

(19)



(11)

EP 3 119 542 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

29.04.2020 Bulletin 2020/18

(51) Int Cl.:

B21J 5/08 ^(2006.01)

B21K 1/12 ^(2006.01)

(86) International application number:

PCT/JP2015/058650

(21) Application number: **15714685.3**

(22) Date of filing: **17.03.2015**

(87) International publication number:

WO 2015/141865 (24.09.2015 Gazette 2015/38)

(54) **SHAFT HOLDING SLEEVE, SHAFT DIAMETER ENLARGING APPARATUS AND JIG FOR SHAFT DIAMETER ENLARGING APPARATUS**

WELLENAUFNAHMEHÜLSE, WELLENDURCHMESSERVERGRÖßERUNGSVORRICHTUNG
UND SPANNVORRICHTUNG FÜR DIE
WELLENDURCHMESSERVERGRÖßERUNGSVORRICHTUNG

MANCHON DE MAINTIEN D'ARBRE, APPAREIL D'AGRANDISSEMENT DE DIAMÈTRE D'ARBRE
ET GABARIT POUR APPAREIL D'AGRANDISSEMENT DE DIAMÈTRE D'ARBRE

(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**

(30) Priority: **19.03.2014 JP 2014056519**

19.03.2014 JP 2014056520

(43) Date of publication of application:

25.01.2017 Bulletin 2017/04

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Description**Technical Field**

5 **[0001]** The present invention relates to a shaft holding sleeve, a shaft diameter enlarging apparatus and a jig for the shaft diameter enlarging apparatus.

Background Art

10 **[0002]** A shaft diameter enlarging method is known as a method for forming a large diameter portion on an axially intermediate portion of a shaft stock. According to an example of the shaft diameter enlarging method, a shaft stock is rotated with a bending angle being given to the shaft stock in a state in which an axial compression stress is applied to the shaft stock, thereby enlarging a portion of the shaft stock to form the large diameter portion.

15 **[0003]** A shaft diameter enlarging apparatus typically includes a pair of shaft holding sleeves for holding respective end portions of a shaft stock and a pair of spindles arranged along a reference line, along which the shaft stock is arranged. Each spindle has a fitting hole into which a corresponding holding sleeve is inserted. The shaft holding sleeves are inserted into the fitting holes of the respective spindles and fixed to the respective spindles. A portion of the shaft stock is enlarged by moving one of the spindles along the reference line to compress the shaft stock in the axial direction thereof and by simultaneously rotating the other spindle in a state in which the other spindle is tilted relative to the reference line (see, e.g., JP2013-166168A). See also JP2000-343172A, on which the preamble of claims 1 and 2 is based.

20 **[0004]** The shaft holding sleeve is exchanged as needed in accordance with, for example, dimensions of shaft stocks or wearing of the shaft holding sleeve due to contact with the shaft stock. However, when inserting or removing the shaft holding sleeve with respect to the fitting hole, the air confined inside the fitting hole may hinder a smooth insertion or removal of the shaft holding sleeve.

25 **[0005]** The shaft holding sleeve may include an outer sleeve fixed to the spindle and an inner sleeve press-fitted in the outer sleeve so that only the inner sleeve need to be exchanged. The inner sleeve is worn due to contact with the shaft stock. Thus, costs can be reduced by exchanging only the inner sleeve.

30 **[0006]** However, the inner sleeve contacts a radially enlarged portion of the shaft stock, and thus as the shaft stock is compressed, a load is exerted on the inner sleeve in a direction opposite to a compression direction in which the shaft stock is compressed. If the load exerted on the inner sleeve is excessive, the inner sleeve may be displaced relative to the outer sleeve in the direction opposite to the compression direction.

Summary of Invention

35 **[0007]** The present invention has been made in view of above, and it is an object thereof to improve a shaft diameter enlarging work.

40 **[0008]** According to an aspect of the present invention, a shaft holding sleeve according to claims 1 or 2 is provided. A shaft holding sleeve is inserted in a fitting hole of a compressing machine that applies an axial compression stress to a shaft stock to hold an end portion of the shaft stock during a shaft diameter enlarging process for radially enlarging a portion of the shaft stock. The shaft holding sleeve includes a front end surface to be inserted in the fitting hole, an exposed portion to be exposed to an outside of the fitting hole, and at least one air communication passage extending from the front end surface to a surface of the exposed portion.

45 **[0009]** According to another aspect of the present invention, a shaft diameter enlarging apparatus includes a pair of shaft holding sleeves described above to hold respective end portions of a shaft stock, a compressing machine having fitting holes into which the pair of shaft holding sleeves are inserted respectively, the compressing machine being configured to compress the shaft stock W having the respective end portions held by the pair of shaft holding sleeves in an axial direction of the shaft stock, and a load generation device configured to apply, to an intermediate portion of the shaft stock having the respective end portions held by the pair of shaft holding sleeves, an alternating load in a direction intersecting the axial direction.

50 **[0010]** According to another aspect of the present invention, a jig for use with the shaft diameter enlarging apparatus described above is provided. The jig includes a mounting surface on which the shaft holding sleeve is mounted when inserting the shaft holding sleeve into the fitting hole. In a state in which the jig is attached to an opening edge portion of the fitting hole, the mounting surface is flush with an inner peripheral surface of the fitting hole.

55 **[0011]** Other aspects and advantages of the invention will be apparent from the following description, the drawings and the claims.

Brief Description of Drawings

[0012]

Figs. 1A to 1E are diagrams schematically illustrating an example of a shaft diameter enlarging method;
 Figs. 2A to 2C are diagrams schematically illustrating another example of the shaft diameter enlarging method;
 Figs. 3A and 3B are diagrams schematically illustrating yet another example of the shaft diameter enlarging method;
 Figs. 4A and 4B are diagrams schematically illustrating yet another example of the shaft diameter enlarging method;
 Figs. 5A and 5B are diagrams schematically illustrating yet another example of the shaft diameter enlarging method;
 Fig. 6 is a side view of an example of a shaft diameter enlarging apparatus for performing the shaft diameter enlarging method illustrated in Figs. 1A to 1E;
 Fig. 7 is a sectional view of a shaft holding sleeve and a spindle of the shaft diameter enlarging apparatus of Fig. 6;
 Fig. 8 is a front view of the shaft holding sleeve of Fig. 7;
 Fig. 9 is a sectional view of another example of the shaft holding sleeve;
 Fig. 10 is a side view of yet another example of the shaft holding sleeve;
 Fig. 11 is a perspective view of yet another example of the shaft holding sleeve;
 Fig. 12 is a sectional view of another example of the shaft holding sleeve and the spindle;
 Fig. 13 is a diagram illustrating a configuration of the shaft holding sleeve of Fig. 12;
 Fig. 14 is a diagram illustrating a configuration of another example of the shaft holding sleeve of Fig. 12;
 Fig. 15 is a side view illustrating an example of a jig for the shaft diameter enlarging apparatus;
 Fig. 16 is a sectional view illustrating another example of the jig for the shaft diameter enlarging apparatus; and
 Fig. 17 is a front view of the jig for the shaft diameter enlarging apparatus of Fig. 16.

Description of Embodiments

[0013] Figs. 1A to 5B are diagrams illustrating various examples of a shaft diameter enlarging method.

[0014] In the shaft diameter enlarging method shown in Figs. 1A to 1E, a shaft stock W is rotated while a bending angle is applied to the shaft stock W in a state in which an axial compression stress is exerted thereon, thereby enlarging a portion of the shaft stock W.

[0015] As shown in Fig. 1A, both end portions of the shaft stock W are respectively inserted into a pair of shaft holding sleeves 1a and 1b arranged on a reference line A to face each other. In addition, both end portions of the shaft stock W are respectively abutted to bottoms of the shaft holding sleeves 1a and 1b, and thus the shaft stock W is sandwiched by the pair of shaft holding sleeves 1a and 1b. A predetermined gap D is interposed between the pair of shaft holding sleeves 1a and 1b and the gap D is determined depending on an axial length and an outer diameter of a radially enlarged portion formed on the shaft stock W.

[0016] As shown in Fig. 1B, the shaft holding sleeve 1b is translated along the reference line A so that the shaft stock W sandwiched by the pair of shaft holding sleeves 1a and 1b is axially compressed. Then, the shaft holding sleeve 1a is tilted relative to the reference line A and also rotated, so that the shaft stock W sandwiched by the pair of shaft holding sleeves 1a and 1b is bent about a bending center O on the reference line A and also is rotated about an axis of the shaft stock W. Due to bending and rotating of the shaft stock W, an alternating load in a direction intersecting an axial direction of the shaft stock W is exerted on the bent portion (an intermediate portion) of the shaft stock W at an inner side and an outer side thereof in a bending direction.

[0017] As shown in Fig. 1C, because the shaft stock W is compressed in the axial direction thereof, the inner side of the bent portion of the shaft stock W is swelled by plastic deformation, and swelling by plastic deformation is grown over the entire circumference thereof, so that the bent portion of the shaft stock W is thickened.

[0018] As shown in Fig. 1D, when the gap between the pair of shaft holding sleeves 1a and 1b reaches a target gap (the axial length of the radially enlarged portion of the shaft stock W), compression of the shaft stock W is stopped and the shaft holding sleeve 1a that has been tilted relative to the reference line A is again arranged along the reference line A, so that bending of the shaft stock W is restored. According to the above procedures, enlarging processing of the shaft stock W is finished and then rotating of the shaft stock W is stopped.

[0019] Then, as shown in Fig. 1E, the shaft stock W is separated from the pair of shaft holding sleeves 1a and 1b.

[0020] A shaft diameter enlarging method shown in Figs. 2A to 2C is identical to the shaft diameter enlarging method of Figs. 1A to 1E, in that as a shaft stock W is bent and is rotated about an axis thereof, an alternating load is exerted on a bent portion (an intermediate portion) of the shaft stock W. In this shaft diameter enlarging method, instead of tilting one shaft holding sleeve 1a relative to the reference line A, the shaft holding sleeve 1a is slid in the direction intersecting the reference line A, thereby bending the shaft stock W.

[0021] In a shaft diameter enlarging method shown in Figs. 3A and 3B, an end portion of a shaft stock W is rotatably held in a non-constraint state by one shaft holding sleeve 1a, an end portion of the shaft stock W is non-rotatably held

in a constraint state by the other shaft holding sleeve 1b, and then the shaft holding sleeve 1a and the end portion of the shaft stock W held by the shaft holding sleeve 1a is pivoted about the reference line A, thereby bending the shaft stock W and also exerting an alternating load on a bent portion (an intermediate portion) of the shaft stock W.

[0022] In a shaft diameter enlarging method shown in Figs. 4A and 4B, end portions of a shaft stock W are non-rotatably held in a constraint state by shaft holding sleeves 1a and 1b, respectively, and one shaft holding sleeve 1a is reciprocatingly rotated about the reference line A, thereby exerting an alternating load on an intermediate portion of the shaft stock W.

[0023] In a shaft diameter enlarging method shown in Figs. 5A and 5B, instead of displacement or rotation of shaft holding sleeves 1a and 1b or shaft stock W, a bending or twisting oscillation is applied from an oscillation generator OSC to the shaft stock W, thereby exerting an alternating load on an intermediate portion of the shaft stock W.

[0024] Fig. 6 shows a configuration of one example of a shaft diameter enlarging apparatus for performing the shaft diameter enlarging method shown in Figs. 1A and 1E.

[0025] The shaft diameter enlarging apparatus 10 shown in Fig. 6 includes a pair of shaft holding sleeves 11 for holding end portions of a shaft stock and a pair of holder units 12a, 12b arranged to be spaced from each other along a reference line A, along which the shaft stock is arranged. One holder unit 12a is supported on a base 13 to be tiltable relative to the reference line A. The other holder unit 12b is supported on the base 13 to be movable along the reference line A.

[0026] Each of the holder units 12a, 12b includes a spindle 14, on which the shaft holding sleeve is mounted, a housing 15 for rotatably supporting the spindle 14, and a cylinder 16 for pushing the end portion of the shaft stock, which has been inserted in the shaft holding sleeve 11, out of the shaft holding sleeve 11. The spindle 14 of each of the holder unit 12a, 12b is arranged on the reference line A.

[0027] The shaft diameter enlarging apparatus 10 includes a translational driving unit 17 for moving the holder unit 12b along the reference line A, a tilting unit 18 for tilting the holder unit 12a relative to the reference line A and a rotation driving unit 19 for rotating the spindle 14 of the holder unit 12a. The holder units 12a, 12b and the translational driving unit 17 form a compressing machine for compressing the shaft stock in an axial direction of the shaft stock. The holder units 12a, 12b, the tilting unit 18 and the rotation driving unit 19 form a load generation device for exerting, on an intermediate portion of the shaft stock, an alternating load in a direction intersecting the axial direction (the reference line A) of the shaft stock.

[0028] Figs. 7 and 8 show configurations of the shaft holding sleeve 11 and the spindle 14.

