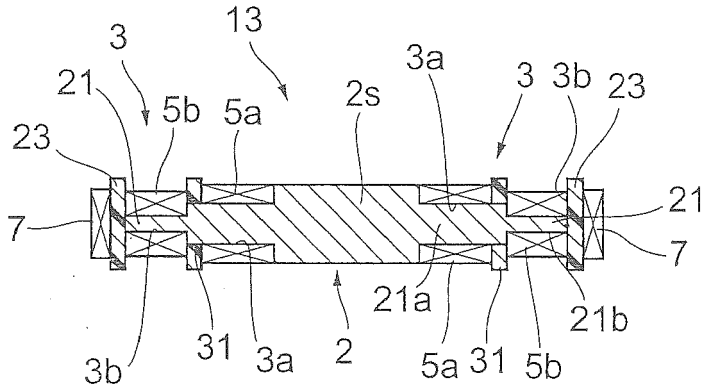
13
3
21
5b
5a
2s
3a
3
3b
23
23
7
21
7
3b
31
3a
2
21a
5a
31
5b
21b

Fig.5B

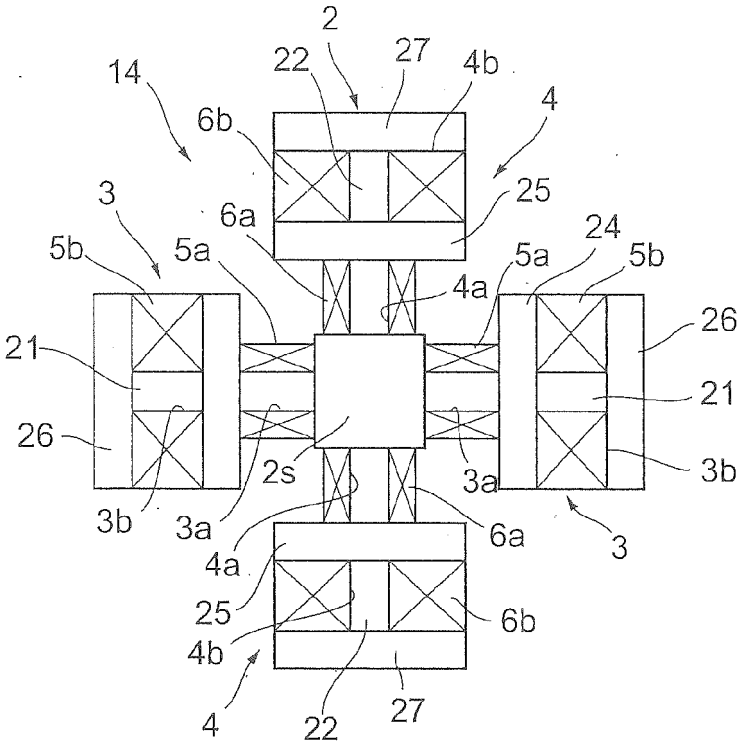
2
22
27
4b
14
6b
4
25
3
6a
24
5b
5a
5a
5b
4a
26
21
21
26
3b
2s
3a
3b
3a
6a
3
4a
25
6b
4b
4
22
27

Fig.6

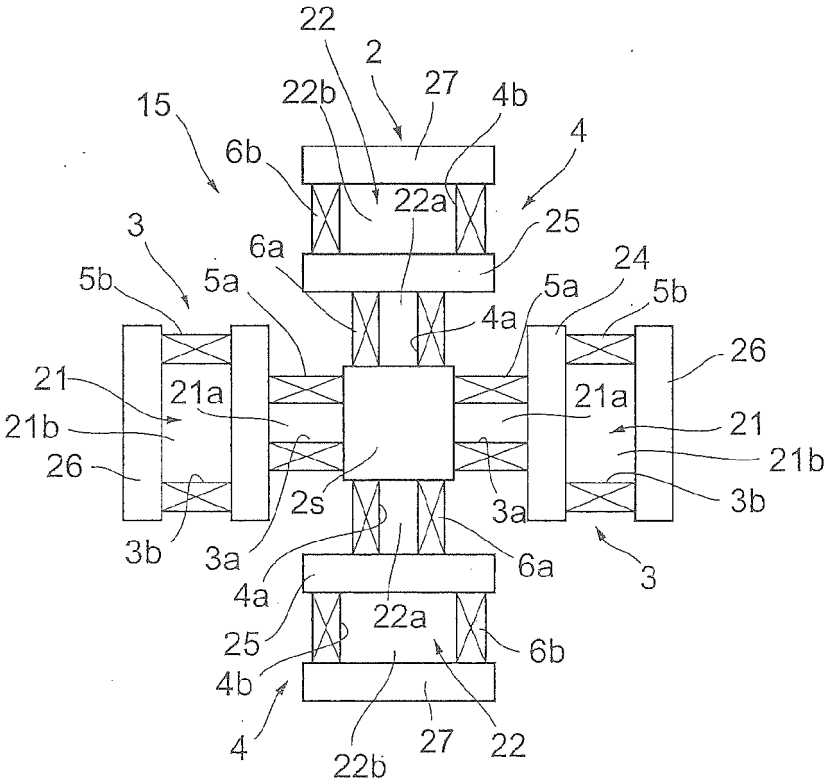
22
2
22b
27
4b
15
6b
4
22a
25
3
6a
24
5b
5a
5a
5b
4a
26
21
21a
21a
21
21b
21b
26
2s
3a
3b
3b
3a
6a
3
4a
22a
25
6b
4b
4
22b
27
22

