(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 952 273 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
09.12.2015 Bulletin 2015/50

(21) Application number: **13873655.8**

(22) Date of filing: **03.12.2013**

(51) Int Cl.:
B21H 1/18 *(2006.01)* ***B21J 5/06*** *(2006.01)*
B21J 5/08 *(2006.01)* ***B21K 21/06*** *(2006.01)*
B21K 21/16 *(2006.01)* ***B21K 23/04*** *(2006.01)*

(86) International application number:
PCT/JP2013/082464

(87) International publication number:
WO 2014/119120 (07.08.2014 Gazette 2014/32)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **30.01.2013 JP 2013015916**

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA**
Toyota-shi, Aichi-ken, 471-8571 (JP)

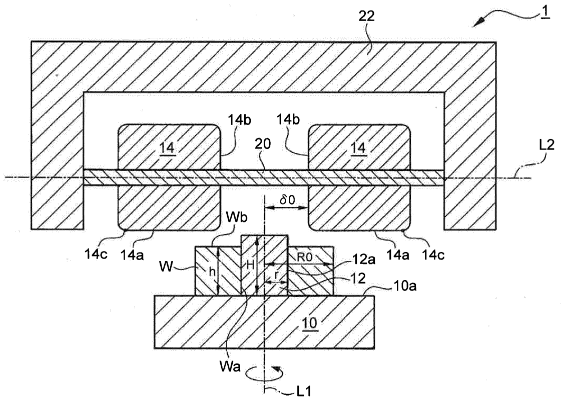
(72) Inventors:
- **SUKEDA Takuya**
Toyota-shi
Aichi 471-8571 (JP)
- **INOSHITA Hirohumi**
Toyota-shi
Aichi 471-8571 (JP)
- **HIRAI Naoki**
Toyota-shi
Aichi 471-8571 (JP)
- **ISHIKAWA Yoshinori**
Toyota-shi
Aichi 471-8571 (JP)
- **NAITO Hideji**
Toyota-shi
Aichi 471-8571 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) FORGING DEVICE AND FORGING METHOD

(57) In a forging device including a rotating table and a shaping roller, which forging device forges a workpiece such that an outer peripheral surface of the shaping roller is pressed against an end surface of the workpiece in a central-axis direction of the workpiece while the workpiece is rotated by the rotating table, the shaping roller is placed apart from a rotation axis, and a position of that end of the outer peripheral surface of the shaping roller which is opposite to a rotation-axis side in a central-axis direction of the shaping roller is placed at an outer side in a radial direction of the workpiece relative to a position of an outer peripheral surface of the workpiece that has been forged.

FIG. 1



EP 2 952 273 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a forging device and a forging method each of which performs molding such that a shaping roller is pressed against a workpiece so as to expand the workpiece in a radial direction and a central-axis direction of the workpiece.

BACKGROUND ART

[0002] Patent Document 1 describes a forging method for performing diameter expansion molding to expand a cylindrical metal workpiece in a radial direction of the workpiece. In the forging method of Patent Document 1, the workpiece is rotated around a central axis of the workpiece, and a cylindrical shaping roller is pressed against that end surface of the workpiece thus rotated which is on one side in a central-axis direction of the workpiece. The shaping roller makes contact with the workpiece as such, and then, the shaping roller is moved down with the shaping roller being rotated with the workpiece. Hereby, a pressure is applied to the workpiece from the shaping roller, so that the workpiece can be expanded in the radial direction.

Citation List

Patent Documents

[0003] Patent Document 1: Japanese Patent Application Publication No. 2011-224605 (JP 2011-224605 A)

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0004] However, in the forging method of Patent Document 1, although it is possible to perform diameter expansion molding to expand the workpiece in the radial direction of the workpiece, it is difficult to perform boss molding to form a boss portion formed by raising a central part of the workpiece in the central-axis direction of the workpiece. In view of this, it is necessary to separately perform a step of performing the boss molding after a step of performing diameter expansion molding is performed first by the forging method of Patent Document 1. Accordingly, different forging devices are required for respective steps at the time when a forging having a boss portion is manufactured, which increases cost.

[0005] In view of this, the present invention has been accomplished in order to solve the above problems, and an object of the present invention is to provide a forging device and a forging method each of which can manufacture a forging having a boss portion while achieving reduction in cost.

Means for Solving the Problem

[0006] One aspect of the present invention to solve the above problems is characterized in that: in a forging device including a rotating table that rotates around a rotation axis, and a cylindrical shaping roller, the forging device forging a cylindrical workpiece such that an outer peripheral surface of the shaping roller is pressed against an end surface of the workpiece in a central-axis direction of the workpiece while the workpiece is rotated by the rotating table around a central axis of the workpiece, the shaping roller is placed apart from the rotation axis, and a position of that end of the outer peripheral surface of the shaping roller which is opposite to a rotation-axis side in a central-axis direction of the shaping roller is placed at an outer side in a radial direction of the workpiece relative to a position of an outer peripheral surface of the workpiece that has been forged.

[0007] According to the above aspect, it is possible to perform diameter expansion molding to expand the cylindrical workpiece in the radial direction such that the outer peripheral surface of the shaping roller is pressed against the end surface of the workpiece in the central-axis direction of the workpiece while the workpiece is rotated by the rotating table around the central axis of the workpiece. Further, since the shaping roller is placed apart from the rotation axis of the rotating table, a material of the workpiece flows toward the rotation-axis side relative to the shaping roller, so that boss molding to form a boss portion formed by raising a central part of the workpiece in the central-axis direction of the workpiece can be performed. Thus, the diameter expansion molding and the boss molding can be performed at the same time. This makes it possible to manufacture a forging having the boss portion while achieving reduction in cost.

[0008] Further, the position of that end of the outer peripheral surface of the shaping roller which is opposite to the rotation-axis side in the central-axis direction of the shaping roller is placed at the outer side in the radial direction of the workpiece relative to the position of the outer peripheral surface of the workpiece that has been forged. This causes such a state where the outer peripheral surface of the shaping roller is pressed against a large area of the end surface of the workpiece in the central-axis direction of the workpiece, during the forging of the workpiece. This makes it possible to secure accuracy of the end surface of the workpiece that has been forged, by the outer peripheral surface of the shaping roller. This can accordingly improve the accuracy of the end surface of the workpiece that has been forged.

[0009] In the forging device, it is preferable that: the forging device include a cylindrical mandrel; a central axis of the mandrel accord with the rotation axis; the shaping roller have an inner end surface placed at the rotation-axis side in the central-axis direction of the shaping roller; and a distance between the central axis of the mandrel and the inner end surface be larger than a radius of the mandrel but smaller than a radius of the workpiece.

[0010] According to the above aspect, by flowing the material of the workpiece between the outer peripheral surface of the mandrel and the inner end surface of the shaping roller, it is possible to form the boss portion having a hollow cylindrical shape in the central part of the workpiece. Since the material of the workpiece flows while making close contact with the outer peripheral surface of the mandrel, it is possible to secure desired accuracy in an inner peripheral surface of the boss portion by managing accuracy of the outer peripheral surface of the mandrel.

[0011] It is preferable that the forging device include two shaping rollers.

[0012] According to the above aspect, it is possible to shorten a time to forge the workpiece. Also, the accuracy of the end surface of the workpiece is improved.

[0013] In the forging device, it is preferable that a central axis of the shaping roller be generally perpendicular to the rotation axis.

[0014] According to the above aspect, it is possible to simplify a mechanism for supporting the shaping roller. Particularly, in a case where two shaping rollers are provided, the two shaping rollers can be integrated with each other by one shaft member while central axes of the two shaping rollers accord with each other. This makes it possible to simplify the mechanism for supporting the two shaping rollers.

