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(54) **SPIN FORMING DEVICE**

(57) An object of the present invention is to reduce heat transferred from a plate through a receiving jig to a rotating shaft in a spinning forming device. A spinning forming device (1A) includes: a receiving jig (3) supporting a central portion of a plate (9) to be formed; a rotating shaft (2) to which the receiving jig (3) is attached; a heater (6) configured to heat a transform target portion (91) of the plate (9) by induction heating; and a processing tool (7) configured to press the transform target portion (91) to transform the plate (9). The receiving jig (3) is configured to suppress heat transfer from the plate (9) to rotating shaft (2).

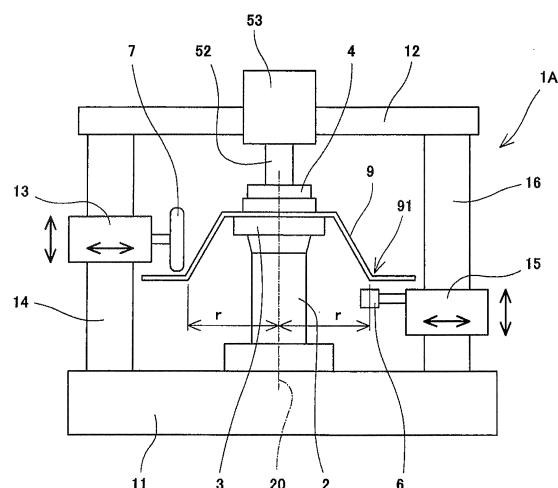


Fig. 1

Description

Technical Field

[0001] The present invention relates to a spinning forming device configured to form a plate in a desired shape while rotating the plate.

Background Art

[0002] Conventionally known is a spinning forming device configured to transform a plate by pressing a processing tool against the plate while rotating the plate. The spinning forming device normally includes a mandrel (shaping die) attached to a rotating shaft and performs forming in such a manner that the plate is pressed against the mandrel by the processing tool.

[0003] In recent years, proposed is a spinning forming device configured to perform spinning forming while locally heating the plate. For example, as a spinning forming device for a titanium alloy, PTL 1 discloses a spinning forming device configured such that a portion of the plate which is pressed against the mandrel by a spatula (processing tool) is heated by high frequency induction heating.

Citation List

Patent Literature

[0004] PTL 1: Japanese Laid-Open Patent Application Publication No. 2011-218427

Summary of Invention

Technical Problem

[0005] The inventors of the present invention have found that by locally heating the plate by induction heating, the plate can be transformed into a final shape in the atmosphere without using the mandrel. From this point of view, in an application (Japanese Patent Application No. 2012-178269) preceding the present application, the applicant of the present application has proposed a spinning forming device including, instead of the mandrel, a receiving jig configured to support a central portion of the plate. According to this spinning forming device, in the atmosphere away from the receiving jig, a transform target portion of the plate is heated by a heater and is pressed by the processing tool. To be specific, the plate is not pressed against the receiving jig by the processing tool. In other words, unlike the mandrel, the receiving jig does not include a shaping surface.

[0006] Generally, the receiving jig is smaller in size than the mandrel, and a heat capacity thereof is small. Therefore, a part of the heat applied to the plate by the induction heating is transferred through the receiving jig to the rotating shaft in a short period of time. If a large

amount of heat is transferred to the rotating shaft, the rotating shaft may change in quality, or the durability of the rotating shaft may deteriorate.

[0007] An object of the present invention is to reduce the heat transferred from the plate through the receiving jig to the rotating shaft in the spinning forming device.

Solution to Problem

[0008] To solve the above problems, the present invention provides, as one aspect, a spinning forming device including: a receiving jig supporting a central portion of a plate to be formed; a rotating shaft to which the receiving jig is attached; a heater configured to heat a transform target portion of the plate by induction heating; and a processing tool configured to press the transform target portion to transform the plate, wherein the receiving jig is configured to suppress heat transfer from the plate to the rotating shaft.

[0009] According to the above configuration, the heat transfer from the plate to the rotating shaft is suppressed by the receiving jig itself. Therefore, the heat transfer from the plate to the rotating shaft can be reduced. With this, the change in quality of the rotating shaft and the deterioration of the durability of the rotating shaft can be suppressed.

[0010] For example, the receiving jig has any of the following configurations 1) to 4).

1) The receiving jig includes: a main body having a disk shape; and a heat insulator disposed between the main body and the plate or between the main body and the rotating shaft.

2) The receiving jig includes: a main body having a disk shape; and a ring portion projecting from a peripheral portion of the main body to contact the plate.

3) The receiving jig has a hollow structure whose internal space is filled with air or a vacuum.

4) An opening is provided at a middle of the plate, and the receiving jig includes: a main body which has a disk shape and on which an edge portion of the plate is placed, the edge portion surrounding the opening; and a tubular portion which projects from the main body in an axial direction of the rotating shaft and is fitted in the opening.

[0011] In the above configuration 2), a cross-sectional shape of the ring portion may be pointed toward the plate, and through holes or grooves may be provided at the ring portion so as to connect an inner peripheral surface of the ring portion and an outer peripheral surface of the ring portion.

[0012] In each of the above configurations 1) to 4), the spinning forming device may further include: a fixing jig sandwiching the plate together with the receiving jig; and a pressurizing rod to which the fixing jig is attached and which presses the plate against the receiving jig via the fixing jig, wherein the fixing jig is configured to suppress

the heat transfer from the plate to the pressurizing rod. According to this configuration, the heat transferred from the plate through the fixing jig to the pressurizing rod can be reduced, and the change in quality of the pressurizing rod and the deterioration of the durability of the pressurizing rod can be suppressed.

[0013] For example, the fixing jig has any of the following configurations 5) to 7).

5) The fixing jig includes: a main body having a disk shape; and a heat insulator disposed between the main body and the plate or between the main body and the pressurizing rod.

6) The fixing jig includes: a main body having a disk shape; and a ring portion projecting from a peripheral portion of the main body to contact the plate.

7) The fixing jig has a hollow structure whose internal space is filled with air or a vacuum.

[0014] In the above configuration 6), a cross-sectional shape of the ring portion may be pointed toward the plate, and through holes or grooves may be provided at the ring portion so as to connect an inner peripheral surface of the ring portion and an outer peripheral surface of the ring portion.

[0015] The present invention provides, as another aspect, a spinning forming device including: a receiving jig supporting a central portion of a plate to be formed; a rotating shaft to which the receiving jig is attached; a heater configured to heat a transform target portion of the plate by induction heating; a processing tool configured to press the transform target portion to transform the plate; and a fixing jig sandwiching the plate together with the receiving jig, wherein the fixing jig is constituted by a peripheral wall and a ceiling wall so as to open toward the plate and is configured such that air supplied by an air blowing means to an inside of the fixing jig through an inlet provided at a center of the ceiling wall flows out through an outlet provided at the peripheral wall.

[0016] According to the above configuration, the heat applied to the plate is radiated to the air flowing through the inside of the fixing jig. Therefore, the heat transfer from the plate through the receiving jig to the rotating shaft can be reduced. With this, the change in quality of the rotating shaft and the deterioration of the durability of the rotating shaft can be suppressed.

[0017] The spinning forming device may be configured such that the receiving jig is constituted by a peripheral wall and a bottom wall so as to open toward the plate and is configured such that the air supplied to the inside of the fixing jig is introduced to an inside of the receiving jig through an opening provided at the plate and is discharged through a discharge port provided at the peripheral wall. According to this configuration, the heat is radiated from the receiving jig itself to the air flowing through the inside of the receiving jig. Therefore, the heat transfer to the rotating shaft can be further reduced.

[0018] The spinning forming device may be configured

such that: a through hole is provided at a region of the bottom wall of the receiving jig which overlaps the rotating shaft; and an air passage through which the through hole communicates with a space around the rotating shaft is formed at the rotating shaft. According to this configuration, the rotating shaft can be further effectively protected from the heat.

