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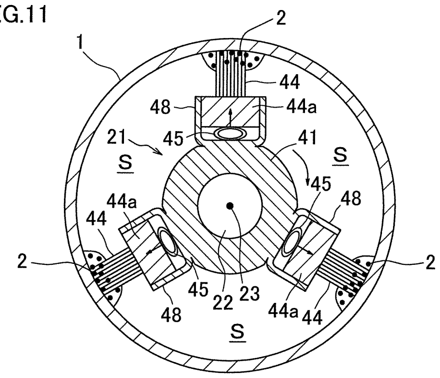
(54) DEVICE FOR POLISHING METAL PIPE INNER SURFACE, AND METAL PIPE

(57) A jig 21 includes an elastic brush 44 protruding in a radial direction orthogonal to an axis 23 and a tube 46 provided on the inner side of the brush 44 in the radial direction. The length between the leading end of the brush 44 and the axis 23 is equal to or longer than a half of the inner diameter of a stainless steel pipe 1. In a state in which the jig 21 is provided inside the stainless steel pipe 1, the tube 46 presses the brush 44 outward in the radial direction, with the result that the leading end portion of the brush 44 applies internal pressure to the inner surface of the stainless steel pipe 1 while being in contact with the inner surface of the stainless steel pipe 1, in a state in which the leading end portion of the brush 44 stands up. As a result of this, a polishing agent supplied from the pump 12 is adhered to the inner surface of the stainless steel pipe 1. The polishing agent adhered to the inner surface of the stainless steel pipe 1 is pressed onto the inner surface of the stainless steel pipe 1 by the brush 44.

FIG.11



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Description

[Technical Field]

[0001] The present invention relates to a device for polishing an inner surface of a metal pipe and a metal pipe having an inner surface polished by using this device.

[Background Art]

[0002] According to a known method of polishing an inner surface of a metal pipe, surface preparation is performed by a polishing material with a small grit size and then final polishing is performed by a polishing material with a large grit size. This polishing method is employed in so-called longitudinal polishing (see Patent Literature 1) in which a polishing belt is pressed onto an inner surface of a metal pipe and the inner surface of the metal pipe is polished by moving the polishing belt in the longitudinal direction of the metal pipe.

[Citation List]

[Patent Literatures]

[0003] [Patent Literature 1] Japanese Laid-Open Patent Publication No. H11-188594

[Summary of Invention]

[Technical Problem]

[0004] The longitudinal polishing recited in Patent Literature 1 is disadvantageous in that the inner surface of the metal pipe after the polishing is coarse. The technology is therefore not suitable for pipes used in facilities for manufacturing drugs and foods. Such facilities require a metal pipe having an inner surface with lower surface roughness.

[0005] The longitudinal polishing of Patent Literature 1 is further disadvantageous in that dust generated by the polishing of the inner surface of the metal pipe disperses in the atmospheric air and a time required for the polishing is long because a worn polishing belt must be replaced with a new polishing belt.

[0006] The invention was done to solve the problems above, and an object of the invention is to provide a device for polishing an inner surface of a metal pipe by which a metal pipe having a mirror-finished inner surface is formed, and to provide a metal pipe having an inner surface polished by the device.

[0007] Another object of the invention is to provide a device for polishing an inner surface of a metal pipe, which prevents dust generated by polishing from dispersing to the atmospheric air and shortens a time required for polishing as compared to known longitudinal polishing, and to provide a metal pipe having an inner surface polished by the device.

[Solution to Problem]

[0008] A device of the present invention for polishing an inner surface of a metal pipe that is a polishing target includes: a rotational body which extends in a direction of an axis; a drive unit which is configured to rotate the rotational body about the axis; and a supply unit which is configured to supply a polishing solution in which a granular polishing agent is mixed with a liquid to inside of the metal pipe, wherein, the rotational body includes an elastic brush protruding in a radial direction orthogonal to the axis and an inner elastic body provided on the inner side of the brush in the radial direction, the distance between the axis and a leading end of the brush is equal to or longer than a half of the inner diameter of the metal pipe, and the inner surface is polished in such a way that the inner elastic body presses the brush outward in the radial direction while the rotational body is provided inside the metal pipe, the leading end portion of the brush applies internal pressure to the inner surface of the metal pipe while being in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up (erect), and the polishing agent supplied from the supply unit to the inner surface of the metal pipe is adhered to the inner surface of the metal pipe and is pressed onto the inner surface of the metal pipe by the leading end portion of the brush.

[0009] In the present invention, a metal pipe is a pipe made of metal, a hollow cylinder made of metal, or a tube made of metal. In the present invention, a device for polishing an inner surface of a metal pipe is a device for polishing an inner surface of a pipe made of metal, a device for polishing an inner surface of a hollow cylinder made of metal, or a device for polishing an inner surface of a tube made of metal.

[0010] In the present invention, "an elastic brush protruding in a radial direction orthogonal to an axis" encompasses not only a case where the entirety of the brush is elastic and protrudes in the radial direction orthogonal to the axis but also a case where part of the brush is elastic and protrudes in the radial direction orthogonal to the axis. For example, in regard to brushes having filaments, a brush in which some of the filaments are elastic and protrude in the radial direction orthogonal to the axis is "an elastic brush protruding in the radial direction orthogonal to the axis". In regard to the brushes having filaments, a brush in which all of the filaments are elastic and protrude in the radial direction orthogonal to the axis is "an elastic brush protruding in the radial direction orthogonal to the axis". In the present invention, an expression "a leading end portion of a brush is in contact with an inner surface of a metal pipe" indicates that, when a brush has filaments and the filaments of the brush oppose an inner surface of a metal pipe, the expression encompasses not only a case where leading end portions of all of the filaments of the brush are in contact with the inner surface of the metal pipe but also a case where leading end portions of some of the filaments of the brush are in contact with the inner surface of the metal pipe. An inner elastic body is preferably elastically deformable in a radial direction of a rotational body.

[0011] In the inner surface polishing device described above, the length between the axis and the leading end of the brush is equal to or longer than a half of the inner diameter of the metal pipe, and the inner elastic body elastically deforms in the radial direction. When the rotational body is inserted into the metal pipe, the inner elastic body elastically deforming inward in the radial direction presses the brush outward in the radial direction. As a result, the leading end portion of the brush applies internal pressure to the inner surface of the metal pipe while being in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up. In this state, the rotational body is rotated by the drive unit. Consequently, the polishing solution supplied to the inside of the metal pipe is pressed onto the inner surface of the metal pipe by the leading end portion of the brush, and is adhered to the inner surface of the metal pipe. The brush is rotated about the axis while applying the internal pressure to the inner surface of the metal pipe through the polishing agent adhered to the inner surface of the metal pipe. The polishing agent provided between the brush and the inner surface of the metal pipe moves in the circumferential direction on the inner surface of the metal pipe together with the brush, while being pressed onto the inner surface of the metal pipe by the brush. As a result, the inner surface of the metal pipe is polished and the stainless steel pipe having the mirror-finished inner surface is formed.

[0012] The device of the present invention is preferably arranged such that, when the rotational body is provided inside the metal pipe, the leading end portion of the brush applies the internal pressure of equal to or more than 80N to the inner surface of the metal pipe while the leading end portion of the brush is in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up. The device of the present invention is preferably arranged such that, when the rotational body is provided inside the metal pipe, the leading end portion of the brush applies the internal pressure of equal to or less than 300N to the inner surface of the metal pipe while the leading end portion of the brush is in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up. The device of the present invention is further preferably arranged such that, when the rotational body is provided inside the metal pipe, the leading end portion of the brush applies the internal pressure of equal to or more than 80N and equal to or less than 300N to the inner surface of the metal pipe while the leading end portion of the brush is in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up.

[0013] When the internal pressure is less than 80N, the force with which the leading end portion of the brush presses the polishing agent onto the inner surface of the stainless steel pipe is low and polishing tends to be insufficient. When the internal pressure of equal to or more than 80N is applied to the inner surface of the metal pipe, it is possible to suppress the polishing of the inner surface of the metal pipe from becoming difficult. When the internal pressure is more than 300N, the brush tends to be warped and may not stand up. When the internal pressure of not more than 300N is applied to the inner surface of the metal pipe, warpage of the brush is suppressed.

[0014] The device of the present invention is preferably arranged such that the rotational body includes a brush receiver which supports the brush and the inner elastic body provided on the inner side of the brush in the radial direction, and the brush receiver supports the brush to be movable in the radial direction.

[0015] When the inner elastic body elastically deforming inward in the radial direction presses the brush outward in the radial direction, the leading end portion of the brush reliably applies internal pressure to the inner surface of the metal pipe while being in contact with the inner surface of the metal pipe in a state in which the leading end portion of the brush stands up, thanks to the brush receiver. This ensures the pressing of the polishing agent onto the inner surface of the metal pipe.

[0016] The device of the present invention is preferably arranged such that the brush receiver includes side walls that are provided on the respective sides of the brush, and the side walls support the brush to be movable in the radial direction.

[0017] Because the side walls of the brush receiver support the brush to be movable in the radial direction, when the inner elastic body elastically deforming inward in the radial direction presses the brush outward in the radial direction, the leading end portion of the brush reliably applies internal pressure to the inner surface of the metal pipe while being in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up. This ensures pressing of the polishing agent onto the inner surface of the metal pipe by the brush.

[0018] The device of the present invention is preferably arranged such that the rotational body includes a main body extending in the direction of the axis of the rotational body, the brush is provided on the outer side of the main body in the radial direction, and the inner elastic body is provided between the main body and the brush.

[0019] With this arrangement, the inner elastic body presses the brush outward in the radial direction. In the arrangement above, the inner elastic body may directly press the brush. When the inner elastic body directly presses the brush, pressing of the polishing agent onto the inner surface of the metal pipe is facilitated.

[0020] The device of the present invention is preferably arranged such that the brush is provided along the direction of the axis of the rotational body, and on the inner side of the brush in the radial direction, the inner elastic body is provided along the direction of the axis of the rotational body.