[0029] The spindle 14 is provided with a fitting hole 20, into which the shaft holding sleeve 11 is inserted, and a pin insertion hole 21 connected to the fitting hole 20. A pressure receiving plate 22 for bearing the shaft holding sleeve 11 is fitted in the fitting hole 20, and the pressure receiving plate 22 is butted and fixed to a shoulder 23 formed inside the fitting hole 20. The pin insertion hole 21 is provided to extend through the spindle 14 along a center axis (reference line A) of the spindle 14, and a knock pin 24 of the cylinder 16 (see Fig. 6) is inserted through the pin insertion hole 21.

[0030] The shaft holding sleeve 11 has a cylindrical portion 30 for receiving the end portion of the shaft stock and a backing metal 31 fitted in the cylindrical portion 30. The cylindrical portion 30 has an accommodated portion 32 received in the fitting hole 20 of the spindle 14 in a state in which the shaft holding sleeve 11 is inserted in the fitting hole 20, and an exposed portion 33 exposed out of the fitting hole 20. The exposed portion 33 is formed to have a diameter smaller than that of the accommodated portion 32, and a shoulder 34 is formed on a connection portion between the exposed portion 33 and the accommodated portion 32. The backing metal 31 forming a bottom of the shaft holding sleeve 11 is supported by the knock pin 24 and bears an end surface of the shaft stock W. Thus, the backing metal 31 is configured to be pressed by the knock pin 24, so that the end portion of the shaft stock W inserted in the shaft holding sleeve 11 is pushed out of the shaft holding sleeve 11.

[0031] The shaft holding sleeve 11 inserted in the fitting hole 20 of the spindle 14 is fixed to the spindle 14 as the shoulder 34 of the cylindrical portion 30 is pressed by a flange pipe 35 fastened to an opening end of the spindle 14 in which the fitting hole 20 is opened.

[0032] The shaft holding sleeve 11 is appropriately exchanged depending on dimensions of shaft stocks. Also, the shaft holding sleeve 11 receives a reaction force of an alternating load exerted on the shaft stock, and in particular, a relatively large load is applied to a surface 30a of an opening portion of the shaft holding sleeve 11. Accordingly, the shaft holding sleeve 11 is worn due to repeated uses and thus appropriately exchanged.

[0033] When along with exchange of the shaft holding sleeve 11, the shaft holding sleeve 11 is inserted in and removed from the fitting hole 20 of the spindle 14, air is confined inside the fitting hole 20 by the shaft holding sleeve 11, the spindle 14, the pressure receiving plate 22 and the knock pin 24, and therefore the shaft holding sleeve 11 is provided with an air communication passage for communicating the inside of the fitting hole 20 with the outside.

[0034] According to the invention, the air communication passage of the shaft holding sleeve 11 is composed of a groove 36 formed in an outer peripheral surface of the accommodated portion 32. The groove 36 is provided to extend from a front end surface of the shaft holding sleeve 11 on a side (a bottom side) of an insertion direction into the fitting hole 20 along an axial direction of the shaft holding sleeve 11 to reach a surface of the exposed portion 33. Although at least one groove 36 is sufficient as the air communication passage, a plurality of grooves may be provided to be spaced

from each other in a circumferential direction of an outer surface of the accommodated portion 32 as in the shown example.

[0035] If the groove 36 as the air communication passage is not present, the inside of the fitting hole 20 is at a negative pressure relative to an ambient pressure when the shaft holding sleeve 11 is removed therefrom, whereas the inside of the fitting hole 20 is at a positive pressure relative to the ambient pressure when the shaft holding sleeve 11 is inserted therein, thereby hindering the shaft holding sleeve 11 from being smoothly inserted and removed. Contrarily, because the inside of the fitting hole 20 is communicated with the outside by the groove 36, the inside of the fitting hole 20 is kept at the ambient pressure or a difference in pressure from the ambient pressure is reduced. Accordingly, the shaft holding sleeve 11 can be smoothly inserted and removed, so that the replacement of the shaft holding sleeve 11 can be facilitated, thereby contributing to an overall improvement in the shaft diameter enlarging work.

[0036] Alternatively, the air communication passage of the shaft holding sleeve 11 is not limited to the groove 36 in so far as the air communication passage extends from the front end surface of the shaft holding sleeve 11 inserted in the fitting hole 20 to a surface of the exposed portion 33. According to the invention, as shown in Fig. 9, the air communication passage is alternatively configured as a through hole 37 extending from the front end surface of the shaft holding sleeve 11 to the opposite end surface thereof.

[0037] As shown in Fig. 10, an attaching portion 39, to which a lifting lug 38 is detachably fastened, may be provided on the outer peripheral surface of the shaft holding sleeve 11. Because the shaft holding sleeve 11 has a weight of about 60kg for a large article and thus is relatively heavy although being varied depending on the shaft stock to be held, the shaft holding sleeve 11 can be suspended via the lifting lug 38 so that the burden of workers in an operation of exchanging the shaft holding sleeve 11 can be reduced. Thus, workability in exchanging of the shaft holding sleeve 11 can be further improved.

[0038] In the example shown in Figs. 6 and 7, the flange pipe 35 for fixing the shaft holding sleeve 11 to the spindle 14 is constructed as a separate body from the cylindrical portion 30 of the shaft holding sleeve 11. However, as shown in Fig. 11, the cylindrical portion 30 may be integrally provided with a flange portion 40. In this case, the flange portion 40 may be provided with a handle 41 as a grip portion. When the handle 41 is provided, operations of inserting and removing the shaft holding sleeve into and from the fitting hole 20 of the spindle 14 can be easily performed, and thus workability in exchanging of the shaft holding sleeve can be further improved.

[0039] According to another example, the shaft holding sleeve 11 has a cylindrical outer sleeve 30A, an inner sleeve 30B inserted in the outer sleeve 30A and a backing metal 31 fitted in the inner sleeve 30B. The outer sleeve 30A is inserted in the fitting hole 20 of the spindle 14, and the outer sleeve 30A and the inner sleeve 30B inserted in the outer sleeve 30A are supported at rear end surfaces thereof by the pressure receiving plate 22. Also, the shoulder 34 provided on an outer peripheral surface of the outer sleeve 30A is pressed by the flange pipe 35 fastened to the opening end of the spindle 14 in which the fitting hole 20 is opened, and as a result, the outer sleeve 30A is fixed to the spindle 14. The inner sleeve 30B receives the end portion of the shaft stock W. The backing metal 31 forming a bottom of the shaft holding sleeve 11 is supported by the knock pin 24 and bears an end surface of the shaft stock W. Thus, the backing metal 31 is configured to be pressed by the knock pin 24, so that the end portion of the shaft stock W inserted in the shaft holding sleeve 11 is pushed out of the shaft holding sleeve 11.

[0040] The inner sleeve 30B receives a reaction force of an alternating load exerted on the shaft stock, and in particular, a relatively large load is applied to a surface 30a of an opening portion of the inner sleeve 30B. Accordingly, the inner sleeve 30B is worn due to repeated uses. The inner sleeve 30B inserted in the outer sleeve 30A can be removed from the outer sleeve 30A, so that only the inner sleeve 30B can be exchanged depending on a wear degree.

[0041] The inner sleeve 30B contacts the radially enlarged portion of the shaft stock during the shaft diameter enlarging process, and thus as the shaft stock W is compressed, a load is exerted on the inner sleeve 30B in a direction opposite to a compression direction of the shaft stock W. For such a load, the outer sleeve 30A and the inner sleeve 30B are provided with an engaging structure for preventing a movement thereof in the direction opposite to the compression direction of the shaft stock W.

[0042] Fig. 13 shows one example of the engaging structure provided in the outer sleeve 30A and the inner sleeve 30B.

[0043] An annular concave-convex portion 70 is provided on an inner peripheral surface of the outer sleeve 30A and an annular concave-convex portion 71 to be engaged with the concave-convex portion 70 of the outer sleeve 30A is provided on an outer peripheral surface of the inner sleeve 30B. The concave-convex portions 70, 71 of the outer sleeve 30A and the inner sleeve 30B are engaged with each other, thereby preventing the inner sleeve 30B from being displaced in the direction opposite to the compression direction of the shaft stock due to the load.

[0044] A depth D of the concave portion and a height H of the convex portion in each of the concave-convex portions 70, 71 is preferably equal to or greater than 50 μm and equal to or smaller than 1% of an outer diameter of the inner sleeve 30B. Thus, an engaging force larger than a friction caused by press-fitting when the outer sleeve 30A and the inner sleeve 30B has a typical surface roughness can be obtained, thereby reliably preventing the inner sleeve 30B from being moved in the direction opposite to the compression direction of the shaft stock.

[0045] In the above configuration, the inner sleeve 30B is inserted into the outer sleeve 30A, for example, by shrinkage fitting. While each of the concave-convex portions 70, 71 of the outer sleeve 30A and the inner sleeve 30B has a plurality

of concave portions and convex portions, according to an alternative example, only one pair of concave portion and convex portion may be provided.

[0046] Fig. 14 shows another example of the engaging structure provided in the outer sleeve 30A and the inner sleeve 30B.

[0047] In the example shown in Fig. 14, each concave portion and convex portion of the concave-convex portions 70, 71 of the outer sleeve 30A and the inner sleeve 30B is configured in a saw-tooth shape extending away from a center axis (the reference line A) of the outer sleeve 30A and the inner sleeve 30B in the direction opposite to the compression direction in which the shaft stock is compressed. Also, the inner peripheral surface of the outer sleeve 30A and the outer peripheral surface of the inner sleeve 30B are formed in a tapered shape extending away from the center axis (the reference line A) of the outer sleeve 30A and the inner sleeve 30B in the direction opposite to the compression direction.

[0048] According to this example, the inner sleeve 30B can be inserted into the outer sleeve 30A by press fitting, thereby facilitating insertion of the inner sleeve 30B into the outer sleeve 30A.

[0049] To suppress wearing of the shaft holding sleeve 11 due to contact with the shaft stock, a hard material is preferably used as a material for the shaft holding sleeve 11 (or the inner sleeve 30B of the shaft holding sleeve 11). By suppressing wearing of the shaft holding sleeve 11, a frequency of exchanging the shaft holding sleeve 11 (or the inner sleeve 30B of the shaft holding sleeve 11) can be lowered, thereby improving the shaft diameter enlarging work.

[0050] As a base material forming the shaft holding sleeve 11 (or the inner sleeve 30B of the shaft holding sleeve 11), a material having a Rockwell hardness (JIS G 0202) of HRC58 or more can be preferably used, and the material can include die steels, such as SKD11, high speed steels, such as SKH51, semi-high speed steels or like.

[0051] Also, from the viewpoint of suppressing wearing of the shaft holding sleeve 11, a surface hardening treatment may be applied on the shaft holding sleeve 11 (or the inner sleeve 30B of the shaft holding sleeve 11). When the surface hardening treatment is performed, the Vickers hardness (JIS Z 2244) of the hardened surface is preferably equal to or greater than HV1200, more preferably equal to or greater than HV3000. It is also preferable that the hardened surface be smooth. Examples of surface hardening treatment include coating, such as vanadium-based coating, chromium-based coating, titanium-based coating or diamond-like carbon (DLC) coating, nitriding and the like.

[0052] The surface hardening treatment is performed at least on a surface 30a of the opening portion of the shaft holding sleeve 11, and also may be performed on the entire inner peripheral surface of the cylindrical portion 30 including the surface 30a of the opening portion (or the entire inner peripheral surface of the inner sleeve 30B of the shaft holding sleeve 11) or may be performed on the entire surface of the shaft holding sleeve 11 (or the entire surface of the inner sleeve 30B of the shaft holding sleeve 11).

[0053] When a coating is formed as the surface hardening treatment, the coating may be composed of a single layer coating formed by various coatings listed above or a multilayer coating formed by one or more thereof. Examples of method of forming the coating can include salt bath immersion method (thermo-reactive deposition and diffusion method), chemical vapor deposition (CVD), physical vapor deposition (PVD), plasma CVD (PCVD) and the like.

[0054] From the viewpoint of improving the shaft diameter enlarging work, a jig may be used when exchanging the shaft holding sleeve 11.

[0055] Fig. 15 shows a configuration of one example of a jig for the shaft diameter enlarging apparatus.

[0056] The jig 50 shown in Fig. 15 has a plurality of cylindrical guide rods 51 (only one is shown in the figure). Screw holes are provided in the opening end of the spindle 14 to which the flange pipe 35 of the shaft holding sleeve 11 is fastened. The guide rod 51 shown in Fig. 15 is fastened to one of the screw holes located vertically below the fitting hole 20 so that it is attached to an opening edge portion of the fitting hole 20.

[0057] The shaft holding sleeve 11 is seated on the plurality of guide rods 51 and thus mounted on the guide rods 51. An outer peripheral surface of each guide rod 51 is flush with the inner peripheral surface of the fitting hole 20 along a generatrix line of the outer peripheral surface thereof that contacts the mounted shaft holding sleeve 11, so that the shaft holding sleeve 11 is smoothly moved from on the guide rods 51 into the fitting hole 20 and also from the fitting hole 20 onto the guide rods 51. Therefore, operations of inserting and removing the shaft holding sleeve 11 can be easily performed, and thus workability in exchanging of the shaft holding sleeve 11 can be further improved.