[0019] The spinning forming device may be configured such that the heater is provided on an opposite side of the processing tool across the plate. According to this configuration, the heater can be located immediately close to the transform target portion of the plate regardless of the shape of the plate during processing. With this, the transform target portion can be appropriately heated.

Advantageous Effects of Invention

[0020] According to the present invention, the heat transferred from the plate through the receiving jig to the rotating shaft can be reduced.

Brief Description of Drawings

[0021]

Fig. 1 is a schematic configuration diagram of a spinning forming device according to Embodiment 1 of the present invention.

Fig. 2A is a plan view of a heater. Fig. 2B is a cross-sectional view taken along line II-II of Fig. 2A.

Fig. 3 is a cross-sectional view of major portions of the spinning forming device shown in Fig. 1.

Fig. 4 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 2 of the present invention.

Fig. 5 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 3 of the present invention.

Fig. 6 is a cross-sectional view of major portions of the spinning forming device according to Modification Example 1 of Embodiment 3.

Fig. 7 is a cross-sectional view of major portions of the spinning forming device according to Modification Example 2 of Embodiment 3.

Fig. 8A is a cross-sectional view of major portions of the spinning forming device according to Modification Example 3 of Embodiment 3. Fig. 8B is a plan view of a receiving jig.

Fig. 9 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 4 of the present invention.

Fig. 10 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 5 of the present invention.

Fig. 11 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 6 of the present invention.

Fig. 12 is a cross-sectional view of major portions of a spinning forming device according to Embodiment 7 of the present invention.

Description of Embodiments

[0022] Hereinafter, embodiments of the present invention will be explained in reference to the drawings.

Embodiment 1

[0023] Fig. 1 shows a spinning forming device 1A according to Embodiment 1 of the present invention. The spinning forming device 1A includes a rotating shaft 2, a receiving jig 3 attached to the rotating shaft 2, and a fixing jig 4. The receiving jig 3 supports a central portion of a plate 9 to be formed, and the fixing jig 4 sandwiches the plate 9 together with the receiving jig 3. The spinning forming device 1A further includes: a heater 6 configured to locally heat a transform target portion 91 of the plate 9 by induction heating, the transform target portion 91 being located away from a center axis 20 of the rotating shaft 2 by a predetermined distance r ; and a processing tool 7 configured to press the transform target portion 91 to transform the plate 9.

[0024] A direction (axial direction) in which the center axis 20 of the rotating shaft 2 extends is a vertical direction in the present embodiment. However, the axial direction of the rotating shaft 2 may be a horizontal direction or an oblique direction. A lower portion of the rotating shaft 2 is supported by a base 11. A motor (not shown) configured to rotate the rotating shaft 2 is disposed in the base 11. An upper surface of the rotating shaft 2 is flat, and the receiving jig 3 is fixed to the upper surface of the rotating shaft 2.

[0025] The plate 9 is, for example, a flat circular plate. However, the shape of the plate 9 may be a polygonal shape or an oval shape. The plate 9 is not necessarily flat over the entirety. For example, the central portion of the plate 9 may be thicker than an outer peripheral portion of the plate 9, or the entire plate 9 or a part of the plate 9 may be processed in advance to have a tapered shape. The material of the plate 9 is not especially limited and is, for example, a titanium alloy.

[0026] The receiving jig 3 has a size within a circle defined by a forming start position of the plate 9. For example, in a case where the receiving jig 3 has a circular shape in a plan view, a maximum diameter of the receiving jig 3 is equal to or smaller than a diameter of the circle defined by the forming start position of the plate 9. Unlike conventional shaping dies, the plate 9 is not transformed by being pressed against a radially outer side surface of the receiving jig 3.

[0027] The fixing jig 4 is attached to a pressurizing rod 52. The pressurizing rod 52 is driven by a driving portion 53 in an upper-lower direction to press the plate 9 against the receiving jig 3 via the fixing jig 4. For example, the pressurizing rod 52 and the driving portion 53 constitute

a hydraulic cylinder. The driving portion 53 is fixed to a frame 12 disposed above the rotating shaft 2, and a bearing rotatably supporting the pressurizing rod 52 is incorporated in the driving portion 53.

[0028] The heater 6 and the processing tool 7 are respectively located at positions opposed to each other across the center axis 20 of the rotating shaft 2. However, the heater 6 and the processing tool 7 are not necessarily located at such opposed positions. In the present embodiment, the processing tool 7 is disposed at a front surface side of the plate 9 (i.e., above the plate 9), and the heater 6 is disposed at a rear surface side of the plate 9 (i.e., under the plate 9). In other words, the heater 6 is located on the opposite side of the processing tool 7 across the plate 9. In a case where the heater 6 is disposed on the opposite side of the processing tool 7 across the plate 9 as above, the heater 6 can be located immediately close to the transform target portion 91 of the plate 9 regardless of the shape of the plate 9 during processing. With this, the transform target portion 91 can be appropriately heated. It should be noted that the heater 6 may be disposed at the front surface side of the plate 9 so as to be located at the same side as the processing tool 7.

[0029] The heater 6 is moved by a first horizontal movement mechanism 15 in a radial direction around the center axis 20 of the rotating shaft 2, and the first horizontal movement mechanism 15 is moved in the vertical direction by a first vertical movement mechanism 16. Similarly, the processing tool 7 is moved by a second horizontal movement mechanism 13 in the radial direction around the center axis 20 of the rotating shaft 2, and the second horizontal movement mechanism 13 is moved in the vertical direction by a second vertical movement mechanism 14. Each of the first vertical movement mechanism 16 and the second vertical movement mechanism 14 extends so as to couple the base 11 and the frame 12.

[0030] In the present embodiment, used as the processing tool 7 is a roller configured to follow the rotation of the plate 9 to rotate. However, the processing tool 7 is not limited to the roller and may be a component including a spatula.

[0031] As shown in Figs. 2A and 2B, the heater 6 includes: a conducting wire 61 including a coil portion 62 having a doubled circular-arc shape; and cores 65 configured to collect magnetic force generated around the coil portion 62. The coil portion 62 includes a pair of circular-arc portions spaced apart from each other in the radial direction around the center axis 20 of the rotating shaft 2. The cores 65 are supported by a supporting plate not shown. The frequency of an alternating current flowing through the conducting wire 61 is not especially limited and is desirably a high frequency of 5 to 400 kHz. To be specific, it is desirable that the induction heating by the heater 6 be high frequency induction heating. According to the induction heating, the temperature of a lower surface of the transform target portion 91 which is opposed to the coil portion 62 becomes the highest by a skin effect. For example, in a case where the material of

the plate 9 is the titanium alloy, the temperature of the lower surface of the transform target portion 91 is about 500 to 1,000°C.

[0032] Next, details of the receiving jig 3 and the fixing jig 4 will be explained in reference to Fig. 3.

[0033] The receiving jig 3 is configured to suppress heat transfer from the plate 9 to the rotating shaft 2. Specifically, the receiving jig 3 includes: a main body 31 having a disk shape perpendicular to the center axis 20 of the rotating shaft 2 (see Fig. 1); and a heat insulator 32 disposed between the main body 31 and the plate 9. The main body 31 is made of a metal. The heat insulator 32 may be an organic material or an inorganic material. It is desirable that the heat insulator 32 have a certain degree of stiffness such that the thickness thereof does not change even at the time of the operation of the pressurizing rod 52. Examples of the heat insulator 32 include low heat conductive materials, such as ceramics and the titanium alloy, and examples of the ceramics include zirconia, alumina, and silicon nitride.