[0021] According to the arrangement above, the inner elastic body presses the brush entirely in the direction of the axis of the rotational body. Furthermore, the inner elastic body evenly presses the brush entirely in the direction of the axis of the rotational body. With this arrangement, on the inner surface of the metal pipe, the entirety of the polishing agent between the brush and the inner surface of the metal pipe is reliably pressed onto the inner surface of the metal pipe.

[0022] The device of the present invention is preferably arranged such that the rotational body further includes one or more brush each of which is identical with the brush, the brushes are provided to be separated from one another in the circumferential direction of the rotational body, and a space is formed between brushes neighboring in the radial direction of the rotational body.

[0023] According to the arrangement above, when the rotational body is provided inside the metal pipe, a space is formed between two neighboring brushes of the rotational body. When the polishing solution is supplied to the inside of the metal pipe by the supply unit, the polishing solution spreads from one end to the other end of the metal pipe through the space between two neighboring brushes of the rotational body. This makes it possible to cause the polishing agent to be adhered to the inner surface of the metal pipe entirely from one end to the other end of the metal pipe.

[0024] The device of the present invention is preferably arranged such that the brushes are provided at regular intervals in a circumferential direction of the rotational body.

[0025] Because the brushes are provided at regular intervals in the circumferential direction of the rotational body, the internal pressures applied from the leading end portions of the respective brushes to the inner surface of the metal pipe are substantially identical with one another. This makes it possible to polish the inner surface of the metal pipe evenly in the circumferential direction.

[0026] The device of the present invention is preferably arranged such that the rotational body further includes one or more brush identical with the brush and one or more brush receiver identical with the brush receiver, the brush receivers support the brushes, respectively, and the brushes and the brush receivers supporting the respective brushes are provided at regular intervals in a circumferential direction of the rotational body.

[0027] Because the brushes are provided at regular intervals in the circumferential direction of the rotational body, the internal pressures applied from the leading end portions of the respective brushes to the inner surface of the metal pipe are substantially identical with one another. Furthermore, because all brushes are supported by the brush receivers to be movable in the radial directions, all brushes reliably apply the internal pressure to the inner surface of the metal pipe. This makes it possible to polish the inner surface of the metal pipe evenly in the circumferential direction.

[0028] The device of the present invention is preferably arranged such that, in a state in which the rotational body is provided inside the metal pipe, when the leading end portions of the brushes are in contact with the inner surface of the metal pipe, at least some of the leading end portions of the brushes are perpendicular to a tangent where the leading end portions are in contact with the inner surface of the metal pipe.

[0029] The rotational body is provided inside the metal pipe, the leading end portions of the brushes are in contact with the inner surface of the metal pipe, and at least some of the leading end portions of the brushes are perpendicular to a tangent where the leading end portions are in contact with the inner surface of the metal pipe. In this case, the parts perpendicular to the tangent where the leading end portions are in contact with the inner surface of the metal pipe reliably press the inner surface of the metal pipe in the radial direction. Because the polishing agent between the brush and the inner surface of the metal pipe is reliably pressed onto the inner surface of the metal pipe, the metal pipe having the mirror-finished inner surface can be formed.

[0030] The device of the present invention is preferably arranged such that the drive unit moves the rotational body along the axis while rotating the rotational body about the axis.

[0031] Because the drive unit moves the rotational body while rotating the rotational body about the axis, the inner surface of a metal pipe can be polished even if the metal pipe is longer than the rotational body.

[0032] Preferably, the device of the present invention further includes one or more rotational body identical with the rotational body, the rotational bodies being connected to one another in the direction of the axis by a shaft. Preferably, furthermore, the distance between the rotational bodies neighboring in the direction of the axis is shorter than the length of each of the rotational bodies in the direction of the axis.

[0033] With these arrangements, because the rotational bodies are connected in accordance with the length of a metal pipe, the rotational bodies polish the inner surface of the metal pipe while pressing the polishing agent onto the inner surface of the metal pipe, even when the metal pipe is, for example, a long metal pipe that is 4 meters or more in length.

[0034] The device of the present invention is preferably arranged such that, in the state in which the rotational body is provided inside the metal pipe, the inner elastic body is compressed and the inner elastic body elastically presses the brush outward in the radial direction.

[0035] With this arrangement, the brush reliably applies the internal pressure to the inner surface of the metal pipe. As a result, the polishing agent between the leading end portion of the brush and the inner surface of the metal pipe is reliably pressed onto the inner surface of the metal pipe.

[0036] A metal pipe of the present invention has an inner surface polished by the above-described device, arithmetic average roughness (Ra) of the inner surface being less than 0.1 μm. With the inner surface polishing device described above, the metal pipe having the mirror-finished inner surface can be formed.

[0037] A metal pipe of the present invention has an inner surface polished by the device described above and is equal to or longer than 4 meters in length. With the inner surface polishing device described above, the long metal pipe having the mirror-finished inner surface can be formed.

[0038] In the present invention, a metal pipe is a pipe made of metal, a hollow cylinder made of metal, or a tube made of metal.

[Advantageous Effects of Invention]

[0039] According to the present invention, the length between the axis of the rotational body and the leading end of the brush is equal to or longer than a half of the inner diameter of the metal pipe, and the inner elastic body elastically deforms. On this account, when the rotational body is inserted into the metal pipe, the inner elastic body that is elastically deformed on account of the inward movement of the brush presses the brush outward in the radial direction. Due to this, the leading end portion of the brush makes contact with and apply internal pressure to the inner surface of the metal pipe, while the leading end portion of the brush, which is pressed radially outward, is maintained to stand up. As the rotational body provided inside the metal pipe is rotated in a state in which the polishing solution has been supplied, the leading end portion of the brush presses the polishing solution onto the inner surface of the metal pipe while being maintained to stand up, with the result that the polishing agent is adhered to the inner surface of the metal pipe. Because the rotational body rotates about the axis while the brush applies internal pressure to the metal pipe through the polishing agent, the polishing agent adhered to the inner surface of the metal pipe polishes the inner surface of the metal pipe in the circumferential direction. Consequently, the metal pipe having the mirror-finished inner surface is formed. Furthermore, because the dust generated at the time of polishing the inner surface of the metal pipe is mixed into the polishing solution, dispersion of the dust to the atmospheric air is prevented. Furthermore, frictional heat generated by the polishing of the inner surface of the metal pipe by the polishing agent is absorbed by the liquid and cooled. If the inner surface of a metal pipe is polished by using a file, it is necessary to replace a worn file with a new file. Meanwhile, because the inner surface of the metal pipe is polished by the polishing agent, the rotational body is not worn. Because it is unnecessary to replace the rotational body with new one, the polishing time is short as compared to a case where a file is used.

[Brief Description of Drawings]

[0040]

FIG. 1 is a schematic cross section of a device for polishing an inner surface of a metal pipe of an embodiment of the present invention.

FIG. 2 is a partially enlarged top view of jigs connected by a shaft.

FIG. 3 is a cross section of a jig cut along an A-A line in FIG. 2.

FIG. 4 is a cross section of a metal pipe.

FIG. 5 is a schematic cross section of an inner surface polishing device in which a metal pipe is being provided.

FIG. 6 is a schematic cross section of the inner surface polishing device in which the metal pipe has been provided and fixed.

FIG. 7 is a partially enlarged top view showing a state in which a metal pipe is being moved from the other end portion to one end portion of a jig unit.

FIG. 8 is a partially enlarged top view of the other end portion of the jig unit, showing a state in which the metal pipe has been positioned.

FIG. 9 is a cross section of part of a jig inserted into the metal pipe.

FIG. 10 is a partially enlarged cross section of a leading end portion of the brush of FIG. 9.

FIG. 11 is a cross section cut along a B-B line in FIG. 8, which shows a state in which a polishing solution is supplied to the inside of the metal pipe and the jig is rotated.

FIG. 12 is a partially enlarged cross section of the jig shown in FIG. 11.

[Description of Embodiments]

[0041] The following describes an embodiment of the present invention with reference to attached drawings.

[0042] An inner surface polishing device 10 shown in FIG. 1, which is a device for polishing an inner surface of the present embodiment, is configured to polish an inner surface of a long metal pipe (polishing target) that is 4 meter long. The embodiment deals with a case where the metal pipe is a stainless steel pipe. In the present embodiment and in an example and a comparative example that will be explained later, a stainless steel pipe is a pipe made of stainless steel, a hollow cylinder made of stainless steel, or a tube made of stainless steel. A stainless steel pipe having an inner surface polished by the inner surface polishing device 10 is used in apparatuses for manufacturing foods and drugs. Usage of this device, however, is not particularly limited. Arithmetic average roughness (Ra) of an inner surface of a stainless steel pipe polished by the inner surface polishing device 10 is less than 0.1 μm.

[0043] The inner surface polishing device 10 is capable of polishing an inner surface of not only a stainless steel pipe but also a pipe made of metal that is not stainless steel, such as titanium and brass, a hollow cylinder, or a tube. In the present embodiment, the long stainless steel pipe that is 4 meter long is polished. However, the length of a metal pipe to be polished is not particularly limited. An inner surface of a metal pipe that is shorter than 4 meters may be polished, or an inner surface of a metal pipe that is longer than 4 meters, e.g., a metal pipe that is 6 meter long may be polished.

[0044] As discussed below, the inner surface polishing device 10 is configured to polish an inner surface of a stainless steel pipe by using a wet polishing agent mixed into a liquid. On this account, in order to prevent leakage of the liquid to the outside, the inner surface polishing device 10 is covered with a box-shaped cover (not illustrated). However, the cover is not explained for the purpose of convenience.

