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(71) Applicant: **Nippon Steel & Sumikin Engineering Co., Ltd.**
Tokyo 141-8604 (JP)

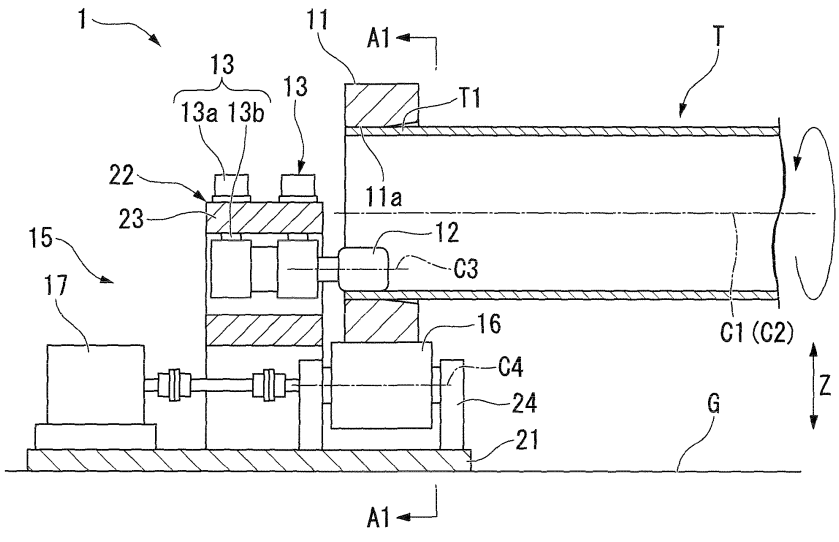
(72) Inventors:
- **HOSODA, Hiroyuki**
  Tokyo 141-8604 (JP)
- **IKEZAKI, Toru**
  Tokyo 141-8604 (JP)
- **TORII, Tadashi**
  Tokyo 141-8604 (JP)

(74) Representative: **Vossius & Partner**
Siebertstrasse 4
81675 München (DE)

(54) PIPE MATERIAL CORRECTION APPARATUS AND PIPE MATERIAL CORRECTION METHOD

(57) The apparatus is used for reforming a pipe member by improving the roundness of an axial region which is at least a part of the pipe member in a direction of an axis of the pipe member, the apparatus includes: an anvil ring disposed outside the pipe member so that a circularly-formed inner circumference face of the anvil ring is opposed to an outer circumference face of the axial region; an inner roller disposed inside the pipe member so that an outer circumference face of the inner roller is in contact with an inner circumference face of the axial region; a pressing unit which apples a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member, thereby causing plastic deformation at the axial region by using the inner circumference face of the anvil ring as a reforming face; and a rotation unit which rotates the pipe member with respect to the inner roller around the axis of the pipe member.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an apparatus and a method of reforming a pipe member by improving the roundness of the pipe member.

[0002] The present application claims the right of priority to Japanese Patent Application No.2011-086185 filed on April 8, 2011 and Japanese Patent Application No.2012-084810 filed on April 3, 2012, with the content cited herewith.

Background Art

[0003] A pipe member used for pipe lines and pilings may cause joint failure or become poor in quality when being jointed by welding or mechanical joints, if the pipe member is not sufficiently ensured for roundness. Therefore, various parts (axial regions) of the pipe member in an axial direction have been increased in roundness in advance.

[0004] For example, there is known a reformation apparatus disclosed in Patent Document 1 as an apparatus for reforming a pipe member by improving the roundness of the pipe member.

[0005] This reformation apparatus is provided with a first hydraulic cylinder disposed on an outside of an end of a pipe member via a cover plate and an elastic body which is disposed inside a pipe channel of the pipe member and swells out in a radial direction of the pipe member when pressed by a second hydraulic cylinder in an axial direction of the pipe member.

[0006] When the reformation apparatus is used, first, the first hydraulic cylinder is actuated to apply loads to a deformed end of the pipe member, thereby keeping the shape of the end in a precisely round state. The shape of the pipe member is measured by a displacement gage which is connected to the cover plate.

[0007] Moreover, the elastic body is disposed inside the pipe channel and pressed in the axial direction of the pipe member by the second hydraulic cylinder. Thereby, the elastic body is allowed to swell out in the radial direction of the pipe member and adjusted so that stress of the pipe member in a circumferential direction gives 100% to 120% of yield stress. In this case, the loads applied by the first hydraulic cylinder are released while the loads applied by the second hydraulic cylinder are increased, thus adjusting the stress of the pipe member in the circumferential direction to give 100% to 200% of yield stress. After this state has been kept for a certain period of time (for example, about 30 seconds), the loads applied by the second hydraulic cylinder are decreased to terminate reformation of the pipe member.

[0008] The pipe member is reformed in the above-described manner, by which remaining stress of the pipe member in the circumferential direction is almost evenly distributed. Therefore, the end of the pipe member is reformed to be round.

Prior Art Document

Patent Document

[0009] Patent Document 1: Japanese Published Examined Patent Application No.S60-45013

Summary of the Invention

Problems to be Solved by the Invention

[0010] However, in the reformation apparatus disclosed in Patent Document 1, various procedures are conducted, for example, alternate actuation and halt of both the hydraulic cylinders. As a result, there is a problem that a longer time for reforming the pipe member is needed.

[0011] The present invention has been made in view of the above problems, an object of which is to provide an apparatus of reforming a pipe member which is capable of reforming the pipe member by improving the roundness of an axial region of the pipe member in a short period of time, and to provide a method of reforming the pipe member.

Means for Solving the Problems

[0012] An aspect of the present invention is an apparatus of reforming a pipe member by improving the roundness of an axial region of the pipe member which is at least a part of the pipe member in a direction of an axis of the pipe member, the apparatus includes: an anvil ring which is disposed on an outside of the pipe member so that a circularly-formed inner circumference face of the anvil ring is opposed to an outer circumference face of the axial region of the pipe member; an inner roller which is disposed on an inside of the pipe member so that an outer circumference face of the inner roller is in contact with an inner circumference face of the axial region of the pipe member; a pressing unit configured

to apply a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member, thereby causing plastic reformation at the axial region of the pipe member by using the inner circumference face of the anvil ring as a reforming face; and a rotation unit configured to rotate the pipe member with respect to the inner roller around the axis of the pipe member.

[0013] Thereby, the axial region of the pipe member can be reformed in a circular form along the inner circumference face of the anvil ring. In this case, regarding the plastic deformation occurring in the pipe member, due to a mechanism similar to rolling, compressive deformation of the pipe member in the thickness direction at a line contact region between the inner roller, the anvil ring and the pipe member is converted to elongation deformation of the pipe member in a circumferential direction thereof because the volume of the pipe member as an object is never change even if the shape of the pipe member may vary. The elongation deformation in the circumferential direction is limited in its shape by the inner circumference face of the anvil ring in its deformation direction, and the pipe member undergoes deformation of the shape according to the shape of the inner circumference face of the anvil ring. As a result, it is possible to reform the axial region of the pipe member in a short period of time.

[0014] In the apparatus of the present invention, it may be such that the pressing unit configured to press the inner roller to the inner circumference face of the pipe member toward the anvil ring, thereby applying a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member. Thereby, the pipe member can be appropriately reformed for its cross-sectional shape by actions of the pressing unit which applies a pressing force to the inner roller.

[0015] In the apparatus of the present invention, it may be such that the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the anvil ring. Thereby, the anvil ring becomes greater in outer diameter than the pipe member, thus making it possible to easily apply a greater torque to the pipe member.

[0016] In the apparatus of the present invention, it may be such that the rotation unit includes: an outer roller in which a rotation axis of the outer roller is parallel with an axis of the anvil ring and an outer circumference face of the outer roller is in contact with the outer circumference face of the anvil ring and which is disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller; and a roller driving motor configured to rotate the outer roller around the rotation axis of the outer roller. Thereby, the pipe member is deformed via the anvil ring by being held between the inner roller and the outer roller in the radial direction of the anvil ring, thus making it possible to reform the pipe member at high accuracy, with deformation of the anvil ring kept low, even where the reformation loads are great.

[0017] In the apparatus of the present invention, it may be such that the rotation unit includes: a pair of outer rollers in which a rotation axis of each of the outer rollers is parallel with an axis of the anvil ring and an outer circumference face of each of the outer rollers is in contact with the outer circumference face of the anvil ring and which are disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller so as to separate from each other in a circumferential direction of the anvil ring; and a roller driving motor configured to rotate the pair of outer rollers around the rotation axis of each of the outer rollers in the same direction. Thereby, the anvil ring is reliably supported so as to be held between the pair of outer rollers, thus making it possible to increase a relative rotation force between the pipe member and the inner roller.

[0018] In the apparatus of the present invention, it may be such that the rotation unit includes a guide roller in which a rotation axis of the guide roller is parallel with the axis of the anvil ring and an outer circumference face of the guide roller is in contact with the outer circumference face of the anvil ring, and which is configured to guide the pipe member and the inner roller so as to make a relative rotation around the axis of the pipe members, wherein the guide roller is installed on the rotation unit with the outer rollers. It is, thereby, possible to make the relative rotation between the pipe member and the inner roller more stable.

[0019] The apparatus of the present invention may further include a base configured to support the inner roller and the outer rollers so as to rotate around the rotation axis of each of the rollers and to which the pressing unit and the roller driving motor are installed. For example, the base is disposed on a horizontal face in a state that a position of the inner roller is secured, the roundness of the axial region of the pipe member can be improved to reform the pipe member while rotating the pipe member to which the anvil ring is attached.

[0020] In the apparatus of the present invention, it may be such that the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the inner roller. Thereby, the inner roller applies a driving force directly to the pipe member, thus making it possible to more reliably rotate the pipe member around the axis of the pipe member.

[0021] In the apparatus of the present invention, it may be such that the apparatus is provided with a plurality of the inner rollers, wherein the axis of the pipe member given as a symmetrical axis of the inner rollers. It is, thereby, possible to reform the axial region of the pipe member into a substantially circular shape in a shorter period of time.

[0022] In the apparatus of the present invention, it may be such that the pressing unit is configured to press the anvil ring to the outer circumference face of the pipe member toward the inner roller, thereby applying a pressure contact

force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member. Thus, the pipe member can be reformed by actions of the pressing unit which applies a pressing force to the anvil ring.

[0023] In the apparatus of the present invention, it may be such that the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the anvil ring. Since the outer diameter of the anvil ring becomes greater than that of the pipe member, it is possible to easily apply a greater torque to the pipe member.

[0024] In the apparatus of the present invention, it may be such that the rotation unit includes: an outer roller in which a rotation axis of the outer roller is parallel with an axis of the anvil ring and an outer circumference face of the outer roller is in contact with the outer circumference face of the anvil ring, and which is disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller; and a roller driving motor configured to rotate the outer roller around the rotation axis of the outer roller. Thereby, the pipe member can be deformed by being held via the anvil ring between the inner roller and the outer roller in the radial direction of the anvil ring. It is, therefore, possible to reform the pipe member at high accuracy, with deformation of the anvil ring kept low, even where reformation loads are great.

[0025] In the apparatus of the present invention, it may be such that the pressing unit is configured to press the anvil ring via the outer roller to the outer circumference face of the pipe member toward the inner roller. Thereby, the apparatus can be made simple in structure.

[0026] In the apparatus of the present invention, it may be such that the rotation unit includes a guide roller in which a rotation axis of the guide roller is parallel with the axis of the anvil ring and an outer circumference face of the guide roller is in contact with the outer circumference face of the anvil ring, and which is configured to guide the pipe member and the inner roller so as to make a relative rotation around the axis of the pipe member, wherein the guide roller is installed on the rotation unit with the outer rollers. Thereby, it is possible to make the relative rotation between the pipe member and the inner roller more stable.

[0027] The apparatus of the present invention may further include a constant-pressure control unit configured to control a pressing force of the pressing unit to a constant level not dependent upon a change in thickness of the pipe member. Thereby, loads necessary for plastic deformation are made stable to improve shaping accuracy.

[0028] In the apparatus of the present invention, it may be such that the anvil ring is dividable into a plurality of anvil rings in a circumferential direction of the anvil ring. Thereby, the anvil ring can be located at any position easily in the axial direction of the pipe member.

