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(54) **COIL DEVICE**

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(57) **ABSTRACT**

A coil device includes an inner core having a winding core and a pair of flanges, a wire, an outer core arranged outside the inner core, a first terminal with a first wirebound having a first wirebound bottom arranged axially on a core end surface of the outer core and connected to a first end of the wire, and a second terminal with a second wirebound having a second wirebound bottom arranged on the core end surface and connected to a second end of the wire. The first wirebound has a first wire fixing portion bending from the first wirebound bottom toward a first rotating direction and fixing the first end. The second wirebound has a second wire fixing portion bending from the second wirebound bottom toward the same rotating direction as the first rotating direction and fixing the second end.

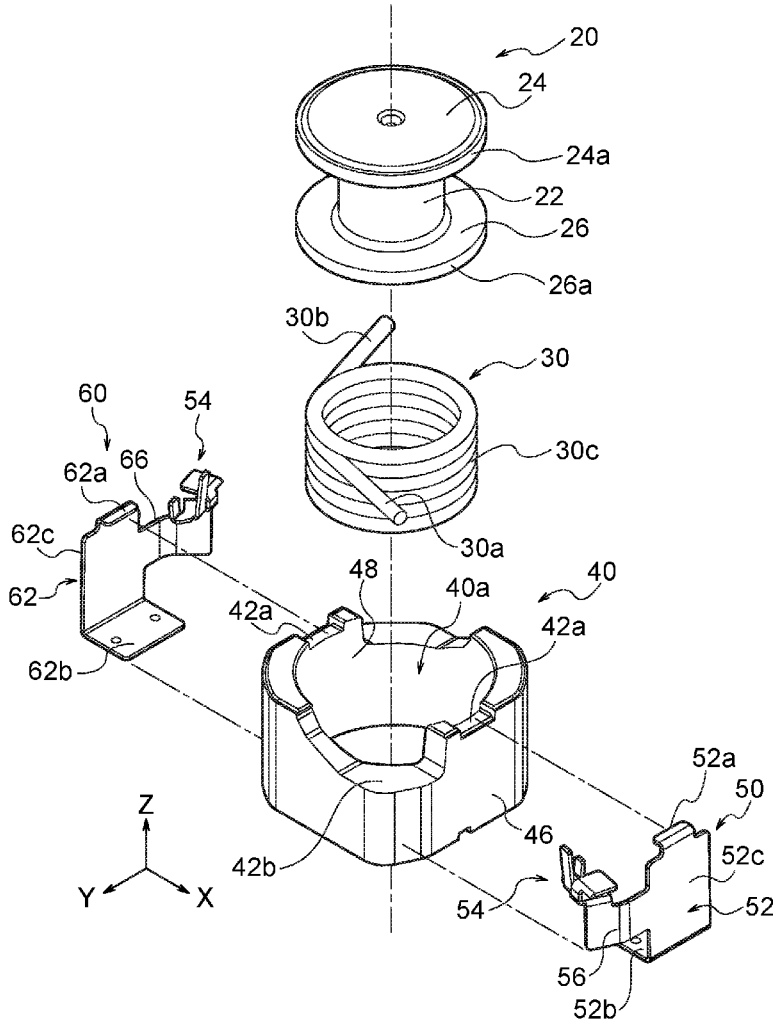


FIG. 1

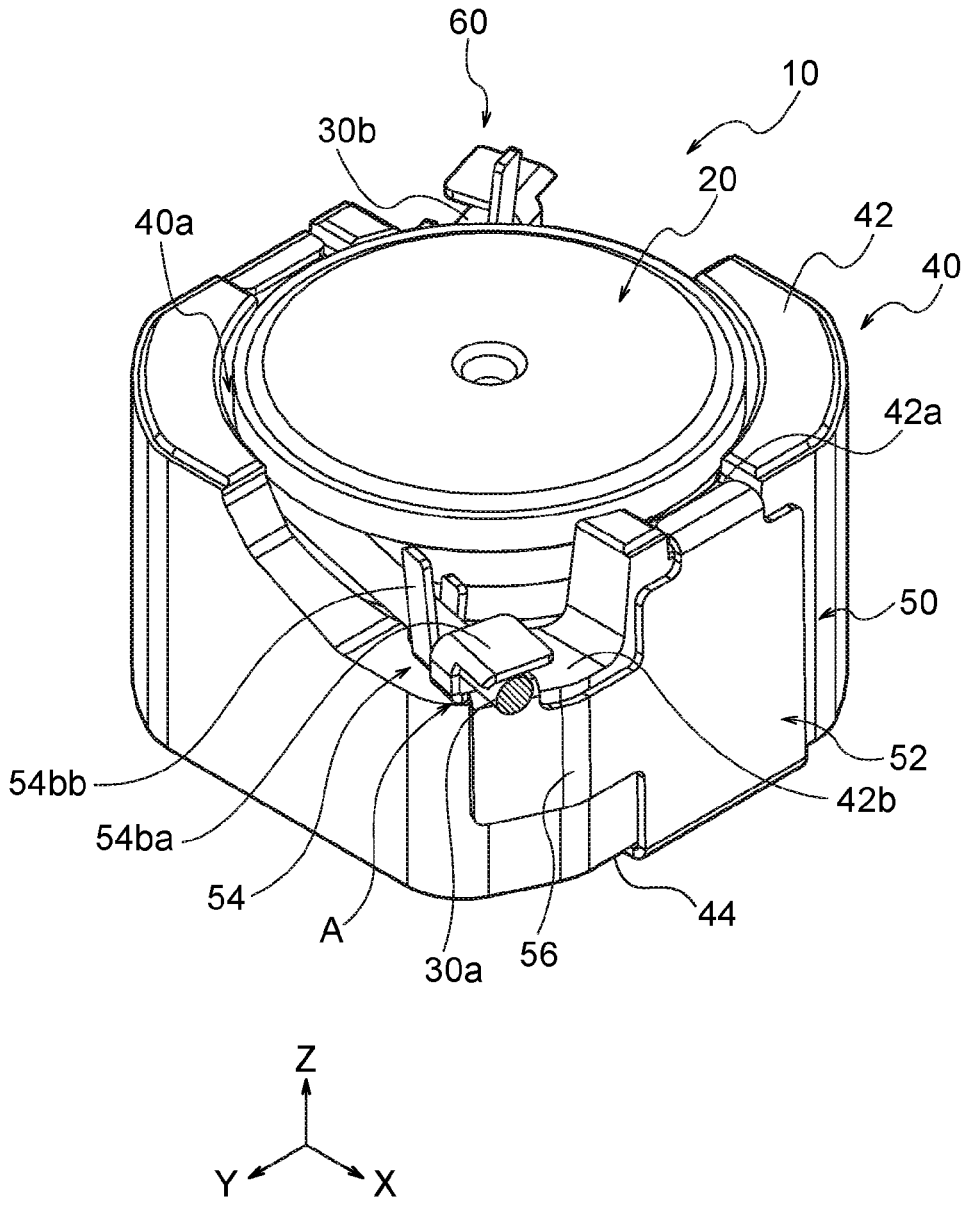
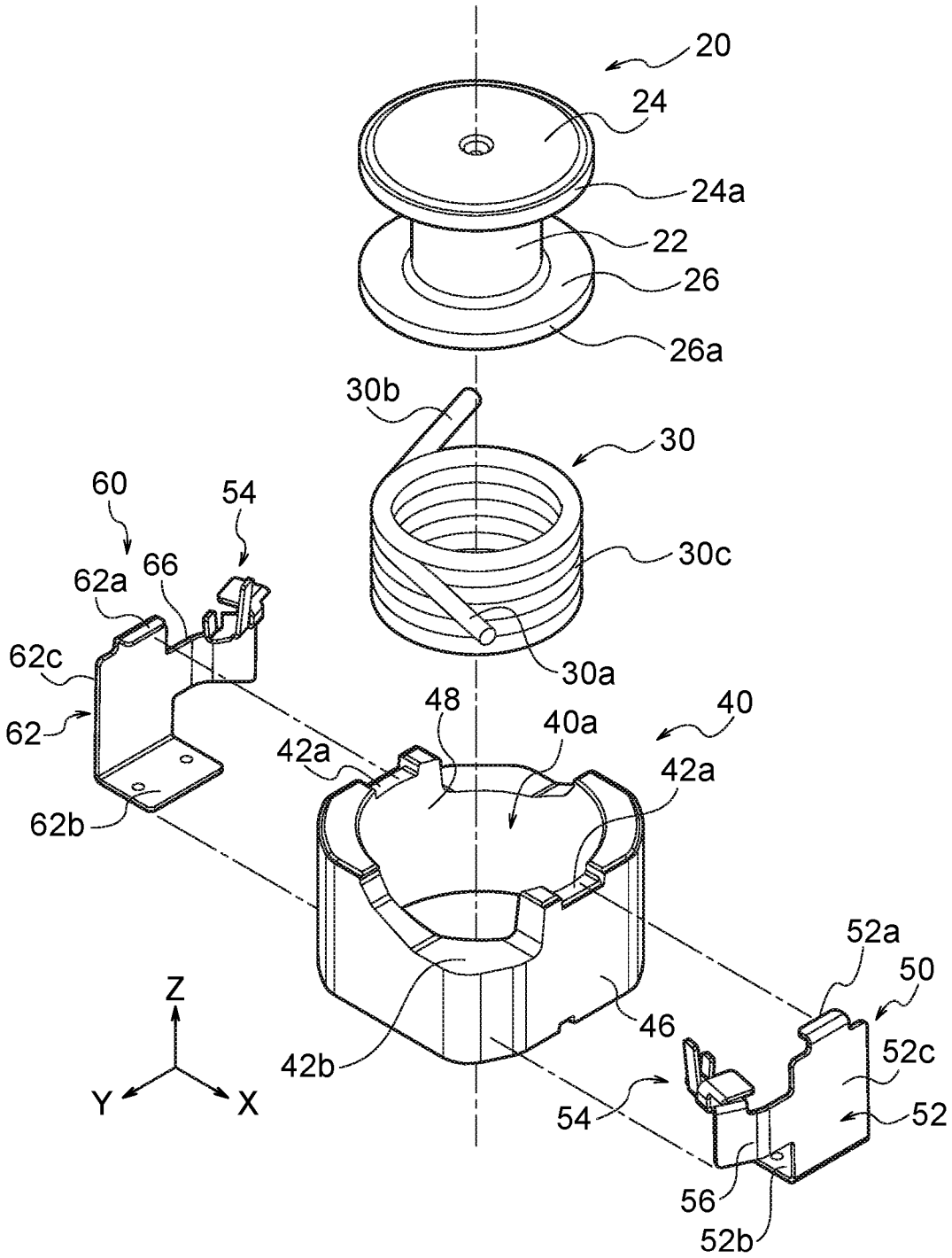