[0058] Also, in the shown example, each of the guide rods 51 is provided at a distal end thereof with a large diameter stopper portion 52, and the stopper portion 52 is abutted to the shaft holding sleeve 11 to prevent the shaft holding sleeve 11 from being dropped out, in a case where the shaft holding sleeve 11 is excessively moved toward the distal ends of the guide rods 51, such as when the shaft holding sleeve 11 is removed from the fitting hole 20.

[0059] After the shaft holding sleeve 11 is inserted into the fitting hole 20, the guide rods 51 are separated from the spindle 14, and then instead of the guide rods 51, the flange pipe 35 is fastened to the spindle 14 so that the shaft holding sleeve 11 is fixed to the spindle 14.

[0060] Figs. 16 and 17 show a configuration of another example of the jig for the shaft diameter enlarging apparatus.

[0061] The jig 60 shown in Figs. 16 and 17 is formed in an annular shape and is fitted on the outer side of the opening end of the spindle 14 to be mounted to the spindle 14. The jig 60 has a half-cylindrical support portion 62 formed to protrude from a lower edge, in the vertical direction, of an opening 61 exposing the fitting hole 20, and the shaft holding

sleeve 11 is mounted to the support portion 62. An inner peripheral surface of the support portion 62 is flush with the inner peripheral surface of the fitting hole 20, so that the shaft holding sleeve 11 is smoothly moved from on the support portion 62 into the fitting hole 20 and also from the fitting hole 20 onto the support portion 62. According to the jig 60 of the present example, the jig 60 can be easily mounted to and removed from the spindle 14 and workability in exchanging of the shaft holding sleeve 11 can be further improved.

[0062] In the foregoing, although the shaft holding sleeve, the shaft diameter enlarging apparatus and the jig for the shaft diameter enlarging apparatus of the present invention has been described, as an example, with respect to the shaft diameter enlarging apparatus 10 for performing the shaft diameter enlarging method shown in Figs. 1A to 1E, shaft diameter enlarging apparatuses for performing the shaft diameter enlarging methods respectively shown in Figs. 2A to 5B are only different in a holder unit or an operating manner of the spindle for exerting an alternating load on the intermediate portion of the shaft stock, and thus the configurations of the shaft holding sleeve and the jig for the shaft diameter enlarging apparatus as described above can be also applied to such shaft diameter enlarging apparatuses.

[0063] Next, Examples of the shaft holding sleeve 11 (or the inner sleeve 30B of the shaft holding sleeve 11) and life evaluations thereof will be described.

[0064] Regarding Example 1, semi-high speed steel was used as the base material, and surface hardening treatment was omitted. As for Example 2, semi-high speed steel was used as the base material and nitriding was performed as surface hardening treatment. As for Example 3, SKH51 (high speed steel) was used as the base material, and as surface hardening treatment, a VC (vanadium carbide) coating was formed by TD Process (trademark), a type of salt bath immersion method. Base material hardnesses and surface properties of the sleeves of Examples 1 to 3 are shown in Table 1.

Table 1

	Example 1	Example 2	Example 3
Base material	Semi-high speed steel	Semi-high speed steel	SKH51
Base material hardness	HRC 60-64	HRC 60-64	HRC 60-64
Surface hardening	No	Nitriding	VC coating formin by TD Process
Surface hardness		HV1250	HV3000 or more
Galling life	0	11	396

[0065] With respect to each of the sleeves of Examples 1 to 3, shaft diameter enlarging process was repeatedly performed under the same conditions by the shaft diameter enlarging apparatus 10 described above, and then the number of shaft stocks processed until a visible galling (adhesion wear) occurred was evaluated as a life. The evaluation results are shown in Table 1. From the evaluation results shown in Table 1, it can be found that wearing of the sleeves due to contact with shaft stocks can be suppressed by performing the surface hardening treatment. In addition, by suppressing wearing of the shaft holding sleeve 11, a frequency of exchanging the sleeves can be lowered, thereby improving the shaft diameter enlarging work.

[0066] According to one or more embodiments of the present invention, a shaft holding sleeve 11 is inserted in a fitting hole 20 of a compressing machine 12a, 12b, 17 that applies an axial compression stress to a shaft stock W to hold an end portion of the shaft stock W during a shaft diameter enlarging process for radially enlarging a portion of the shaft stock W. The shaft holding sleeve 11 includes a front end surface to be inserted in the fitting hole 20, an exposed portion 33 to be exposed to an outside of the fitting hole 20, and at least one air communication passage 36, 37 extending from the front end surface to a surface of the exposed portion 33.

[0067] The air communication passage 36, 37 may include a groove 36 formed on an outer peripheral surface of the shaft holding sleeve 11.

[0068] The air communication passage 36, 37 may include a through hole 37 extending from the front end surface to an opposite end surface of the shaft holding sleeve 11.

[0069] The shaft holding sleeve 11 may further include an attaching portion 39 provided on an outer peripheral surface of the shaft holding sleeve 11, the attaching portion 39 being configured such that a lifting lug 38 is attachable and detachable with respect to the attaching portion 39.

[0070] The shaft holding sleeve 11 may further include a grip portion 41 provided on the exposed portion 33.

[0071] The shaft holding sleeve 11 may further include a surface-hardened portion 30a at least at an opening portion of the shaft holding sleeve 11 from which the end portion of the shaft stock W is inserted into the shaft holding sleeve 11.

[0072] A Vickers hardness of the surface-hardened portion 30a may be equal to or greater than HV1200.

[0073] According to one or more embodiments of the present invention, a shaft diameter enlarging apparatus 10

includes a pair of shaft holding sleeves 11 described above to hold respective end portions of a shaft stock, a compressing machine 12a, 12b, 17 having fitting holes 20 into which the pair of shaft holding sleeves 11 are inserted respectively, the compressing machine 12a, 12b, 17 being configured to compress the shaft stock W having the respective end portions held by the pair of shaft holding sleeves 11 in an axial direction of the shaft stock W, and a load generation device 18, 19 configured to apply, to an intermediate portion of the shaft stock W having the respective end portions held by the pair of shaft holding sleeves 11, an alternating load in a direction intersecting the axial direction.

[0074] According to one or more embodiments of the present invention, a jig 50, 60 for use with the shaft diameter enlarging apparatus 10 described above is provided. The jig 50, 60 includes a mounting surface on which the shaft holding sleeve 11 is mounted when inserting the shaft holding sleeve 11 into the fitting hole 20. In a state in which the jig 50, 60 is attached to an opening edge portion of the fitting hole 20, the mounting surface is flush with an inner peripheral surface of the fitting hole 20.

[0075] According to one or more embodiments of the present invention, a shaft holding sleeve 11 is configured to hold an end portion W of a shaft stock during a shaft diameter enlarging process for radially enlarging a portion of the shaft stock W. The shaft holding sleeve 11 includes a cylindrical outer sleeve 30A adapted to be fixed to a compressing machine 12a, 12b, 17 that applies an axial compression stress to the shaft stock W, and an inner sleeve 30B provided inside the outer sleeve. The inner sleeve 30B is configured to accommodate the end portion of the shaft stock W and is arranged to contact the radially enlarged portion of the shaft stock W. The outer sleeve and the inner sleeve are provide with an engaging structure 70, 71 configured to prevent a relative movement of the inner sleeve 30B with respect to the outer sleeve 30A in a direction opposite to a compression direction in which the shaft stock W is compressed.

[0076] The engaging structure 70, 71 may be provided on an inner peripheral surface of the outer sleeve 30A and on an outer peripheral surface of the inner sleeve 30B.

[0077] The engaging structure 70, 71 may include an annular concave-convex portion.

[0078] Each concave portion and convex portion of the engaging structure 70, 71 may be configured in a saw-tooth shape extending away from a center axis A of the outer sleeve 30A and the inner sleeve 30B in the direction opposite to the compression direction.

[0079] The inner peripheral surface of the outer sleeve and the outer peripheral surface of the inner sleeve may be formed in a tapered shape extending away from the center axis A of the outer sleeve 30A and the inner sleeve 30B in the direction opposite to the compression direction.

[0080] A depth of each concave portion and a height of each convex portion of the engaging structure 70, 71 may be equal to or greater than 50 μm and equal to or smaller than 1% of an outer diameter of the inner sleeve 30B.

[0081] The shaft holding sleeve 11 may further include a surface-hardened portion 30a at least at an opening portion of the inner sleeve 30B from which the end portion of the shaft stock W is inserted into the shaft holding sleeve 11.

[0082] A Vickers hardness of the surface-hardened portion 30a may be equal to or greater than HV1200.

Claims

1. A shaft holding sleeve (11) to be inserted in a fitting hole (20) of a compressing machine (12a, 12b, 17) that applies an axial compression stress to a shaft stock (W) to hold an end portion of the shaft stock (W) during a shaft diameter enlarging process for radially enlarging a portion of the shaft stock (W), the shaft holding sleeve (11) comprising:

a front end surface to be inserted in the fitting hole (20);

an opening portion from which the end portion of the shaft stock (W) is to be inserted into the shaft holding sleeve (11);

an exposed portion (33) to be exposed, in use, to an outside of the fitting hole (20); **characterized in that it** comprises furthermore

at least one air communication passage (36, 37) extending from the front end surface to a surface of the exposed portion (33), wherein the at least one air communication passage (36, 37) comprises a groove (36) formed on an outer peripheral surface of the shaft holding sleeve (11).

2. A shaft holding sleeve (11) to be inserted in a fitting hole (20) of a compressing machine (12a, 12b, 17) that applies an axial compression stress to a shaft stock (W) to hold an end portion of the shaft stock (W) during a shaft diameter enlarging process for radially enlarging a portion of the shaft stock (W), the shaft holding sleeve (11) comprising:

a front end surface to be inserted in the fitting hole (20);

an opening portion from which the end portion of the shaft stock (W) is to be inserted into the shaft holding sleeve (11);

an exposed portion (33) to be exposed, in use, to an outside of the fitting hole (20); **characterized in that it**

comprises furthermore

at least one air communication passage (36, 37) extending from the front end surface to a surface of the exposed portion (33), wherein the at least one air communication passage (36, 37) comprises a through hole (37) extending from the front end surface to an opposite end surface of the shaft holding sleeve (11).

3. The shaft holding sleeve (11) according to claim 1 or 2, comprising an attaching portion (39) provided on an outer peripheral surface of the shaft holding sleeve (11), the attaching portion (39) being configured such that a lifting lug (38) is attachable and detachable with respect to the attaching portion (39).

4. The shaft holding sleeve (11) according to any one of claims 1 to 3, comprising a grip portion (41) provided on the exposed portion (33).

5. The shaft holding sleeve (11) according to any one of claims 1 to 4, comprising a surface-hardened portion (30a) at least at the opening portion of the shaft holding sleeve (11) from which the end portion of the shaft stock (W) is inserted into the shaft holding sleeve (11).

6. The shaft holding sleeve (11) according to claim 1 or 2, comprising:

a cylindrical outer sleeve (30A) adapted to be fixed to the compressing machine (12a, 12b, 17); and an inner sleeve (30B) provided inside the outer sleeve (30A), the inner sleeve (30B) being configured to accommodate the end portion of the shaft stock (W) and arranged to contact a radially enlarged portion of the shaft stock (W),

wherein the outer sleeve (30A) and the inner sleeve (30B) are provide with an engaging structure (70, 71) configured to prevent a relative movement of the inner sleeve (30B) with respect to the outer sleeve (30A) in a direction opposite to a compression direction in which the shaft stock (W) is compressed.

7. The shaft holding sleeve (11) according to claim 6, wherein the engaging structure (70, 71) is provided on an inner peripheral surface of the outer sleeve (30A) and on an outer peripheral surface of the inner sleeve (30B).

8. The shaft holding sleeve (11) according to claim 7, wherein the engaging structure (70, 71) comprises an annular concave-convex portion.

9. The shaft holding sleeve (11) according to claim 8, wherein each concave portion and convex portion of the engaging structure (70, 71) are configured in a saw-tooth shape extending away from a center axis (A) of the outer sleeve (30A) and the inner sleeve (30B) in the direction opposite to the compression direction, wherein preferably the inner peripheral surface of the outer sleeve (30A) and the outer peripheral surface of the inner sleeve (30B) are formed in a tapered shape extending away from the center axis (A) of the outer sleeve (30A) and the inner sleeve (30B) in the direction opposite to the compression direction.

10. The shaft holding sleeve (11) according to any one of claims 8 to 9, wherein a depth of each concave portion and a height of each convex portion of the engaging structure (70, 71) are equal to or greater than 50 μm and equal to or smaller than 1% of an outer diameter of the inner sleeve (30B).

11. The shaft holding sleeve (11) according to any one of claims 6 to 10, comprising a surface-hardened portion (30a) at least at the opening portion of the inner sleeve (30B) from which the end portion of the shaft stock (W) is inserted into the shaft holding sleeve (11).

12. The shaft holding sleeve (11) according to claim 5 or 11, wherein a Vickers hardness of the surface-hardened portion (30a) is equal to or greater than HV1200.

