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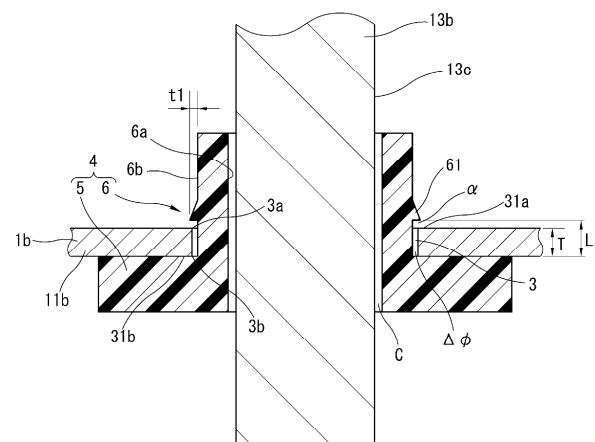
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(54) **BEARING STRUCTURE OF MOVABLE SIDE ENERGIZING SHAFT, VACUUM INTERRUPTER, AND VACUUM INTERRUPTER MANUFACTURING METHOD**

(57) The present invention is applied with a bearing (4) comprising: a flange-like part (5) that is in the form of a ring having a diameter larger than an opening diameter of a flange through-hole (3) on the other side in the shaft center direction; and a cylindrical wall part (6) that extends from the inner circumferential edge part of the flange-like part (5) along the shaft center direction. On the cylindrical wall part (6), claw parts (61) are formed on the outer circumferential surface (6b), and the outer diameter of the location where the claw parts (61) are formed is larger than the opening diameter of the flange through-hole (3) on one side in the shaft center direction. Further, on the cylindrical wall part (6), a plurality of slit holes having a shape that penetrates in the radial direction and extends in the shaft center direction and a shape that opens to one side in the shaft center direction are formed in the circumferential direction at prescribed intervals. Each piece of the cylindrical wall part, which is a site between the slit holes, is elastically deformable in the radial direction.

FIG. 2



Description

Technical Field

[0001] The present invention relates to a bearing structure for a movable side current-carrying shaft, a vacuum interrupter, and a method for manufacturing a vacuum interrupter, and relates to techniques applicable to various electric power facilities and others.

Background Art

[0002] For example, for use in various electric power facilities, a vacuum interrupter has a vacuum vessel composed of an insulating tubular body having a first side (fixed side) and a second side (movable side) in an axial direction of the tubular body (hereinafter simply referred to as the axial direction), wherein the first side is sealed with a fixed side flange, and the second side is sealed with a movable side flange. Inside the vacuum chamber, a fixed electrode and a movable electrode are arranged so as to face each other in the axial direction.

[0003] A fixed side current-carrying shaft is arranged inside the vacuum vessel with respect to the fixed side flange, extending from the inside of the vacuum vessel in the axial direction, and having an end portion supporting the fixed electrode.

[0004] The movable side flange is formed with a flange through hole extending through the movable side flange in the axial direction, wherein a bearing is mounted to the flange through hole to guide a movable side current-carrying shaft in the axial direction (for example, to guide the movable side current-carrying shaft non-rotatably). The movable side current-carrying shaft is supported inside the vacuum vessel with respect to the movable side flange via a bellows that is expandable and contractible in the axial direction.

[0005] With the vacuum interrupter configured as described above, the movable side current-carrying shaft (and the movable electrode) can be moved while being guided in the axial direction, with the vacuum vessel (specifically, radially outside the bellows inside the vacuum vessel) maintained in vacuum state. In accordance with movement of the movable side current-carrying shaft, the movable electrode can be brought into contact with and separated from the fixed electrode (a contact point can be opened or closed).

[0006] When the movable side current-carrying shaft is moved in the axial direction, frictional force may occur between the movable side current-carrying shaft and the bearing, which could cause the bearing to come loose and detach (fall out) from the flange through hole. For such situations, as disclosed in patent document 1, one solution is to use an adhesive to bond the bearing to the movable side flange to prevent the bearing from detaching from the flange through hole.

[0007] Furthermore, if the movable side current-carrying shaft rotates, its rotational force may be applied to the

bellows or other components, potentially causing damage. For such situations, the bearing may be configured to guide the movable side current-carrying shaft in the axial direction non-rotatably (for example, in patent document 2, an insertion guide (reference numeral 11) is formed with contact surfaces (reference numeral 12) forming a width across flats).

[0008] In addition, a configuration is known in which an opening side of a tubular wall portion (guide hole) of a bearing through which a movable side current-carrying shaft is inserted has an increased diameter to allow a certain degree of radial oscillation of the movable side current-carrying shaft (for example, a configuration disclosed in patent document 3).

Prior Art Document(s)

Patent Document(s)

[0009]

Patent Document 1: Japanese Patent Application Publication No. 9-17298

Patent Document 2: Published Japanese Translation of PCT International Publication No. 2016-535400

Patent Document 3: Japanese Patent Application No. 2016-110920

Summary of Invention

Problem(s) to be Solved by Invention

[0010] Bonding of a bearing to a movable side flange using an adhesive may be implemented by interposing the adhesive between the bearing and the movable side flange, and then allowing the adhesive to dry and solidify. However, this solidification takes a certain amount of time, which may lead to a decrease in productivity.

[0011] Furthermore, many adhesives are flammable, which may lower the heat resistance temperature of vacuum interrupters. Use of such a vacuum interrupter may be restricted (for example, to prevent places where the adhesive is applied from getting too hot).

[0012] It is also conceivable to fasten and fix the bearing to the movable side flange using bolts or the like instead of an adhesive. However, this may lead to increased assembly time, structural complexity, larger size, higher cost, etc.

[0013] Therefore, it is desirable to prevent the bearing from detaching from the flange through hole without using adhesives, bolts, or the like.

[0014] The present invention has been made in view of the above technical problems, and is targeted for providing a technique that can prevent a bearing from detaching from a flange through hole without using adhesives, bolts, etc., and thereby contribute to improving productivity.

Means to Solve Problem(s)

[0015] The bearing structure for the movable side current-carrying shaft, the vacuum interrupter, and the method for manufacturing the vacuum interrupter according to the present invention can contribute to solving the foregoing problems.

[0016] First, a bearing structure for a movable side current-carrying shaft according to an embodiment is configured wherein: a vacuum vessel has an insulating tubular body; a fixed electrode and a movable electrode are arranged in the vacuum vessel so as to face each other in an axial direction of the tubular body; and the movable side current-carrying shaft supports the movable electrode movably in the axial direction.

[0017] The tubular body has a fixed side as a first side in the axial direction, and a movable side as a second side in the axial direction, wherein the fixed side is sealed by a fixed side flange, and wherein the movable side is sealed by a movable side flange; the movable side flange includes a flange through hole extending through the movable side flange in the axial direction; the movable side current-carrying shaft is inserted through the flange through hole, extends in the axial direction, and has a first side portion in the vacuum vessel with respect to the movable side flange, wherein the first side portion is supported via a bellows, wherein the bellows is expandable and contractible in the axial direction; and a bearing is mounted non-rotatably to the flange through hole so as to guide the movable side current-carrying shaft in the axial direction non-rotatably.

[0018] The bearing includes: a flange portion having an annular shape larger in diameter than a second side opening of the flange through hole, and extending along an opening edge surface around the second side opening; and a tubular wall portion having a tubular shape extending from an inner peripheral edge of the flange portion toward the first side, inserted into the flange through hole in a direction from the second side toward the first side, and arranged to guide the movable side current-carrying shaft in the axial direction, wherein the movable side current-carrying shaft is inserted inside an inner peripheral surface of the tubular shape.