[0015] Another aspect of the present invention to solve the above problems is characterized in that: in a forging method for forging a cylindrical workpiece, by use of a rotating table that rotates around a rotation axis, and a cylindrical shaping roller, such that an outer peripheral surface of the shaping roller is pressed against an end surface of the workpiece in a central-axis direction of the workpiece while the workpiece is rotated by the rotating table around a central axis of the workpiece, the shaping roller is placed apart from the rotation axis, and a position of that end of the outer peripheral surface of the shaping roller which is opposite to a rotation-axis side in the central-axis direction of the shaping roller is placed at an outer side in a radial direction of the workpiece relative to a position of an outer peripheral surface of the workpiece that has been forged.

[0016] According to the above aspect, it is possible to perform diameter expansion molding to expand the cylindrical workpiece in the radial direction such that the outer peripheral surface of the shaping roller is pressed against the end surface of the workpiece in the central-axis direction of the workpiece while the workpiece is rotated by the rotating table around the central axis of the workpiece. Further, since the shaping roller is placed apart from the rotation axis of the rotating table, a material of the workpiece flows toward the rotation-axis side relative to the shaping roller, so that boss molding to form a boss portion formed by raising a central part of the workpiece in the central-axis direction of the workpiece can be performed. Thus, the diameter expansion molding and the boss molding can be performed at the same time. This makes it possible to manufacture a forging having the boss portion while achieving reduction in cost.

[0017] Further, the position of that end of the outer peripheral surface of the shaping roller which is opposite to the rotation-axis side in the central-axis direction of the shaping roller is placed at the outer side in the radial direction of the workpiece relative to the position of the outer peripheral surface of the workpiece that has been forged. This causes such a state where the outer peripheral surface of the shaping roller is pressed against a large area of the end surface of the workpiece in the central-axis direction of the workpiece, during the forging of the workpiece. This makes it possible to secure accuracy of the end surface of the workpiece that has been forged, by the outer peripheral surface of the shaping roller. This can accordingly improve the accuracy of the end surface of the workpiece that has been forged.

[0018] In the forging method, it is preferable that: a cylindrical mandrel be used; a central axis of the mandrel accord with the rotation axis; the shaping roller have an inner end surface placed at the rotation-axis side in the central-axis direction of the shaping roller; and a distance between the central axis of the mandrel and the inner end surface be larger than a radius of the mandrel but smaller than a radius of the workpiece.

[0019] According to the above aspect, by flowing the material of the workpiece between the outer peripheral surface of the mandrel and the inner end surface of the shaping roller, it is possible to form the boss portion having a hollow cylindrical shape in the central part of the workpiece. Since the material of the workpiece flows while making close contact with the outer peripheral surface of the mandrel, it is possible to secure desired accuracy in an inner peripheral surface of the boss portion by managing accuracy of the outer peripheral surface of the mandrel.

[0020] In the forging method, it is preferable that two shaping rollers be used.

[0021] According to the above aspect, it is possible to shorten a time to forge the workpiece. Also, the accuracy of the end surface of the workpiece is improved.

[0022] In the forging method, it is preferable that a central axis of the shaping roller be generally perpendicular to the rotation axis.

[0023] According to the above aspect, it is possible to simplify a mechanism for supporting the shaping roller. Particularly, in a case where two shaping rollers are provided, the two shaping rollers can be integrated with each other by one shaft member while central axes of the two shaping rollers accord with each other. This makes it possible to simplify the mechanism for supporting the two shaping rollers.

Advantageous Effects of Invention

[0024] According to the forging device and the forging method of the present invention, it is possible to manufacture a forging having a boss portion while achieving reduction in cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

[FIG. 1] FIG. 1 is a sectional view illustrating a schematic configuration of a forging device of the present embodiment, and illustrates a state before forging is performed on a workpiece.

[FIG. 2] FIG. 2 is a sectional view illustrating the schematic configuration of the forging device of the present embodiment, and illustrates a state after the forging is performed on the workpiece.

[FIG. 3] FIG. 3 is a view to describe a principle to perform diameter expansion molding and boss molding on the workpiece.

[FIG. 4] FIG. 4 is a sectional view taken along a line A-A in FIG. 3.

[FIG. 5] FIG. 5 is a view to describe a conventional technique.

[FIG. 6] FIG. 6 is a sectional view illustrating a schematic configuration of a forging device of a modification.

[FIG. 7] FIG. 7 is a sectional view illustrating a schematic configuration of a forging device of a modification.

[FIG. 8] FIG. 8 is a sectional view illustrating a schematic configuration of a forging device of a modification.

[FIG. 9] FIG. 9 is a top view of a mandrel in the forging device of the modification illustrated in FIG. 8.

[FIG. 10] FIG. 10 is a sectional view illustrating a schematic configuration of a forging device of a modification.

[FIG. 11] FIG. 11 is a sectional view illustrating a schematic configuration of a forging device of a modification.

MODES FOR CARRYING OUT THE INVENTION

[0026] The following describes an embodiment of the present invention in detail with reference to the drawings.

<Description of Forging Device>

[0027] Initially described is a configuration of a forging device 1. Here, FIGS. 1 and 2 are each a sectional view illustrating a schematic configuration of the forging device 1 of the present embodiment. FIG. 1 illustrates a state before forging is performed on a workpiece W, and FIG. 2 illustrates a state after the forging is performed on the workpiece W. As illustrated in FIGS. 1, 2, the forging device 1 includes a rotating table 10, a mandrel 12, a shaping roller 14, roller moving means (not shown), and so on.

[0028] The rotating table 10 rotates around a rotation axis L1. Further, the rotating table 10 rotates the workpiece W placed on a surface 10a, around a central axis of the workpiece W.

[0029] The mandrel 12 is formed in a cylindrical shape. The mandrel 12 is placed on the surface 10a of the rotating table 10 so that a central axis of the mandrel 12 accords with the rotation axis L1 of the rotating table 10. When the workpiece W is placed on the surface 10a of the rotating table 10, the mandrel 12 is inserted inside an inner peripheral surface Wa of the workpiece W, and the workpiece W is placed on the surface 10a of the rotating table 10 with an outer peripheral surface 12a of the mandrel 12 making contact with the inner peripheral surface Wa of the workpiece W. This allows the central axis of the workpiece W to accord with the rotation axis L1 and the central axis of the mandrel 12.

[0030] The shaping roller 14 is formed in a cylindrical shape. Further, the shaping roller 14 includes an outer peripheral surface 14a, an inner end surface 14b, and so on. Here, the inner end surface 14b is an end surface on a rotation-axis-L1 side in a central-axis-L2 direction of the shaping roller 14.

[0031] In an example illustrated in FIG. 1, two shaping rollers 14 are provided. The two shaping rollers 14 are placed at respective positions whose phases are shifted by 180° to each other in a rotation direction of the rotating table 10. The two shaping rollers 14 are integrated with each other by a shaft 20 in such a state where their central axes L2 accord with each other. The shaft 20 is attached to a housing 22 in a rotatable state. Because of this, the two shaping rollers 14 integrated with each other by the shaft 20 rotate integrally around the central axes L2 of the shaping rollers 14.

[0032] Further, as illustrated in FIG. 1, the shaping roller 14 is placed apart from the rotation axis L1. That is, a gap is provided between the rotation axis L1 and the inner end surface 14b of the shaping roller 14 (more specifically, an intersection of the inner end surface 14b with the central axis L2). A distance $\delta 0$ between the rotation axis L1 and the inner end surface 14b is larger than a radius r of the mandrel 12, but smaller than a radius R0 of the workpiece W.

[0033] Further, the central axis L2 of the shaping roller 14 is generally perpendicular to the rotation axis L1. More specifically, the central axis L2 intersects with the rotation axis L1 at an angle of 90° $\pm$ 10° (that is, 80° to 100°), for example.

[0034] Note that materials of the rotating table 10, the mandrel 12, and the shaping roller 14 may be cold working tool steel (SKD11, SKH), cemented carbide, and the like, for example. Further, the outer peripheral surface 14a of the shaping roller 14 is a part that makes contact with the workpiece W, which will be described later. On this account, it is desirable that coating be performed on the outer peripheral surface 14a of the shaping roller 14 so as to maintain a surface state.