The fixing jig 4 is configured to suppress the heat transfer from the plate 9 to the pressurizing rod 52. Specifically, the fixing jig 4 includes: a main body 41 having a disk shape perpendicular to the center axis 20 of the rotating shaft 2; a heat insulator 42 disposed between the main body 41 and the plate 9; and a boss portion 40 interposed between the main body 41 and the pressurizing rod 52 and having a smaller diameter than the main body 41. The main body 41 is made of a metal. The heat insulator 42 may be an organic material or an inorganic material. As with the heat insulator 32 of the receiving jig 3, the heat insulator 42 of the fixing jig 4 may be an organic material or an inorganic material. The material of the heat insulator 42 may be the same as or different from the material of the heat insulator 32.

[0034] In the illustrated example, the diameter of the main body 41 of the fixing jig 4 is slightly smaller than the diameter of the main body 31 of the receiving jig 3. However, the sizes of these diameters may be opposite to each other or may be the same as each other.

[0035] As explained above, in the spinning forming device 1A of the present embodiment, since the receiving jig 3 includes the heat insulator 32, the heat transfer from the plate 9 to the rotating shaft 2 is suppressed by the receiving jig 3 itself. Therefore, the heat transfer from the plate 9 to the rotating shaft 2 can be reduced, and the change in quality of the rotating shaft 2 and the deterioration of the durability of the rotating shaft 2 can be suppressed.

[0036] In the present embodiment, since the fixing jig 4 includes the heat insulator 42, the heat transferred from the plate 9 through the fixing jig 4 to the pressurizing rod 52 can be reduced, and the change in quality of the pressurizing rod 52 and the deterioration of the durability of the pressurizing rod 52 can be suppressed.

Modification Example

[0037] In the above embodiment, the pressurizing rod 52 presses the plate 9 against the receiving jig 3 via the fixing jig 4. However, the pressurizing rod 52 is not necessarily required. For example, the fixing jig 4 may be fixed to the receiving jig 3 together with the plate 9 by fastening members, such as bolts or clamps. In this case, the fixing jig 4 may be constituted only by the main body 41. This modification is applicable to the embodiments described below.

[0038] Further, in the above embodiment, the processing tool 7 is disposed above the plate 9, and the plate 9 is processed by the processing tool 7 so as to accommodate the receiving jig 3, that is, open downward. However, the processing tool 7 may be disposed under the plate 9, and the plate 9 may be processed by the processing tool 7 so as to accommodate the fixing jig 4, that is, open upward. Or, to form a projection(s) and a depression(s) on the plate 9, the position of the processing tool 7 may be changed from the upper side of the plate 9 to the lower side of the plate or vice versa in the middle of the processing of the plate 9.

Embodiment 2

[0039] Next, a spinning forming device 1B according to Embodiment 2 of the present invention will be explained in reference to Fig. 4. In the present embodiment and Embodiments 3 to 7 described below, the same reference signs as Embodiment 1 are used for the same components, and a repetition of the same explanation is avoided.

[0040] The spinning forming device 1B of the present embodiment is the same in configuration as the spinning forming device 1A of Embodiment 1 except for the receiving jig 3 and the fixing jig 4. In the present embodiment, the heat insulator 32 of the receiving jig 3 is disposed between the main body 31 and the rotating shaft 2, not between the main body 31 and the plate 9. Similarly, the heat insulator 42 of the fixing jig 4 is disposed between the boss portion 40 and the pressurizing rod 52, not between the main body 41 and the plate 9.

[0041] The spinning forming device 1B configured as above can also have the same effects as the spinning device 1A of Embodiment 1.

Embodiment 3

[0042] Next, a spinning forming device 1C according to Embodiment 2 of the present invention will be explained in reference to Fig. 5. In the present embodiment, the receiving jig 3 is also configured to suppress the heat transfer from the plate 9 to the rotating shaft 2, and the fixing jig 4 is also configured to suppress the heat transfer from the plate 9 to the pressurizing rod 52.

[0043] The receiving jig 3 includes: the main body 31 having the disk shape perpendicular to the center axis

20 of the rotating shaft 2; and a ring portion 33 extending upward from a peripheral portion of the main body 31 to contact the plate 9. In the present embodiment, since the upper surface of the ring portion 33 is flat, the ring portion 33 surface-contacts the plate 9.

[0044] The fixing jig 4 includes: the main body 41 having the disk shape perpendicular to the center axis 20 of the rotating shaft 2; a ring portion 43 extending downward from a peripheral portion of the main body 41 to contact the plate 9; and the boss portion 40 interposed between the main body 41 and the pressurizing rod 52 and having a smaller diameter than the main body 41. In the present embodiment, since a lower surface of the ring portion 43 is flat, the ring portion 43 surface-contacts the plate 9.

[0045] The spinning forming device 1C configured as above can also have the same effects as the spinning device 1 A of Embodiment 1.

Modification Example

[0046] In the above embodiment, a cross-sectional shape of the ring portion 33 of the receiving jig 3 is a rectangular shape. However, as shown in Fig. 6, the cross-sectional shape of the ring portion 33 of the receiving jig 3 may be a triangular shape pointed upward toward the plate 9. In this case, the ring portion 33 line-contacts the plate 9. This configuration is especially useful in the case of bending the plate 9 at a position where the ring portion 33 and the plate 9 contact each other. The triangular shape that is the cross-sectional shape of the ring portion 33 may be a right angled triangle as shown in Fig. 6 or an isosceles triangle inclining toward both sides from an apex contacting the plate 9.

[0047] Similarly, although not shown, the cross-sectional shape of the ring portion 43 of the fixing jig 4 may be a triangular shape pointed downward toward the plate 9.

[0048] As shown in Fig. 7, through holes 34 may be provided at the ring portion 33 of the receiving jig 3 so as to connect an inner peripheral surface of the ring portion 33 and an outer peripheral surface of the ring portion 33. The heat transfer to the rotating shaft 2 can be further reduced by the through holes 34.

[0049] Similarly, through holes 44 may be provided at the ring portion 43 of the fixing jig 4 so as to connect an inner peripheral surface of the ring portion 43 and an outer peripheral surface of the ring portion 43. The heat transfer to the pressurizing rod 52 can be further reduced by the through holes 44.

[0050] Or, as shown in Figs. 8A and 8B, instead of the through holes 34, grooves 35 may be provided at the ring portion 33 of the receiving jig 3 so as to connect the inner peripheral surface of the ring portion 33 and the outer peripheral surface of the ring portion 33. Similarly, instead of the through holes 44, grooves 45 may be provided at the ring portion 43 of the fixing jig 4 so as to connect the inner peripheral surface of the ring portion 43 and the outer peripheral surface of the ring portion

43. The depth of each groove (35, 45) may be equal to or less than the height of the ring portion (33, 43).

[0051] In a case where the through holes (34, 44) or the grooves (35, 45) are provided at the ring portion (33, 43), the cross-sectional shape of the ring portion may be a triangular shape pointed toward the plate 9.

Embodiment 4

[0052] Next, a spinning forming device 1D according to Embodiment 4 of the present invention will be explained in reference to Fig. 9. In the present embodiment, the receiving jig 3 is also configured to suppress the heat transfer from the plate 9 to the rotating shaft 2, and the fixing jig 4 is also configured to suppress the heat transfer from the plate 9 to the pressurizing rod 52.

[0053] Specifically, the receiving jig 3 is constituted only by the main body 31 having a hollow structure, and the fixing jig 4 is constituted by the main body 41 having a hollow structure and the boss portion 40. An internal space 37 of the main body 31 of the receiving jig 3 may be filled with air or may be a vacuum. Similarly, an internal space 47 of the main body 41 of the fixing jig 4 may be filled with air or may be a vacuum. To manufacture the main body whose internal space is a vacuum, a sealed box may be formed by electron beam welding in a vacuum chamber.

[0054] The spinning forming device 1D can also have the same effects as the spinning device 1 A of Embodiment 1.

Embodiment 5

[0055] Next, a spinning forming device 1E according to Embodiment 5 of the present invention will be explained in reference to Fig. 10. In the present embodiment, the receiving jig 3 is also configured to suppress the heat transfer from the plate 9 to the rotating shaft 2. However, the fixing jig 4 is constituted only by: the main body 41 having the disk shape perpendicular to the center axis 20 of the rotating shaft 2; and the boss portion 40.

