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(54) **Title:** APPARATUS AND METHOD FOR REHABILITATING SUPERANNUATED PIPE

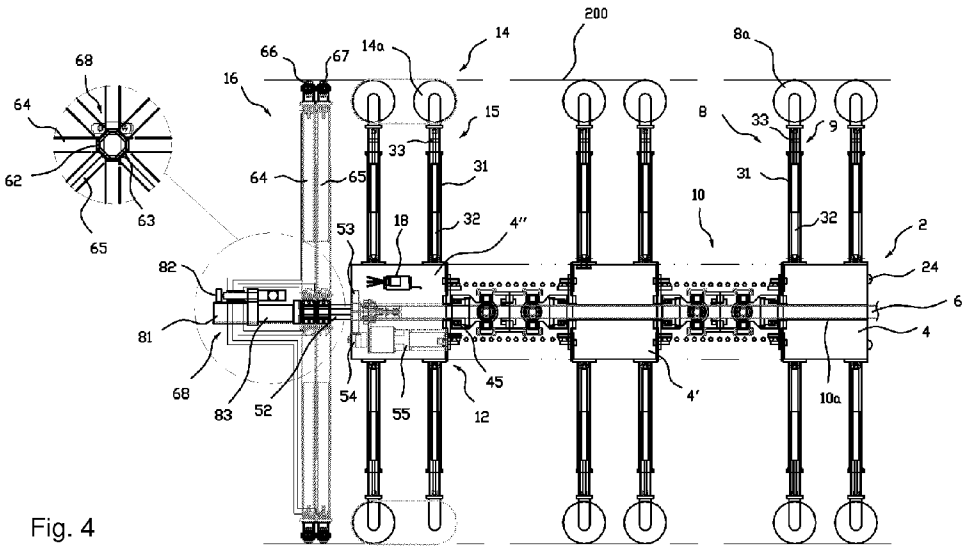

Fig. 4

(57) **Abstract:** The present invention relates to rehabilitating apparatus and method of superannuated pipe for removing coal-tar enamel coated inner surface on the middle or large pipe and scale layer growing on the inner surface of water pipe by the rust and then continuously carry out the polishing and painting processes using single cleaning pipe robot. Rehabilitating apparatus and method of superannuated pipe comprising: a main body having plural segmentation pipes and first moving element; a joints for changing of direction connect the plural segmentation pipes to bend the segmentation pipes corresponding with curvature of the superannuated bending pipe; a rotation means being connected to the center of end one out of the joints for changing of direction; a scale removing means expanding to radius direction of the rotation means, which minutely draw cut lines while the rotation to circumference direction of the superannuated pipe so that exfoliate the scale on the inner surface of the pipe; and polishing means and painting means for carrying out post-processes after removing the scale layer.

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Description

APPARATUS AND METHOD FOR REHABILITATING SUPERANNUATED PIPE

Technical Field

[1] The embodiments described herein relate to an apparatus and a method for rehabilitating a superannuated pipe, capable for rehabilitating the superannuated pipe by removing coal tar or solidified scales (hereinafter, referred to as 'scales'), which are coated on an inner surface of the superannuated pipe, and then lining the pipe and, more particularly, to an apparatus and a method for rehabilitating a superannuated pipe, capable of effectively removing a scale layer formed on the inner surface of the superannuated pipe and performing subsequent processes, such as a sanding process and a lining process, using one cleaning robot.

[2]

Background Art

[3] In general, a cast iron pipe and a steel pipe are mainly used as a water pipe having a large and middle sized diameter to supply tap water, a pipe line for carrying various kinds of fluid such as oil, a gas pipe, a sewage pipe (hereinafter, commonly referred to as a 'pipe') for transferring sewage, etc. If such cast iron pipe and steel pipe are used for a long time, corrosion due to superannuation is caused to the cast iron pipe and steel pipe, so a solidified scale layer is formed on an inner wall of the pipe.

[4] The scale layer formed at the inner wall of the pipe prevents fluid from being flown smoothly, reducing fluidity of fluid. The scale layer attached to the inner surface of the pipe dissolves in the fluid, resulting in contamination of the fluid. In addition, the scale layer causes a serious problem in maintaining a function of the pipe network, and increases energy consumption. In order to solve the above problems, the pipe needs to be periodically cleaned. However, actually, it is difficult to clean the pipe periodically when taking manpower and cost into consideration.

[5] In the case that the corrosion product is seriously formed on the inner surface of the pipe or the pipe is expected to be broken due to superannuation, the improvement work (replacement or rehabilitation) is performed on the superannuated pipe.

[6] A cleaning and a lining are representative examples of the rehabilitation method for the superannuated pipe that are applied to the improvement for the pipe.

[7] Hereinafter, a conventional cleaning method for rehabilitating the superannuated pipe will be briefly described with reference to FIG. 1.

[8] As shown in drawings, the conventional cleaning method includes a first step (S1) for examining the inside of the pipe. In a second step (S2), after water is shut off, the

pipe is cut to be inspected. In the second step, a cleaning apparatus including a scraper, a wire brush, a high pressure spray cleaner, etc. is repeatedly hoisted several times using a power winch to peel off the scales attached to the inner surface of the pipe and discharge the scales to the outside. In a third step (S3), water remaining in the pipe is removed, and then air is introduced inside the pipe through a blower such that the pipe is dried. In a fourth step (S4), when the inner surface of the pipe is dried, a hose equipped with a spray head is inserted into a pipe body. Epoxy resin paint or polyurea, etc. is sprayed to the inner surface of the pipe body through the spray head, thereby performing the lining. In a fifth step (S5), after the epoxy paint or polyurea is completely cured, the inside of the pipe is cleaned. After that, the cut pipes are rejoined such that water flows in the pipe. Finally, soil and sand are poured on the pipe, thereby completing the rehabilitation work.

[9] A scraper-water jet scheme, in which sediments are dredged by hauling an apparatus and high pressure water is used, and an air sand scheme have been developed as the cleaning method to remove the scales from the superannuated pipe. Such schemes are generally performed as a pretreatment of a pipe lining.

[10] The scraper-water jet scheme, in which sediments are dredged by hauling the apparatus and high pressure water is used, is performed by repeating a scraper process and a water jet process several times, so the cleaning method is complicated and the cleaning time is increased. In addition, cleaning is not uniformly performed, so the lining work may not be perfectly performed. In addition, since the pipe must be accommodated in the scraper, the scraper-water jet scheme is not suitable for the pipe having a large diameter. The air sand scheme is performed by spraying sand against a surface of the pipe by using air pressure. The air sand scheme can achieve desired cleaning quality, but require great air pressure when cleaning the pipe having the large diameter. Thus, the air sand scheme is suitable for the pipe having a small diameter, but is not suitable for the pipe having the large diameter.

[11] Meanwhile, the superannuated pipe includes a drain pipe coated with coal tar enamel serving as anti-corrosive additives for preventing the inner surface of the pipe from being corroded. Although the coal tar enamel coated on the drain pipe is harmful to the human body, since the coal tar enamel is rigidly hardened in the drain pipe, the coal tar enamel is not easily removed through the conventional cleaning apparatus and method.

[12] According to the conventional method for rehabilitating the superannuated water pipe, equipment dedicated for the cleaning and lining work must be used and thus a great cost is required to purchase such equipment.

[13] In the case of the lining work, the nozzle deviates from the center of the pipe when passing through a curved pipe and a close-fit pipe of the superannuated pipe, so that sprayed paint may not uniformly reach the pipe. Therefore, uniform lining can not be

achieved.

[14] The conventional lining apparatus used in the lining process may have a spray mechanism driven by a spray motor and a pressure spray mechanism.

[15] As shown in FIG. 2, in the spay mechanism driven by the spray motor, a nozzle 204 having a plurality of discharge holes 204a is installed at a front end of the spray motor 202, and the spray motor 202 is operated such that paint supplied through a hose 206 is discharged toward a surface of the pipe 100 through the nozzle 204. As shown in FIG. 3, in the pressure spraying mechanism, a nozzle tip 304, which is bent at an angle of 90 degrees, rotates by a rotary motor 302 to supply epoxy resin paint at predetermined pressure. However, according to the spray mechanism driven by the spray motor, even though a plurality of discharges holes 204a are formed in the nozzle 204, the epoxy resin paint is discharged through one of the discharge holes 204a due to centrifugal force caused by the rotation of the spraying motor 202. Therefore, the lining process must be repeated several times. In addition, according to the pressure spray mechanism, the paint is discharged through the single nozzle tip 304, so the lining process must be repeatedly performed several times. Therefore, time for the lining process is lengthened, and the center of the lining apparatus does not match with the center of the pipe, causing a difficulty in forming a layer having uniform thickness.

[16]

Disclosure of Invention

Technical Problem

[17] Embodiments of the present invention are directed to providing an apparatus and a method for rehabilitating a superannuated pipe capable of effectively removing scale by drawing a cutting line on a scale layer solidified on an inner surface of the superannuated pipe.

[18] Another object of the present invention is to provide an apparatus and a method for rehabilitating a superannuated pipe, capable of simplifying a rehabilitation process and reducing time spent for the rehabilitation process by removing scale and performing the subsequent processes such as sanding and lining processes by using one cleaning robot.

[19] Still another object of the present invention is to provide an apparatus and a method for rehabilitating a superannuated pipe, capable of effectively performing cleaning and lining processes for a middle scale pipe or a large scale pipe.

[20] Yet still another object of the present invention is to provide an apparatus and a method for rehabilitating a superannuated pipe, which enable a cleaning robot to smoothly pass through a bending pipe having a predetermined radius of curvature, a portion of the superannuated pipe having a relatively reduced diameter, or a portion of

the superannuated pipe having a relatively extended diameter in a state in which a body of the cleaning robot is uniformly coincident with the center of the superannuated pipe , thereby obtaining a smooth pipe inner surface or forming a uniform film on the pipe inner surface in a lining process by applying striking pressure to scale attached to the pipe inner surface.

[21]

Technical Solution

[22] The foregoing and/or other aspects of the present invention are achieved by providing an apparatus for rehabilitating a superannuated pipe. The apparatus includes a body configured to move in a straight line in an inner surface of the superannuated pipe and have a plurality of articulated pipes formed with a hollow hole for allowing a hose to pass therethrough to supply fluid from an outside; first movable devices configured to extend at an isometric angle from an outer peripheral surface of each articulated pipe of the body toward a pipe surface, and have first absorbers, which are compressed and expanded corresponding to pressing pressure against the pipe surface, and first wheels that make contact with the pipe surface, respectively; a directional joint configured to have a center portion formed with a through hole for allowing the hose to pass therethrough, interconnect the articulated pipes of the body, and allow the articulated pipes to change a direction of the articulated pipes while being bent corresponding to curvature of a curved pipe, thereby providing the body with superior bending property when the body passes through the curved pipe; a rotation device configured to be coupled with the center portion of the directional joint; second movable devices configured to extend at an equal angel from an outer peripheral surface of an articulated pipe at a rear end of the body toward the pipe surface, and travel along a convex-concave section, which is caused by the scales generated on an inner surface of the pipe, by using second absorbers, which are compressed and expanded corresponding to the pressing pressure against the pipe surface, and second wheels that make contact with the pipe surface, respectively; a scale removing device configured to extend from a central shaft of the rotation device in a radial direction of the pipe, and have an end that separates scales from the pipe surface by drawing cutting lines in a circumferential direction while being rotated in contact with the pipe surface at predetermined pressure; a pipe grinding device configured to be radially installed on the central shaft of the rotation device, instead of the scale removing device, and to polish an inner surface of the pipe by discharging striking pieces toward the inner surface of the pipe, which has no scales through a subsequent process of a scale removing process; and a lining device configured to be installed on the central shaft of the rotation device, instead of the pipe grinding device, and to form a lining by

discharging pigments toward the polished inner surface of the pipe after the grinding process.

[23] A cleaning robot includes a traction device configured to be installed on an articulated pipe at a front end of the body to draw the body, or is moved back through self-propelling scheme using a dredging vehicle.

[24] In another aspect of the present invention, there is provided a method for re habilitating a superannuated pipe including inspecting an inner surface of the superannuated pipe; inserting a cleaning robot into the superannuated pipe and driving a camera to investigate a front portion of the superannuated pipe; inspecting a front portion of the superannuated pipe by driving a camera; rotating a rotation member by driving a reduction motor provided in the cleaning robot, drawing cutting lines on a circumferential surface of the superannuated pipe by using a disc cutter of a scale removing device, which is coupled with the rotating member, according to rotation of the rotating member, and separating scales from the inner surface of the superannuated pipe; coupling a sand spry device with the rotation member instead of the scale removing device and spraying sand onto a surface of the superannuated pipe to perform a pipe grinding process; removing scale pieces and the sand from the superannuated pipe, coupling a lining device to the rotation member after removing the scale removing device, spraying a pigment including a base and a curing agent on the surface of the superannuated pipe to form a film having a desired thickness, and finishing a rehabilitation work of the superannuated pipe; and curing epoxy resin pigments coated on the surface such that water flows through the superannuated pipe.

[25]

Advantageous Effects

[26] Operations and effects of the present invention having the features are as follows.

[27] According to the present invention, the body includes a plurality of articulate pipes, and each articulate pipe is coupled with each directional joint. Due to the structure, when the body passes a bending pipe having a predetermined radius of curvature, the body is flexibly bent corresponding to the radius of the curvature. Simultaneously, the body passes the bending pipe while a rotation axis of the body is coincident with a center of the bending pipe. Accordingly, a disc cutter of the scale removing device is deeply inserted into a scale layer on the inner surface of the superannuated pipe. Then, the disc cutter of the scale removing device draws the cutting line on the scale layer and cut the scale while rotating in a circumferential direction of the pipe inner surface. As a result, a scale layer grown on the pipe inner surface or a coal tar layer coated with anti-corrosive additives on the pipe inner surface are clearly and effectively removed without damaging a pipe preform.

[28] In addition, according to the present invention, the clean robot moves in a state in which the centers of the body and the pipe are coincident with a rotation center of the scale removing device. After the cleaning process has been completed, the sand spraying process, which is the subsequent process, is performed, so that the pipe inner surface is uniformly ground. In addition, in the lining process employing epoxy resin pigment, a film is coated on the pipe inner surface with a uniform thickness.

[29] According to the present invention, the scale removing device, the sanding device for grinding the pipe inner surface and the lining device can be alternately used. One cleaning robot can remove scale from the pipe inner surface, polish the pipe inner surface, and perform the lining process for the pipe inner surface. Accordingly, the method for rehabilitating the superannuated pipe can be very simplified. In addition, since the rehabilitating process is very simple, an amount of air can be significantly reduced.