13. A shaft diameter enlarging apparatus (10) comprising:

a pair of shaft holding sleeves (11) according to any one of claims 1 to 12 to hold respective end portions of a shaft stock;

a compressing machine (12a, 12b, 17) having fitting holes (20) into which the pair of shaft holding sleeves (11) are inserted respectively, the compressing machine (12a, 12b, 17) being configured to compress the shaft stock (W) having the respective end portions held by the pair of shaft holding sleeves (11) in an axial direction of the shaft stock (W); and

a load generation device (12a, 12b, 18, 19) configured to apply, to an intermediate portion of the shaft stock (W) having the respective end portions held by the pair of shaft holding sleeves (11), an alternating load in a direction intersecting the axial direction.

14. A combination of a jig (50, 60) and the shaft diameter enlarging apparatus (10) according to claim 13, the jig (50, 60) comprising a mounting surface on which the shaft holding sleeve (11) is mounted when inserting the shaft holding sleeve (11) into the fitting hole (20), wherein, in a state in which the jig (50, 60) is attached to an opening edge portion of the fitting hole (20), the mounting surface is flush with an inner peripheral surface of the fitting hole (20).

Patentansprüche

1. Schaftaufnahmehülse (11), die in eine Passöffnung (20) einer Kompressionsmaschine (12a, 12b, 17) eingesetzt werden soll, die eine axiale Kompressionsbelastung an einen Schaftkörper (W) anlegt, um einen Endabschnitt des Schaftkörpers (W) während eines Schaftdurchmesserergrößerungsprozesses zu halten, um einen Abschnitt des Schaftkörpers (W) radial zu vergrößern, wobei die Schaftaufnahmehülse (11) umfasst:

eine vordere Endfläche, die in die Passöffnung (20) eingesetzt werden soll;
einen Öffnungsabschnitt, von dem aus der Endabschnitt des Schaftkörpers (W) in die Schaftaufnahmehülse (11) eingesetzt werden soll;
einen freiliegenden Abschnitt (33), der im Gebrauch außerhalb der Passöffnung (20) freiliegen soll;
dadurch gekennzeichnet, dass sie darüber hinaus umfasst:
mindestens einen Luftverbindungsdurchgang (36, 37), der sich von der vorderen Endfläche zu einer Fläche des freiliegenden Abschnitts (33) erstreckt, wobei der mindestens eine Luftverbindungsdurchgang (36, 37) eine Nut (36) umfasst, die an einer Außenumfangsfläche der Schaftaufnahmehülse (11) ausgebildet ist.

2. Schaftaufnahmehülse (11), die in eine Passöffnung (20) einer Kompressionsmaschine (12a, 12b, 17) eingesetzt werden soll, die eine axiale Kompressionsbelastung an einen Schaftkörper (W) anlegt, um einen Endabschnitt des Schaftkörpers (W) während eines Schaftdurchmesserergrößerungsprozesses zu halten, um einen Abschnitt des Schaftkörpers (W) radial zu vergrößern, wobei die Schaftaufnahmehülse (11) umfasst:

eine vordere Endfläche, die in die Passöffnung (20) eingesetzt werden soll;
einen Öffnungsabschnitt, von dem aus der Endabschnitt des Schaftkörpers (W) in die Schaftaufnahmehülse (11) eingesetzt werden soll;
einen freiliegenden Abschnitt (33), der im Gebrauch außerhalb der Passöffnung (20) freiliegen soll;
dadurch gekennzeichnet, dass sie darüber hinaus umfasst:
mindestens einen Luftverbindungsdurchgang (36, 37), der sich von der vorderen Endfläche zu einer Fläche des freiliegenden Abschnitts (33) erstreckt, wobei der mindestens eine Luftverbindungsdurchgang (36, 37) eine Durchgangsöffnung (37) umfasst, die sich von der vorderen Endfläche zu einer entgegengesetzten Endfläche der Schaftaufnahmehülse (11) erstreckt.

3. Schaftaufnahmehülse (11) nach Anspruch 1 oder 2, einen Befestigungsabschnitt (39) umfassend, der an einer Außenumfangsfläche der Schaftaufnahmehülse (11) vorgesehen ist, wobei der Befestigungsabschnitt (39) so ausgelegt ist, dass eine Hebeöse (38) bezüglich des Befestigungsabschnitts (39) anbringbar und lösbar ist.

4. Schaftaufnahmehülse (11) nach einem der Ansprüche 1 bis 3, ein Griffstück (41) umfassend, das am freiliegenden Abschnitt (33) vorgesehen ist.

5. Schaftaufnahmehülse (11) nach einem der Ansprüche 1 bis 4, einen oberflächengehärteten Abschnitt (30a) zumindest am Öffnungsabschnitt der Schaftaufnahmehülse (11) umfassend, von dem aus der Endabschnitt des Schaftkörpers (W) in die Schaftaufnahmehülse (11) eingesetzt wird.

6. Schaftaufnahmehülse (11) nach Anspruch 1 oder 2, umfassend:

eine zylindrische Außenhülse (30A), die dazu angepasst ist, an der Kompressionsmaschine (12a, 12b, 17) befestigt zu werden; und
eine Innenhülse (30B), die im Inneren der Außenhülse (30A) vorgesehen ist, wobei die Innenhülse (30B) dazu

ausgelegt ist, den Endabschnitt des Schaftkörpers (W) aufzunehmen, und dazu eingerichtet ist, einen radial vergrößerten Abschnitt des Schaftkörpers (W) zu berühren,
wobei die Außenhülse (30A) und die Innenhülse (30B) mit einer Eingriffsstruktur (70, 71) versehen sind, die dazu ausgelegt ist, eine relative Bewegung der Innenhülse (30B) bezüglich der Außenhülse (30A) in einer zur Kompressionsrichtung, in welcher der Schaftkörper (W) komprimiert wird, entgegengesetzten Richtung zu verhindern.

7. Schaftaufnahmehülse (11) nach Anspruch 6, wobei die Eingriffsstruktur (70, 71) an einer Innenumfangsfläche der Außenhülse (30A) und an einer Außenumfangsfläche der Innenhülse (30B) vorgesehen ist.

8. Schaftaufnahmehülse (11) nach Anspruch 7, wobei die Eingriffsstruktur (70, 71) einen ringförmigen konkav-konvexen Abschnitt umfasst.

9. Schaftaufnahmehülse (11) nach Anspruch 8, wobei jeder konkave Abschnitt und konvexe Abschnitt der Eingriffsstruktur (70, 71) in einer Sägezahnform ausgebildet ist, die sich von einer Mittelachse (A) der Außenhülse (30A) und der Innenhülse (30B) weg in der zur Kompressionsrichtung entgegengesetzten Richtung erstreckt, wobei vorzugsweise die Innenumfangsfläche der Außenhülse (30A) und die Außenumfangsfläche der Innenhülse (30B) in einer sich verjüngenden Form ausgebildet sind, die sich von der Mittelachse (A) der Außenhülse (30A) und der Innenhülse (30B) weg in der zur Kompressionsrichtung entgegengesetzten Richtung erstreckt.

10. Schaftaufnahmehülse (11) nach einem der Ansprüche 8 bis 9, wobei eine Tiefe jedes konkaven Abschnitts und eine Höhe jedes konvexen Abschnitts der Eingriffsstruktur (70, 71) gleich oder größer als 50 μm und gleich oder kleiner als 1 % eines Außendurchmessers der Innenhülse (30B) sind.

11. Schaftaufnahmehülse (11) nach einem der Ansprüche 6 bis 10, einen oberflächengehärteten Abschnitt (30a) zumindest am Öffnungsabschnitt der Innenhülse (30B) umfassend, von dem aus der Endabschnitt des Schaftkörpers (W) in die Schaftaufnahmehülse (11) eingesetzt wird.

12. Schaftaufnahmehülse (11) nach Anspruch 5 oder 11, wobei eine Vickers-Härte des oberflächengehärteten Abschnitts (30a) gleich oder größer als HV 1200 ist.

13. Schaftdurchmesserergrößerungsvorrichtung (10), umfassend:

ein Paar von Schaftaufnahmehülsen (11) nach einem der Ansprüche 1 bis 12, um jeweilige Endabschnitte eines Schaftkörpers zu halten;

eine Kompressionsmaschine (12a, 12b, 17) mit Passöffnungen (20), in die das Paar der Schaftaufnahmehülsen (11) jeweils eingesetzt sind, wobei die Kompressionsmaschine (12a, 12b, 17) dazu ausgelegt ist, den Schaftkörper (W) mit den jeweiligen Endabschnitten, die durch das Paar der Schaftaufnahmehülsen (11) gehalten werden, in einer axialen Richtung des Schaftkörpers (W) zu komprimieren; und

eine Lasterzeugungsanordnung (12a, 12b, 18, 19), die dazu ausgelegt ist, an einen Zwischenabschnitt des Schaftkörpers (W) mit den jeweiligen durch das Paar der Schaftaufnahmehülsen (11) gehaltenen Endabschnitten, eine Wechsellast in einer die axiale Richtung schneidenden Richtung anzulegen.

14. Kombination aus einer Einspannvorrichtung (50, 60) und einer Schaftdurchmesserergrößerungsvorrichtung (10) nach Anspruch 13, wobei die Einspannvorrichtung (50, 60) eine Anbringungsfläche umfasst, auf der die Schaftaufnahmehülse (11) angebracht wird, wenn die Schaftaufnahmehülse (11) in die Passöffnung (20) eingesetzt wird, wobei in einem Zustand, in dem die Einspannvorrichtung (50, 60) an einem Öffnungsrandabschnitt der Passöffnung (20) befestigt ist, die Anbringungsfläche mit einer Innenumfangsfläche der Passöffnung (20) bündig ist.

Revendications

1. Manchon de maintien d'arbre (11) destiné à être inséré dans un trou d'ajustement (20) d'une machine de compression (12a, 12b, 17) qui applique un effort de compression axial à un fût d'arbre (W) pour maintenir une partie d'extrémité du fût d'arbre (W) pendant un processus d'agrandissement de diamètre d'arbre destiné à agrandir radialement une partie du fût d'arbre (W), le manchon de maintien d'arbre (11) comprenant :

une surface d'extrémité avant destinée à être insérée dans le trou d'ajustement (20) ;

une partie ouverture depuis laquelle la partie d'extrémité du fût d'arbre (W) est destinée à être insérée dans le manchon de maintien d'arbre (11) ;

une partie exposée (33) destinée à être exposée, en utilisation, à un extérieur du trou d'ajustement (20) ;

caractérisé en ce qu'il comprend en outre

au moins un passage de communication d'air (36, 37) s'étendant depuis la surface d'extrémité avant à une surface de la partie exposée (33), sachant que l'au moins un passage de communication d'air (36, 37) comprend une rainure (36) formée sur une surface périphérique extérieure du manchon de maintien d'arbre (11).

2. Manchon de maintien d'arbre (11) destiné à être inséré dans un trou d'ajustement (20) d'une machine de compression (12a, 12b, 17) qui applique un effort de compression axial à un fût d'arbre (W) pour maintenir une partie d'extrémité du fût d'arbre (W) pendant un processus d'agrandissement de diamètre d'arbre destiné à agrandir radialement une partie du fût d'arbre (W), le manchon de maintien d'arbre (11) comprenant :

une surface d'extrémité avant destinée à être insérée dans le trou d'ajustement (20) ;

une partie ouverture depuis laquelle la partie d'extrémité du fût d'arbre (W) est destinée à être insérée dans le manchon de maintien d'arbre (11) ;

une partie exposée (33) destinée à être exposée, en utilisation, à un extérieur du trou d'ajustement (20) ;

caractérisé en ce qu'il comprend en outre

au moins un passage de communication d'air (36, 37) s'étendant depuis la surface d'extrémité avant à une surface de la partie exposée (33), sachant que l'au moins un passage de communication d'air (36, 37) comprend un trou traversant (37) s'étendant depuis la surface d'extrémité avant à une surface d'extrémité opposée du manchon de maintien d'arbre (11).

3. Le manchon de maintien d'arbre (11) selon la revendication 1 ou 2, comprenant une partie de fixation (39) disposée sur une surface périphérique extérieure du manchon de maintien d'arbre (11), la partie de fixation (39) étant configurée de sorte qu'une patte de levage (38) puisse être attachée et détachée par rapport à la partie de fixation (39).

4. Le manchon de maintien d'arbre (11) selon l'une quelconque des revendications 1 à 3, comprenant une partie poignée (41) disposée sur la partie exposée (33).

5. Le manchon de maintien d'arbre (11) selon l'une quelconque des revendications 1 à 4, comprenant une partie à surface trempée (30a) au moins au niveau de la partie ouverture du manchon de maintien d'arbre (11) depuis laquelle la partie d'extrémité du fût d'arbre (W) est insérée dans le manchon de maintien d'arbre (11).