[0035] Further, the roller moving means is attached to the housing 22. The roller moving means moves the housing 22 in parallel along a rotation-axis-L1 direction of the rotating table 10, so as to move the two shaping rollers 14 in parallel to the rotation axis L1. Note that the roller moving means is a ball screw, a hydraulic mechanism, or the like, for example.

[0036] Further, the forging device 1 includes a controlling portion (not shown). The controlling portion is constituted by a microcomputer, for example, and controls driving of the rotating table 10, the roller moving means, and so on.

<Description of Forging Method>

[0037] Next will be described a forging method for forging the workpiece W by use of the forging device 1, as an operation of the forging device 1 having the above configuration.

[0038] In the present embodiment, first, the workpiece W having a hollow cylindrical shape is placed on the surface 10a of the rotating table 10. At this time, the mandrel 12 is inserted inside the inner peripheral surface Wa of the workpiece W so that the central axis of the workpiece W accords with the rotation axis L1 of the rotating table 10. Note that a height H (a length in the rotation-axis-L1 direction) of the mandrel 12 is larger than a height h (a length in the rotation-axis-L1 direction) of the workpiece W.

[0039] Then, the rotating table 10 and the mandrel 12 are rotated around the rotation axis L1 (the central axis of the mandrel 12, the central axis of the workpiece W). Hereby, the workpiece W is rotated around the rotation axis L1.

[0040] Then, the shaping roller 14 is moved toward the workpiece W by the roller moving means. Then, the outer peripheral surface 14a of the shaping roller 14 is pressed against an end surface Wb of the workpiece W (an end surface thereof at a shaping-roller-14 side in the central-axis direction of the workpiece W), so that the shaping roller 14 makes contact with the workpiece W. Here, as described above, the workpiece W is being rotated around the rotation axis L1. Because of this, when the shaping roller 14 makes contact with the workpiece W as described above, the shaping roller 14 rotates following the workpiece W. That is, the shaping roller 14 rotates around the central axis L2.

[0041] Further, the shaping roller 14 is moved toward the workpiece W by the roller moving means. This causes a pressure to be applied to the end surface Wb of the workpiece W from the shaping roller 14, so that the workpiece W expands outwardly in a radial direction of the workpiece W. Hereby, diameter expansion molding is performed on the workpiece W.

[0042] Further, in the present embodiment, the distance $\delta 0$ between the rotation axis L1 of the rotating table 10 (the central axis of the workpiece W) and the inner end surface 14b of the shaping roller 14 is larger than the radius r of the mandrel 12, but smaller than the radius R0 (see FIG. 1) of the workpiece W before the workpiece W is forged and a radius R1 (see FIG. 2) of the workpiece W after the workpiece W is forged. Hereby, at the time when the workpiece W is forged and after the workpiece W is forged, the shaping roller 14 is separated from the mandrel 12, as illustrated in FIG. 2. More specifically, the outer peripheral surface 12a of the mandrel 12 is separated from the inner end surface 14b of the shaping roller 14 by a distance $\delta 1$, so that a gap is provided between the outer peripheral surface 12a of the mandrel 12 and the inner end surface 14b of the shaping roller 14. Because of this, when a pressure is applied to the end surface Wb of the workpiece W from the shaping roller 14 as described above, a radially inner part of the workpiece W is raised toward a shaping-roller-14 side in the rotation-axis-L1 direction, as illustrated in FIG. 2. Hereby, a boss portion Wc raised in the central-axis direction of the workpiece W is formed at a central part of the workpiece W. Thus, boss molding is performed on the workpiece W.

[0043] Here, the following more specifically describes how the diameter expansion molding and the boss molding are performed on the workpiece W. At the time when the workpiece W is forged, the shaping roller 14 revolves around the rotation axis L1 of the rotating table 10 as illustrated in FIG. 3, when viewed from the workpiece W. At this time, due to movement of an intersection between the workpiece W and the shaping roller 14, a material of the workpiece W flows toward an outer-peripheral-surface-Wd side of the workpiece W so that the material is scraped off, as illustrated in FIG. 4, and also flows toward a rotation-axis-L1 side (a mandrel-12 side). When the material of the workpiece W flows toward the outer-peripheral-surface-Wd side of the workpiece W, the diameter expansion molding to expand the workpiece W in the radial direction of the workpiece W is performed. Further, when the material of the workpiece W flows toward the rotation-axis-L1 side (the mandrel-12 side), the material of the workpiece W flows to the central-axis direction of the workpiece W along the outer peripheral surface 12a of the mandrel 12. Hereby, the boss molding to form the boss portion Wc is performed.

[0044] As described above, in the present embodiment, it is possible to perform the diameter expansion molding and the boss molding on the workpiece W at the same time.

[0045] Here, in a conventional technique (e.g., Japanese Patent Application Publication No. 61-144232 (JP 61-144232 A), at the time when a workpiece W0 is forged and after the workpiece W0 is forged, a position of an outer end 104 on a shaping surface 102 of a shaping roller 100 is placed at an inner side in a radial direction of the workpiece W relative to a position of an outer periphery WOb of the workpiece W0, as illustrated in FIG. 5. This causes such a state that the shaping surface 102 of the shaping roller 100 is pressed against only part of an end surface W0a of the workpiece W0 in the radial direction of the workpiece W0, so that accuracy of the end surface W0a of the workpiece W0 that has been forged might decrease.

[0046] In contrast, in the forging device 1 of the present embodiment, a position of that outer end 14c of the outer peripheral surface 14a of the shaping roller 14 which is opposite to the rotation-axis-L1 side in the central-axis-L2 direction is placed at an outer side in the radial direction of the workpiece W relative to a position of the outer peripheral surface Wd of the workpiece W that has been forged, as illustrated in FIG. 2. This causes such a state where the outer peripheral surface 14a of the shaping roller 14 is pressed against a large area of the end surface Wb of the workpiece W in the radial direction of the workpiece W, from the beginning of the forging of the workpiece W to the end of the forging. This makes it possible to secure accuracy of the end surface Wb of the workpiece W that has been forged, by the outer peripheral surface 14a of the shaping roller 14. This accordingly improves accuracy of the end surface Wb of the workpiece W that has been forged.

[0047] Further, in comparison with conventional die forging (forging using a molding die), the forging device 1 can perform the diameter expansion molding and the boss molding at a low load.

[0048] Further, in the present embodiment, since the material of the workpiece W flows while making close contact with the mandrel 12 from the beginning of molding, accuracy of an inside diameter of the workpiece W that has been forged can be easily secured.

[0049] Note that such an example in which only one shaping roller 14 is provided can be considered as a modification.

[0050] Further, as another modification, such an example in which a mandrel 12 is provided separately from a rotating table 10 can be considered, as illustrated in FIG. 6. Further, as illustrated in FIG. 7, such an example in which a surface 10a of a rotating table 10 is formed as an inclined surface, and an outer peripheral surface 14a of a shaping roller 14 is formed to be inclined relative to a central axis L2 can be also considered. Further, as illustrated in FIGS. 8, 9, splines may be formed on an outer peripheral surface 12a of a mandrel 12. This makes it possible to form a boss portion Wc while forming splines on an inner peripheral surface Wa of a workpiece W. Further, as illustrated in FIG. 10, such an example in which a surface 10a of a rotating table 10 is formed to have a waveform shape.

[0051] Further, as another modification, a forging device that does not include a mandrel 12 can be considered, as illustrated in FIG. 11. At this time, a workpiece W that has not been forged yet is formed in a solid cylindrical shape. Note that FIGS. 6 to 8, 10, and 11 partially illustrate a forging device.

[0052] Further, as a modification, such an example in which a central axis L2 of a shaping roller 14 intersects with a rotation axis L1 of a rotating table 10 at an angle of 45° to 90° can be considered.