[30]

Brief Description of Drawings

[31] FIG. 1 is a flowchart representing a conventional process for rehabilitating a superannuated pipe;

[32] FIGS. 2 and 3 are views representing a lining apparatus according to the related art;

[33] FIG. 4 is a view representing an apparatus for rehabilitating a superannuated pipe according to the present invention;

[34] FIG. 5 is a sectional view representing a gas absorber used to damp a wheel shown in FIG. 4;

[35] FIG. 6 is a sectional view representing a movable device which passes through an oval pipe by the gas absorber;

[36] FIG. 7 is a plan view representing a directional joint according to a first embodiment of the present invention;

[37] FIG. 8 is an exploded perspective view representing the directional joint;

[38] FIG. 9 is an assembled perspective view representing the directional joint;

[39] FIG. 10 is a perspective view representing a spring mounted on the directional joint;

[40] FIG. 11 is a sectional view representing a detailed structure of a first pressing unit corresponding to a main part of a scale removing device according to the first embodiment of the present invention;

[41] FIG. 12 is a sectional view representing a piston type hydraulic supply unit corresponding to a main part of the scale removing apparatus according to the first embodiment of the present invention;

[42] FIG. 13 is a view representing the structure of an apparatus for rehabilitating a superannuated pipe according to a second embodiment of the present invention;

[43] FIG. 14 is a sectional view representing a detailed structure of second and third rotation devices according to the second embodiment of the present invention;

[44] FIG. 15 is a front view representing a scale removing device shown in FIG. 9 and used in the second embodiment of the present invention;

[45] FIG. 16 is a front view representing a structure configured to remove scale peeling piece, which is delaminated from a surface of the pipe by a disc cutter according to the second embodiment of the present invention;

[46] FIG. 17 is a view representing a sand spraying device, which substitutes for the scale removing device of the first embodiment to perform a grinding process on the superannuated pipe;

[47] FIG. 18 is a view representing a detail structure of a sand spraying nozzle part shown in FIG. 16;

[48] FIG. 19 is a view representing a lining apparatus, which substitutes for the sand spraying device of the first embodiment to perform a lining process corresponding to a final finishing process;

[49] FIG. 20 is a view representing an apparatus for rehabilitating a superannuated pipe according to a third embodiment of the present invention;

[50] FIG. 21 is a front view representing a scale removing device according to the third embodiment of the present invention;

[51] FIG. 22 is a schematic view representing oil pressure distributed from a first hydraulic supply unit to a first absorber according to the third embodiment of the present invention;

[52] FIG. 23 is a sectional view representing a detailed structure of a pressing unit configured to transfer power to the scale removing device according to the third embodiment of the present invention;

[53] FIG. 24 is a plan view representing a directional joint according to a fourth embodiment of the present invention;

[54] FIG. 25 is an exploded perspective view representing the directional joint shown in FIG. 24;

[55] FIG. 26 is a schematic view representing four angular positions of the directional joint shown in FIG. 24;

[56] FIG. 27 is an assembled perspective view of the directional joint; and

[57] FIG. 28 is a view representing a path by which oil pressure is supplied to the pressing unit according to the fourth embodiment of the present invention.

[58]

Best Mode for Carrying out the Invention

[59] Hereinafter, preferred embodiments of the present invention will be described in

detail with reference to FIGS. 3 to 30.

[60] An apparatus and a method for rehabilitating a superannuated pipe 200 according to the present invention are realized to remove a scale layer derived from corrosion product formed or coal tar coated on a surface of a middle-scaled or large-scaled pipe and then perform grinding and lining processes by using one cleaning robot.

[61] FIG. 4 is a view showing a structure of the apparatus for rehabilitating the superannuated pipe 200 according to a first embodiment of the present invention.

[62] As shown in FIG. 4, the present invention provides a body 2 that moves in a straight line along an inner surface of the superannuated pipe 200. The body 2 includes a plurality of first to third articulate pipes 4, 4' and 4" having hollows allowing a first hose 6 to pass therethrough to supply a fluid.

[63] The first to third articulate pipes 4, 4' and 4" are provided on outer circumferential surfaces thereof with first movable devices 8 extending toward the surface of the superannuated pipe 200 at an isometric angle and move along the inner surface thereof. Each movable device 8 includes a first absorber 9 elastically operating corresponding to pressing pressure relative to the pipe inner surface when the body 2 moves, and a first wheel 8a making contact with the pipe inner surface.

[64] First directional joints 10 are interposed among the first to third articulate pipes 4, 4' and 4" of the body 2. Each first directional joint 10 is provided at a central portion thereof with a first through hole 10a allowing the first hose 6 to pass therethrough. The first directional joint 10 provides a superior bending property to the body 2 when the body 2 passes through a bending portion of the superannuated pipeline 200. In addition, the first to third articulate pipes 4, 4' and 4" can change the direction thereof corresponding to curvature of the bending portion.

[65] The third articulate pipe 4" includes a first rotating device 12 rotating by external power. The third articulate pipe 4" is provided on the outer circumferential surface thereof with second movable devices 14 extending toward the pipe inner surface at an isometric angle to move along the inner surface of the superannuated pipeline 200. Each second movable device 14 includes a second absorber 15 elastically operating corresponding to pressing pressure relative to the pipe inner surface, and a second wheel 14a making contact with the pipe inner surface.

[66] The first rotating device 12 is provided thereon with a first scale removing device 16 radially extending toward the pipe inner surface from a central shaft thereof. The first scale removing device 16 rotates in a state in which an end thereof makes contact with the pipe inner surface under predetermined pressure. The first scale removing device 16 can draw a fine cutting line on the scale layer of the surface of the superannuated pipeline 200 to delaminate the scale layer from the pipe inner surface.

[67] The third articulate pipe 4" is provided on the outer circumferential surface thereof

with a camera 18 photographing a removed state of the scale layer.

[68] The first rotating device 12 is provided on the central shaft thereof with a pipe surface grinding device 20 (see FIGS. 17 and 18) instead of the first scale removing device 16, and the pipe surface grinding device 20 is used in the next process of a scale removing process. The pipe surface grinding device 20 sprays striking pieces toward the pipe inner surface, from which the scale layer has been previously removed, to smoothly polish the pipe inner surface.

[69] In addition, the first rotating device 12 is provided on the central shaft thereof with a lining device 22 (See FIG. 19) instead of the pipe surface grinding device 20. The lining device 22 sprays paint toward the pipe inner surface through the next process of a grinding process to form lining.

[70] According to the first embodiment, the first articulate pipe 4 of the body 2 may further include a first traction ring 24 used to track the body 2 forward. In addition, the cleaning robot may be moved by a self-propelling vehicle instead of the above tracking scheme.

[71] According to the first embodiment of the present invention, components of each device will be described in detail below.

[72] The first and second absorbers 9 and 15 of the first and second movable devices 8 and 14 have generally known structures, and may employ various mechanical, gas, and hydraulic schemes.

[73] For example, FIG. 5 shows that the first and second movable devices 8 and 14 include gas absorbers, and details thereof will be described below.

[74] As shown in FIG. 5, the first and second absorbers 9 and 15 include a first absorber cylinder 31, a rod piston 32, and a free piston 33. The first absorber cylinder 31 is mounted on the first to third articulate pipes 4, 4' and 4" of the body 2 at a right angle while radially extending from the first to third articulate pipes 4, 4' and 4". The first absorber cylinder 31 contains gas and oil. The rod piston 32 has one side coupled with the first to third articulate pipes 4, 4' and 4" and the other side inserted into the first absorber cylinder 31. The free piston 33 is provided in the first absorber cylinder 31 to prevent gas and oil from being mixed with each other. The free piston 33 compresses the first absorber cylinder 31 through pressure exerted on the first and second wheels 8a and 14a.

[75] Hereinafter, the operation of the first and second absorbers 9 and 15 will be described.

[76] If the first and second wheels 8a and 14a are pressed by external force, the gas contained at an upper portion of the free piston 33 is compressed. The compressive force presses the rod piston 32 to compress the oil, thereby reducing a length of the first absorber cylinder 31. In contrast, if the first and second wheels 8a and 14a are

released, the oil that has been compressed by the rod piston 32 returns to an original position thereof while pressing the free piston 33, thereby extending the first absorber cylinder 31.

[77] Even if the first and second absorbers 9 passes through an oval pipe as well as a circular pipe, the first and second absorbers 9 and 15 operate such that a center of the pipe is coincident with centers of the articulate pipes. Accordingly, the first and second movable devices 8 and 14 can stably move in the pipe.

[78] FIG. 6 is a view showing the operational state of the first absorber 9 when the body 2 passes through the superannuated pipe 200 having an oval shape.

[79] As shown in FIG. 6, in a state in which a radius of the superannuated pipe 200 is changed, the first absorber cylinder 31 located at a side of a short diameter (i.e., a side in which the first wheel 8a is pressed) of the superannuated pipe 200 is compressed. In contrast, the first absorber cylinder 31' located at a side of a long diameter (i.e., a side in which the first wheel 8a' is pressed) of the superannuated pipe 200 is extended by the pressure of the free piston 33.

[80] The first and second wheels 8a and 14a have a disc shape. However, the present invention is not limited thereto. For example, the first and second wheels 8a and 14a may include a pair of wheels having a disc shape like wheels of an airplane, so that the contact area between the wheels 8a and 14a and the superannuated pipe 200 can be expanded. This is necessary for preventing the wheels 8a and 14a from rotating in a rotation direction of the first scale removing device 16 when the first scale removing device 16 delaminates the scale layer from the superannuated pipe 200 while rotating. In addition, the wheels 8a and 14a may have a caterpillar track.

[81] FIGS. 7 to 10 show components of the first directional joint 10 in detail.

[82] The first directional joint 10 has a pair structure in which two members are engaged with each other while facing each other, thereby changing a direction. The first directional joint 10 includes a first universal shaft member 41 provided at a central portion thereof with a second through hole 41a, into which the first hose 6 is inserted. The first universal shaft member 41 has first upper and lower pins 41b and first left and right pins 41b' protrude therefrom at a right angle. The first universal shaft member 41 includes first and second directional brackets 42 and 42' having one side thereof with third through holes 42a, respectively, such that the first upper and lower pins 41b and the first left and right pins 41b' are inserted into the third through holes 42a. The first and second directional brackets 42 and 42' include first and second space part 42b and 42b' used to support components. The first and second directional brackets 42 and 42' change an angle, which is defined by two shafts, about the first upper and lower pins 41b and the first left and right pins 41b' to change the direction of the first articulate pipe 4. A first bearing 43 is fitted around the first upper/lower pin 41b and the first

right/left pin 41b' of the first universal shaft member 41. The first bearing 43 is supported by a retainer 44. The first bearing 43 allows the first and second directional brackets 42 and 42' to smoothly rotate with first and second supporting member which are described later. Rotary bushings 45 are fitted into the first and second space part 42b and 42b' of the first and second directional brackets 42 and 42'. The rotary bushing 45 is fitted around the central shaft of the first rotating device 12, such that the first rotating device 12 smoothly rotates. A second bearing 46 is interposed between the first directional bracket 42 or the second directional bracket 42' and the rotary bushing 45. The retainer 44 is coupled with first and second supporting members 47 and 47', which are formed at central portions thereof with first and second supporting member through holes 47a and 47a', respectively, by a bolt. The first and second supporting members 47 and 47' are coupled with each other while facing each other and crossing the first and second directional brackets 42 and 42'. The first and second supporting members 47 and 47' include a connection bundle 48 is provided at the center of a contact portion of the first and second supporting members 47 and 47'. The connection bundle 48 includes a cylindrical member 48a, a fixing cap 48b, and a set screw 48c. The cylindrical member 48a includes a hollow hole 48a' allowing the first hose 6 to pass therethrough. The fixing cap 48b is coupled with one side of the cylindrical member 48a by using a screw to prevent the cylindrical member 48a from being separated. The set screw 48c penetrates from the fixing cap 48b to the cylindrical member 48a such that the screw is not released. A first spring 50 is fitted around an outer circumferential surface of the first and second directional brackets 42 and 42' to restrict a bending angle of the first and second directional brackets 42 and 42'.

[83] The first directional joint 10 may further include a furrow pipe (not shown) covering an outer circumferential surface of the first spring 50 to prevent foreign matters from being introduced into the first spring 50.

[84] The above structure of the first directional joint 10 provides a superior bending property to the body 2 while offsetting eccentric errors when the body 2 passes through the bending portion of the superannuated pipe 200. The first directional joint 10 operates corresponding to the curvature of the bending portion such that the center of the body 2 is coincident with the center of the superannuated pipe 200. In other words, the first and second directional brackets 42 and 42' can rotate about the universal shaft member 41 at an angle of 360°. The first to third articulate pipes 4, 4' and 4" are rotated through the rotary bushing 45 by a rotation angle of the first and second directional brackets 42 and 42'. Accordingly, while the center of the first to third articulate pipes 4, 4' and 4" is being kept to be coincident with the center of the superannuated pipe 200 due to the operation of the first directional joint 10, the first to third articulate pipes 4, 4' and 4" are bent corresponding to the curvature of the bending

portion to smoothly pass through the bending portion. When the first and second directional brackets 42 and 42' are turned, the first spring 50 is bent with the first and second directional bracket 42 and 42', thereby maintaining the first directional joint 10 within a predetermined angle range. In other words, the first and second directional brackets 42 and 42' are bent only within an allowable range of the first spring 50, so that a bending angle of the first directional joint 10 is restricted. Through the above operation, the body 2 passes through the bending portion of the superannuated pipe 200 in a state in which the center of the superannuated pipe 200 is coincident with the center of the body 2.

[85] As shown in FIG. 4, the first rotating device 12 includes a first shaft 52, a first driven gear 53, a first driving gear 54, and a first reduction motor 55. The first shaft 52 is fitted into the rotary bushing 65. The driven gear 53 is fitted around the first shaft 52. The driving gear 54 is geared with the driven gear 53 to transmit rotary power to the driven gear 53. The reduction motor 55 supplies the rotary power to the driving gear 54. A front end of the first shaft 52 that rotates by receiving the rotary power of the first driven gear 53 has an octagonal profile.

[86] The first scale removing device 16 includes a first support 62, a second support 63, first and second pressing units 64 and 65, first and second disc cutters 66 and 67, and a first hydraulic supply unit 68. The first support 62 has the shape of a rectangular frame, and is fitted into the octagonal end surface of the first shaft 52 to be rotated. The second support 63 is fitted into the octagonal end surface of the first shaft 52 to be rotated. The second support 63 that has the shape of a rectangular frame is provided at a rear end of the first support 62 in a state in which the second support 63 is tilted at an angle of 45°about the rear end of the first support 62. The first and second pressing units 64 and 65 radially extend at a right angle toward the inner surface of the superannuated pipe 200 from outer circumferential surfaces of the first and second supports 62 and 63. The first and second pressing units 64 and 65 apply predetermined pressure to the pipe inner surface. The first and second disc cutters 66 and 67 are mounted on front ends of the first and second pressing units 64 and 65, respectively. While rotating along the outer circumferential surface of the superannuated pipe 200, the first and second disc cutters 66 and 67 draw cutting lines on the scale layer to finely cut away the scale layer. The first hydraulic supply unit 68 is mounted on the front end of the first support 62 to apply pressure to the first and second pressing units 64 and 65.

[87] Hereinafter, the structure of the first and second pressing units 64 and 65 will be described in detail with reference to FIG. 11. According to the present embodiment, since the first and second pressing units 64 and 65 have the same structure, only the first pressing unit 64 will be representatively described.

[88] As shown in FIG. 11, the first pressing unit 64 includes a first cylinder 71, a second cylinder 72, a fixed rod 73, a third cylinder 74, a push rod 75, a fourth cylinder 76, and sealing members 77. The first cylinder 71 is installed in a rectangular side of the first support 62, and provided therein with a cavity. The second cylinder 72 is inserted into the first cylinder 71 while moving up and down. The second cylinder 72 is provided at a front end thereof with the first disk cutter 66. The fixed rod 73 is installed in the cavity of the first cylinder 71, and includes a first hydraulic chamber 73a for introducing/discharging hydraulic pressure into/form in accordance with the movement of the second cylinder. The third cylinder 74 is fitted around the fixed rod to form the first hydraulic chamber 73a. The push rod 75 is installed in a cavity of the second cylinder 72 and provided therein with a second hydraulic chamber 75a. The fourth cylinder 76 is fitted around the push rod 75 while being coupled with the third cylinder 74. The sealing members 77 are interposed between the third cylinder 74 and the push rod 75 and between the push rod 75 and the fourth cylinder 76 to maintain air-tightness.