6. Le manchon de maintien d'arbre (11) selon la revendication 1 ou 2, comprenant :

un manchon extérieur cylindrique (30A) apte à être fixé à la machine de compression (12a, 12b, 17) ; et

un manchon intérieur (30B) disposé à l'intérieur du manchon extérieur (30A), le manchon intérieur (30B) étant configuré pour loger la partie d'extrémité du fût d'arbre (W) et agencé pour entrer en contact avec une partie radialement agrandie du fût d'arbre (W),

sachant que le manchon extérieur (30A) et le manchon intérieur (30B) sont pourvus d'une structure de mise en prise (70, 71) configurée pour empêcher un mouvement relatif du manchon intérieur (30B) par rapport au manchon extérieur (30A) dans une direction opposée à une direction de compression dans laquelle le fût d'arbre (W) est comprimé.

7. Le manchon de maintien d'arbre (11) selon la revendication 6, sachant que la structure de mise en prise (70, 71) est disposée sur une surface périphérique intérieure du manchon extérieur (30A) et sur une surface périphérique extérieure du manchon intérieur (30B).

8. Le manchon de maintien d'arbre (11) selon la revendication 7, sachant que la structure de mise en prise (70, 71) comprend une partie concave-convexe annulaire.

9. Le manchon de maintien d'arbre (11) selon la revendication 8, sachant que chaque partie concave et chaque partie convexe de la structure de mise en prise (70, 71) sont configurées en forme de dents de scie s'étendant en s'éloignant d'un axe médian (A) du manchon extérieur (30A) et du manchon intérieur (30B) dans la direction opposée à la direction de compression,

sachant que de préférence la surface périphérique intérieure du manchon extérieur (30A) et la surface périphérique extérieure du manchon intérieur (30B) sont formées en forme conique s'étendant en s'éloignant de l'axe médian

(A) du manchon extérieur (30A) et du manchon intérieur (30B) dans la direction opposée à la direction de compression.

- 5 10. Le manchon de maintien d'arbre (11) selon l'une quelconque des revendications 8 à 9, sachant qu'une profondeur de chaque partie concave et une hauteur de chaque partie convexe de la structure de mise en prise (70, 71) sont égales ou supérieures à 50 μm et égales ou inférieures à 1 % d'un diamètre extérieur du manchon intérieur (30B).
- 10 11. Le manchon de maintien d'arbre (11) selon l'une quelconque des revendications 6 à 10, comprenant une partie à surface trempée (30a) au moins au niveau de la partie ouverture du manchon intérieur (30B) depuis laquelle la partie d'extrémité du fût d'arbre (W) est insérée dans le manchon de maintien d'arbre (11).
12. Le manchon de maintien d'arbre (11) selon la revendication 5 ou 11, sachant qu'une dureté de Vickers de la partie à surface trempée (30a) est égale ou supérieure à HV1200.
- 15 13. Appareil d'agrandissement de diamètre d'arbre (10) comprenant :

une paire de manchons de maintien d'arbre (11) selon l'une quelconque des revendications 1 à 12 pour maintenir des parties d'extrémité respectives d'un fût d'arbre ;
une machine de compression (12a, 12b, 17) présentant des trous d'ajustement (20) dans lesquels la paire de
20 manchons de maintien d'arbre (11) sont insérés respectivement, la machine de compression (12a, 12b, 17) étant configurée pour comprimer le fût d'arbre (W) dont les parties d'extrémité respectives sont maintenues par la paire de manchons de maintien d'arbre (11) dans une direction axiale du fût d'arbre (W) ; et
un dispositif de génération de charge (12a, 12b, 18, 19) configuré pour appliquer à une partie intermédiaire du fût d'arbre (W) dont les parties d'extrémité sont maintenues par la paire de manchons de maintien d'arbre (11)
25 une charge alternante dans une direction croisant la direction axiale.
14. Combinaison d'un gabarit (50, 60) et de l'appareil d'agrandissement de diamètre d'arbre (10) selon la revendication 13, le gabarit (50, 60) comprenant une surface de montage sur laquelle le manchon de maintien d'arbre (11) est monté lors de l'insertion du manchon de maintien d'arbre (11) dans le trou d'ajustement (20),
30 sachant que, dans un état dans lequel le gabarit (50, 60) est attaché à une partie bord d'ouverture du trou d'ajustement (20), la surface de montage est de niveau avec une surface périphérique intérieure du trou d'ajustement (20).