FIG. 2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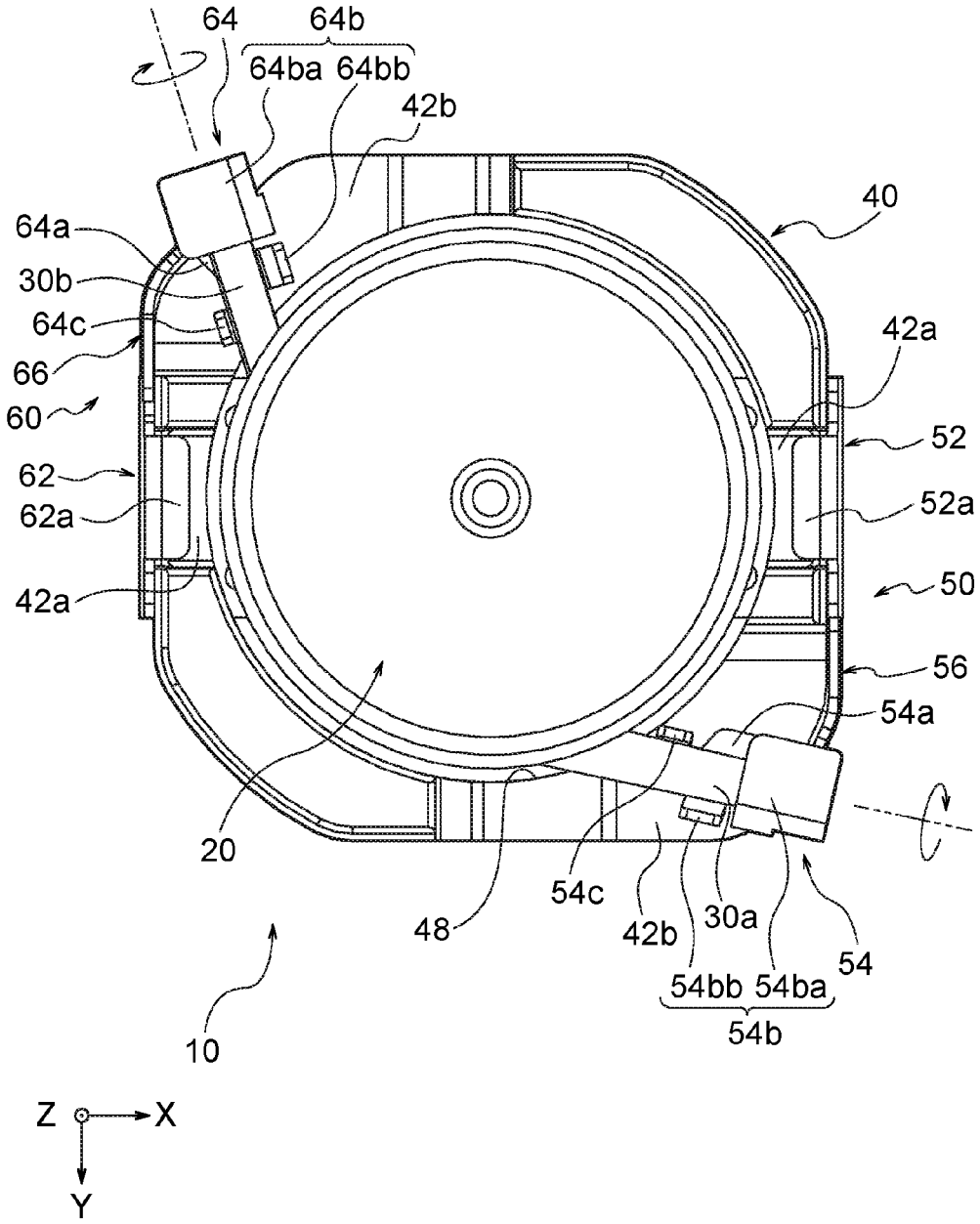
24
24a
22
26
26a
30b
30
30c
30a
60
54
62a
66
62c
62
62b
48
40a
40
42a
42a
42b
46
52a
50
52c
52
54
56
52b
Z
Y
X

FIG. 3


64
64b
64ba 64bb
42b
40
64a
30b
64c
66
60
42a
52
62
62a
52a
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56
54a
20
54c
48
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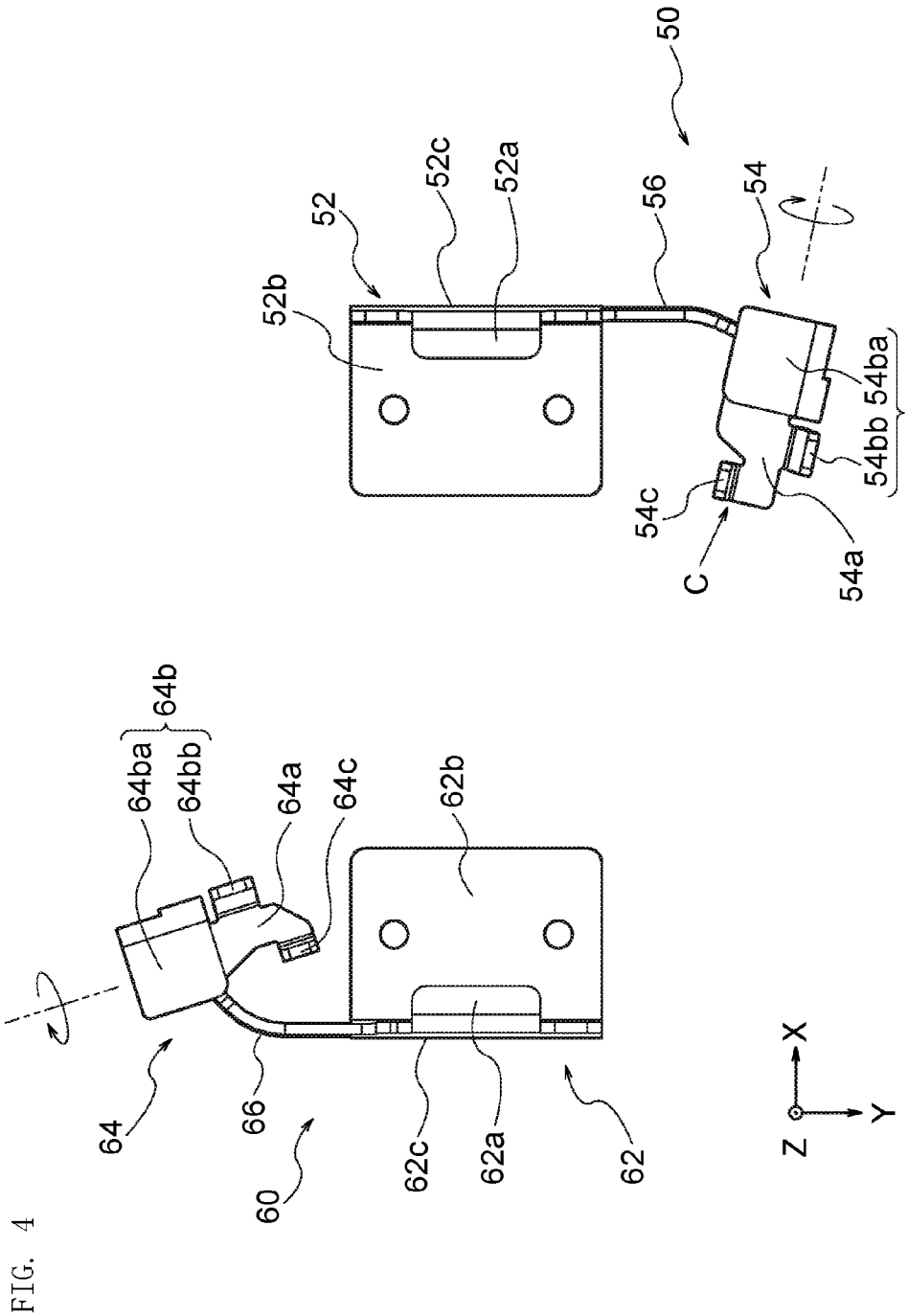
30a
54
54bb 54ba
54b
10
Z
X
Y


50
52
52c
52a
56
54
52b
54ba
54b
54bb
54c
C
54a
64b
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64c
62b
64
66
60
62c
62a
62
X
Y
Z