[0045] FIG. 6 shows a case where a stainless steel pipe (metal pipe) 1 is provided in the inner surface polishing device 10 shown in FIG. 1. As shown in FIG. 6, the inner surface polishing device 10 includes a pump (supply unit) (see FIG. 6), jigs (rotational bodies) 21 (see FIG. 1), and a motor (drive unit) 30 (see FIG. 1 and FIG. 6). The pump 12 is a supply unit configured to supply a polishing solution into the stainless steel pipe 1 while the stainless steel pipe 1 is provided in and fixed to the inner surface polishing device 10. Each jig 21 is a rotational body that rotates inside the stainless steel pipe 1. The motor 30 is a drive unit configured to rotationally drive the jig 21 about an axis 23.

[0046] As shown in FIG. 6, the pump 12 communicates with a tank 13 which stores the polishing solution. The polishing solution in the tank 13 is ejected from a leading end 14 of the pump 12. In the state in which the stainless steel pipe 1 is provided in the inner surface polishing device 10, the leading end 14 of the pump 12 is connected, through a pipe (not illustrated), to an opening at an end portion of the stainless steel pipe 1, which is on the side opposite to the motor 30. While the inner surface polishing device 10 in which the stainless steel pipe 1 is provided is driven, the pump 12 discharges the polishing solution and supplies this solution to the inside of the stainless steel pipe 1. The polishing solution supplied to the stainless steel pipe 1 is drained from an opening at an end portion of the stainless steel pipe 1 on the motor 30 side. The drained polishing solution flows into a collector 16 provided below the stainless steel pipe 1 and the jigs 21 (see FIG. 1), and is stored in a drain pan 17. The collector 16 is integrally formed with the unillustrated cover.

[0047] The polishing solution is a liquid mixture of a liquid and a granular polishing agent. The liquid is water in the present embodiment, but the liquid is not limited to this. The liquid may be acidic water or an organic solvent, for example. Specific examples of the liquid include alcohol, oil, ethanol, and nitric acid. Any kinds of liquid can be used as long as the liquid can be mixed with the polishing agent and used for polishing metal.

[0048] The polishing agent is aluminum oxide in the present embodiment, but the polishing agent is not limited to this. An example of the polishing agent is a wet-type polishing agent. The polishing agent is preferably larger in specific weight than water and higher in hardness than metal that is the polishing target. Examples of such a polishing agent include carbide and oxide. Specific examples of the polishing agent are carbon and diamond. Any kinds of polishing agents can be used as long as the agent can be mixed with the liquid and used for polishing metal.

[0049] As the polishing agent is pressed onto the inner surface of the stainless steel pipe 1 by the jigs 21 (see FIG. 1), the inner surface of the stainless steel pipe 1 is polished. The inner surface polishing device 10 of the present embodiment is provided with eight jigs 21, and these jigs 21 are connected to one another by a shaft 22 in the direction of the axis 23. To put it differently, the inner surface of the stainless steel pipe 1 (see FIG. 6) that is 4 meter long is polished by using the eight jigs 21. For the sake of convenience, hereinafter, the eight jigs 21 and the shaft 22 will be collectively termed a jig unit 20.

[0050] As shown in FIG. 1, one end portion of the jig unit 20 on the motor 30 side (i.e., one end portion of the shaft 22) is supported by the motor 30 to be rotatable. The other end portion of the jig unit 20 on the side opposite to the motor 30 (i.e., the other end portion of the shaft 22) is supported by a supporting leg 33c standing on the ground. The jig unit 20 is supported at the shaft 22 by unillustrated supporting legs that are provided at predetermined intervals between the motor 30 and the supporting leg 33c. A leading end portion of the supporting leg 33c supports the shaft 22 by sandwiching the shaft 22. As the leading end portion is opened and closed, the jig unit 20 is supported and the support of the jig unit 20 is canceled. When the stainless steel pipe 1 is moved from the other end portion toward the one end portion of the jig unit 20 while the stainless steel pipe 1 covers the jig unit 20, the supporting leg 33c cancels the support of the jig unit 20.

[0051] FIG. 2 is a partially enlarged top view showing three jigs 21 on the other end portion side, which are remote from the motor 30 among the jigs in the jig unit 20. While the jig unit 20 includes eight jigs 21, the figure shows only three of these jigs 21 as representative ones. All of the eight jigs 21 are identical in shape, and the length of each jig 21 is L1. The jigs 21 are provided at regular intervals each of which is L2. The distance L2 between neighboring jigs 21 is shorter than the length L1 of each jig 21.

[0052] FIG. 3 is a cross section cut along an A-A line in FIG. 2, and is an enlarged cross section of a jig 21 cut along the direction orthogonal to the axis 23. The jig 21 is fixed to the shaft 22 and rotates together with the shaft 22. The jig 21 includes a main body 41 extending in the direction of the axis 23, brushes 44 each of which protrudes outward from the main body 41 in a radial direction orthogonal to the axis 23, is provided on the outer side in the radial direction, and is movable in the radial direction, and tubes (inner elastic bodies) 45 that are provided between the axis 23 and the brushes 44 and are inner elastic bodies elastically pressing the brushes 44 outward in the radial directions.

[0053] The main body 41 is cylindrical in shape in a cross section orthogonal to the axis 23. The main body 41 is integrally formed with three concave brush receivers 48 that are provided at equal intervals in the circumferential direction of the main body 41. In each brush receiver 48, a base portion 44a of the brush 44 and the tube 45 are provided. The brush 44 and the tube 45 are supported by the brush receiver 48.

[0054] The brush 44 includes a large number of resin filaments (bristles) and is elastic. The brush 44 encompasses the base portion 44a in which the large number of resin filaments are planted. Each resin filament constituting the brush 44 of the present embodiment is circular in cross section cut along the direction orthogonal to the direction in which each resin filament extends. As long as the brush 44 is able to maintain a state in which the bristles stand up when the jig 21 inserted into the stainless steel pipe 1 rotate, the diameter of each resin filament of the brush 44 (i.e., the diameter of a plane perpendicular to the longitudinal direction) is not particularly limited. For example, a resin filament that is equal to or more than 0.2 mm and equal to or less than 0.6 mm in diameter (hereinafter, filament diameter) may be employed.

[0055] The brush 44 is supported by side walls 48a of the brush receiver 48 to be movable in the radial direction. The brush 44 is provided on the outer side of the tube 45 in the radial direction, and linearly extends to be in parallel to the axis 23. In the present embodiment, three brushes 44 are provided at equal intervals in the circumferential direction of the main body 41. The number of the brushes 44 may not be three. The brush 44 supported by the brush receiver 48 protrudes from the main body 41 in the direction (radial direction) orthogonal to the axis 23, i.e., stands up along the radial direction. The brush 44 is elastically pressed outward in the radial direction by the tube 45 and is engaged with a stopper (not illustrated) provided on the brush receiver 48. With this arrangement, the state of supporting the brush 44 by the brush receiver 48 is maintained. The length L3 between the leading end of the brush 44 and the axis 23 is longer than the length L4 (see FIG. 4) that is half as long as the inner diameter of the stainless steel pipe 1. The expression "the brush 44 and its leading end portion stand up" indicates that the brush 44 and its leading end portion extend linearly, and does not encompass cases where the brush 44 and its leading end portion are warped or bended.

[0056] The inner elastic member is a tube 45 made of resin, and is elastic. In the brush receiver 48, the tube 45 is provided between the axis 23 and the brush 44, i.e., on the inner side of the brush 44 in the radial direction. The tube 45 provided in the brush receiver 48 is positioned between a bottom wall 48b of the brush receiver 48 and the brush 44 and is elastically deformed. The tube 45 makes contact with the brush 44 and directly presses the brush 44 outward in the radial direction. Because the tube 45 extends from one end to the other end of the brush 44 in the longitudinal direction of the brush 44 (i.e., in the direction in parallel to the axis 23), the tube 45 evenly presses the brush 44 over the entire length of the brush 44.

[0057] Referring back to FIG. 1, the motor 30 moves the jigs 21 about the axis 23 while rotating the jigs 21 about the axis 23. The motor 30 is fixed to a base plate 32 that is movable on a pair of rails 31 in the direction of the axis 23. The pair of rails 31 are aligned in the horizontal direction, and are fixed to a supporting plate 34 that is attached to the supporting leg 33a and the supporting leg 33b standing on the ground.

[0058] The base plate 32 is driven along the axis 23 by a rackand-pinion mechanism. An unillustrated motor is mounted on the base plate 32. This motor rotates a pinion gear 37 through a shaft 36. As the pinion gear 37 engaged with a rack gear 38 attached to the supporting leg 33a and the supporting leg 33b rotates, the motor 30 moves along the axis 23 together with the base plate 32.

[0059] The following will describe a method of polishing the inner surface of the stainless steel pipe 1 by using the inner surface polishing device 10.

[0060] FIG. 5 is a schematic cross section of the inner surface polishing device 10 in which the stainless steel pipe 1 is being provided. In FIG. 5, the stainless steel pipe 1 is moved in the direction of the axis 23 from the other end portion toward the one end portion of the jig unit 20 so as to cover the jigs 21 (see FIG. 7), and the stainless steel pipe 1 is positioned. FIG. 8 is a partially enlarged top view of the other end portion of the jig unit 20, which shows a state in which the stainless steel pipe 1 is positioned. When the stainless steel pipe 1 is positioned and fixed, all jigs 21 are provided inside the stainless steel pipe 1. When the stainless steel pipe 1 is positioned, the opening at the end portion of the stainless steel pipe 1 on the side opposite to the motor 30 is connected to the leading end 14 of the pump 12 (see FIG. 6) through a pipe (not illustrated). Therefore it becomes possible to supply the polishing solution in the tank 13 to the inside of the stainless steel pipe 1.