[0019] The tubular wall portion has an outer peripheral surface formed with a nail portion protruding radially outward from the tubular wall portion; slits formed in the tubular wall portion and arranged at predetermined intervals in a circumferential direction of the tubular wall portion, wherein each of the slits has a shape extending radially through the tubular wall portion, extending in the axial direction, and having an opening facing the first side; tubular wall portion pieces formed between corresponding adjacent two of the slits in the circumferential direction of the tubular wall portion, wherein each of the tubular wall portion pieces is structured to be elastically deformed radially of the tubular wall portion; and the tubular wall portion has an outer periphery at a location where the nail portion is formed, wherein the outer per-

iphery is larger in diameter than a first side opening of the flange through hole.

[0020] Furthermore, a following mathematical expression (1) is satisfied:

$$L \geq T \quad \dots(1)$$

where L represents a distance between the flange portion and the nail portion, and T represents a dimension of the flange through hole in the axial direction.

[0021] The bearing structure may be further configured wherein following mathematical expressions (2) and (3) are satisfied:

$$\Delta\phi < t1 < C \quad \dots(2)$$

$$L = T + \Delta T + \alpha \quad \dots(3)$$

where $\Delta\phi$ represents a dimensional tolerance in diameter of the flange through hole, t1 represents a dimension of the nail portion in a direction where the nail portion protrudes, C represents a clearance dimension between the tubular wall portion and the movable side current-carrying shaft, ΔT represents a dimensional tolerance of T, and α represents a dimension of play provided between the nail portion and an opening edge surface around the first side opening of the flange through hole.

[0022] The bearing structure may be further configured wherein: the nail portion has a shape whose radial outward protrusion gradually increases from the first side to the second side; and the nail portion has a surface on the second side, wherein the surface is formed flat along the opening edge surface around the first side opening of the flange through hole.

[0023] The bearing structure may be further configured wherein: the opening edge surface around the second opening is formed with at least one recess; and the flange portion is formed with a protrusion that corresponds in position to the recess and is structured to be fitted into the recess.

[0024] The bearing structure may be further configured wherein a plurality of the recesses are formed at predetermined intervals in the circumferential direction in the opening edge surface around the second side opening, and are rotationally symmetric in the opening edge surface with respect to the axial direction as an axis of symmetry.

[0025] The bearing structure may be further configured wherein the protrusion is formed in the flange portion on a root side of the tubular wall portion piece.

[0026] The bearing structure may be further configured wherein a following mathematical expression (4) is satisfied:

$$t2 > \Delta T + \alpha \quad \dots(4)$$

where ΔT represents a dimensional tolerance of T , α represents a dimension of play provided between the nail portion and an opening edge surface around the first side opening of the flange through hole, and t_2 represents a dimension of the protrusion in a direction of protrusion.

[0027] A vacuum interrupter according to an embodiment has the bearing structure described above.

[0028] A method for manufacturing the vacuum interrupter according to an embodiment includes: a vacuum brazing operation of inserting the movable side current-carrying shaft through the flange through hole, and with the movable side current-carrying shaft made to extend in the axial direction, brazing a first side portion of the movable side current-carrying shaft to a side of the movable side flange inside of the vacuum vessel via the bellows; and a bearing fitting operation of fitting the bearing into the flange through hole at a second side of the movable side current-carrying shaft, after the vacuum brazing operation.

Effects of Invention

[0029] As described above, according to the present invention, it is possible to prevent the bearing from detaching from the flange through hole without using adhesives or bolts, thereby contributing to improved productivity and other benefits.

Brief Description of Drawings

[0030]

FIG. 1 is a schematic diagram (a longitudinal cross-sectional view taken along a plane in an axial direction) illustrating a schematic configuration of a vacuum interrupter 1A according to an embodiment 1. FIG. 2 is a schematic diagram (an enlarged view) illustrating a major part of FIG. 1 (containing a bearing 4).

FIG. 3 is a schematic diagram illustrating a schematic configuration of the bearing 4, where (A) is a view from a radially outer side, and (B) is an enlarged view of a region enclosed by a circle indicated by a symbol X in (A).

FIG. 4 is a schematic diagram illustrating a schematic configuration of the bearing 4, where (A) is a view from a first side in the axial direction, (B) is a view from a second side in the axial direction, and (C) is a radial cross-sectional view of a movable side current-carrying shaft 13b.

FIG. 5 is a schematic diagram illustrating a schematic configuration of a movable side flange 1b, where (A) is a longitudinal cross-sectional view taken along a plane in the axial direction (a cross-sectional view along a line B-B), and (B) is a view from the second side in the axial direction).

Mode(s) for Carrying Out Invention

[0031] A bearing structure for a movable side current-carrying shaft, a vacuum interrupter, and a method for manufacturing a vacuum interrupter according to embodiments of the present invention are completely different from a configuration in which a bearing is simply bonded to a movable side flange with an adhesive (hereinafter referred to as conventional configuration).

[0032] In other words, according to the present embodiment, a bearing is applied to a flange through hole, wherein the bearing can be inserted through the flange through hole with elastic deformation (can be fitted by a so-called snap-fit structure).

[0033] Specifically, the bearing to be applied includes: an annular flange portion having a larger diameter than an opening diameter of an opening on a second side (movable side) in the axial direction of the flange through hole; and a tubular wall portion extending in the axial direction from an inner peripheral edge of the flange portion.

[0034] The tubular wall portion has an outer peripheral surface formed with a nail portion protruding radially outward from the tubular wall portion. The tubular wall portion has an outer periphery at a location where the nail portion is formed, wherein the outer periphery is larger in diameter than an opening diameter of an opening on a first side (fixed side) in the axial direction of the flange through hole.

[0035] Furthermore, the tubular wall portion is formed with slits arranged at predetermined intervals in a circumferential direction of the tubular wall portion (hereinafter simply referred to as a circumferential r direction as appropriate), wherein each of the slits has a shape extending radially through the tubular wall portion (hereinafter simply referred to as a radial direction as appropriate), extending in the axial direction, and having an opening facing the first side in the axial direction. This allows each tubular wall portion piece, which is formed between corresponding two of the slits in the tubular wall portion, to be elastically deformable in the radial direction.

[0036] Furthermore, the following mathematical expression (1) is satisfied, where L represents a distance between the flange portion and the nail portion, and T represents a dimension of the flange through hole in the axial direction.

$$L \geq T \quad \dots(1)$$

When the tubular wall portion of the bearing is inserted through the flange through hole from the second side toward the first side in the axial direction, the tubular wall portion pieces elastically deform radially inward while the nail portion of the tubular wall portion is located inside the flange through hole. Then, after the nail portion of the tubular wall disengages from the flange through hole to

the first side in the axial direction, each tubular wall portion piece elastically returns to its original position. As a result, the bearing engages with the flange through hole in such a manner that the movable side flange (the wall forming the flange through hole) is sandwiched in the axial direction between the flange portion and the nail portion.

[0037] Since the bearing is engaged with the flange through hole in this manner, detachment of the bearing from the flange through hole is suppressed (an engaged state is maintained) without the use of adhesives or bolts. Furthermore, since adhesives are not required, it is possible to avoid limitations on the use of vacuum interrupters as is the case with conventional configurations.

[0038] For establishment of a vacuum state inside a vacuum vessel, various components serving for the vacuum state (e.g., tubular body, fixed side flange, movable side flange, bellows, movable side current-carrying shaft, etc.) are assembled using a vacuum brazing operation.