[89] As shown in FIG. 4, the first hydraulic supply unit 68 includes a first hydraulic tank 81, a first hydraulic distributor 82, and a first hydraulic motor pump 83. The first hydraulic distributor 82 is installed at one side of the first hydraulic tank 81 to distribute hydraulic pressure into the first and second pressing units 64 and 65. The first hydraulic motor pump 83 supplies the hydraulic pressure from the first hydraulic tank 81 to the first hydraulic distributor 82. Although not shown in drawings, the first hydraulic motor pump 83 includes a solenoid valve and an accumulator. The solenoid valve controls the inflow and outflow of oil into/from the first hydraulic distributor 82 through an on/off operation. The accumulator constantly maintains pressure discharged to the first hydraulic distributor 82.

[90] As shown in FIG. 12, the first hydraulic supply unit 68 employs a piston scheme.

[91] In other words, as shown in FIG. 12, the first hydraulic supply unit 68 employing a piston scheme includes a fifth cylinder 85, a piston packing 86, a second spring 87, a pressing bolt 88, and a pressure gauge 89. The fifth cylinder 85 is provided at one side thereof with a third hydraulic chamber 85a. The piston packing 86 is installed at one side of the third hydraulic chamber 85a of the fifth cylinder 85. The piston packing 86 moves in a straight line to discharge fluid contained in the third hydraulic chamber 85a to an exterior by shrinking space of the third hydraulic chamber 85a. The second spring 87 is provided at one side of the piston packing 86 to apply predetermined pressure to the piston packing 86. The pressing bolt 88 is installed in the fifth cylinder 85. The pressing bolt 88 includes a disc plate 88a positioned at one side of the second spring 87 to control spring force such that the second spring 87 constantly applies predetermined pressure. The pressure gauge 89 checks the pressure of the third hydraulic

chamber 85a.

[92] According to the first embodiment, four pressing units are installed in the first and second supports 62 and 63, respectively, so that a total of eight pressing units are retained, and each pressing unit includes a disc cutter having three blades. However, the present invention is not limited to the above structure.

[93] Hereinafter, an apparatus for rehabilitating the superannuated pipe 200 according to a second embodiment of the present invention will be described with reference to FIGS. 13 to 18.

[94] According to the second embodiment of the present invention, a second scale removing device 90 including the combination of third and fourth pressing units 91 and 92 and third and fourth disc cutters 93 and 94 is additionally provided on a rear portion of the first and second pressing units 64 and 65.

[95] Hereinafter, the structure of the apparatus for rehabilitating the superannuated pipe according to the second embodiment of the present invention will be described. The same reference numerals will be assigned to elements identical to those of the first embodiment, and details thereof will be omitted in order to avoid redundancy.

[96] As shown in FIG. 13, the apparatus for rehabilitating the superannuated pipe according to the second embodiment of the present invention includes a second hydraulic supply unit 95, a third rotating device 97, a second rotating device 96, and a third hydraulic supply unit 98. The second hydraulic supply unit 95 applies hydraulic pressure to the third and fourth pressing units 91 and 92. The third rotating device 97 rotates forward (or backward) the first and second pressing units 64 and 65. The second rotation unit 96 is spaced apart from the third rotating device 97 by a pre-determined distance to rotate backward (or forward) the third and fourth pressing units 91 and 92. The third hydraulic supply unit 98 applies hydraulic pressure to the second movable device 14.

[97] The second rotating device 96 includes a second shaft 102, a rotary joint 101, a second driven gear 103, a second driving gear 104, and a second reduction motor 105. The second shaft 102 serves as a rotation axis of the third and fourth pressing units 91 and 92 and has a hollow. The rotary joint 101 is mounted on an outer circumferential surface of the second shaft 102. The second driven gear 103 is fitted around the second shaft 102. The second driving gear 104 is geared with the second driven gear 103 to transmit rotary power to the second driven gear 103. The second reduction motor 105 supplies the rotary power to the second driving gear 104.

[98] The third rotating device 99 includes a third shaft 106, a third driven gear 107, a third driving gear 108, and a third reduction motor 109. The third shaft 106 passes through the hollow of the second shaft 102. The third shaft 106 has a bearing 106 interposed between the second shaft 102 and the third shaft 106. The third driven gear 107 is

fitted around the third shaft 106. The third driving gear 108 is geared with the third driven gear 107 to transmit rotary power to the third driven gear 107. The third reduction motor 109 transmits the rotary power to the third driving gear 108.

[99] As shown in FIG. 16, the first and second disc cutters 66 and 67 further include a delaminated-scale piece removing device 99 having an L-shaped profile. The delaminated-scale piece removing device 99 removes scale pieces, which have been delaminated by the first and second disc cutters 66 and 67 and have fallen on the floor of the superannuated pipe, while rotating.

[100] In the above structure, if the third rotating device 97 rotates forward (or backward), the first and second pressing units 64 and 65 coupled to the third rotating device 97 rotate forward (or backward). Accordingly, the first and second disc cutters 66 and 67 cut and delaminate scales while rotating forward (or backward) along the outer circumferential surface of the superannuated pipe. Simultaneously, the second rotating device 96 rotates backward (or forward) to rotate the third and fourth pressing units 91 and 92 backward (or forward). Accordingly, the third and fourth disc cutters 93 and 94 cut away and delaminate scales while rotating backward (o forward) along the outer circumferential surface of the superannuated pipe. Then, the third and fourth disc cutters 93 and 94 finely draw cutting lines along the cutting lines made by the first and second disc cutters 66 and 67. Therefore, scales can be finely cut away and easily delaminated by the cutting lines continuously made by the first and second disc cutters 66 and 67 and the third and fourth disc cutters 93 and 94. In addition, since the second and third rotating devices 96 and 97 rotate backward and forward, respectively, twist force is cancelled. Thus, the body 2 can move while maintaining balance.

[101] In the first and second embodiments of the first scale removing device 16, blades of the first to fourth disc cutters 66, 67, 93, and 94 include synthetic diamond, or high-strength carbon steel such as spring steel. The blades of the first to fourth disc cutters 66, 67, 93, and 94 includes at least S45C carbon steel.

[102] The first to fourth disc cutters 66, 67, 93, and 94 have blades facing an outer circumferential surface of the superannuated pipe 200. In particular, as shown in FIG. 15, the first to fourth disc cutters 66, 67, 93, and 94 have convex-concave blades. The convex-concave blades can open a cut scale layer only by drawing a cutting line along the outer circumferential surface of the superannuated pipe 200. Accordingly, the scale layer can be easily delaminated from the superannuated pipe 200. In other words, when the first and second supports 62 and 63 rotate, the first hydraulic supply unit 68 applies pressure to the first and second supports 62 and 63, so that the blades of the first to fourth disc cutters 66, 67, 93, and 94 rotate in a state in which the blades are deeply inserted into the scale layer. Accordingly, plurality of cutting lines are finely drawn in a circumferential direction of the superannuated pipe 200. In this process, the scale

layer is opened and delaminated by the concave-convex blades.

[103] FIGS.17 and 18 are sectional views showing the coupling structure of the second and third rotating devices 96 and 97 and the second scale removing device 90 and the structure of the second hydraulic supply unit 95.

[104] As shown in FIGS.17 and 18, first and second bending joints 172 and 172' are installed between the second and third rotating devices 96 and 97 and the second scale removing device 90 to provide a flexible bending property. The first and second bending joints 172 and 172' are paired. The first and second bending joints 172 and 172' allow the second scale removing device 90 to smoothly pass a bending pipe along the center of the bending pipe.

[105] The first bending joint 172 includes a first connection bracket 174 and a second connection bracket 176. The first connection bracket 174 is coupled to an end of the second shaft 102 of the second rotating device 96. The second connection bracket 176 is coupled to an end of a central shaft 102' of the second scale removing device 90. The first and second connection brackets 174 and 176 make contact with each other while facing each other. Third bearings 178 are installed at the first and second connection brackets 174 and 176.

[106] The second bending joint 172' includes a third connection bracket 180, a fourth connection bracket 182, fourth bearings 184, and a third spring 186. The third connection bracket 180 is coupled with an end of a third shaft 106 of the third rotating device 97. The fourth connection bracket 182 is coupled to an end of a central shaft 106' of the second scale removing device 90. The fourth bearings 184 are installed at the first and second connection brackets 174 and 176. The third spring 186 is fitted around an outer circumferential surface of the third and fourth connection brackets 180 and 182 to restrict bending angles thereof.

[107] As described above, the first and second connection brackets 174 and 176 make contact with each other while facing each other, and the third and fourth connection brackets 180 and 182 make contact with each other while facing each other. Accordingly, when passing through the bent pipe, the second scale removing device 90 can be smoothly bent by the third and fourth bearings 178 and 184. In this case, the second scale removing device 90 may be bent within an allowable angle range of the third spring 186.

[108] According to the present embodiment, the second hydraulic supply unit 95 applying hydraulic pressure to the second scale removing device 90 may have a different structure. In other words, first and second hydraulic supply passages 192 and 194 for the movement of the first and second pressing units 64 and 65 are formed on the outer circumferential surface of the central shaft 106' of the second scale removing device 90. Up/down movable blocks 196 and 198 are mounted on side surfaces of the third

and fourth pressing units 91 and 92.

[109] Reference numeral 191 represents a cable drum transmitting power to a hydraulic pump 190.

[110] In detail, as shown in FIG. 18, the hydraulic pump 190 supplies hydraulic pressure to the first and second pressing units 64 and 65 through the first and second hydraulic supply passages 192 and 194 of the central shaft 102' so that the first and second pressing units 64 and 65 move up or down. In addition, if the hydraulic pressure is supplied to the up/down movable blocks 196 and 198 from the hydraulic pump 190 through a third hose 199, the third and fourth pressing units 91 and 92 move up and down.

[111] Hereinafter, the pipe surface grinding device 20 to perform a grinding process for a pipe, which is the next process of a scale removing process, will be described with reference to FIGS. 19 and 20.

[112] As shown in FIGS. 19 and 20, the pipe surface grinding device 20 includes a nipple 121, a striking piece spraying nozzle 122, a second hose 123, a third support 124, a third absorber 125, a fixing support 126, an auxiliary support 127, a nozzle support bar 128, a fourth spring 129, an interval adjusting rod 130, a striking piece vessel 131, a first caterpillar 132, and a first motor 133. The nipple 121 is coupled with the first shaft 52. The striking piece spraying nozzle 122 is coupled with the nipple 121, and has an end tilted at an angle of 45° about the pipe inner surface. The second hose 123 couples the nipple 121 with the striking piece spraying nozzle 122. The third support 124 is fitted around the first shaft 52. The third absorber 125 radially extends toward the pipe inner surface from the third support 124, and includes a third wheel 125a closely making contact with the pipe inner surface. The fixing support 126 has one end fixed to the third absorber 125, the other end fixed to the striking piece spraying nozzle 122, and a middle portion having a joint part 126a to prevent the striking piece spraying nozzle 122 from being pushed back due to spray pressure. The auxiliary support 127 protrudes perpendicularly to the fixing support 126, and is provided at an end thereof with a ring. The nozzle support bar 128 has one side fixed to the striking piece spraying nozzle 122 and the other side fitted into the ring of the auxiliary support 127 to prevent the striking piece spraying nozzle 122 from being pushed back due to striking pressure. The fourth spring 120 allows the nozzle support bar 128 to be elastically pushed back. The interval adjusting rod 130 has one side supported on the outer circumferential surface of the third absorber 125 and the other side fixing the end of the fixing support 126 to adjust a striking interval of the striking piece spraying nozzle 122. The striking piece vessel 131 is installed at the front end of the body 2, and coupled to the first hose 6. The first caterpillar 132 is installed below the striking piece vessel 131. The first motor 133 is mounted on the first caterpillar 132 to drive the first

caterpillar 132.

[113] The pipe surface grinding device 20 further includes an anti-bending member 134 mounted on the joint part 126a of the fixing support 126 to prevent the fixing support 126 from being bent upward.

[114] In the pipe surface grinding device 20, striking pieces may include silica or metal pieces obtained by cutting wire. According to the embodiment of the present invention, silica is employed as the striking pieces for the purpose of explanation.

[115] Hereinafter, description will be made regarding the lining device 22 to perform a lining process that is the final process after grinding the pipe inner surface with reference to FIG. 21.

[116] As shown in FIG. 21, the lining device 22 includes a fourth support 141, a fourth absorber 142, a pigment supply line 143, interval adjusting member 144, first and second lining nozzles 145 and 146, a fifth support 147, a base pigment tank 148, a curing agent tank 149, a sixth hydraulic supply unit 150, a sixth support 151, a second caterpillar 152, and a second motor 153. The fourth support 141 is fitted around the first shaft 52. The fourth absorber 142 radially extends toward the pipe inner surface from an outer circumferential surface of the fourth support 141, and includes a fourth wheel 142a closely making contact with the pipe inner surface. The pigment supply line 143 extends perpendicularly to the fourth absorber 142. The interval adjusting member 144 has one side supported on an outer surface of the fourth absorber 142, and the other side that fixes an end of the pigment supply line 143 to adjust an interval between the pigment supply line 143 and the pipe inner surface. The first and second lining nozzles 145 and 146 are coupled to the end of the pigment supply line 143 to spray pigments toward the pipe inner surface. The fifth support 147 supports the first and second lining nozzles 145 and 146. The base pigment tank 148 is mounted on the front end of the body 2. The curing agent tank 149 is installed at one side of the base pigment tank 148. The sixth hydraulic supply unit 150 supplies a base and a curing agent to the first hose 6. The sixth support 151 is installed below the base pigment tank 148 and the curing agent tank 149 to supply the base pigment tank 148 and the curing agent tank 149. The second caterpillar 152 is installed below the sixth support 151. The second motor 153 is mounted on the second caterpillar 152 to drive the second cat erpillar 152.

[117] In this case, the first and second lining nozzles 145 and 146 have difference in their lengths. Accordingly, the first and second lining nozzles 145 and 146 can spray pigments with the maximum spray width through one rotation operation, so that lining efficiency can be improved.

[118] FIGS. 22 to 30 show an apparatus for rehabilitating the superannuated pipe 200 according to a third embodiment of the present invention.

[119] The same reference numerals will be assigned elements identical to those of the first embodiment, and details thereof will be omitted in order to avoid redundancy.

[120] As shown in FIGS. 22 and 23, according to the third embodiment of the present invention, a third scale removing device 302' including a fifth pressing unit 312 and a fifth disc cutter 314 is provided on an outer circumferential surface of the fifth articulate pipe 304', which is provided at a rear end of the apparatus, at a predetermined angle, and a plurality of third scale removing devices are arranged in a horizontal direction with a predetermined interval.

[121] As shown in FIG. 23, 15 fifth pressing units 312 are circularly arranged on an outer circumferential surface of each articulate pipe 304 at an angle of 24°, and 6 fifth pressing units 312 may be located in a horizontal direction. In addition, three fifth disc cutters 314 may be mounted on a front end of each fifth pressing unit.