<Effect of Present Embodiment>

[0053] In the present embodiment, in the forging device 1 which includes the rotating table 10 that rotates around the rotation axis L1, and the cylindrical shaping roller 14, and which forges the cylindrical workpiece W such that the outer peripheral surface 14a of the shaping roller 14 is pressed against the end surface Wb of the workpiece W in the central-axis direction of the workpiece W while the workpiece W is rotated by the rotating table 10 around the central axis of the workpiece W, the shaping roller 14 is placed apart from the rotation axis L1, and the position of that outer end 14c of the outer peripheral surface 14a of the shaping roller 14 which is opposite to the rotation-axis-L1 side in the central-axis-L2 direction of the shaping roller 14 is placed at the outer side in the radial direction of the workpiece W relative to the position of the outer peripheral surface Wd of the workpiece W that has been forged.

[0054] As such, the diameter expansion molding to expand the cylindrical workpiece W in the radial direction can be performed such that the outer peripheral surface 14a of the shaping roller 14 is pressed against the end surface Wb of the workpiece W in the central-axis-L2 direction of the workpiece W while the workpiece W is rotated by the rotating table 10 around the central axis of the workpiece W. Further, since the shaping roller 14 is placed apart from the rotation axis L1 of the rotating table 10, the material of the workpiece W flows toward the rotation-axis-L1 side relative to the shaping roller 14, so that the boss molding to form the boss portion Wc formed by raising a central part of the workpiece W in the central-axis direction of the workpiece W can be performed. Thus, the diameter expansion molding and the boss molding can be performed at the same time. This makes it possible to manufacture a forging having the boss portion Wc while achieving reduction in cost.

[0055] Further, the position of that outer end 14c of the outer peripheral surface 14a of the shaping roller 14 which is opposite to the rotation-axis-L1 side of the rotating table 10 in the central-axis-L2 direction of the shaping roller 14 is placed at the outer side in the radial direction of the workpiece W relative to the position of the outer peripheral surface Wd of the workpiece W that has been forged. This causes such a state where the outer peripheral surface 14a of the shaping roller 14 is pressed against a large area of the end surface Wb of the workpiece W, in the central-axis direction of the workpiece W, during the forging of the workpiece W. This makes it possible to secure accuracy of the end surface Wb of the workpiece W that has been forged, by the outer peripheral surface 14a of the shaping roller 14. This can accordingly improve the accuracy of the end surface Wb of the workpiece W that has been forged.

[0056] Further, it is preferable that: the forging device 1 include the cylindrical mandrel 12; the central axis of the mandrel 12 accord with the rotation axis L1 of the rotating table 10; the shaping roller 14 have the inner end surface 14b placed at the rotation-axis-L1 side in the central-axis-L2 direction of the shaping roller 14; and the distance $\delta 1$ between the central axis of the mandrel 12 and the inner end surface 14b be larger than the radius of the mandrel 12, but smaller than the radius of the workpiece.

[0057] Hereby, by flowing the material of the workpiece W between the outer peripheral surface 12a of the mandrel 12 and the inner end surface 14b of the shaping roller 14, it is possible to form the boss portion Wc having a hollow cylindrical shape in the central part of the workpiece W. Since the material of the workpiece W flows while making close contact with the outer peripheral surface 12a of the mandrel 12, it is possible to secure desired accuracy on an inner peripheral surface of the boss portion Wc by managing accuracy of the outer peripheral surface 12a of the mandrel 12.

[0058] Further, when the forging device 1 includes two shaping rollers 14, it is possible to shorten a time to forge the workpiece W. Also, the accuracy of the end surface Wb of the workpiece W is improved.

[0059] Further, in the forging device 1, the central axis L2 of the shaping roller 14 is generally perpendicular to the rotation axis L1 of the rotating table 10. This makes it possible to simplify a mechanism for supporting the shaping roller 14. Particularly, in a case where two shaping rollers 14 are provided, the two shaping rollers 14 can be integrated with each other by one shaft 20 while central axes of the two shaping rollers 14 accord with each other. This accordingly makes it possible to simplify the mechanism for supporting the two shaping rollers 14. Accordingly, the two shaping rollers 14 can be easily handled. Further, a force that can be added to the workpiece W from the shaping rollers 14 can be increased. Also, rigidity of the shaping rollers 14 can be obtained.

[0060] Note that the above embodiment is merely an example, and does not limit the present invention at all. It goes without saying that the present invention can be altered or modified variously within a range which does not deviate from the gist of the present invention.

INDUSTRIAL APPLICABILITY

[0061] A forging manufactured by the forging device 1 and the forging method of the present invention is suitable for a power transmission component. For example, the forging is most suitable for steel components used for power transmission, such as a gear wheel and a shaft used in an automobile, a construction vehicle, a construction machine, and the like, and particularly, a transmission gear wheel of an automobile and a sheave of CVT.

Description of the Reference Numerals

[0062]

1	forging device
10	rotating table
10a	surface
12	mandrel
12a	outer peripheral surface
14	shaping roller
14a	outer peripheral surface
14b	inner end surface
14c	outer end
20	shaft
22	housing
L1	rotation axis
L2	central axis
W	workpiece
Wa	inner peripheral surface
Wb	end surface
Wc	boss portion
Wd	outer peripheral surface
H	height (of mandrel)
h	height (of workpiece)
r	radius (of mandrel)
R0	radius (of workpiece that has not been forged)
R1	radius (of workpiece that has been forged)
$\delta 0$	distance
$\delta 1$	distance

Claims

1. A forging device including a rotating table that rotates around a rotation axis, and a cylindrical shaping roller, the forging device forging a cylindrical workpiece such that an outer peripheral surface of the shaping roller is pressed against an end surface of the workpiece in a central-axis direction of the workpiece while the workpiece is rotated by the rotating table around a central axis of the workpiece, the forging device being **characterized in that**:

    the shaping roller is placed apart from the rotation axis; and
    a position of that end of the outer peripheral surface of the shaping roller which is opposite to a rotation-axis side in a central-axis direction of the shaping roller is placed at an outer side in a radial direction of the workpiece relative to a position of an outer peripheral surface of the workpiece that has been forged.

2. The forging device according to claim 1, **characterized by** comprising:

    a cylindrical mandrel, wherein:

        a central axis of the mandrel accords with the rotation axis;
        the shaping roller has an inner end surface placed at the rotation-axis side in the central-axis direction of the shaping roller; and
        a distance between the central axis of the mandrel and the inner end surface is larger than a radius of the mandrel but smaller than a radius of the workpiece.

3. The forging device according to claim 1 or 2, **characterized by** comprising:

two shaping rollers.

4. The forging device according to any one of claims 1 to 3, **characterized in that**:

a central axis of the shaping roller is generally perpendicular to the rotation axis.

5. A forging method for forging a cylindrical workpiece, by use of a rotating table that rotates around a rotation axis, and a cylindrical shaping roller, such that an outer peripheral surface of the shaping roller is pressed against an end surface of the workpiece in a central-axis direction of the workpiece while the workpiece is rotated by the rotating table around a central axis of the workpiece, the forging method being **characterized in that**:

the shaping roller is placed apart from the rotation axis; and
a position of that end of the outer peripheral surface of the shaping roller which is opposite to a rotation-axis side in a central-axis direction of the shaping roller is placed at an outer side in a radial direction of the workpiece relative to a position of an outer peripheral surface of the workpiece that has been forged.

6. The forging method according to claim 5, **characterized in that**:

a cylindrical mandrel is used;
a central axis of the mandrel accords with the rotation axis;
the shaping roller has an inner end surface placed at the rotation-axis side in the central-axis direction of the shaping roller; and
a distance between the central axis of the mandrel and the inner end surface is larger than a radius of the mandrel but smaller than a radius of the workpiece.

7. The forging method according to claim 5 or 6, **characterized in that**:

two shaping rollers are used.

8. The forging method according to any one of claims 5 to 7, **characterized in that**:

a central axis of the shaping roller is generally perpendicular to the rotation axis.