[0039] However, during the vacuum brazing operation, a brazing material placed at a point of assembly is heated and melted. Accordingly, when a flammable adhesive is present as in conventional configurations, the vacuum brazing operation may be hindered (or inhibited). Therefore, when using adhesives, the movable side current-carrying shaft is first inserted through the flange through hole and made to extend in the axial direction, and after performing the vacuum brazing operation described above, the bearing is fitted to the second side of the movable side current-carrying shaft in the axial direction and bonded to the movable side flange.

[0040] On the other hand, the bearing according to the present embodiment is only required to be inserted through a flange through hole with elastic deformation, and can be easily composed of various materials. Therefore, for example, if the bearing according to the present embodiment is made of a resin material, and the heat resistance temperature of the resin material is higher than the vacuum brazing temperature, the bearing may be engaged with the flange through hole in advance in a step prior to the vacuum brazing operation described above.

[0041] Furthermore, after the vacuum brazing operation described above, each component may undergo thermal expansion depending on its material and shape. For example, when the movable side flange undergoes thermal expansion, dimensional errors within tolerances may occur in the axial dimension (T) and diameter of the flange through hole.

[0042] The bearing according to the present embodiment may be designed to take into account dimensional tolerances and the like resulting from the vacuum brazing operation described above (for example, the design may be carried out to satisfy mathematical expressions (2) and (3) as in embodiment 1 described below). This makes it possible to engage the bearing with the flange through hole as desired in a subsequent operation, even if dimensional errors within tolerances occur in the flange

through hole during the vacuum brazing operation.

[0043] The present embodiment is only required to contain the bearing structure with which the bearing can be inserted through the flange through hole with elastic deformation as described above. It is possible to appropriately adopt common technical knowledge from various fields (vacuum interrupter field, bearing field, mechanical joining field, vacuum brazing field, etc.) and modify the design as required by referring to prior art documents, etc.

[0044] In the following embodiments 1 and 2, for common features, detailed description has been omitted as appropriate, for example, by referring to the same reference numerals. Furthermore, in FIG. 2 described below, dimensions t1, clearance C, dimensional tolerance ΔT , and play dimension α are depicted in an exaggerated manner for convenience.

<Embodiment 1>

[0045] <Example of General Configuration of Vacuum Interrupter to Which Bearing Structure is Applied> The following describes a schematic configuration example of a vacuum interrupter 1A to which a bearing structure according to embodiment 1 is applied with reference to FIGS. 1 to 5. This vacuum interrupter 1A includes a vacuum vessel 1 composed of an insulating tubular body 10 that has a first side and a second side in its axial direction, wherein the first side is blocked with a fixed side flange 1a, and the second side is blocked with a movable side flange 1b.

[0046] The tubular body 10 shown in FIG. 1 is composed mainly of: a tubular intermediate shield (arc shield) 20 surrounding the outer periphery of a fixed electrode 14a and a movable electrode 14b described below; a fixed side insulating portion 21a connected to the first side in the axial direction of the intermediate shield 20; and a movable side insulating portion 21b connected to the second side in the axial direction of the intermediate shield 20.

[0047] Furthermore, the intermediate shield 20 has a central part where a fixed side extension portion 20a and a movable side extension portion 20b are arranged, wherein the fixed side extension portion 20a extends from the central part to the first side in the axial direction and overlaps with the inner periphery of the fixed side insulating portion 21a, and the movable side extension portion 20b extends from the central part to the second side in the axial direction and overlaps with the inner periphery of the movable side insulating portion 21b.

[0048] The fixed side flange 1a has a disc-shaped portion 11a, and an outer peripheral edge portion 12a that extends from the outer periphery of the disc-shaped portion 11a to the second side in the axial direction and is supported by an end face 2aa of the fixed side insulating portion 21a. Thus, the fixed side flange 1a has a bot-tomed tubular structure as a whole.

[0049] The disc-shaped portion 11a has a central por-

tion from which a columnar fixed side current-carrying shaft 13a extends to the second side in the axial direction (in FIG. 1, the fixed side current-carrying shaft 13a extends through the central portion from the first side to the second side in the axial direction). The fixed side current-carrying shaft 13a has an end portion on the second side in the axial direction which supports a fixed electrode 14a.

[0050] The movable side flange 1b has a disc-shaped portion 11b, and an outer peripheral edge portion 12b that extends from the outer periphery of the disc-shaped portion 11b toward the first side in the axial direction and is supported by an end face 2bb of the movable side insulating portion 21b. Thus, the movable side flange 1b has a bottomed tubular shape as a whole.

[0051] The disc-shaped portion 11b has a central portion formed with a flange through hole 3 having a shape extending through the central portion in the axial direction. A columnar movable side current-carrying shaft 13b is inserted and extends through the flange through hole 3 in the axial direction.

[0052] The movable side current-carrying shaft 13b has an end portion facing the first side in the axial direction which supports a movable electrode 14b. Furthermore, a first side portion of the movable side current-carrying shaft 13b in the axial direction (on the side facing the movable electrode 14b) is supported inside the vacuum vessel 1 with respect to the movable side flange 1b via a tubular bellows 15 that is extendable and retractable in the axial direction and is arranged coaxially with the movable side current-carrying shaft 13b. In the example of FIG. 1, the movable side current-carrying shaft 13b is provided with a tubular bellows shield 16 so as to cover and surround the outer periphery of the bellows 15.

[0053] A bearing 4 is mounted to the flange through hole 3. The bearing 4 is capable of guiding the movable side current-carrying shaft 13b in the axial direction non-rotatably, and is inserted through the flange through hole 3 (inserted so as to be arranged coaxially with the movable side current-carrying shaft 13b and on the outer periphery side of the movable side current-carrying shaft 13b in the flange through hole 3).

[0054] The bearing 4 has a structure that can be inserted through the flange through hole 3 with elastic deformation (for example, the bearing 4 has a flange portion 5 and a tubular wall portion 6 as described below, and has a structure that can be inserted through with a so-called snap-fit structure), and is mounted non-rotatably with respect to the flange through hole 3.

[0055] With the vacuum interrupter 1A configured as described above, the movable side current-carrying shaft 13b (and movable electrode 14b) can be moved while being guided in the axial direction, with the inside of the vacuum vessel 1 (specifically, radially outside the bellows 15 inside the vacuum vessel 1) maintained in vacuum state. In accordance with movement of the movable side current-carrying shaft 13b, the movable electrode 14b can be brought into contact with and separated from the fixed electrode 14a (a contact point 14 can be opened or

closed).

[0056] For the components of the vacuum interrupter 1A, materials, shapes, and others, and processing methods and assembly methods may be appropriately embodied variously depending on an intended use of the vacuum interrupter 1A.

[0057] For example, among the components of the vacuum interrupter 1A, insulating materials (e.g., alumina ceramics) may be used for the fixed side insulating part 21a and the movable side insulating part 21b, resin materials (e.g., heatresistant resin materials) may be used for the bearing 4, and metal materials (e.g., stainless steel (SUS304), oxygen-free copper, titanium) may be used for the others. However, it is preferable to select these materials appropriately, taking into account that expansion (thermal expansion) and residual stress may occur due to assembling of the components.

[0058] <Example of Configuration of Bearing 4> The bearing 4 may have one of various configurations, if it has a structure that can be inserted through the flange through hole 3 with elastic deformation, and can allow the movable side current-carrying shaft 13b to be moved while being guided non-rotatably in the axial direction.

[0059] FIGS. 1 to 4 show an example of the bearing 4, which has a flange portion 5 and a tubular wall portion 6, and can be placed by being inserted through the flange through hole 3 with elastic deformation (a so-called snap-fit structure that can be inserted through).