[122] A blade of the fifth disc cutter 314 is positioned in an axial direction of the superannuated pipe 200. As shown in "A" of FIG.25 in detail, the fifth disc cutter 314 has a concave-convex blade. Due to the concave-convex structure of the fifth disc cutter 314, a scale layer of the superannuated pipe 200 is cut only by drawing a cutting line on the scale layer, and the scale layer is open by the concave-convex blade and delaminated from the superannuated pipe 200.

[123] It is shown that the fifth pressing unit 312 and the fifth disc cutter 314 are mounted only on the fifth articulate pipe 304' provided at a rear end of the apparatus according to the third embodiment of the present invention. However, 15 pressing units and 15 disc cutters may be mounted on remaining articulate pipes 304' and 304" of FIG 22. In this case, the width of cut scale layers of the pipe inner surface becomes relatively narrowed, so that the scale layers can be easily delaminated.

[124] The fourth articulate pipe 304 is provided at an end thereof with a flange 322, and the flange 22 is provided at a central portion thereof with a second traction ring 324 tracking the body 2. In addition, as shown in FIG. 24, the flange 22 includes windows 322a to check a fourth hydraulic supply unit 306.

[125] As shown in FIG. 25, the fifth pressing unit 312 includes a fixed cylinder 332, a sixth cylinder 334, a seventh cylinder 336, a cylinder cap 338, a piston rod 340, and sealing members 342. The fixed cylinder 332 is mounted on the outer circumferential surface of the fifth articulate pipe 304'. The sixth cylinder 334 is fitted into the fixed cylinder 332 to move up and down. The sixth cylinder 334 includes the fifth disc cutter 314 provided at a front end close to the pipe inner surface. The seventh cylinder 336 is installed in a cavity of the fixed cylinder 332, and includes a third hydraulic chamber 336a receiving oil from the fourth hydraulic supply unit 306. The cylinder cap 338 is coupled with the seventh cylinder 336. The piston rod 340 is fitted into the seventh cylinder 336 to move up and down by hydraulic pressure from the third hydraulic

chamber 336a. The sealing members 342 are interposed between the cylinder cap 338 and the piston rod 340, and the seventh cylinder 336 and the piston rod 340 to maintain air-tightness.

[126] As shown in FIGS. 26 and 27, a second directional joint 308 used to change the direction of the body 2 includes a second universal shaft member 351, third to sixth directional brackets 352a, 352b, 352c, and 352d, retainer bearings 353, and a fifth spring 354. The second universal shaft member 351 is provided thereon with four second upper, lower left, and right pins 351a and 351a' protruding therefrom at a right angle, and provided at a center portion thereof with a fifth through hole 351a allowing an oil hose to pass therethrough. The third to sixth directional brackets 352a, 352b, 352c, and 352d have through holes corresponding to the upper and lower pins 351a and left and right pins 351a' of the universal shaft member 351 such that the upper/lower pin 351a and the left/right pin 351a' are fitted into the through holes. The third to sixth directional brackets 352a, 352b, 352c, and 352d are paired to change an angle, which is defined by two shafts, about the upper and lower pins 351a and the left and right pin 351a' of the second universal shaft member 351 to change each direction of fourth to sixth articulate pipes 304, 304' and 304". The retainer bearings 353 are inserted into through holes of the third to sixth directional brackets 352a, 352b, 352c, and 352d such that the third to sixth directional brackets 352a, 352b, 352c, and 352d can be smoothly bent about the second upper and lower pins 351a and the second left and right pins 351a'. The fifth spring 354 is fitted around the third to sixth directional brackets 352a, 352b, 352c, and 352d to restrict a bending angle of the third to sixth directional brackets 352a, 352b, 352c, and 352d.

[127] According to the third embodiment of the present invention, the third to sixth directional brackets 352a, 352b, 352c, and 352d may be welded. Rectangular parts of the third to sixth directional brackets 352a, 352b, 352c, and 352d are bored and coupled with each other by using bolts.

[128] As shown in FIGS. 28 and 29, the third to sixth directional brackets 352a, 352b, 352c, and 352d are tilted at an angle of 22.5°with respect to adjacent brackets. In this case, when the third to sixth directional brackets 352a, 352b, 352c, and 352d move along curvature of the 45°-elbow pipe or 90°-elbow pipe, the above tilting angle of the directional brackets may compensate for the proceeding direction of the brackets, which is changed due to the arc shape of the elbow pipes, so that the third to sixth directional brackets 352a, 352b, 352c, and 352d can smoothly pass through the elbow pipes.

[129] According to the above structure of the second directional joint 308, eccentric errors are canceled when the body 2 passes through a bending portion of the superannuated pipe 200, so that the body 2 can be flexibly bent. In addition, the second directional

joint 308 constantly accepts variable curvature, so that the center of the body 2 can be coincident with the center of the superannuated pipe 200. In other words, the third to sixth directional brackets 352a, 352b, 352c, and 352d are bent about the universal shaft member 351, so that centers of the fourth to sixth articulate pipes 304, 304' and 304" are kept to be coincident with a center of the superannuated pipe 200. In addition, the fourth to sixth articulate pipes 304, 304' and 304" smoothly pass through the bending portion while being bent corresponding to curvature of the bending portion. In this case, bending angles of the third to sixth directional brackets 352a, 352b, 352c, and 352d are restricted such that the third to sixth directional brackets 352a, 352b, 352c, and 352d are bent only to the extent that the fifth spring 354 can be bent. Through the above operation, the body 2 passes through the bending portion of the superannuated pipe 200 in a state in which the center of the superannuated pipe 200 is coincident with the center of the body 2.

[130] As shown in FIG. 30, the fourth hydraulic supply unit 306 (see FIG. 24) and a fifth hydraulic supply unit 310 are installed in parallel to each other in each of the forth to sixth articulate pipes 304, 304' and 304".

[131] The fourth hydraulic supply unit 306 applies hydraulic pressure to the fifth pressing unit 312, and the fifth hydraulic supply unit 310 applies hydraulic pressure to the first movable device 8.

[132] As shown in FIG. 24, the fifth hydraulic supply unit 310 includes a hydraulic supply line 310a and a hydraulic retrieving line 310b. The above structure is identically employed for the fourth hydraulic supply unit 306.

[133] The fourth hydraulic supply unit 306 applies hydraulic pressure to the fifth pressing units 312 mounted on the outer circumferential surface of the fifth articulate pipe 304' at an isometric angle. The fourth hydraulic supply unit 306 includes a second hydraulic tank 361, a second hydraulic motor pump 362, a second hydraulic dividing pipe 363, and a second hydraulic hose 364. The second hydraulic dividing pipe 363 is provided in the fifth articulate pipe 304' to transmit hydraulic pressure to each fifth pressing unit 312 from the second hydraulic tank 361. The second hydraulic hose 364 couples the second hydraulic motor pump 362 with the second hydraulic dividing pipe 363 to provide a flowing path of hydraulic pressure.

[134] Hereinafter, description will be made regarding the method for rehabilitating the superannuated pipe 200 by the apparatus having the above structure according to the first embodiment of the present invention.

[135] In the method for rehabilitating the superannuated pipe 200, before cleaning the superannuated pipe 200, the inner part of the superannuated pipe 200 is inspected, and then a cleaning robot according to the present invention is put into the superannuated pipe 200.

[136] In a state in which the body 2 of the cleaning robot is put into the superannuated pipe 200, the first rotating device 12 and the first scale removing device 16 are driven.

[137] While the body 2 is tracked (or self-propelled) from a rear portion of the superannuated pipe 200, the camera 18 is driven to inspect a front portion of the superannuated pipe 200. The first and second wheels 8a and 14a of the first movable devices 8 and the second movable devices 14 pass a concave-convex surface of the superannuated pipe 200, in which scales are irregularly grown. Even if the first and second wheels 8a and 14a of the first and second movable devices 8 and 14 deviate from a moving path due to the concave-convex pipe inner surface caused by scale, each of the first to third articulate pipes 4, 4' and 4" of the body 2 maintains the center thereof to be coincident with the center of the superannuated pipe 200 through driving of the first directional joint 10.

[138] When the first and second movable devices 8 and 14 move along the surface of the superannuated pipe 200, the first and second movable devices 8 and 14 pass through a section deformed in an oval shape due to soil pressure. In this case, the first and second wheels 8a and 14a of the first and second movable devices 8 and 14 make contact with a region having a smaller diameter (i.e., a short-diameter portion of the superannuated pipe 200) and a region having a large diameter (i.e., a long-diameter portion of the superannuated pipe 200). If the first and second wheels 8a and 14a are pressed in the short-diameter portion of the superannuated pipe 200, the size of the first and second movable devices 8 and 14 is reduced due to compression of the first and second absorbers 9 and 15. In contrast, in the long-diameter portion, the wheels 8a and 14a closely make contact with the long-diameter portion due to expansion of the first and second absorbers 9 and 15.

[139] With the movement of the body 2, the first reduction motor 55 receives external power to rotate. The rotary power of the first reduction motor 55 is transmitted to the first shaft 52 through the first driving gear 54 and the first driven gear 53. Therefore, as the first shaft 52 rotates, the first scale removing device 16 coupled to the first shaft 52 rotates.

[140] When the first scale removing device 16 rotates, the first hydraulic supply unit 68 supplies hydraulic pressure to the first and second pressing units 64 and 65. If the blades of the first and second disc cutters 66 and 67 are deeply inserted into the scale layer and rotated such that cutting lines are drawn in a circumferential direction of the superannuated pipe 200, scale attached to the surface of the superannuated pipe 200 are finely cut and delaminated.

[141] If the scale layer is delaminated, scale pieces are discharged to an exterior. Thereafter, the pipe surface grinding device 20 is coupled with the first shaft 52 instead of the first scale removing device 16, so that a grinding process for the pipe inner

surface which is the subsequent process is performed.

[142] If the pipe surface grinding device 20 is driven, silica is transferred to the first shaft 52 from the striking piece vessel 131 to the first shaft 52 through the first hose 6 under predetermined pressure. Silica supplied through the striking piece spraying nozzle 122 strikes the pipe inner surface to remove remaining scales, thereby making the pipe inner surface smooth. When silica is sprayed, the joint part 126a of the fixing support 126 and the fourth spring 129 prevent the striking piece spraying nozzle 122 from being pushed back due to pressure to strike the pipe inner surface.

[143] Finally, after the grinding process has been completed, silica and scale pieces are discharged to the outside of the pipe. Then, the striking piece spraying device 20 is disconnected from the first shaft 52, the lining device 22 is coupled with the first shaft 52. Thereafter, similarly to the operation of the pipe surface grinding device 20, lining is performed for the pipe inner surface, thereby finishing rehabilitation work of the pipe. In the final stage, after epoxy resin pigment coated on the pipe inner surface is cured, water flows through the pipe.

[144] According to the present invention, the lining process may include epoxy lining or poly-urea lining. In addition, a reverse curing process using a reversing tube may be performed as the subsequent process of the cleaning process instead of the lining process.

[145] Meanwhile, when the cleaning robot according to the present invention passes through the bending portion of the superannuated pipe 200, the first joint 10 coupling the first to third articulate pipes 4, 4' and 4" of the body 2 to each other is bent corresponding to the radius of curvature of the bending portion. In this case, the first spring 50 prevents the first joint 10 from being bent beyond the radius of the curvature of the bending portion. According to the present invention, the first joint 10 is designed such that the bending angle of the first joint 10 does not deviate from the range of 22.5°.

[146] Due to the driving of the first joint 10, the cleaning robot is tracked in a state in which the center of the body 2 is coincident with the center of the superannuated pipe 200, and the first scale removing device 16 rotates without being eccentric.

[147] While certain embodiments have been described above, it will be understood that the embodiments described are by way of example only. Accordingly, the systems and methods described herein should not be limited based on the described embodiments. Rather, the systems and methods described herein should only be limited in light of the claims that follow when taken in conjunction with the above description and accompanying drawings.

[148]

Industrial Applicability

[149] The present invention suggests a method for rehabilitating an underground water supply pipe without excavation. Accordingly, the present invention is applicable to the maintenance of water supply and drainage pipes.

Claims

[1] An apparatus for rehabilitating a superannuated pipe, the apparatus comprising:
a body configured to have a plurality of articulated pipes formed with a hollow hole for allowing a hose to pass therethrough to supply fluid from an outside;
first movable devices configured to extend at an isometric angle from an outer peripheral surface of each articulated pipe of the body toward a pipe surface, and have first absorbers, which are compressed and expanded corresponding to pressing pressure against the pipe surface, and first wheels that make contact with the pipe surface, respectively;
a directional joint configured to have a center portion formed with a through hole for allowing the hose to pass therethrough, interconnect the articulated pipes of the body, and allow the articulated pipes to change a direction of the articulated pipes while being bent corresponding to curvature of a curved pipe, thereby providing the body with superior bending property when the body passes through the curved pipe;
a rotation device configured to be coupled with the center portion of the directional joint; and
a scale removing device configured to extend from a central shaft of the rotation device in a radial direction of the pipe, and have an end that separates scales from the pipe surface by drawing cutting lines in a circumferential direction while being rotated in contact with the pipe surface at predetermined pressure.

[2] The apparatus as claimed in claim 1, further comprising second movable devices configured to extend at an equal angel from an outer peripheral surface of an articulated pipe at a rear end of the body toward the pipe surface, and travel along a convex-concave section, which is caused by the scales generated on an inner surface of the pipe, by using second absorbers, which are compressed and expanded corresponding to the pressing pressure against the pipe surface, and second wheels that make contact with the pipe surface, respectively.

[3] The apparatus as claimed in claim 1, further comprising:
a pipe grinding device configured to be radially installed on the central shaft of the rotation device, instead of the scale removing device, and to polish an inner surface of the pipe by discharging striking pieces toward the inner surface of the pipe, which has no scales through a subsequent process of a scale removing process; and
a lining device configured to be installed on the central shaft of the rotation device, instead of the pipe grinding device, and to form a lining by discharging pigments toward the polished inner surface of the pipe after the grinding process.

[4] The apparatus as claimed in claim 1, further comprising a camera configured to be installed in an articulated pipe at a front end of the body to take a photograph of a state in which the scales are removed from the inner surface of the pipe.

[5] The apparatus as claimed in claim 2, wherein each absorber of the first and second movable devices includes:

first cylinders configured to be mounted on each articulated pipe of the body at an isometric angle while extending in a radial direction, and to have gas and oil therein;

rod pistons configured to have a first side coupled with the articulated pipe and a second side mounted on the first cylinder, respectively; and

free pistons configured to be provided in the first cylinders to prevent mixture of the gas and the oil and to compress the first cylinders by using pressing force of the first and second wheels, respectively.

[6] The apparatus as claimed in one of claims 1 to 5, wherein the directional joint includes:

a universal shaft configured to have a center portion, which is formed with a through hole communicating with the hole formed through the articulated pipe of the body, and upper/lower pins and left/right pins protruding at an angle of 90°;

first and second directional brackets configured to include first sides having through holes, into which the upper/lower pins and the left/right pins of the universal shaft are inserted, and second sides having space sections for supporting parts to change the direction of the articulated pipes by varying an angle, which is defined by two shafts, about the pins of the universal shaft;

a first bearing configured to be inserted into the through holes of the first and second directional brackets to facilitate rotation of the first and second directional brackets about the pins;

first and second supporting members configured to be interposed between the first and second directional brackets to interconnect the first and second directional brackets;

a cylindrical member configured to be installed at a contact portion between the first and second supporting members to interconnect the first and second supporting members, and to be formed with a hollow hole that communicates with the holes of the first and second directional brackets; and

a connection bundle configured to have a fixing cap, which is coupled with one side of the cylindrical member through a screw to prevent separation of the cylindrical member, and a set screw that prevents the screw from being released by passing through from the fixing cap to the cylindrical member.