FIG. 1A

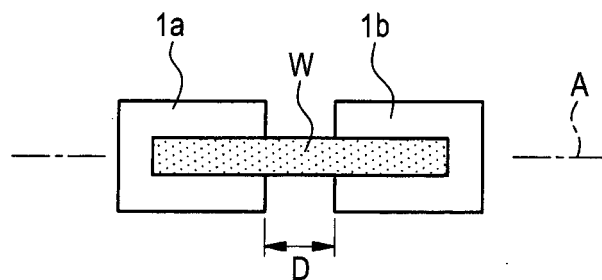


FIG. 1B

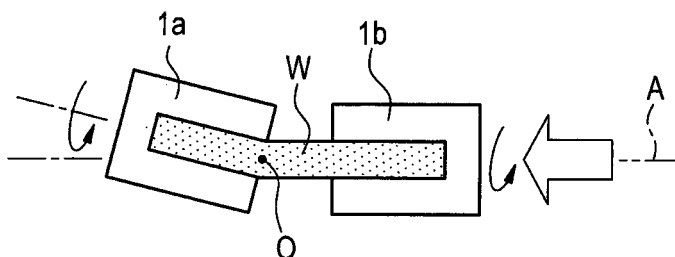


FIG. 1C

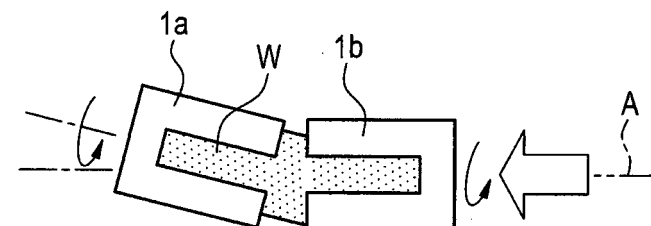


FIG. 1D

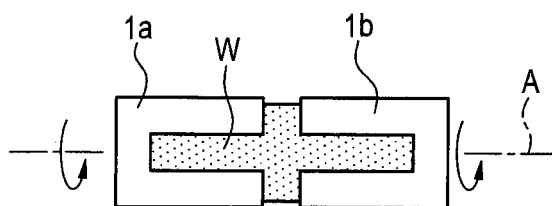


FIG. 1E

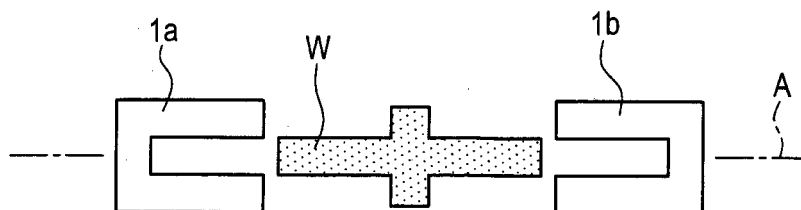


FIG. 2A

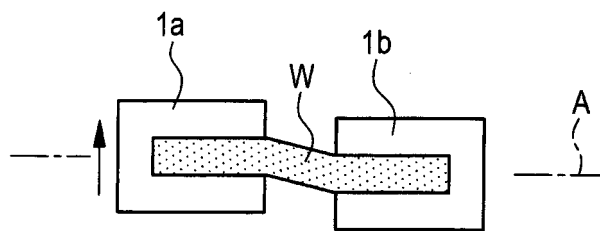


FIG. 2B

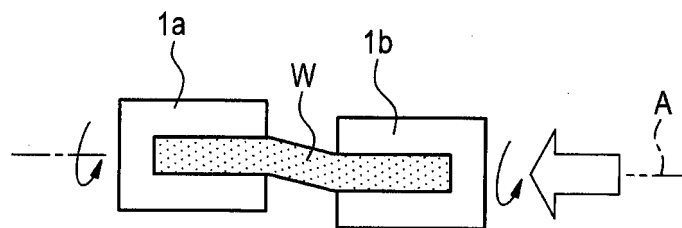


FIG. 2C

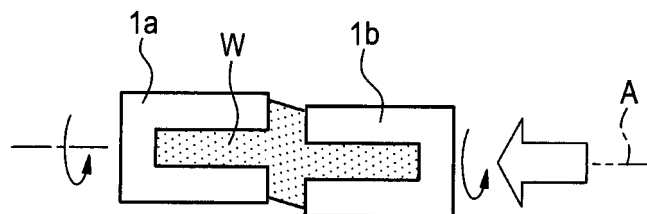


FIG. 3A

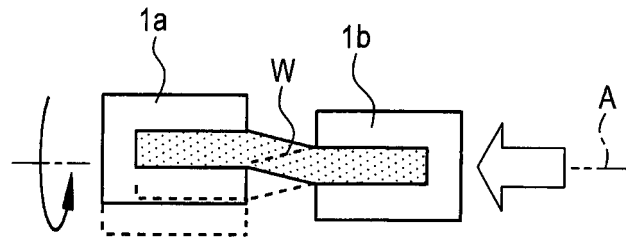


FIG. 3B