[0056] In the present embodiment, a circular opening 92 is provided at a middle of the plate 9. The receiving jig 3 includes: the main body 31 having the disk shape perpendicular to the center axis 20 of the rotating shaft 2; and a circular tubular portion 30 located at a middle of the main body 31 and projecting upward from the main body 31. An outer diameter of the tubular portion 30 is set to be substantially equal to a diameter of the opening 92. To be specific, an edge portion of the plate 9 which surrounds the opening 92 is placed on the main body 31, and the tubular portion 30 is fitted in the opening 92. A space inside the tubular portion 30 serves as a heat insulating layer.

[0057] In the spinning forming device 1E of the present embodiment, since the space inside the tubular portion 30 serves as the heat insulating layer, the heat transfer from the plate 9 to the rotating shaft 2 is suppressed by

the receiving jig 3 itself. Therefore, the heat transfer from the plate 9 to the rotating shaft 2 can be reduced, and the change in quality of the rotating shaft 2 and the deterioration of the durability of the rotating shaft 2 can be suppressed.

[0058] In the present embodiment, a contact area between the fixing jig 4 and the plate 9 is reduced by the opening 92 provided at the plate 9. Therefore, the heat transferred from the plate 9 through the fixing jig 4 to the pressurizing rod 52 can be reduced, and the change in quality of the pressurizing rod 52 and the deterioration of the durability of the pressurizing rod 52 can be suppressed.

Embodiment 6

[0059] Next, a spinning forming device 1F according to Embodiment 6 of the present invention will be explained in reference to Fig. 11. In the present embodiment, the receiving jig 3 is constituted only by the main body 31 having the disk shape perpendicular to the center axis 20 of the rotating shaft 2.

[0060] The fixing jig 4 is constituted by a peripheral wall 48 and a ceiling wall 49 so as to open toward the plate 9 (i.e., downward). In other words, the fixing jig 4 has an inverted petri dish shape. A lower end surface of the peripheral wall 48 surface-contacts the plate 9. An inlet 49a penetrating the ceiling wall 49 is provided at a center of the ceiling wall 49, and outlets 48a penetrating the peripheral wall 48 are provided at the peripheral wall 48. One end of an immovable air supply passage 8 is connected to the inlet 49a so as to be rotatable relative to the fixing jig 4.

[0061] In the present embodiment, the pressurizing rod 52 (see Fig. 1) may or may not be provided. In a case where the pressurizing rod 52 is provided, the air supply passage 8 is formed inside the pressurizing rod 52. In a case where the pressurizing rod 52 is not provided, the air supply passage 8 is constituted by a pipe.

[0062] An air blowing means not shown is connected to the other end of the air supply passage 8. A blower or the like can be used as the air blowing means. By the operation of the air blowing means, the air is supplied through the air supply passage 8 and the inlet 49a of the ceiling wall 49 to the inside of the fixing jig 4, and the air supplied to the inside of the fixing jig 4 flows out through the outlets 48a of the peripheral wall 48.

[0063] According to this configuration, the heat applied to the plate 9 is radiated to the air flowing through the inside of the fixing jig 4. Therefore, the heat transfer from the plate 9 through the receiving jig 3 to the rotating shaft 2 can be reduced. With this, the change in quality of the rotating shaft 2 and the deterioration of the durability of the rotating shaft 2 can be suppressed.

[0064] Instead of the blower connected to the other end of the air supply passage 8, for example, an impeller which is disposed inside the fixing jig 4 and generates air flow by the rotation of the fixing jig 4 may be used as

the air blowing means. Or, both the blower connected to the other end of the air supply passage 8 and the impeller disposed inside the fixing jig 4 may be used as the air blowing means.

Embodiment 7

[0065] Next, a spinning forming device 1G according to Embodiment 7 of the present invention will be explained in reference to Fig. 12. The spinning forming device 1G is obtained by further improving the spinning forming device 1F of Embodiment 6. To be specific, the fixing jig 4 of the spinning forming device 1G is the same as the fixing jig 4 explained in Embodiment 6.

[0066] In the present embodiment, the circular opening 92 is provided at the middle of the plate 9. The receiving jig 3 is constituted by a peripheral wall 38 and a bottom wall 39 so as to open toward the plate 9 (i.e., upward). In other words, the receiving jig 3 has a petri dish shape. An upper end surface of the peripheral wall 38 surface-contacts the plate 9. Discharge ports 38a penetrating the peripheral wall 38 are provided at the peripheral wall 38. To be specific, the air supplied to the inside of the fixing jig 4 is also introduced through the opening 92 of the plate 9 to the inside of the receiving jig 3, and the air is then discharged through the discharge ports 38a of the peripheral wall 38 to the outside.

[0067] According to this configuration, the heat is radiated from the receiving jig 3 itself to the air flowing through the inside of the receiving jig 3. Therefore, the heat transfer to the rotating shaft 2 can be further reduced.

[0068] Further, the present embodiment adopts a configuration for aggressively cooling down the rotating shaft 2. Therefore, the rotating shaft 2 can be further effectively protected from the heat.

[0069] Specifically, a through hole 39a is provided at a region of the bottom wall 39 of the receiving jig 3 which overlaps the rotating shaft 2, and an air passage 23 through which the through hole 39a communicates with a space around the rotating shaft 2 is formed at the rotating shaft 2. Therefore, a part of the air flowing into the receiving jig 3 is discharged through the through hole 39a and the air passage 23 to the space around the rotating shaft 2. In the present embodiment, the through hole 39a is disposed at a center of the bottom wall 39, and the air passage 23 is constituted by: a columnar recession 21 provided at a center of the upper surface of the rotating shaft 2; and lateral holes 22 extending laterally from the recession 21.

[0070] The configuration for cooling down the rotating shaft 2 is not limited to the structure shown in Fig. 12. For example, the air passage 23 may be constituted by grooves formed on the upper surface of the rotating shaft 2 to have a cross shape or a radial shape. The through hole 39a provided at the bottom wall 39 is not necessarily disposed at the center of the bottom wall 39, and through holes 39a may be provided on the same circumference.

Other embodiments

[0071] The receiving jigs 3 and the fixing jigs 4 in Embodiments 1 to 5 may be combined arbitrarily.

Reference Signs List**[0072]**

1A to 1G	spinning forming device
2	rotating shaft
23	air passage
3	receiving jig
30	tubular portion
31	main body
32	heat insulator
33	ring portion
34	through hole
35	groove
37	internal space
38	peripheral wall
38a	discharge port
39	bottom wall
39a	through hole
4	fixing jig
40	boss
41	main body
42	heat insulator
43	ring portion
44	through hole
45	groove
47	internal space
48	peripheral wall
48a	outlet
49	ceiling wall
49a	inlet
52	pressurizing rod
6	heater
7	processing tool
9	plate
91	transform target portion
92	opening

Claims**1.** A spinning forming device comprising:

a receiving jig supporting a central portion of a plate to be formed;
a rotating shaft to which the receiving jig is attached;
a heater configured to heat a transform target portion of the plate by induction heating; and
a processing tool configured to press the transform target portion to transform the plate, wherein the receiving jig is configured to suppress heat

transfer from the plate to the rotating shaft.

2. The spinning forming device according to claim 1, wherein the receiving jig includes: a main body having a disk shape; and a heat insulator disposed between the main body and the plate or between the main body and the rotating shaft.

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3. The spinning forming device according to claim 1, wherein the receiving jig includes: a main body having a disk shape; and a ring portion projecting from a peripheral portion of the main body to contact the plate.

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4. The spinning forming device according to claim 3, wherein a cross-sectional shape of the ring portion is pointed toward the plate.

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5. The spinning forming device according to claim 3 or 4, wherein through holes or grooves are provided at the ring portion so as to connect an inner peripheral surface of the ring portion and an outer peripheral surface of the ring portion.