[7] The apparatus as claimed in claim 6, further comprising a spring configured to be

fitted around outer peripheral surfaces of the first and second directional brackets to restrict an angle at which the first and second directional brackets are bent.

[8] The apparatus as claimed in claim 7, further comprising:
a rotary bushing configured to have a first side inserted into the space sections of the first and second directional brackets and a second sideinserted into a center portion of one side of the rotation device to facilitate rotation of the rotation device; and
a second bearing configured to be interposed between the first and second directional brackets and the rotary bushing.

[9] The apparatus as claimed in claim 1, wherein the rotation device includes:
a first shaft configured to be coupled with the directional joint to serve as a central shaft of the scale removing device;
a first driven gear configured to be fitted around the first shaft to transfer rotational force to the first shaft;
a first driving gear configured to be engaged with the first driven gear to transfer the rotational force to the first driven gear; and
a first reduction motor configured to provide the first driving gear with the rotational force.

[10] The apparatus as claimed in claim 1, wherein the rotation device includes:
a third rotation device configured to have a third shaft coupled with the directional joint to serve as a central shaft of the scale removing device, a third driven gear fitted around the third shaft to transfer rotational force to the third shaft, a third driving gear engaged with the third driven gear, and a third reduction motor that provides the third driving gear with the rotational force; and
a second rotation device configured to have a second shaft formed with a hollow section into which the third shaft is inserted, a bearing interposed between the third shaft and the second shaft, a rotary joint installed on an outer surface of the second shaft, a second driven gear fitted around the second shaft to transfer rotational force to the second shaft, a second driving gear engaged with the second driven gear, and a second reduction motor that provides the second driving gear with the rotational force.

[11] The apparatus as claimed in claim 9, wherein the scale removing device includes:
a first support configured to be fitted around a front end of the first shaft to rotate about the front shaft;
a second configured to be fitted around a front end of the first shaft to rotate about the front shaft, and installed at a rear end of the first support while maintaining an angle of 45°relative to the first support;
first and second pressing units configured to radially extend from outer surfaces

of the first and second supports, respectively, the first pressing units being spaced apart from each other at an angle of 90 and the second pressing units being spaced apart from each other at an angle of 90 to press an inner surface of the pipe at predetermined pressure;

first and second disc cutters configured to be mounted on front ends of the first and second pressing units to draw the cutting lines on a scale layer while being rotated along a circumferential surface of the pipe; and

a first hydraulic supply unit configured to be installed at a front end portion of the first support to provide the first and second pressing units with pressing force.

[12] The apparatus as claimed in claim 10, wherein the scale removing device includes:

first and second pressing units configured to have first ends, into which the third shaft of the third rotation device is inserted, and second ends, which extend at an equal interval in a radial direction of the pipe to press an inner surface of the pipe at predetermined pressure, respectively;

first and second disc cutters configured to be mounted on front end portions of the first and second pressing units to draw the cutting lines on a scale layer while being rotated along a circumferential surface of the pipe;

a first hydraulic supply unit configured to be installed above the third rotation device to provide the first and second pressing units with pressing force;

third and fourth pressing units configured to have first ends, into which the second shaft of the second rotation device is inserted, and second ends, which extend at an equal interval in the radial direction of the pipe to press the inner surface of the pipe at predetermined pressure, respectively;

third and fourth disc cutters configured to be mounted on front end portions of the third and fourth pressing units to draw the cutting lines on the scale layer while being rotated along the circumferential surface of the pipe; and

a second hydraulic supply unit configured to be installed at a side of the second rotation device to provide the third and fourth pressing units with pressing force.

[13] The apparatus as claimed in claim 10 or 11, further comprising a plate for removing scale peeling pieces, which is configured to be installed one side of the first and second disc cutters to remove the scales while being rotated, the scales being separated by the first and second disc cutters and fallen on a bottom of the pipe

[14] The apparatus as claimed in claim 12, wherein each of the first to fourth pressing units includes:

a first cylinder configured to be mounted on the third and second shafts;

a second cylinder configured to be inserted into an inner surface of the first cylinder while moving up and down, and to have a front end portion having a corresponding disc cutter while being adjacent to the pipe surface;
a fixed rod configured to be installed in a cavity of the first cylinder and to have a first hydraulic chamber to receive or discharge fluid pressure in accordance with the up/down movement of the second cylinder;
a third cylinder configured to be coupled with an outer surface of the fixed rod to form the first hydraulic chamber;
a push rod configured to be installed in a cavity of the second cylinder and to have a second hydraulic chamber therein;
a fourth cylinder configured to be installed outside the push rod while being coupled with the third cylinder; and
sealing members configured to be interposed between the third cylinder and the push rod and between the push rod and the fourth cylinder to maintain air-tightness.

[15] The apparatus as claimed in claim 12, wherein each of the first and second hydraulic supply units includes:
a hydraulic tank;
a hydraulic distributor configured to be installed at one side of the hydraulic tank to distribute fluid pressure to the first to fourth pressing units; and
a hydraulic motor pump configured to supply the fluid pressure from the hyraulic tank to the hydraulic distributor.

[16] The apparatus as claimed in claim 12, wherein each of the first and second hydraulic supply units includes:
a fifth cylinder configured to be provided at one side thereof with a hydraulic chamber;
a piston packing configured to be installed at one side of the hydraulic chamber of the fifth cylinder to reduce a space of the hydraulic chamber, and to linearly move to discharge pressure fluid in the hydraulic chamber to an outside;
a spring configured to be provided at one side of the piston packing to press the piston packing at predetermined pressure; and
a fastening bolt configured to be installed in the fifth cylinder and provided with a disc plate positioned at one side of the spring to control the spring such that the spring has constant compressive pressure.

[17] The apparatus as claimed in claim 12, further comprising first and second bending joints configured to be installed between the second and third rotation devices and a scale removing device to provide the scale removing device with superior bending property,

wherein the first bending joint includes:
a first connection bracket configured to be coupled with an end of the second shaft of the second rotation device;
a second connection bracket configured to be coupled with an end of a central shaft of the scale removing device; and
bearings configured to be installed at the first and second connection brackets,
wherein the second bending joint includes:
a third connection bracket configured to be coupled with an end of the third shaft of the third rotation device;
a fourth connection bracket configured to be coupled to the end of the central shaft of the scale removing device;
the bearings configured to be installed at the first and second connection brackets; and
a spring configured to be fitted around the third and fourth connection brackets to restrict bending angles of the third and fourth connection brackets.

[18] The apparatus as claimed in claim 17, wherein each of the first and second hydraulic supply units includes:
a hydraulic pump configured to be installed a front end of the scale removing device;
a hydraulic supply passage configured to be axially formed on a circumferential surface of the central shaft of the scale removing device to move the first and second pressing units up and down;
up/down movable blocks configured to be installed at sides of the third and fourth pressing units, and to provide fluid pressure from the hydraulic pump to the third and fourth pressing units; and
a hydraulic hose configured to be coupled the hydraulic pump with the up/down movable blocks to supply the up/down movable blocks with fluid pressure.

[19] The apparatus as claimed in claim 1, wherein the pipe grinding device includes
a nipple configured to be coupled to the rotation device;
a spray nozzle for spraying striking pieces, which is configured to be coupled with the nipple and to have an end inclined at an angle of 45°elative to the pipe surface;
a hose configured to couple the nipple with the striking-fragment spray nozzle;
a third support configured to be inserted into the rotation device;
a third absorber configured to extend from the third support in a radial direction of the pipe, and to include a third wheel closely making contact with the pipe surface;
a fixing support configured to have a first end fixed to the third absorber, a

second end fixed to the spray nozzle, and an articulation section at an intermediate portion thereof to prevent the spray nozzle from being pushed back due to spray pressure;

an anti-bending member configured to be mounted on the articulation section of the fixing support to prevent the fixing support from being bent upward;

an auxiliary support configured to protrude perpendicularly to the fixing support and to have a ring at an end thereof;

a nozzle support bar configured to have a first side fixed to the spray nozzle and a second side inserted into the ring of the auxiliary support to prevent the spray nozzle from being pushed back due to striking pressure;

a spring configured to be fitted around the nozzle support bar to allow the nozzle support bar to be elastically pushed back;

an interval adjusting rod configured to have a first side supported by an outer surface of the third absorber and a second side fixing an end of the fixing support to adjust a striking interval of the spray nozzle; and

a supply unit configured to be installed at a rear end of the body to supply the hose with striking pieces.

[20] The apparatus as claimed in claim 19, wherein the striking pieces include silica.

[21] The apparatus as claimed in claim 3, wherein the lining device includes:

a fourth support configured to be coupled with the rotation device;

a fourth absorber configured to extend from a circumferential surface of the fourth support in the radial direction of the pipe, and to include a fourth wheel closely making contact with the pipe surface;

a pigment supply line configured to extend from the fourth absorber perpendicularly to the fourth absorber;

an interval adjusting rod configured to have a first side, which is supported by an outer surface of the fourth absorber, and a second side that fixes an end of the pigment supply line to adjust an interval between the pigment supply line and the pipe surface;

first and second lining nozzles configured to be coupled with the end of the pigment supply line to spray pigments toward the pipe surface;

a support configured to support the first and second lining nozzles;

a base pigment tank configured to be installed at a rear end of the body;

a curing agent tank configured to be installed at one side of the base pigment tank;

a hydraulic supply unit configured to supply the hose with base and curing agent;

a base configured to be installed below the base pigment tank and the curing agent tank to support the base pigment tank and the curing agent tank;

a caterpillar configured to be installed at a lower end of the base; and
a motor configured to be mounted on the caterpillar to drive the caterpillar.

[22] The apparatus as claimed in claim 21, wherein the first and second lining nozzles are configured to have difference in length to spray the pigments at a maximum spray angle through a one-time rotation operation.

[23] The apparatus as claimed in claim 1, further comprising a traction device configured to be installed on an articulated pipe at a front end of the body to draw the body.

[24] An apparatus for rehabilitating a superannuated pipe, the apparatus comprising:
a body configured to linearly move along an inner surface of a superannuated pipe and to have a plurality of articulated pipes formed with a hollow hole for receiving a hose to supply fluid from an outside;
first movable devices configured to extend at an isometric angle from an outer peripheral surface of each articulated pipe of the body toward a pipe surface, and having first absorbers, which are compressed and expanded corresponding to pressing pressure against the pipe surface, and first wheels that make contact with the pipe surface, respectively;
a directional joint configured to have a center portion formed with a through hole for allowing the hose to pass therethrough, to interconnect the articulated pipes of the body, and to allow the articulated pipes to change a direction of the articulated pipes at an angle of 360°thereby providing the body with superior bending property when the body passes through a curved pipe;
a rotation device configured to be coupled with one end of the directional joint while being rotated by external power ;
second movable devices configured to extend at an isometric angle from an outer peripheral surface of the rotation device toward a pipe surface, and to have second absorbers, which are compressed and expanded corresponding to pressing pressure against the pipe surface, and second wheels that make contact with the pipe surface, respectively; and
a scale removing device configured to extend from a central shaft of the rotation device in a radial direction of the pipe, and to have an end that separates scales from the pipe surface by drawing first cutting lines in a circumferential direction and drawing second cutting lines perpendicularly to the first cutting lines while being rotated in contact with the pipe surface at predetermined pressure.

[25] A method for rehabilitating a superannuated pipe, the method comprising:
inspecting an inner surface of the superannuated pipe;
inserting a cleaning robot into the superannuated pipe and driving a camera to investigate a front portion of the superannuated pipe;

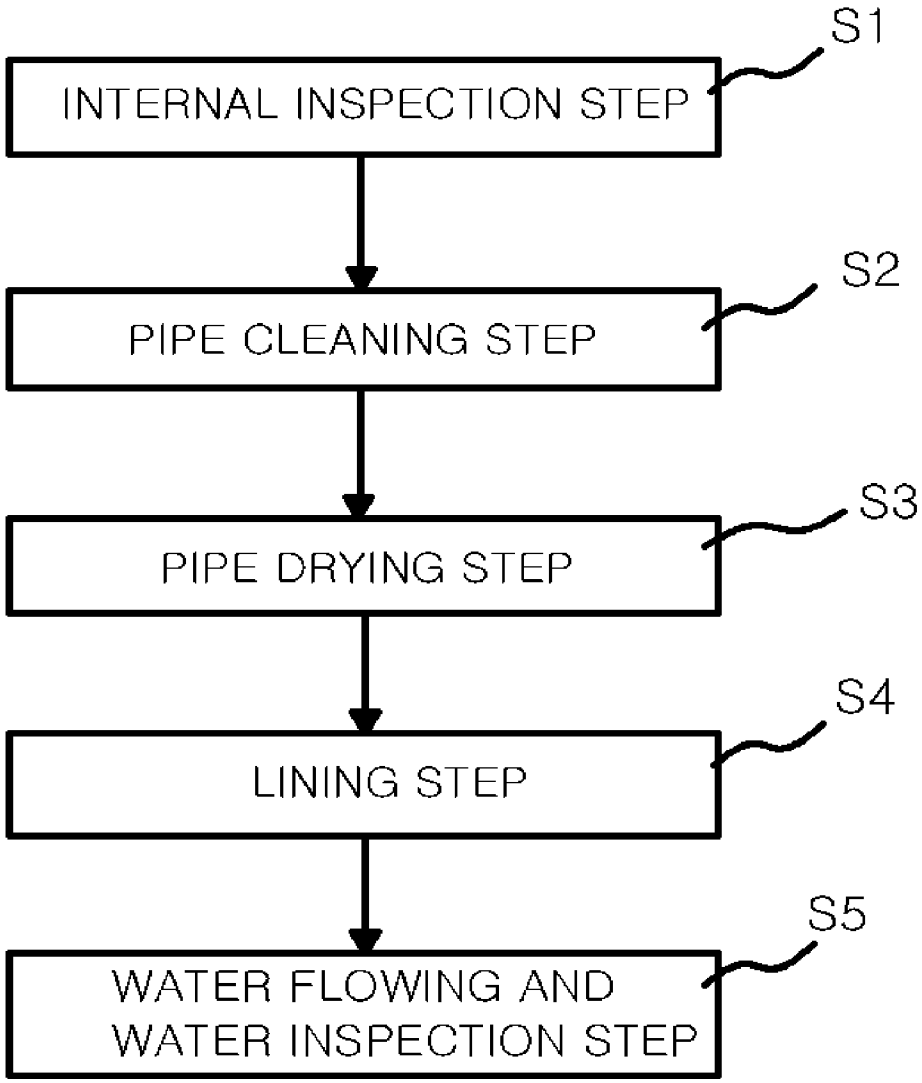
rotating a rotation member by driving a reduction motor provided in the cleaning robot, drawing cutting lines on a circumferential surface of the superannuated pipe by using a disc cutter of a scale removing device, which is coupled with the rotating member, according to rotation of the rotating member, and separating scales from the inner surface of the superannuated pipe;

removing the scales in the superannuated pipe, coupling a sand spray device to the rotation member after removing the scale removing device through a post-treatment process, and performing a pipe grinding process by spraying sands onto the inner surface of the superannuated pipe;

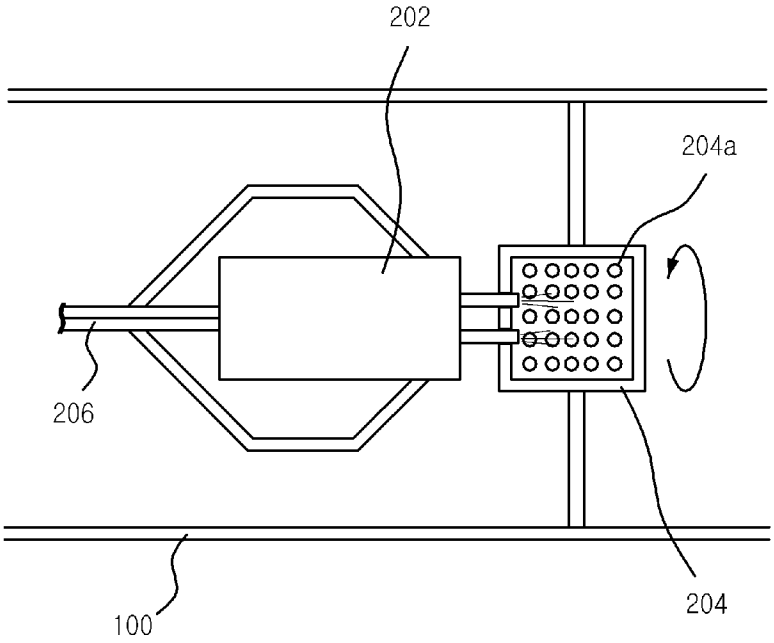
removing the sands and scale pieces, coupling a lining device to the rotation member after removing the sand spray device, and forming a film having desired thickness by spraying epoxy resin pigments including base and curing agent onto the inner surface of the superannuated pipe, thereby completing rehabilitation work for the superannuated pipe; and

curing the epoxy resin pigments coated on the inner surface of the superannuated pipe, and allowing water to flow in the superannuated pipe.