[0029] In the apparatus of the present invention, it may be such that the anvil ring is divided into a plurality of pieces in a circumferential direction of the anvil ring, and a positioning pin is allowed to penetrate through an overlapping portion formed to an end of each of pieces adjacent to each other, thereby coupling the pieces adjacent to each other to assemble the anvil ring which is constant in diameter, and

a sliding mechanism configured to support the pieces so as to slide freely only by a predetermined range in the circumferential direction of the anvil ring, with the positioning pin kept removed, is installed between the overlapping portions of the pieces. Thereby, the pieces are allowed to slide without complete disassembly of the anvil ring, by which the anvil ring is increased in diameter to adjust a position. As a result, the anvil ring can be improved an ease of attachment thereof to the pipe member.

[0030] The other aspect of the present invention is a method of reforming a pipe member by improving the roundness of an axial region of a pipe member which is at least a part of the pipe member in al direction of an axis of the pipe member, the method incudes: disposing an anvil ring on an outside of the pipe member so that an inner circumference face of the anvil ring which is formed in a ring shape and has the circular inner circumference face is opposed to an outer circumference face of an axial region of the pipe member; disposing an inner roller on an inside of the pipe member so that an outer circumference face of the anvil ring is in contact with the inner circumference face of the axial region of the pipe member; applying a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member, thereby causing plastic deformation at the axial region of the pipe member by using the inner circumference face of the anvil ring as a reforming face; and rotating the pipe member with respect to the inner roller around the axis of the pipe member. Thereby, without complete disassembly of the anvil ring, the anvil ring can be increased in diameter to adjust the position. As a result, the anvil ring can be improved the ease of attachment thereof to the pipe member.

[0031] It is, thereby, possible to reform the axial region of the pipe member into a circular form along the inner circumference face of the anvil ring. In this case, regarding the plastic deformation occurring in the pipe member, due to a mechanism similar to rolling, compressive deformation of the pipe member in the thickness direction at a line contact region between the inner roller, the anvil ring and the pipe member are converted to elongation deformation of the pipe member in a circumferential direction of the pipe member because the volume of the pipe member as an object is never changed even if the shape of the pipe member varies. The elongation deformation in the circumferential direction is limited in its shape by the inner circumference face of the anvil ring in its deformation direction, and the pipe member undergoes deformation of the shape following the shape of the inner circumference face of the anvil ring. As a result, it

is possible to reform the axial region of the pipe member in a short period of time.

[0032] The method of the present invention may further include moving the pipe member with respect to the anvil ring and the inner roller in the direction of the axis of the pipe member, thereby shifting a position of the axial region to be reformed. As a result, the area of the axial region which is precisely reformed can be expanded.

Effects of the Invention

[0033] The present invention is able to provide an apparatus of reforming a pipe member by improving the roundness of an axial region of the pipe member in a short period of time, and to provide a method of reforming the pipe member.

Brief Description of the Drawings

[0034]

Fig. 1 is a sectional side view of a part of an apparatus of the first embodiment in the present invention.
Fig. 2 is a sectional view taken along the line A1 to A1 in Fig. 1.
Fig. 3 is a flow chart for explaining a method of the first embodiment in the present invention.
Fig. 4 is a perspective view showing examples (a) and (b) of a pipe member to be reformed by the method of reforming the pipe member.
Fig. 5 is a side sectional view for explaining a fixing device attachment step in the method of reforming the pipe member.
Fig. 6 is a front sectional view showing an apparatus of a modified example of the first embodiment in the present invention.
Fig. 7 is a side sectional view showing the apparatus of the modified example of the first embodiment in the present invention.
Fig. 8 is a front sectional view showing the apparatus of the modified example of the first embodiment in the present invention.
Fig. 9 is a side sectional view showing an apparatus of the second embodiment in the present invention.
Fig. 10 is a sectional view taken along the line A2 to A2 in Fig. 9.
Fig. 11 is a side sectional view showing an apparatus of a modified example of the second embodiment in the present invention.
Fig. 12 is a front view showing an apparatus of the third embodiment in the present invention.
Fig. 13 is a front view showing an apparatus of the fourth embodiment in the present invention.
Fig. 14 is a side view showing the apparatus of reforming the pipe member.
Fig. 15 is a side view showing an apparatus of a modified example of the fourth embodiment in the present invention.
Fig. 16 is a configuration diagram of an anvil ring used in an apparatus of the fifth embodiment in the present invention in which (a) is a perspective view showing an assembly state, (b) is a perspective view of major parts showing a sliding mechanism of pieces to be assembled the anvil ring, and (c) is a perspective view of major parts showing the pieces separated from each other.
Fig. 17 is a chart showing results of reforming the pipe member by the apparatus of the present invention.

Best Mode for Carrying Out the Invention

[0035] Hereinafter, the first embodiment of an apparatus for a pipe member according to the present invention will be described with reference to Fig. 1 to Fig. 8.

[0036] As shown in Fig. 1 and Fig. 2, the apparatus 1 is used to reform a pipe member T by improving the roundness of the pipe member. It is noted that in the present description, the roundness means the difference between a maximum outer diameter and a minimum outer diameter on a cross section of the pipe member. Moreover, an improvement of the roundness means that the pipe member is reformed so as to bring the roundness of the pipe member to zero. The cross-sectional shape of the pipe member is brought into a precise circle as the roundness of the pipe member is improved so as to be close to zero.

[0037] Hereinafter, an example in which the apparatus 1 is used to reform one end (axial region) T1 of the pipe member T in a direction of axis C1 of the pipe member T will be described.

[0038] The apparatus 1 of the present embodiment is provided with an anvil ring 11, an inner roller 12, a hydraulic jack (pressing unit) 13 and a rotation unit 15. The anvil ring 11 is formed in a ring shape, and an inner circumference face 11 a thereof is attached to an outer circumference face of one end T1 of the pipe member T. An outer circumference face of the inner roller 12 is in contact with an inner circumference face of the one end T1 of the pipe member T. The hydraulic jack 13 presses the inner roller 12 to the inner circumference face of the one end T1. The rotation unit 15

rotates the pipe member T attached to the anvil ring 11 with respect to the inner roller 12.

[0039] An axis C1 of the pipe member T, an axis C2 of the anvil ring 11 and an axis C3 of the inner roller 12 are all set so as to face in a horizontal direction. The inner roller 12 is disposed on an inside of a lower end of the pipe member T.

[0040] The inner circumference face 11 a of the anvil ring 11 is formed to be a round shape or almost round shape when viewed in parallel in a direction of the axis C2 of the anvil ring 11. The anvil ring 11 is made of a metal such as iron or steel. It is preferable that the stiffness property of the anvil ring 11 is sufficiently higher than the stiffness property of the pipe member T. The anvil ring 11 is attached so as to be coaxial or in parallel with the one end T1 of the pipe member T.

[0041] The inner diameter of the anvil ring 11 is set so as to be slightly smaller than the outer diameter of the pipe member T. When the anvil ring 11 is attached to the pipe member T, the pipe member T is swaged. That is, it is preferable that the anvil ring 11 is attached to the one end T1 in a firmly fixed state. It is, however, acceptable that the inner diameter of the anvil ring 11 is not necessarily set so as to be smaller than the outer diameter of the pipe member T. It is also acceptable that a certain gap is found at sites other than a load application site between the anvil ring 11 and the pipe member T.

[0042] The apparatus 1 is provided with a base 21 which is formed in a plate shape. The base 21 is disposed on a horizontal face G. A supporting base 22 is fixed on an upper face of the base 21 and the hydraulic jack 13 is attached to a lower face of a top plate 23 of the supporting base 22. The hydraulic jack 13 is provided with a main body 13a and a piston 13b. The main body 13a is able to move the piston 13b by hydraulic pressure in a vertical direction Z which is a direction orthogonal to the axis C1 of the pipe member T. The hydraulic jack 13 is designed for its output so as to cause plastic deformation at the one end T1 by pressing the inner roller 12 to the inner circumference face of the one end T1 of the pipe member T.

[0043] In the present embodiment, the inner roller 12 is formed substantially in a cylindrical shape. The inner roller 12 is attached to the leading end of the piston 13b so as to rotate around the center axis C3 thereof. The inner roller 12 is disposed inside a pipe channel of the pipe member T in such a manner that the center axis C3 is parallel with the axis C1 of the pipe member T and the outer circumference face thereof is in contact with the inner circumference face of the one end T1 of the pipe member T. The outer diameter of the inner roller 12 is set so as to be smaller than the inner diameter of the pipe member T. The inner roller 12 is constituted by coating a protective layer on the surface of iron or steel, for example.

[0044] The rotation unit 15 is provided with an outer roller 16 in which an outer circumference face of the outer roller 16 is in contact with the outer circumference face of the anvil ring 11, a roller driving motor 17 which rotates the outer roller 16 around a center axis C4 thereof and a pair of guide rollers 18 which guide the pipe member T so as to rotate around the axis C1 thereof.

[0045] As shown in Fig. 1, the outer roller 16 is disposed so that the center axis C4 thereof is parallel with the axis C2 of the anvil ring 11 and supported so as to rotate freely around the center axis C4 by a turntable 24 fixed on an upper face of the base 21. As shown in Fig. 2, the outer roller 16 is disposed outside a part of the anvil ring 11 adjacent to the inner roller 12 in the radial direction.

[0046] In the following description, the radial direction of the anvil ring 11 and the circumferential direction of the anvil ring 11 are simply referred to as respectively "radical direction" and "circumferential direction." In the present embodiment, the outer roller 16 is disposed perpendicularly below the inner roller 12, while the anvil ring 11 and the pipe member T are held between the outer roller 16 and the inner roller 12. Further, as shown in Fig. 1, the roller driving motor 17 is attached to an upper face of the base 21.

[0047] As described so far, in the present embodiment, the rotation unit 15 is constituted in such a manner that a driving force which rotates the pipe member T around the axis C1 of the pipe member T is applied to the pipe member T via the anvil ring 11.

[0048] Each of the guide rollers 18 is disposed in such a manner that a center axis C5 of the guide roller 18 is parallel with the axis C2 of the anvil ring 11 and an outer circumference face thereof is in contact with the outer circumference face of the anvil ring 11. The guide roller 18 is disposed in such a manner that a difference between a distance from the axis C2 of the anvil ring 11 to the center axis C4 of the outer roller 16 and the distance to the axis C5 of the guide roller 18 is equal to a difference between the radius of the outer roller 16 and the radius of the guide roller 18. The guide roller 18 is supported by the turntable 25 fixed on the upper face of the base 21 so as to rotate freely around the center axis C5. The outer roller 16 and the guide roller 18 are formed with a metal or a hard resin in substantially a cylindrical shape.

[0049] Next, the present embodiment of a method for a pipe member according to the present invention will be described in a case where the apparatus 1 is used to reform the one end T1 of the pipe member T.

[0050] As shown in Fig. 3, this method includes a fixing device attachment step S1 in which the anvil ring 11 is attached to the one end T1 of the pipe member T and a pipe member reformation step S2 in which the pipe member T is rotated with respect to the inner roller 12 to reform the shape of the pipe member T.

[0051] The pipe member T to be reformed by using the present method includes, for example, such that there is found a deformed part T2 found having a locally recessed part or a locally raised part at the one end T1 as shown in Fig. 4(a)

and that the entire cross-sectional shape of the one end T1 is not circular but oval wherein the roundness of the oval is less than that of the precise circle as shown in Fig. 4(b).

[0052] First, in the fixing device attachment step S1, as shown in Fig.5, the anvil ring 11 is attached to the outer circumference face of the one end T1 of the pipe member T. At this time, the anvil ring 11, the inner diameter of which is slightly smaller than the outer diameter of the pipe member T is selected. It is preferable that various types of anvil rings different in inner diameter are made available in dealing with various types of pipe members.

[0053] Next, in a state that the inner roller 12 is allowed to move upward by using the hydraulic jack 13, the pipe member T to which the anvil ring 11 has been attached is allowed to move. The outer circumference faces of the outer roller 16 and the pair of guide rollers 18 are individually brought into contact with the outer circumference face of the anvil ring 11. Moreover, the inner roller 12 is disposed inside the pipe channel of the pipe member T. After that, the inner roller 12 is allowed to move downward by using the hydraulic jack 13 so that the inner roller 12 is pressed to the inner circumference face of the one end T1 of the pipe member T. Thereby, a pressure contact force is applied between the outer circumference face of the pipe member T and the inner circumference face of the anvil ring 11, causing plastic deformation at the one end T1 of the pipe member T by using the inner circumference face of the anvil ring 11 as a reforming face. At the same time, the roller driving motor 17 is actuated to rotate the pipe member T around the axis C1 of the pipe member T with respect to the inner roller 12. At this time, the center axis C3 of the inner roller 12 is parallel with the axis C1 of the pipe member T.