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6. The spinning forming device according to claim 1, wherein the receiving jig has a hollow structure whose internal space is filled with air or a vacuum.

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7. The spinning forming device according to claim 1, wherein:

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an opening is provided at a middle of the plate; and

the receiving jig includes

a main body which has a disk shape and on which an edge portion of the plate is placed, the edge portion surrounding the opening, and a tubular portion which projects from the main body in an axial direction of the rotating shaft and is fitted in the opening.

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8. The spinning forming device according to any one of claims 1 to 7, further comprising:

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a fixing jig sandwiching the plate together with the receiving jig; and

a pressurizing rod to which the fixing jig is attached and which presses the plate against the receiving jig via the fixing jig, wherein the fixing jig is configured to suppress the heat transfer from the plate to the pressurizing rod.

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9. The spinning forming device according to claim 8, wherein the fixing jig includes: a main body having a disk shape; and a heat insulator disposed between the main body and the plate or between the main body and the pressurizing rod.

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10. The spinning forming device according to claim 8, wherein the fixing jig includes: a main body having a disk shape; and a ring portion projecting from a peripheral portion of the main body to contact the plate.

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11. The spinning forming device according to claim 10, wherein a cross-sectional shape of the ring portion is pointed toward the plate.

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12. The spinning forming device according to claim 10 or 11, wherein through holes or grooves are provided at the ring portion so as to connect an inner peripheral surface of the ring portion and an outer peripheral surface of the ring portion.

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13. The spinning forming device according to claim 8, wherein the fixing jig has a hollow structure whose internal space is filled with air or a vacuum.

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14. A spinning forming device comprising:

a receiving jig supporting a central portion of a plate to be formed;

a rotating shaft to which the receiving jig is attached;

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a heater configured to heat a transform target portion of the plate by induction heating;

a processing tool configured to press the transform target portion to transform the plate; and

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a fixing jig sandwiching the plate together with the receiving jig, wherein

the fixing jig is constituted by a peripheral wall and a ceiling wall so as to open toward the plate and is configured such that air supplied by an air blowing means to an inside of the fixing jig through an inlet provided at a center of the ceiling wall flows out through an outlet provided at the peripheral wall.

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15. The spinning forming device according to claim 14, wherein:

the receiving jig is constituted by a peripheral wall and a bottom wall so as to open toward the plate and is configured such that the air supplied to the inside of the fixing jig is introduced to an inside of the receiving jig through an opening provided at the plate and is discharged through a discharge port provided at the peripheral wall.

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16. The spinning forming device according to claim 15, wherein:

a through hole is provided at a region of the bottom wall of the receiving jig which overlaps the rotating shaft; and

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an air passage through which the through hole

communicates with a space around the rotating shaft is formed at the rotating shaft.

17. The spinning forming device according to any one of claims 1 to 16, wherein the heater is provided on an opposite side of the processing tool across the plate.