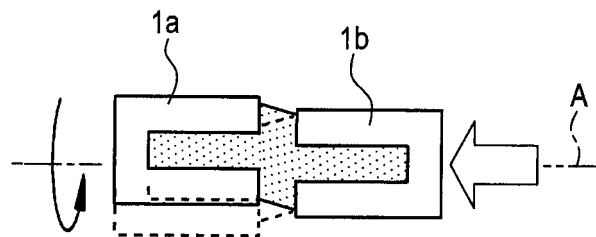


FIG. 4A

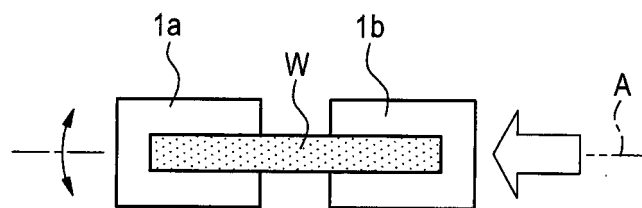


FIG. 4B

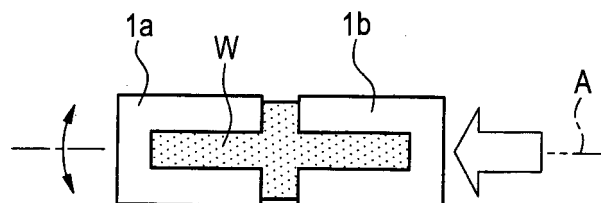


FIG. 5A

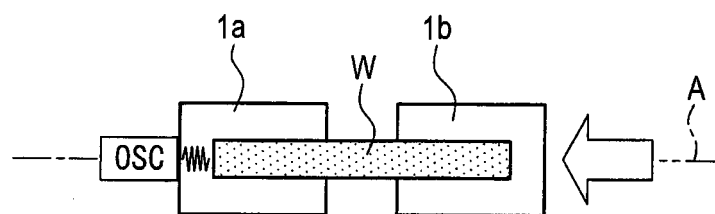


FIG. 5B

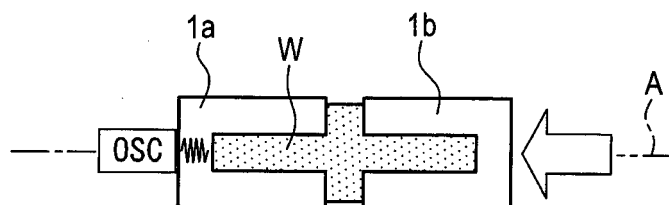


FIG. 6

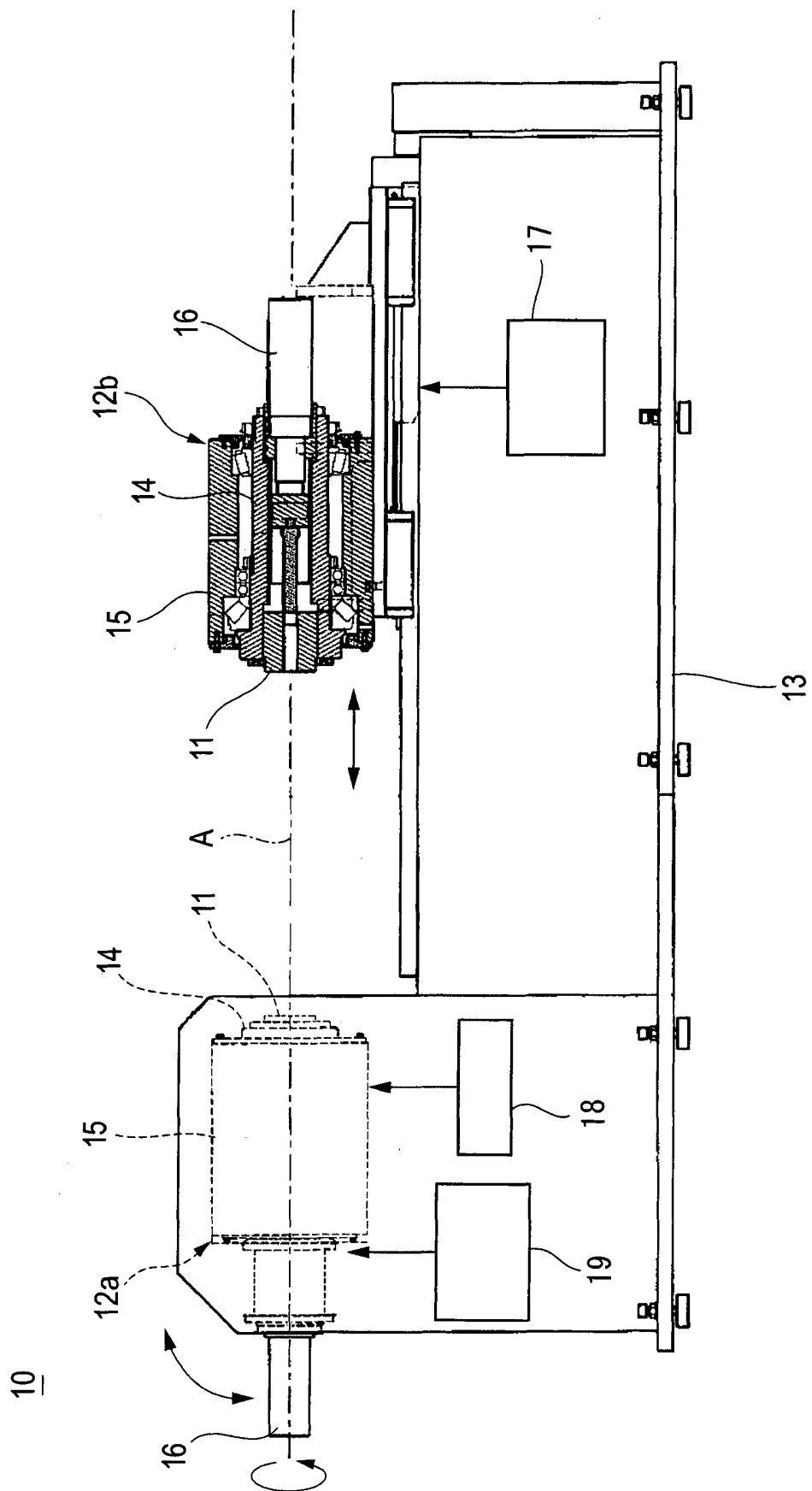


FIG. 7

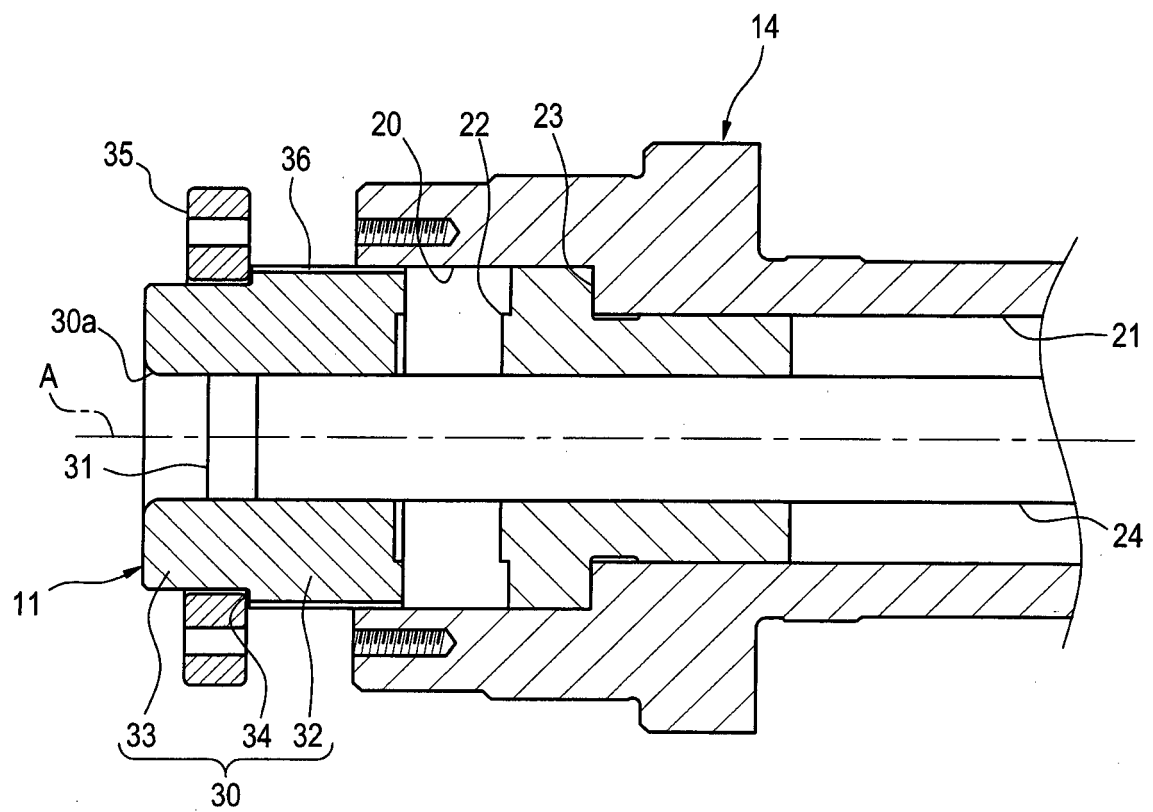


FIG. 8

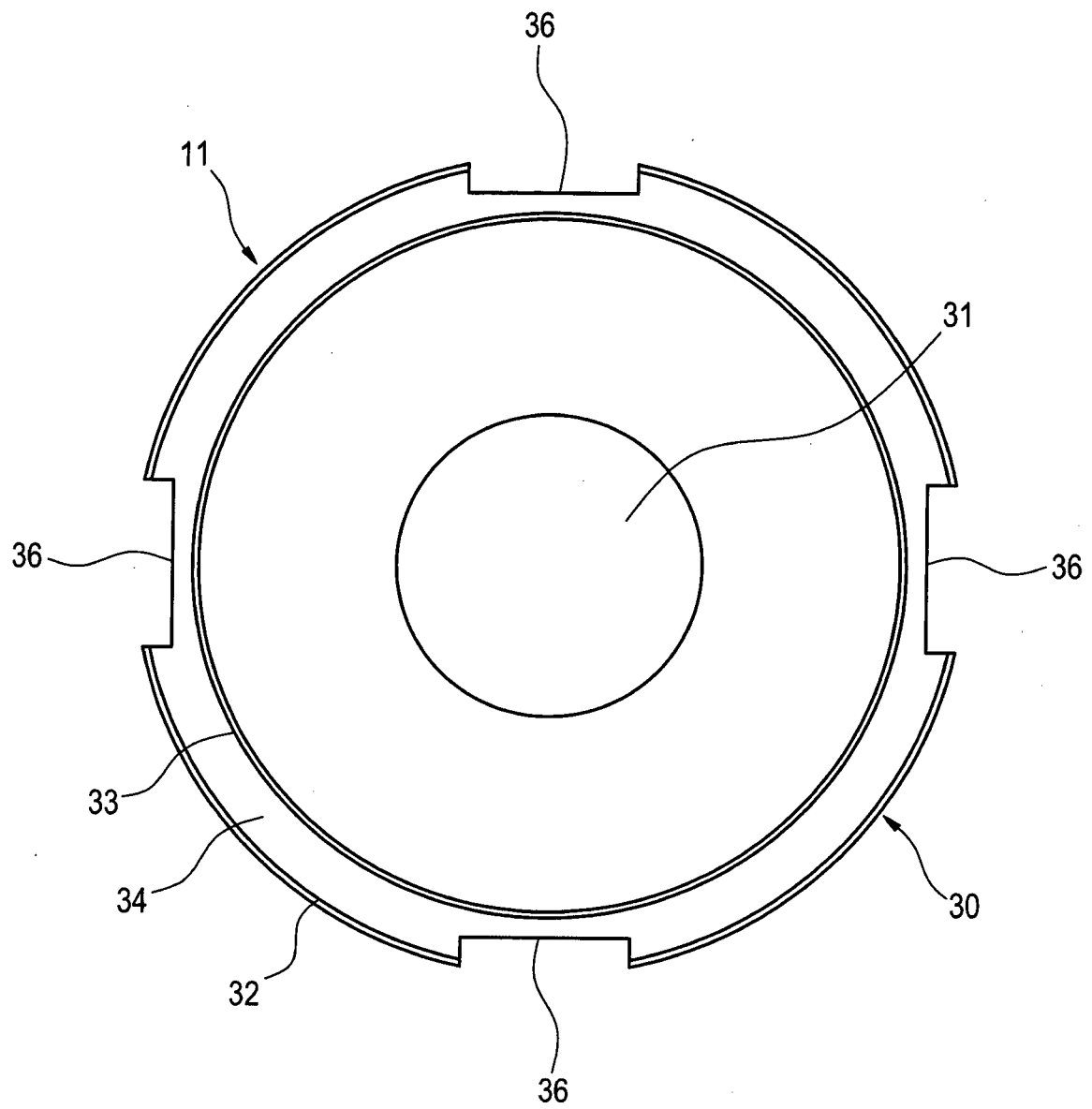


FIG. 9

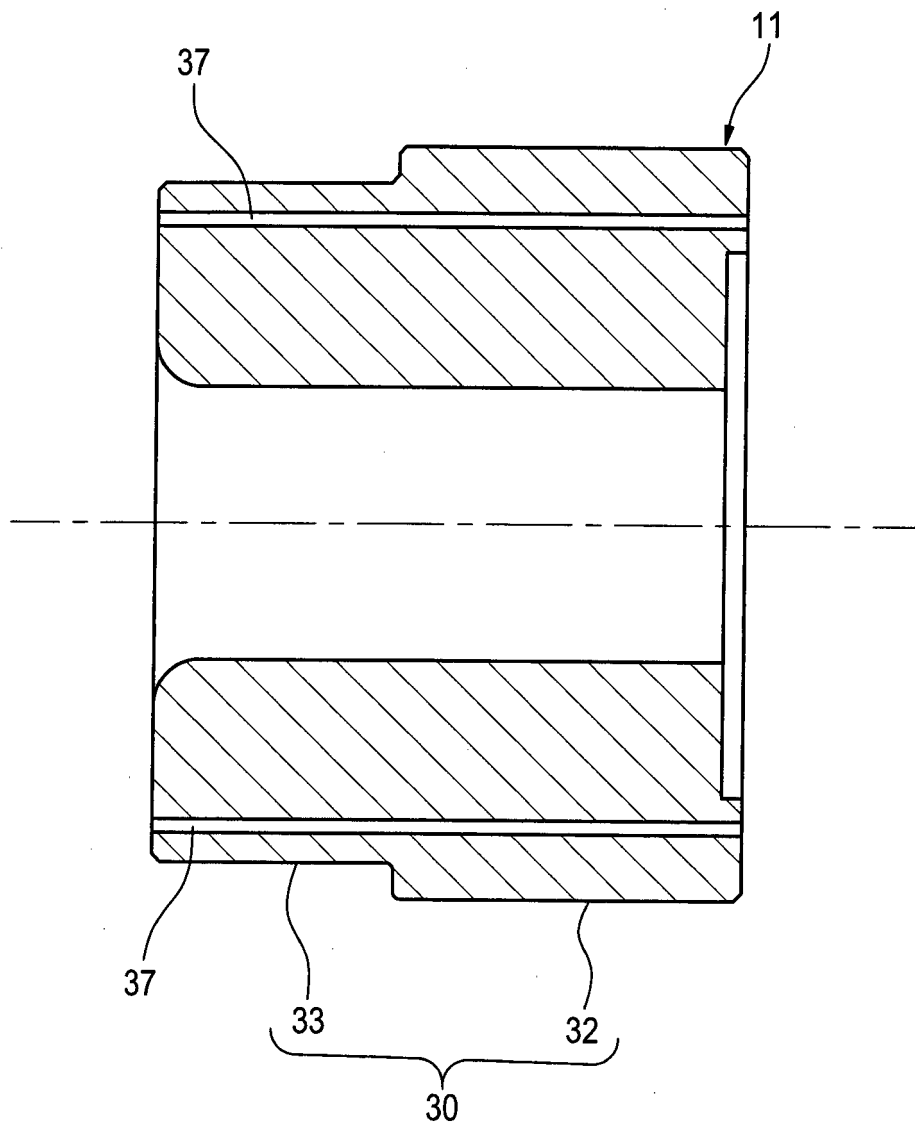


FIG. 10