FIG. 1

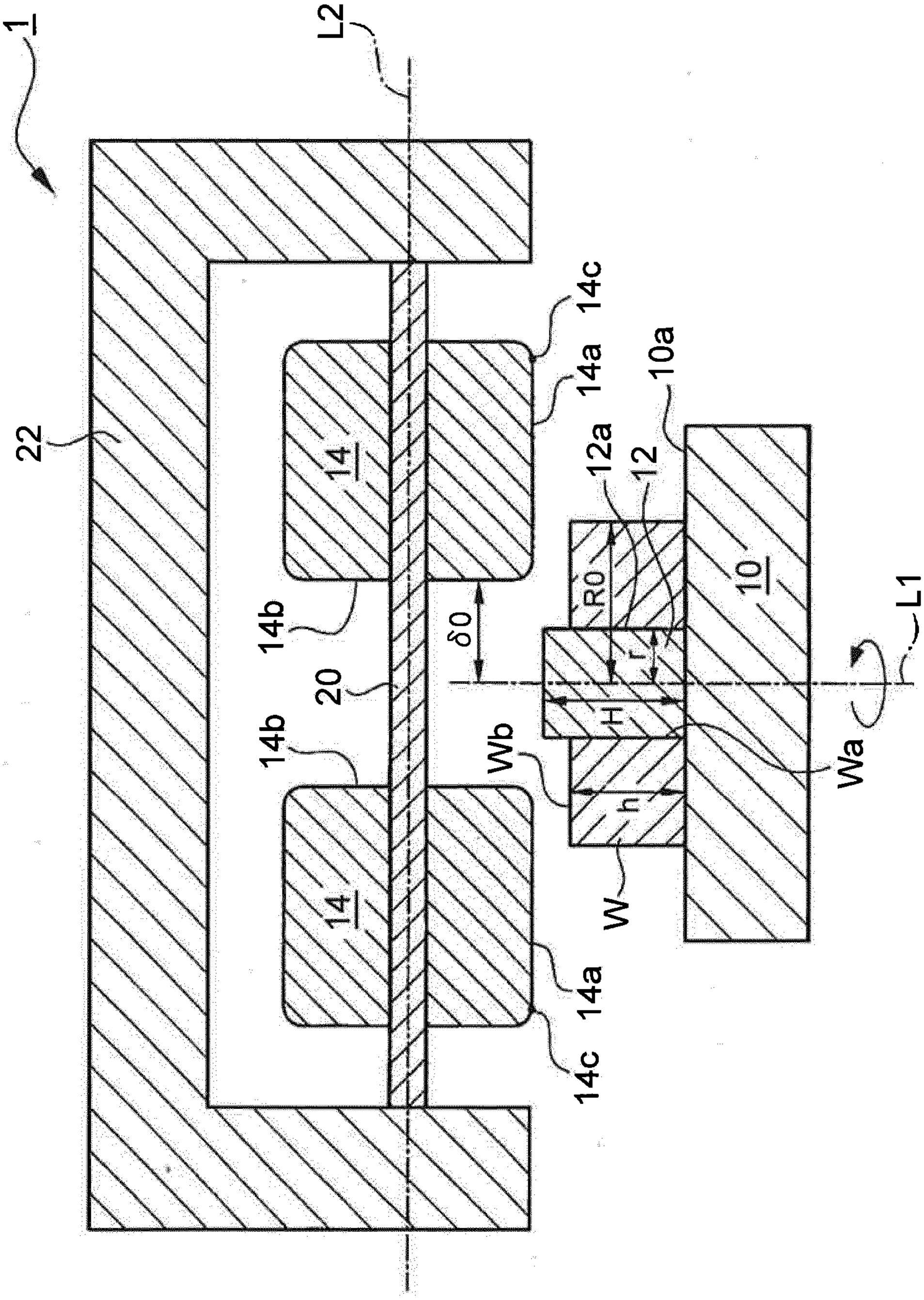


FIG. 2

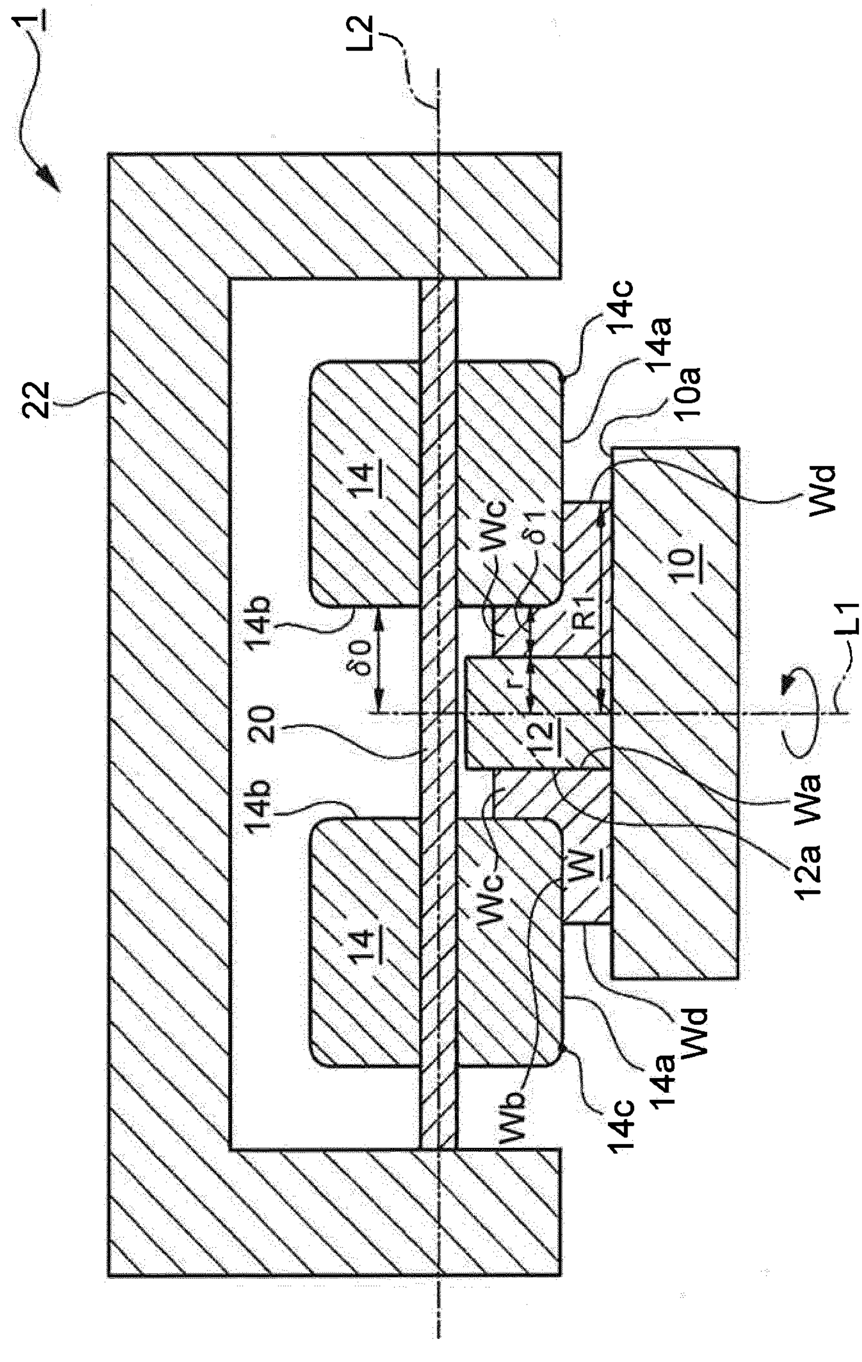

1
L2
22
14c
14a
10a
Wd
14
10
Wc
δ1
14b
δ0
R1
r
L1
20
12
Wa
14b
12a
Wc
W
14
Wd
Wb
14a
14c