[0060] The flange portion 5 has an annular shape with a larger diameter than the opening 3b on the second axial side of the flange through hole 3, and extends along an opening edge surface 31b around the opening 3b.

[0061] The tubular wall portion 6 has a tubular shape that extends from an inner peripheral edge portion 51 of the flange portion 5 toward the first side in the axial direction, and is capable of being inserted into the flange through hole 3 from the second side toward the first side in the axial direction. Furthermore, the tubular wall portion 6 has an inner peripheral surface 6a that is formed to allow the movable side current-carrying shaft 13b to be inserted therethrough, and to guide the inserted movable side current-carrying shaft 13b in the axial direction.

[0062] The tubular wall portion 6 has an outer peripheral surface 6b that is formed with a nail portion 61 protruding radially outward from the tubular wall portion 6. The tubular wall portion 6 has an outer periphery at a location where the nail portion 61 is formed, wherein the outer periphery is larger in diameter than the first axial side opening 3a of the flange through hole 3.

[0063] Furthermore, the following mathematical expression (1) is satisfied, where L represents a distance between the flange portion 5 and the nail portion 61, and T represents a dimension of the flange through hole 3 in the axial direction (generally equal to the thickness of the disc-shaped portion 11b in the example of the drawings).

$$L \geq T \dots(1)$$

The tubular wall portion 6 is formed with slits 62 extending radially through the tubular wall portion 6. The slits 62 (four slits in FIGS. 3 and 4) are formed at predetermined intervals in the circumferential direction of the tubular wall portion 6, and each have a shape that extends in the axial direction and has an opening facing the second side in the axial direction. Accordingly, four tubular wall portion pieces 60 are formed between corresponding two of the slits 62 in the circumferential direction of the tubular wall portion 6, where each tubular wall portion piece 60 has a first axial side portion that is configured to be elastically deformable in the radial direction.

[0064] When the tubular wall portion 6 of the bearing 4 is inserted through the flange through hole 3 from the second side toward the first side in the axial direction, the first axial side portion of each tubular wall portion piece 60 is elastically deform radially inward while the nail portion 61 of the tubular wall portion 6 is located inside the flange through hole 3. Then, after the nail portion 61 of the tubular wall portion 6 is released from the flange through hole 3 to the first side in the axial direction, the tubular wall portion piece 60 elastically returns to its original position.

[0065] As a result, the bearing 4 engages with the flange through hole 3, sandwiching the movable side flange 1b (the wall forming the flange through hole 3) in the axial direction between the flange portion 5 and the nail portion 61. This engaged state is easier to maintain.

[0066] In the example shown in the drawings, the nail portion 61 has a shape whose radial outward protrusion gradually increases from the first side to the second side in the axial direction. Furthermore, the surface on the second side in the axial direction of the nail portion 61 is formed flat along the opening edge surface 31a around the opening 3a of the flange through hole 3. This shape of nail portion 61 makes it easier to insert the bearing 4 into the flange through hole 3, and after insertion and engagement, maintain the engaged state of the bearing 4.

[0067] <Example of Assembly Method for Bearing 4> For example, each component for vacuum state inside the vacuum vessel 1 (in FIG. 1, the tubular body 10, the fixed side flange 1a, the movable side flange 1b, the bellows 15, the movable side current-carrying shaft 13b, etc.; hereinafter, these are simply referred to as vacuum state components as appropriate) is assembled by a vacuum brazing operation. However, with regard to bearing 4, if the heat resistance temperature of the bearing 4 is higher than a vacuum brazing temperature, the bearing 4 may be mounted in a step prior to the vacuum brazing operation or in a step after the vacuum brazing operation.

[0068] On the other hand, if the heat resistance temperature of the bearing 4 is lower than the vacuum brazing temperature, the vacuum brazing operation and a bearing fitting operation may be performed in order as shown below. First, in the vacuum brazing operation, brazing material is appropriately placed in advance at points of assembly of the vacuum state components, and the vacuum state components are assembled as shown

in FIG. 1. Then, the assembled vacuum state components are heat-treated and vacuum-brazed in a vacuum furnace.

[0069] This vacuum brazing operation sets the movable side current-carrying shaft 13b such that the movable side current-carrying shaft 13b is inserted through the flange through hole 3 and extends in the axial direction, and the first axial side portion of the movable side current-carrying shaft 13b is supported (brazed) to the inside of the vacuum vessel 1 of the movable side flange 1b via the bellows 15.

[0070] Next, in the bearing fitting operation, the tubular wall portion 6 of the bearing 4 is first positioned to face the second side in the axial direction of the movable side current-carrying shaft 13b, and then fitted to the second side in the axial direction of the movable side current-carrying shaft 13b. Then, the fitted bearing 4 is moved toward the first side in the axial direction and inserted into the flange through hole 3 (inserted over the outer periphery of the movable side current-carrying shaft 13b), thereby achieving the engagement state shown in FIGS. 1 and 2.

[0071] Furthermore, if dimensional errors within tolerances occur in the flange through hole 3 after the vacuum brazing operation, it is possible that the subsequent bearing fitting operation may be hindered. For such situations, the bearing 4 may be designed appropriately in advance, taking into account dimensional tolerances, as shown below.

[0072] First, the bearing 4 is designed to satisfy the following mathematical expressions (2) and (3), where $\Delta\phi$ represents a dimensional tolerance in diameter of the flange through hole 3, t_1 represents a dimension of the nail portion 61 in a direction where the nail portion (61) protrudes, C represents a clearance dimension between the tubular wall portion 6 and the movable side current-carrying shaft 13b, ΔT represents a dimensional tolerance of the dimension T of the flange through hole 3 in the axial direction, and α represents a dimension of play provided between the nail portion 61 and the opening edge surface 31a around the opening 3a of the flange through hole 3 (for example, an extremely narrow gap).

$$\Delta\phi < t_1 < C \quad \dots(2)$$

$$L = T + \Delta T + \alpha \quad \dots(3)$$

With the bearing 4 designed in this way, even if dimensional errors within tolerances occur in the flange through hole 3 after the vacuum brazing operation, the bearing fitting operation can be carried out appropriately to engage the bearing 4 with the flange through hole 3 as desired.

[0073] <Example of Configuration for Setting Movable Side Current-Carrying Shaft 13b Non-Rotatable> The configuration for setting the movable side current-carrying shaft 13b non-rotatable with respect to the tubular wall

portion 6 of the bearing 4 is not particularly limited, and may be implemented by various forms.

[0074] For example, the outer peripheral surface 13c of the movable side current-carrying shaft 13b is formed with an outer peripheral flat surface 13d having a shape that is aligned with a tangent plane of the outer peripheral surface 13c, and the inner peripheral surface 6a of the tubular wall portion 6 is formed with an inner peripheral flat surface 6c at a position corresponding to the outer peripheral flat surface 13d, wherein the inner peripheral flat surface 6c has a shape that is aligned with the outer peripheral flat surface 13d.

[0075] With this configuration, for example, even when a rotational force is applied to the movable side current-carrying shaft 13b, contact between the outer peripheral flat surface 13d and the inner peripheral flat surface 6c suppresses the movable side current-carrying shaft 13b from being rotated (maintains the movable side current-carrying shaft 13b non-rotatable).

[0076] The outer peripheral flat surface 13d and inner peripheral flat surface 6c are not limited to a single combination, but a plurality of the combinations may be provided at predetermined intervals in the circumferential direction. In the example of FIG. 4, the outer peripheral surface 13c of the movable side current-carrying shaft 13b has two outer flat surfaces 13d formed parallel to each other, thereby forming a so-called two sided width shape.