Fig.7

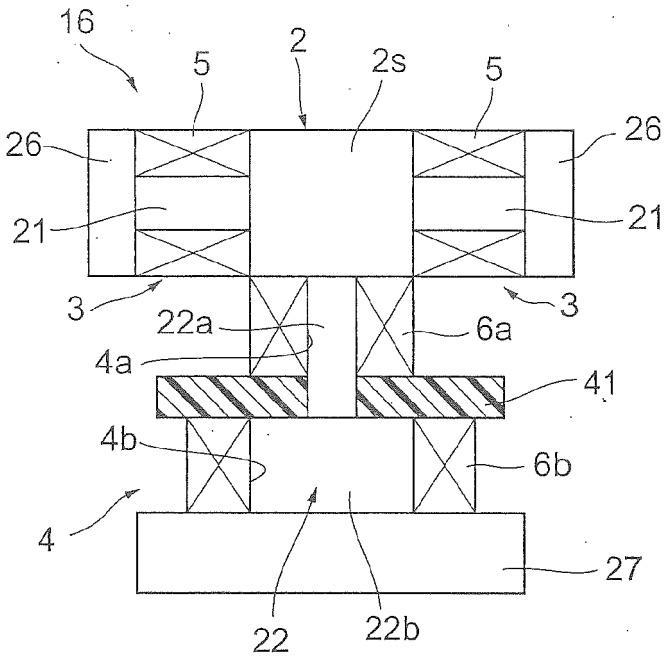
16
5
2
2s
5
26
26
21
21
3
3
22a
6a
4a
41
4b
6b
4
27
22
22b

Fig.8

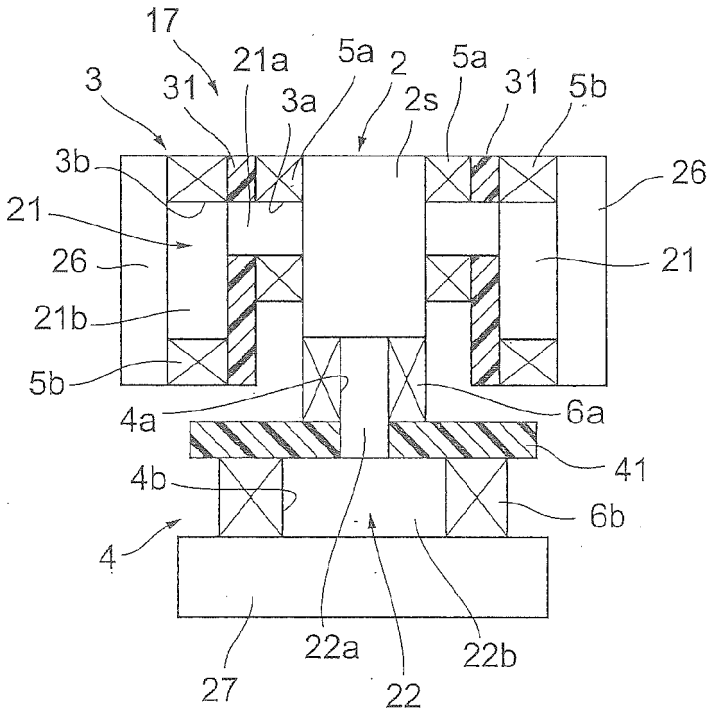
17
21a
5a
2
5a
3
31
3a
2s
31
5b
3b
26
21
26
21
21b
5b
4a
6a
41
4b
6b
4
27
22a
22
22b

Fig.9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003092509 A **[0003] [0005] [0006]**
- WO 2007116797 A **[0003] [0004] [0008]**