



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

(43) Date of publication:
05.08.2020 Bulletin 2020/32

(51) Int Cl.:
F28G 3/14 (2006.01) **B08B 9/023** (2006.01)
F22B 37/48 (2006.01) **F23J 3/00** (2006.01)

(21) Application number: **18866120.1**

(86) International application number:
PCT/JP2018/037865

(22) Date of filing: **11.10.2018**

(87) International publication number:
WO 2019/074039 (18.04.2019 Gazette 2019/16)

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

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(30) Priority: **12.10.2017 JP 2017198620**

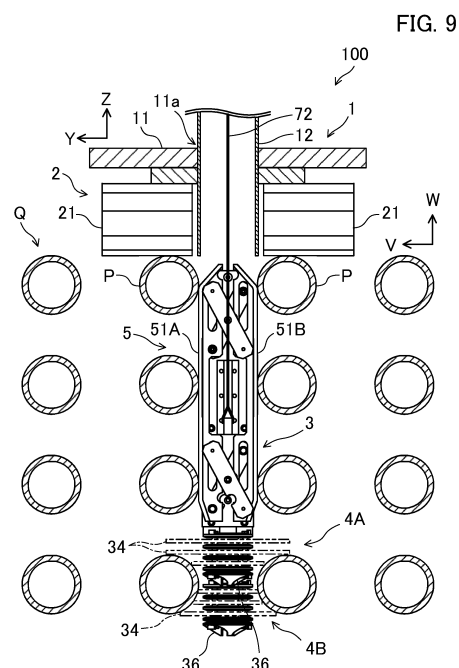
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(54) **CLEANING MECHANISM AND CLEANING APPARATUS PROVIDED WITH SAME**

(57) A cleaning mechanism 3 cleans the surfaces of pipes P included in a pipe group Q while traveling in the pipe group Q. The cleaning mechanism 3 includes: a rotating shaft 32 configured to rotate about a predetermined rotation axis A; and scrapers 34 configured to contact the surfaces of the pipes P to thereby remove deposits on the surfaces of pipes P. The scrapers 34 are coupled to the rotating shaft 32 to expand radially outward about the rotation axis A by a centrifugal force of the rotation shaft 32. While passing by the pipes P, the scrapers 34 contact the surfaces of the pipes P while changing radial expansion in conformity with the surface shapes of the pipes P.



Description

FIELD

[0001] The technique disclosed here relates to a cleaning mechanism and a cleaning apparatus provided with the same.

BACKGROUND

[0002] There has been known a cleaning mechanism configured to remove deposits deposited on the surfaces of pipes such as boiler pipes. Patent Document 1, for example, describes a cleaning mechanism configured to remove deposits by striking a pipe with a striking arm.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Patent Application Publication No. 11-237199

SUMMARY

TECHNICAL PROBLEM

[0004] However, in a case where deposits are firmly deposited on pipes, for example, it is difficult to sufficiently remove deposits on the pipes only by striking the pipes as described above.

[0005] The technique disclosed here has been made in view of the foregoing circumstances, and has an object of sufficiently removing deposits on the surface of a pipe.

SOLUTION TO PROBLEM

[0006] A cleaning mechanism disclosed here is a cleaning mechanism configured to clean the surface of a pipe included in a pipe group while traveling in the pipe group. The cleaning mechanism includes: a rotation shaft configured to rotate about a predetermined rotation axis; and a cleaner configured to remove a deposit on a surface of the pipe by contact with the surface of the pipe. The cleaner is coupled to the rotation shaft to expand radially outward about the rotation axis by a centrifugal force of the rotation shaft. When the cleaning mechanism passes by the tube, the cleaners are brought into contact with the surface of the pipe while changing radial expansion in conformity with a surface shape of the tube.

[0007] The term "contact with the surface of a pipe" here includes not only a direct contact with the pipe but also an indirect contact with the pipe. For example, in a case where hard clinkers or the like that cannot be fully removed remain on the surface of a pipe, the term includes an indirect contact with the surface of the pipe through the clinkers or the like. The same holds hereinafter.

[0008] A cleaning mechanism disclosed here is a cleaning mechanism configured to clean a surface of a pipe included in a pipe group while traveling in the pipe group. The cleaning mechanism includes: a rotation shaft configured to rotate about a predetermined rotation axis; and a contact part configured to contact the surface of the pipe to thereby remove a deposit on the surface of the pipe. The contact part is coupled to the rotation shaft such that the contact part expands radially outward about the rotation axis by a centrifugal force of the rotation shaft, and contacts the surface of the pipe while changing radial expansion of the contact part in conformity with a surface shape of the pipe when the contact part passes by the pipe.

ADVANTAGES OF INVENTION

[0009] The cleaning mechanism is capable of sufficiently removing deposits on the surface of a pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a side view of a cleaning apparatus.

FIG. 2 is a front view of the cleaning apparatus.

FIG. 3 is a view of the cleaning mechanism seen in a Y-axis direction.

FIG. 4 is a cross-sectional view of a cleaning unit taken along line S-S in FIG. 3 in a state where scrapers are housed.

FIG. 5 is a cross-sectional view of the cleaning unit taken along line S-S in FIG. 3 in a state where the scraper expand.

FIG. 6 is a view of the cleaning mechanism seen in an X-axis direction in a state where a guide retracts. FIG. 7 is a view of the cleaning mechanism seen in the X-axis direction in a state where the guide expands.

FIG. 8 is a cross-sectional view of a first blade taken in T-T line in FIG. 7.

FIG. 9 is a view of a state where the cleaning mechanism cleans pipes seen in the X-axis direction.

FIG. 10 is a view of the cleaning apparatus moving in parallel with pipes seen in the X-axis direction.

FIG. 11 is a view of the cleaning apparatus moving in parallel with pipes seen in a Z-axis direction.

FIG. 12 is a view of the cleaning apparatus turning on pipes seen in the X-axis direction.

FIG. 13 is a view of the cleaning apparatus turning on pipes seen in the Z-axis direction.

DESCRIPTION OF EMBODIMENTS

[0011] An exemplary embodiment will be described in detail hereinafter with reference to the drawings.

[0012] A cleaning apparatus 100 according to an embodiment cleans deposits deposited on the surfaces of

pipes included in a pipe group. In this embodiment, a case where the cleaning apparatus 100 cleans heat exchanger pipes of a boiler will be described. FIG. 1 is a side view of the cleaning apparatus 100. FIG. 2 is a front view of the cleaning apparatus 100, and is partially a cross-sectional view.

[0013] The boiler includes a pipe group Q (see FIG. 2) formed by a plurality of pipes P. In the pipes P, fluid such as water is distributed. The pipes P are heat exchanger pipes and perform heat exchange with heat generated in a combustion chamber of the boiler. The plurality of pipes P extend in a horizontal direction and are arranged in the horizontal direction and a vertical direction. That is, in the pipe group Q, a plurality of pipes P are arranged in parallel in the horizontal direction, and the plurality of pipes P are arranged in parallel in the vertical direction.

[0014] In some cases, one pipe P and another pipe P are connected to each other at their ends to form one pipe. Specifically, in the pipe group Q, a single pipe extends in the horizontal direction and then turns back and extends in the horizontal direction again in one case, or in another case, a single pipe extends in the horizontal direction and then turns back and extends in the horizontal direction again repeatedly to thereby meander as a whole. In this description, even in such cases, each portion extending in the horizontal direction will be regarded as a single pipe P. Thus, even for a pipe that is actually continuous, a plurality of portions of the pipe extending in the horizontal direction will be referred to as a plurality of pipes P.

[0015] In the boiler, ashes generated by combustion can be deposited on pipes P. Part of the ashes is melted to become clinkers. In such a manner, deposits such as ashes and clinkers deposited on the surfaces of the pipes P. The deposits herein are not limited to those in direct contact with the surfaces of the pipes P and include those stacked on deposits in direct contact with the surfaces of the pipes P. For example, the deposits include not only ashes in direct contact with the surfaces of pipes P but also ashes deposited on the ashes in direct contact with the surfaces of the pipes P.

[0016] The cleaning apparatus 100 is placed on at least two pipes P arranged in the horizontal direction. The cleaning apparatus 100 includes an apparatus body 1, a traveling mechanism 2 provided to the apparatus body 1 and configured to travel on at least two pipes P, and a cleaning mechanism 3 configured to move downward from the apparatus body 1 and upward to the apparatus body 1 and clean deposits on the surfaces of pipes P below the traveling mechanism 2. The cleaning apparatus 100 may include an elevation mechanism 7 that moves the cleaning mechanism 3 downward from the traveling mechanism 2 and upward to the traveling mechanism 2. The cleaning apparatus 100 may include a body controller 8 configured to control the cleaning apparatus 100. The cleaning apparatus 100 may include an external controller 9 that is operated by an operator when the operator inputs an instruction. The cleaning apparatus 100

causes the elevation mechanism 7 to move the cleaning mechanism 3 downward and upward between two pipes P on which the traveling mechanism 1 is placed to clean deposits deposited on the two pipes P and pipes P arranged below the two pipes P. FIG. 2 does not show the elevation mechanism 7, the body controller 8, and the external controller 9.

[0017] For convenience of description, an X axis, a Y axis, and a Z axis that are orthogonal to one another with respect to the cleaning apparatus 100 are defined. The X axis is defined in the traveling direction of the cleaning apparatus 100 (i.e., the traveling direction of the traveling mechanism 2), the Z axis is defined in an up-and-down direction of the cleaning apparatus 100 (e.g., a raising-and-lowering direction of the elevation mechanism 7), and the Y axis is defined in the width direction of the cleaning apparatus 100 (e.g., the direction orthogonal to both of the traveling direction and the up-and-down direction).

[0018] An U axis, a V axis, and a W axis that are orthogonal to one another with respect to the pipe group Q are defined. The U axis is defined in the direction in which pipes P extend, the V axis is defined in a horizontal direction orthogonal to the U axis, and the W axis is defined in a vertical direction orthogonal to the U axis.

[0019] The apparatus body 1 includes a flat-plate base 11 expanding in an XY plane, and a case 12 provided on the base 11 and configured to house the cleaning mechanism 3. An opening 11a (see FIG. 2) is formed substantially at the center of the base 11 and penetrates the base 11. The case 12 is formed into a rectangular cylindrical shape having a substantially rectangular cross section whose longitudinal direction is the X-axis direction. The case 12 penetrates the opening 11a of the base 11. The apparatus body 1 includes a plurality of sensors (not shown) configured to detect pipes P.

[0020] The traveling mechanism 2 includes two crawlers 21 attached to the lower surface of the base 11. The crawlers 21 are configured to travel in the X-axis direction. That is, the rotation axes of driving wheels of the crawlers 21 extend in the Y-axis direction. The two crawlers 21 are disposed in the Y-axis direction with the opening 11a of the base 11 interposed therebetween.

[0021] The cleaning mechanism 3 includes a frame 31 (see FIG. 1), three cleaning units 4 (see FIG. 2) supported by the frame 31, and a guide 5 configured to guide the cleaning mechanism 3 in a traveling direction while the cleaning mechanism 3 travels in the pipe group Q, which will be specifically described later. While cleaning is not performed, the cleaning mechanism 3 is housed in the case 12. In performing cleaning, the cleaning mechanism 3 moves downward from the case 12, and while traveling in the pipe group Q, cleans the surfaces of pipes P included in the pipe group Q.

[0022] The elevation mechanism 7 includes two winches 71 and wires 72 wound by the winches 71. The winches 71 are disposed on the upper surface of the base 11. The two winches 71 are disposed to sandwich the case

12 in the X-axis direction. The wires 72 are wound around reels of the winches 71. One end of each of the wires 72 is attached to the cleaning mechanism 3. That is, the cleaning mechanism 3 is hung by the two wires 72, and is moved downward and upward in the Z-axis direction by the elevation mechanism 7. The case 12 has a notch (not shown) for avoiding interference with the reels and the wires 72.

[0023] The body controller 8 is mounted on the apparatus body 1. The body controller 8 is formed by a processor. In response to an instruction from the external controller 9, the body controller 8 controls sections of the cleaning apparatus 100. For example, based on an output of a sensor for detecting the pipes P, the body controller 8 determines a positional relationship between the apparatus body 1 and the pipes P. With reference to the output from the sensor, the body controller 8 causes the cleaning apparatus 100 to move to a position indicated by the instruction of the external controller 9. The body controller 8 operates the cleaning mechanism 3 and the elevation mechanism 7.