[0077] Furthermore, instead of simply providing multiple outer circumferential flat surfaces 13d and inner circumferential flat surfaces 6c, they may also be appropriately provided so as to be rotationally symmetrical with respect to the axial direction (180-degree rotational symmetry in FIG. 4). In this case, the position of the movable side current-carrying shaft 13b when it is inserted into the bearing 4 has rotational symmetry, which may make the operation of insertion (positioning, etc.) easier.

[0078] <Example of Configuration for Setting Bearing 4 No-Rotatable> The configuration for setting the bearing 4 non-rotatable with respect to the flange through hole 3 is not particularly limited, and may be implemented by various forms. For example, this configuration may be embodied similarly to the configuration for setting the movable side current-carrying shaft 13b non-rotatable (with formation of the outer peripheral flat surface 13d and the inner peripheral flat surface 6c), but may be implemented as discussed in embodiment 2 described below.

[0079] According to the embodiment 1 described above, it becomes easier to insert the bearing 4 into the flange through hole 3 and engage the bearing 4 without using adhesives or bolts, and to maintain this engaged state, thereby contributing to improved productivity and other benefits.

<Embodiment 2>

[0080] The following describes an embodiment 2 in

which the bearing 4 is made unable to rotate with respect to the flange through hole 3. In this embodiment 2, for example, as shown in FIG. 5, a recess 32 is formed in the opening edge surface 31b around the opening 3b of the movable side flange 1b. Furthermore, for example, as shown in FIGS. 3 and 4, a protrusion 52 is formed in the flange portion 5 of the bearing 4 at a position corresponding to the recess 32, with a shape that allows it to be fitted into the recess 32.

[0081] With this configuration in which the recess 32 and the protrusion 52 are formed, it is possible to engage the bearing 4 with the flange through hole 3 such that the protrusion 52 is fitted into the recess 32.

While the protrusion 52 remains fitted into the recess 32 (hereinafter referred to as fitted state as appropriate), even when a rotational force is applied to the bearing 4, the bearing 4 is suppressed from rotating (a state of non-rotation is maintained).

[0082] The protrusion 52 may be formed at any position corresponding to the recess 32 as described above, but preferably the protrusion 52 is formed in the flange portion 5 on the root side of the tubular wall portion piece 60. This serves to thicken the tubular wall portion 60 depending on the shape and position of the protrusion 52, thereby improving mechanical strength of the tubular wall portion 60.

[0083] The recess 32 and the protrusion 52 are not limited to a single combination, but a plurality of the combinations (four combinations in FIGS. 3 to 5) may be provided at predetermined intervals in the circumferential direction.

[0084] Furthermore, instead of simply providing multiple recesses 32 and protrusions 52, they may be appropriately arranged to be rotationally symmetrical with respect to the axial direction (90-degree rotational symmetry in FIG. 4). In this case, the position of the bearing 4 when it engages with the flange through hole 3 has rotational symmetry, which may make the operation of engagement (positioning, etc.) easier.

[0085] Furthermore, if dimensional errors within tolerances occur in the flange through hole 3 after the vacuum brazing operation, it is possible that the protrusion 52 cannot be maintained fitted in the recess 32. For such situations, the bearing 4 may be designed appropriately so as to satisfy a mathematical expression (4) below. In the mathematical expression (4) below, t_2 represents a dimension of the protrusion 52 in the direction of protrusion.

$$t_2 > \Delta T + \alpha \quad \dots(4)$$

With the bearing 4 designed in this way, even when dimensional errors within tolerances occur in the flange through hole 3 after the vacuum brazing operation, the bearing fitting operation can be carried out appropriately, and it becomes easier to maintain the protrusion 52 fitted in the recess 32.

[0086] The above-described embodiment 2 can produce the following effects, in addition to the same effects as in embodiment 1. Namely, since the flange through hole 3 itself does not need to be designed with consideration for a non-rotatable state, it is possible to contribute to cost reduction by forming the flange through hole 3 in a shape that is relatively easy to manufacture (for example, a circular shape).

[0087] Although the present invention has been described in detail only with respect to the specific embodiments described above, it is obvious to those skilled in the art that a wide variety of modifications are possible within the scope of the technical concept of the present invention, and it is natural that such modifications fall within the scope of the patent claims.

Description of Reference Signs

[0088]

1A...Vacuum interrupter, 1...Vacuum vessel,
1a...Fixed side flange, 1b...Movable side flange,
13b...Movable side current-carrying shaft,
14a...Fixed electrode, 14b...Movable electrode,
15...Bellows,
3...Flange through hole, 32...Recess,
4...Bearing,
5...Flange portion, 52...Protrusion,
6...Tubular wall portion, 60...Tubular wall portion piece,
61...Nail portion, 62...Slit.

Claims

1. A bearing structure for a movable side current-carrying shaft, wherein:

a vacuum vessel has an insulating tubular body;
a fixed electrode and a movable electrode are arranged in the vacuum vessel so as to face each other in an axial direction of the tubular body;
the movable side current-carrying shaft supports the movable electrode movably in the axial direction;
the tubular body has a fixed side as a first side in the axial direction, and a movable side as a second side in the axial direction, wherein the fixed side is sealed by a fixed side flange, and wherein the movable side is sealed by a movable side flange;
the movable side flange includes a flange through hole extending through the movable side flange in the axial direction;
the movable side current-carrying shaft is inserted through the flange through hole, extends in the axial direction, and has a first side portion

in the vacuum vessel with respect to the movable side flange, wherein the first side portion is supported via a bellows, wherein the bellows is expandable and contractible in the axial direction;

a bearing is mounted non-rotatably to the flange through hole so as to guide the movable side current-carrying shaft in the axial direction non-rotatably;

the bearing includes:

a flange portion having an annular shape larger in diameter than a second side opening of the flange through hole, and extending along an opening edge surface around the second side opening; and

a tubular wall portion having a tubular shape extending from an inner peripheral edge of the flange portion toward the first side, inserted into the flange through hole in a direction from the second side toward the first side, and arranged to guide the movable side current-carrying shaft in the axial direction, wherein the movable side current-carrying shaft is inserted inside an inner peripheral surface of the tubular shape;

the tubular wall portion has an outer peripheral surface formed with a nail portion protruding radially outward from the tubular wall portion; slits formed in the tubular wall portion and arranged at predetermined intervals in a circumferential direction of the tubular wall portion, wherein each of the slits has a shape extending radially through the tubular wall portion, extending in the axial direction, and having an opening facing the first side;

tubular wall portion pieces formed between corresponding adjacent two of the slits in the circumferential direction of the tubular wall portion, wherein each of the tubular wall portion pieces is structured to be elastically deformed radially of the tubular wall portion;

the tubular wall portion has an outer periphery at a location where the nail portion is formed, wherein the outer periphery is larger in diameter than a first side opening of the flange through hole; and

a following mathematical expression (1) is satisfied:

$$L \geq T \quad \dots(1)$$

where L represents a distance between the flange portion and the nail portion, and T represents a dimension of the flange through hole in the axial direction.

2. The bearing structure according to claim 1, wherein following mathematical expressions (2) and (3) are satisfied:

$$\Delta\phi < t_1 < C \quad \dots(2) \quad 5$$

$$L = T + \Delta T + \alpha \quad \dots(3) \quad 10$$

where $\Delta\phi$ represents a dimensional tolerance in diameter of the flange through hole, t_1 represents a dimension of the nail portion in a direction where the nail portion protrudes, C represents a clearance dimension between the tubular wall portion and the movable side current-carrying shaft, ΔT represents a dimensional tolerance of T , and α represents a dimension of play provided between the nail portion and an opening edge surface around the first side opening of the flange through hole.