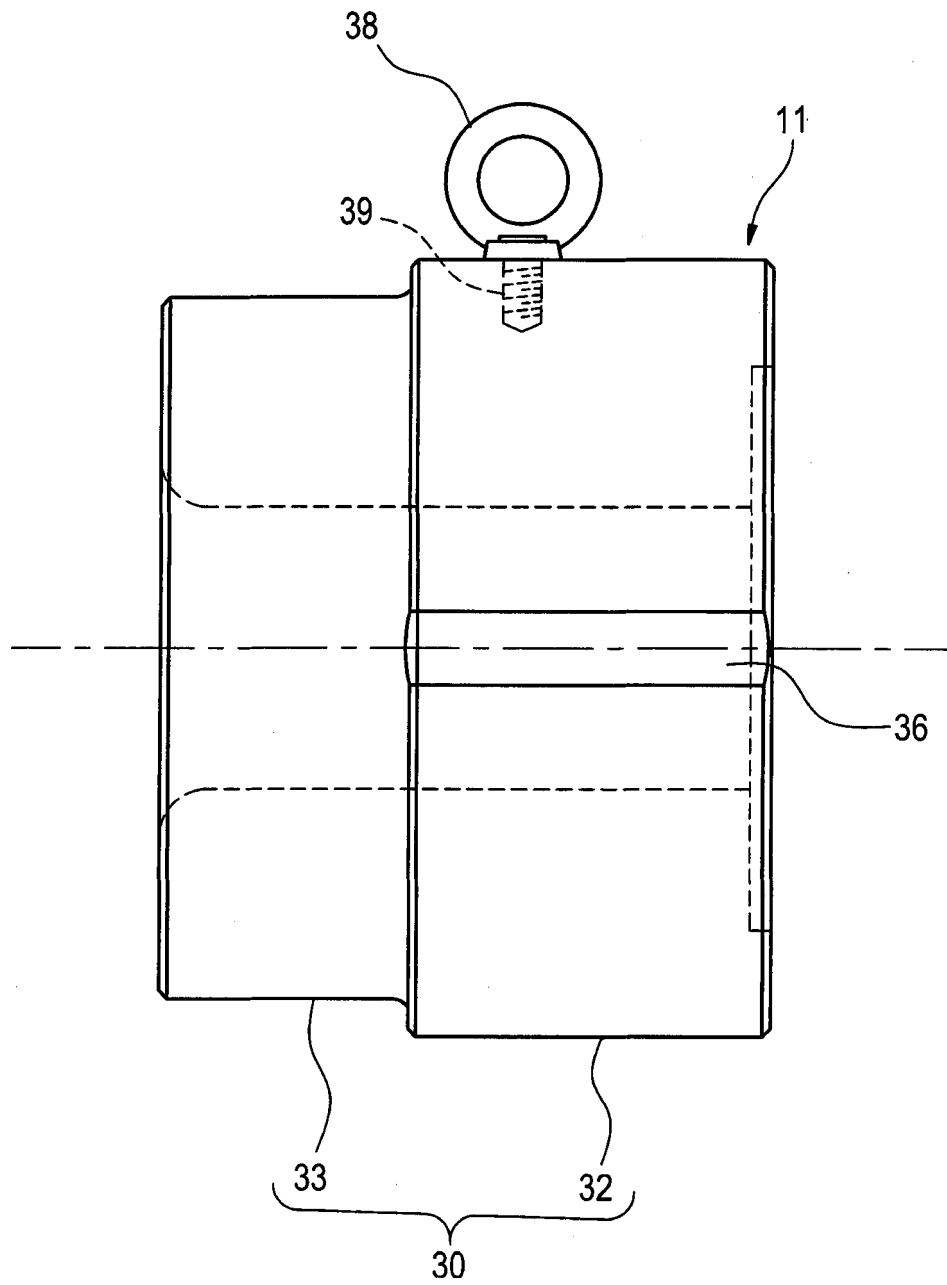


FIG. 11

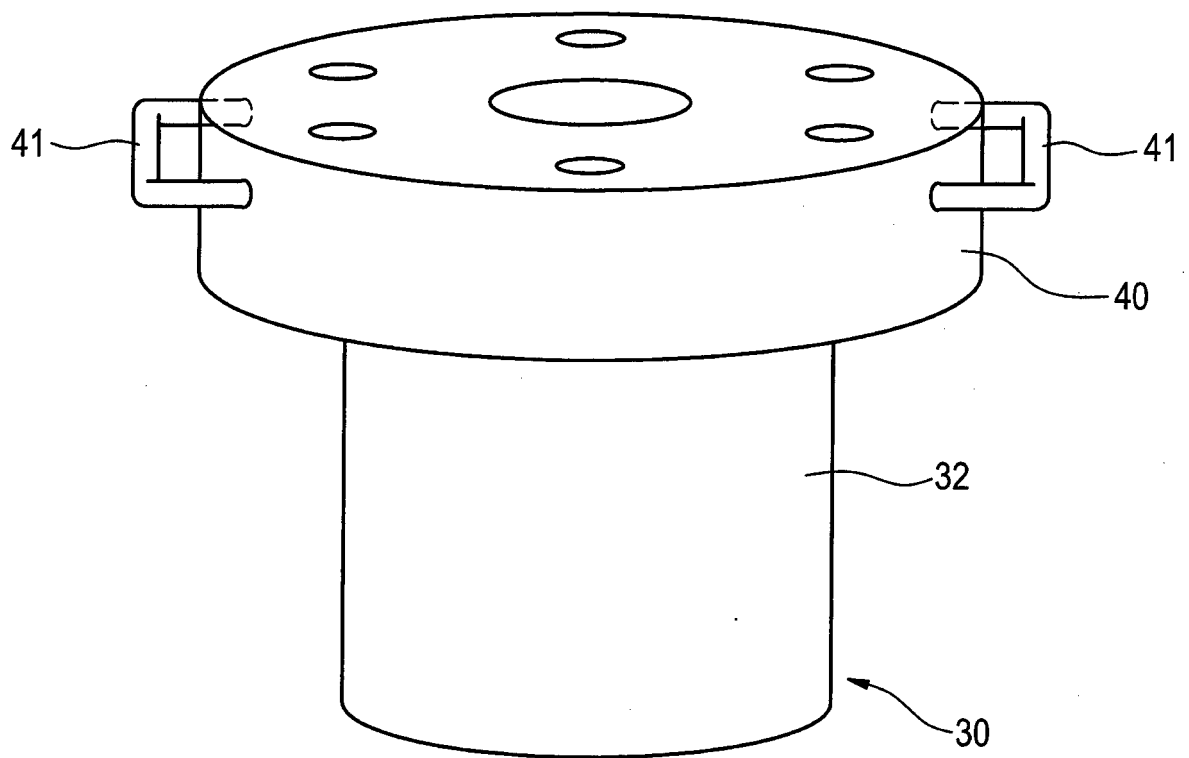


FIG. 12

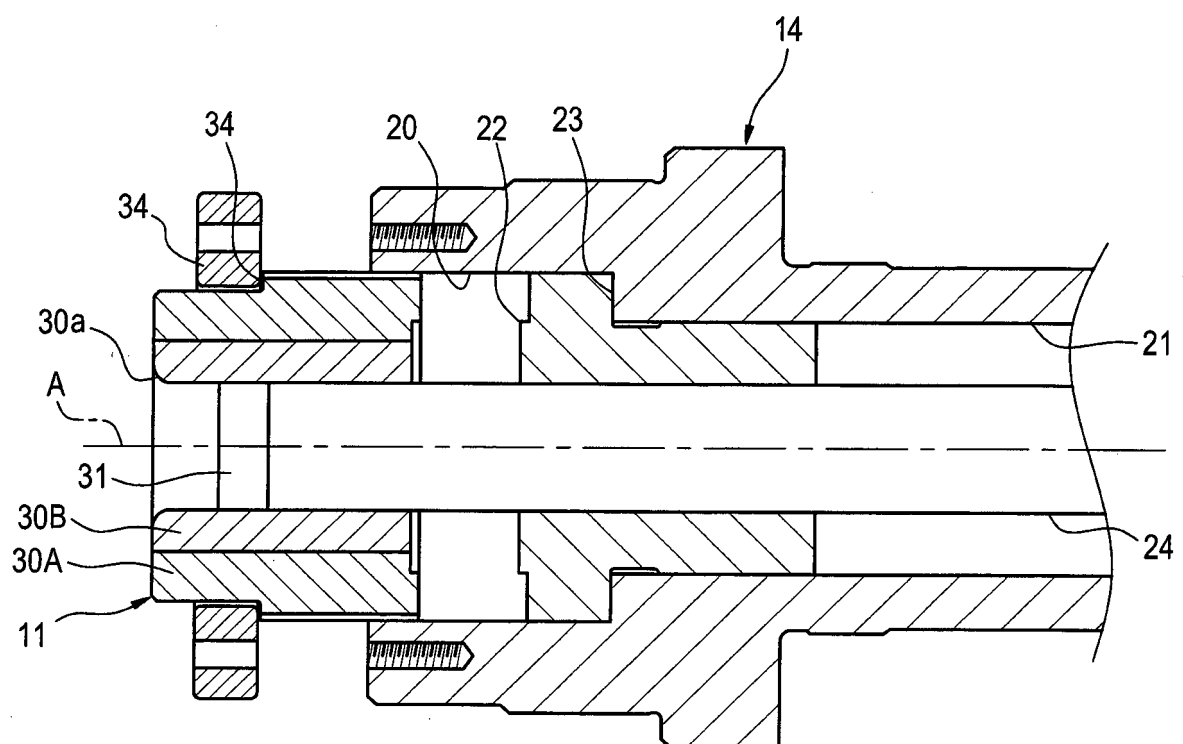


FIG. 13

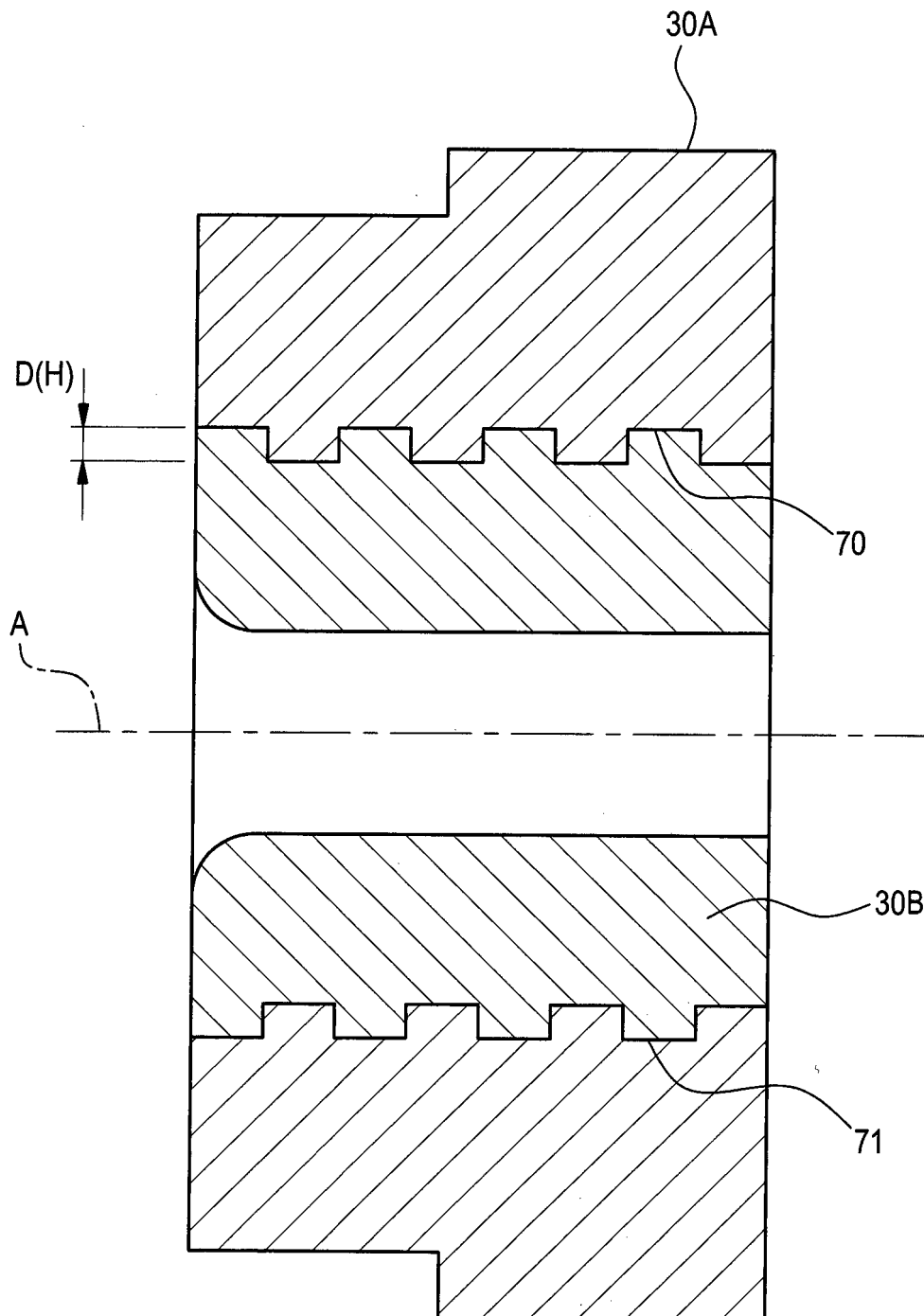


FIG. 14

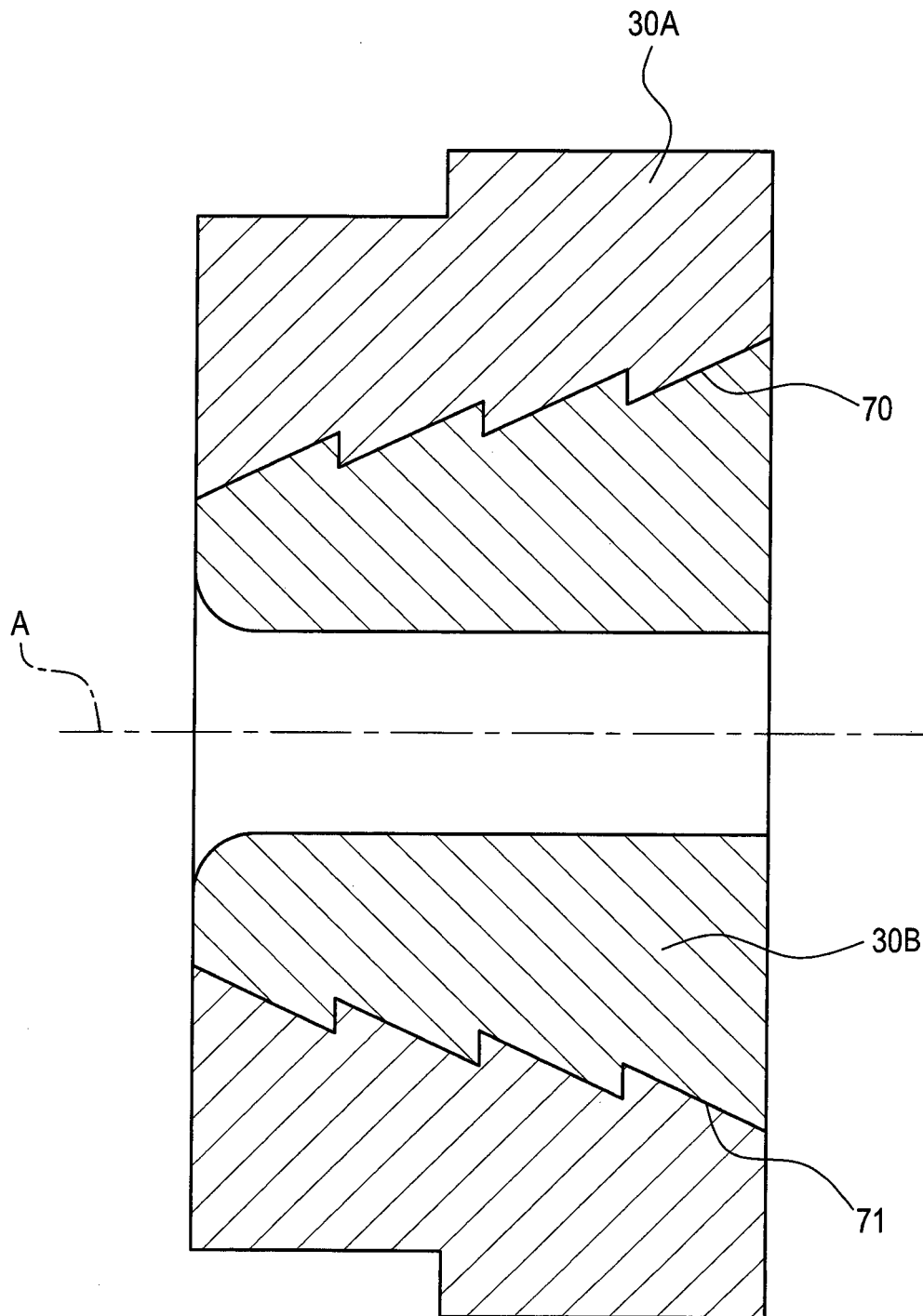


FIG. 15

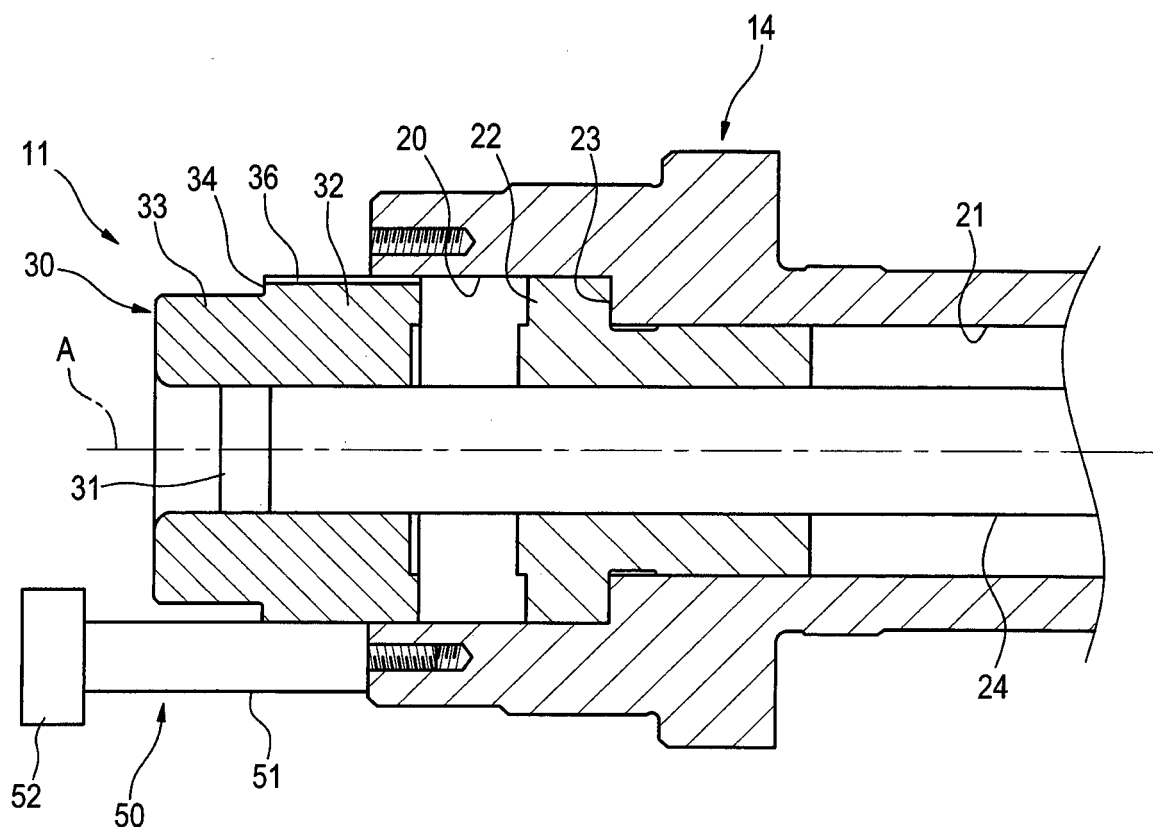


FIG. 16

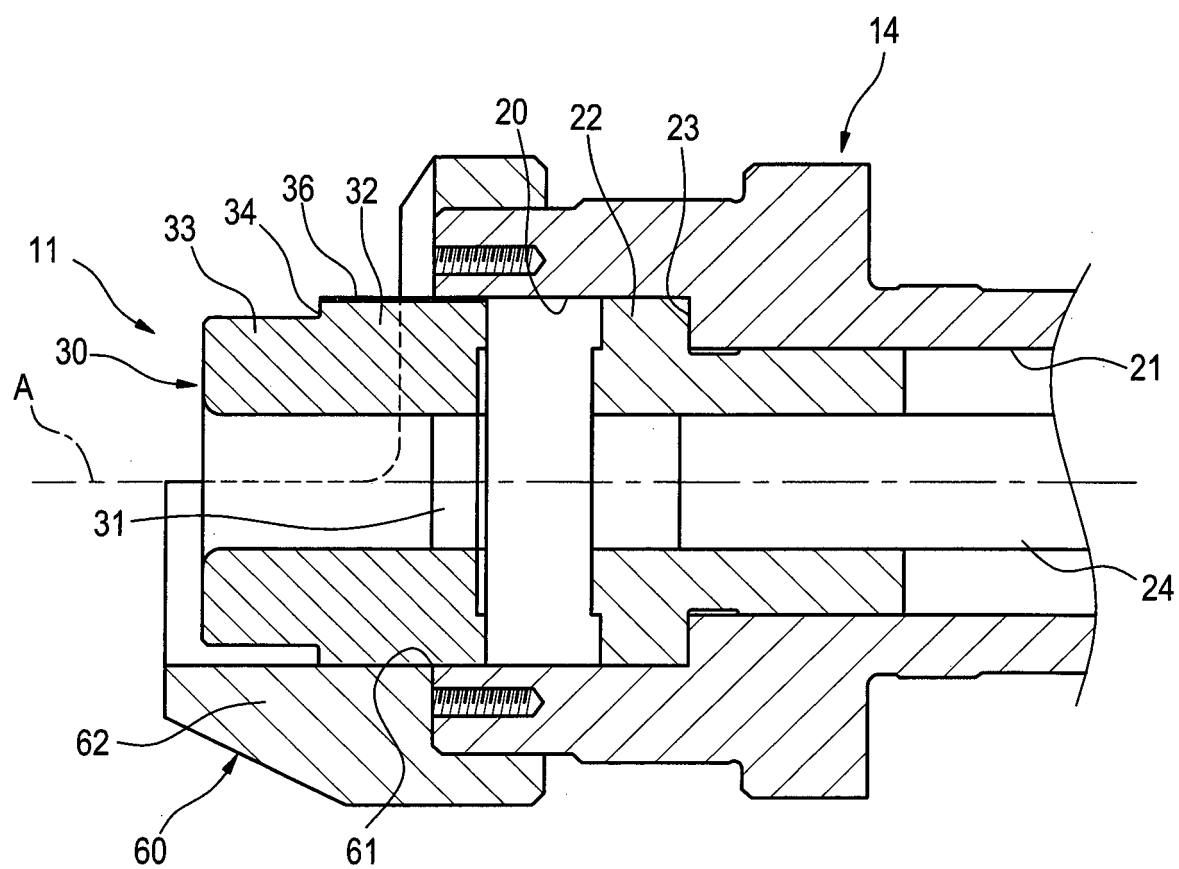
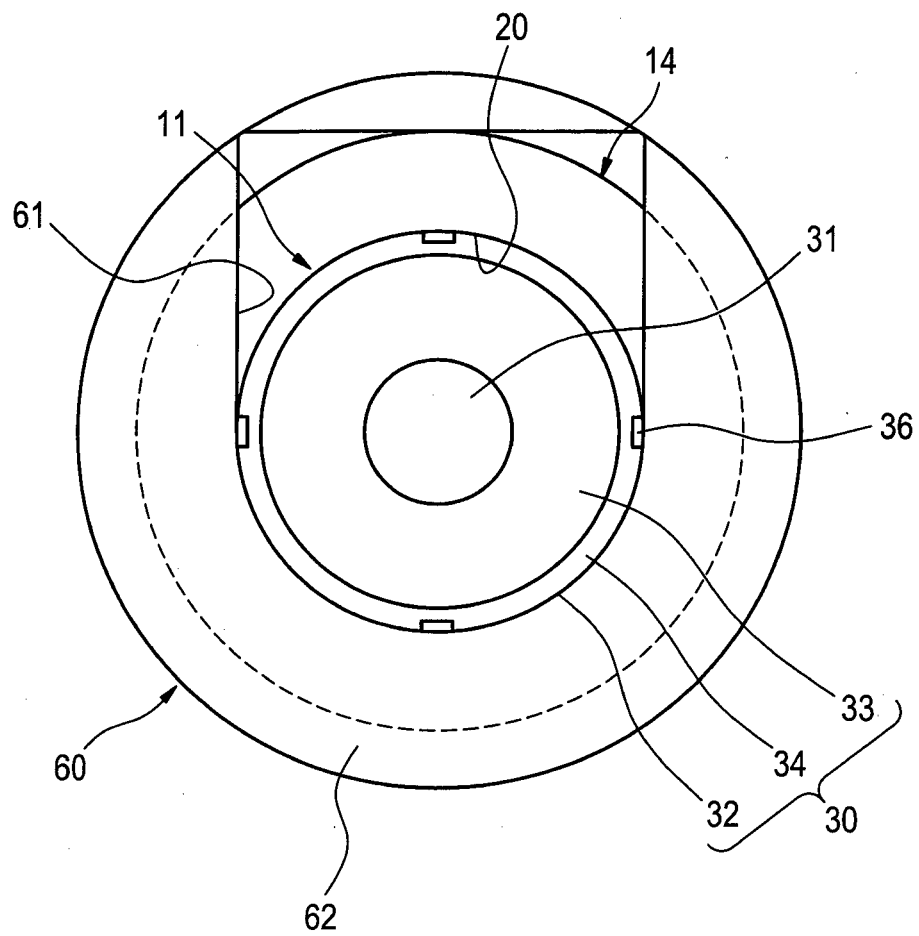


FIG. 17



REFERENCES CITED IN THE DESCRIPTION

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