[0024] The external controller 9 is connected to the body controller 8 through a cable 91. The operator inputs an instruction to the body controller 8 by operating the external controller 9. For example, the external controller 9 can input an operation instruction to the cleaning apparatus 100 as an instruction. In addition, the external controller 9 may input a travel distance related to an operation.

[0025] The cleaning mechanism 3 will now be described in further detail. FIG. 3 is a view of the cleaning mechanism 3 seen in the Y-axis direction. FIG. 4 is a cross-sectional view of the cleaning unit 4 taken along line S-S in FIG. 3 in a state where scrapers 34 are housed. FIG. 5 is a cross-sectional view of the cleaning unit 4 taken along line S-S in FIG. 3 in a state where the scrapers 34 expands. FIG. 6 is a view of the cleaning mechanism 3 seen in the X-axis direction in a state where the guide 5 retracts. FIG. 7 is a view of the cleaning mechanism 3 seen in the X-axis direction in a state where the guide 5 expands. FIG. 8 is a cross-sectional view of a first blade 51A taken in T-T line in FIG. 7.

[0026] As illustrated in FIG. 3, the frame 31 has a substantially rectangular frame shape. The frame 31 is provided with a cover 31a so that the frame 31 is formed in a box shape as a whole. Each of a pair of vertical frames 31b disposed at both ends of the frame 31 in the X-axis direction and extending in the Z-axis direction has a hook 31c to which the corresponding wire 72 of the elevation mechanism 7 is attached.

[0027] The shape of the frame 31 seen in the Z-axis direction (i.e., in the raising-and-lowering direction of the cleaning mechanism 3) extends off from a circle whose diameter is an interval G_v (see FIG. 2) in the V-axis direction between two pipes P on which the cleaning apparatus 100 is placed. Specifically, the dimension of the frame 31 in the Y-axis direction is smaller than the interval G_v between the two pipes P. On the other hand, the di-

mension of the frame 31 in the X-axis direction is larger than the interval G_v between the two pipes P. That is, in a case where the X-axis direction of the cleaning apparatus 100 coincides with the U-axis direction of the pipe group Q, the frame 31 can enter between the two pipes P. The frame 31 is an example of a support.

[0028] The three cleaning units 4 are supported by the frame 31. The three cleaning units 4 project downward from the bottom of the frame 31.

[0029] The three cleaning units 4 are arranged in the X-axis direction. The three cleaning units 4 are located at different positions in the Z-axis direction (i.e., the raising-and-lowering direction of the cleaning apparatus 3). Specifically, the cleaning unit 4 at the middle projects below the cleaning units 4 at the sides. In the following description, in a case where the three cleaning units 4 are individually identified, these cleaning units 4 will be referred to as a "first cleaning unit 4A," a "second cleaning unit 4B," and a "third cleaning unit 4C" in the order of arrangement in the X-axis direction.

[0030] The cleaning units 4 are configured to be brought into contact with pipes P while rotating about the rotation axis A parallel to the Z axis (i.e., parallel to the raising-and-lowering direction of the cleaning mechanism 3) to thereby remove deposits on the surface of the pipes P. Specifically, as illustrated in FIG. 3, each of the cleaning units 4 includes a rotation shaft 32 that rotates about the rotation axis A extending in parallel with the Z axis, scrapers 34 configured to contact the surfaces of the pipes P to thereby remove deposits on the surfaces of pipes P, disks 35 disposed coaxially with the rotation axis A, and a drill 36 disposed on the rotation axis A and at the tip of the cleaning unit 4. The rotation shaft 32 extends along the rotation axis A. The rotation shaft 32 is driven to rotate by a motor (not shown) supported by the frame 31. The cleaning units 4 are an example of a cleaner, and the scrapers 34 are an example of the contact part.

[0031] A tip end of the rotation shaft 32 is provided with the disks 35, the scrapers 34, and the drill 36. The four disks 35 are arranged at regular intervals on the same axis as the rotation axis A. The disks 35 are non-rotatably attached to the rotation shaft 32. That is, the disks 35 rotate together with the rotation shaft 32. The diameters of the disks 35 are smaller than the interval G_v between two pipes P.

[0032] The four disks 35 form three gaps. As illustrated in FIGS. 4 and 5, three scrapers 34 are disposed in each gap. Three swing shafts 37 extending along swing axes B parallel to the rotation axis A are disposed between each adjacent two of the disks 35. The three swing shafts 37 are arranged at regular intervals about the rotation axis A at positions eccentric from the rotation axis A. The scrapers 34 are swingably coupled to the swing shafts 37. The scrapers 34 have substantially arc shapes. The scrapers 34 are made of, for example, an aluminium alloy, carbon steel, urethane rubber, or brass.

[0033] As illustrated in FIG. 4, in a state where tip ends

34a of the scrapers 34 that are ends of the scrapers 34 opposite to the swing axes B are closest to the rotation axis A, the scrapers 34 are completely housed inside the gap between the two disks 35. That is, the scrapers 34 are housed inside outer peripheries E of the disks 35. While the scrapers 34 are housed in the disks 35, the shapes of the cleaning units 4 when seen in the Z-axis direction (i.e., the raising-and-lowering direction of the cleaning mechanism 3) are within a circle whose diameter is the interval G_v between two pipes P. The expression "housed inside the outer peripheries E" means that the scrapers 34 do not extend off from the outer peripheries E. That is, while the scrapers 34 are housed between the disks 35, the scrapers 34 may be flush with the outer peripheries E.

[0034] On the other hand, as illustrated in FIG. 5, the scrapers 34 swing such that the tip ends 34a move away from the rotation axis A by a centrifugal force of the rotation shaft 32, and the scrapers 34 expand radially outward about the rotation axis A. At this time, the scrapers 34 project outward from the outer peripheries E of the disks 35 (i.e., expand off outward from the outer peripheries E).

[0035] In the following description, "the radial direction" or "radially" refers to a radial direction about the rotation axis A, unless otherwise stated.

[0036] In the state where the scrapers 34 are housed in the disks 35, the direction in which the scrapers 34 extend from the swing shafts 37 toward the tip ends 34a is opposite to the rotation direction of the rotation shaft 32. That is, the scrapers 34 are housed within the outer peripheries E of the disks 35 with the tip ends of the scrapers 34 located behind the swing shafts 37 in the rotation direction of the rotation shaft 32. Accordingly, even when the scrapers 34 contact an object while expanding and rotating about the rotation axis A, the scrapers 34 swing to a direction in which the scrapers 34 are housed inside the disks 35 so that rotation of the scrapers 34 about the rotation axis A is maintained.

[0037] As illustrated in FIG. 3, the drills 36 are located at the tip ends of the rotation shafts 32. The drills 36 are non-rotatably attached to the rotation shafts 32. That is, the drills 36 rotate together with the rotation shaft 32. The drills 36 have substantially conical shapes, that is, have acuminate shapes. The drills 36 have grooves for releasing swarf produced by drilling by the drills 36.

[0038] In addition, as illustrated in FIGS. 3, 6, and 7, each of the pair of vertical frames 31b of the frame 31 is provided with the guide 5. The guide 5 includes a pair of a first blade 51A and a second blade 51B. The guide 5 may also include four first through fourth links 61 through 64 for coupling the first blade 51A and the second blade 51B to the vertical frames 31b. The first blade 51A and the second blade 51B have symmetric shapes. The first blade 51A and the second blade 51B are brought into contact with pipes P outside the guide 5 in the Y-axis direction to thereby guide the cleaning mechanism 3. In a case where the first blade 51A and the second blade

51B are not distinguished from each other, the first blade 51A and the second blade 51B will be simply referred to as the blades 51." All the first through fourth links 61 through 64 have the same shape. In a case where the first link 61, the second link 62, the third link 63, and the fourth link 64 are not distinguished from one another, these links will be simply referred to as the "links 6."

[0039] The blades 51 have shapes extending in the Z-axis direction. Each of the blades 51 has an edge 53 substantially extending in the Z-axis direction at the outside in the Y-axis direction (i.e., at the side of the frame 31 opposite to the center in the Y-axis direction). The edge 53 contacts the pipes P. As illustrated in FIGS. 6 and 7, both ends of the edge 53 in the Z-axis direction are tilted relative to the Z axis such that the edge 53 approaches the inside in the Y-axis direction toward the tip end of the edge 53. The cross-sectional shape of the edge 53 taken in the XY plane (i.e., plane orthogonal to the traveling direction of the cleaning mechanism 3) is an acuminate shape that tapers to the outside in the Y-axis direction (i.e., gradually becomes slender toward pipes P at outer positions in the Y-axis direction), as illustrated in FIG. 8. The first through fourth links 61 through 64 are coupled to each blade 51.

[0040] A longitudinal center portion of each link 6 is rotatably attached to the vertical frames 31b. The first link 61 and the second link 62 are attached to an identical rotation axis C. The third link 63 and the fourth link 64 are attached to an identical rotation axis D. One longitudinal end (hereinafter referred to as a "first end") of each link 6 is coupled to the first blade 51A, and the other longitudinal end (hereinafter referred to as a "second end") of each link 6 is coupled to the second blade 51B.

[0041] Specifically, the first end 61a of the first link 61 is attached to a long hole 54 formed in the first blade 51A and extending in the Z-axis direction such that the first end 61a is rotatable and slidable in the long hole 54. The second end 61b of the first link 61 is rotatably attached to the second blade 51B. The first end 62a of the second link 62 is rotatably attached to the first blade 51A. The second end 62b of the second link 62 is attached to a long hole 54 formed in the second blade 51B and extending in the Z-axis direction such that the second end 62b is rotatable and slidable in the long hole 54.

[0042] Similarly, the first end 63a of the third link 63 is attached to the long hole 54 formed in the first blade 51A and extending in the Z-axis direction such that the first end 63a is rotatable and slidable in the long hole 54. The second end 63b of the third link 63 is rotatably attached to the second blade 51B. The first end 64a of the fourth link 64 is rotatably attached to the first blade 51A. The second end 64b of the fourth link 64 is attached to the long hole 54 formed in the second blade 51B and extending in the Z-axis direction such that the second end 64b is rotatable and slidable in the long hole 54.

[0043] The first link 61 and the second link 62 are biased by a coil spring (not shown) about the rotation axis C such that the first end 61a of the first link 61 and the

second end 62b of the second link 62 move away from each other in the Y-axis direction and the second end 61b of the first link 61 and the first end 62a of the second link 62 move away from each other in the Y-axis direction.

[0044] Similarly, the third link 63 and the fourth link 64 are biased by a coil spring (not shown) about the rotation axis D such that the first end 63a of the third link 63 and the second end 64b of the fourth link 64 move away from each other in the Y-axis direction and the second end 63b of the third link 63 and the first end 64a of the fourth link 64 move away from each other in the Y-axis direction.

[0045] In this manner, the first blade 51A and the second blade 51B are biased away from each other in the Y-axis direction while keeping postures extending in the Z-axis direction. That is, the first blade 51A and the second blade 51B are biased to push the edges 53 against pipes P located outside the guide 5 in the Y-axis direction. In moving in the Y-axis direction, the first blade 51A and the second blade 51B also move in the Z-axis direction. As illustrated in FIG. 7, the first blade 51A and the second blade 51B expand off from the frame 31 in the Y-axis direction in the most expanded state. The hook 31c is located at a position at which the hook 31c does not interfere with the first blade 51A, the second blade 51B, and the first through fourth links 61 through 64 that move in the manner described above.

[0046] The thus-configured cleaning mechanism 3 can be housed in the case 12 as illustrated in FIGS. 1 and 2. A distance between the edges 53 of the pair of blades 51 at the most expanded state in the Y-axis direction is larger than a dimension of the case 12 in the Y-axis direction. That is, in the state where the cleaning mechanism 3 is housed in the case 12, the pair of blades 51 retracts in the Y-axis direction, and the edges 53 are in contact with the inner surface of the case 12. Accordingly, the cleaning mechanism 3 is positioned with respect to the Y-axis direction in the case 12.

[0047] Subsequently, an operation of the cleaning apparatus 100 will be described. FIG. 9 is a view of a state where the cleaning mechanism 3 cleans pipes P seen in the X-axis direction.