FIG. 4

FIG. 5

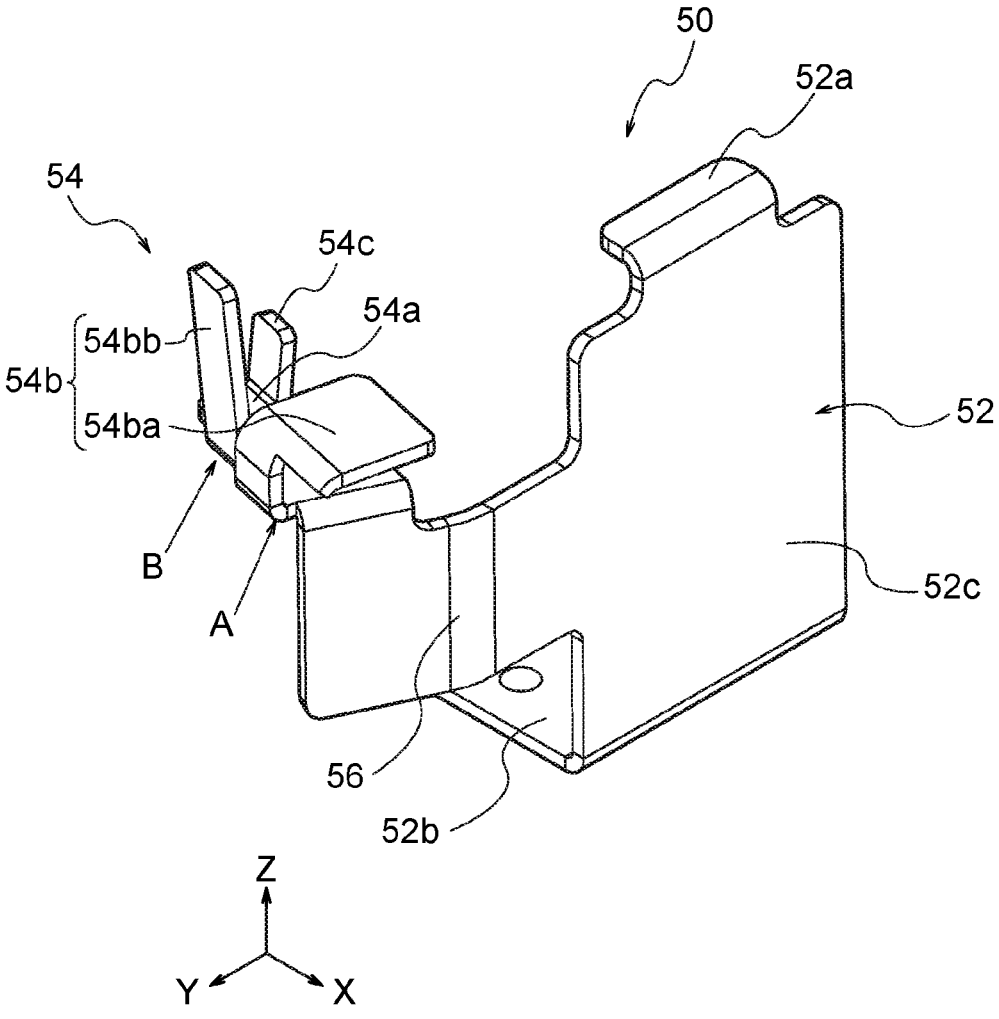


FIG. 6

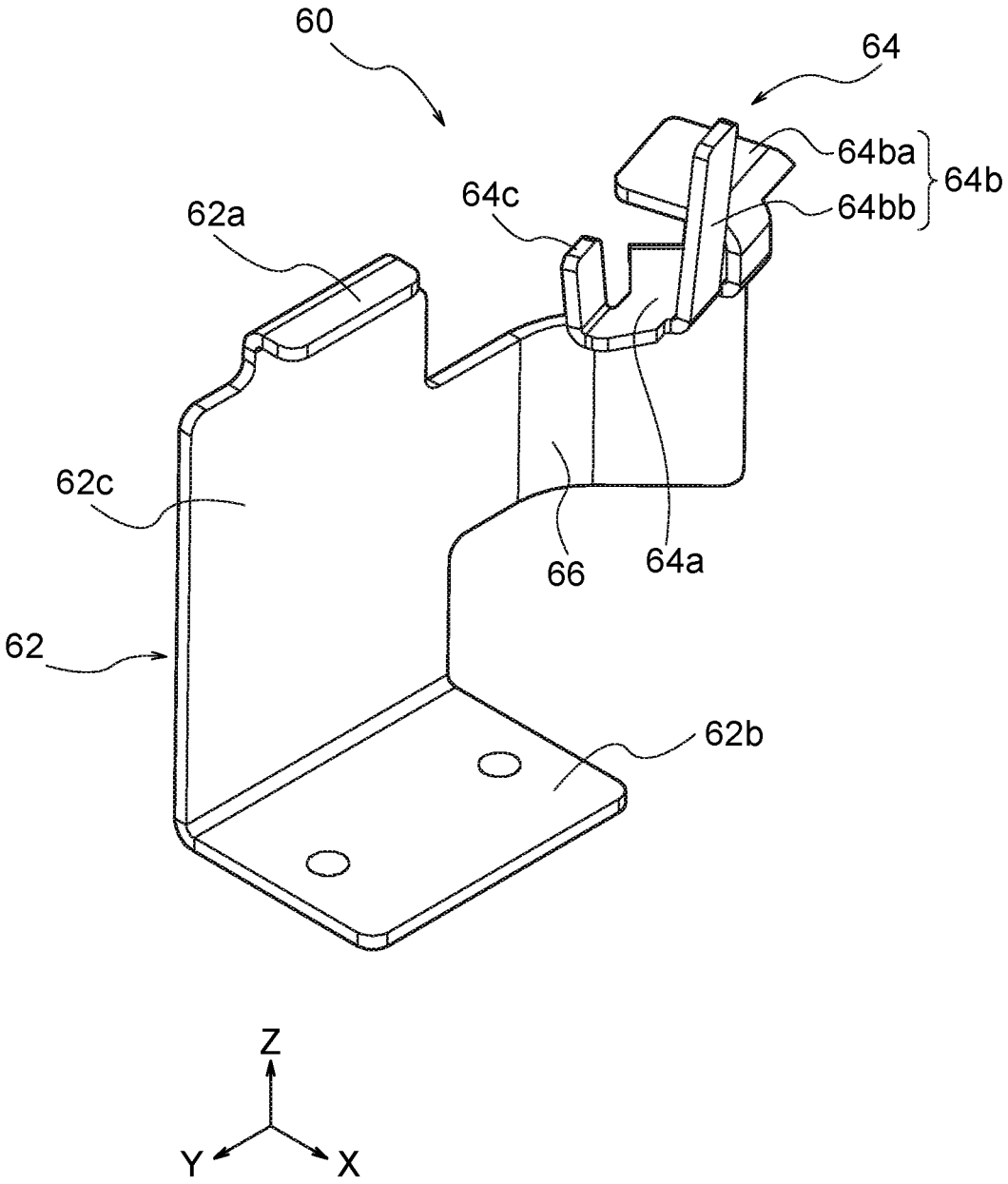


FIG. 7

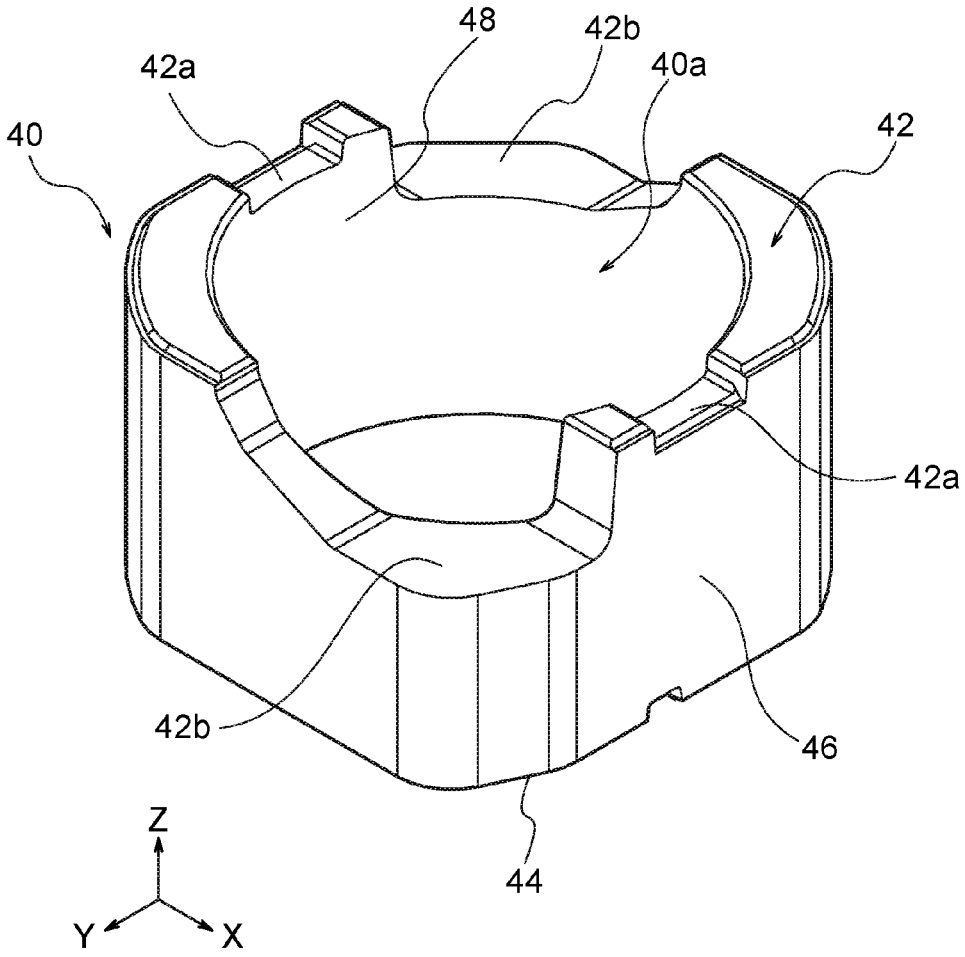


FIG. 8

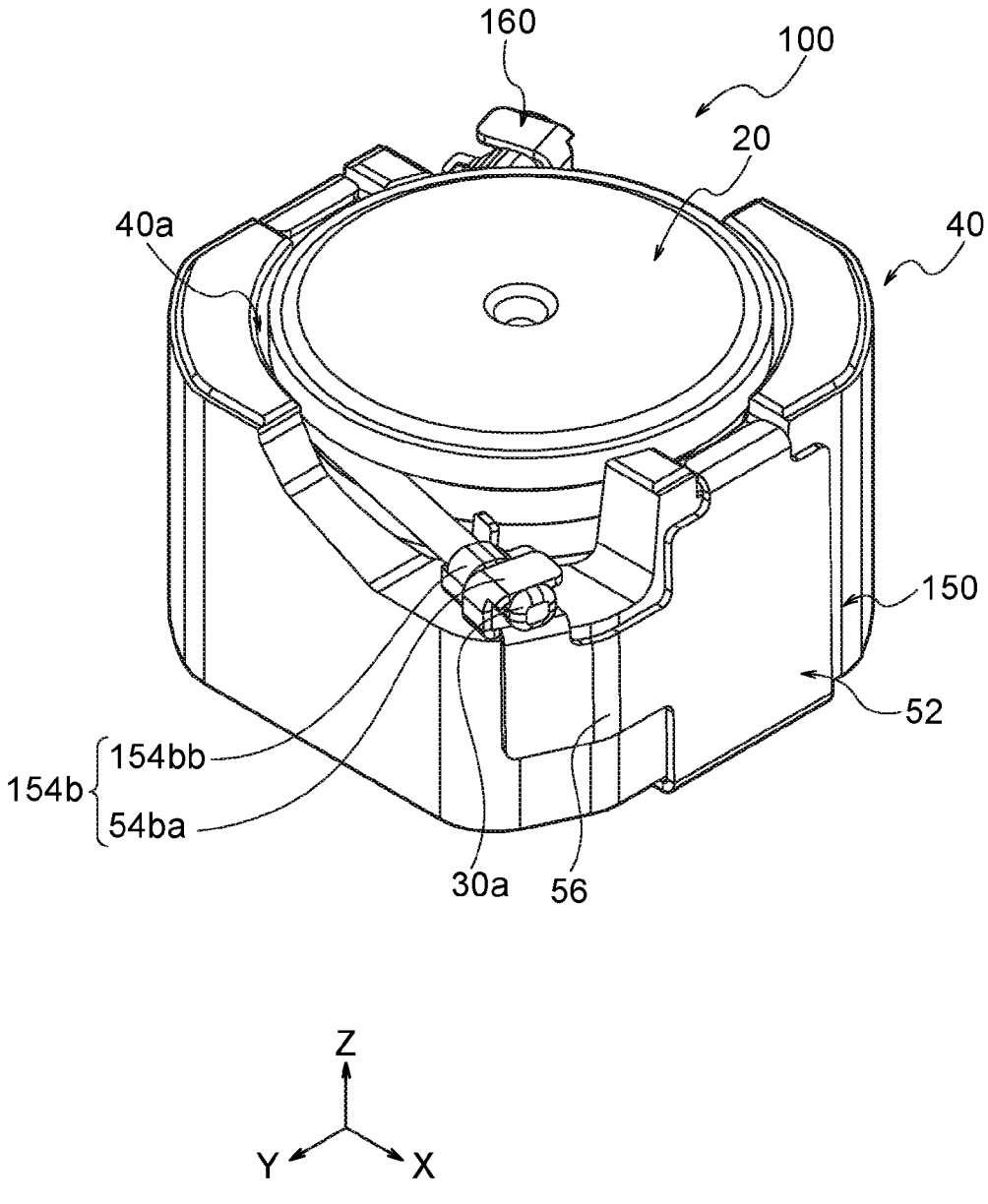


FIG. 9

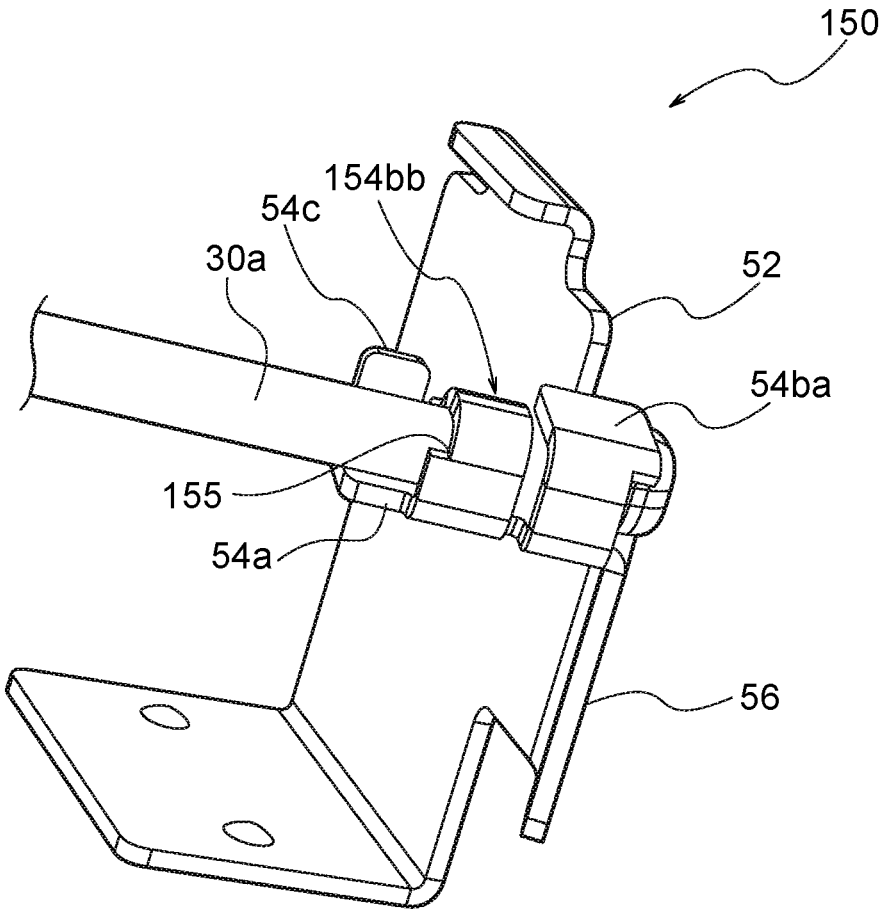
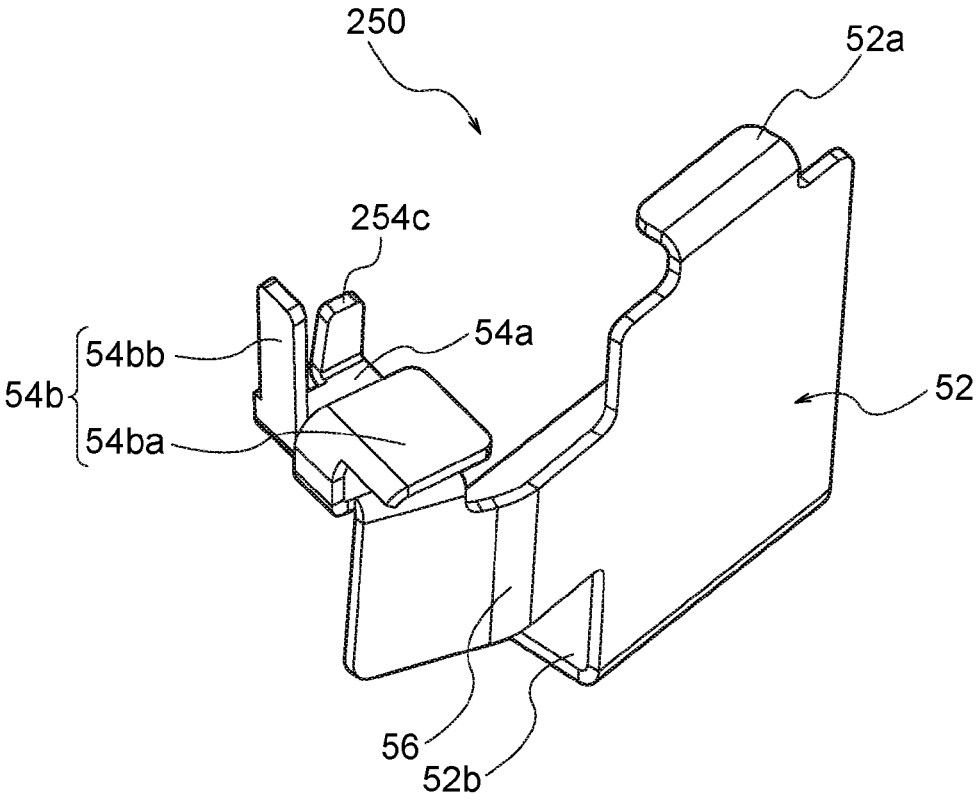


FIG. 10



COIL DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a coil device, and in particular to a coil device provided with an inner core wound by a wire and an outer core arranged on an outer periphery of the inner core.

2. Description of the Related Art

[0002] The prior art proposes a coil device provided with an inner core constituted by a drum core wound by a wire and an outer core having a through hole housing the inner core. A terminal electrode electrically connected to an end of the wire is fixed to the outer core, and electric power is supplied to the wire of the drum core via the terminal electrode.

[0003] There has been proposed a shape of the terminal electrode attached to the outer core having a fixing portion fixed to the outer core, a wirebound portion connected to the end of the wire, and a connection portion connecting the fixing portion and the wirebound portion. Furthermore, there has been proposed a preferable shape of the wirebound portion easily and securely fixing the wire to the terminal electrode by having a pressing portion that presses the end of the wire.

[0004] Patent Document 1: JP 2015-37156A

SUMMARY OF THE INVENTION

[0005] However, the shape of the wirebound portion in the prior art has a problem that a positional displacement of a center of the inner core to the outer core is generated at the time of pressing the end of the wire by the pressing portion of the wirebound portion. Such a problem of positional displacement is required to be improved for the achievement of downsizing of the coil device and the prevention of characteristic variations of the coil device.