FIG. 3

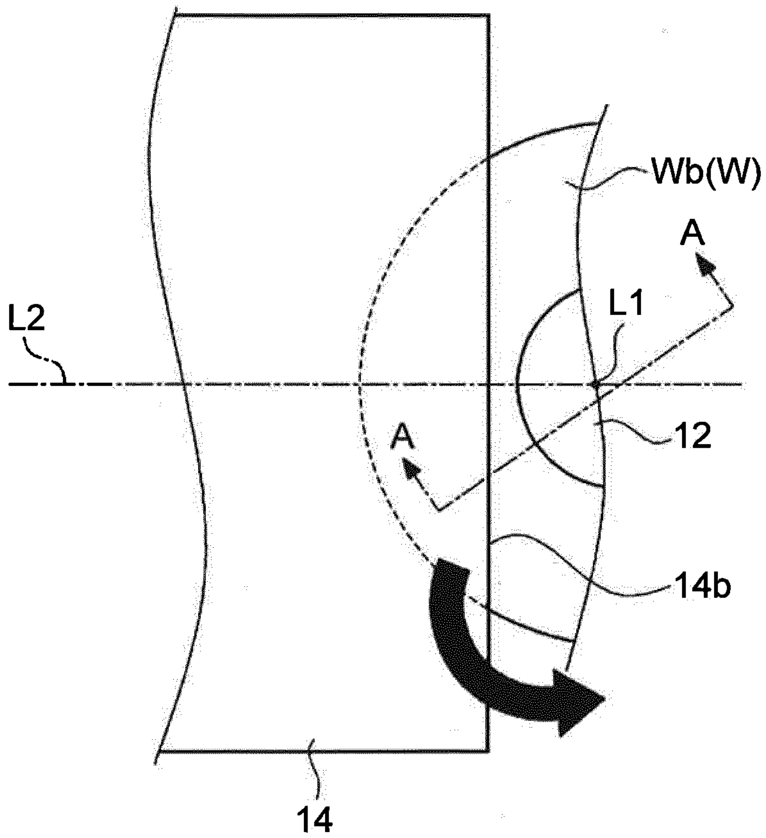


FIG. 4

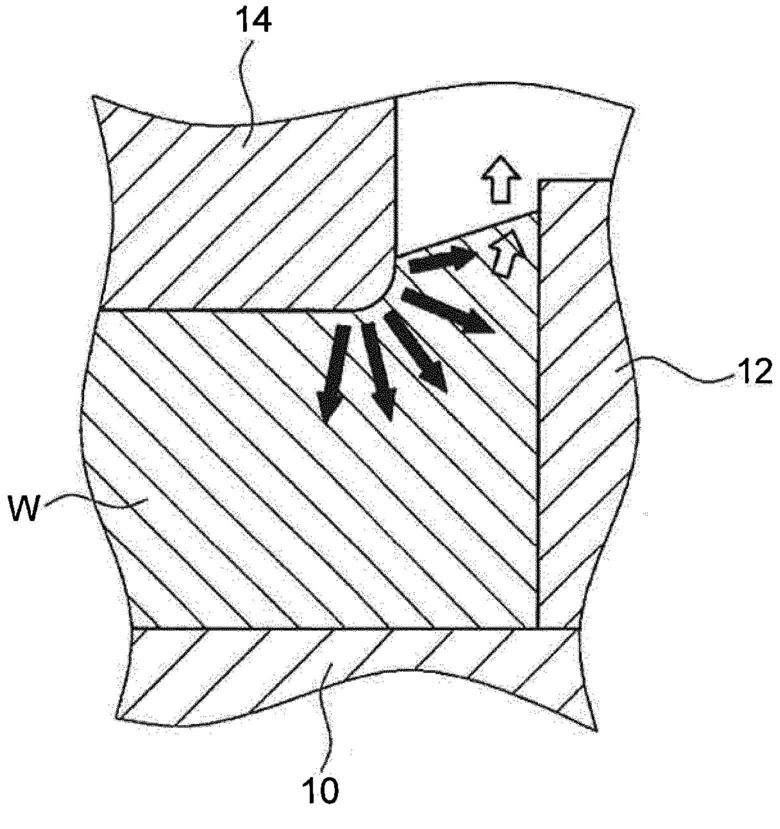


FIG. 5

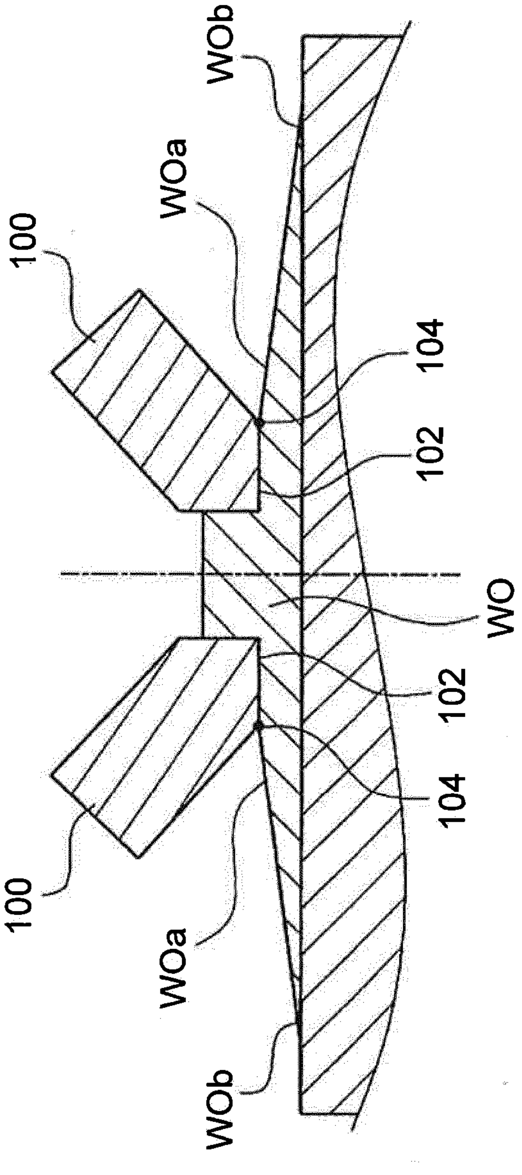
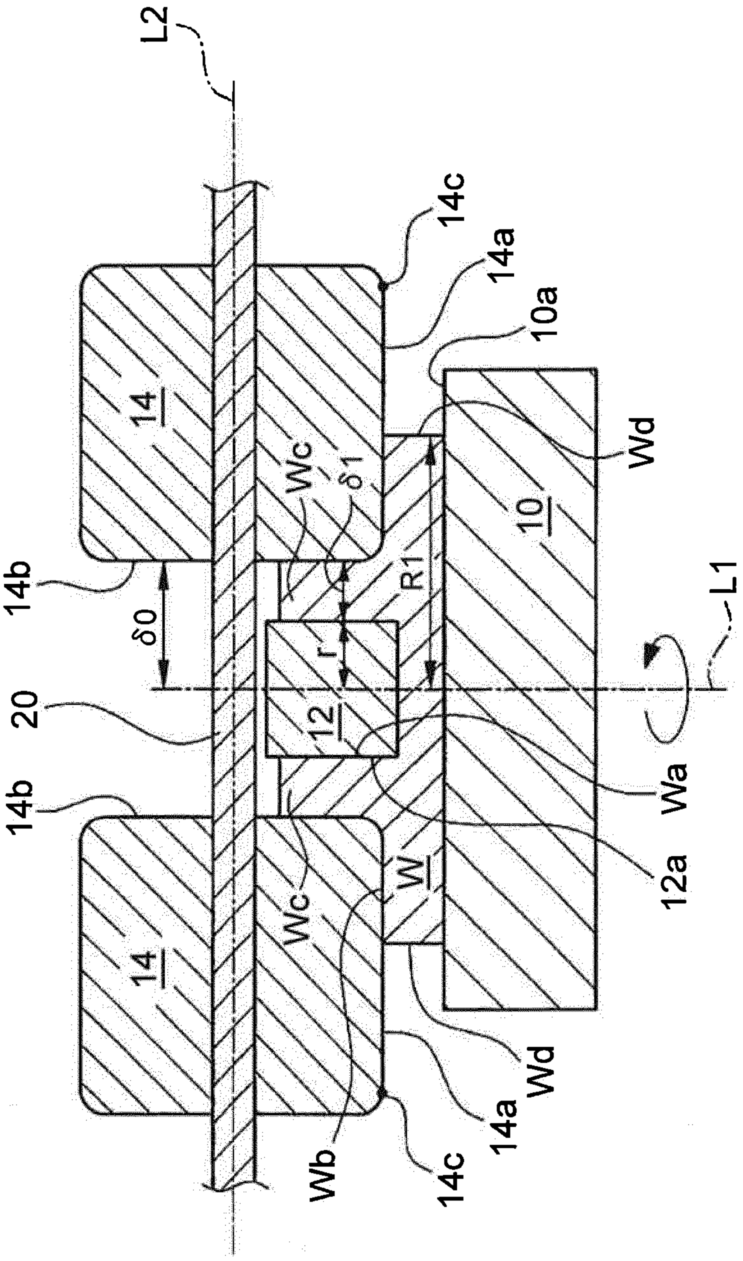