[0061] As shown in FIG. 3, the length L3 between the leading end of the brush 44 and the axis 23 is longer than the length L4 that is half as long as the inner diameter of the stainless steel pipe 1. On this account, as shown in FIG. 9, when the jigs 21 are inserted into the stainless steel pipe 1, the brushes 44 move inward in the radial directions and the tubes 45 are compressed. Because the tubes 45 elastically press the brushes 44 outward in the radial directions, the leading end portions of the brushes 44 make contact with the inner surface of the stainless steel pipe 1 and impart a certain degree of internal pressure thereto, while the brushes 44 are maintained to stand up. At this stage, as shown in FIG. 10, the leading end portions of at least some of the brushes 44 are perpendicularly in contact with the inner surface of the stainless steel pipe 1. In the present embodiment, the internal pressure applied from the leading end portion of the brush 44 to the inner surface of the stainless steel pipe 1 is preferably 80N or more. In the present embodiment, the internal pressure applied from the leading end portion of the brush 44 to the inner surface of the stainless steel pipe 1 is preferably 300N or less. When the internal pressure is less than 80N, the force with which the leading end portion of the brush 44 presses the polishing agent onto the inner surface of the stainless steel pipe 1 is low and polishing tends to be insufficient. Meanwhile, when the internal pressure is more than 300N, the brush 44 tends to be warped and may not stand up.

[0062] When the polishing solution is supplied from the tank 13 shown in FIG. 6 to the inside of the stainless steel pipe 1, the polishing solution passes through spaces S (see FIG. 11) formed between the inner surface of the stainless steel pipe 1 and the surfaces of the jig 21, with the result that the polishing solution spreads from one end to the other end of the stainless steel pipe 1. In this state, as the motor 30 rotates the jigs 21 about the axis 23, the polishing solution is gathered to the leading end portions of the brushes 44 on account of the centrifugal force. The leading end portions of the brushes 44 press the polishing solution onto the inner surface of the stainless steel pipe 1, with the result that the polishing agent 2 is adhered to the inner surface of the stainless steel pipe 1. Furthermore, because the tube 45 elastically presses each brush 44 outward in the radial direction, the brush 44 and its leading end portion are maintained to stand up while the jig 21 is rotating (see FIG. 12). In this way, because the brush 44 rotates about the axis 23 while applying internal pressure to the stainless steel pipe 1 through the polishing agent 2, the polishing agent 2 adhered to the inner surface of the stainless steel pipe 1 polishes the inner surface of the stainless steel pipe 1 in the circumferential direction.

[0063] As described above, in the present embodiment, when the jigs 21 are inserted into the stainless steel pipe 1, the tubes 45 are elastically deformed (compressed) inward. Each tube 45, which is elastically deformed inward, elastically presses the brush 44 outward in the radial direction. Due to this, the tube 45 makes contact with and apply internal pressure to the inner surface of the metal pipe, while the leading end portion of the brush 44, which is pressed radially outward, is maintained to stand up. As the polishing solution is supplied to the inside of the stainless steel pipe 1 and the jigs 21 are rotated, the leading end portion of each brush 44 rotates while being maintained to stand up. At this stage, the leading end portion of the brush 44 presses the adhered polishing agent onto the inner surface of the stainless steel pipe 1. As a result, the polishing agent polishes the inner surface in the circumferential direction. The present invention therefore relates to a device for polishing an inner surface of a metal pipe solely by physical polishing.

[0064] The motor 30 moves the jigs 21 along the axis 23 while rotating the jigs 21 about the axis. Because the jigs 21 are provided at regular intervals, the motor 30 moves the jigs 21 in the direction of the axis 23 by the distance L2 between the neighboring jigs 21. As a result of this, the inner surface of the stainless steel pipe 1 is entirely polished by the jigs 21 and the polishing agent 2. When the jigs 21 are provided at the intervals L2 in this way, the driving force for rotating the jigs 21 about the axis 23 is small and hence the motor 30 is downsized and the power consumption is decreased, as compared to a case where a single jig that is identical in length with the stainless steel pipe 1 is used. Furthermore, counteracting force from the inner surface of the stainless steel pipe 1 is suppressed, and damage on the jig unit 20 is avoided.

[Characteristics of Inner Surface Polishing Device of Present Embodiment]

[0065] The inner surface polishing device 10 of the stainless steel pipe 1 of the present embodiment has the following characteristics.

[0066] As shown in FIG. 3, in the inner surface polishing device 10 of the present embodiment, the length between the axis 23 of the jig 21 and the leading end of the brush 44 is equal to or longer than the length L4 that is half as long as the inner diameter of the stainless steel pipe 1, and the tube 45 is elastically deformed. On this account, when the jig 21 is inserted into the stainless steel pipe 1, the tube 45 that is elastically deformed inward presses the brush 44 outward in the radial direction. Due to this, the brush 44 makes contact with and apply internal pressure to the inner surface of the stainless steel pipe 1, while the leading end portion of the brush 44, which is pressed radially outward , is in a state in which the leading end portion stands up. With this arrangement, as the jigs 21 provided inside the stainless steel pipe 1 are rotated in the state in which the polishing solution has been supplied, the leading end portions of the brushes 44 press the polishing agent onto the inner surface of the stainless steel pipe 1, with the result that the polishing agent is adhered to the inner surface of the stainless steel pipe 1. Because the jigs 21 rotate about the axis 23 while the brushes 44 apply internal pressure to the stainless steel pipe 1 through the polishing agent, the polishing agent 2 adhered to the inner surface of the stainless steel pipe 1 polishes the inner surface of the stainless steel pipe 1 in the circumferential direction. Consequently, the stainless steel pipe 1 having the mirror-finished inner surface is formed.

[0067] In the inner surface polishing device 10 of the present embodiment, because the dust generated at the time of polishing the inner surface of the stainless steel pipe 1 is mixed into the polishing solution, dispersion of the dust to the atmospheric air is prevented. Furthermore, frictional heat generated by the polishing of the inner surface of the stainless steel pipe 1 by the polishing agent 2 is absorbed by the liquid and cooled. If the inner surface of a stainless steel pipe is polished by using a file, it is necessary to replace a worn file with a new file. Meanwhile, because in the present invention the inner surface of the stainless steel pipe 1 is polished by the polishing agent 2, the jigs 21 are not worn. Because it is unnecessary to replace the jigs 21 with new ones, the polishing time is short.

[0068] In the inner surface polishing device 10 of the present embodiment, preferably, the leading end portion of the brush 44 makes contact with the inner surface of the metal pipe while being maintained to stand up, and applies internal pressure of equal to or more than 80N. In the inner surface polishing device 10 of the present embodiment, the applied internal pressure is preferably not more than 300N. When the internal pressure is less than 80N, the force with which the leading end portion of the brush 44 presses the polishing agent onto the inner surface of the stainless steel pipe 1 is low and polishing tends to be insufficient. This problem is suppressed by the arrangement above. Meanwhile, when the internal pressure is more than 300N, the brush 44 tends to be warped and may not stand up. This problem is also suppressed by the arrangement above.

[0069] In the inner surface polishing device 10 of the present embodiment, the tube 45 provided between the axis 23 and the brush 44 may extend in the longitudinal direction of the brush 44 (i.e., in the direction in parallel to the axis 23). With this arrangement, the tube 45 evenly presses the brush 44 over the entire length of the brush 44.

[0070] In the inner surface polishing device 10 of the present embodiment, because the brushes 44 are provided at equal intervals in the circumferential direction of the main body, the leading end portions of the brushes 44 making contact with the inner surface of the stainless steel pipe 1 apply the internal pressure evenly.

[0071] In the inner surface polishing device 10 of the present embodiment, the leading end portion of each brush 44 perpendicularly makes contact with the inner surface of the stainless steel pipe 1 when the jig 21 is provided inside the stainless steel pipe 1. This indicates that the leading end portion of the brush 44 makes contact with and applies internal pressure to the inner surface of the stainless steel pipe 1, while the leading end portion of the brush is maintained to stand up. Because the jigs 21 rotate about the axis 23 in this state while the brushes 44 apply internal pressure to the stainless steel pipe 1 through the polishing agent 2, the polishing agent 2 adhered to the inner surface of the stainless steel pipe 1 polishes the inner surface of the stainless steel pipe 1 in the circumferential direction. Consequently, the stainless steel pipe 1 having the mirror-finished inner surface is formed.

[0072] In the inner surface polishing device 10 of the present embodiment, the polishing solution is injected from one end toward the other end of the stainless steel pipe 1, in the state in which the jigs 21 are provided inside the stainless steel pipe 1. As shown in FIG. 11, the spaces S are formed between the inner surface of the stainless steel pipe 1 and the surfaces of the jig 21. On this account, the polishing solution injected into the stainless steel pipe 1 spreads from one end to the other end of the stainless steel pipe 1 through the spaces S.

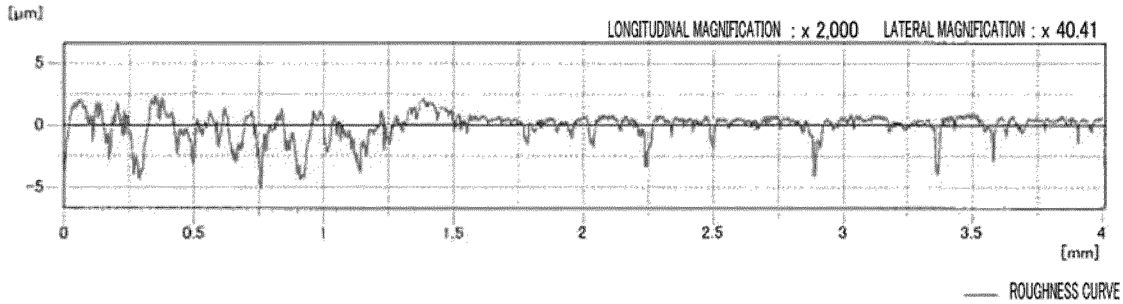
[0073] In the inner surface polishing device 10 of the present embodiment, as shown in FIG. 1, the motor 30 moves the jigs 21 along the axis 23 while rotating the jigs 21 about the axis 23. On this account, the entire inner surface of the stainless steel pipe 1 can be polished even if the stainless steel pipe 1 is longer than the jigs 21.