[0054] As described above, the inner circumference face of the one end T1 is reformed all over the circumference thereof by using the inner roller 12, by which the deformed part T2 is decreased in deformation and the oval shape is corrected, thus the roundness of the pipe member T is increased. Where one rotation of the pipe member T around the axis C1 does not provide sufficient reformation, the pipe member T is rotated repeatedly around the axis C1, thus making it possible to improve the roundness of the pipe member T. In this case, regarding plastic deformation occurring in the pipe member T, due to a mechanism similar to rolling, compressive deformation in the radial direction at a line contact region between the inner roller 12, the anvil ring 11 and the pipe member T is converted to elongation deformation in the circumferential direction because the volume of the pipe member as an object is never change even if the shape of the pipe member may vary. The elongation deformation in the circumferential direction is limited in its shape by the inner circumference face 11a of the anvil ring 11 in a deformation direction thereof, and the shape of the pipe member T proceeds to deform in accordance with the shape of the inner circumference face 11 a of the anvil ring 11. As a result, the reformation is performed effectively.

[0055] As described so far, according to the apparatus 1 and the method of the present invention for reforming the pipe member, while the anvil ring 11 is used to support the outer circumference face of the one end T1 of the pipe member T, the inner roller 12 is pressed to the inner circumference face of the one end T1, causing plastic deformation at the one end T1 and also rotating the pipe member T around the axis C1 with respect to the inner roller 12. It is, therefore, possible to reform the one end T1 of the pipe member T into a round shape along the inner circumference face 11 a of the anvil ring 11.

[0056] Further, a pressure contact force is applied between the anvil ring 11 and the pipe member T, and also the pipe member T is rotated around the axis C1 to reform the pipe member T. Thus, as compared with the conventional apparatus disclosed in Patent Document 1, the pipe member can be reformed by improving the roundness thereof in a short period of time.

[0057] The rotation unit 15 is constituted so that a driving force which rotates the pipe member T around the axis C1 is applied to the pipe member T via the anvil ring 11. Since the anvil ring 11 becomes greater in outer diameter than the pipe member T, it is possible to easily apply a great torque to the pipe member T.

[0058] The rotation unit 15 is provided with the outer roller 16 and the roller driving motor 17. The pipe member T is deformed via the anvil ring 11 by being held between the inner roller 12 and the outer roller 16 in the radial direction. It is, thereby, possible to reform the pipe member T at high accuracy, with deformation of the anvil ring 11 kept low, even where reforming loads are great.

[0059] Since the rotation unit 15 is provided with the guide roller 18, it is able to rotate the pipe member T more stably around the axis C1 of the pipe member T with respect to the inner roller 12. The apparatus 1, is provided with the base 21. Moreover, the base 21 is disposed on the horizontal face G, by which the pipe member T to which the anvil ring 11 has been attached is rotated around the axis C1, with the inner roller 12 secured at a fixed position, thus making it possible to improve the roundness of the one end T1 of the pipe member T. Further, the stiffness property of the anvil ring 11 is set to be sufficiently higher than the stiffness property of the pipe member T. It is, thereby, possible to uniformly reform the pipe member T according to the inner circumference face 11 a of the anvil ring 11 not dependent upon initial remaining stress or deformation of the pipe member T.

[0060] It is noted that in the present embodiment, as will be described hereinafter, the apparatus 1 can be changed in configuration in various ways.

[0061] For example, in an apparatus 2 for reforming the pipe member as shown in Fig. 6, it is acceptable that a plurality of inner rollers 12 (two rollers in this modified example) are provided, with the axis C1 of the pipe member T given as a

symmetrical axis. In this modified example, each of the inner rollers 12 is provided with the hydraulic jack 13 which presses the inner roller 12 to the inner circumference face of the one end T1. The apparatus 2 is constituted as described above, thus making it possible to reform the one end T1 into a shape closer to a circle in a shorter period of time.

[0062] Further, in an apparatus 3 for reforming the pipe member as shown in Fig. 7, in place of the rotation unit 15 of the apparatus 1 of the first embodiment, it is acceptable that a rotation unit 31 is provided. The rotation unit 31 is provided with a roller driving motor 32 which rotates an inner roller 12 around the center axis C3. The rotation unit 31 of the modified example is constituted so as to apply a driving force which rotates a pipe member T around the axis C1 to the pipe member T via the inner roller 12. Since the apparatus 3 its constituted as described above, it is possible to rotate the pipe member T around the axis C1 of the pipe member T with respect to the inner roller 12. The inner roller 12 is used to directly apply the driving force to the pipe member T, thereby reliably rotating the pipe member T around the axis C1, for example, even where there is a gap between the pipe member T and the anvil ring 11.

[0063] It is also acceptable that the apparatus 1 is further provided with a roller driving motor 32, and both the inner roller 12 and the outer roller 16 are used to rotate the pipe member T.

[0064] In an apparatus 4 for reforming the pipe member as shown in Fig. 8, it is acceptable that an outer roller 16 is disposed below the inner roller 12 and a guide roller 18 is disposed on a position separated from the outer roller 16 in the circumferential direction in the apparatus 1. Since the apparatus 4 is constituted as described above, it is possible to firmly support the inner roller 12 from below by using one inner roller 12 and one guide roller 18.

[0065] In the first embodiment and the modified examples, the guide roller 18 is not a necessary component. There is a case where only the inner roller 12 and the guide roller 18 can be used to firmly support the pipe member T to which the anvil ring 11 has been attached.

[0066] Moreover, the second embodiment of the present invention will be described with reference to Fig. 9 to Fig. 11. The same parts as those of the previous embodiments will be given the same reference numerals, and a description thereof is omitted here. Only different points will be described here.

[0067] As shown in Fig. 9 and Fig. 10, an apparatus 5 of the present embodiment is constituted in such a manner that an inner roller 12 is rotated around the axis C1 of a pipe member T, with the pipe member T fixed. The apparatus 5 is not provided with the base 21 installed on the apparatus 1 of the first embodiment but provided with a rotation unit 41 in place of the rotation unit 15.

[0068] The rotation unit 41 is provided with a pair of outer rollers 16 in which a center axis C4 thereof is parallel with the axis C2 of the anvil ring 11 and an outer circumference face thereof is disposed so as to be in contact with the outer circumference face of the anvil ring 11 and a roller driving motor 17 which rotates the pair of outer rollers 16 around the center axis C4 in the same direction. As shown in Fig. 10, the pair of outer rollers 16 are disposed so as to be put on the outer circumference of the anvil ring 11 adjacent to the inner roller 12 and to separate from each other in the circumferential direction of the anvil ring 11.

[0069] In the present embodiment, the roller driving motor 17 is attached to the turntable 24, and the turntable 24 is fixed on a supporting base 22. Moreover, the inner roller 12, the hydraulic jack 13, the pair of outer rollers 16 and the roller driving motor 17 are formed integrally on the supporting base 22, and the roller driving motor 17 is driven to rotate the pipe member T around the axis C1 thereof.

[0070] According to the thus constituted apparatus 5 of the present embodiment, it is possible to improve the roundness of the one end T1 of the pipe member T by a simple configuration. Further, since the pair of outer rollers 16 are provided, the anvil ring 11 can be firmly supported so as to be held between the outer rollers 16. Moreover, the inner roller 12 is able to rotate the pipe member T at a higher speed.

[0071] Even where, for example, the pipe member T is greater in outer diameter and cannot be rotated around the axis C1, the inner roller 12 is rotated around the axis C1, thus making it possible to reform the one end T1 of the pipe member T.

[0072] In the present embodiment, in an apparatus 6 for reforming the pipe member as shown in Fig. 11, in place of the rotation unit 41 of the apparatus 5, the previously described rotation unit 31, that is, a roller driving motor 32 may be provided. Since the apparatus 6 is constituted as described above, the roller driving motor 32 is actuated to rotate an inner roller 12 around the center axis C3. It is, thereby, possible to rotate the inner roller 12 around the axis C1 with respect to a pipe member T.

[0073] It is acceptable that the apparatus 5 of the present embodiment is further provided with the roller driving motor 32, by which both the inner roller 12 and the outer roller 16 are used to rotate the pipe member T.

[0074] Next, the third embodiment of the present invention will be described with reference to Fig. 12. The same parts as those of the previous embodiments will be given the same reference numerals, and a Description thereof is omitted here. Only different points will be described here.

[0075] An apparatus 7 for reforming the pipe member of the present embodiment is provided with the previously described anvil ring 11, three inner rollers 12, a pressing unit 51 used to bias each of the inner rollers 12 outward in the radial direction, and a rotation unit (not illustrated).

[0076] The pressing unit 51 is provided with a main body 52 which is disposed on the axis C1 at one end T1 of a pipe

member T, three supporting members 53, each of which is disposed at an equal angle in the circumferential direction around the axis C1 outside the main body 52, and three spring members 54 which connect the individual supporting members 53 with the main body 52.

[0077] Each of the supporting members 53 supports the inner roller 12 so as to rotate around the center axis C3 of the inner roller 12. The spring member 54 is adjusted in such a manner that the inner roller 12 is biased outward in the radial direction, with the inner roller 12 kept in contact with the inner circumference face of the one end T1, thereby causing plastic deformation at the one end T1. That is, a stress which is applied to the one end T1 by the spring member 54 when the inner roller 12 is brought into contact with the inner circumference face of the one end T1 is set equal to or greater than yield stress of a material with which the pipe member T is formed. The rotation unit rotates each of the inner rollers 12 around the center axis C3 in the same direction.

[0078] Where the thus constituted apparatus 7 of the present embodiment is used to reform the one end T1 of the pipe member T, first, in a fixing device attachment step S1, similar to the first embodiment, the anvil ring 11 is attached to the outer circumference face of the one end T1 of the pipe member T.

[0079] Next, in a pipe member reformation step S2, the inner roller 12, the supporting member 53 and the spring member 54 which are integrally formed with the main body 52 are disposed inside a pipe channel of the one end T1. Moreover, the inner roller 12 is biased outward in the radial direction by the spring member 54, causing plastic deformation at the one end T1. The rotation unit is used to rotate each of the inner rollers 12, thereby improving the roundness of the one end T1 all over the circumference.

[0080] Next, the fourth embodiment of the present invention will be described with reference to Fig. 13 and Fig. 14.

[0081] In the first embodiment to the third embodiment, a description has been given of a case where the inner roller is pressed to the inner circumference face of the pipe member T by using the hydraulic jack 13, and a pressure contact force is applied between the outer circumference face of the pipe member T and the inner circumference face of the anvil ring 11 is described. As shown in Fig. 13, in an apparatus 101 of the fourth embodiment, a hydraulic jack 113 is used to apply an upward pressing force to an outer roller 116, by which an anvil ring 11 is pressed to an outer circumference face of a pipe member T toward an inner roller 112. Therefore, the outer roller 116 is allowed to move vertically and the position of the inner roller 112 is firmly fixed.

[0082] Hereinafter, a case where one end (axial region) T1 of the pipe member T in the axis C1 is reformed by the apparatus 1 will be described.

[0083] The apparatus 101 of the present embodiment is, as shown in Fig. 13, provided with an anvil ring 11, an inner roller 112, an outer roller 116, a roller driving motor 114, a pair of guide rollers 118; and a hydraulic jack (pressing unit) 113.

[0084] The anvil ring 11 is disposed on an outside of a pipe member T so that an inner circumference face 11 a of the anvil ring 11, which is circularly formed, is opposed to an outer circumference face of one end T1 of the pipe member T. The inner roller 112 is disposed in an inside of the pipe member T in such a manner that an outer circumference face thereof is brought into contact with the inner circumference face of the one end T1 of the pipe member T. The outer roller 116 is in contact with the outer circumference face of the anvil ring 11 to apply a rotation force and an upward pressing force to the anvil ring 11. The roller driving motor 114 rotates and drives the outer roller 116. The guide roller 118 is brought into contact with the outer circumference face of the anvil ring 11 to support the anvil ring 11 and also guides the anvil ring 11 to rotate. The hydraulic jack 113 applies an upward pressing force to the outer roller 116.

[0085] The outer roller 116, the roller driving motor 114 and the guide roller 118 constitute a rotation unit 115 which rotates the pipe member T and the inner roller 112 relatively around the axis C1 of the pipe member T.

[0086] In this case, as shown in Fig. 13 and Fig. 14, the axis C1 of the pipe member T, the axis C2 of the anvil ring 11, the axis C3 of the inner roller 112 and the axis C4 of the outer roller 116 are all set so as to be in parallel with each other and face horizontally. The inner roller 112 is disposed in the inside of the lower end of the pipe member T, and the outer roller 116 is disposed perpendicularly below the inner roller 112.