[0006] The present invention has been achieved under such circumstances. It is an object of the invention to provide a coil device capable of preventing a positional displacement of an inner core with respect to an outer core.

[0007] The coil device according to the present invention is a coil device including:

[0008] an inner core having a winding core with column shape extending in an axial direction and a pair of flanges arranged on both sides of the winding core;

[0009] a wire having a winding portion winding around the winding core;

[0010] an outer core having a through hole inserted by the inner core and being arranged on an outer periphery of the inner core;

[0011] a first terminal portion provided with a first wirebound portion having a first wirebound bottom portion arranged on a core end surface of one of end surfaces of the outer core in the axial direction and connected to a first end of one of ends of the wire; and

[0012] a second terminal portion provided with a second wirebound portion having a second wirebound bottom portion arranged at a position rotated in a peripheral direction by a predetermined angle from the first wirebound bottom portion on the core end surface and connected to a second end of the other end of the wire,

[0013] wherein the first wirebound portion is provided with a first wire fixing portion bending from the first wirebound bottom portion toward a first rotating direction as seen from a tip side of the first end and fixing the first end, and

[0014] the second wirebound portion is provided with a second wire fixing portion bending from the second wirebound bottom portion toward the same rotating direction as the first rotating direction as seen from a tip side of the second end and fixing the second end.