3. The bearing structure according to claim 1, wherein:

the nail portion has a shape whose radial outward protrusion gradually increases from the first side to the second side; and
the nail portion has a surface on the second side, wherein the surface is formed flat along the opening edge surface around the first side opening of the flange through hole.

4. The bearing structure according to claim 1, wherein:

the opening edge surface around the second opening is formed with at least one recess; and
the flange portion is formed with a protrusion that corresponds in position to the recess and is structured to be fitted into the recess.

5. The bearing structure according to claim 4, wherein a plurality of the recesses are formed at predetermined intervals in the circumferential direction in the opening edge surface around the second side opening, and are rotationally symmetric in the opening edge surface with respect to the axial direction as an axis of symmetry.

6. The bearing structure according to claim 4, wherein the protrusion is formed in the flange portion on a root side of the tubular wall portion piece.

7. The bearing structure according to claim 4, wherein a following mathematical expression (4) is satisfied:

$$t_2 > \Delta T + \alpha \quad \dots(4) \quad 55$$

where ΔT represents a dimensional tolerance of T , α represents a dimension of play provided between the

nail portion and an opening edge surface around the first side opening of the flange through hole, and t_2 represents a dimension of the protrusion in a direction of protrusion.

8. A vacuum interrupter comprising the bearing structure according to any one of claims 1 to 7.

9. A method for manufacturing the vacuum interrupter according to claim 8, comprising:

a vacuum brazing operation of inserting the movable side current-carrying shaft through the flange through hole, and with the movable side current-carrying shaft made to extend in the axial direction, brazing a first side portion of the movable side current-carrying shaft to a side of the movable side flange inside of the vacuum vessel via the bellows; and

a bearing fitting operation of fitting the bearing into the flange through hole at a second side of the movable side current-carrying shaft, after the vacuum brazing operation.