[0087] The inner circumference face 11 a of the anvil ring 11 is formed into a round shape or a substantially round shape when viewed in parallel in a direction of the axis C2 of the anvil ring 11. The anvil ring 11 is made of a metal such as iron or steel. It is preferable that the stiffness property of the anvil ring 11 is sufficiently higher than the stiffness property of the pipe member T.

[0088] The inner diameter of the anvil ring 11 is set so as to be slightly greater than the outer diameter of the pipe member T. The anvil ring 11 is set for its inner diameter in such a manner that a slight gap is found between an inside of an upper end of the anvil ring 11 and an outside of an upper end of the pipe member T, when the anvil ring 11 is disposed on the outside of the pipe member T and supported by the outer roller 116.

[0089] As shown in Fig. 14, the apparatus 101 is provided with a base 121. Moreover, the base 121 is provided with running wheels 151 for movement and disposed on a horizontal face G. A supporting base 122 is installed upright on an upper face of the base 121. A base part of a supporting shaft 140 which supports the inner roller 112 is fixed on the supporting base 122, with the axis pointed horizontally. The inner roller 112 formed in a substantially cylindrical shape is attached to an outside of a narrow radial part 141 at the leading end of the supporting shaft 140 so as to rotate freely around the center axis C3 thereof via a bearing 142. The outer diameter of the inner roller 112 is set smaller than the

inner diameter of the pipe member T and the inner roller 112 is constituted, for example, by coating a protective layer on the surface of iron or steel.

[0090] Further, a fixture frame 123 is installed on the base 121, and a vertical movement frame 124 used to support the outer roller 116 is supported on the fixture frame 123 so as to slide freely in the vertical direction. The vertical movement frame 124 is allowed to move vertically by the hydraulic jack 113 disposed below the vertical movement frame 124. A supporting shaft 125 used to support the outer roller 116 via a bearing 126 so as to rotate freely is fixed on the vertical movement frame 124.

[0091] A gear 127 is attached to the outer roller 116 so as to rotate integrally with the outer roller 116. The gear 127 meshes with a gear 132 which rotates integrally with a driven shaft 130 supported on the vertical movement frame 124 so as to rotate freely via a bearing 131. The driven shaft 130 is coupled to a driving shaft of the roller driving motor 114 fixed to the base 121 via a rotary joint 119. Rotation of the roller driving motor 114 is transmitted via the rotary joint 119 to the driven shaft 130, irrespective of vertical movement of the vertical movement frame 124. Moreover, the rotation which has been transmitted to the driven shaft 130 is transmitted to the outer roller 116 via the gear 132 and the gear 127. Further, a pressing force in the vertical direction Z which has been transmitted to the vertical movement frame 124 by the hydraulic jack 113 is transmitted to the outer roller 116 via the supporting shaft 125 and the bearing 126.

[0092] The hydraulic jack 113 is set for its output in such a manner that the anvil ring 11 is pressed via the outer roller 116 to the outer circumference face of the one end T1 of the pipe member T, thereby applying a pressure contact force between the inner circumference face 11 a of the anvil ring 11 and the outer circumference face of the pipe member T, thus making it possible to cause plastic deformation at the one end T1 of the pipe member T by using the inner circumference face 11 a of the anvil ring 11 as a reforming face. As shown in Fig. 13, an accumulator 117 is interposed at a midpoint to a hydraulic pressure supplying channel of the hydraulic jack 113 as a constant-pressure control unit which controls a pressing force of the hydraulic jack 113 to the anvil ring 11 so as to be a constant level dependent upon change in thickness of the pipe member T. The accumulator 117 acts to absorb variation in loads due to stroke change of the hydraulic jack 113.

[0093] As described so far, in the present embodiment, the rotation unit 115 is constituted so as to apply a driving force to rotate the pipe member T around the axis C1 of the pipe member T to the pipe member T via the anvil ring 11. Each of the guide rollers 118 is disposed in such a manner that the center axis thereof is parallel with the axis C2 of the anvil ring 11 and the outer circumference face thereof is in contact with the outer circumference face of the anvil ring 11. The guide roller 118 is disposed so that a difference between a distance from the axis C1 of the pipe member T to the center axis C4 of the outer roller 116 and a distance to the center axis of the guide roller 118 is equal to the difference between a radius of the outer roller 116 and a radius of the guide roller 18. Each of the outer roller 116 and the guide roller 118 is made of a metal, a hard resin or the like and is formed into a substantially circular shape.

[0094] A pipe member reformation method in which the apparatus 101 is used to reform the one end T1 of the pipe member T will be described. Where the pipe member T is reformed, first, the anvil ring 11 is disposed on the outside of the one end T1 of the pipe member T and the inner roller 112 is also disposed on the inside of the one end T1 of the pipe member T. At this time, the anvil ring 11, the inner diameter of which is slightly greater than the outer diameter of the pipe member T is selected. It is preferable that various types of anvil rings different in inner diameter are made available in dealing with various types of pipe members.

[0095] Moreover, the outer circumference faces of the outer roller 116 and the pair of guide rollers 118 are individually brought into contact with the outer circumference face of the anvil ring 11. Moreover, the outer roller 116 is moved upward by using the hydraulic jack 113, the inner circumference face 11 a of the anvil ring 11 is pressed to the outer circumference face of the one end T1 of the pipe member T by the outer roller 116, and a pressure contact force is applied to the outer circumference face of the pipe member T and the inner circumference face of the anvil ring 11 to cause plastic deformation at the one end T1 of the pipe member T by using the inner circumference face 11 a of the anvil ring 11 as a reforming face. At the same time, the roller driving motor 114 is actuated to rotate the outer roller 116, by which the pipe member T is rotated via the anvil ring 11 around the axis C1 of the pipe member T with respect to the inner roller 112.

[0096] As described above, the one end T1 is reformed all over the outer circumference face thereof by the anvil ring 11 and the deformed part T2 is decreased in deformation or the oval shape is adjusted to result in an improvement of the roundness of the pipe member T. Where one rotation of the pipe member T around the axis C1 does not provide sufficient reformation, the pipe member T is repeatedly rotated around the axis C1 to improve the roundness of the pipe member T. In this case, plastic deformation occurring in the pipe member T is due to introduction of a local force into a line contact region between the inner roller 112, the anvil ring 111 and the pipe member T. Therefore, deformation is limited to an extremely small region and proceeds without spring-back by a mechanism similar to metal rolling. As a result, the reformation is performed effectively.

[0097] As described so far, according to the apparatus 101 and the pipe member reformation method of the present embodiment, the anvil ring 11 is pressed to the outer circumference face of the one end T1 of the pipe member T by the outer roller 116, with the outer circumference face of the one end T1 of the pipe member T supported by the anvil ring 11. Moreover, the pipe member T is rotated around the axis C1 with respect to the inner roller 112, while causing

plastic deformation at the one end T1. It is, therefore, possible to reform the one end T1 of the pipe member T into a round shape along the inner circumference face 11 a of the anvil ring 11.

[0098] The rotation unit 115 is constituted so as to apply a driving force which rotates the pipe member T around the axis C1 to the pipe member T via the anvil ring 11. Since outer diameter of the anvil ring 11 is greater than that of the pipe member T, it is possible to easily apply a great torque to the pipe member T.

[0099] The rotation unit 115 is provided with the outer roller 116 and the roller driving motor 114. The pipe member T is deformed via the anvil ring 11 by being held between the inner roller 112 and the outer roller 116 in the radial direction. Thereby it is possible to reform the pipe member T at a high accuracy, with deformation of the anvil ring 11 kept low, even where reforming loads are large.

[0100] Since the rotation unit 115 is provided with the guide roller 118, it is able to rotate more stably the pipe member T around the axis C1 of the pipe member T with respect to the inner roller 112. The apparatus 101 is provided with the base 121. The base 121 is disposed on the horizontal face G and, thereby, it is possible to rotate the pipe member T on which the anvil ring 11 has been disposed around the axis C1 and improve the roundness of the one end T1 of the pipe member T, with the position of the inner roller 112 fixed. Further, the stiffness property of the anvil ring 11 is set sufficiently higher than the stiffness property of the pipe member T. It is, thereby, possible to reform uniformly the pipe member T along the inner circumference face 11 a of the anvil ring 11, not dependent upon initial remaining stress or deformation of the pipe member T.

[0101] In the present embodiment, as will be described hereinafter, the apparatus 101 can be changed in configuration.

[0102] For example, in an apparatus 102 of the modified example as shown in Fig. 15, the narrow radial part 141 of the supporting shaft 140 of the inner roller 112 is increased in length and the fixture frame 123 which supports the outer roller 116 is kept apart from the supporting base 122, thus making it possible to reform an axial region further behind the one end T1 of the pipe member T.

[0103] In the above configuration, the pipe member T is allowed to make a relative movement to the apparatus 102 in the axial direction as indicated by the arrow X for each axial region which can be treated by one reformation step. It is, thereby, possible to reform a range from the one end T1 to sites which are covered by the inner roller 112 and the outer roller 116. The area of the axial region to be reformed can be expanded while maintaining a constant value of the reforming load. For example, after the beginning of the reformation from the one end T1 of the pipe member T, the pipe member T is moved a distance equal to the width of the axial region to be reformed in the direction of the axis of the pipe member T with respect to the apparatus 102 fixed in place, while applying the reforming load to the pipe member T. The above procedures are repeated, thus making it possible to expand the width of the axial region to be reformed in the longitudinal direction of the pipe member without changing the value of the reforming load.

[0104] Further, the inner roller 112 is attached via the bearing 142. Therefore, the inner roller 112 is changed in diameter and the outer roller 116 is adjusted for its height by the hydraulic jack, thus making it possible to easily cope with a difference in diameter or thickness of the pipe member T.

[0105] Where the inner roller 112 is decreased further in diameter, in place of the bearing installed at the narrow radial part 141, a bearing is disposed between the supporting shaft 140 and the supporting base 122. It is, thereby, possible to support the supporting shaft itself on the supporting base 122 so as to rotate freely, with the narrow radial part given directly as an inner roller.

[0106] Next, an anvil ring 11 B which is used in the fifth embodiment of the present invention will be described with reference to Fig. 16.

[0107] Fig. 16 is a configuration diagram of the anvil ring. In this figure, (a) is a perspective view which shows an assembly state of the anvil ring, (b) is a perspective view of major parts which shows a sliding mechanism of pieces assembling the anvil ring, and (c) is a perspective view of major parts which shows a disassembled state of the adjacent pieces.

[0108] The anvil ring 11 B can be used in place of the anvil ring 11 of the apparatus used in the first embodiment to the fourth embodiment. This anvil ring is divided in the circumferential direction into a plurality of pieces 201 identical in shape (three pieces in this illustrated example). Axially rectangular recessed portions 202 which are opposed to each other at the both ends of the piece 201 are installed at the both ends thereof, thereby providing an overlapping portion 203 in which the recessed portions face in the opposite direction at the both ends. Moreover, the overlapping portions 203 of the adjacent pieces 201 are overlapped to constitute the anvil ring 11B which is constant in diameter.

[0109] The overlapping portion 203 is provided with a positioning hole 204 through which the positioning pin 210 penetrates and a long hole 205 which is longer in the circumferential direction and into which an adjustment pin 220 is inserted. In a state that the adjustment pin 220 is inserted into the long hole 205, the positioning pin 210 is kept removed, by which the pieces 201 can be retained so as to slide freely in the circumferential direction 201 only by a predetermined range regulated by the long hole 205 and the adjustment pin 220, with the pieces 201 being coupled in a ring shape. In this case, a sliding mechanism is constituted in combination of the long hole 205 with the adjustment pin 220. It is noted that a bolt is used in the positioning pin 210 and the adjustment pin 220. Moreover, a nut 221 is screwed with the tip of the bolt, thus making it possible to prevent removal of the positioning pin 210 and the adjustment pin 220 and also tighten

them. The positioning pin 210 fixes the shape of the anvil ring 11 B after assembly of the anvil ring 11 B.

[0110] As described so far, where the anvil ring 11 B (division type) is used, time necessary for attachment and detachment can be shortened. Further, the pieces 201 are allowed to slide by the adjustment pin 220, thus making it possible to increase the diameter of the anvil ring 11 B. It is, therefore, possible to easily move the anvil ring 11 B on attachment, detachment or change in position of the anvil ring 11 B.

[0111] As described so far, according to the thus constituted apparatus of the present embodiment, it is possible to improve the roundness of the one end T1 of the pipe member T in simple configuration and in a shorter period of time.