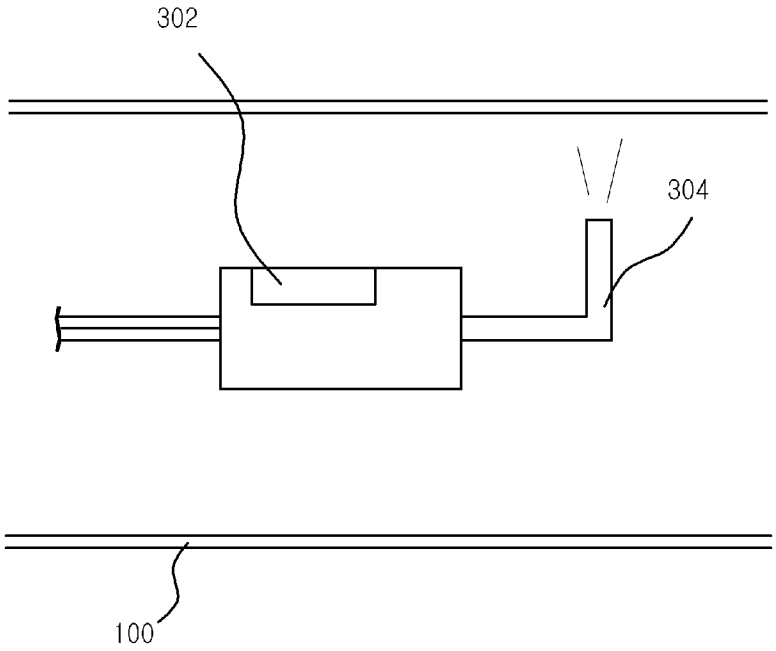
[Fig. 1]


S1
INTERNAL INSPECTION STEP
S2
PIPE CLEANING STEP
S3
PIPE DRYING STEP
S4
LINING STEP
S5
WATER FLOWING AND
WATER INSPECTION STEP

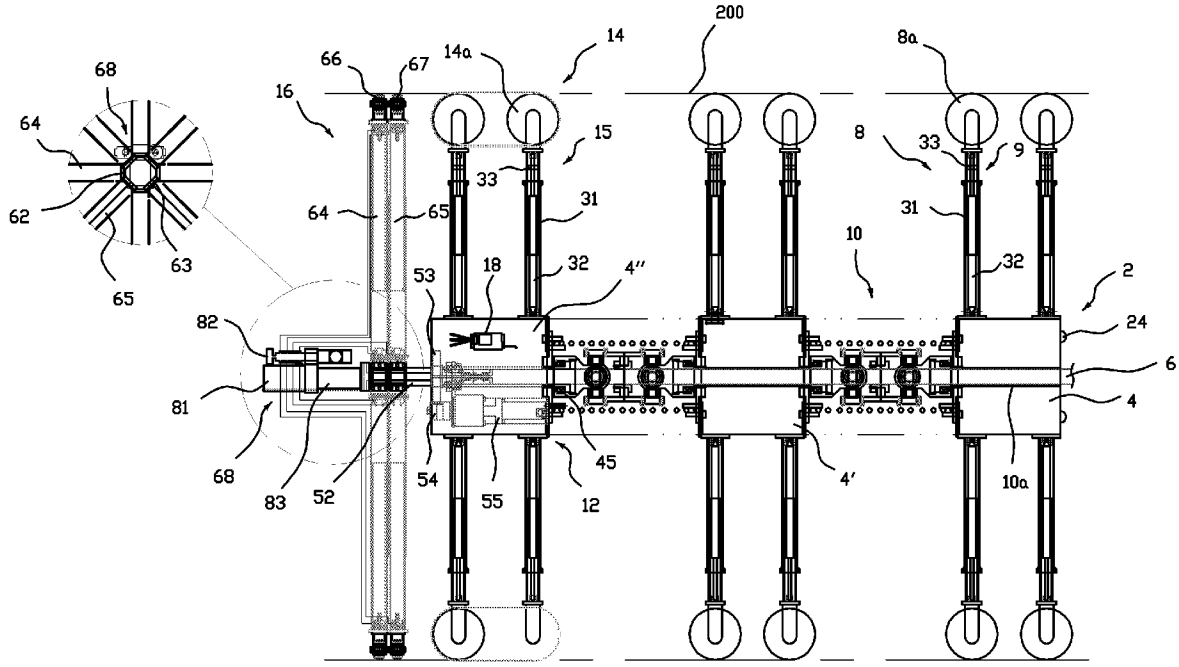
[Fig. 2]



[Fig. 3]



[Fig. 4]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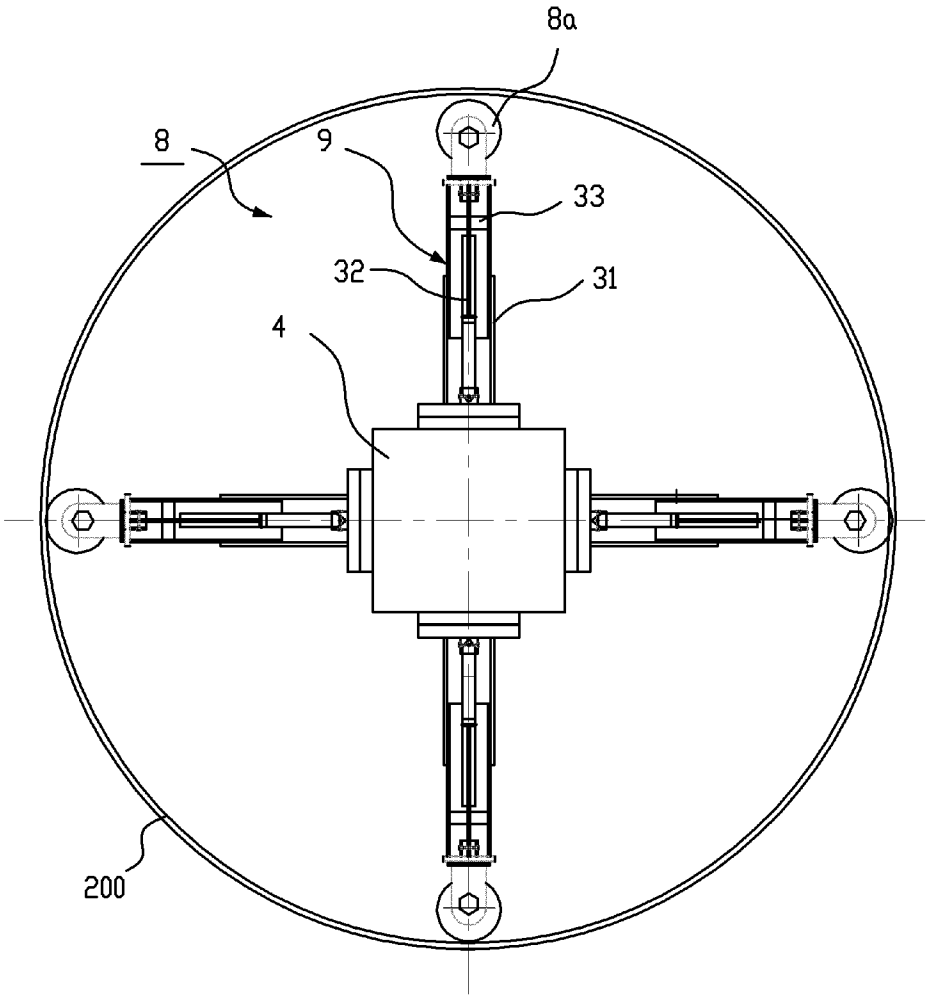
[Fig. 5]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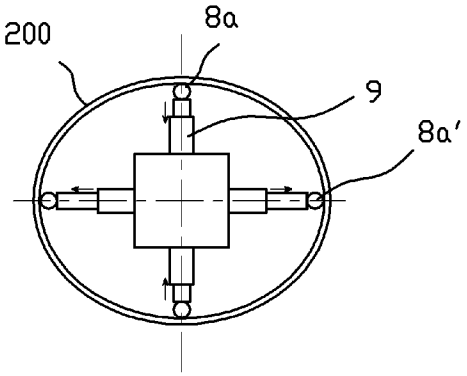
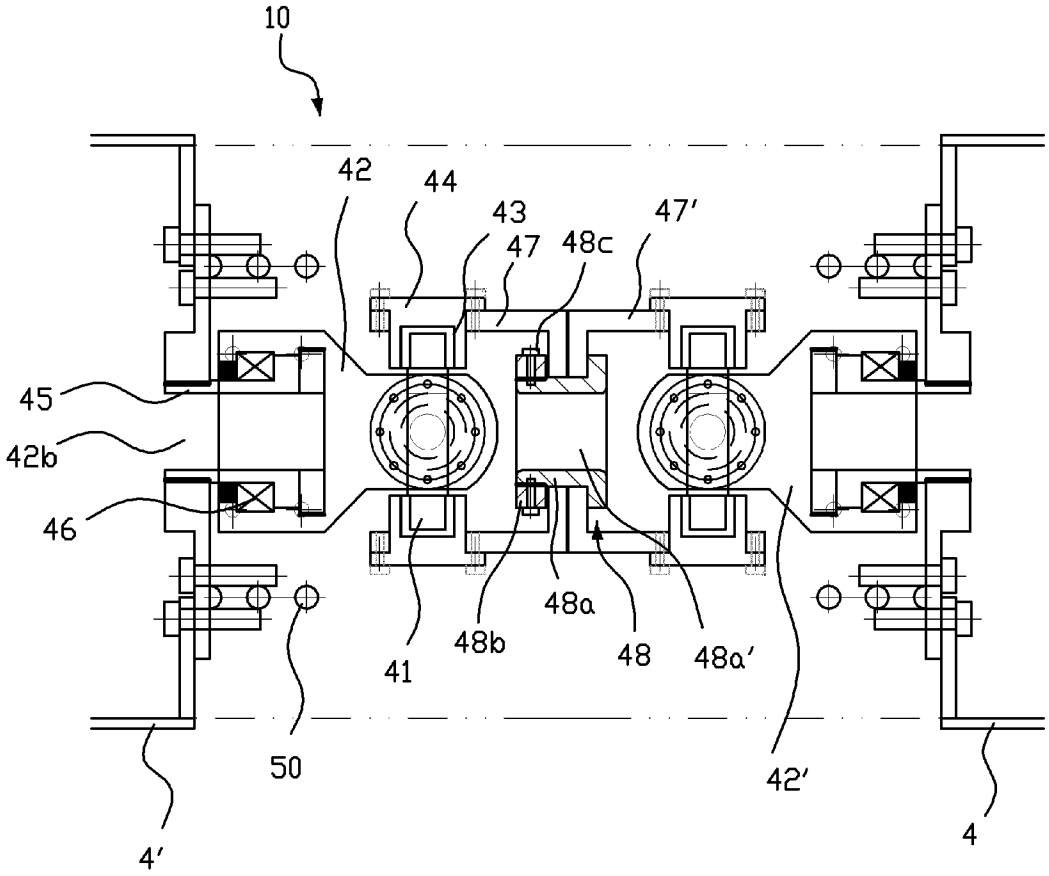
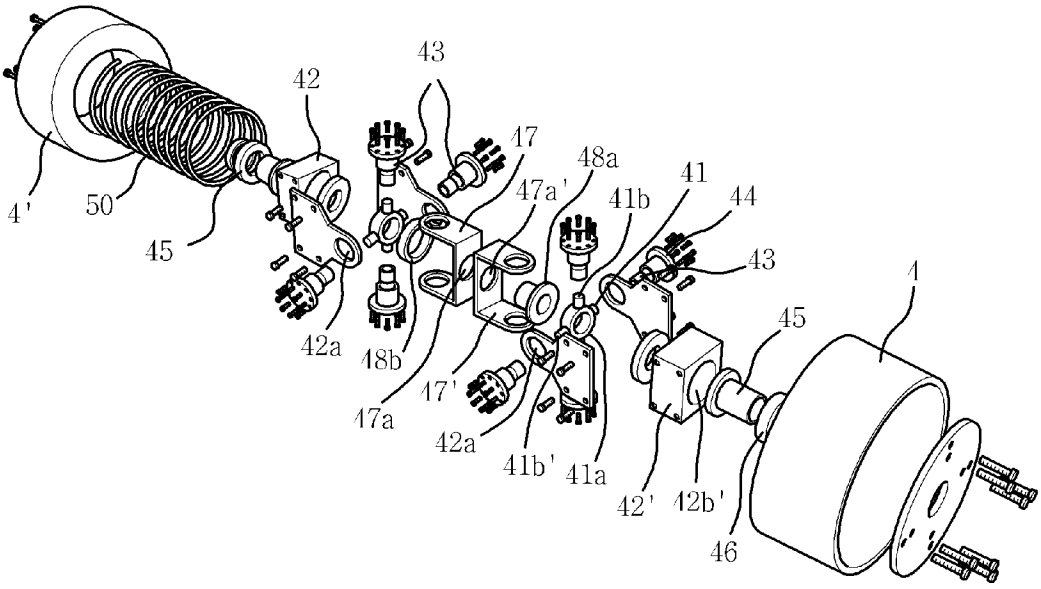
[Fig. 6]