[0074] In the inner surface polishing device 10 of the present embodiment, the jigs 21 are connected to one another by the shaft 22 in the direction of the axis 23. Because the jigs 21 are connected in accordance with the length of a metal pipe, the jigs 21 press the polishing agent 2 onto the inner surface of the metal pipe and polish the inner surface, even when the metal pipe is, for example, a long metal pipe that is 4 meters or more in length.

<Example>

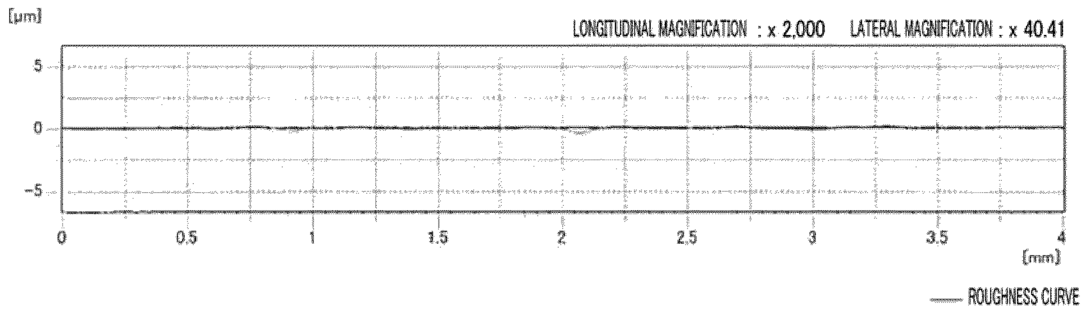
[0075] The inventors of the subject application measured arithmetic average roughness (Ra) of an inner surface of a stainless steel pipe 1 polished by using the inner surface polishing device 10, and compared the measured roughness with arithmetic average roughness (Ra) of an inner surface of a known stainless steel pipe.

<Table 1>



[0076] As a comparative example, Table 1 shows a graph of arithmetic average roughness (Ra) in the circumferential direction of an inner surface of a stainless steel pipe polished by known longitudinal polishing. With this longitudinal polishing, the inner surface of the stainless steel pipe was polished through five steps. A 90 grit file was used in the first step, a 120 grit file was used in the second step, a 140 grit file was used in the third step, a 240 grit file was used in the fourth step, and a 400 grit file was used in the fifth step. The grit size of each file is based on JIS R6010 "Coated abrasive grain sizes". Two pipes were selected from among stainless steel pipes polished by the longitudinal polishing, and arithmetic average roughness (Ra) in the circumferential direction of each of these two pipes were measured. The arithmetic average roughness of the first pipe was 0.7576 μm, and the arithmetic average roughness of the second pipe was 0.6103 μm.

<Table 2>



[0077] Table 2 shows a graph of arithmetic average roughness (Ra) in the circumferential direction of an inner surface of a stainless steel pipe 1 polished by the inner surface polishing device 10 of the present invention. In this polishing, a polishing solution in which water as a liquid was mixed with aluminum oxide as a polishing agent was used. In the first step, brushes 44 with the filament size (diameter of filament) of 0.5 mm were used, and jigs 21 were rotated at 300 rpm for 30 minutes. At a given timing in the first step, the internal pressure with which each brush 44 pressed the inner surface of the stainless steel pipe 1 was measured. The measured internal pressure was equal to or more than 120N and equal to or less than 160N. In the subsequent second step, brushes 44 with the filament size (diameter of filament) of 0.4 mm were used, and jigs 21 were rotated at 300 rpm for 30 minutes. At a given timing in the second step, the internal pressure with which each brush 44 pressed the inner surface of the stainless steel pipe 1 was measured. The measured internal pressure was equal to or more than 160N and equal to or less than 270N. Two pipes were selected from among the stainless steel pipes polished by the two steps, and arithmetic average roughness (Ra) in the circumferential direction of each of these two pipes were measured. The arithmetic average roughness of the first pipe was 0.093 μm, and the arithmetic average roughness of the second pipe was 0.096 μm. The result shows that the arithmetic average roughness (Ra) of the inner surface of the stainless steel pipe 1 of the present invention is less than 0.1 μm. It is noted that this arithmetic average roughness (Ra) is based on JIS B0031 (1994).

[0078] Thus, the embodiment of the present invention is described hereinabove. However, the specific structure of the present invention shall not be interpreted as to be limited to the above described embodiment. The scope of the present invention is defined not by the above embodiment but by claims set forth below, and shall encompass the equivalents in the meaning of the claims and every modification within the scope of the claims.

[0079] In the embodiment above, the inner surface of the stainless steel pipe 1 that is 4 meter long is polished by using eight jigs 21. The disclosure, however, is not limited to this arrangement. A single jig that is identical in length with the stainless steel pipe may be used. In this case, the motor 30 and the jig 21 may not be moved in the direction of the axis 23 (see, e.g., FIG. 1). The number of jigs may not be eight. Plural jigs, e.g., two or three jigs may be used.

[0080] While in the embodiment above the distance between two neighboring jigs 21 is L2 and L2 is shorter than the length L1 of each jig 21, the disclosure is not limited to this arrangement. As long as the entire inner surface of the stainless steel pipe can be polished by moving the motor 30 in the axial direction, the distance L2 may be identical with the length L1 of the jig or longer than the length L1 of the jig.

[0081] While in the embodiment above the length L3 (see FIG. 3) between the leading end of the brush 44 and the axis 23 is longer than the length L4 (see FIG. 4) that is half as long as the inner diameter of the stainless steel pipe 1, the disclosure is not limited to this arrangement. The length L3 may be identical with the length L4.

[0082] While in the embodiment above the inner elastic body provided between the axis 23 and the brush 44 is an elastic tube 45 (see FIG. 3), the disclosure is not limited to this arrangement. The inner elastic body may be a spring or rubber, for example.

[0083] In the embodiment above, as shown in FIG. 3, the base portion 44a of the brush 44 is provided inside the brush receiver 48. Alternatively, the base portion 44a may be partially provided inside the brush receiver 48, or the base portion 44a and at least some of resin filaments (bristles) planted in the base portion 44a may be provided inside the brush receiver 48.

[0084] While in the embodiment above the brush receiver 48 has the side walls 48a and the bottom wall 48b as shown in FIG. 3, the brush receiver may be arranged differently.

[0085] In the embodiment above, as shown in FIG. 3, the base portion 44a of the brush 44 is provided on the outer side of the tube 45 in the radial direction, and the tube 45 directly presses the base portion 44a of the brush 44. In this regard, another member may be provided between the tube 45 and the brush 44.

[0086] In the embodiment above, as shown in FIG. 3, three brushes 44 and three brush receivers 48 supporting the brushes 44 are provided at regular intervals in the circumferential direction of the jig 21. In this connection, brushes 44 and brush receivers 48 supporting the brushes 44 may not be provided at regular intervals in the circumferential direction of the jig 21. The number of pairs of brushes 44 and brush receivers 48 supporting the brushes 44 provided in the circumferential direction of the jig 21 may be one, two, four, or more than four. Furthermore, a brush 44 and a tube 45 provided on the inner side of the brush 44 in the radial direction may be entirely continuous in the circumferential direction of the jig 21.

[Reference Signs List]

[0087]

1 stainless steel pipe (polishing target)
2 polishing agent
10 inner surface polishing device
12 pump (supply unit)
21 jig (rotational body)
22 shaft
23 axis
30 motor (drive unit)
41 main body
44 brush
45 tube (inner elastic body)
S space

Claims

1. A device for polishing an inner surface of a metal pipe that is a polishing target, the device comprising:

a rotational body which extends in a direction of an axis;
a drive unit which is configured to rotate the rotational body about the axis; and
a supply unit which is configured to supply a polishing solution in which a granular polishing agent is mixed with a liquid to inside of the metal pipe, wherein,
the rotational body includes an elastic brush protruding in a radial direction orthogonal to the axis and an inner elastic body provided on the inner side of the brush in the radial direction,

the distance between the axis and a leading end of the brush is equal to or longer than a half of the inner diameter of the metal pipe, and
the inner surface is polished in such a way that the inner elastic body presses the brush outward in the radial direction while the rotational body is provided inside the metal pipe, the leading end portion of the brush applies internal pressure to the inner surface of the metal pipe while being in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up, and the polishing agent supplied from the supply unit to the inner surface of the metal pipe is adhered to the inner surface of the metal pipe and is pressed onto the inner surface of the metal pipe by the leading end portion of the brush.

2. The device according to claim 1, wherein, when the rotational body is provided inside the metal pipe, the leading end portion of the brush applies the internal pressure of equal to or more than 80N to the inner surface of the metal pipe while the leading end portion of the brush is in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up.

3. The device according to claim 1 or 2, wherein, when the rotational body is provided inside the metal pipe, the leading end portion of the brush applies the internal pressure of equal to or less than 300N to the inner surface of the metal pipe while the leading end portion of the brush is in contact with the inner surface of the metal pipe, in a state in which the leading end portion of the brush stands up.

4. The device according to any one of claims 1 to 3, wherein, the rotational body includes a brush receiver which supports the brush and the inner elastic body provided on the inner side of the brush in the radial direction, and the brush receiver supports the brush to be movable in the radial direction.

5. The device according to claim 4, wherein,

the brush receiver includes side walls that are provided on the respective sides of the brush, and
the side walls support the brush to be movable in the radial direction.

6. The device according to any one of claims 1 to 5, wherein,

the rotational body includes a main body extending in the direction of the axis of the rotational body,
the brush is provided on the outer side of the main body in the radial direction, and
the inner elastic body is provided between the main body and the brush.

7. The device according to any one of claims 1 to 6, wherein,

the brush is provided along the direction of the axis of the rotational body, and
on the inner side of the brush in the radial direction, the inner elastic body is provided along the direction of the axis of the rotational body.