[0112] A detailed description of the first embodiment to the fifth embodiment of the present invention has been given with reference to the drawings. A specific configuration shall not be, however, limited to these embodiments, and modifications of configurations within a scope not departing from the gist of the present invention are included in the present invention. As a matter of course, the configurations of these embodiments can be utilized in an appropriate combination.

[0113] For example, from the first embodiment to the third embodiment, a description has been given of a case where an axial region is the one end T1 of the pipe member T. However, the axial region shall not be limited to the one end T1 of the pipe member T but may include any part such as a center part of the pipe member T in a direction of the axis C1. There is no particular restriction on a material which constitutes the pipe member T including iron, steel, copper, brass and aluminum.

[0114] Further, in the first embodiment and the second embodiment, the inner diameter of the anvil ring 11 is set slightly smaller than the outer diameter of the pipe member T. It is, however, acceptable that the inner diameter of the anvil ring 11 is set to be larger than the outer diameter of the pipe member T. In this case, when the pipe member T is reformed, the roundness is improved so that the one end T1 is increased in diameter.

[0115] Still further, in the first embodiment to the fourth embodiment, the hydraulic jacks 13, 113 have been used as a pressing unit. However, the pressing unit shall not be limited to the hydraulic jack but may include a motor-equipped electric jack.

[0116] In addition, in the first embodiment to the fourth embodiment, there is no restriction on the number of the inner rollers 12, 112 installed on the pipe member reformation apparatus and three or more rollers may be installed. In the first embodiment and the second embodiment, it is acceptable that, with no roller driving motor 17 or the roller driving motor 32 being installed, the pipe member T is rotated around the axis C1 by the use of an external force.

(Experiment)

[0117] Experiment results obtained by reforming the one end T1 of the pipe member T by using the apparatus 101 of the fourth embodiment will be described.

[0118] The following are specifications of major constituents of the apparatus 101 as well as a specification of the pipe member T used in the experiment.

anvil ring 11: inner diameter of 461 mm; outer diameter of 700 mm
·Inner roller 112: outer diameter of 225 mm
·Outer roller 116: outer diameter of 540 mm
·Pipe member T: API (American Petroleum Institute) 5L x-65 (UOE steel pipe) Outer diameter of 18 inches (457.2 mm); thickness of 17.5 mm
Roundness of one end T1, 1.0 mm or more
·Pressing width of the pipe member T (length in the direction of the axis C1) by the anvil ring 11 and the inner roller 112: 120 mm

(Experiment procedures)

[0119] An upward pressing force by the hydraulic jack 113 was changed from 100 tons (9.8×10^5N) to 140 tons.

[0120] The number of rotations used to rotate the pipe member T around the axis C1 was fixed at 5 times.

[0121] As described previously, the roundness means a difference between the maximum outer diameter and minimum outer diameter of the one end T1. An allowance of roundness of the pipe member T is 0.01 times the outer diameter, which is about 4.6 mm in the case of an outer diameter of 18 inches.

(Experiment results)

[0122] The experiment results are shown in Fig. 17. In Fig. 17, a horizontal axis indicates a pressing force by the hydraulic jack 113, while a longitudinal axis indicates roundness after the pipe member T was rotated 5 times.

[0123] It has been found from the results that when the pressing force is set to be 130 tons or more, the roundness of the one end T1 can be improved to 0.6 mm or less.

Industrial Applicability

[0124] The present invention relates to an apparatus capable of reforming a pipe member by improving the roundness of an axial region which is at least a part of the pipe member in the axial direction. The present invention is able to improve the roundness of the axial region of the pipe member in a short period of time.

Description of Reference Numerals

[0125]

1, 2, 3, 4, 5, 6, 101, 102:	apparatus for reforming pipe member
11, 11B:	anvil ring
11a:	inner circumference face
12, 112:	inner roller
13, 113:	hydraulic jack (pressing unit)
15, 31, 41, 115:	rotation unit
16, 116:	outer roller
17, 32, 114:	roller driving motor
18, 118:	guide roller
21:	base
51:	pressing unit
117:	accumulator (constant-pressure control unit)
201:	pieces
203:	overlapping portion
205:	long hole (sliding mechanism)
210:	positioning pin
220:	adjustment pin (sliding mechanism)
C1:	axis
T:	pipe member
T1:	one end (axial region)

Claims

1. An apparatus of reforming a pipe member by improving the roundness of an axial region of the pipe member which is at least a part of the pipe member in a direction of an axis of the pipe member, the apparatus comprising:

an anvil ring which is disposed on an outside of the pipe member so that a circularly-formed inner circumference face of the anvil ring is opposed to an outer circumference face of the axial region of the pipe member;

an inner roller which is disposed on an inside of the pipe member so that an outer circumference face of the inner roller is in contact with an inner circumference face of the axial region of the pipe member;
a pressing unit configured to apply a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member, thereby causing plastic deformation at the axial region of the pipe member by using the inner circumference face of the anvil ring as a reforming face; and
a rotation unit configured to rotate the pipe member with respect to the inner roller around the axis of the pipe member.

2. The apparatus according to claim 1, wherein
the pressing unit configured to press the inner roller to the inner circumference face of the pipe member toward the anvil ring, thereby applying a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member.

3. The apparatus according to claim 2, wherein
the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the anvil ring.

4. The apparatus according to claim 3, wherein
the rotation unit comprises:

an outer roller in which a rotation axis of the outer roller is parallel with an axis of the anvil ring and an outer circumference face of the outer roller is in contact with the outer circumference face of the anvil ring, and which is disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller; and
a roller driving motor configured to rotate the outer roller around the rotation axis of the outer roller.

5. The apparatus according to claim 3, wherein
the rotation unit comprises:

a pair of outer rollers in which a rotation axis of each of the outer rollers is parallel with an axis of the anvil ring and an outer circumference face of each of the outer rollers is in contact with the outer circumference face of the anvil ring, and which are disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller so as to separate from each other in a circumferential direction of the anvil ring; and
a roller driving motor configured to rotate the pair of outer rollers around the rotation axis of each of the outer rollers in the same direction.

6. The apparatus according to claim 4 or claim 5, wherein
the rotation unit comprises
a guide roller in which a rotation axis of the guide roller is parallel with the axis of the anvil ring and an outer circumference face of the guide roller is in contact with the outer circumference face of the anvil ring, and which is configured to guide the pipe member and the inner roller so as to make a relative rotation around the axis of the pipe member, wherein
the guide roller is installed on the rotation unit with the outer rollers.

7. The apparatus according to claim 4 or claim 5 further comprising
a base configured to support the inner roller and the outer rollers so as to rotate around the rotation axis of each of the rollers and to which the pressing unit and the roller driving motor are installed.

8. The apparatus according to claim 2, wherein
the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the inner roller.

9. The apparatus according to any one of claim 1 to claim 8, wherein
the apparatus is provided with a plurality of the inner rollers, wherein the axis of the pipe member given as a symmetrical axis of the inner rollers.

10. The apparatus according to claim 1, wherein
the pressing unit is configured to press the anvil ring to the outer circumference face of the pipe member toward the inner roller, thereby applying a pressure contact force between the inner circumference face of the anvil ring and

the outer circumference face of the pipe member.

11. The apparatus according to claim 10, wherein
the rotation unit is configured to apply a driving force to rotate the pipe member around the axis of the pipe member to the pipe member via the anvil ring.

12. The apparatus according to claim 11, wherein
the rotation unit comprises:

an outer roller in which a rotation axis of the outer roller is parallel with an axis of the anvil ring and an outer circumference face of the outer roller is in contact with the outer circumference face of the anvil ring, and which is disposed on an outside of the anvil ring in a radial direction of the anvil ring with respect to the inner roller; and
a roller driving motor configured to rotate the outer roller around the rotation axis of the outer roller.

13. The apparatus according to claim 12, wherein
the pressing unit is configured to press the anvil ring via the outer roller to the outer circumference face of the pipe member toward the inner roller.

14. The apparatus according to claim 12 or claim 13, wherein
the rotation unit comprises
a guide roller in which a rotation axis of the guide roller is parallel with the axis of the anvil ring and an outer circumference face of the guide roller is in contact with the outer circumference face of the anvil ring, and which is configured to guide the pipe member and the inner roller so as to make a relative rotation around the axis of the pipe member, wherein
the guide roller is installed on the rotation unit with the outer rollers.

15. The apparatus according to any one of claim 1 to claim 14, further comprising
a constant-pressure control unit configured to control a pressing force of the pressing unit to a constant level not dependent upon a change in thickness of the pipe member.

16. The apparatus according to any one of claim 1 to claim 15, wherein
the anvil ring is dividable into a plurality of anvil rings in a circumferential direction of the anvil ring.

17. The apparatus according to claim 16, wherein
the anvil ring is divided into a plurality of pieces in a circumferential direction of the anvil ring, and a positioning pin is allowed to penetrate through an overlapping portion formed to an end of each of pieces adjacent to each other, thereby coupling the pieces adjacent to each other to assemble the anvil ring which is constant in diameter, and
a sliding mechanism configured to support the pieces so as to slide freely only by a predetermined range in the circumferential direction of the anvil ring, with the positioning pin kept removed, is installed between the overlapping portions of the pieces.

18. A method of reforming a pipe member by improving the roundness of an axial region of a pipe member which is at least a part of the pipe member in a direction of an axis of the pipe member, the method comprising:

disposing an anvil ring on an outside of the pipe member so that an inner circumference face of the anvil ring which is formed in a ring shape and has the circular inner circumference face is opposed to an outer circumference face of an axial region of the pipe member;
disposing an inner roller on an inside of the pipe member so that an outer circumference face of the anvil ring is in contact with the inner circumference face of the axial region of the pipe member;
applying a pressure contact force between the inner circumference face of the anvil ring and the outer circumference face of the pipe member, thereby causing plastic deformation at the axial region of the pipe member by using the inner circumference face of the anvil ring as a reforming face; and
rotating the pipe member with respect to the inner roller around the axis of the pipe member.

19. The method according to claim 18, further comprising
moving the pipe member with respect to the anvil ring and the inner roller in the direction of the axis of the pipe member, thereby shifting a position of the axial region to be reformed.