FIG. 6



L2
14c
14a
10a
Wd
14
Wc
δ1
10
R1
L1
14b
δ0
r
20
12
Wa
14b
12a
W
14
Wc
Wd
14a
Wb
14c

FIG. 7

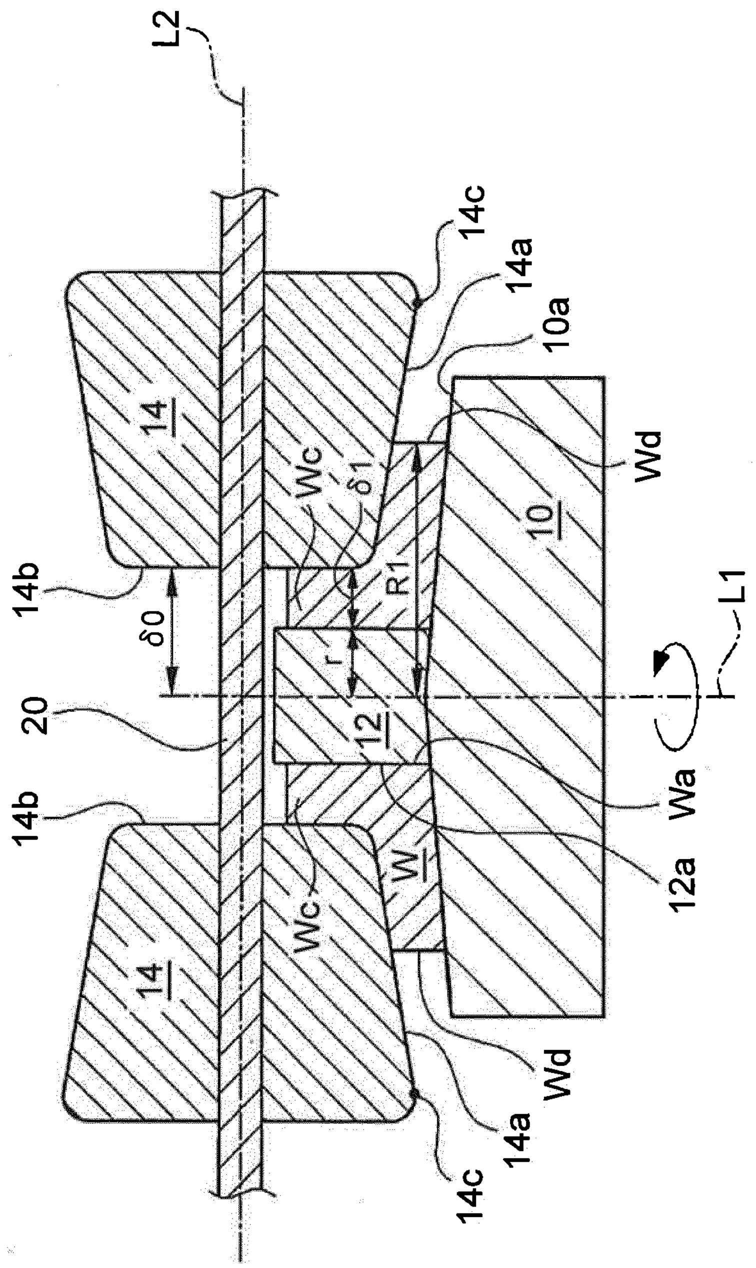

L2
14c
14a
10a
14
Wd
Wc
δ1
10
14b
δ0
R1
L1
r
20
12
Wa
14b
W
12a
Wc
14
Wd
14a
14c

FIG. 8

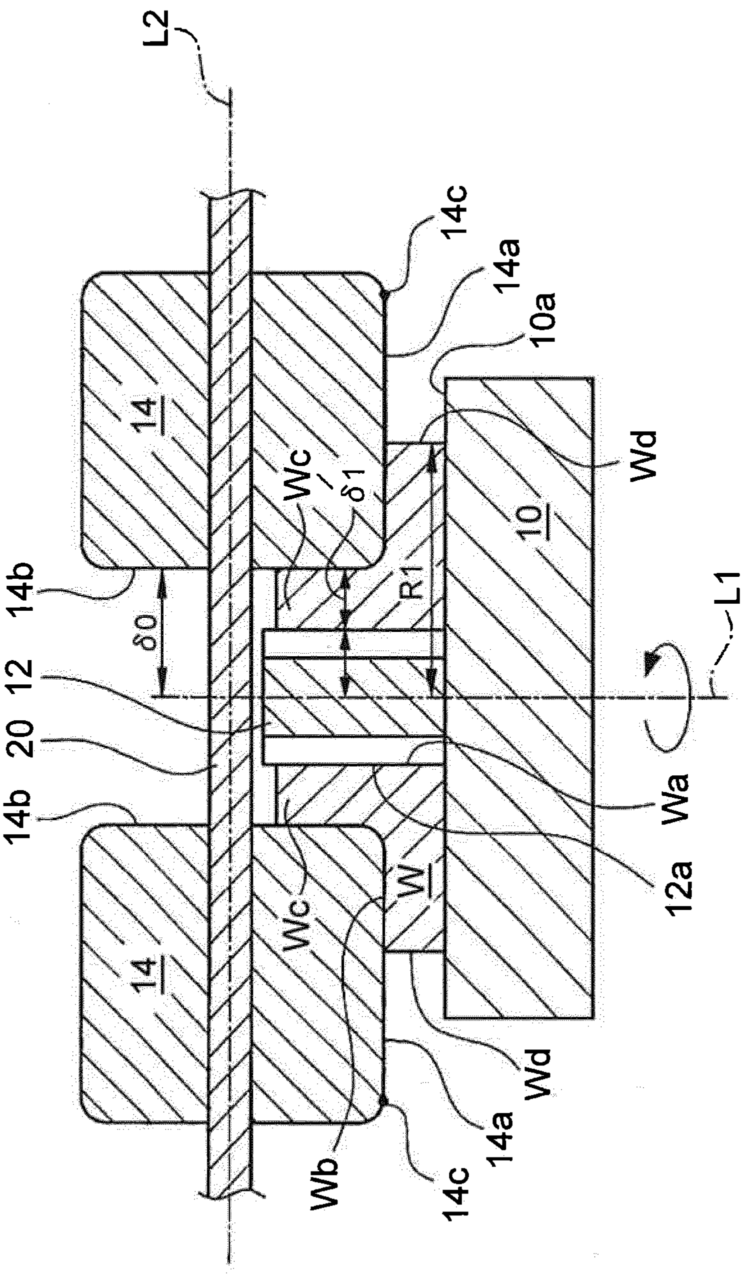

L2
14c
14a
10a
Wd
14
Wc
δ1
10
R1
L1
δ0
14b
12
20
Wa
12a
W
14b
14
Wc
Wd
14a
Wb
14c