8. The device according to any one of claims 1 to 7, wherein,

the rotational body further includes one or more brush each of which is identical with the brush,
the brushes are provided to be separated from one another in the radial direction of the rotational body, and
a space is formed between brushes neighboring in the radial direction of the rotational body.

9. The device according to any one of claims 1 to 8, wherein,
the brushes are provided at regular intervals in a circumferential direction of the rotational body.

10. The device according to claim 4 or 5, wherein,

the rotational body further includes one or more brush identical with the brush and one or more brush receiver identical with the brush receiver,
the brush receivers support the brushes, respectively, and
the brushes and the brush receivers supporting the respective brushes are provided at regular intervals in a circumferential direction of the rotational body.

11. The device according to any one of claims 1 to 10, wherein,

in a state in which the rotational body is provided inside the metal pipe,
when the leading end portions of the brushes are in contact with the inner surface of the metal pipe, at least some of the leading end portions of the brushes are perpendicular to a tangent where the leading end portions are in contact with the inner surface of the metal pipe.

12. The device according to any one of claims 1 to 11, wherein,
the drive unit moves the rotational body while rotating the rotational body about the axis.

13. The device according to any one of claims 1 to 12, further comprising one or more rotational body identical with the rotational body, the rotational bodies being connected to one another in the direction of the axis by a shaft.

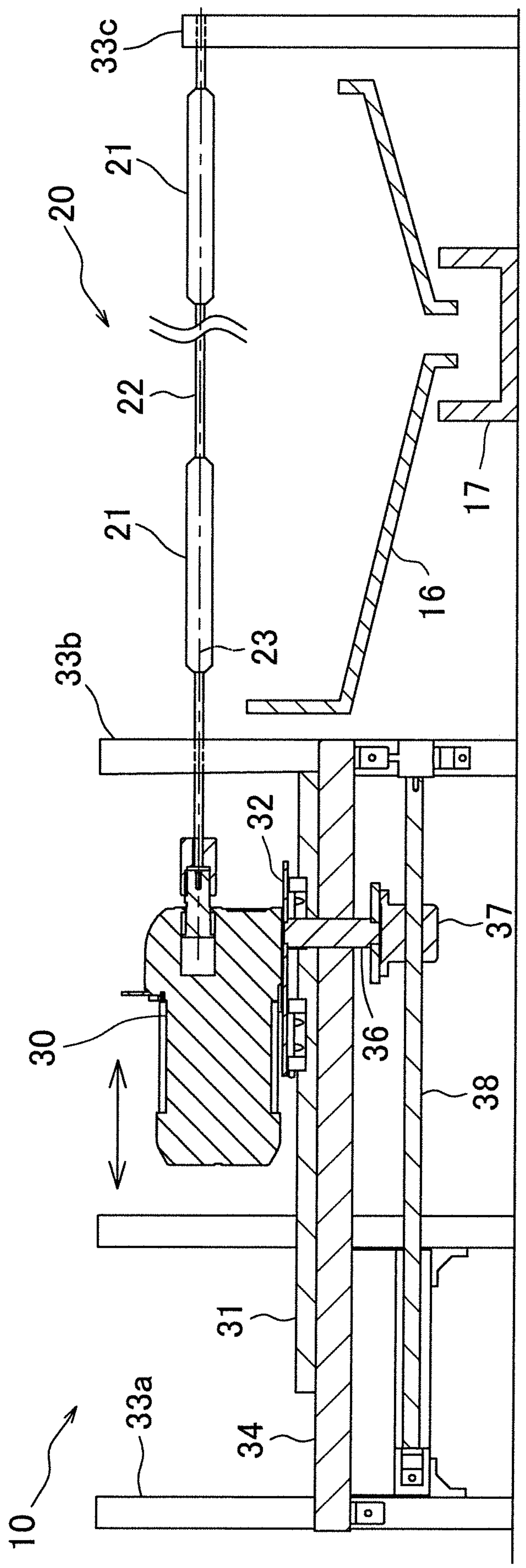
14. The device according to claim 13, wherein, the distance between the rotational bodies neighboring in the direction of the axis is shorter than the length of each of the rotational bodies in the direction of the axis.

15. The device according to any one of claims 1 to 14, wherein,
in the state in which the rotational body is provided inside the metal pipe, the inner elastic body is compressed and the inner elastic body elastically presses the brush outward in the radial direction.

16. A metal pipe having an inner surface polished by the device of any one of claims 1 to 15, arithmetic average roughness (Ra) of the inner surface being less than 0.1 μm.

17. A metal pipe having an inner surface polished by the device of any one of claims 1 to 16 and being equal to or longer than 4 meters in length.

FIG.1



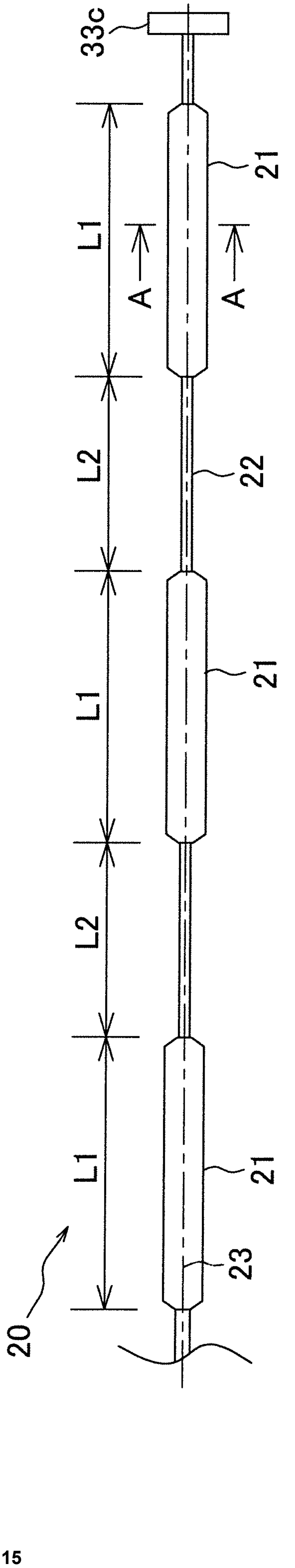


FIG.2

FIG.3

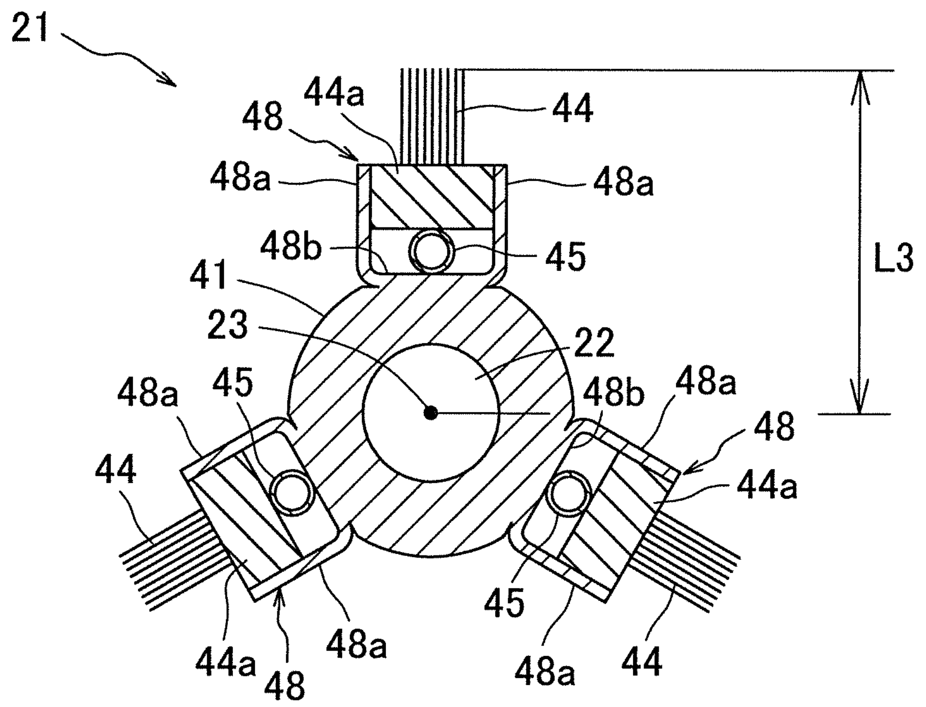

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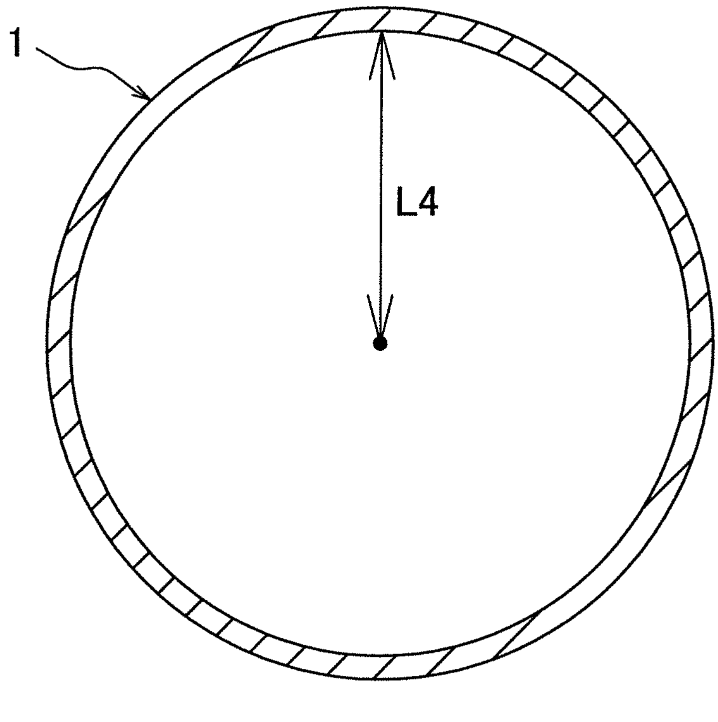
FIG.4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L4