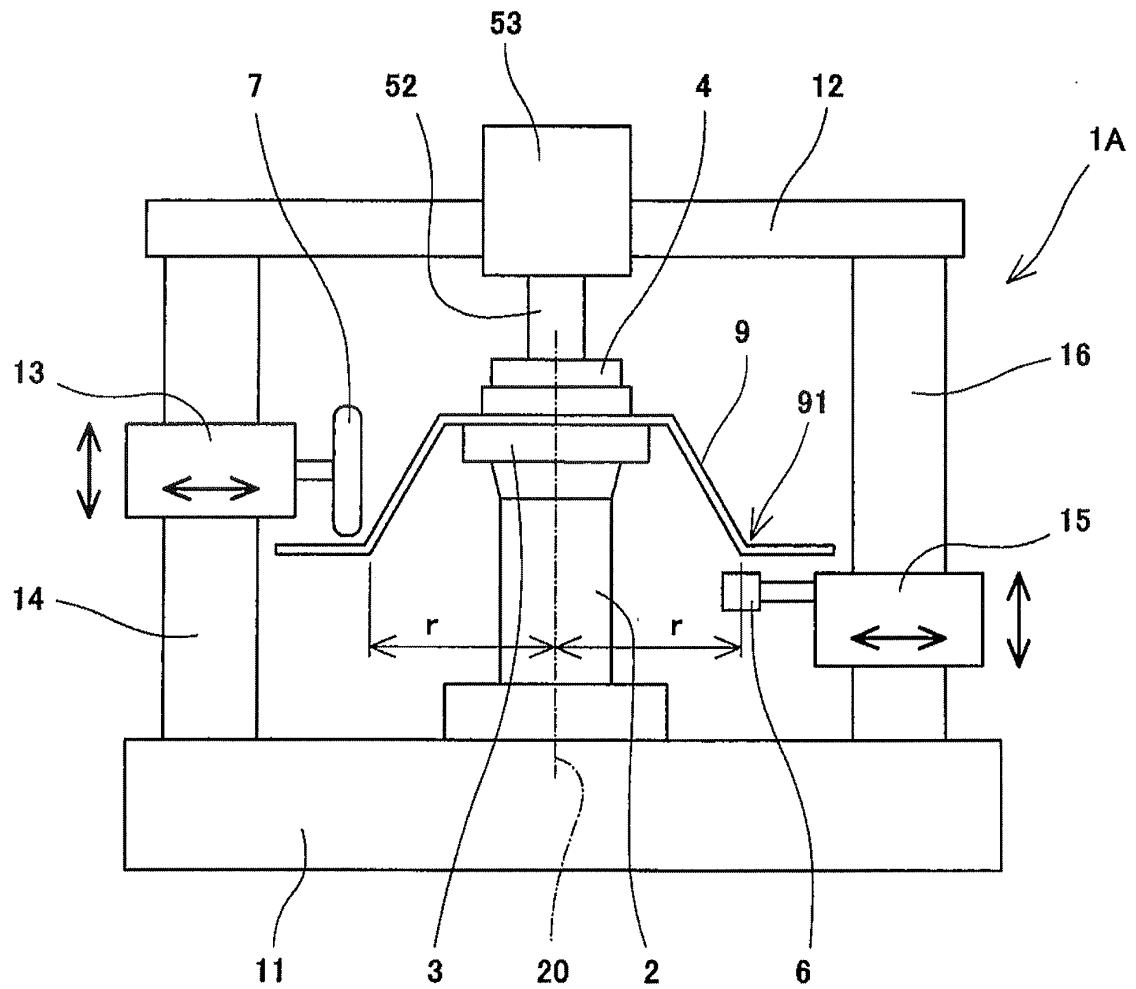


Fig. 1

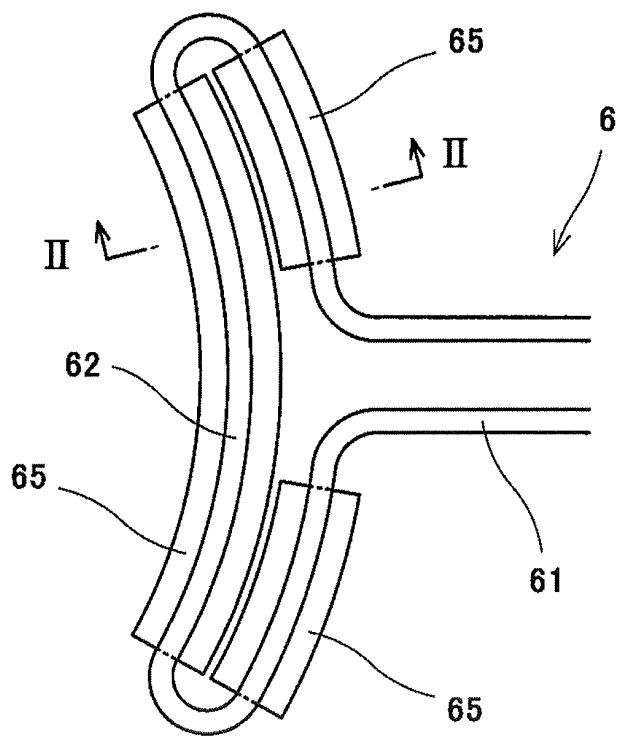


Fig. 2A

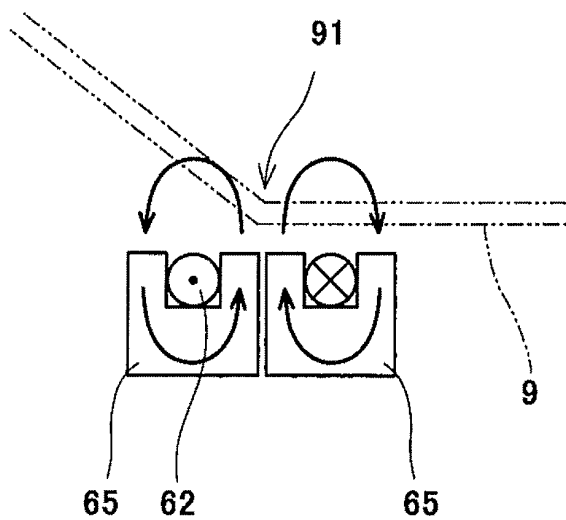


Fig. 2B

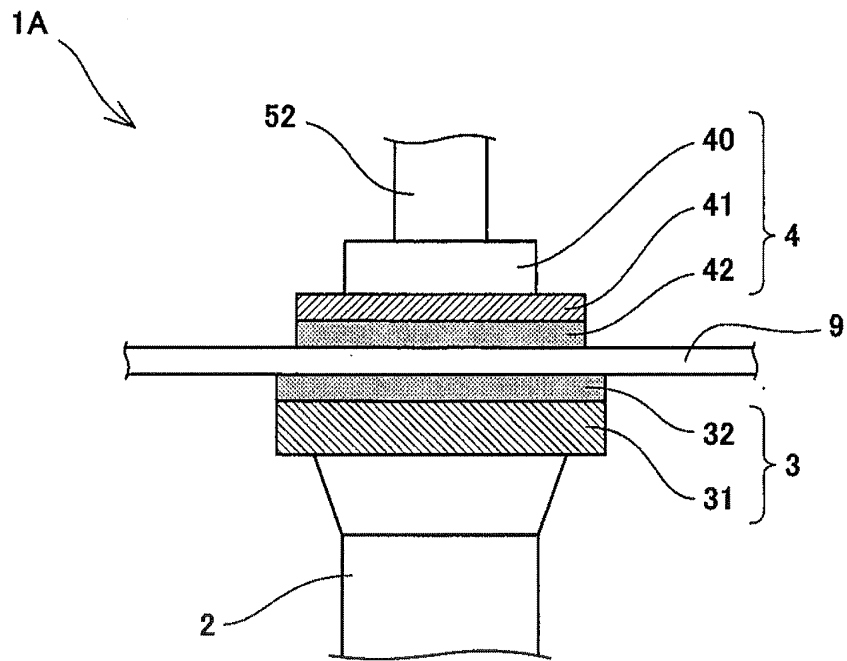


Fig. 3

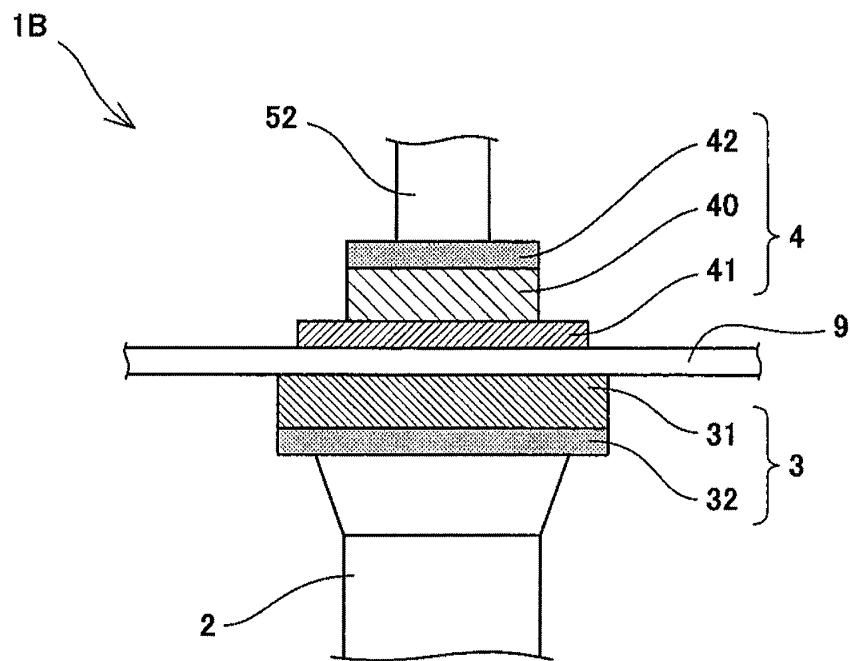


Fig. 4

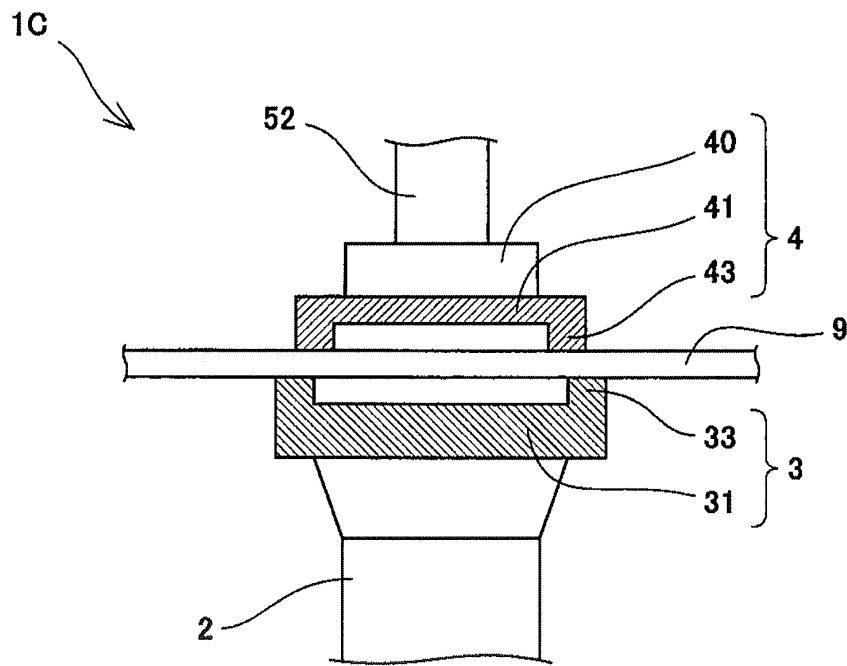


Fig. 5

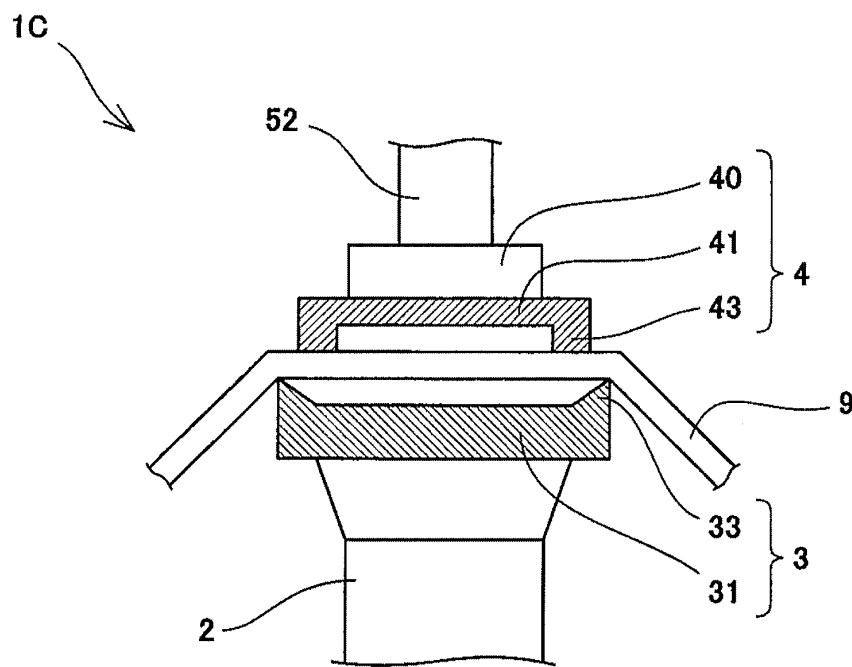


Fig. 6

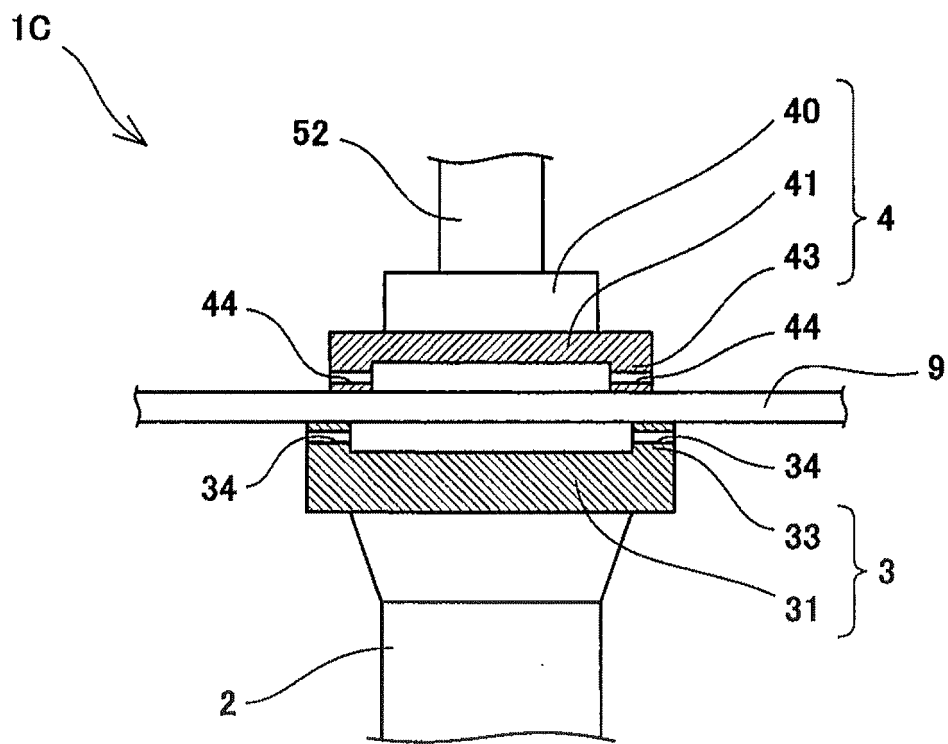


Fig. 7

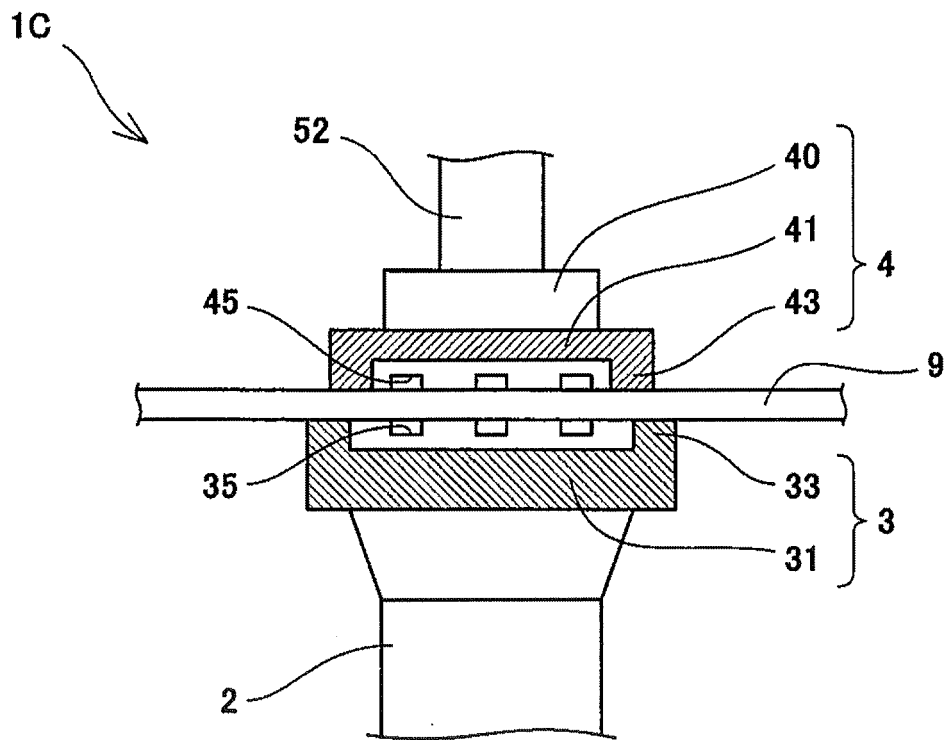


Fig. 8A

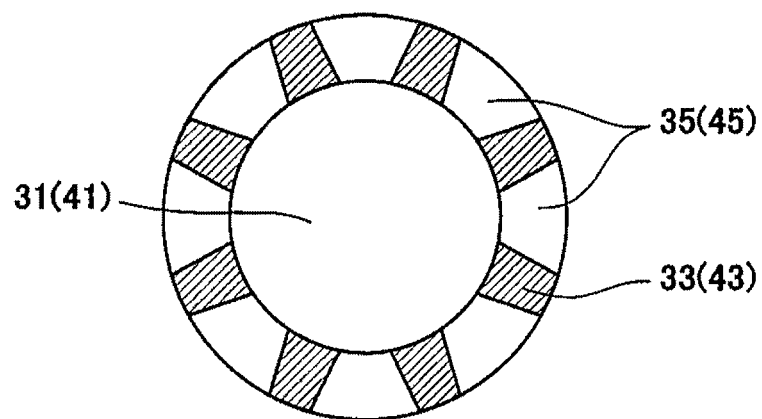


Fig. 8B

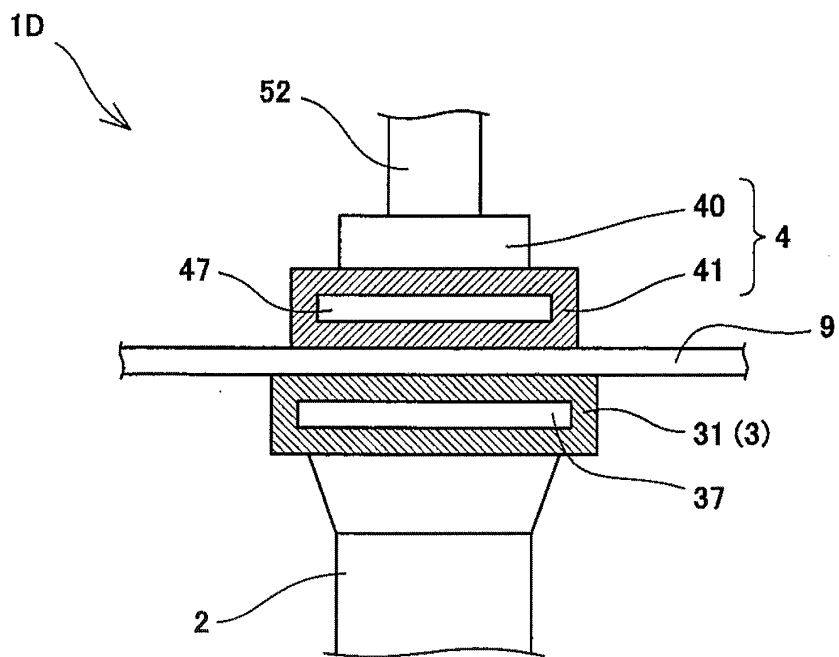


Fig. 9

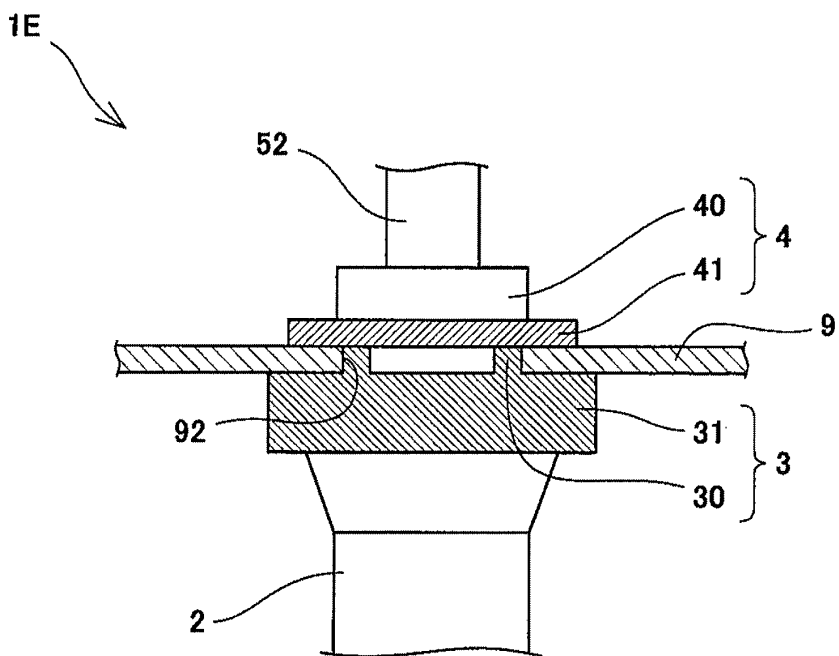


Fig. 10

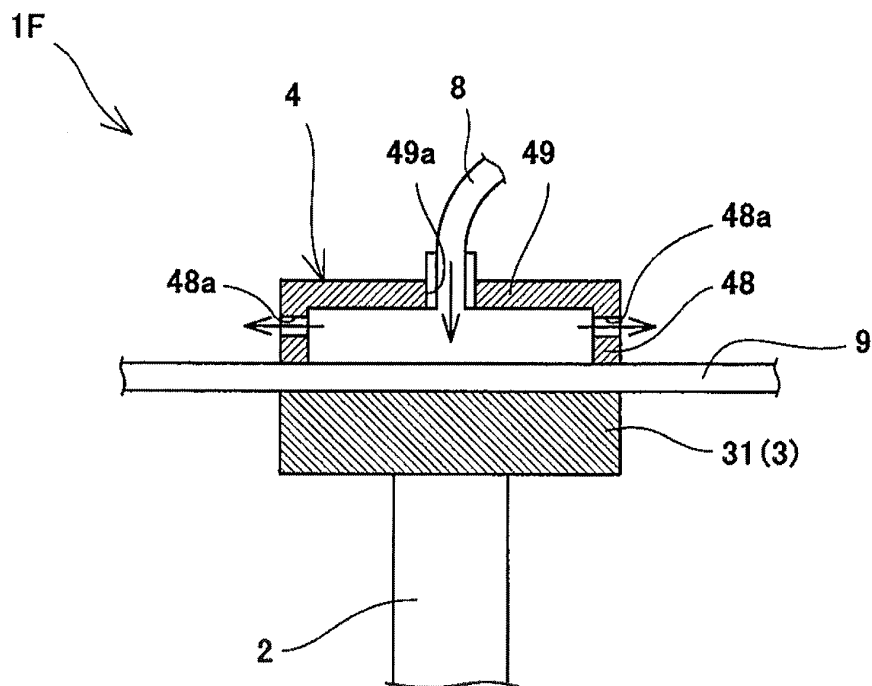


Fig. 11

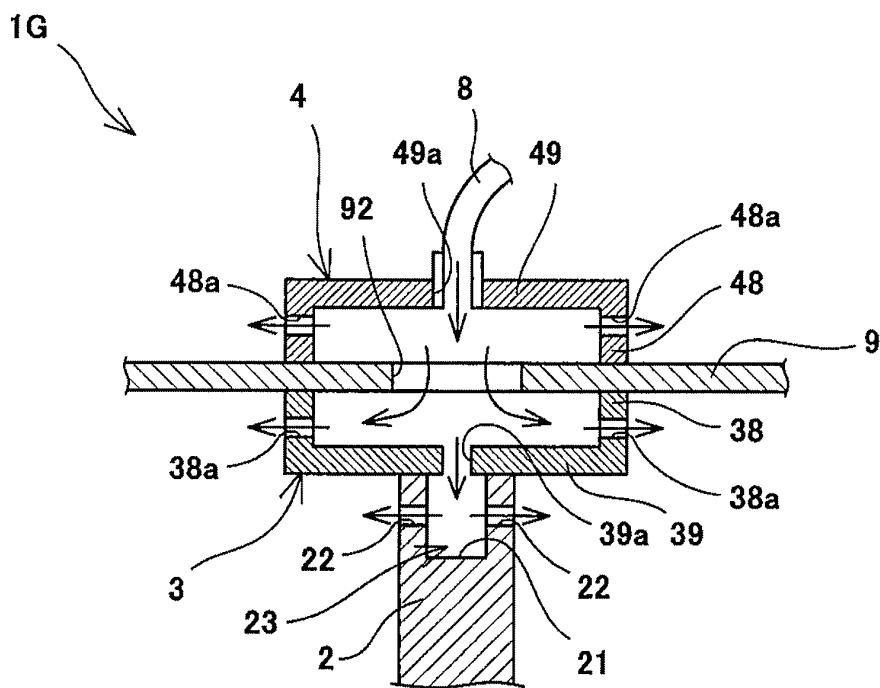


Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/006971

A. CLASSIFICATION OF SUBJECT MATTER

B21D22/14 (2006.01) i