[0048] The cleaning apparatus 100 causes the cleaning mechanism 3 to move downward and upward between two pipes P to thereby clean the two pipes P and pipes P below the two pipes P in the Z-axis direction.

[0049] First, an operator places the cleaning apparatus 100 on pipes P. The operator operates the external controller 9 to cause the cleaning apparatus 100 to move to a cleaning start position. For example, the cleaning start position is a position in which the two crawlers 21 are placed on two pipes P such that the crawlers 21 are in parallel with the pipes P, the cleaning apparatus 100 is located at one end of the two pipes P in the U-axis direction, and the cleaning mechanism 3 is located between the two pipes P in the V-axis direction. Movement of the cleaning apparatus 100 to the cleaning start position may be performed by visual observation by the operator or by detecting the cleaning start position with the sensor of

the cleaning apparatus 100. In the case of visual observation by the operator, an input from the external controller 9 may be an instruction for an operation such as forward movement, backward movement, or turning of the cleaning apparatus 100 and additionally for a travel distance of the cleaning apparatus 100.

[0050] When the cleaning apparatus 100 moves to the cleaning start position, the operator inputs an instruction for starting cleaning through the external controller 9.

[0051] When receiving a cleaning instruction, the body controller 8 drives the rotation shaft 32 of the cleaning mechanism 3 so that the rotation shaft 32 rotates, and in this state, causes the elevation mechanism 7 to move the cleaning mechanism 3 downward between two pipes P. The scrapers 34 expand radially outward about the rotation axis A by a centrifugal force caused by rotation of the rotation shaft 32.

[0052] Since the scrapers 34 expand by a centrifugal force, if a sufficient space is not present, the scrapers 34 do not expand to the maximum, and expand in an allowable range. That is, in a case where space radially outside the scrapers 34 differs among positions in the Z-axis direction, the scrapers 34 gradually move downward while changing the degree of expansion in accordance with the space radially outside the scrapers 34. In the case where the cleaning mechanism 3 moves downward in the pipe group Q, at a position where no pipes P are present radially outside the scrapers 34 or a position where although pipes P are present radially outside the scrapers 34 but the scrapers 34 do not reach the pipes P, as illustrated in FIG. 9, the scrapers 34 expand to the maximum (see the scrapers 34 in a relatively upper portion of the first cleaning unit 4A in FIG. 9). At a position in which pipes P are present radially outside the scrapers 34 and the scrapers 34 reach the pipes P, the scrapers 34 expand to the degree at which the scrapers 34 contact the pipes P (see the scrapers 34 in a relatively lower portion of the first cleaning unit 4A and the scrapers 34 in the second cleaning unit 4B in FIG. 9). Consequently, in passing by the pipes P, the scrapers 34 contact the surfaces of the pipes P while changing the radial expansion in conformity with the surface shapes of the pipes P.

[0053] That is, the scrapers 34 enter between a plurality of pipes P arranged along the traveling direction of the cleaning mechanism 3 (i.e., arranged in the W-axis direction) and remove deposits between the plurality of pipes P and also contact the surfaces of the plurality of pipes P to remove deposits on the pipes P. Consequently, the scrapers 34 remove not only deposits deposited on portions of the surfaces of the pipes P facing a space in which the cleaning mechanism 3 passes but also deposits deposited on portions (i.e., deep portions) of the surfaces of the pipes P away from the space in a direction intersecting with the traveling direction of the cleaning mechanism 3 (e.g., the V-axis direction).

[0054] Preferably, a diameter of a circumscribed circle F (see FIG. 5) of the scrapers 34 in the most expanded state of the scrapers 34 is larger than a distance between

the axis centers of two pipes P disposed in the V-axis direction. Accordingly, the scrapers 34 can remove deposits on substantially a half circumference of the surfaces of the pipes P by passing by the pipes P in the W-axis direction.

[0055] In this manner, the scrapers 34 scrape off deposits deposited on the surfaces of the pipes P.

[0056] At this time, the scrapers 34 are disposed between two disks 35. Thus, when the cleaning units 4 rotate or when the scrapers 34 contact another object such as a pipe P, a deviation of the scrapers 34 in the Z-axis direction can be reduced by the disks 35.

[0057] While the cleaning mechanism 3 passes in a narrow gap, expansion of the scrapers 34 can be suppressed. When the expansion of the scrapers 34 is at minimum, the scrapers 34 are housed in the disks 35. That is, when seen to the Z-axis direction, the minimum outer shape of the cleaning units 4 is the outer shape of the disks 35. Here, if the disks 35 are not provided, the minimum outer shape of the cleaning units 4 is formed by outer edges of the three scrapers 34 whose tip ends are located near the rotation shaft 32 (a state where the disks 35 are omitted in FIG. 4). The minimum outer shape of the cleaning units 4 in this case is not a complete circle, and has a recess between two adjacent scrapers 34 and has unevenness as a whole. When the cleaning units 4 as rotation bodies having such unevenness contact pipes P or the like, large repulsion occurs from the pipes P. On the other hand, the presence of the disks 35 can reduce repulsion occurring when the cleaning units 4 contact pipes P or the like.

[0058] Here, while the cleaning mechanism 3 moves downward between two pipes P, deposits such as ashes are present in front of the cleaning mechanism 3 in the traveling direction (i.e., below the cleaning mechanism 3) in some cases. For example, when the thickness of deposits on the surfaces of pipes P increases, the interval between two pipes P covered with deposits in the V-axis direction decreases. If the amount of deposits is large, the interval between the two pipes P in the V-axis direction might be filled with deposits. If this interval is smaller than the diameters of the disks 35 or the dimension of the frame 31 in the Y-axis direction, when the cleaning mechanism 3 moves downward, the disks 35 and the frame 31 might interfere deposits to hinder the downward movement of the cleaning mechanism 3. The scrapers 34 can remove deposits radially outside the disks 35, but cannot remove deposits below the disks 35. In view of this, the tip ends of the cleaning units 4 are provided with the drills 36. While the cleaning mechanism 3 moves downward, the drills 36 rotate together with the rotation shaft 32. Thus, while the cleaning mechanism 3 moves downward, the drills 36 drill deposits below the cleaning mechanism 3. Accordingly, the cleaning mechanism 3 can move downward smoothly.

[0059] In addition, while the cleaning mechanism 3 travels in the pipe group Q, the guide 5 guides the cleaning mechanism 3. Specifically, the first blade 51A and

the second blade 51B of the guide 5 are biased in such a direction that the first blade 51A and the second blade 51B move apart from each other in the Y-axis direction. Accordingly, the first blade 51A contacts a pipe P at one side in the V-axis direction, and the second blade 51B contacts a pipe P at the other side in the V-axis direction. In this manner, the cleaning mechanism 3 is positioned in the V-axis direction with respect to the pipes P located at both sides in the V-axis direction. Specifically, the cleaning mechanism 3 is positioned at the center in the V-axis direction between pipes P disposed in the V-axis direction. In addition, since the cross-sectional shapes of the edges 53 of the first blade 51A and the second blade 51B that contact the pipes P have acuminate shapes tapering toward the outside in the Y-axis direction, even if deposits are deposited on the surfaces of the pipes P, the edges 53 cut into the deposits and easily contact the surfaces of the pipes P. Consequently, the accuracy in positioning the cleaning mechanism 3 can be enhanced.

[0060] Both ends of the edges 53 of the first blade 51A and the second blade 51B in the Z-axis direction are tilted toward the inside in the Y-axis direction as approaching the tip ends thereof. That is, the distance between the edges 53 of the first blade 51A and the second blade 51B in the Y-axis direction decreases toward the tip ends. Thus, when the first blade 51A and the second blade 51B enter between two pipes P, ends of the first blade 51A and the second blade 51B in the Z-axis direction are not caught by the pipes P so that the first blade 51A and the second blade 51B can enter between the two pipes P smoothly.

[0061] When the cleaning mechanism 3 moves downward so that the cleaning units 4 pass by the lowest pipes P among pipes P to be cleaned, the cleaning mechanism 3 is caused to move upward by the elevation mechanism 7. The arrival at the lowest position of the cleaning mechanism 3 may be visually observed by the operator or may be detected by a sensor provided in the cleaning apparatus 3. Alternatively, at the start of cleaning, the operator may input a distance to which the cleaning mechanism 3 moves downward.

[0062] While the cleaning mechanism 3 moves upward, the scrapers 34 also contact the surfaces of pipes P while changing radial expansion in conformity with the surface shape of the pipes P to thereby scrape deposits deposited on the surfaces of the pipes P. That is, the cleaning mechanism 3 cleans the surfaces of the pipes P with the scrapers 34 in both of downward movement and upward movement.

[0063] Since the cleaning mechanism 3 includes the three cleaning units 4 arranged in the X-axis direction, three different portions of pipes P in the U-axis direction are cleaned by one set of downward movement and upward movement of the cleaning mechanism 3.

[0064] When reciprocation of the cleaning mechanism 3 in the up-and-down direction is finished, the cleaning apparatus 100 moves to a predetermined distance in the

U-axis direction along two pipes P. Thereafter, the cleaning mechanism 3 moves downward and upward again. That is, the cleaning mechanism 3 cleans portions of pipes P different in the U-axis direction from those cleaned in the previous downward and upward movement of the cleaning mechanism 3. In this manner, the apparatus body 1 repeatedly moves and stops along at least two pipes P included in the pipe group Q by traveling of the traveling mechanism 2, and the cleaning mechanism 3 moves downward and upward at a position at which the apparatus body 1 stops to thereby clean at least two pipes P.

[0065] The movement of the cleaning apparatus 100 in the U-axis direction may be automatically performed by the cleaning apparatus 100 when elevation of the cleaning mechanism 3 is finished, or may be performed by an input by the operator of an instruction through the external controller 9.

[0066] In this manner, the cleaning apparatus 100 repeatedly moves the cleaning mechanism 3 downward and upward while changing the position in the U-axis direction. When movement from one end to the other end, in the U-axis direction, of two pipes P on which the cleaning apparatus 100 is placed is finished, the cleaning apparatus 100 finishes cleaning a gap between the two pipes P on which the cleaning apparatus 100 is placed.

[0067] The arrival of the cleaning apparatus 100 at the other end of the two pipes P in the U-axis direction may be visually observed by the operator or may be detected by a sensor provided in the cleaning apparatus 100. Alternatively, at the start of cleaning, the operator may input a travel distance of the cleaning apparatus 100 in the U-axis direction.

[0068] Subsequently, the cleaning apparatus 100 moves in the V-axis direction and causes the cleaning mechanism 3 to be located at a different gap between two pipes P. Specifically, the cleaning apparatus 100 turns from a state where the two crawlers 21 are parallel to the pipes P to a state where the two crawlers 21 are substantially orthogonal to the pipes P. Then, the cleaning apparatus 100 moves across the pipes P, and moves to a position at which the cleaning mechanism 3 is located on an adjacent gap between two pipes P to the gap between two pipes P for which cleaning has been finished. When the cleaning mechanism 3 moves to the adjacent gap between the adjacent two pipes P, the cleaning apparatus 100 turns to a state where the two crawlers 21 are parallel to the pipes P. After the turning, the cleaning apparatus 100 moves to an end of the two pipes P in the U-axis direction. One of new two pipes P is a pipe P of the two pipes P for which cleaning has been previously finished.

[0069] Thereafter, the cleaning apparatus 100 performs similar cleaning on new two pipes P and pipes P below the two pipes P. In this manner, the cleaning apparatus 100 repeats the cleaning described above while changing two pipes P on which the cleaning apparatus 100 are to be placed, thereby cleaning pipes P included

in the pipe group Q.

[0070] Here, turning of the cleaning apparatus 100 after cleaning between a pair of pipes P, movement of the cleaning apparatus 100 across pipes P, next turning of the cleaning apparatus 100, and movement of the cleaning apparatus 100 to an end of another pair of pipes P in the U-axis direction may be automatically performed by the cleaning apparatus 100 or may be performed by an input of an instruction from the operator through the external controller 9. In the case where the operator inputs an instruction, all the turning, movement, next turning, and movement of the cleaning apparatus 100 may be performed based on one instruction, or an instruction may be input for each of the turning, cross-movement, re-turning, and movement of the cleaning apparatus 100.