FIG. 1

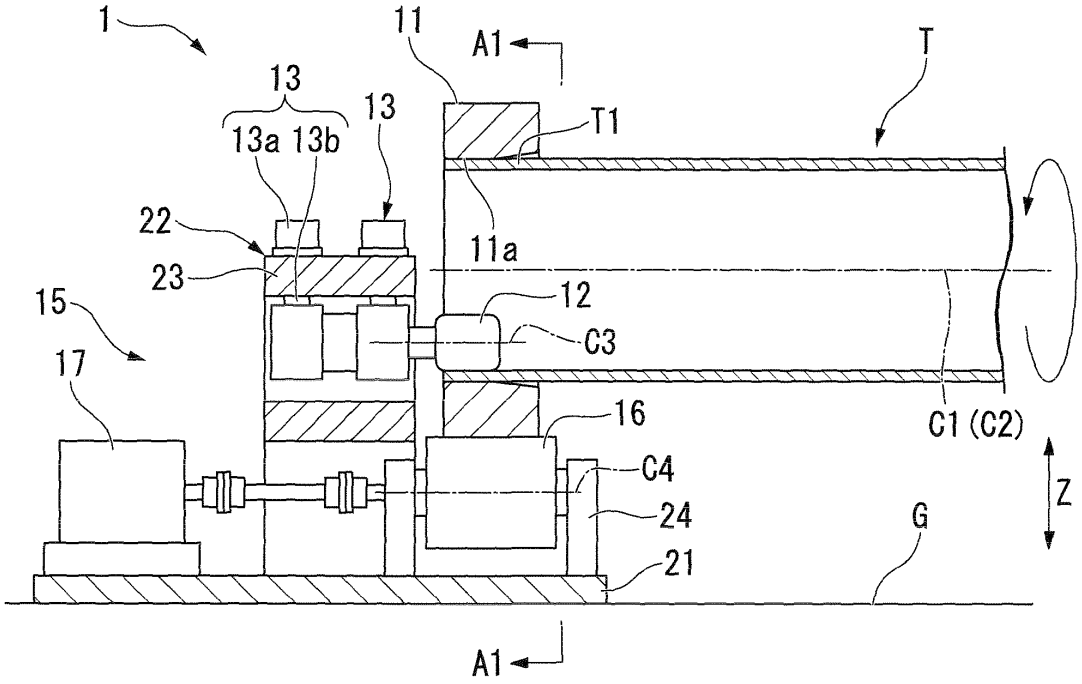

1
11
A1
T
13
13a 13b
13
T1
22
11a
23
12
15
C3
17
16
C1 (C2)
C4
Z
24
G
21
A1

FIG. 2

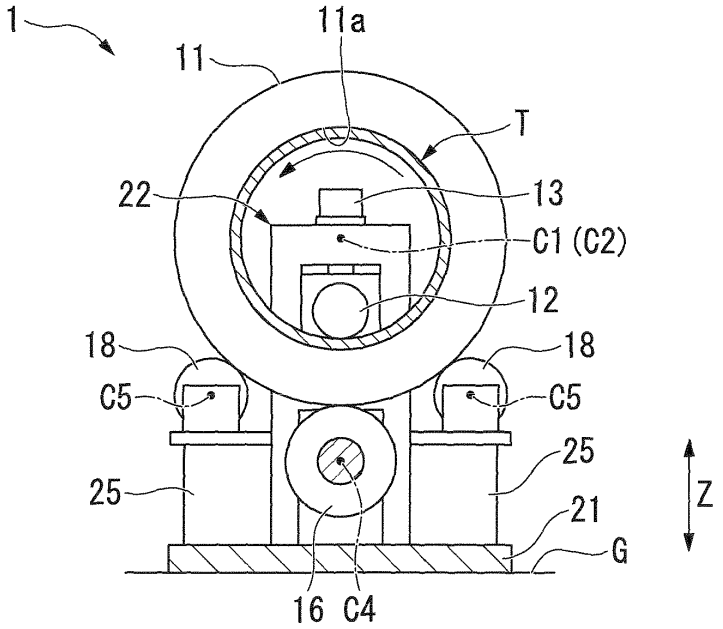

1
11a
11
T
22
13
C1 (C2)
12
18
18
C5
C5
25
25
Z
21
G
16
C4

FIG. 3

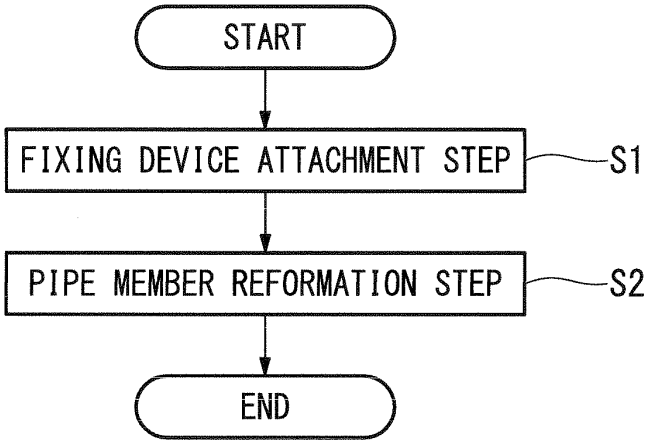

START
FIXING DEVICE ATTACHMENT STEP
S1
PIPE MEMBER REFORMATION STEP
S2
END

FIG. 4

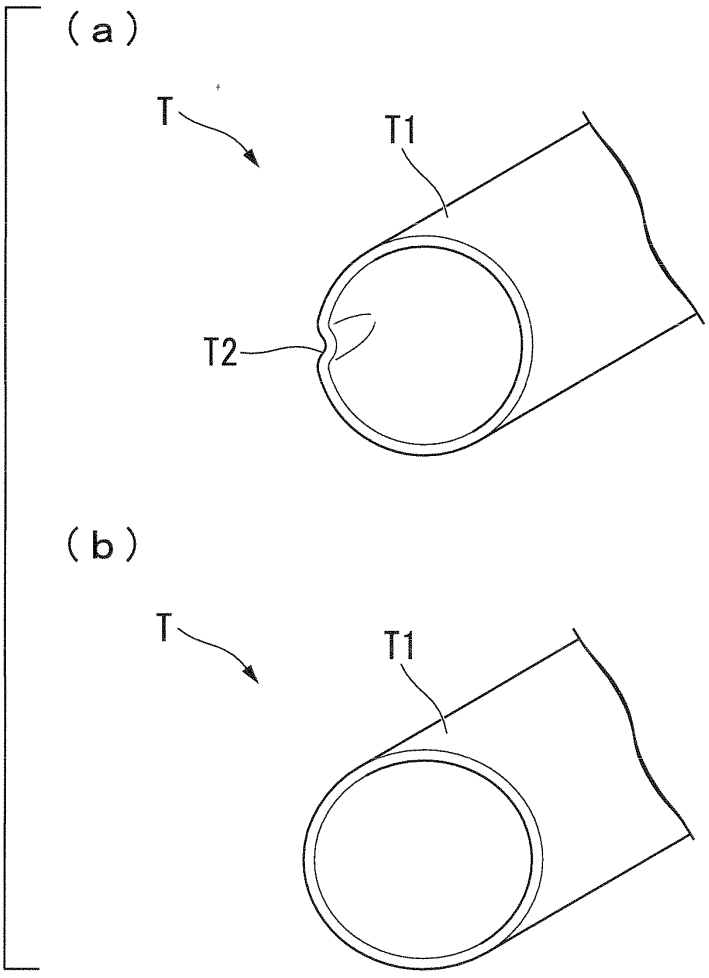

(a)
T
T1
T2
(b)
T
T1

FIG. 5

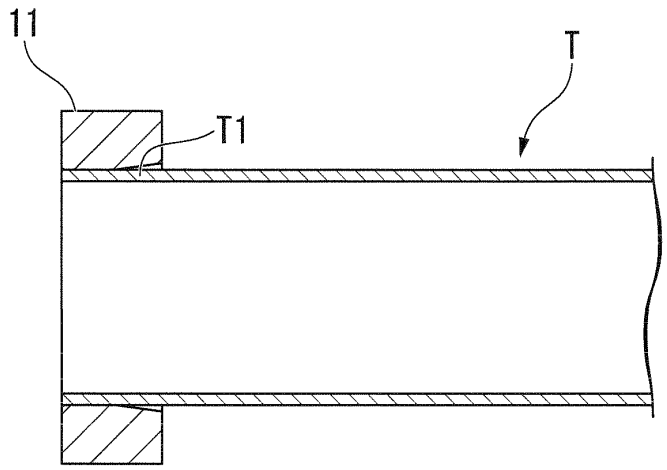


FIG. 6

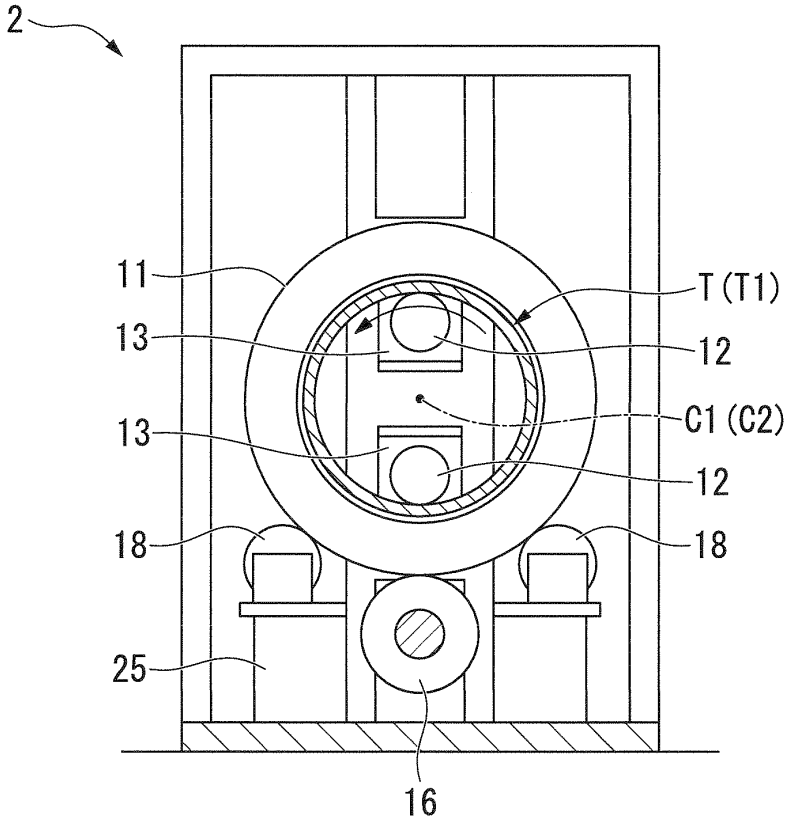


FIG. 7

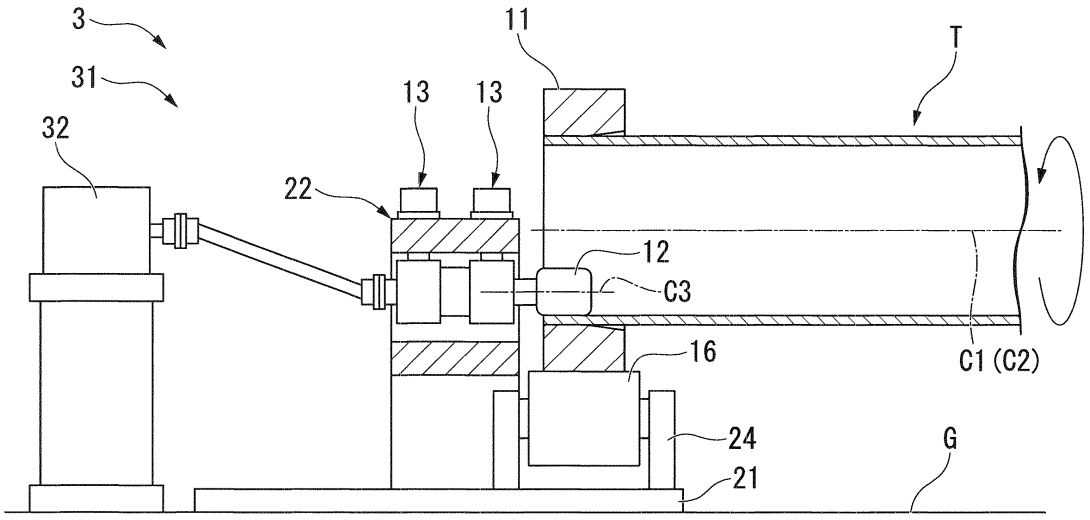


FIG. 8

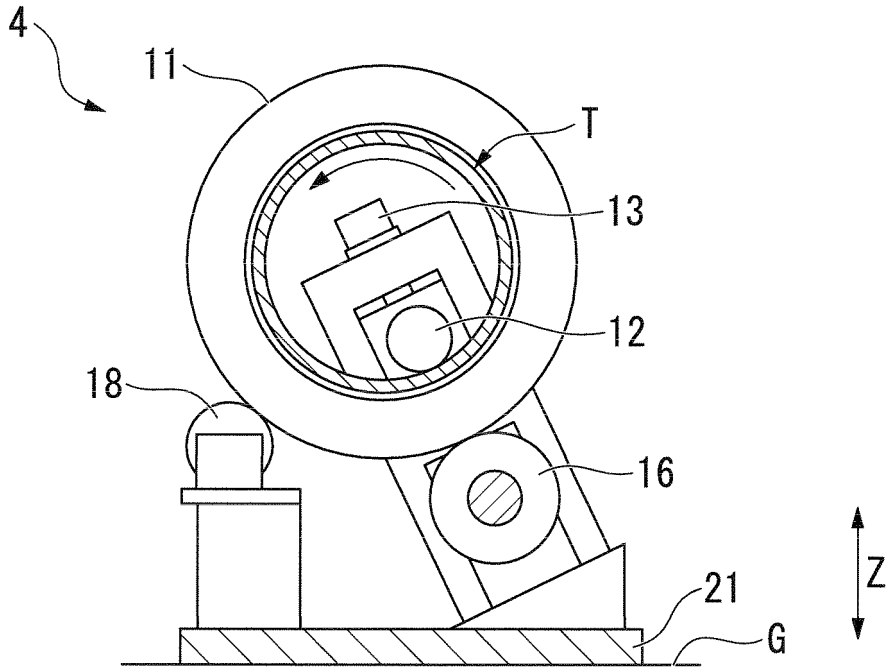