[0015] In the coil device according to the prevent invention, the first wire fixing portion of the first terminal portion bends toward the first rotating direction and fixes the first end of the wire, and the second wire fixing portion of the second terminal portion bends toward the same rotating direction as the first rotating direction and fixes the second end of the wire. In the coil device having the first terminal portion and the second terminal portion, even if the first and second wire fixing portions bend and fix both ends of the wire, a force toward a direction where a center of the inner corner is displaced is hard to be generated even though a force toward a direction where the inner core is rotated is generated, and it is possible to prevent a problem of positional displacement of a center of the inner core to the outer core.

[0016] For example, the first wirebound portion may be provided with a first support portion protruding from the first wirebound bottom portion toward a reverse rotating direction of the first rotating direction as seen from the tip side of the first end and touching the first end on its winding side compared to the first wire fixing portion, and

[0017] the second wirebound portion may be provided with a second support portion protruding from the second wirebound bottom portion toward a reverse rotating direction of the first rotating direction as seen from the tip side of the second end and touching the second end on its winding side compared to the second wire fixing portion.

[0018] With the support portion protruding from the wirebound bottom portion toward the reverse rotating side, it is possible to prevent a problem that a force of moving or rotating the inner core is generated when the fixing portion fix the end of the wire. When the support portion touches the end of the wire on the winding side from the wire fixing portion, it is possible to prevent a problem that the support portion becomes unobstructive at the time of permanently fixing the first wire fixing portion and the first end. With the support portion, a heat at the time of permanently fixing the first wire fixing portion and the first end can be prevented from being transmitted to the winding portion.

[0019] Incidentally, the winding side of the first end means a side of the first end near the winding portion, and the winding side of the second end means a side of the second end near the winding portion.

[0020] For example, the first wire fixing portion may be provided with a first welding portion welded to the first end and a first caulking portion connected to the first wirebound bottom portion with a predetermined space to the first welding portion and temporarily fixing the first end on its winding side compared to the first welding portion, and

[0021] the second wire fixing portion may be provided with a second welding portion welded to the second end and a second caulking portion connected to the second wirebound bottom portion with a predetermined space to the

second welding portion and temporarily fixing the second end on its winding side compared to the second welding portion.

[0022] When the wire fixing portion is provided with the welding portion for permanently fixing the end of the wire and the caulking portion for temporarily fixing the end of the wire, it is possible to easily and quickly fix the end of the wire and improve accuracy of fixed positions of the wire, the inner core, and the like.

[0023] For example, a connection position between the first wirebound bottom portion and the first welding portion may be distant from the first end more than a connection position between the first wirebound bottom portion and the first caulking portion, and

[0024] a connection position between the second wirebound bottom portion and the second welding portion may be distant from the second end more than a connection position between the second wirebound bottom portion and the second caulking portion.

[0025] When the connection position between the welding portion and the wirebound bottom portion is distant more than the connection position between the caulking portion and the wirebound bottom position, the end of the wire temporarily fixed by the caulking portion receives a force at the time of bending the welding portion, and it is possible to prevent a problem of positional displacement of the end of the wire and the inner core.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is a whole perspective view of a coil device according to First Embodiment of the present invention.

[0027] FIG. **2** is an exploded perspective view of the coil device shown in FIG. **1**.

[0028] FIG. **3** is a plane view of the coil device shown in FIG. **1**.

[0029] FIG. **4** is a plane view showing an arrangement of a first terminal portion and a second terminal portion of the coil device show in FIG. **1**.

[0030] FIG. **5** is a perspective view of the first terminal portion of the coil device shown in FIG. **1**.

[0031] FIG. **6** is a perspective view of the second terminal portion of the coil device shown in FIG. **1**.

[0032] FIG. **7** is a perspective view of an outer core of the coil device shown in FIG. **1**.

[0033] FIG. **8** is a whole perspective view of a coil device according to First Variation.

[0034] FIG. **9** is a partially enlarged view showing a fixing portion of a first terminal portion and a first end of the coil device shown in FIG. **8**.

[0035] FIG. **10** is a perspective view showing a first terminal portion according to Second Variation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] FIG. **1** is a whole perspective view of a coil device **10** according to First Embodiment of the present invention. The coil device **10** has an inner core **20** with a drum shape, a wire **30** winding around the inner core **20**, an outer core **40** arranged on an outer periphery of the inner core **20**, and a first terminal portion **50** and a second terminal portion **60** of a pair of terminal portions attached to the outer core **40**. For example, the coil device **10** is mounted on a substrate or so in a state where a winding core **22** of the inner core **20** has an axial direction corresponding to a vertical direction to a mounting surface. In the following explanation, as shown in FIG. **1**, the Z-axis direction is an axial direction of the winding core **22** of the inner core **20**, and the X-axis direction and the Y-axis direction are directions perpendicular to the Z-axis. In the present specification, an upward direction means a positive direction of the Z-axis, and a downward direction means a negative direction of the Z-axis unless otherwise specified.

[0037] FIG. **2** is an exploded perspective view of the coil device **10** shown in FIG. **1**. The inner core **20** has the winding core **22** with column shape extending in the axial direction and an upper flange **24** and a lower flange **26** of a pair of flanges arrange on both ends of the winding core **22**. The inner core **20** is wound by the wire **30**. A winding portion **30***c* winding around the winding core **22** is arranged on the surface of the winding core **22**, and a first end **30***a* and a second end **30***b* of ends of the wire **30** are pulled out in the vicinity of the upper flange **24** from the surface of the winding core **22** toward the outer diameter side.

[0038] The outer core **40** is provided with a through hole **40***a* inserted by the inner core **20**. As shown in FIG. **1**, the inner core **20** wound by the wire **30** is housed in the through hole **40***a* of the outer core **40** in a state where the coil device **10** is assembled. As shown in FIG. **2** and FIG. **7**, a wall surface of the through hole **40***a* is constituted by a core inner peripheral surface **48** of an inner peripheral surface of the outer core **40**.

[0039] Thus, as shown in FIG. **2**, the core inner peripheral surface **48** of the outer core **40** opposes to an upper flange outer peripheral surface **24***a* of an outer peripheral surface of the upper flange **24** of the inner core **20** and a lower flange outer peripheral surface **26***a* of an outer peripheral surface of the lower flange **26** of the inner core **20**. A predetermined space (gap) is formed between the core inner peripheral surface **48** of the outer core **40** and the upper and lower flange outer peripheral surfaces **24***a* and **26***a* of the inner core **20**. The core inner peripheral surface **48** and the upper and lower flange outer peripheral surfaces **24***a* and **26***a* are joined by an adhesive hardened portion (not shown) formed in such a manner that an adhesive of an epoxy based resin, a urethane based resin, or the like is hardened, and the outer core **40** and the inner core **20** are fixed mutually. Thus, the adhesive hardened portion is arranged in the core inner peripheral surface **48** and the upper and lower flange outer peripheral surfaces **24***a* and **26***a*. The outer core **40** is connected to the inner core **20** and forms a magnetic path, and the adhesive hardened portion present between the outer core **40** and the inner core **20** function as a gap material.

[0040] As shown in FIG. **3** of a plane view seeing the outer core **4** from the axial direction (Z-axis direction), the outer core **40** has an approximately rectangular outer peripheral shape having four corners of R shape when viewing the outer core **40** from the axial direction. In contrast, the core inner peripheral surface **48** of the outer core **40** has a circular peripheral shape when viewing the outer core **40** from the axial direction, and has a peripheral shape different from that of a core outer peripheral surface **46** of the outer core **40**. Thus, a radial thickness of the outer core **40** determined by a radial distance between the core inner peripheral surface **48** and the core outer peripheral surface **46** varies along the peripheral direction of the outer core **40**.

[0041] A core upper surface **42** is a core end surface that is one (Z-axis positive direction) of end surfaces of the outer

core **40**, and is provided with a pair of engagement end surfaces **42***a* and a pair of support end surfaces **42***b*. A first upper surface portion **52***a* of the first terminal portion **50** and a second upper surface portion **62***a* of the second terminal portion **60** mentioned below are engaged on the engagement end surfaces **42***a*. The engagement end surfaces **42***a* are formed on both ends in the X-axis direction in the middle part of the core upper surface **42** in the Y-axis direction.

[0042] As shown in FIG. **3**, the support end surfaces **42***b* are formed on two corners positioned on a diagonal line on the core upper surface **42**. The support end surfaces **42***b* are respectively provided with a first wirebound bottom portion **54***a* of the first terminal portion **50** and a second wirebound bottom portion **64***a* of the second terminal portion **60**. As shown in FIG. **7**, the support end surfaces **42***b* have a short distance to a core lower surface **44** of an end surface of the outer core **40** in the downward direction compared to the engagement end surfaces **42***a* and are arranged lower than the engagement end surfaces **42***a*. As shown in FIG. **3**, the support end surfaces **42***b* have a maximum thickness in the radial direction that is larger than that of the engagement end surfaces **42***a*.

[0043] As shown in FIG. **2**, the first terminal portion **50** is provided with a first fixing portion **52** fixed to the outer core **40**, a first wirebound portion **54** connected to the first end **30***a* of one of ends of the wire **30**, and a first connection portion **56** connecting the first wirebound portion **54** and the first fixing portion **52**. The first terminal portion **50** is attached to the X-axis positive direction side of the outer core **40**.

[0044] As shown in FIG. **2** and FIG. **5**, the first fixing portion **52** is provided with a first upper surface portion **52***a*, a first lower surface portion **52***b*, and a first side surface portion **52***c*. The first upper surface portion **52***a* is engaged with the engagement end surface **42***a* on the X-axis positive direction side of the outer case **40**. The first lower surface portion **52***b* is engaged with the core lower surface **44** of the outer core **40**. The first side surface portion **52***c* connects the first upper surface portion **52***a* and the first lower surface portion **52***b* and opposes to the core outer peripheral surface **46** of the outer core **40**. The first upper surface portion **52***a* and the first lower surface portion **52***b* form an angle of approximately 90 degrees to the first side surface portion **52***c* (approximately L shape with the first side surface portion **52***c*) and are connected to the upper and lower ends of the first side surface portion **52***c*. The first lower surface portion **52***b* is provided with a convex portion engaged with a concave portion formed on the core lower surface **44** of the outer core **40**.