[0071] Next, movement of the cleaning apparatus 100 will be described more specifically. FIG. 10 is a view of the cleaning apparatus 100 moving in parallel with pipes P seen in the X-axis direction. FIG. 11 is a view of the cleaning apparatus 100 moving in parallel with the pipes P seen in the Z-axis direction. FIG. 12 is a view of the cleaning apparatus 100 turning on the pipes P seen in the X-axis direction. FIG. 13 is a view of the cleaning apparatus 100 turning on the pipes P seen in the Z-axis direction. FIGS. 11 and 13 schematically illustrate the cleaning apparatus 100. FIGS. 11 and 13 illustrate only one of the three cleaning units 4 located at the same position in the W-axis direction as pipes P on which the cleaning apparatus 100 is placed.

[0072] As described above, in cleaning pipes P included in the pipe group Q by the cleaning apparatus 100, the cleaning apparatus 100 travels on the pipes P. Because of deposits deposited on the surfaces of the pipes P, the crawlers 21 can slip and spin. Thus, it can be difficult in some cases to cause the cleaning apparatus 100 to travel to a desired position. In view of this, the cleaning apparatus 100 uses the cleaning units 4 as a guide for traveling to thereby achieve movement to the desired position.

[0073] Basically, in travelling on pipes P, the cleaning apparatus 100 moves while the cleaning units 4 are lifted as illustrated in FIG. 2 (a state where the cleaning units 4 do not project downward from the traveling mechanism 2) in order not to cause interference between the cleaning units 4 and the pipes P.

[0074] However, while the cleaning apparatus 100 moves in the U-axis direction along two pipes P in order to clean portions of the pipes P different in the U-axis direction, the cleaning apparatus 100 causes the cleaning units 4 to project downward from the traveling mechanism 2 as illustrated in FIG. 10, and travels with the cleaning units 4 being positioned between two pipes P on which the cleaning apparatus 100 is placed. Since the cleaning units 4 are positioned between the two pipes P, deviation of the cleaning apparatus 100 in the V-axis direction is restricted in moving along the two pipes P, as illustrated in FIG. 11. That is, the cleaning units 4 serve as a guide for movement of the cleaning apparatus 100

in parallel with the pipes P.

[0075] At this time, the plurality of cleaning units 4 are preferably positioned between the two pipes P. Since the first cleaning unit 4A and the third cleaning unit 4C are located at the same position in the Z-axis direction in the cleaning mechanism 3, the first cleaning unit 4A and the third cleaning unit 4C are caused to enter between two pipes P. Since the plurality of cleaning units 4 arranged in the X-axis direction are positioned between the two pipes P, rotation of the cleaning apparatus 100 about the Z axis is restricted while the cleaning apparatus 100 moves along the two pipes P.

[0076] In some cases, the cleaning apparatus 100 moves across pipes P, as in the case of changing two pipes P to be cleaned, for example. In such cases, the cleaning apparatus 100 needs to turn in direction from the state where the crawlers 21 are parallel to pipes P. In turning, the cleaning apparatus 100 drives the two crawlers 21 in opposite directions. Specifically, one of the crawlers 21 is driven to travel to one side in the X-axis direction, whereas the other crawler 21 is driven to travel to the other side in the X-axis direction. Accordingly, the cleaning apparatus 100 turns about an axis parallel to the Z axis. However, if deposits (e.g., ashes) are deposited on the surface of pipes P in contact with the crawlers 21, the crawlers 21 might spin so that the cleaning apparatus 100 fails to turn sufficiently. For example, if only one of the crawlers 21 spins, the cleaning apparatus 100 moves to the traveling direction of the other crawler 21.

[0077] To prevent this, the cleaning apparatus 100 turns with one of the cleaning units 4 being positioned between two pipes P. In the cleaning mechanism 3, the second cleaning unit 4B projects below the first cleaning unit 4A and the third cleaning unit 4C, and thus, as illustrated in FIG. 12, the second cleaning unit 4B is caused to enter between the two pipes P. The scrapers 34 can be housed in the disks 35. The outer diameters of the disks 35 are smaller than the interval between two pipes P. That is, the outer shape of the second cleaning unit 4B when seen in the Z-axis direction is within a circle whose diameter is the interval between two pipes P. Thus, even in the state where the second cleaning unit 4B is positioned between two pipes P, the cleaning apparatus 100 is allowed to turn. When seen in the Z-axis direction, the lateral dimension of the frame 31 is smaller than the interval of the two pipes P, whereas the longitudinal dimension of the frame 31 is larger than the interval of the two pipes P. Accordingly, the frame 31 does not enter between the two pipes P.

[0078] In the manner described above, when the second cleaning unit 4B enters between two pipes P, even if a driving force of one of the crawlers 21 is dominant over that of the other, the cleaning apparatus 100 cannot move freely. When the cleaning apparatus 100 continues traveling with the second cleaning unit 4B engaged with two pipes P and driving forces of the two crawlers 21 imbalanced, a friction force is gradually exerted between

the pipes P and the spinning crawlers 21, and then, the cleaning apparatus 100 starts turning. Consequently, as illustrated in FIG. 13, even when the cleaning apparatus 100 cannot turn at the same place, the cleaning apparatus 100 moves little by little along two pipes P and finally starts turning.

[0079] Thereafter, when the two crawlers 21 become substantially orthogonal to pipes P, the cleaning apparatus 100 causes the elevation mechanism 7 to lift the cleaning mechanism 4 such that the cleaning units 4 between the two pipes P are pulled from between the two pipes P.

[0080] When the cleaning units 4 come to be in a state where the cleaning units 4 do not project downward from the traveling mechanism 2, the cleaning apparatus 100 moves across pipes P. The cleaning apparatus 100 moves to a position at which the second cleaning unit 4B is located at a gap between two pipes P to be next cleaned, in the V-axis direction. When the cleaning apparatus 100 moves to this position, the cleaning apparatus 100 moves the cleaning mechanism 4 downward such that only the second cleaning unit 4B enters between the two pipes P. In this state, the cleaning apparatus 100 turns in the manner as described above. At this time, the cleaning apparatus 100 turns to a position at which the two crawlers 21 are parallel to the two pipes P.

[0081] When the two crawlers 21 become parallel to the two pipes P, the cleaning apparatus 100 moves the cleaning mechanism 4 downward such that a plurality of cleaning units 4 (specifically the first cleaning unit 4A and the third cleaning unit 4C) enter between the two pipes P. In the state where the plurality of cleaning units 4 are positioned between two pipes P as described above, the cleaning apparatus 100 moves along the two pipes P to a position at which cleaning is started again.

[0082] As described above, in the case of using the cleaning units 4 as a guide, the cleaning apparatus 100 drives and rotates the rotation shaft 32 in causing the cleaning units 4 to enter between pipes P and in turning or moving with the cleaning units 4 being positioned between the pipes P. Since the rotation shaft 32 rotates, when the scrapers 34 contact an object, a component of causing the scrapers 34 to be housed in the disks 35 is exerted on the scrapers 34. Accordingly, even when the scrapers 34 contact an object, the scrapers 34 are caused to swing in the direction of being housed in the disks 35 so that rotation of the scrapers 34 is maintained. That is, substantially, contact of the disks 35 with pipes P restricts movement of the cleaning apparatus 100. A rotation speed of the rotation shaft 32 while the cleaning units 4 serve as a guide is set to be lower than a rotation speed of the rotation shaft 32 while the cleaning units 4 clean pipes P.

[0083] As described above, the cleaning mechanism 3 configured to clean the surfaces of pipes P included in the pipe group Q while traveling in the pipe group Q, includes: the rotation shaft 32 configured to rotate about the predetermined rotation axis A; and the scrapers 34

(contact part) configured to clean deposits on the surfaces of pipes P by contact with the surfaces of the pipes P. The scrapers 34 are coupled to the rotation shaft 32 (specifically indirectly coupled through the disks 35 and the swing shafts 37) to expand radially outward about the rotation axis A by a centrifugal force of the rotation shaft 32. While the scrapers 34 pass by pipes P, the scrapers 34 contact the surfaces of the pipes P while changing the radial expansion in conformity with the surface shape of the pipes P.

[0084] In traveling in the pipe group Q, the cleaning mechanism 3 travels in a space where no pipes P are present, such as a space between pipes P and pipes P. In such a case, on portions of the pipes P facing a space in which the cleaning mechanism 3 passes, removal of deposits is relatively easy. However, deposits are also present on portions of the pipes P away from the space in a direction intersecting with the traveling direction of the cleaning mechanism 3.

[0085] On the other hand, the scrapers 34 expand radially outward by a centrifugal force of the rotation shaft 32. Thus, in the absence of restriction to the radially outward expansion of the scrapers 34, the scrapers 34 expand to the maximum, whereas in the presence of restriction to the radially outward expansion of the scrapers 34, the scrapers 34 expand to an allowable range. Such scrapers 34 are allowed to expand to enter between a plurality of pipes P arranged along the traveling direction of the cleaning mechanism 3.

[0086] However, if the scrapers 34 continue to expand in this manner, the scrapers 34 interfere with the pipes P to hinder traveling of the cleaning mechanism 3. On the other hand, since the scrapers 34 merely expand by a centrifugal force of the rotation shaft 32, when the scrapers 34 are brought into contact with pipes P, the scrapers 34 change the expansion in conformity with the surface shape of the pipes P and do not hinder traveling of the cleaning mechanism 3 anymore. If the distance to the pipes P is long, the degree of the radially outward expansion of the scrapers 34 is large, and if the distance to the pipes P is short, the degree of the radially outward expansion of the scrapers 34 is small. In this manner, the scrapers 34 contact the surfaces of the pipes P while changing radial expansion in conformity with the surface shape of the pipes P in accordance with traveling of the cleaning mechanism 3.

[0087] As a result, the scrapers 34 contact not only portions of the pipes P facing a space in which the cleaning mechanism passes or portions close to the space, but also portions of the pipe P away from the space. Thus, the scrapers 34 can contact a relatively large area on the surfaces of the pipes P and scrape deposits. In addition, even in a case where the plurality of pipes P have uneven shapes or the plurality of pipes P are non-uniformly arranged, the scrapers 34 flexibly change their expansion so that deposits on the pipes P can be scraped in conformity with the uneven shapes or arrangement of the pipes P. Accordingly, the cleaning mechanism 3 can suf-

ficiently remove deposits on the surfaces of the pipes P.

[0088] From another viewpoint, the cleaning mechanism 3 configured to clean the surfaces of pipes P included in the pipe group Q includes: the rotation shaft 32 configured to rotate about the predetermined rotation axis A; and the scrapers 34 (contact part) configured to contact the surfaces of the pipes P to thereby remove deposits on the surfaces of the pipes P. The scrapers 34 are swingably coupled to the swing shafts 37 that rotate together with the rotation shaft 32. The scrapers 34 are caused to swing around the swing shafts 37 by a centrifugal force of the rotation shaft 32 to expand radially outward about the rotation axis A.

[0089] With this configuration, the scrapers 34 expand radially outward while being caused to swing by a centrifugal force of the rotation shaft 32. The configuration in which the scrapers 34 expand radially outward by a centrifugal force of the rotation shaft 32 is conceivable as a configuration in which the scrapers 34 slide radially. In such a configuration, a range in which the scrapers 34 are allowed to expand radially (i.e., a range in which the scrapers 34 are allowed to expand radially from a most shrunk state in the radially inward direction to a most expanded state in the radially outward direction) is determined by a distance in which the scrapers 34 are allowed to slide radially. On the other hand, in the configuration in which the scrapers 34 slide as described above, the range in which the scrapers 34 are allowed to expand radially depends on a length from the swing shafts 37 to the scrapers 34, and can be made larger than that in the configuration in which the scrapers 34 simply slide radially.

[0090] Consequently, the scrapers 34 are allowed to significantly expand to contact even portions of pipes P away from a space in which the cleaning mechanism passes. Thus, the scrapers 34 can contact a relatively large area of the surfaces of the pipes P and scrape deposits as described above. Accordingly, the cleaning mechanism 3 can sufficiently remove deposits on the surfaces of the pipes P.

[0091] The cleaning mechanism 3 further includes the disks 35 disposed coaxially with the rotation axis A. The scrapers 34 are housed inside the outer peripheries E of the disks 35, and when the scrapers 34 expand by a centrifugal force of the rotation shaft 32, the scrapers 34 project outward from the outer peripheries E of the disks 35.