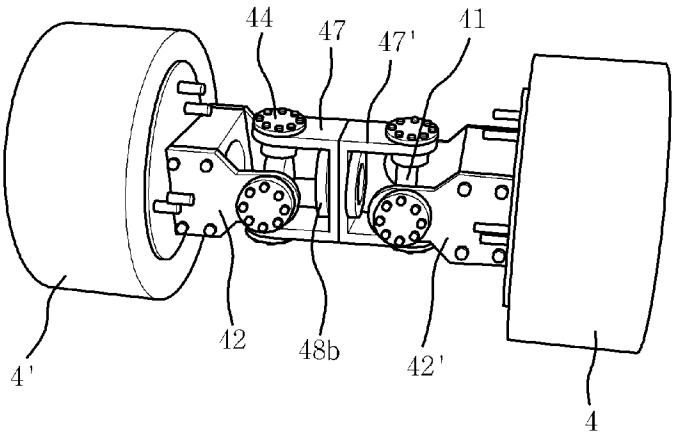
[Fig. 7]



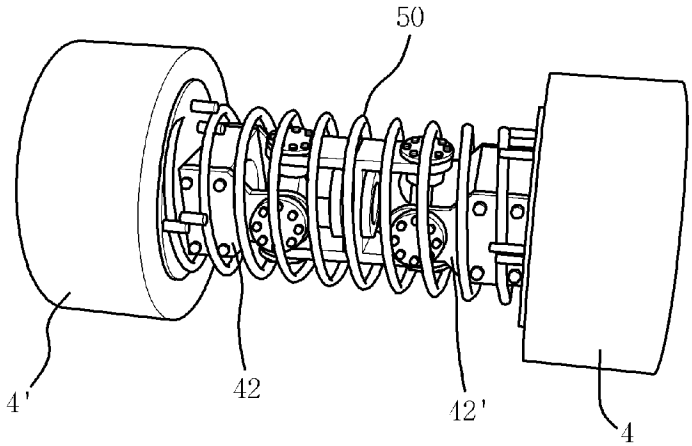
[Fig. 8]



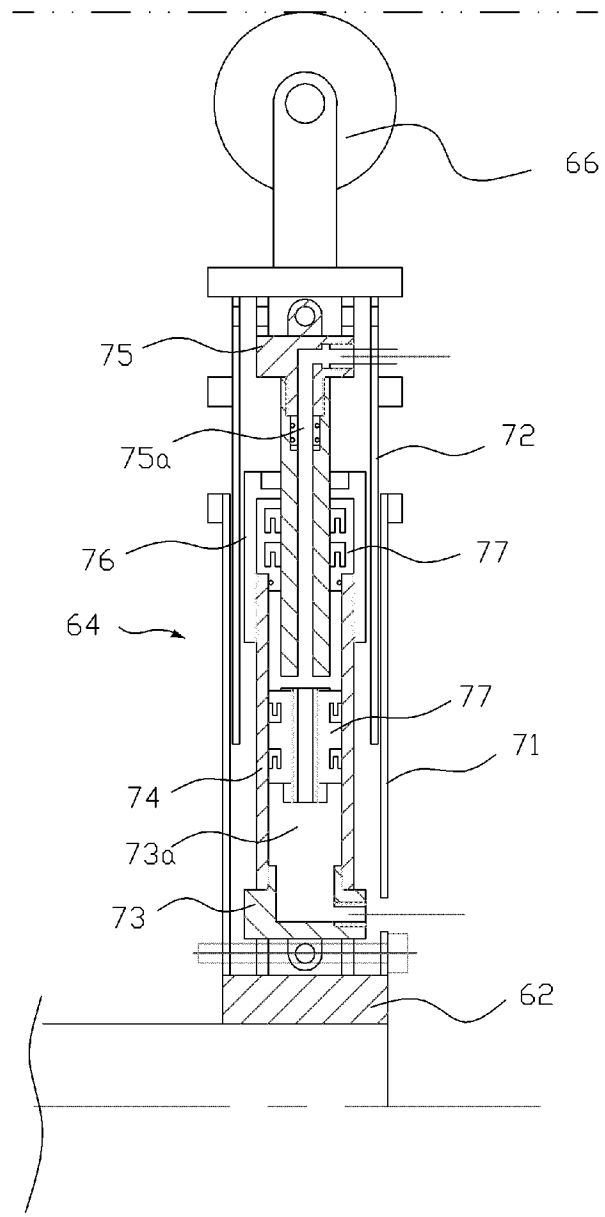
[Fig. 9]



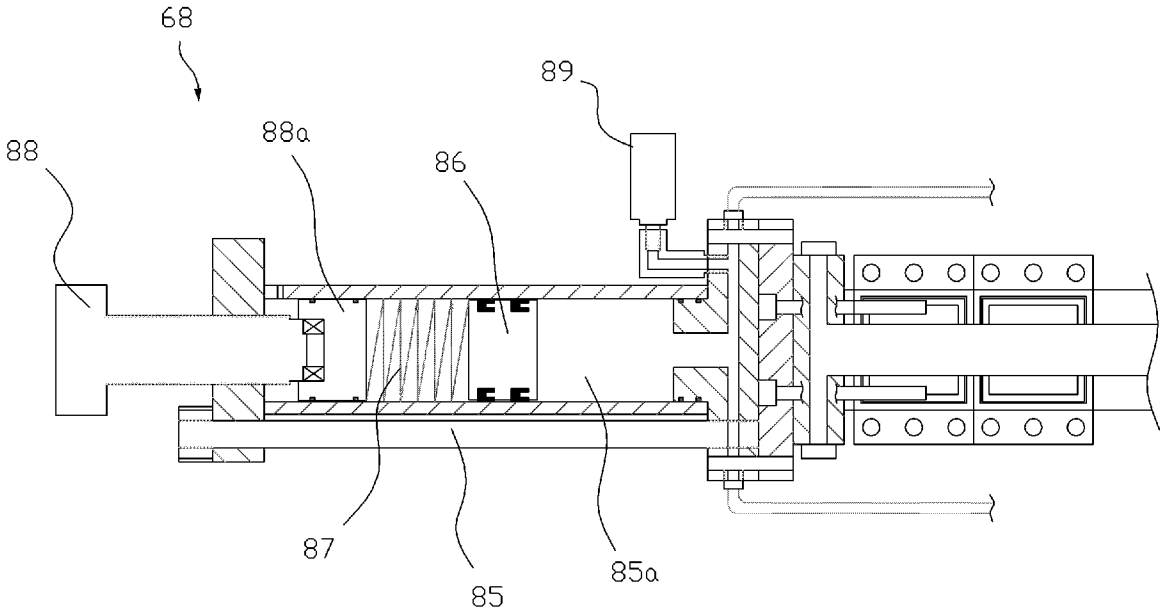
[Fig. 10]



[Fig. 11]