[0045] As shown in FIG. **5**, a radial length of the first upper surface portion **52***a* and a radial length of the first lower surface portion **52***b* are different from each other. As shown in FIG. **3** of a plane view, a radial tip of the first upper surface portion **52***a* is positioned on an outer diameter side of the core inner peripheral surface **48** of the outer core **40**, but as shown in FIG. **2**, a radial tip of the first lower surface portion **52***b* is positioned on an inner diameter side of the lower flange outer peripheral surface **26***a*. The first fixing portion **52** of the first terminal portion **50** is fixed to the outer core **40** via the adhesive hardened portion connecting an inner surface of the first side surface portion **52***c* and the core outer peripheral surface **46** of the outer core **40**.

[0046] As shown in FIG. **4** and FIG. **5**, the first wirebound portion **54** of the first terminal portion **50** is provided with the first wirebound bottom portion **54***a*, a first wire fixing portion **54***b*, and a first support portion **54***c*. The first wirebound bottom portion **54***a* is parallel to the XY plane perpendicular to the axial direction. The first wire fixing portion **54***b* and the first support portion **54***c* are curved toward a predetermined direction to the first wirebound bottom portion **54***a* and are connected thereto. As shown in FIG. **3**, the first wirebound bottom portion **54***a* is arranged on the support end surface **42***b* of the core upper surface **42** of the outer core **40**.

[0047] As shown in FIG. **3**, the first wire fixing portion **54***b* is provided with a first welding portion **54***ba* welded to the first end **30***a* of the wire **30** and a first caulking portion **54***bb* connected to the first wirebound bottom portion **54***a* with a predetermined distance to the first welding portion **54***ba*. As mentioned below, the first caulking portion **54***bb* temporarily fixes the first end **30***a* on the winding side of the first end **30***a* (near the winding portion **30***c* (see FIG. **2**)) compared to the first welding portion **54***ba*.

[0048] As shown in FIG. **3** and FIG. **4**, the first welding portion **54***ba* and first caulking portion **54***bb* constituting the first wire fixing portion **54***b* bend from the first wirebound bottom portion **54***a* toward a clockwise direction of a first rotating direction as seen from a tip side of the first end **30***a* (approximately corresponding to the X-axis positive direction) and fix the first end **30***a*. Incidentally, FIG. **1** to FIG. **6**, etc. show a state where the first caulking portion **54***bb* does not fix the first end **30***a*, but this is for convenience so that the shape of the first caulking portion **54***bb* (and a second caulking portion **64***bb*) is illustrated intelligibly. In the coil device **10** after actually being completed, the first caulking portion **54***bb* (and the second caulking portion **64***bb*) bends further in the clockwise direction from the state shown in FIG. **1** to FIG. **6** and fixes the first end **30***a* by caulking. Since the first caulking portion **54***bb* temporarily fixes the first end **30***a* by caulking, it is advantageous that the first end **30***a* being temporarily fixed (before the first welding portion **54***ba* is welded) is hard to be displaced positionally compared to a conventional terminal having the first end **30***a* sandwiched between V-shape protruding pieces.

[0049] As shown in FIG. **1**, a connection position "A" between the first wirebound bottom portion **54***a* and the first welding portion **54***ba* is distant from the first end **30***a*.

[0050] As shown in FIG. **5**, the connection position "A" between the first wirebound bottom portion **54***a* and the first welding portion **54***ba* is consequently distant from the first end **30***a* more than a connection position "B" between the first wirebound bottom portion **54***a* and the first caulking portion **54***bb*.

[0051] As shown in FIG. **3**, the first support portion **54***c* touches the first end **30***a* on its winding side compared to the first wire fixing portion **54***b*. As shown in FIG. **3** and FIG. **5**, the first support portion **54***c* protrudes from the first wirebound bottom portion **54***a* toward a counterclockwise side of a reverse rotating direction side of the first rotating direction side as seen from the tip side of the first end **30***a*. Thus, the first end **30***a* of the wire **30** is pulled out toward the outer diameter direction on the first wirebound bottom portion **54***a* via between the first support portion **54***c* and the first caulking portion **54***bb*. Incidentally, the first support portion **54***c* does not fix the first end **30***a* in the same manner as the first caulking portion **54***bb* in FIG. **3** to FIG. **5**, etc. In the coil device **10** after being completed, however, the first support portion **54***c* may bend further in the counterclock-

wise direction from the state shown in FIG. **3** to FIG. **5** and fix the first end **30***a* by caulking. The connection position "A" between the first wirebound bottom portion **54***a* and the first welding portion **54***ba* is preferably distant from the first end **30***a* more than a connection position "C" (see FIG. **4**) between the first wirebound bottom portion **54***a* and the first support portion **54***c*.

[0052] As shown in FIG. **1** to FIG. **4**, the first connection portion **56** is arranged along the core outer peripheral surface **46** and connects the first side surface portion **52***c* of the first fixing portion **52** and the first wirebound bottom portion **54***a* of the first wirebound portion **54**. Incidentally, although not limited, the first side surface portion **52***c* of the first fixing portion **52** of the first terminal portion **50** is preferably only one that is directly adhered to the outer core **40**. When only the first side surface portion **52***c* of the first terminal portion **50** is adhered to the outer core **40**, the first wirebound bottom portion **54***a* of the first wirebound portion **54** and the first connection portion **56** oppose to the support end surface **42***b* or the core outer peripheral surface **46** of the outer core **40**, but are not directly fixed to the surface of the outer core **40**.

[0053] As shown in FIG. **2**, the second terminal portion **60** is provided with a second fixing portion **62** fixed to the outer core **40**, a second wirebound portion **64** connected to the second end **30***b* of the other end of the wire **30**, and a second connection portion **66** connecting the second wirebound portion **64** and the second fixing portion **62**. As shown in FIG. **3**, the second wirebound bottom portion **64***a* of the second terminal portion **60** is arranged on the support end surface **42***b* at a position rotated in the peripheral direction by a predetermined angle (approximately 180 degrees in the embodiment) from the first wirebound bottom portion **54***a* of the first terminal portion **50**. The first terminal portion **50** is attached to the negative side in the X-axis direction of the outer core **40**.

[0054] As shown in FIG. **2** and FIG. **6**, the second fixing portion **62** is provided with a second upper surface portion **62***a*, a second lower surface portion **62***b*, and a second side surface portion **62***c*. The second upper surface portion **62***a* is engaged with the engagement end surface **42***a* on the X-axis negative direction side of the outer case **40**. The second lower surface portion **62***b* is engaged with the core lower surface **44** of the outer core **40**. The second side surface portion **62***c* connects the second upper surface portion **62***a* and the second lower surface portion **62***b* and opposes to the core outer peripheral surface **46** of the outer core **40**. The second upper surface portion **62***a* and the second lower surface portion **62***b* form an angle of approximately 90 degrees to the second side surface portion **62***c* (approximately L shape with the second side surface portion **62***c*) and are connected to the upper and lower ends of the second side surface portion **62***c*. The second lower surface portion **62***b* is provided with a convex portion engaged with a concave portion formed on the core lower surface **44** of the outer core **40** in the same manner as the first lower surface portion **52***b*.

[0055] As shown in FIG. **6**, a radial length of the second upper surface portion **62***a* and a radial length of the second lower surface portion **62***b* are different from each other. As shown in FIG. **3** of a plane view, a radial tip of the second upper surface portion **62***a* is positioned on an outer diameter side of the core inner peripheral surface **48** of the outer core **40**, but as shown in FIG. **2**, a radial tip of the second lower surface portion **62***b* is positioned on an inner diameter side of the lower flange outer peripheral surface **26***a*. As is the case with the first fixing portion **52**, the second fixing portion **62** of the second terminal portion **60** is fixed to the outer core **40** via the adhesive hardened portion connecting the inner surface of the second side surface portion **62***c* and the core outer peripheral surface **46** of the outer core **40**.

[0056] As shown in FIG. **4** and FIG. **6**, the second wirebound portion **64** of the second terminal portion **60** is provided with the second wirebound bottom portion **64***a*, a second wire fixing portion **64***b*, and a second support portion **64***c*. The second wirebound bottom portion **64***a* is parallel to the XY plane perpendicular to the axial direction. The second wire fixing portion **64***b* and the second support portion **64***c* are curved toward a predetermined direction to the second wirebound bottom portion **64***a* and are connected thereto. As shown in FIG. **3**, the second wirebound bottom portion **64***a* is arranged on the support end surface **42***b* of the core upper surface **42** of the outer core **40**.

[0057] As shown in FIG. **3**, the second wire fixing portion **64***b* is provided with a second welding portion **64***ba* welded to the second end **30***b* of the wire **30** and a second caulking portion **64***bb* connected to the second wirebound bottom portion **64***a* with a predetermined distance to the second welding portion **64***ba*. The second caulking portion **64***bb* temporarily fixes the second end **30***b* on the winding side of the second end **30***b* (near the winding portion **30***c* (see FIG. **2**)) compared to the second welding portion **64***ba*.

[0058] As shown in FIG. **3** and FIG. **4**, the second welding portion **64***ba* and second caulking portion **64***bb* constituting the second wire fixing portion **64***b* bend from the second wirebound bottom portion **64***a* toward a clockwise direction that is the same rotating direction as the first rotating direction of the first wire fixing portion **54***b* as seen from a tip side of the second end **30***b* (approximately corresponding to the Y-axis negative direction) and fix the second end **30***b*. Incidentally, FIG. **3**, FIG. **4**, FIG. **6**, etc. show a state where the second caulking portion **64***bb* does not fix the second end **30***b*, but in the coil device **10** after being completed, the second caulking portion **64***bb* bends further in the clockwise direction from the state shown in FIG. **3**, FIG. **4**, and FIG. **6** and fixes the second end **30***b* by caulking. Since the second caulking portion **64***bb* temporarily fixes the second end **30***b* by caulking, as is the case with the first caulking portion **54***bb*, it is advantageous that the second end **30***b* being temporarily fixed (before the second welding portion **64***ba* is welded) is hard to be displaced positionally.