[0092] With this configuration, since the scrapers 34 are housed inside the disks 35, the cleaning mechanism 3 can enter a gap larger than the outer diameters of the disks 35 in the pipe group Q. The centrifugal force of the rotation shaft 32 is exerted on the scrapers 34 so that the scrapers 34 project outward from the outer peripheries E of the disks 35 and remove deposits on pipes P.

[0093] In a state where the scrapers 34 are housed in the disks 35, the disks 35 can contact pipes P. Since the disks 35 have circular outer shapes, even when the disks 35 contact pipes P, repulsion from the pipes P can be

reduced.

[0094] The cleaning mechanism 3 further includes the drills 36 disposed on the rotation axis A and located closer to the tip ends of the rotation shaft 32 than the scrapers 34.

[0095] With this configuration, while the cleaning mechanism 3 travels along the direction of the rotation axis A, the drills 36 drill and remove foreign matter such as deposits present forward in the traveling direction. Accordingly, the cleaning mechanism 3 is allowed to travel smoothly.

[0096] The cleaning mechanism 3 further includes the guide 5 configured to guide the cleaning mechanism 3 in the traveling direction while the cleaning mechanism 3 travels in the pipe group Q. The guide 5 includes the edges 53 configured to contact pipes P. The cross-sectional shapes of the edges 53 formed by a plane orthogonal to the traveling direction are acuminate shapes tapering toward the pipes P.

[0097] With this configuration, while the cleaning mechanism 3 travels in the pipe group Q, the guide 5 contacts pipes P and guides the cleaning mechanism 3. At this time, even when deposits are deposited on the surfaces of the pipes P, the edges 53 of the guide 5 cut into deposits and easily contact the surfaces of the pipes P. Accordingly, the accuracy in positioning the cleaning mechanism 3 while the cleaning mechanism 3 travels is enhanced.

[0098] The guide 5 is biased to press the edges 53 against pipes P.

[0099] With this configuration, in the case where the cleaning mechanism 3 travels in the pipe group Q, even if the distance between the cleaning mechanism 3 and pipes P is not uniform, the edges 53 of the guide 5 are allowed to contact the pipes P. That is, the guide 5 can guide the cleaning mechanism 3 flexibly in accordance with pipes P located at various distances from the cleaning mechanism 3.

[0100] The cleaning apparatus 100 includes the apparatus body 1, the cleaning mechanism 3 disposed in the apparatus body 1, and the traveling mechanism 2 disposed in the apparatus body 1. The cleaning mechanism 3 moves downward from the apparatus body 1 and upward to the apparatus body 1 and removes deposits deposited on the surfaces of pipes P below the traveling mechanism 2.

[0101] The cleaning mechanism 3 moves downward from the apparatus body 1 and upward to the apparatus body 1 and enters between at least two pipes P included in the pipe group Q to clean the at least two pipes P.

[0102] The apparatus body 1 repeatedly moves and stops along at least two pipes P included in the pipe group Q by traveling of the traveling mechanism 2. The cleaning mechanism 3 moves downward and upward at a position at which the apparatus body 1 stops, and cleans the at least two pipes P.

Other Embodiments

[0103] As described above, the embodiment has been described as an example of the technique of the present disclosure. The technique disclosed here, however, is not limited to this embodiment, and is applicable to other embodiments obtained by changes, replacements, additions, and/or omissions as necessary. Components described in the above embodiment may be combined as a new embodiment. Components provided in the accompanying drawings and the detailed description can include components unnecessary for solving problems as well as components necessary for solving problems in order to exemplify the technique. Therefore, it should not be concluded that such unnecessary components are necessary only because these unnecessary components are included in the accompanying drawings or the detailed description.

[0104] For example, the cleaning mechanism 3 is included in the cleaning apparatus 100, but the present disclosure is not limited to this configuration. In the configuration described above, the cleaning mechanism 3 is conveyed and moved downward and upward by the cleaning apparatus 100. Alternatively, the cleaning mechanism 3 may be manually operated by an operator. Specifically, an operator may hold the cleaning mechanism 3 so that the cleaning mechanism 3 cleans pipes P while moving in the pipe group Q. Although the cleaning mechanism 3 is included in the cleaning apparatus 100, the configurations of the traveling mechanism 2 and the elevation mechanism 7 are not limited to the configurations described above. For example, the traveling mechanism 2 does not need to be crawlers and may be wheels. The elevation mechanism 7 does not need to be the winches and may be a rack-and-pinion or a pantograph.

[0105] The number of cleaning units 4 included in the cleaning mechanism 3 is not limited to three. The number of cleaning units 4 may be one, two, or four or more. The raising-and-lowering direction of the cleaning mechanism 3, that is, the position of each cleaning unit 4 in the Z-axis direction is not limited to the position described above. For example, the positions of the three cleaning units 4 in the Z-axis direction may be the same. Alternatively, the positions of the three cleaning units 4 in the Z-axis direction may be different from one another.

[0106] The configuration of the cleaning units 4 is not limited to the configuration described above. For example, the number of scrapers 34 included in the cleaning units 4 is not limited to three, and may be one, two, or four or more. The cleaning units 4 may not include the disks 35 or the drills 36. In the cleaning units 4 described above, the plurality of scrapers 34 are disposed in each of three gaps formed by the four disks 35. That is, the three sets of scrapers 34 are provided. However, the number of sets of scrapers 34 may be one, two, or four or more.

[0107] The shape of the scrapers 34 does not need to be an arc shape, and may be linearly, for example. The

scrapers 34 do not need to swing, and may slide. For example, the scrapers 34 may have long holes for allowing the scrapers 34 to be coupled to pins disposed between two disks 35 such that the pins are inserted in the long holes. In this configuration, the scrapers 34 are slidable relative to the pins such that the pins move relatively in the long holes. As long as the scrapers 34 are slidable, when a centrifugal force of the rotation shaft 32 is exerted on the scrapers 34, the scrapers 34 slide by the centrifugal force and expand radially outward.

[0108] The cleaning mechanism 3 includes the guide 5, but does not need to include the guide 5. The configuration of the guide 5 is not limited to the configuration described above. The guide 5 does not need to include the links 6. For example, the blades 51 may be slidably coupled to the frame 31 and biased by a spring or the like outward in the Y-axis direction.

[0109] The cross-sectional shapes of the edges 53 of the blade 51 only need to be acuminate shapes tapering toward pipes P, and portions of the edges 53 closest to the pipes P, that is, portions to contact the pipes P, may be slightly rounded.

INDUSTRIAL APPLICABILITY

[0110] As described above, the technique disclosed here is useful for a cleaning mechanism and a cleaning apparatus including the same.

DESCRIPTION OF REFERENCE CHARACTERS

[0111]

100	cleaning apparatus
3	cleaning mechanism
32	rotation shaft
34	scraper (contact part)
4A	first cleaning unit (cleaner)
4B	second cleaning unit (cleaner)
4C	third cleaning unit (cleaner)
5	guide
53	edge
A	rotation axis
Q	pipe group
P	pipe

Claims

1. A cleaning mechanism configured to clean a surface of a pipe included in a pipe group while traveling in the pipe group, the cleaning mechanism comprising:

a rotation shaft configured to rotate about a predetermined rotation axis; and
a contact part configured to contact the surface of the pipe to thereby remove a deposit on the surface of the pipe, wherein

the contact part

is coupled to the rotation shaft such that the contact part expands radially outward about the rotation axis by a centrifugal force of the rotation shaft, and
contacts the surface of the pipe while changing radial expansion of the contact part in conformity with a surface shape of the pipe when the contact part passes by the pipe.

2. A cleaning mechanism configured to clean a surface of a pipe included in a pipe group, the cleaning mechanism comprising:

a rotation shaft configured to rotate about a predetermined rotation axis; and
a contact part configured to contact the surface of the pipe to thereby remove a deposit on the surface of the pipe, wherein
the contact part is swingably coupled to a swing shaft that rotates together with the rotation shaft, and the contact part swings about the swing shaft by a centrifugal force of the rotation shaft and expands radially outward about the rotation axis.

3. The cleaning mechanism according to claim 1 or 2, further comprising

a disk disposed coaxially with the rotation axis, wherein
the contact part is housed inside an outer periphery of the disk, and in a case where the contact part expands by a centrifugal force of the rotation shaft, the contact part projects outward from the outer periphery of the disk.

4. The cleaning mechanism according to claim 2, further comprising

a disk disposed coaxially with the rotation axis, wherein
the contact part is housed inside an outer periphery of the disk,
in a case where the contact part expands by a centrifugal force of the rotation shaft, the contact part projects outward from the outer periphery of the disk, and

in a state where the contact part is housed inside an outer periphery of the disk, a tip of the contact part is located behind the swing shaft in a rotation direction of the rotation shaft.

5. The cleaning mechanism according to any one of claims 1 to 4, further comprising
a drill disposed on the rotation axis and located closer to a tip of the rotation shaft than the contact part is.

6. The cleaning mechanism according to any one of claims 1 to 5, further comprising the cleaning mechanism further includes a guide configured to guide the cleaning mechanism in a traveling direction when the cleaning mechanism travels in the pipe group, the guide includes a blade having an edge configured to contact the pipe, and a cross-sectional shape of the edge on a plane orthogonal to the traveling direction is an acuminate shape tapering toward the pipe. 5 10
7. The cleaning mechanism according to claim 6, wherein the blade is biased such that the edge is pressed against the pipe. 15
8. The cleaning mechanism according to claim 6 or 7, wherein the blade includes a first blade and a second blade, and while the cleaning mechanism travels between at least two pipes included in a pipe group, the first blade contacts one of the at least two pipes and the second blade contacts the other of the at least two pipes. 20 25
9. A cleaning apparatus comprising:
 - an apparatus body;
 - the cleaning mechanism according to any one of claims 1 to 8 disposed in the apparatus body; and
 - a traveling mechanism disposed in the apparatus body, wherein the cleaning mechanism moves downward from the apparatus body and upward to the apparatus body and removes a deposit deposited on a surface of a pipe located below the traveling mechanism. 30 35 40
10. The cleaning apparatus according to claim 9, wherein the cleaning mechanism moves downward from the apparatus body and upward to the apparatus body and enters between at least two pipes included in a pipe group and cleans the at least two pipes. 45
11. The cleaning apparatus according to claim 9, wherein the apparatus body repeatedly moves and stops along at least two pipes included in a pipe group by traveling of the traveling mechanism, and the cleaning mechanism moves downward and upward at a position at which the apparatus body stops so that the cleaning mechanism cleans the at least two pipes. 50 55