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)

B21D22/14, B21D22/16, B21D22/18

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014

Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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 A	JP 48-41965 A (Ottensener Eisenwerk GmbH), 19 June 1973 (19.06.1973), specification, column 12, line 5 to column 13, line 8; fig. 1 to 5 & US 3815395 A & GB 1374018 A & DE 2148519 A1 & FR 2154721 A1	1-4, 6, 8-11, 13, 17 5, 7, 12, 14-16
Y	JP 2006-341310 A (MT Aerospace AG), 21 December 2006 (21.12.2006), paragraph [0108]; fig. 1 & US 2007/0039366 A1 & EP 1728567 A1 & DE 102005024627 A1	1-4, 6, 8-11, 13, 17

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

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Date of the actual completion of the international search
14 February, 2014 (14.02.14)Date of mailing of the international search report
25 February, 2014 (25.02.14)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/006971

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-192414 A (The Society of Japanese Aerospace Companies, NIPPI Corp.), 11 October 2012 (11.10.2012), fig. 1, 2 (Family: none)	1-17
A	JP 2011-218427 A (The Society of Japanese Aerospace Companies, NIPPI Corp.), 04 November 2011 (04.11.2011), entire text; fig. 1 (Family: none)	1-17
A	JP 2007-260732 A (Nihon Spindle Mfg. Co., Ltd.), 11 October 2007 (11.10.2007), paragraph [0025]; fig. 1, 5 (Family: none)	14-16
E, A	WO 2014/024384 A1 (Kawasaki Heavy Industries, Ltd.), 13 February 2014 (13.02.2014), entire text; all drawings (Family: none)	1-17

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2011218427 A [0004]
- JP 2012178269 A [0005]