[0059] As shown in FIG. **4** and FIG. **6**, a connection position between the second wirebound bottom portion **64***a* and the second welding portion **64***ba* is distant from the second end **30***a* more than a connection position between the second wirebound bottom portion **64***a* and the second caulking portion **64***bb* in the second terminal portion **60** in the same manner as the first terminal portion **50**.

[0060] As shown in FIG. **3**, the second support portion **64***c* touches the second end **30***b* on its winding side compared to the second wire fixing portion **64***b*. As shown in FIG. **3** and FIG. **6**, the second support portion **64***c* protrudes from the second wirebound bottom portion **64***a* toward a counterclockwise side of a reverse rotating direction side of the first rotating direction side as seen from the tip side of the second end **30***b*. Thus, the second end **30***b* of the wire **30** is pulled out toward the outer diameter direction on the second wirebound bottom portion **64***a* via between the second support portion **64***c* and the second caulking portion **64***bb*.

Incidentally, the second support portion **64***c* may bend further in the counterclockwise direction from the state shown in FIG. **3** to FIG. **5** and fix the second end **30***b* by caulking in the coil device **10** after being completed in the same manner as the first support portion **54***c* of the first terminal portion **50**. The connection position between the second wirebound bottom portion **64***a* and the second welding portion **64***ba* is preferably distant from the second end **30***b* more than a connection position between the second wirebound bottom portion **64***a* and the second support portion **64***c*.

[0061] As shown in FIG. **2**, the second connection portion **66** is arranged along the core outer peripheral surface **46** and connects the second side surface portion **62***c* of the second fixing portion **62** and the second wirebound bottom portion **64***a* of the second wirebound portion **64**. Incidentally, although not limited, the second side surface portion **62***c* of the second fixing portion **62** of the second terminal portion **60** is preferably only one that is directly adhered to the outer core **40**. When only the second side surface portion **62***c* of the second terminal portion **60** is adhered to the outer core **40**, the second wirebound bottom portion **64***a* of the second wirebound portion **64** and the second connection portion **66** oppose to the support end surface **42***b* or the core outer peripheral surface **46** of the outer core **40**, but are not directly fixed to the surface of the outer core **40**.

[0062] As clearly shown in FIG. **3** and FIG. **4**, the first terminal portion **50** and the second terminal portion **60** have mutually different shapes. In particular, extending directions of the first wirebound bottom portion **54***a* and the second wirebound bottom portion **64***a* shown in FIG. **4** correspond to pull-out directions of the first and second ends **30***a* and **30***b* of the wire **30**. This enables the coil device **10** to prevent a problem of causing a positional displacement of the inner core **20** due to an elastic force for bending the wire **30**.

[0063] Hereinafter, a manufacturing method of the coil device **10** will be explained. In the manufacture of the coil device **10**, the winding portion **30***c* is firstly formed by winding a lead wire around the winding core **22** of the inner core **20**, and the inner core **20** wound by the winding portion **30***c* is then inserted into the through hole **40***a* of the outer core **40** (see FIG. **2**). The inner core **20** and the outer core **40** are made by any materials, but are made using a soft magnetic material such as ferrite and metal. Any lead wire is used as the lead wire for forming the wire **30** as long as a coated wire whose surface is insulation coated is employed.

[0064] Next, the first and second terminal portions **50** and **60** where an adhesive is applied beforehand to the inner surfaces of the first and second side surface portions **52***c* and **62***c* are attached from the side of the core outer peripheral surface **46** to the outer core **40** (see FIG. **2**). At this time, the first and second upper surface portions **52***a* and **62***a* of the first and second fixing portions **52** and **62** are engaged with the engagement end surfaces **42***a*, the first and second lower surface portions **52***b* and **62***b* touch the core lower surface **44**, and the first and second terminal portions **50** and **60** are thus positioned to the outer core **40**. The first and second ends **30***a* and **30***b* of the wire **30** are arranged along the first wirebound bottom portion **54***a* of the first terminal portion **50** and the second wirebound bottom portion **64***a* of the second terminal portion **60**.

[0065] The first and second terminal portions **50** and **60** are made by any material and any method, and are made by machining a metal plate material such as copper alloy, for example. Incidentally, at this point, the first and second welding portions **54***ba* and **64***ba* of the first and second terminal portions **50** and **60** are not bent to the state shown in FIG. **1** to FIG. **6**, etc., and are in a state where the tips are directed upward in the same manner as the first and second caulking portions **54***bb* and **64***bb*.

[0066] Next, the first caulking portion **54***bb* of the first wire fixing portion **54** and the second caulking portion **64***bb* of the second wire fixing portion **64** in the first and second terminal portions **50** and **60** are bent toward the first rotating direction (clockwise direction) shown in FIG. **3**, are caulked with the first and second ends **30***a* and **30***b* of the wire **30**, and are temporarily fixed to the first and second terminal portions **50** and **60**. Furthermore, insulation coatings of the first and second ends **30***a* and **30***b* on the tip sides from the temporarily fixed portions are peeled, the first and second welding portions **54***ba* and **64***ba* are bent toward the first rotating direction (clockwise direction) to touch the peeled portions of the first and second ends **30***a* and **30***b*, and these portions are welded by laser welding or so. As a result, the first and second terminal portions **50** and **60** and the first and second ends **30***a* and **30***b* are fixed permanently.

[0067] At the end, an adhesive is injected into the space between the upper and lower flange outer peripheral surfaces **24***a* and **26***a* and the core inner peripheral surface **48** using a dispenser or so and is solidified so that the inner core **20** and the outer core **40** are joined, whereby the coil device **10** is obtained. Incidentally, after the temporary fixings by the first and second caulking portions **54***bb* and **64***bb*, the first and second support portions **54***c* and **64***c* may bend toward the counterclockwise direction of the reverse rotating direction of the first rotating direction (clockwise direction) shown in FIG. **2** and caulk the first and second ends **30***a* and **30***b* so that the fixings to the first and second terminal portions **50** and **60** are reinforced.

[0068] In the coil device **10** according to the above-mentioned embodiment, as shown in FIG. **3** or so, the first and second wire fixing portions **54***b* and **64***b*, especially the first and second caulking portions **54***bb* and **64***bb*, both bend from the first and second wirebound bottom portions **54***a* and **64***a* toward the same rotating direction (clockwise direction) and caulk the first and second ends **30***a* and **30***b*. The first caulking portion **54***bb* and the second caulking portion **64***bb* have the same rotating direction, and it is thus possible to effectively prevent a problem of positional displacement of a center of the inner core **20** when the first and second ends **30***a* and **30***b* are fixed to the first and second terminal portions **50** and **60**.

[0069] This is because a resultant force of forces transmitted from the first and second caulking portions **54***bb* and **64***bb* to the inner core **20** via the wire **30** acts toward a direction where the inner core **20** is rotated around the axial direction in such a manner that the first caulking portion **54***bb* and the second caulking portion **64***bb* bend toward the same rotating direction and caulk the first and second ends **30***a* and **30***b*. It is thus possible to prevent a problem of positional displacement of a center of the inner core **20** caused by the forces transmitted to the inner core **20** when the first and second ends **30***a* and **30***b* are caulked by the first and second caulking portions **54***bb* and **64***bb*. Preventing positional displacement of a center of the inner core **20** makes it possible to accurately control a size of a gap formed between the inner core **20** and the outer core **40** and

magnetic properties of the coil device **10** accompanying the size, and enables the coil device **10** to have a favorable productivity.

[0070] As shown in FIG. **3** or so, the first and second terminal portions **50** and **60** have the first and second support portions **54***c* and **64***c* protruding from the first and second wirebound bottom portions **54***a* and **64***a* toward the reverse rotating direction side of the first rotating direction. The first and second support portions **54***c* and **64***c* are in contact with the first and second ends **30***a* and **30***b* on the winding side from the first and second caulking portions **54***bb* and **64***bb* and on the reverse rotating direction side. The first and second support portions **54***c* and **64***c* can receive forces generated when the first and second caulking portions **54***bb* and **64***bb* caulk the first and second ends **30***a* and **30***b*, and it is thus possible to prevent a problem of positional displacement of a center of the inner core **20** in a fixing step by caulking.

[0071] When the first and second terminal portions **50** and **60** have the first and second support portions **54***c* and **64***c*, contact areas between the first and second terminal portions **50** and **60** and the first and second ends **30***a* and **30***b* are large. Thus, the first and second terminal portions **50** and **60** can effectively release a heat generated when the first and second welding portions **54***ba* and **64***ba* are welded to the first and second ends **30***a* and **30***b*, and it is possible to prevent a problem that this heat is transmitted to the winding portion **30***c* and damages the insulation coating or so.

[0072] The first and second wire fixing portions **54***b* and **64***b* shown in FIG. **3** or so have the first and second welding portions **54***ba* and **64***ba* and the first and second caulking portions **54***bb* and **64***bb*, both of which are separately connected to the first and second wirebound bottom portions **54***a* and **64***a*. This enables the first and second terminal portions **50** and **60** to temporarily fix the first and second ends **30***a* and **30***b* in quick and reliable manner by the first and second caulking portions **54***bb* and **64***bb*. When the first and second caulking portions **54***bb* and **64***bb* are arranged on the winding portion sides, a good workability is achieved because the temporarily fixed portions by the first and second caulking portions **54***bb* and **64***bb* become unobstructive at the time of permanent fixings where the first and second welding portions **54***ba* and **64***ba* are welded to the first and second ends **30***a* and **30***b*. Furthermore, this arrangement demonstrates an effect that the heat generated at the time of welding the first and second welding portions **54***ba* and **64***ba* to the first and second ends **30***a* and **30***b* becomes hard to be transmitted to the side of the winding portion **30***c* of the wire **30**.