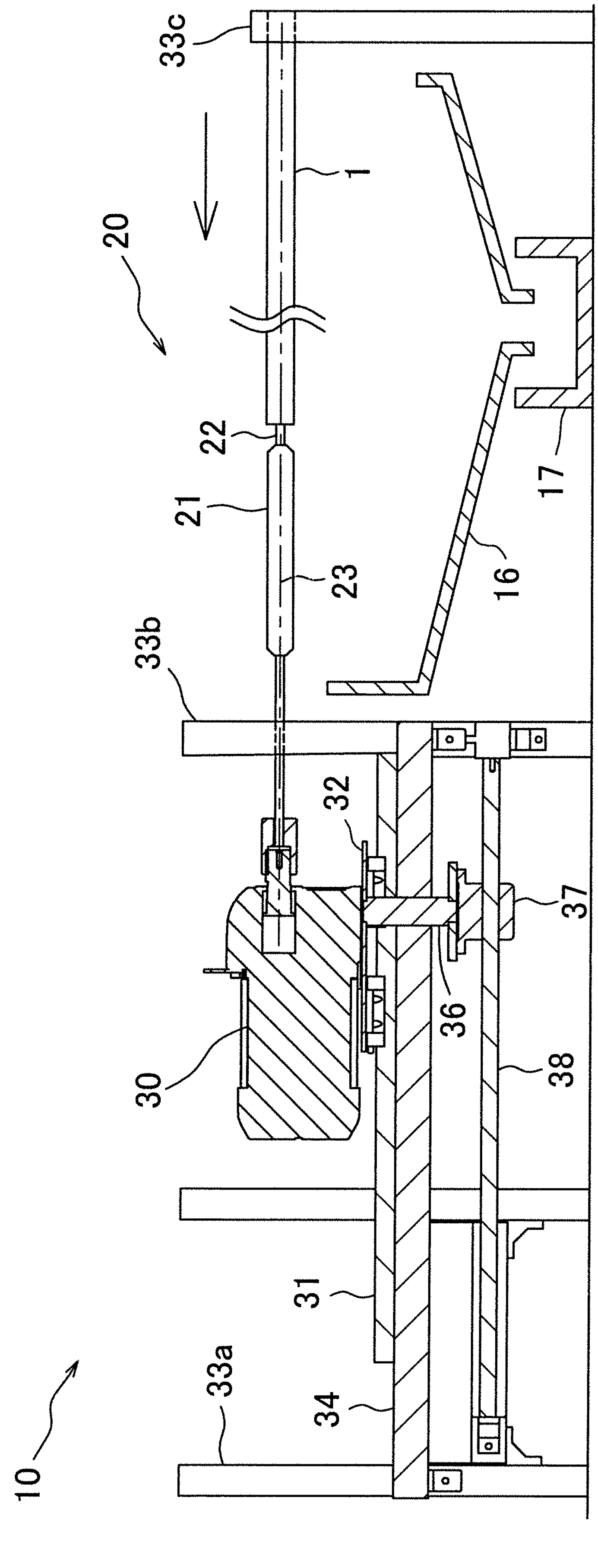

FIG.5

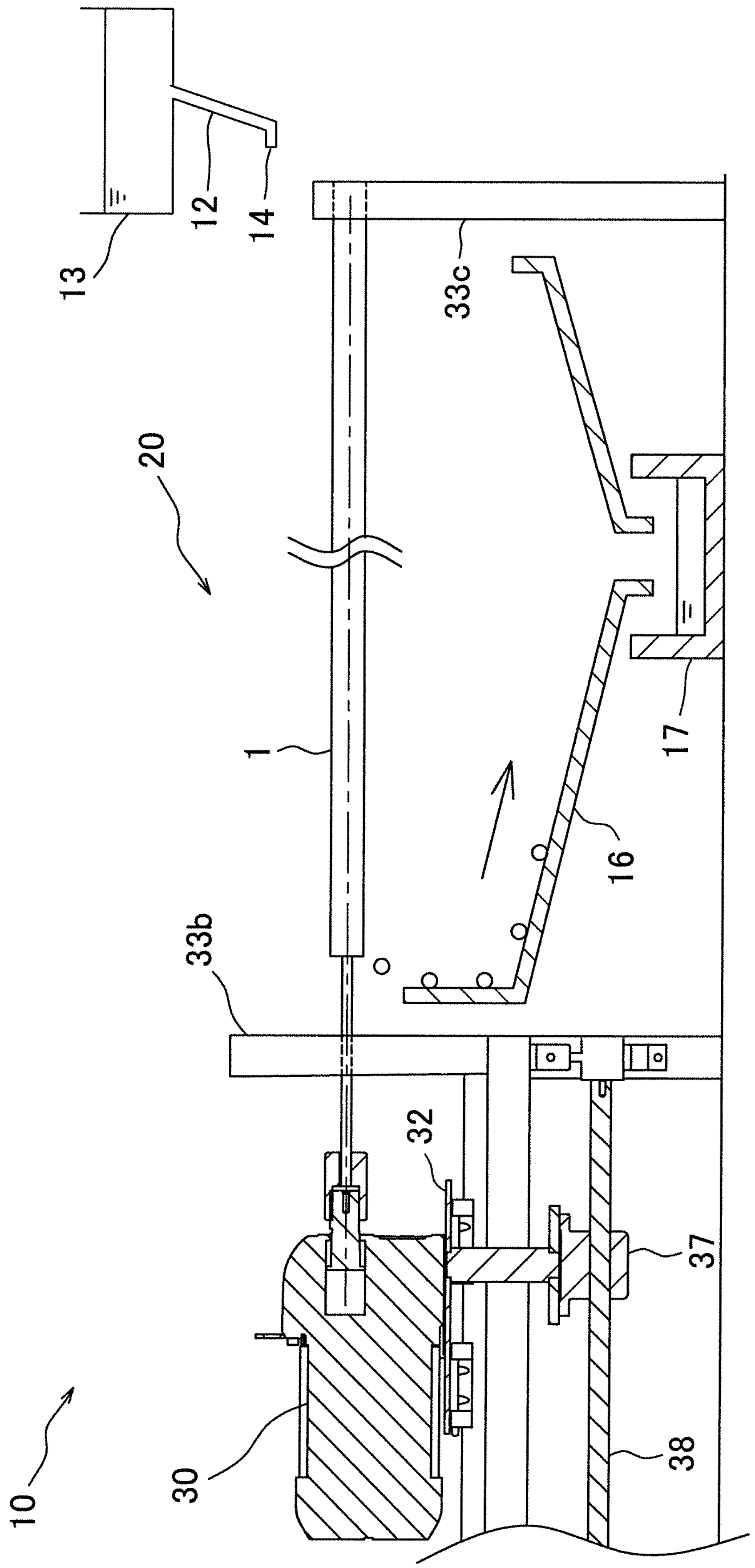

FIG.6

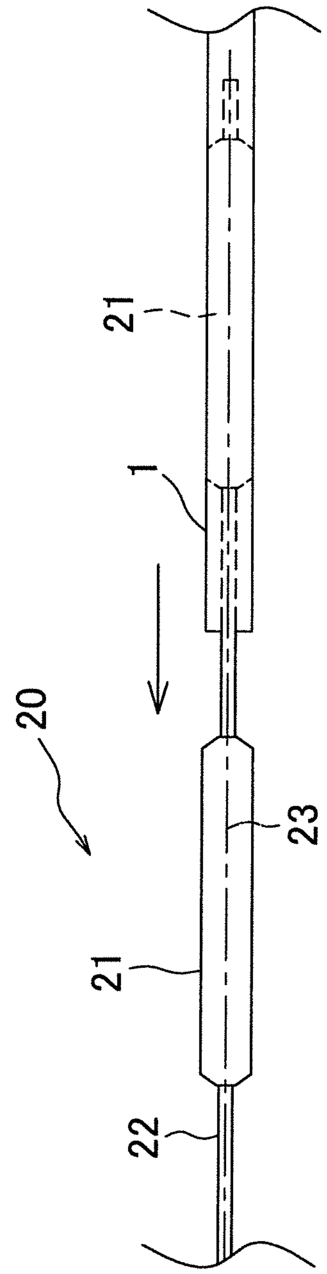

FIG.7

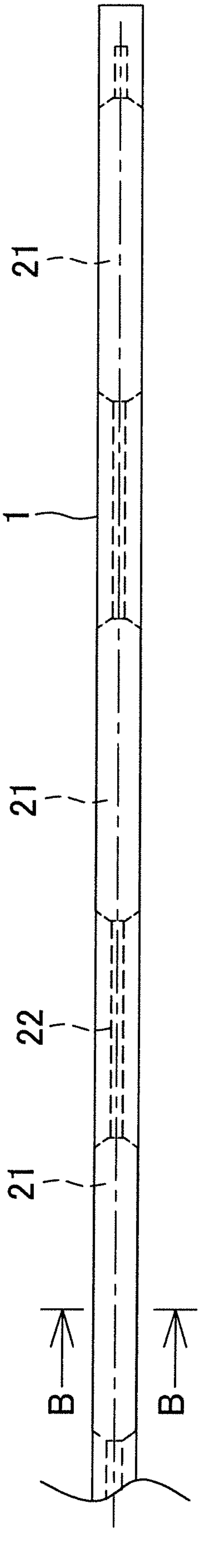

FIG.8

FIG.9

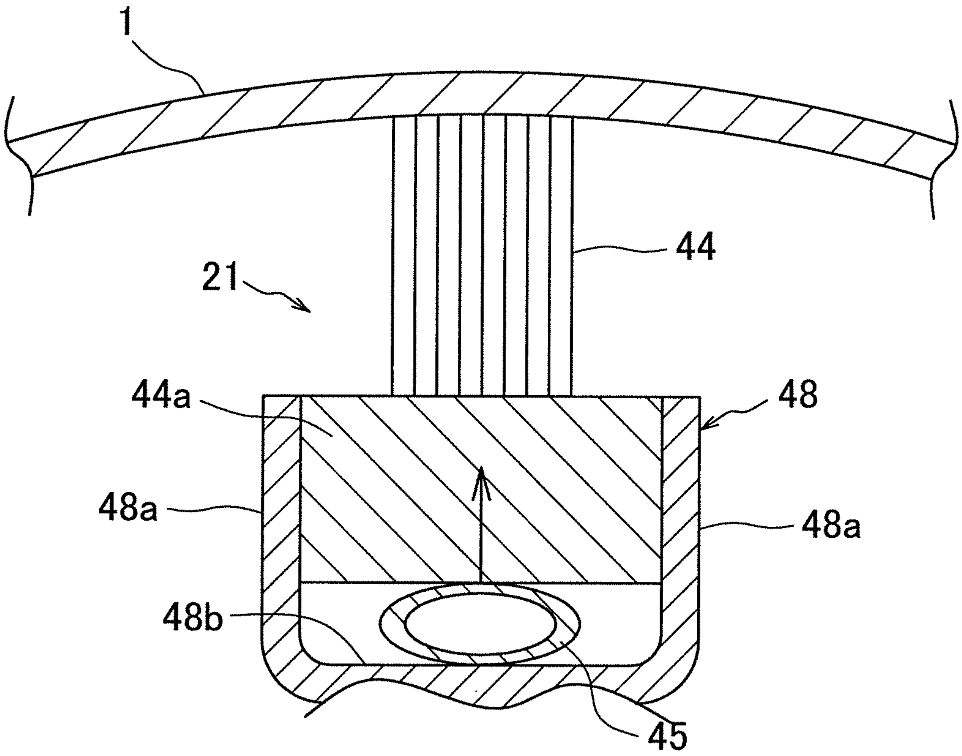

FIG.10

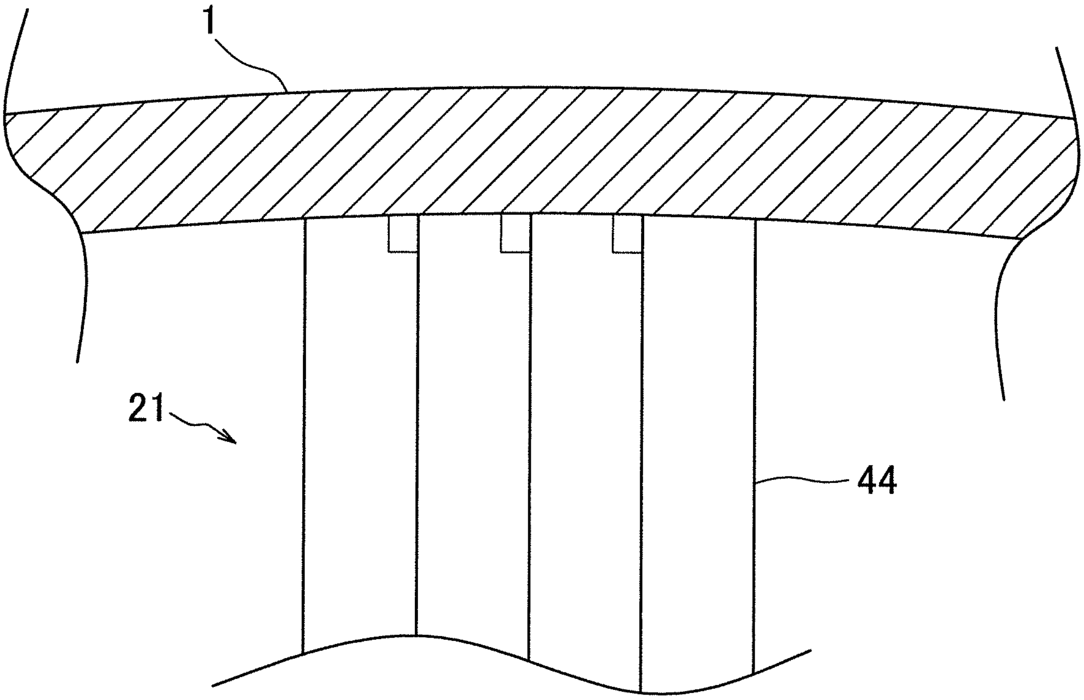

FIG.11

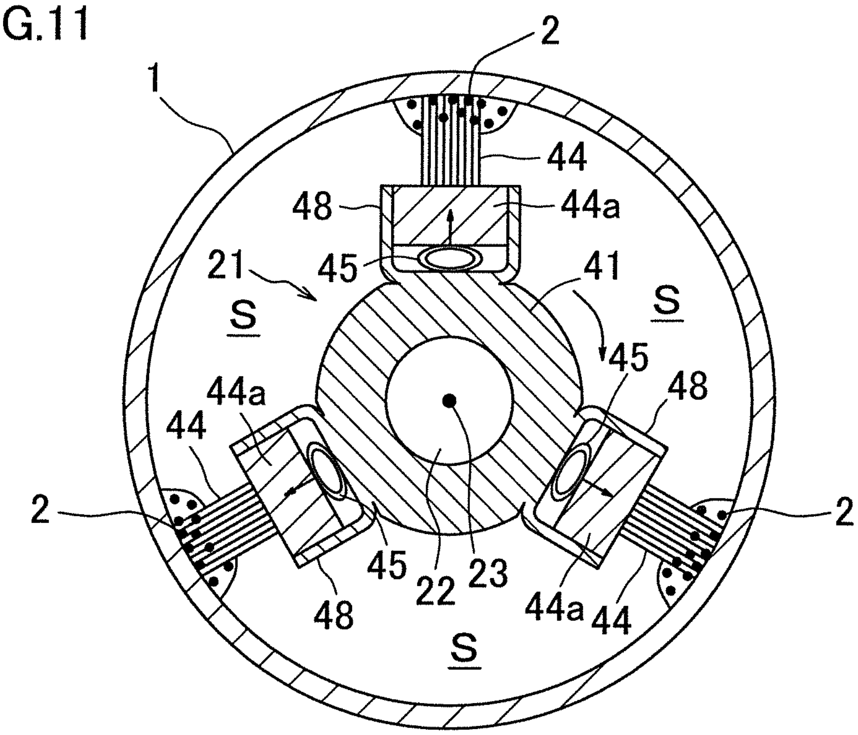
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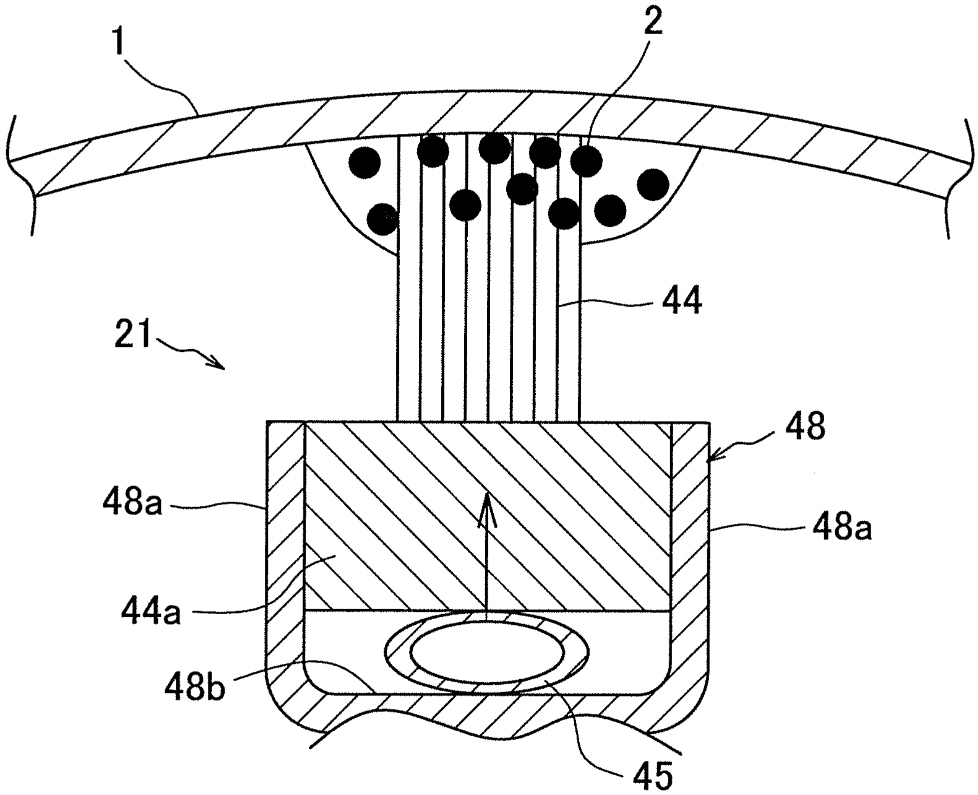
FIG.12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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/025109

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. B24B5/40(2006.01)i, B24B29/00(2006.01)i
FI: B24B5/40 E, B24B29/00 M, B24B29/00 D

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. B24B3/00-7/30, B24B21/00-39/06, B24D3/00-99/00, B08B1/00-1/04

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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	JP 7-276197 A (MATSUMOTO KOKAN KK) 24 October 1995, paragraphs [0002], [0015]-[0017], [0020], [0027]-[0035], [0037], [0038], fig. 4, 5	17 1, 3-15
X Y	JP 61-214958 A (NISSHO STAINLESS KK) 24 September 1986, page 3, upper right column, line 15 to page 4, upper right column, line 8, page 4, upper right column, line 13 to lower left column, line 18, fig. 1	16-17 1, 3-15
Y	JP 2004-243433 A (SHINETSU QUARTZ PROD) 02 September 2004, paragraph [0017]	1, 3-15
Y	JP 5-38629 A (NEC CORP.) 19 February 1993, paragraphs [0003]-[0005], fig. 2	1, 3-15

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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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
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29.07.2020	11.08.2020

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/025109

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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