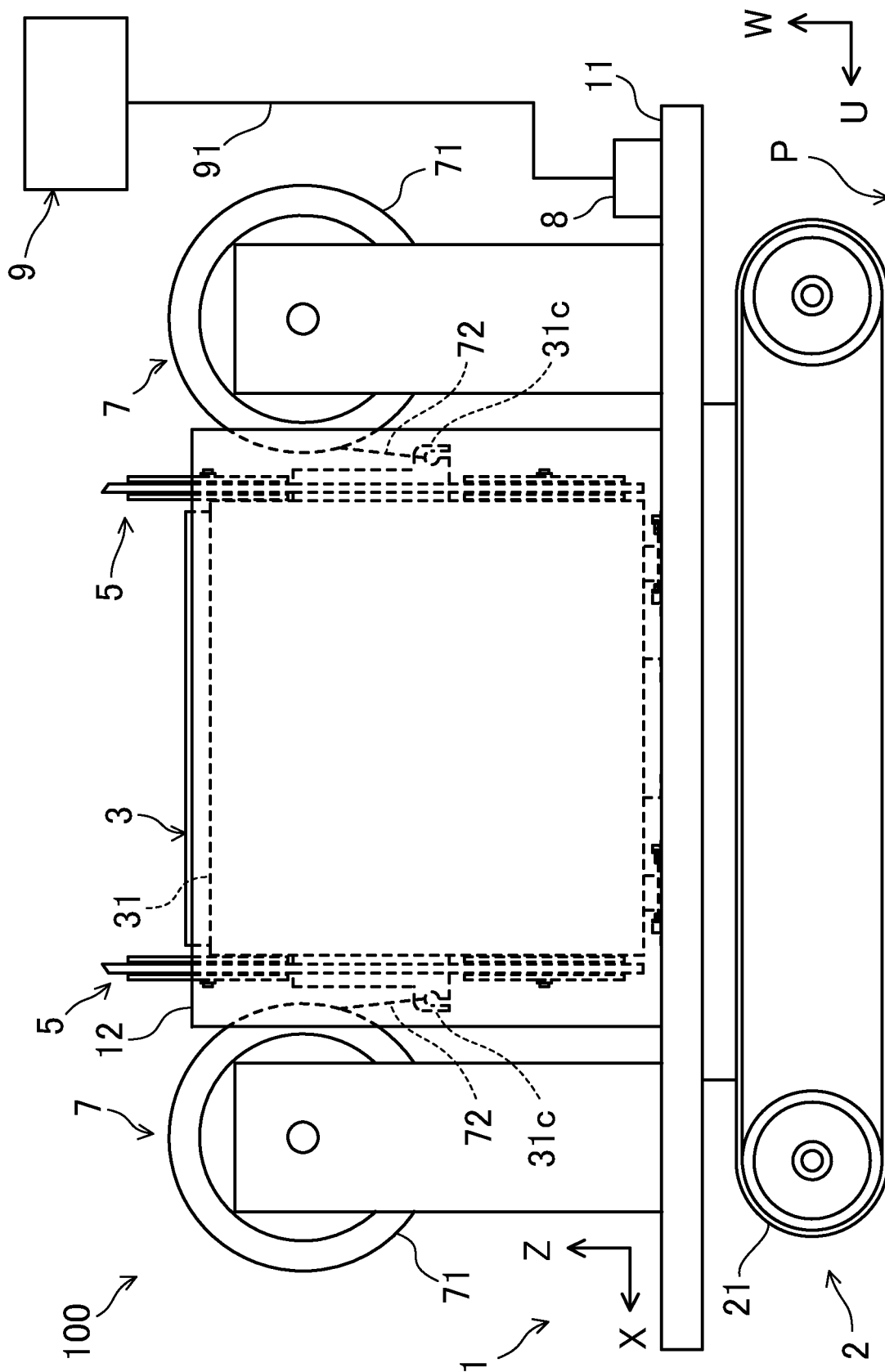


FIG. 1

FIG. 2

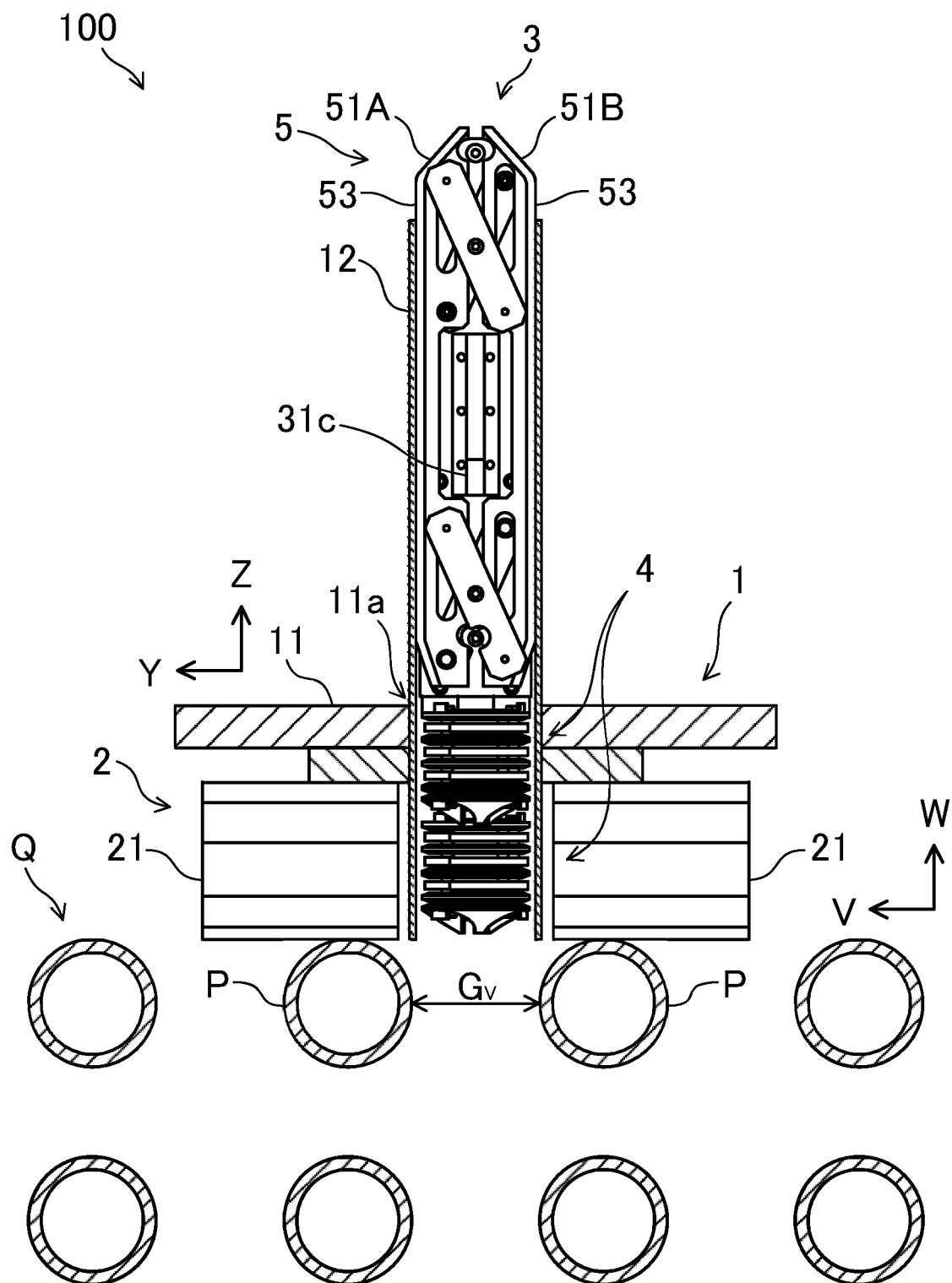


FIG. 3

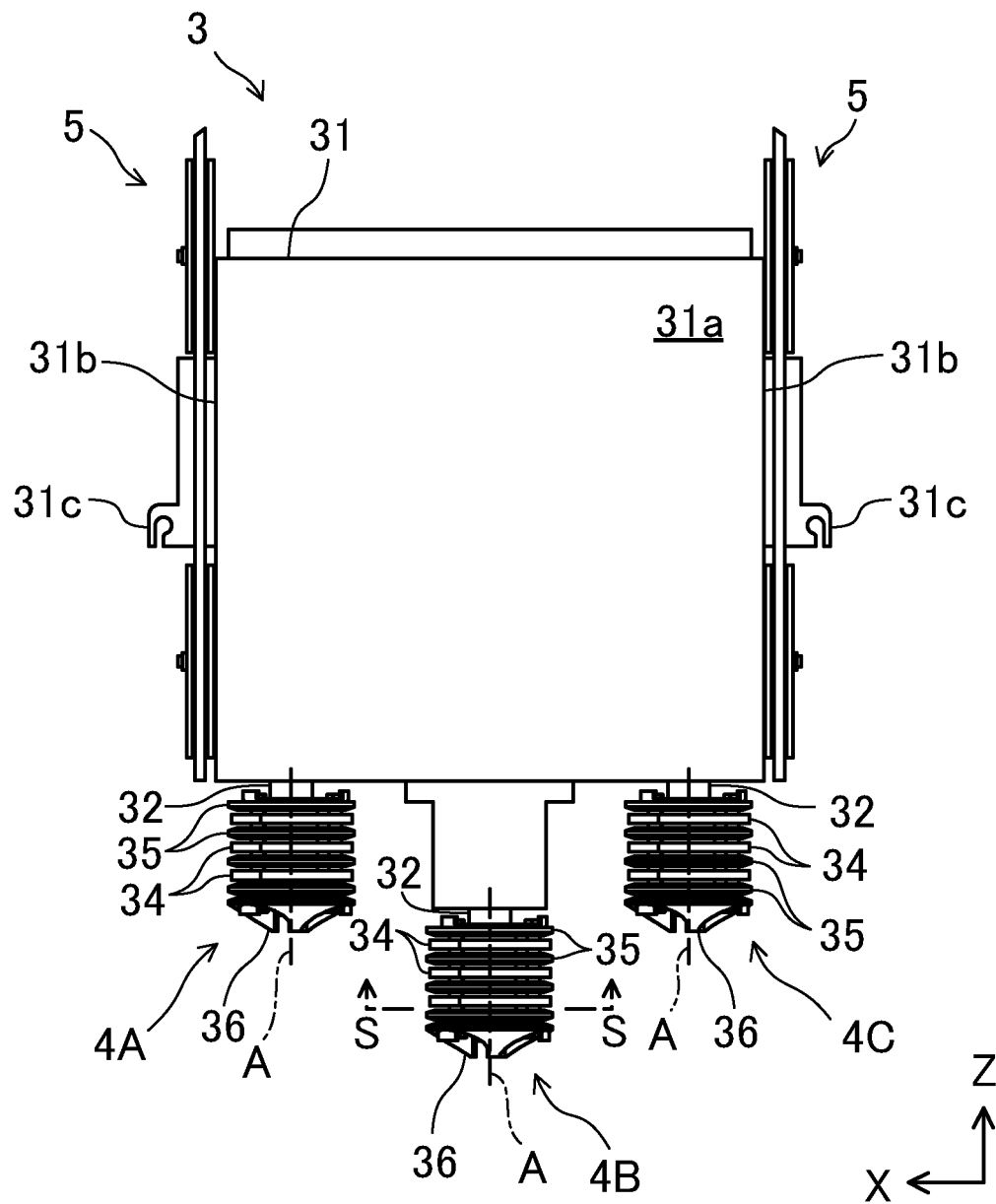


FIG. 4

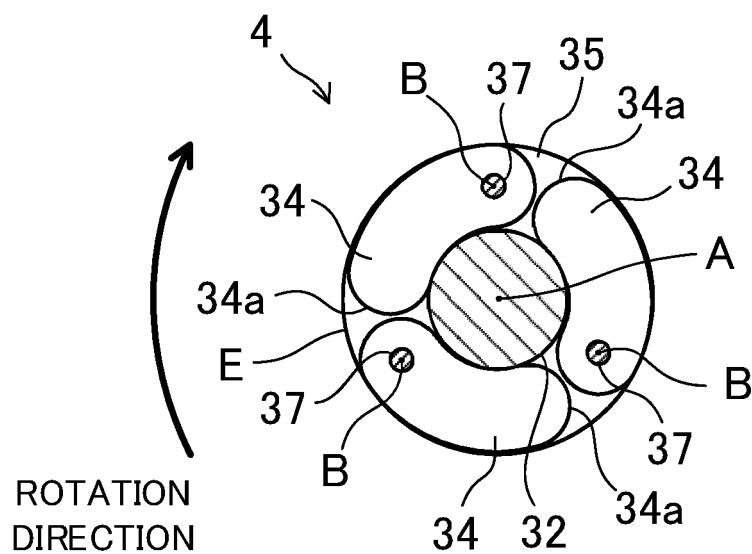


FIG. 5

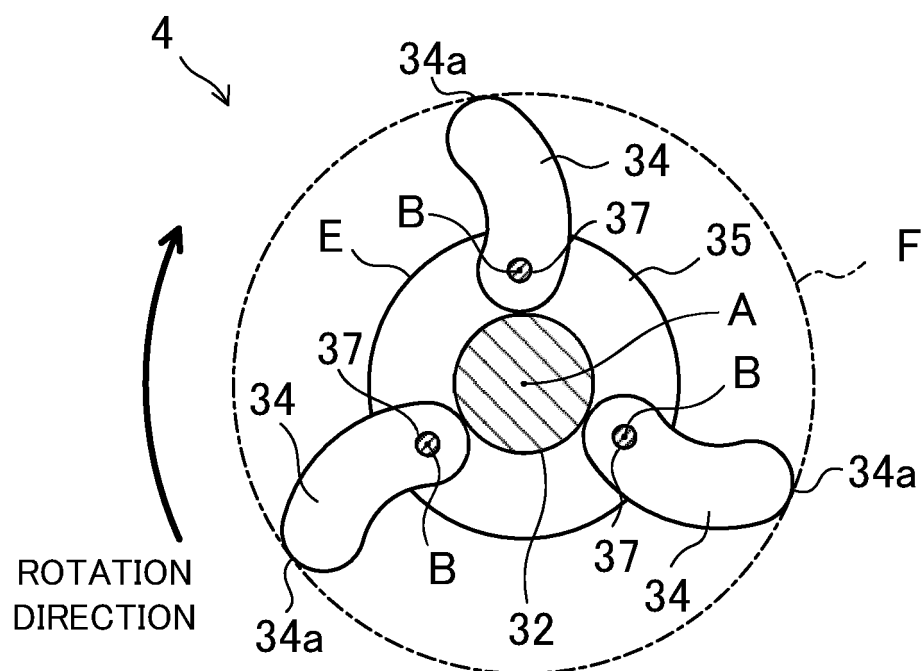


FIG. 6

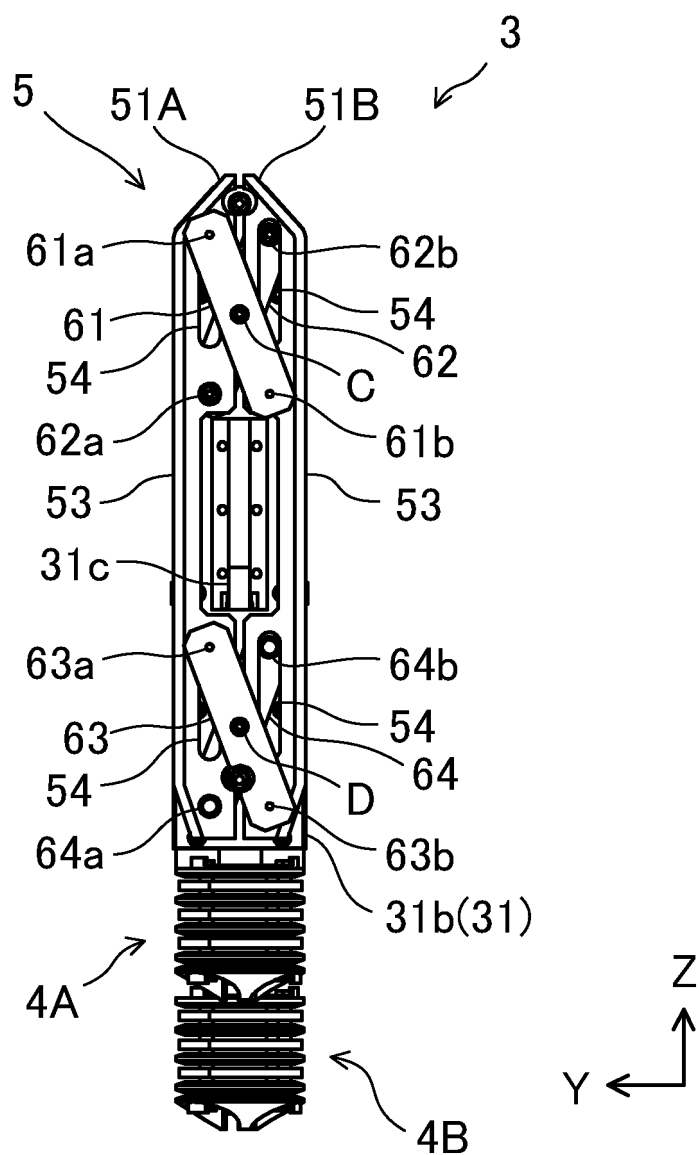


FIG. 7

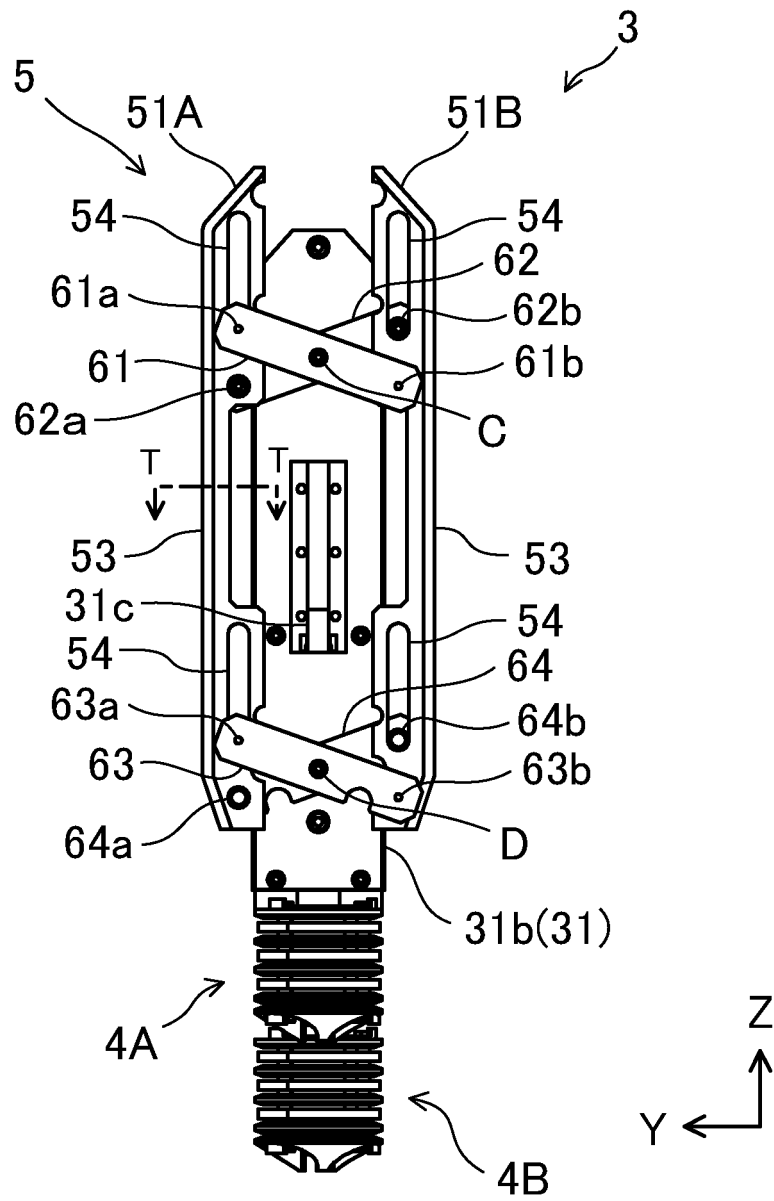


FIG. 8

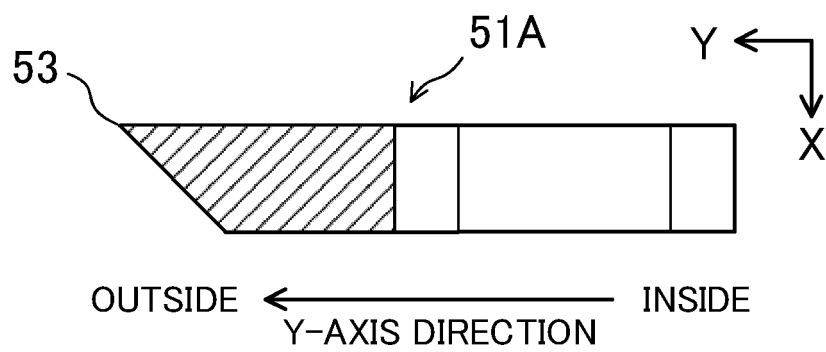


FIG. 9

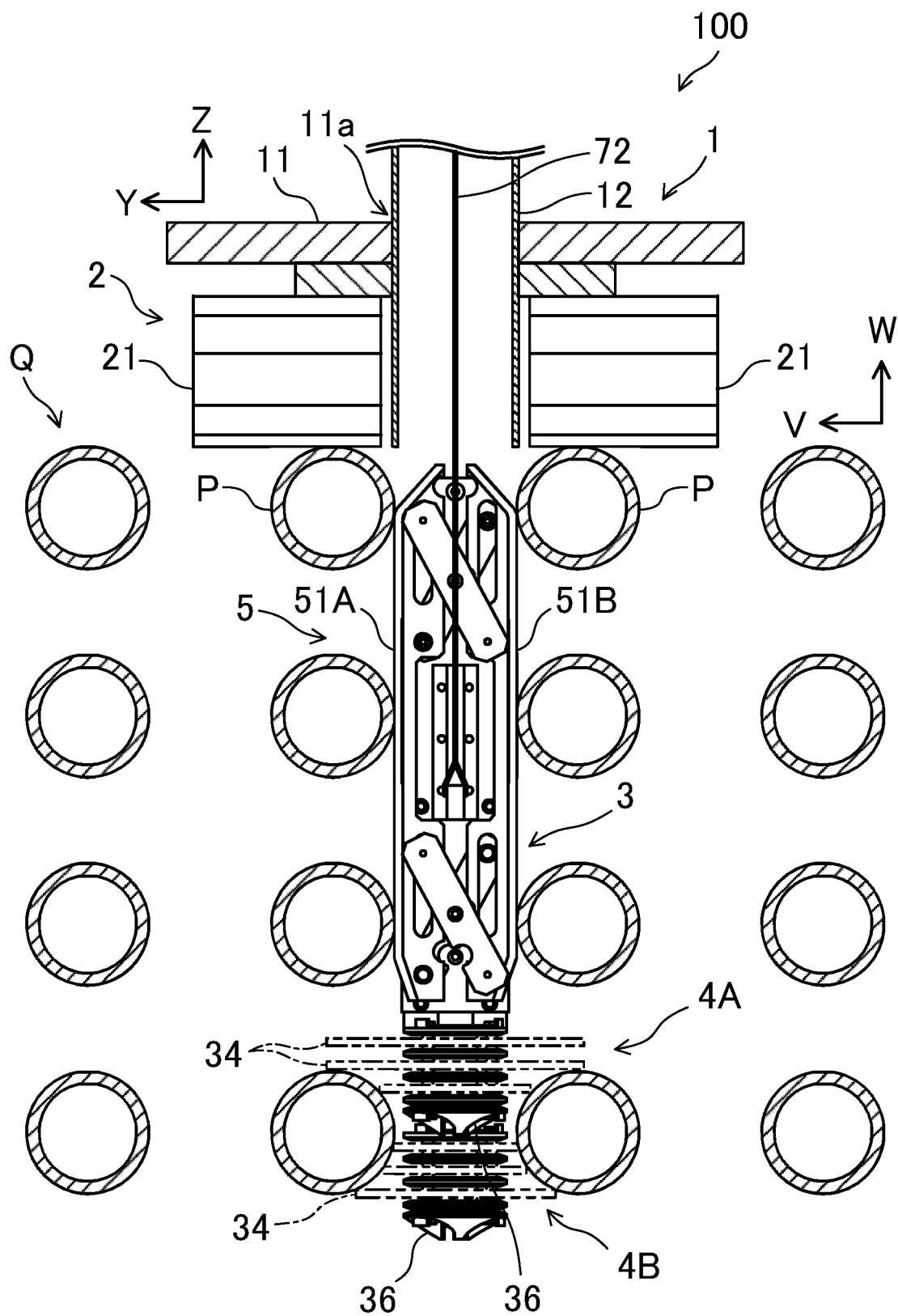


FIG. 10

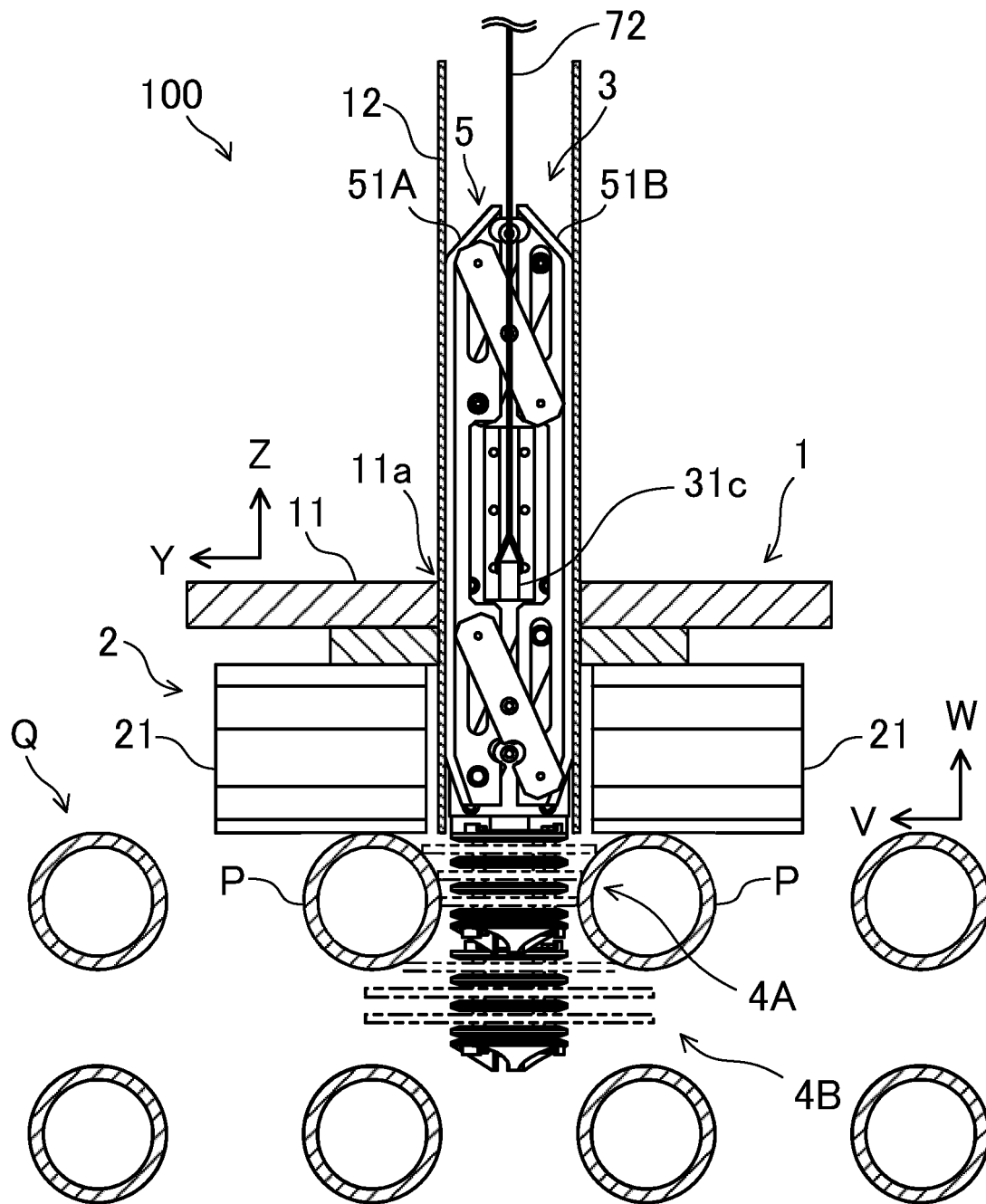


FIG. 11

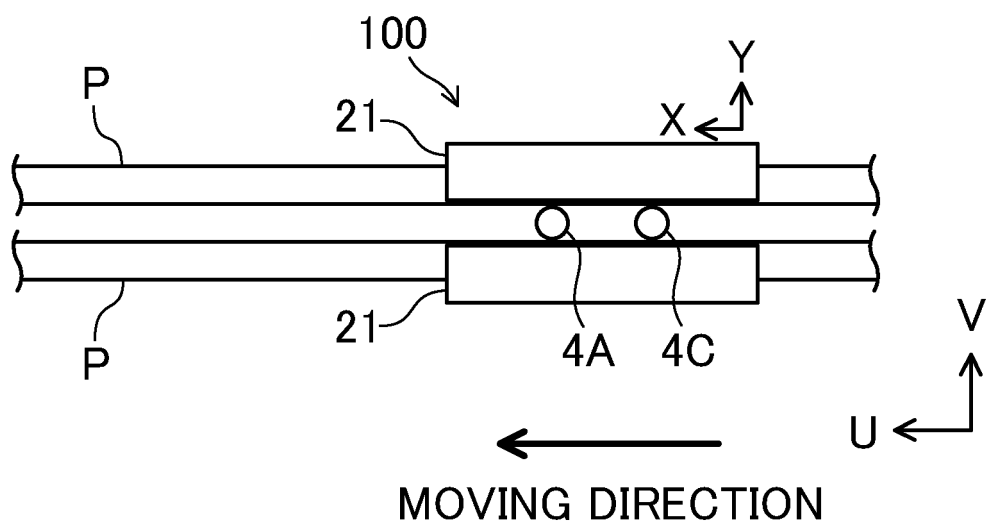


FIG. 12

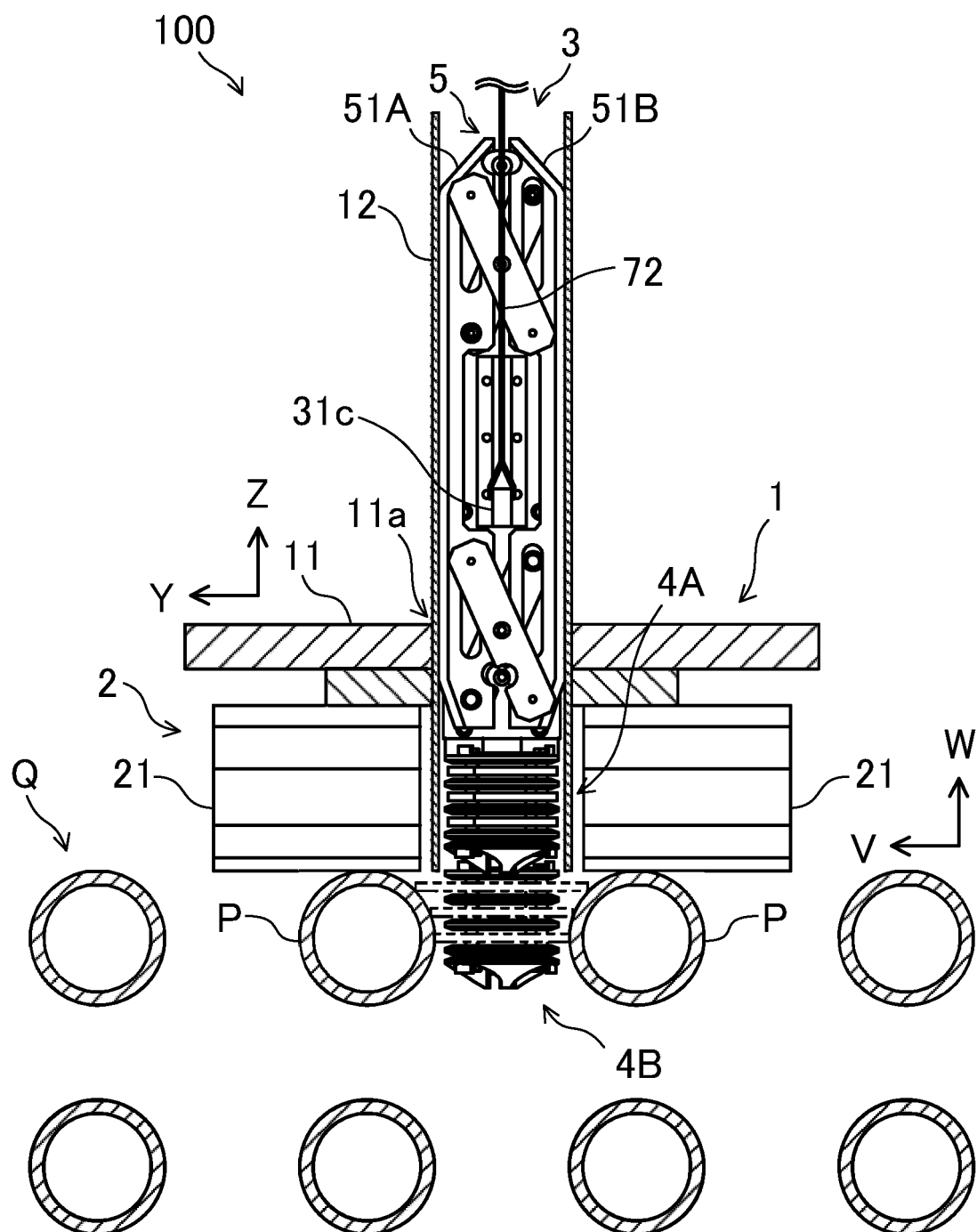
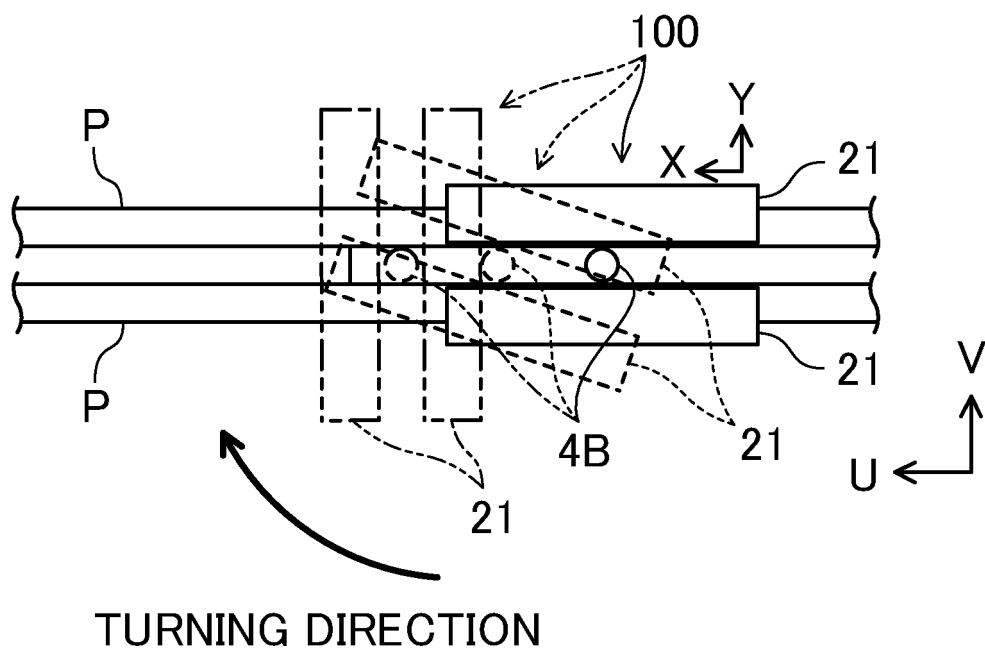


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/037865