[0073] In the coil device **10**, as shown in FIG. **1** and FIG. **5** or so, the connection positions "A" between the first and second welding portions **54***ba* and **64***ba* and the first and second wirebound bottom portions **54***a* and **64***a* are distant from the first and second ends **30***a* and **30***b* more than the connection positions "B" between the first and second caulking portions **54***bb* and **64***bb* and the first and second wirebound bottom portions **54***a* and **64***a*. The coil device **10** can prevent a problem that a force of moving a center position of the inner core **20** is generated when the first and second welding portions **54***ba* and **64***ba* are bent toward the first rotating direction (clockwise direction) after the temporary fixings by the first and second caulking portions **54***bb* and **64***bb*.

[0074] Incidentally, the above-mentioned embodiment is just an example of embodiments included by the present invention, and various modification may be added to the embodiments as long as the problem of the invention can be solved. For example, the inner core **20** is a so-called drum core having flanges on its both ends, but the inner core **20** used for the coil device **10** is not limited to one shown in FIG. **2** or so, and may be one with the winding core **22** and the upper and lower flanges **24** and **26** having a cross sectional shape of ellipse, polygon, etc. The upper and lower flanges **24** and **26** of the inner core **20** may have diameters equal to each other or different from each other.

[0075] FIG. **8** is an external view showing a coil device **100** according to First Variation of the present invention. The coil device **100** according to First Variation is the same as the coil device **10** according to the embodiment except that a first wire fixing portion **154***b* and a second wire fixing portion of first and second terminal portions **150** and **160** have a different shape from that of the coil device **10** shown in FIG. **1**. Thus, in the coil device **100**, only differences from the coil device **10** will be explained, and common parts will not be explained.

[0076] FIG. **9** is a partially enlarged view showing a fixing portion between the first terminal portion **150** and a first end **30***a* of the coil device **100** shown in FIG. **8**, and shows only the first terminal portion **150** and the first end **30***a* of the coil device **100**. As shown in FIG. **9**, a first caulking portion **154***bb* of the first terminal portion **150** has a soft portion **155** that bends more easily than a base portion located closer to the first wirebound bottom portion **54***a* than the soft portion **155**. In the first caulking portion **154***bb*, the portion on the tip side from the soft portion **155** is narrower than the portion on the base portion side from the soft portion **155**. When the first caulking portion **154***bb* is bent to caulk the first end **30***a*, the first caulking portion **154***bb* is bent largely at the soft portion **155**.

[0077] In the first terminal portion **150** having the soft portion **155**, when the first caulking portion **154***bb* is bent to caulk the first end **30***a*, it is thus possible to prevent the base portion of the first caulking portion **154***bb* from providing the first end **30***a* with a force toward directions other than the Z-axis direction and prevent generation of a force of moving the inner core **20**. When the portion on the tip side of the soft portion **155** bends and caulks the first end **30***a*, it is also possible to prevent the other portions of the first terminal portion **150**, such as the first wirebound bottom portion **54***a*. The second terminal portion **160** shown in FIG. **8** has a soft portion similar to that of the first terminal portion **150**.

[0078] Incidentally, the soft portion **155** is not limited to the shape where the first caulking portion **154***bb* is provided with a step and the tip side of the first caulking portion **154***bb* is entirely narrow as shown in FIG. **9**, and may employ a shape where the caulking portion is provided with a slit to be partly narrow, a shape where the caulking portion partly has a small thickness (only the tip side, for example), or the like. Incidentally, FIG. **8** and FIG. **9** show a state where the first caulking portion **154***bb* fixes the first end **30***a*, but the first and second ends **50** and **60** shown in FIG. **1** to FIG. **6** also caulk and fix the first end **30***a* in the coil device **10** after being completed in the same manner as the first caulking portion **154***bb* shown in FIG. **8** and FIG. **9**.

[0079] The first and second caulking portions **54***bb* and **64***bb* shown in FIG. **3** and FIG. **4** are both bent clockwise from the first and second wirebound bottom portions **54***a*

and **64***a*, but may be bent in the same rotating direction. For example, the first and second caulking portions **54***bb* and **64***bb* may be both bent counterclockwise.

[0080] The first and second support portions **54***c* and **64***c* shown in FIG. **1** to FIG. **6** have a bending axis parallel to the extending directions of the first and second ends **30***a* and **30***b* and parallel to bending axes of the first and second wire fixing portions **54***b* and **64***b*, and are bent from the first and second wirebound bottom portion **54***a* and **64***a* toward the reverse rotating direction of the first rotating direction. The first and second support portions **54***c* and **64***c* are, however, not limited to this shape.

[0081] For example, the first and second support portions may be a protrusion bent from the first wirebound bottom portion **54***a* along a bending axis crossing the extending direction of the first end **30***a*, or may be a protrusion protruding from the first wirebound bottom portion **54***a* toward the Z-axis direction, such as a first support portion **254***c* included by a first terminal portion **250** shown in FIG. **10**. The first support portion **254***c* shown in FIG. **10** is hard to be used for caulking the first end **30***a*, but can more securely receive a force generated when the first caulking portion **54***bb* caulks the first and second ends **30***a* and **30***b*. The first terminal portion **250** having the first support portion **254***c* and the second terminal portion having a similar support portion can be used instead of the first and second terminal portions **50** and **60** shown in FIG. **5** and FIG. **6**, for example.

NUMERICAL REFERENCES

[0082] **10** . . . coil device
[0083] **20** . . . inner core
[0084] **22** . . . winding core
[0085] **24** . . . upper flange
[0086] **26** . . . lower flange
[0087] **30** . . . wire
[0088] **30***a* . . . first end
[0089] **30***b* . . . second end
[0090] **30***c* . . . winding portion
[0091] **40** . . . outer core
[0092] **40***a* . . . through hole
[0093] **42** . . . core upper surface
[0094] **42***a* . . . engagement end surface
[0095] **42***b* . . . support end surface
[0096] **44** . . . core lower surface
[0097] **46** . . . core outer peripheral surface
[0098] **48** . . . core inner peripheral surface
[0099] **50** . . . first terminal portion
[0100] **52** . . . first fixing portion
[0101] **52***a* . . . first upper surface portion
[0102] **52***b* . . . first lower surface portion
[0103] **52***c* . . . first side surface portion
[0104] **54** . . . first wirebound portion
[0105] **54***a* . . . first wirebound bottom portion
[0106] **54***b* . . . first wire fixing portion
[0107] **54***ba* . . . first welding portion
[0108] **54***bb* . . . first caulking portion
[0109] **54***c* . . . first support portion
[0110] **56** . . . first connection portion
[0111] **60** . . . second terminal portion
[0112] **62** . . . second fixing portion
[0113] **62***a* . . . second upper surface portion
[0114] **62***b* . . . second lower surface portion
[0115] **62***c* . . . second side surface portion
[0116] **64** . . . second wirebound portion
[0117] **64***a* . . . second wirebound bottom portion
[0118] **64***b* . . . second wire fixing portion
[0119] **64***ba* . . . second welding portion
[0120] **64***bb* . . . second caulking portion
[0121] **64***c* . . . second support portion
[0122] **66** . . . second connection portion

1. A coil device comprising:

an inner core having a winding core with column shape extending in an axial direction and a pair of flanges arranged on both sides of the winding core;

a wire having a winding portion winding around the winding core;

an outer core having a through hole inserted by the inner core and being arranged on an outer periphery of the inner core;

a first terminal portion provided with a first wirebound portion having a first wirebound bottom portion arranged on a core end surface of one of end surfaces of the outer core in the axial direction and connected to a first end of one of ends of the wire; and

a second terminal portion provided with a second wirebound portion having a second wirebound bottom portion arranged at a position rotated in a peripheral direction by a predetermined angle from the first wirebound bottom portion on the core end surface and connected to a second end of the other end of the wire,

wherein the first wirebound portion is provided with a first wire fixing portion bending from the first wirebound bottom portion toward a first rotating direction as seen from a tip side of the first end and fixing the first end, and

the second wirebound portion is provided with a second wire fixing portion bending from the second wirebound bottom portion toward the same rotating direction as the first rotating direction as seen from a tip side of the second end and fixing the second end.

2. The coil device according to claim **1**, wherein

the first wirebound portion is provided with a first support portion protruding from the first wirebound bottom portion toward a reverse rotating direction of the first rotating direction as seen from the tip side of the first end and touching the first end on its winding side compared to the first wire fixing portion, and

the second wirebound portion is provided with a second support portion protruding from the second wirebound bottom portion toward a reverse rotating direction of the first rotating direction as seen from the tip side of the second end and touching the second end on its winding side compared to the second wire fixing portion.

3. The coil device according to claim **1**, wherein

the first wire fixing portion is provided with a first welding portion welded to the first end and a first caulking portion connected to the first wirebound bottom portion with a predetermined space to the first welding portion and temporarily fixing the first end on its winding side compared to the first welding portion, and

the second wire fixing portion is provided with a second welding portion welded to the second end and a second caulking portion connected to the second wirebound bottom portion with a predetermined space to the

second welding portion and temporarily fixing the second end on its winding side compared to the second welding portion.

4. The coil device according to claim **2**, wherein

the first wire fixing portion is provided with a first welding portion welded to the first end and a first caulking portion connected to the first wirebound bottom portion with a predetermined space to the first welding portion and temporarily fixing the first end on its winding side compared to the first welding portion, and

the second wire fixing portion is provided with a second welding portion welded to the second end and a second caulking portion connected to the second wirebound bottom portion with a predetermined space to the second welding portion and temporarily fixing the second end on its winding side compared to the second welding portion.

5. The coil device according to claim **3**, wherein

a connection position between the first wirebound bottom portion and the first welding portion is distant from the first end more than a connection position between the first wirebound bottom portion and the first caulking portion, and

a connection position between the second wirebound bottom portion and the second welding portion is distant from the second end more than a connection position between the second wirebound bottom portion and the second caulking portion.

6. The coil device according to claim **4**, wherein

a connection position between the first wirebound bottom portion and the first welding portion is distant from the first end more than a connection position between the first wirebound bottom portion and the first caulking portion, and

a connection position between the second wirebound bottom portion and the second welding portion is distant from the second end more than a connection position between the second wirebound bottom portion and the second caulking portion.

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