FIG. 1

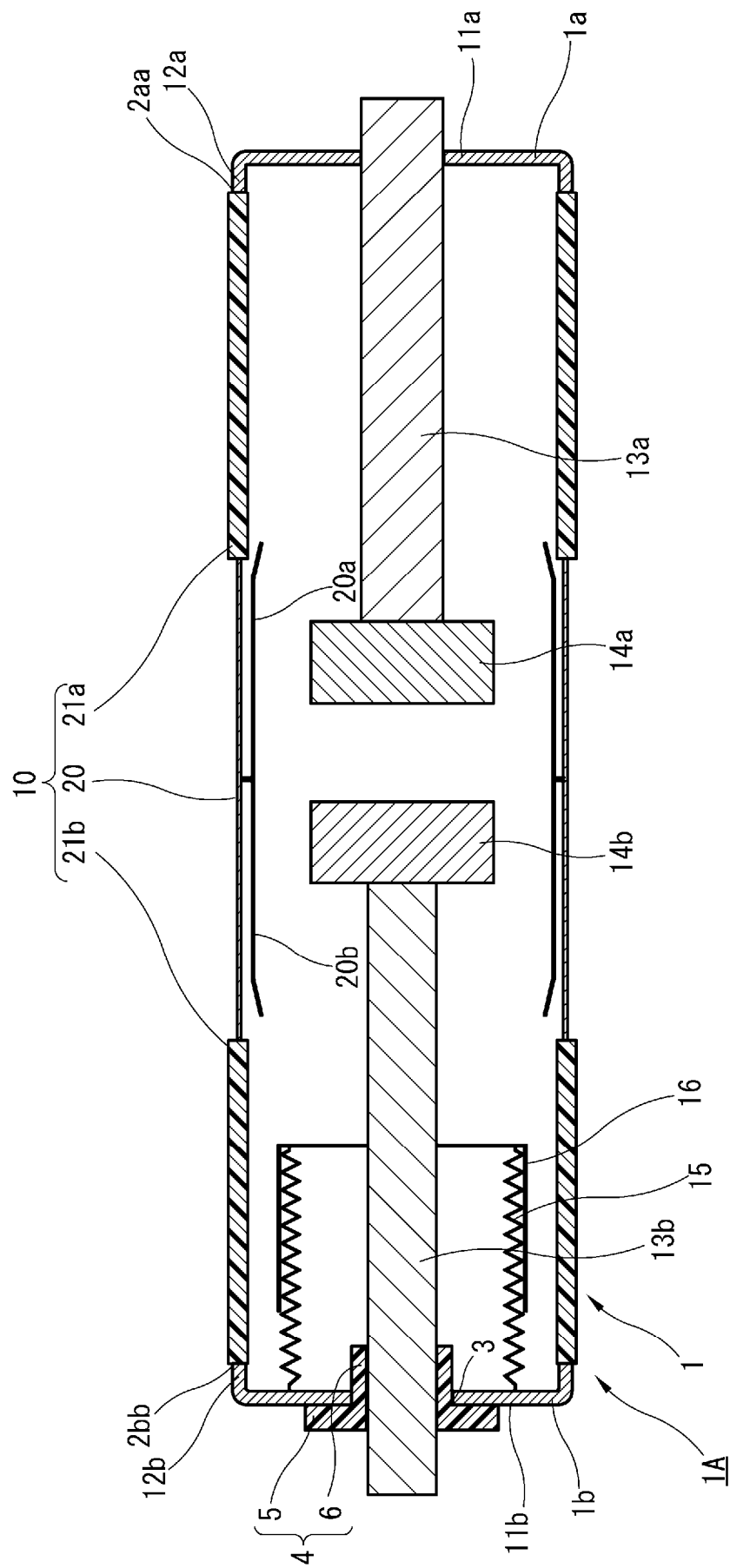


FIG. 2

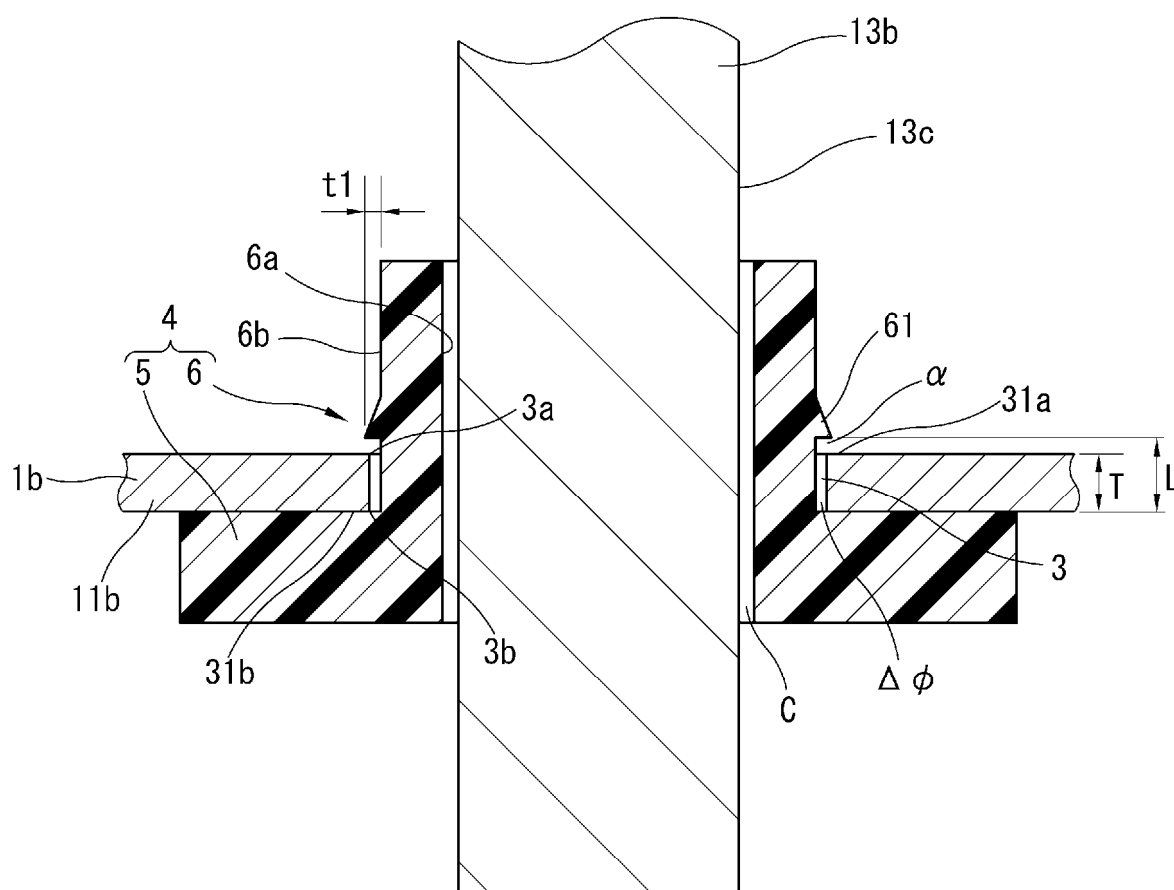


FIG. 3

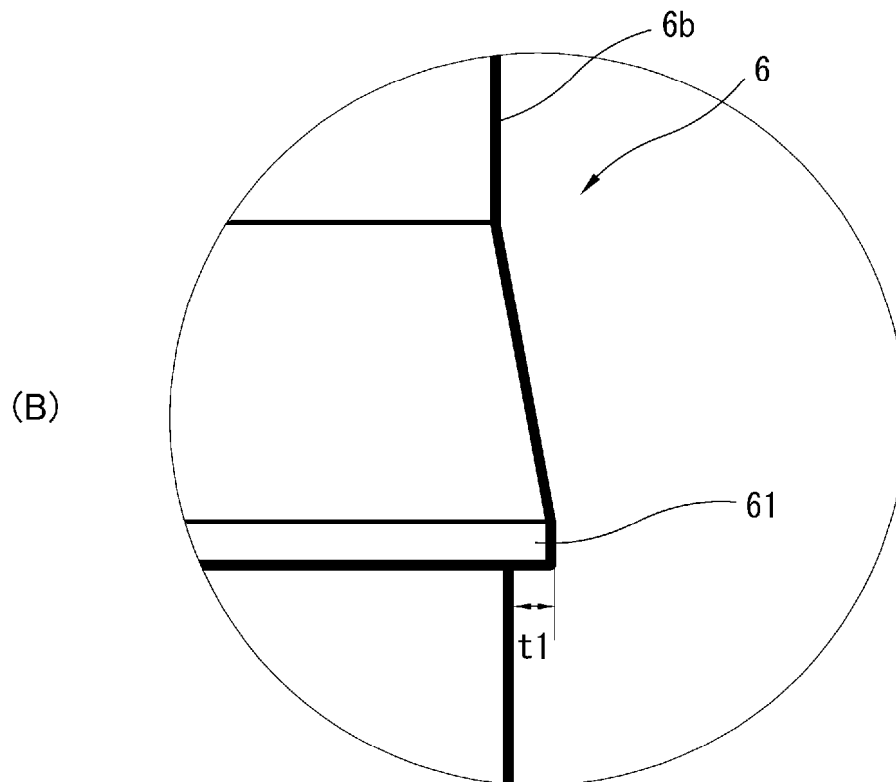
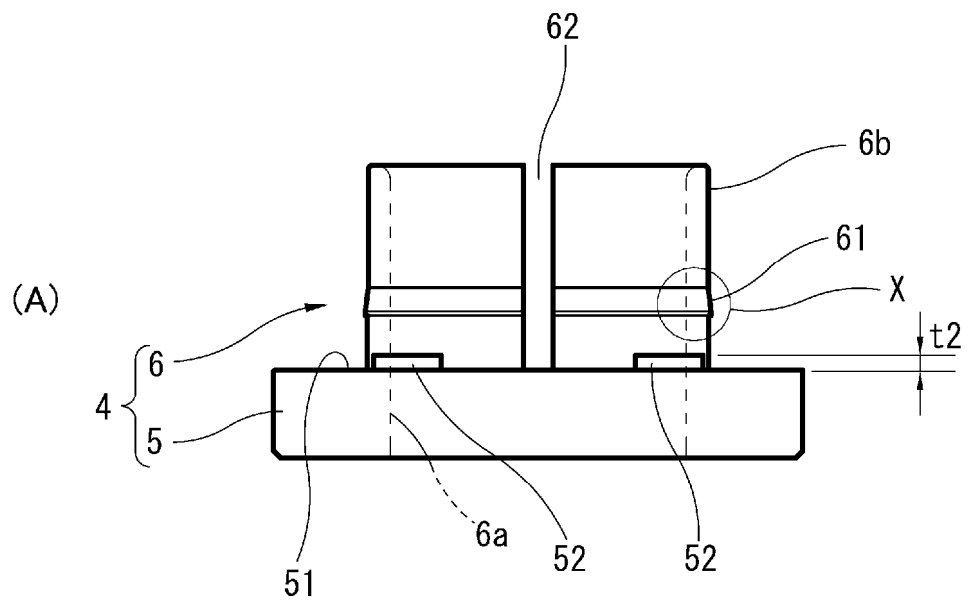