FIG. 9

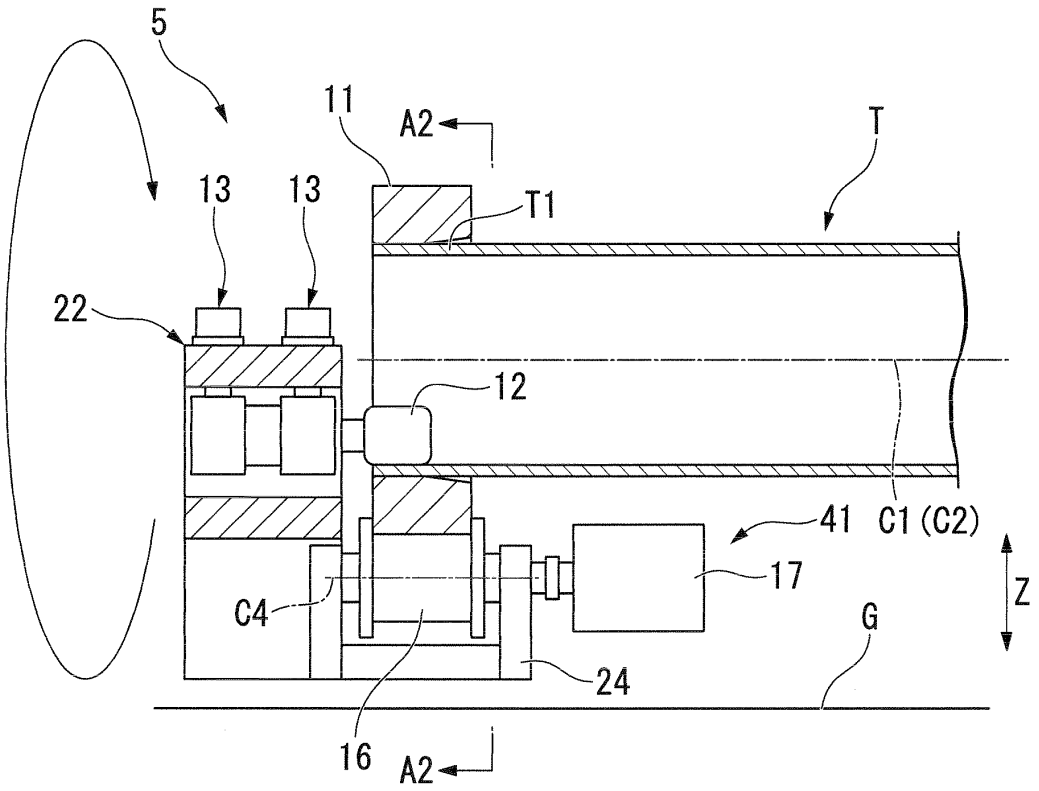

5
11
A2
T
13
13
T1
22
12
41
C1 (C2)
17
Z
C4
G
24
16
A2

FIG. 10

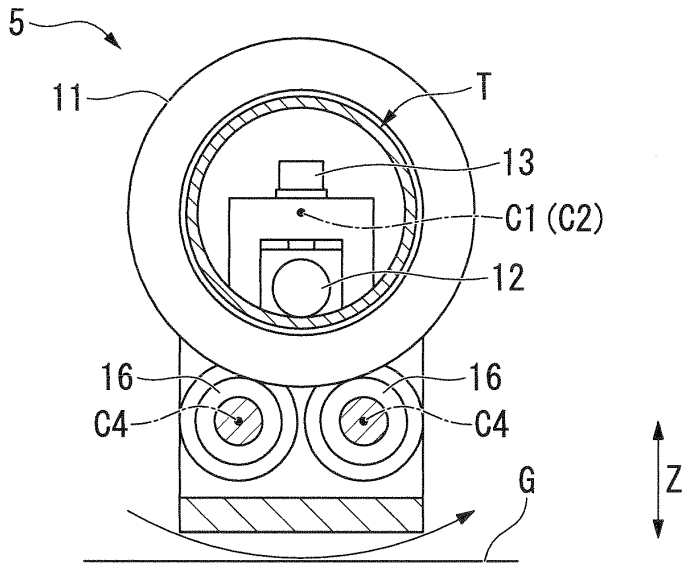

5
11
T
13
C1 (C2)
12
16
16
C4
C4
G
Z

FIG. 11

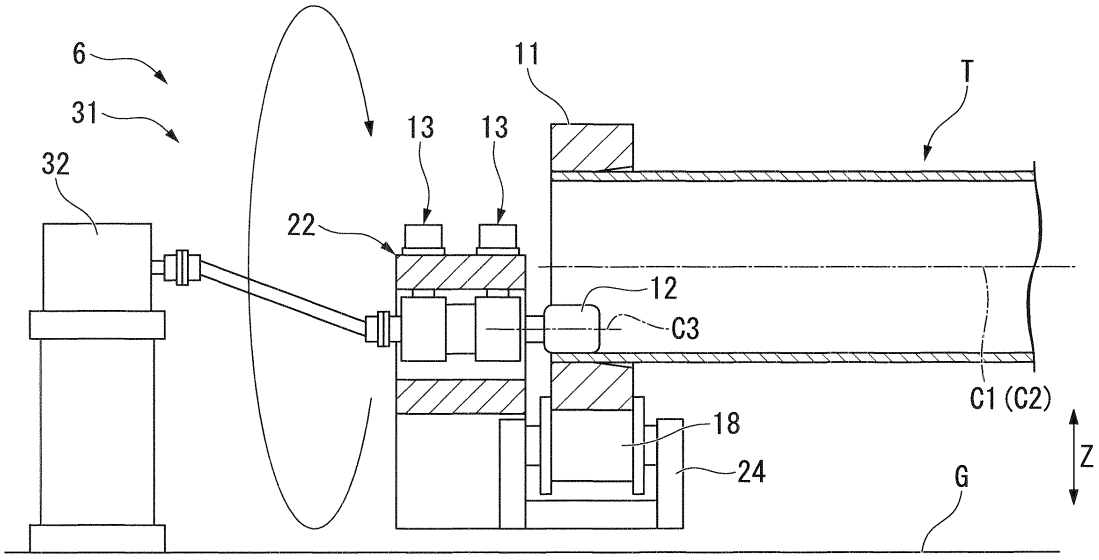


FIG. 12

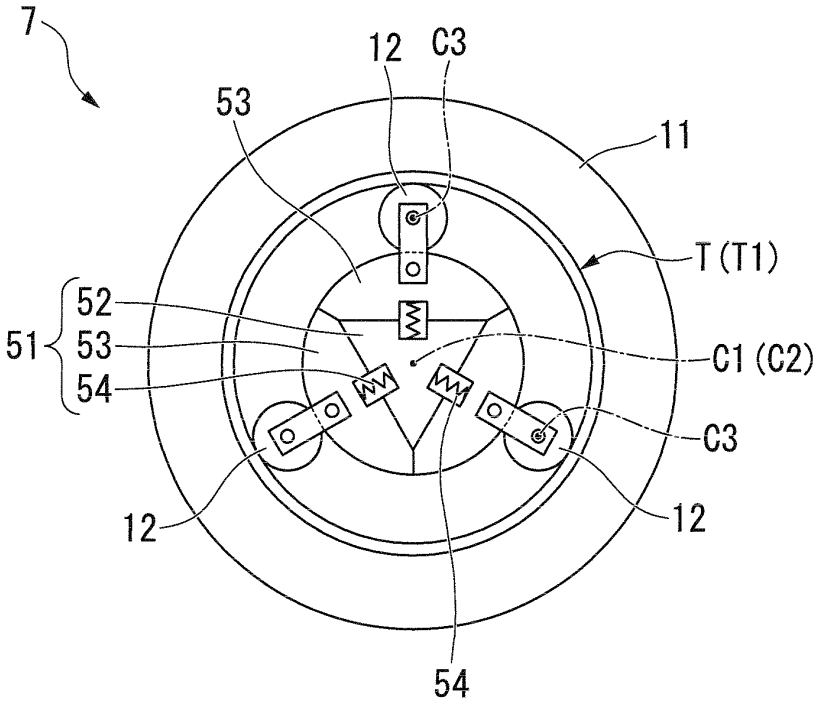

7
12
C3
53
11
T (T1)
52
51
53
54
C1 (C2)
C3
12
12
54

FIG. 13

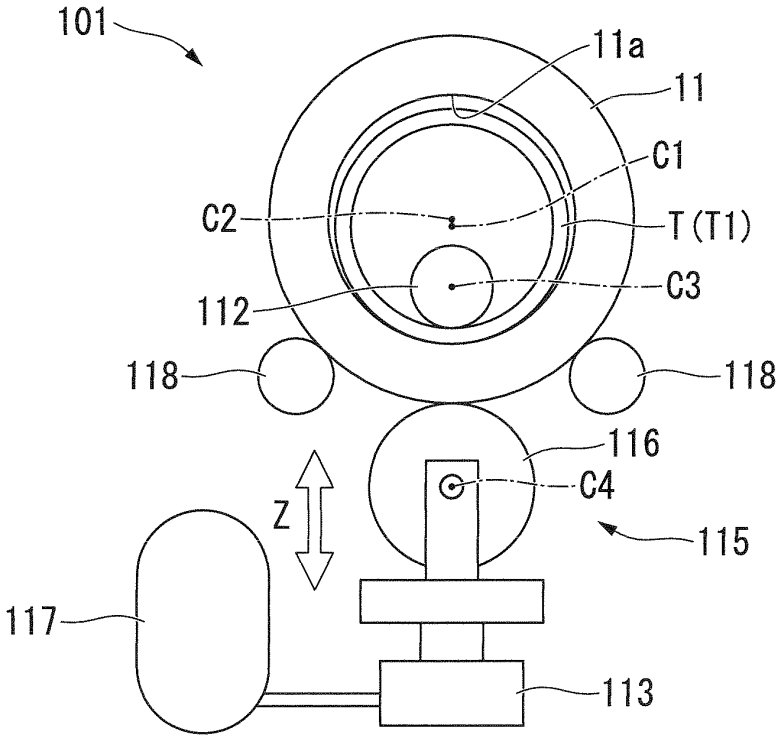

101
11a
11
C1
C2
T (T1)
C3
112
118
118
116
C4
Z
115
117
113

FIG. 14

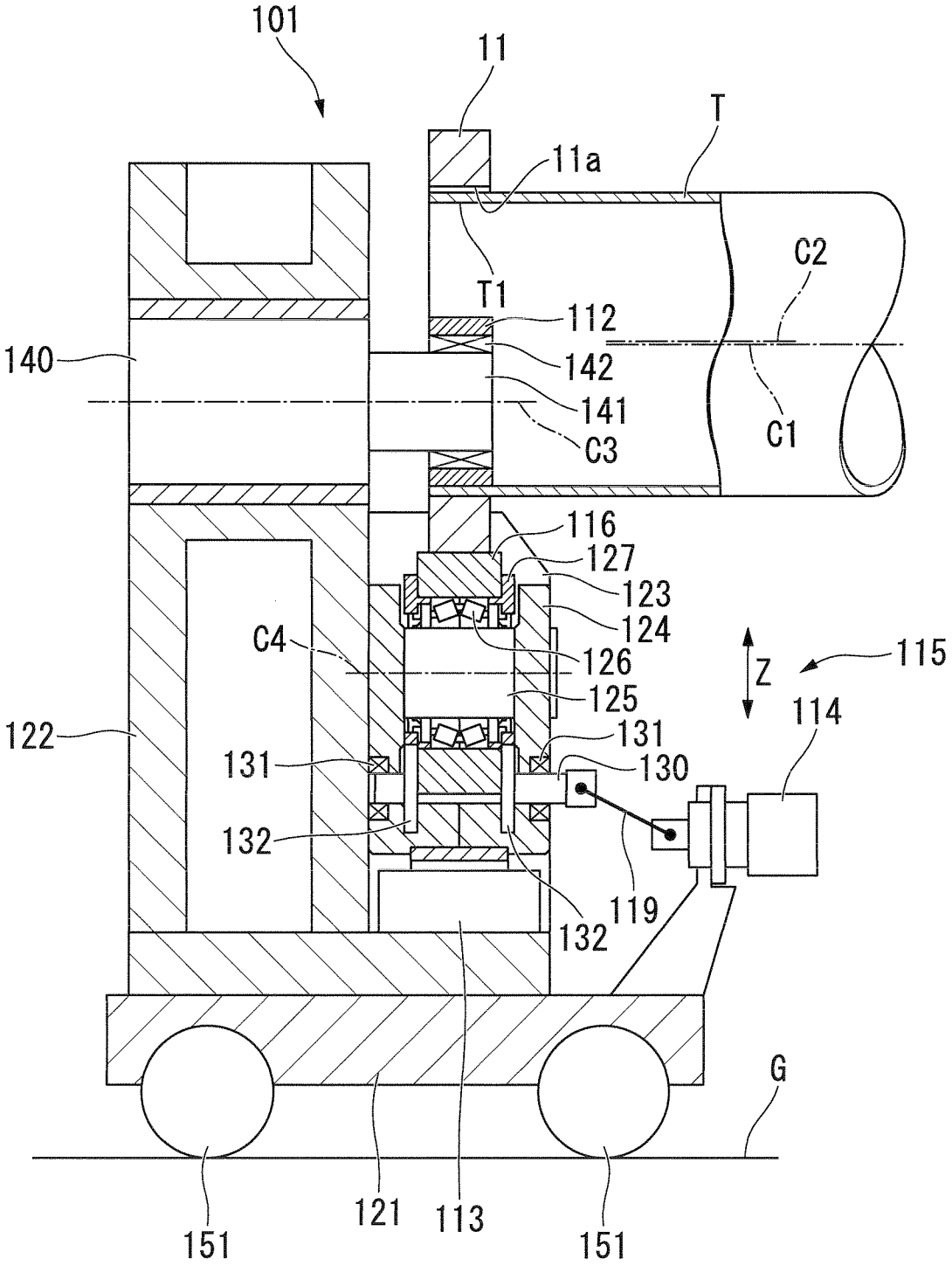

101
11
T
11a
T1
112
142
141
C3
C2
C1
140
116
127
123
124
126
125
C4
122
131
131
130
132
132
119
114
115
Z
G
151
121
113
151