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F28G3/14 (2006.01)i, B08B9/023 (2006.01)i, F22B37/48 (2006.01)i,
F23J3/00 (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)

Int.Cl. F28G3/00-3/16, F28G15/04, B08B9/023, F22B37/48, F23J3/00

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	DE 482728 C3 (KENNEDY, David et al.) 19 September 1929, page 2, line 24 to page 3, line 21, fig. 1-4 (Family: none)	1 9-11 2-8
Y	JP 01-239393 A (THE KANSAI ELECTRIC POWER COMPANY, INCORPORATED, MITSUBISHI HEAVY INDUSTRIES, LTD.) 25 September 1989, page 2, lower right column, line 15 to page 4, lower left column, line 15, fig. 1-3 & US 4907542 A, column 3, line 19 to column 4, line 54, column 5, line 44 to column 6, line 53, fig. 1-3 & EP 333182 A1 & AU 3138889 A & CN 1035886 A & AU 600198 B2	9-11
A	FR 613048 A (SPINOSI, Joseph) 06 November 1926, page 1, lines 1-64, fig. 1-4 (Family: none)	1-11
A	US 2164689 A (SHOVE, Chester L.) 04 July 1939, page 1, line 19 to page 2, line 39, fig. 1-4 (Family: none)	2
P, X	JP 2018-071831 A (MITSUI ZOSEN ENVIRONMENT ENGINEERING CORP.) 10 May 2018, paragraphs [0014]-[0054], fig. 1-6 (Family: none)	1

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

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"&" document member of the same patent family

Date of the actual completion of the international search
13 December 2018 (13.12.2018)

Date of mailing of the international search report
25 December 2018 (25.12.2018)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 11237199 A [0003]