FIG. 4

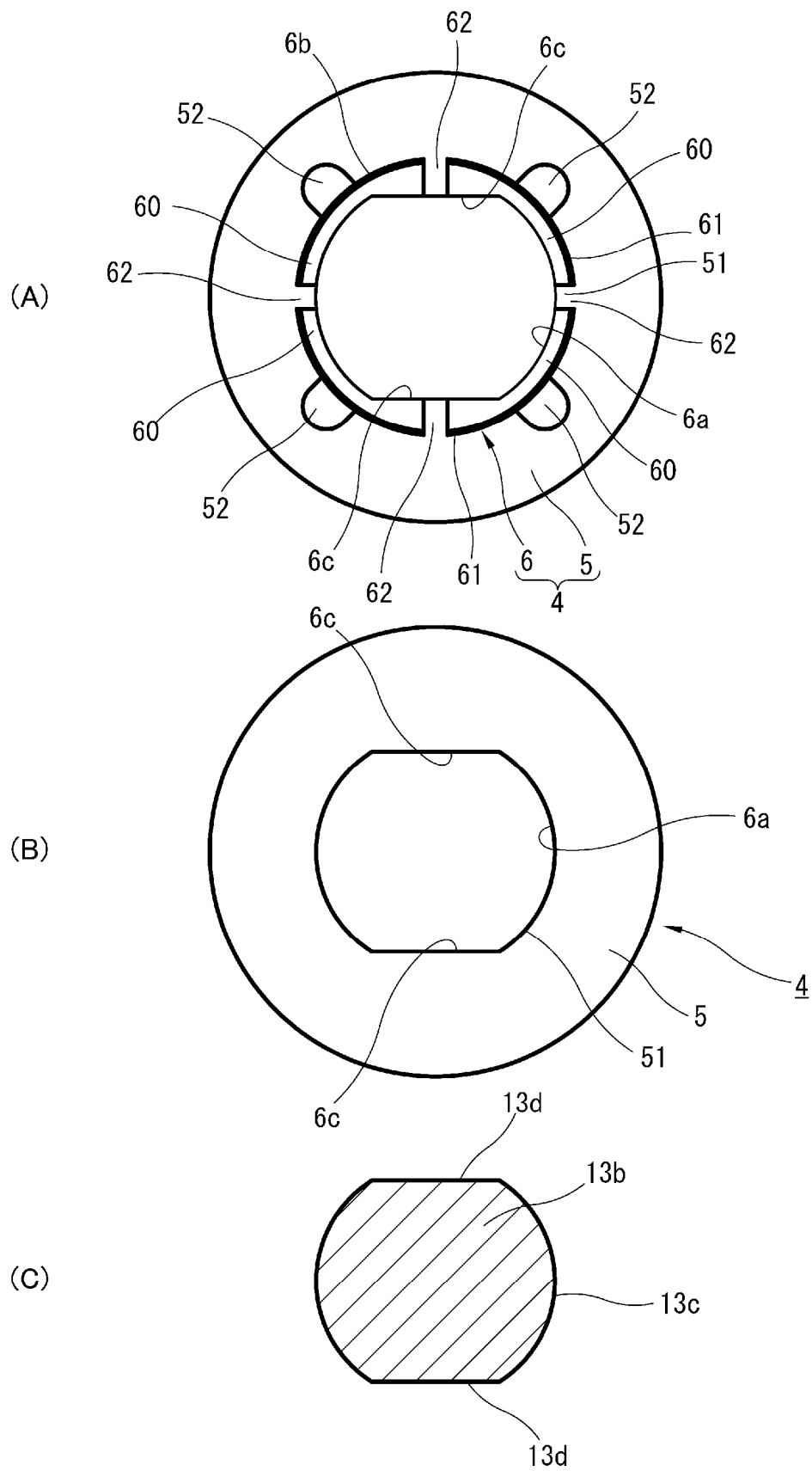
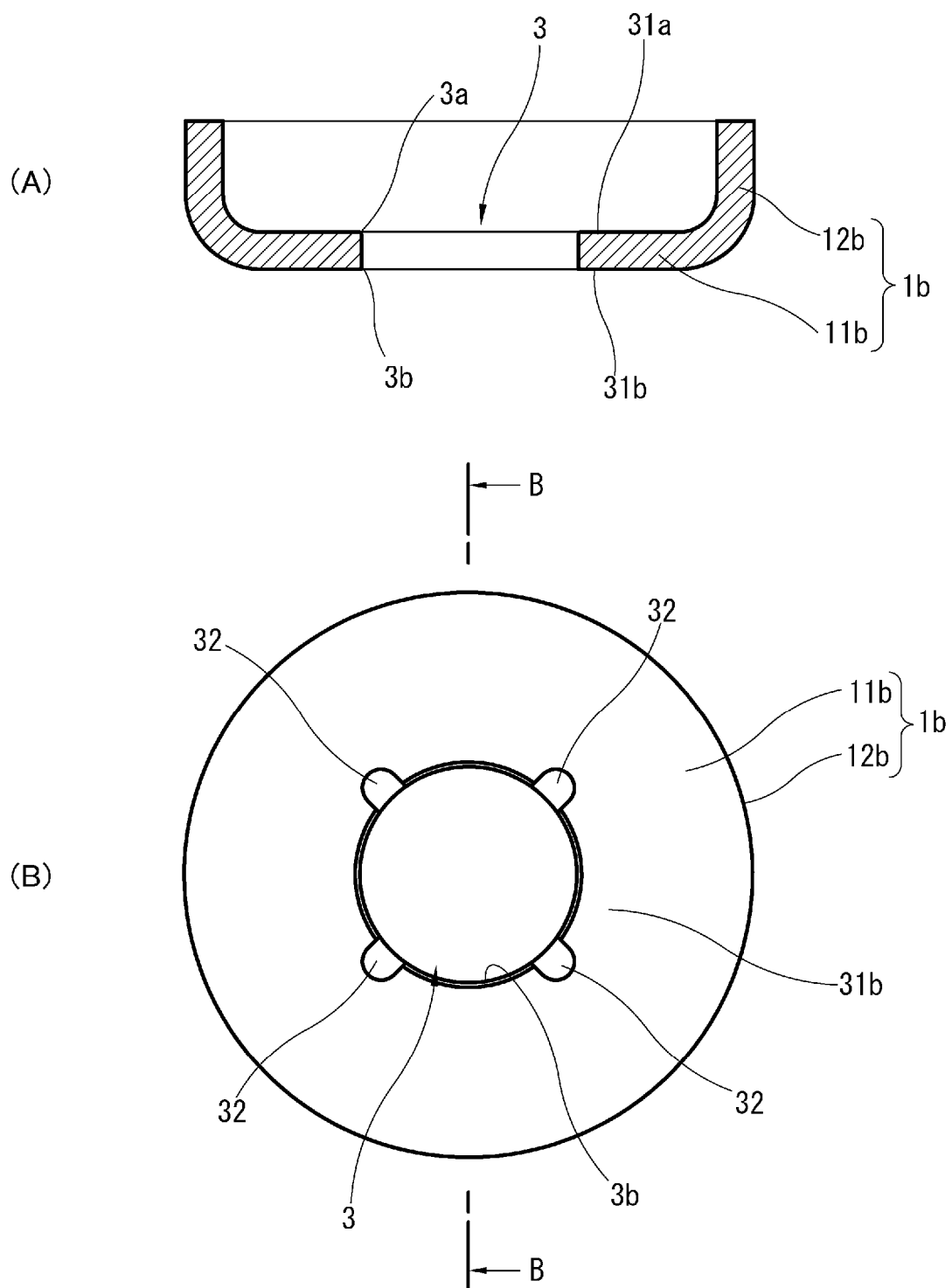


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/033042

A. CLASSIFICATION OF SUBJECT MATTER**H01H 33/662**(2006.01)i

FI: H01H33/662 J

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01H33/662

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2024
 Registered utility model specifications of Japan 1996-2024
 Published registered utility model applications of Japan 1994-2024

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-272600 A (MITSUBISHI ELECTRIC CORPORATION) 20 October 1995 (1995-10-20) paragraphs [0013]-[0020], fig. 1-6	1-9
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 73671/1973 (Laid-open No. 21665/1975) (MEIDENSHA ELECTRIC MFG CO., LTD.) 11 March 1975 (1975-03-11), description, page 2, line 7 - page 3, line 11, fig. 5	1-9
Y	JP 2011-3502 A (MITSUBISHI ELECTRIC CORPORATION) 06 January 2011 (2011-01-06) paragraph [0002], fig. 4	9
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 61168/1988 (Laid-open No. 165541/1989) (KABUSHIKI KAISHA TOSHIBA) 20 November 1989 (1989-11-20), description, page 2, line 19 - page 3, line 7, fig. 2	9

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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“&” document member of the same patent family

Date of the actual completion of the international search

08 October 2024

Date of mailing of the international search report

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Name and mailing address of the ISA/JP

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2024/033042

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	7-272600	A	20 October 1995	(Family: none)	
JP	50-21665	U1	11 March 1975	(Family: none)	
JP	2011-3502	A	06 January 2011	(Family: none)	
JP	1-165541	U1	20 November 1989	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 9017298 A [0009]
- JP 2016 A [0009]
- JP 110920 A [0009]