FIG. 9

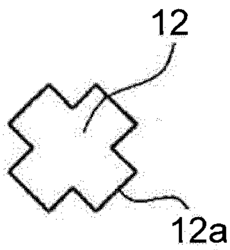


FIG. 10

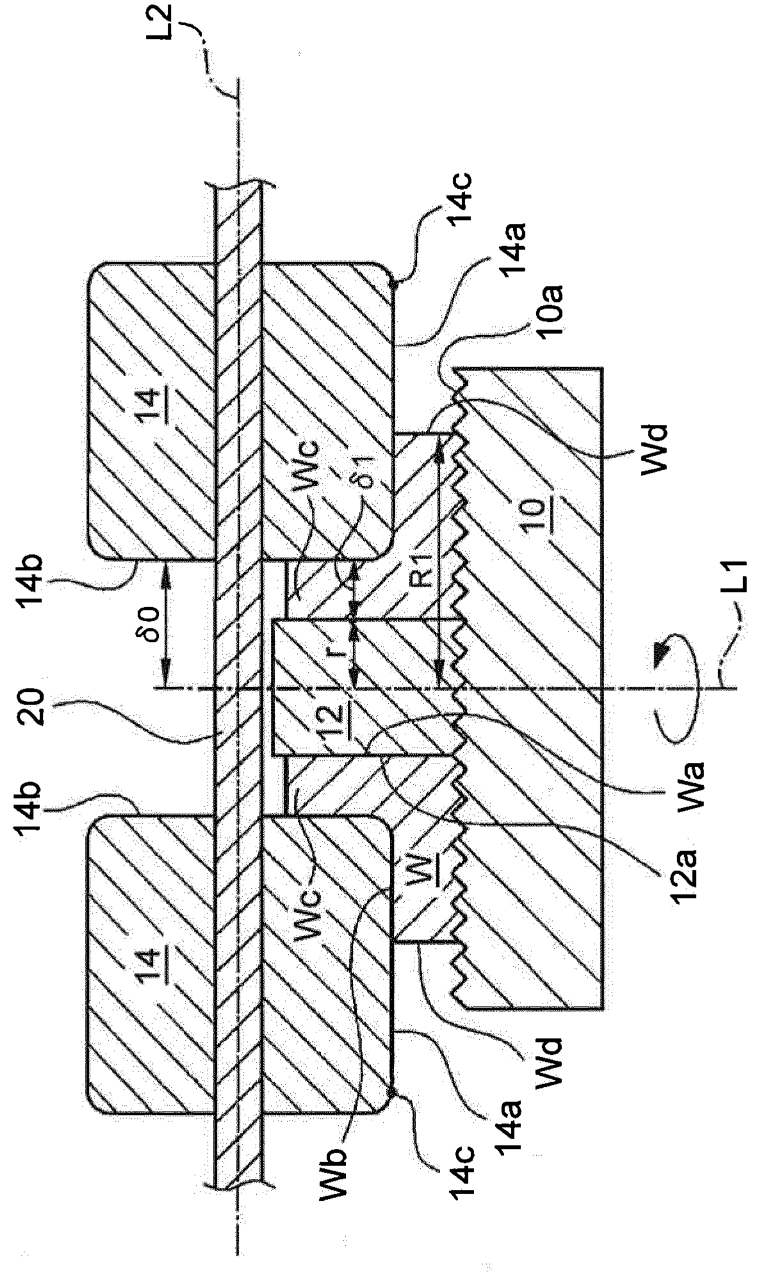
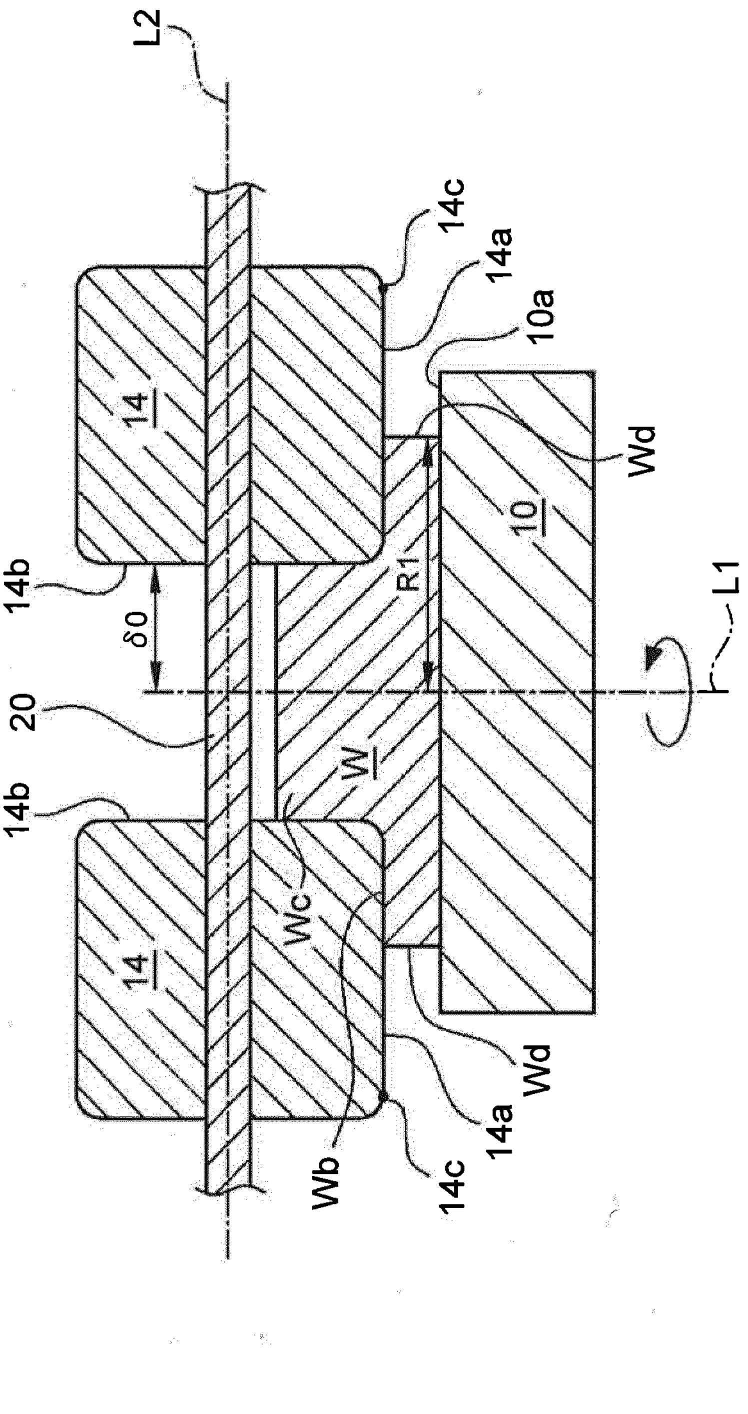

L2
14c
14a
10a
14
Wd
Wc
δ1
10
R1
L1
14b
δ0
r
20
12
Wa
12a
W
Wd
Wb
14a
14c

FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/082464

A. CLASSIFICATION OF SUBJECT MATTER
B21H1/18(2006.01)i, *B21J5/06*(2006.01)i, *B21J5/08*(2006.01)i, *B21K21/06*(2006.01)i, *B21K21/16*(2006.01)i, *B21K23/04*(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)
B21H1/18, B21J5/00, B21J5/06, B21J5/08, B21K21/06, B21K21/16, B21K23/04, B21J9/02

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.
X	JP 2004-098089 A (Mitsubishi Heavy Industries, Ltd.), 02 April 2004 (02.04.2004), paragraphs [0028] to [0032], [0036] to [0040]; fig. 1 to 5 (Family: none)	1-8
X A	JP 2011-224581 A (Toyota Motor Corp.), 10 November 2011 (10.11.2011), paragraphs [0011] to [0012], [0018] to [0020]; fig. 1 to 3 (Family: none)	1,3-5,7-8 2,6

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 February, 2014 (03.02.14)	10 February, 2014 (10.02.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/082464

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2010-094720 A (Toyota Motor Corp.), 30 April 2010 (30.04.2010), paragraphs [0020] to [0026], [0032] to [0037]; fig. 1 to 4 (Family: none)	1,3-5,7-8 2,6
A	JP 2010-099729 A (Toyota Motor Corp.), 06 May 2010 (06.05.2010), paragraphs [0018] to [0043]; fig. 1 to 4 (Family: none)	1-8

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2011224605 A **[0003]**
- JP 61144232 A **[0045]**