FIG. 15

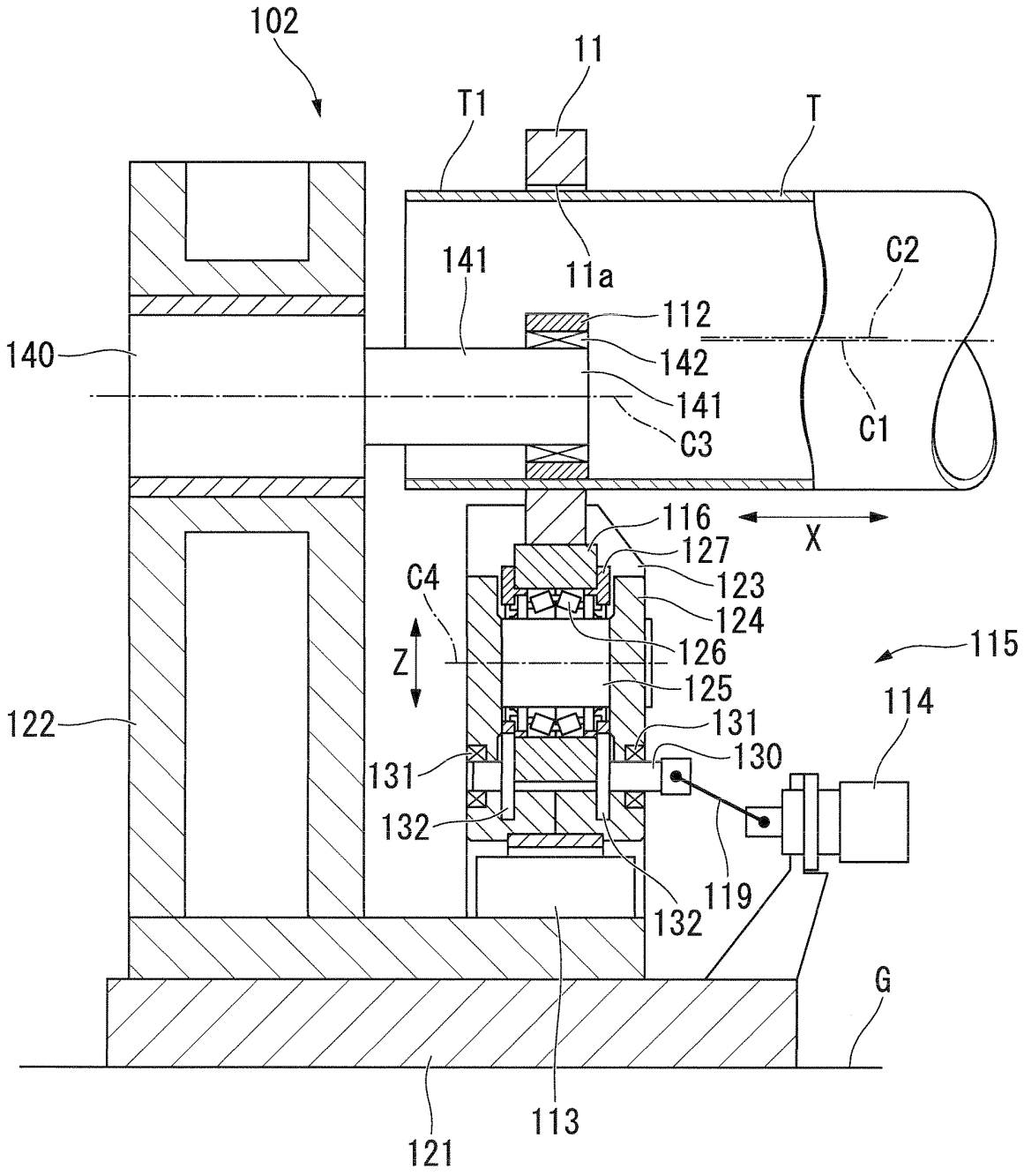

102
11
T1
T
141
11a
C2
112
140
142
141
C3
C1
116
X
127
C4
123
124
Z
126
115
125
122
131
114
131
130
132
119
132
G
113
121

FIG. 16

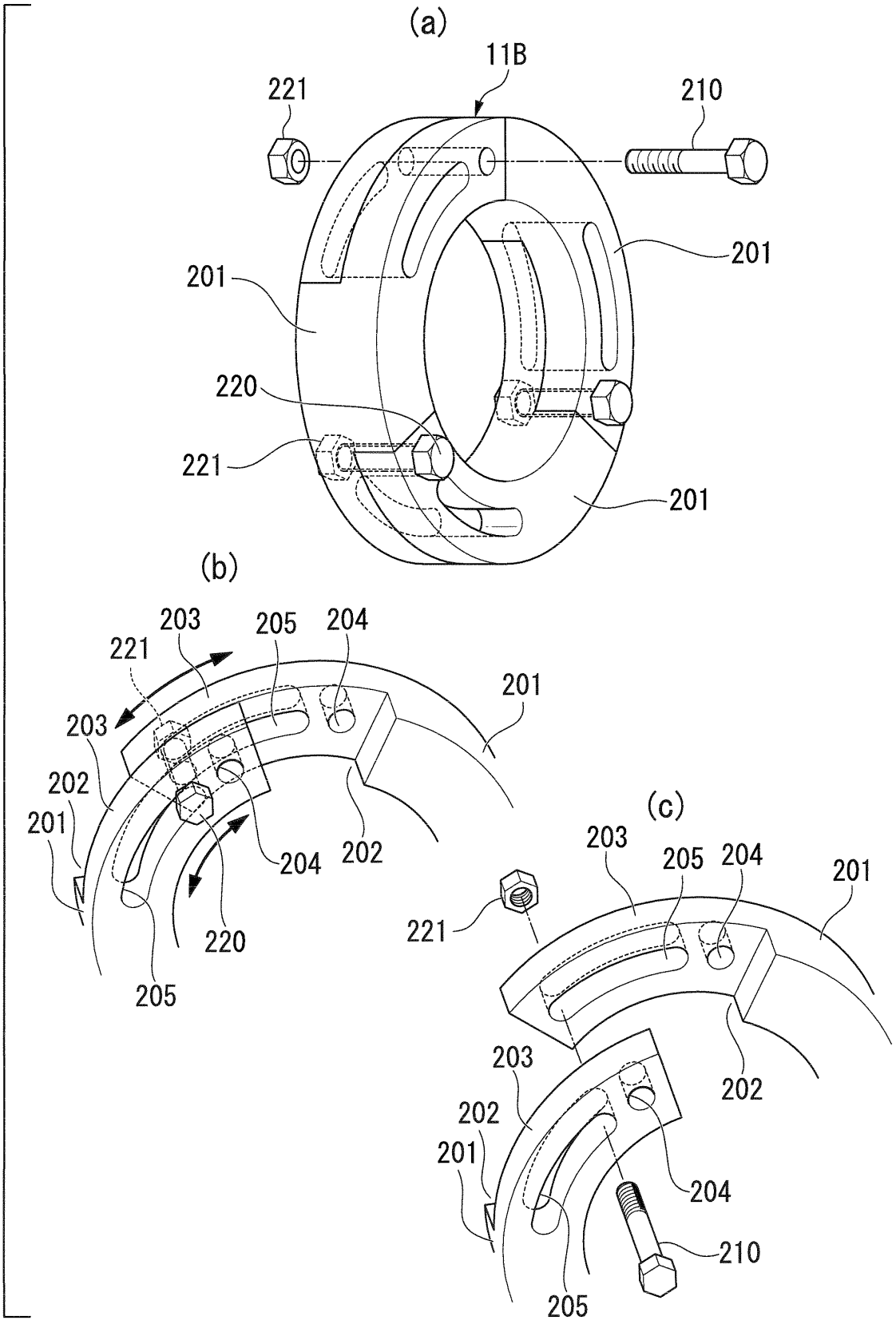
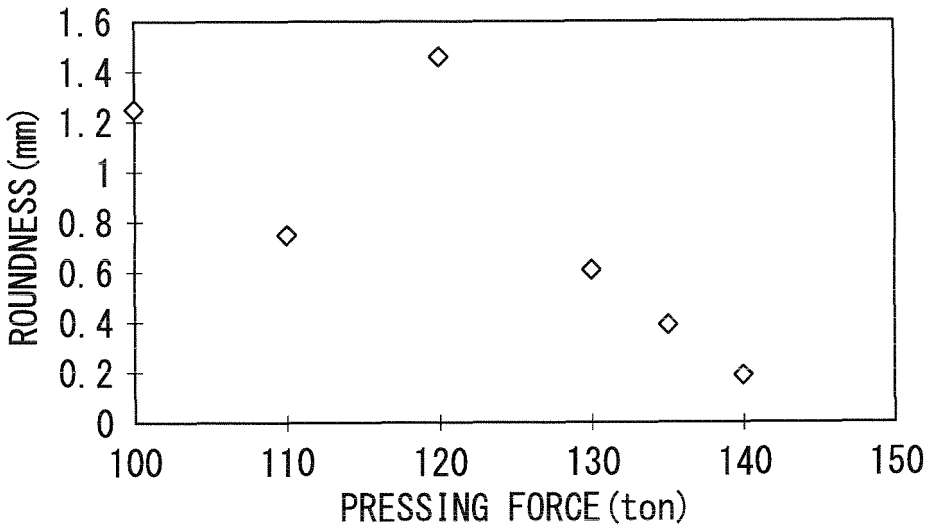

(a)
11B
221
210
201
201
220
221
201
(b)
203
205
204
221
201
203
202
201
204
202
220
205
(c)
203
205
204
201
221
202
203
202
201
204
210
205

FIG. 17


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
ROUNDNESS(mm)
100
110
120
130
140
150
PRESSING FORCE(ton)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/059528

A. CLASSIFICATION OF SUBJECT MATTER
B21D3/14(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21D3/14, B21H5/02

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 20913/1982(Laid-open No. 125617/1983) (Tetsuo TANAKA), 26 August 1983 (26.08.1983), entire text; all drawings (Family: none)	1-14,16,18, 19 15,17
Y A	JP 2004-258027 A (Showa Denko Kabushiki Kaisha), 16 September 2004 (16.09.2004), entire text; all drawings & US 2005/0050745 A1 & WO 2004/025214 A1 & CN 101135557 A & AU 2003268643 A	1-14,16,18, 19 15,17

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

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"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
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"&" document member of the same patent family

Date of the actual completion of the international search 28 June, 2012 (28.06.12)	Date of mailing of the international search report 10 July, 2012 (10.07.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/059528

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 4-237534 A (Toyota Motor Corp.), 26 August 1992 (26.08.1992), paragraph [0015]; fig. 1 (Family: none)	1-14,16,18, 19 15,17
Y	JP 54-17352 A (Kyowa Metal Works, Ltd.), 08 February 1979 (08.02.1979), page 4, lower right column, line 18 to page 5, lower left column, line 20 (Family: none)	16
Y	JP 2010-149128 A (Aisin AW Co., Ltd.), 08 July 2010 (08.07.2010), paragraphs [0042] to [0043]; fig. 7 (Family: none)	19

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011086185 A **[0002]**
- JP 2012084810 A **[0002]**
- JP S6045013 B **[0009]**