[Fig. 12]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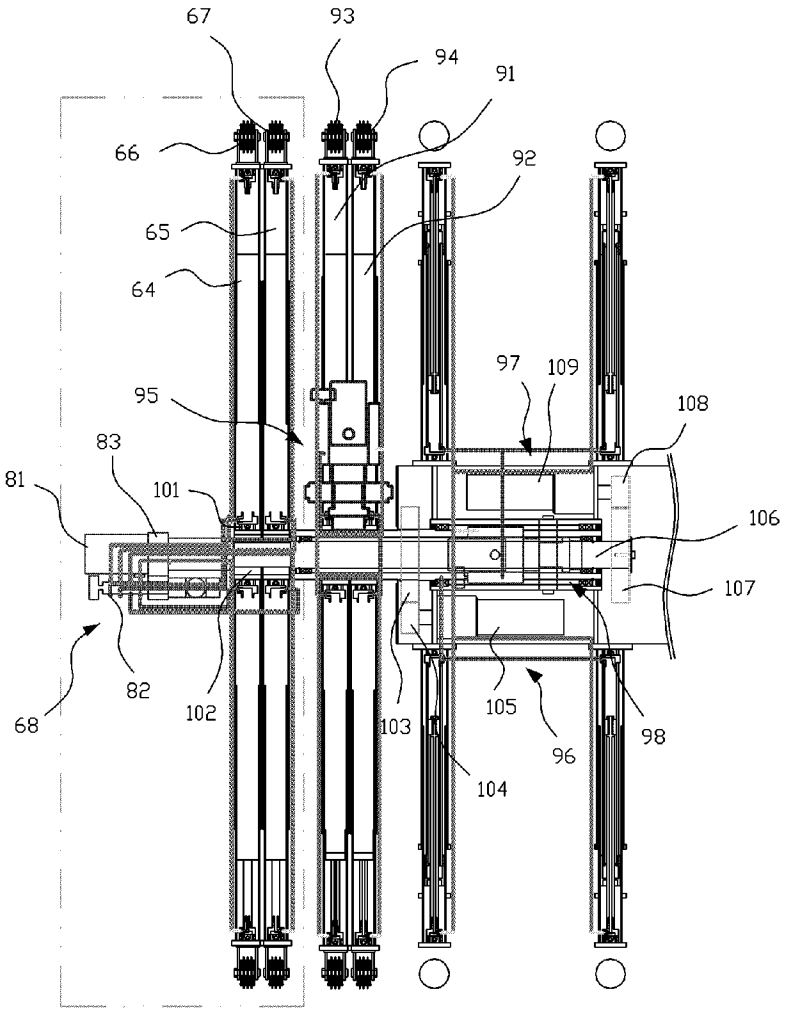
[Fig. 13]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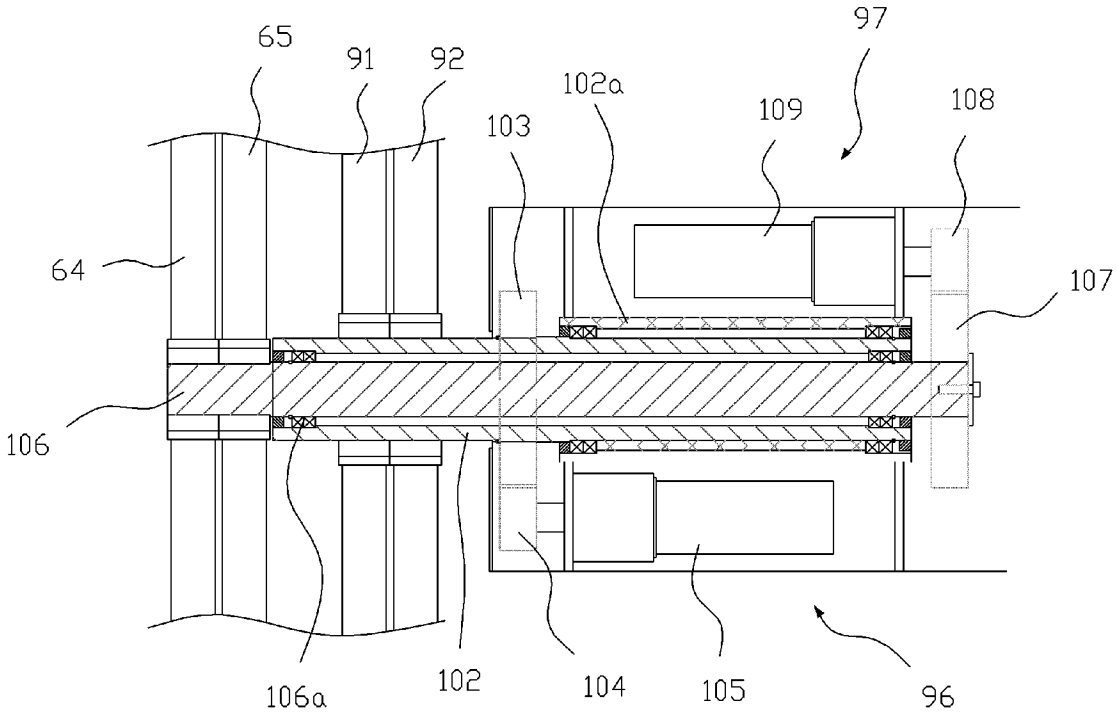
[Fig. 14]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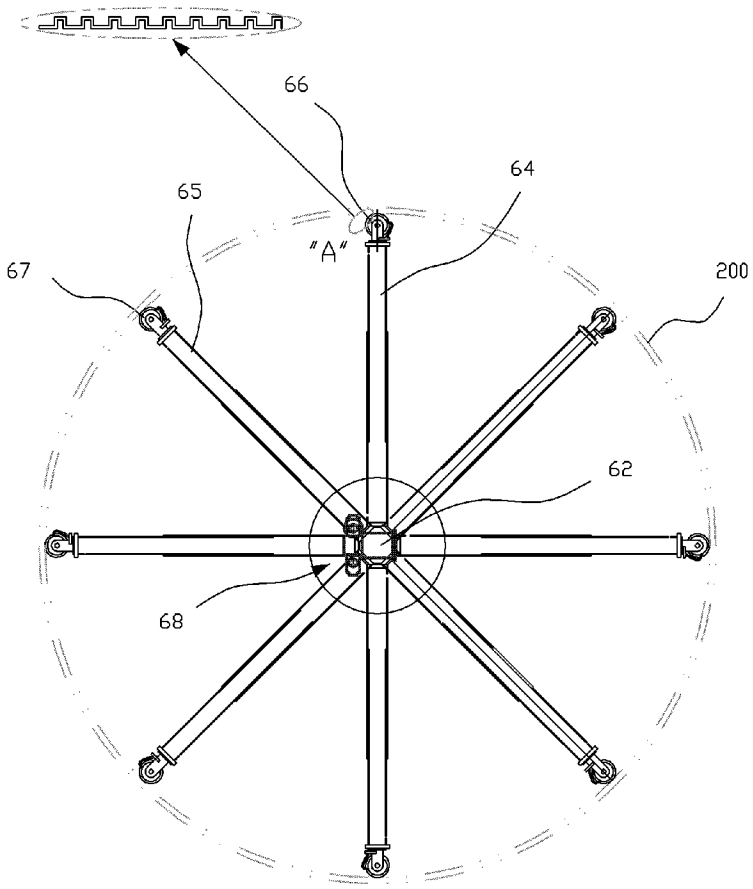
[Fig. 15]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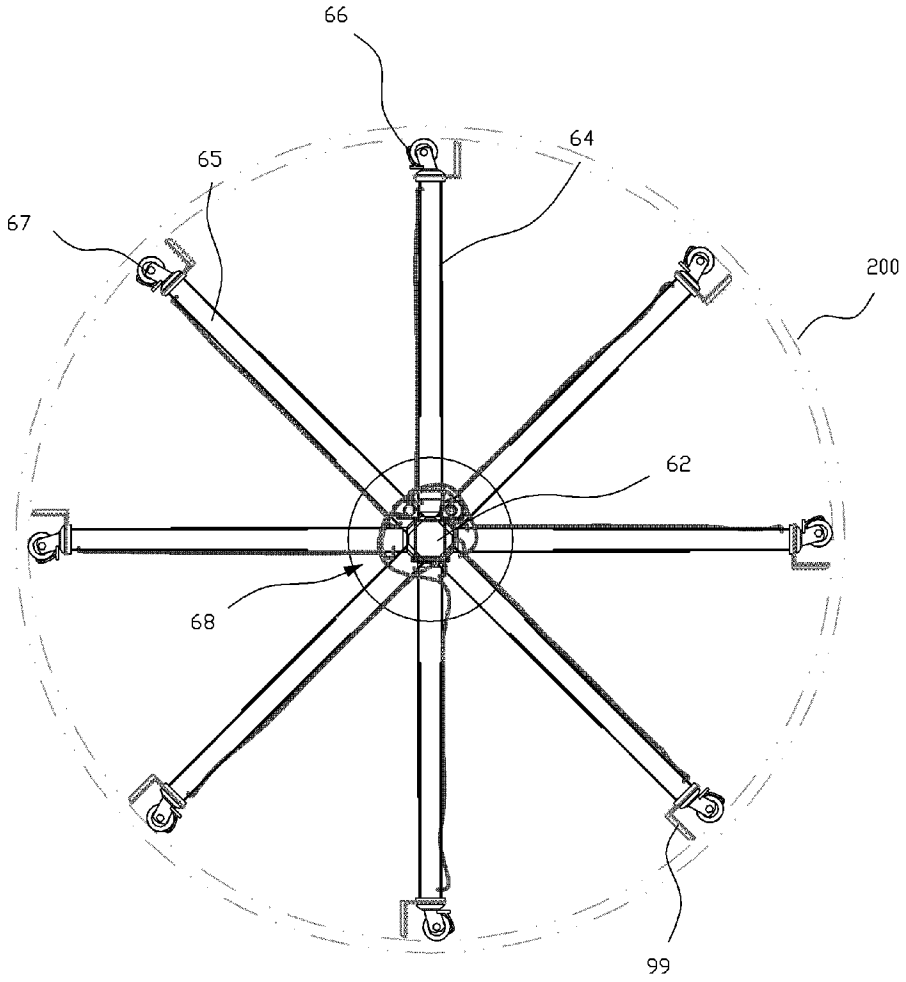
[Fig. 16]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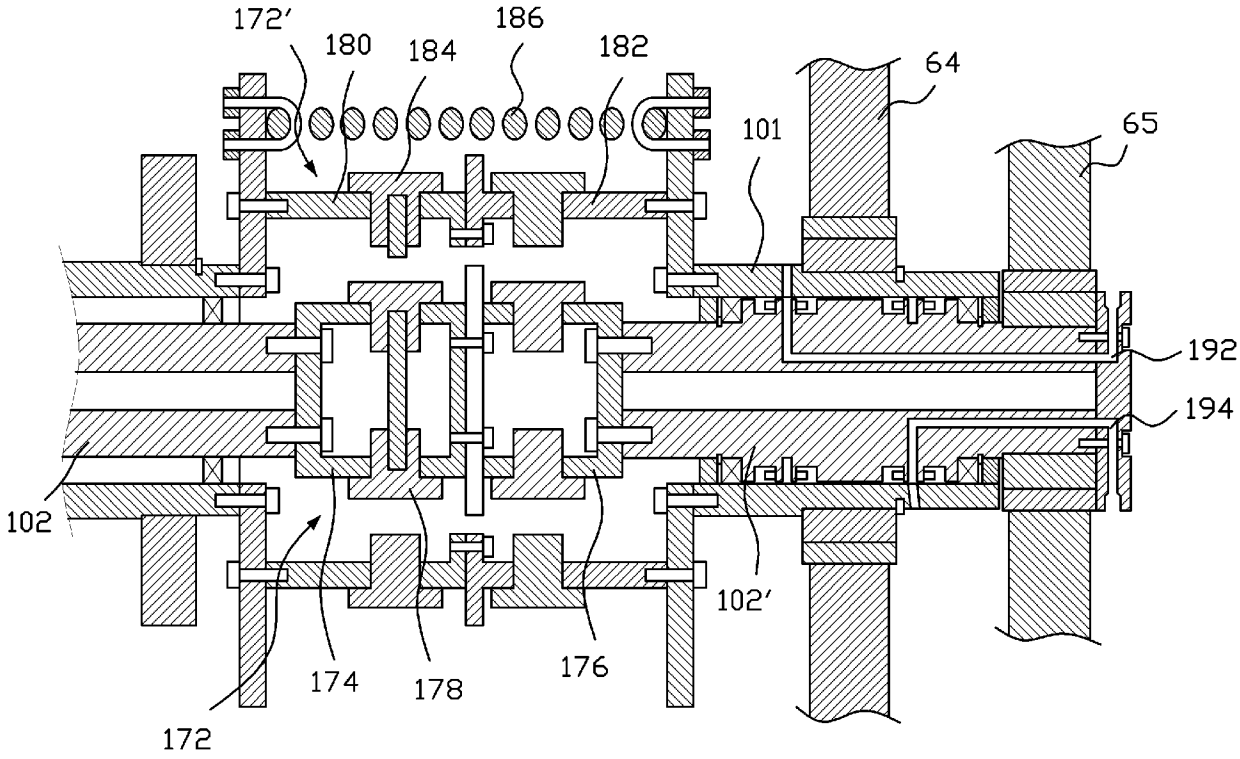
[Fig. 17]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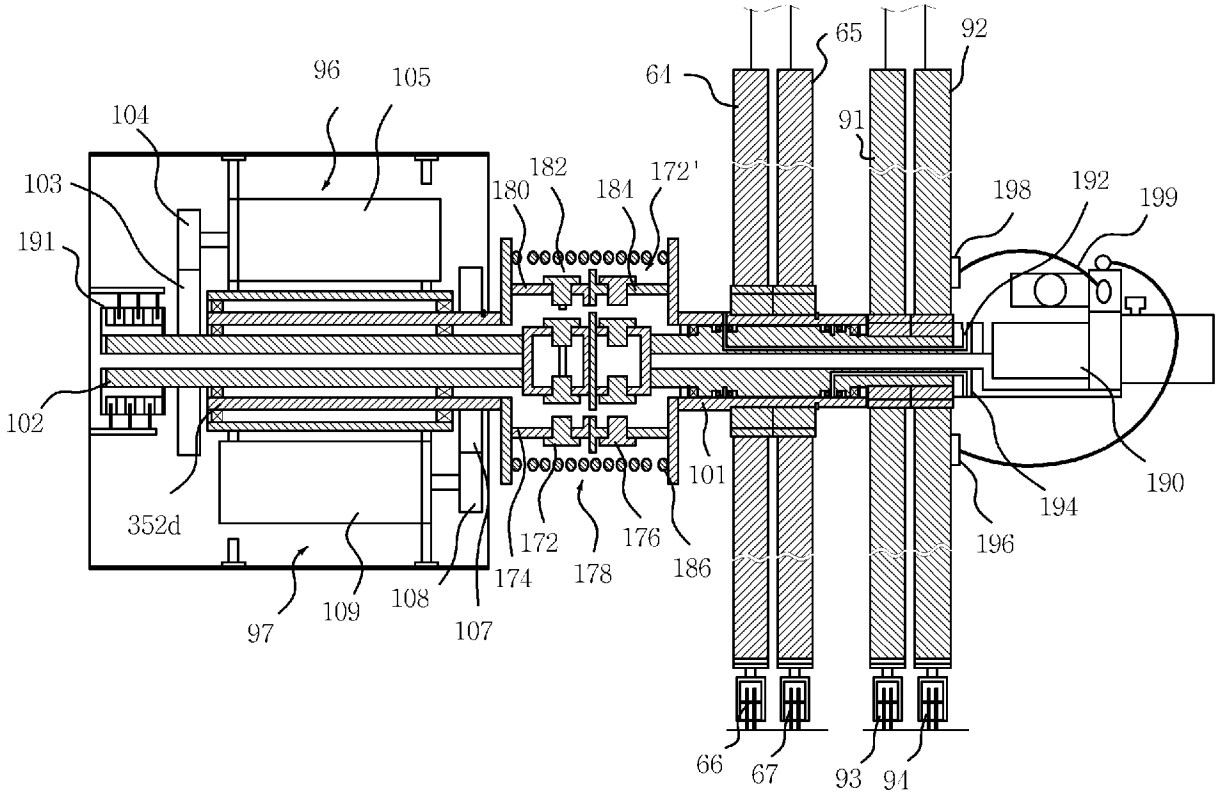
[Fig. 18]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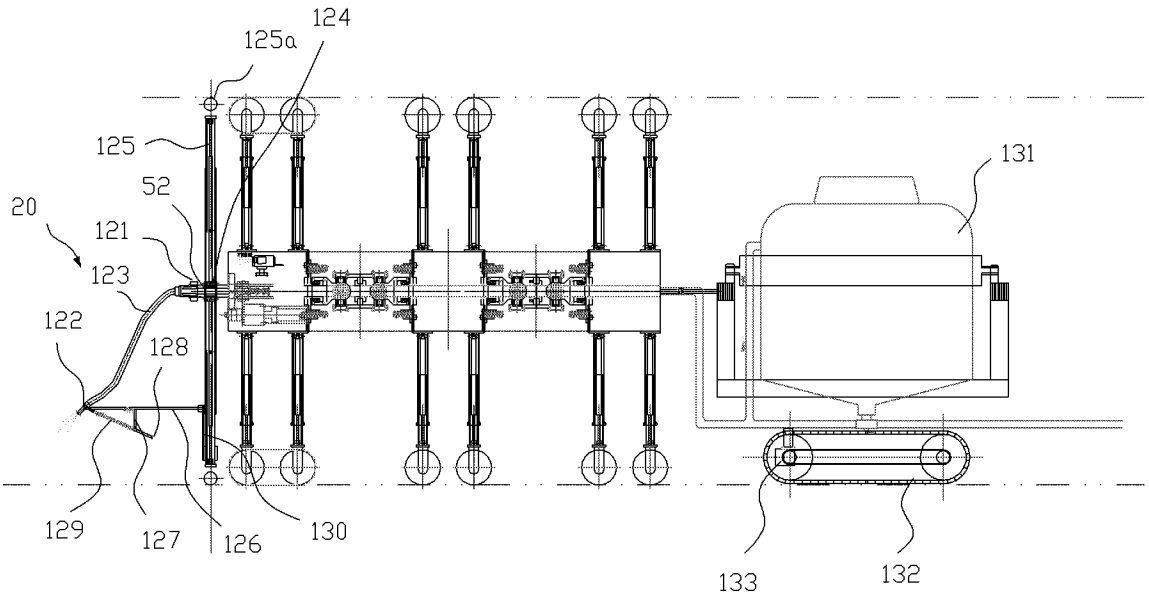
[Fig. 19]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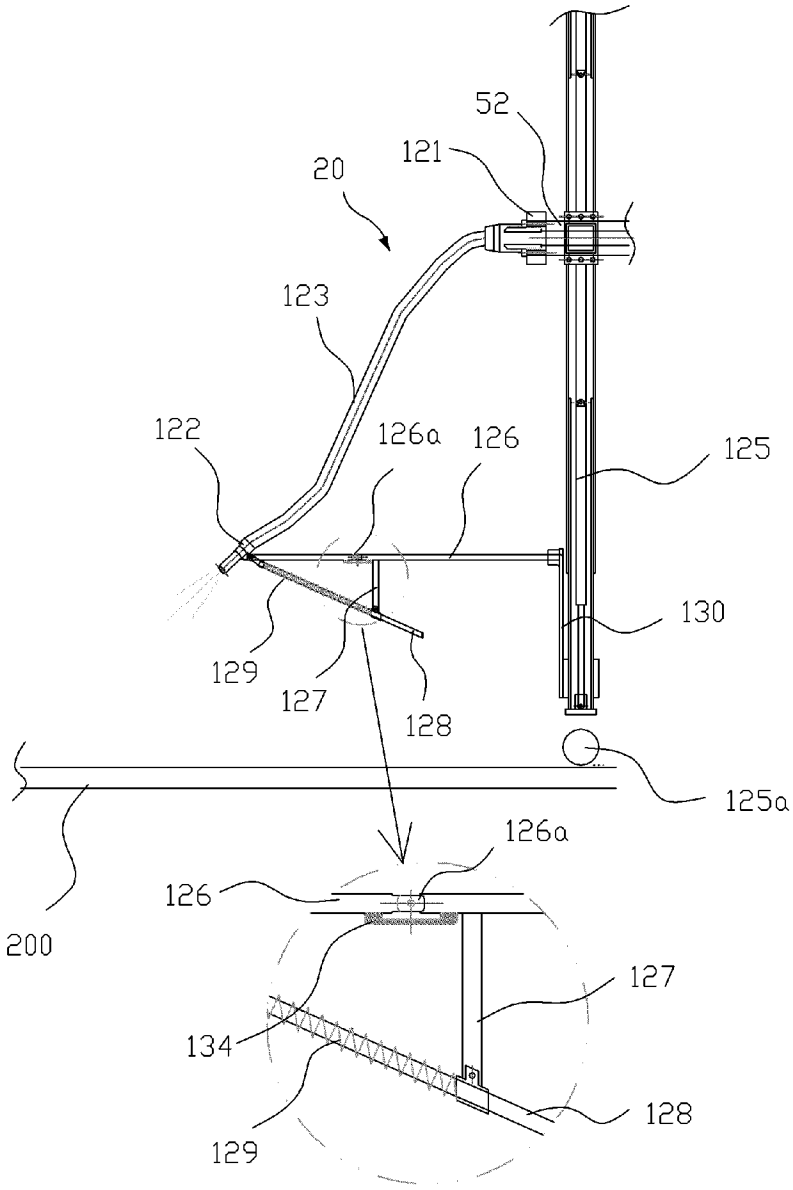
[Fig. 20]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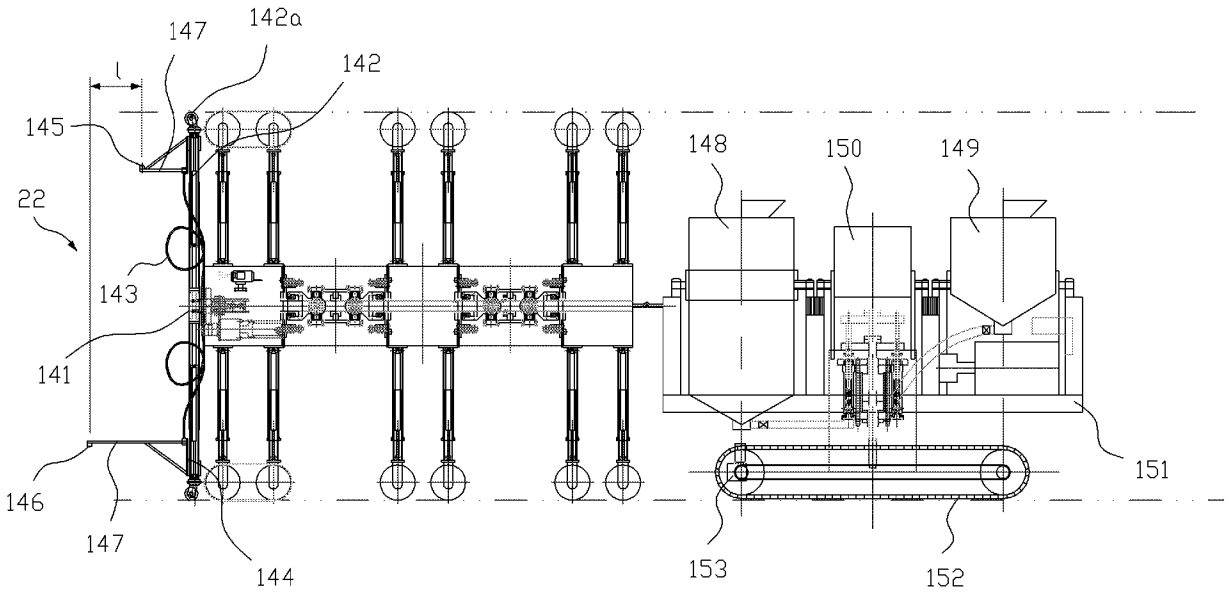
[Fig. 21]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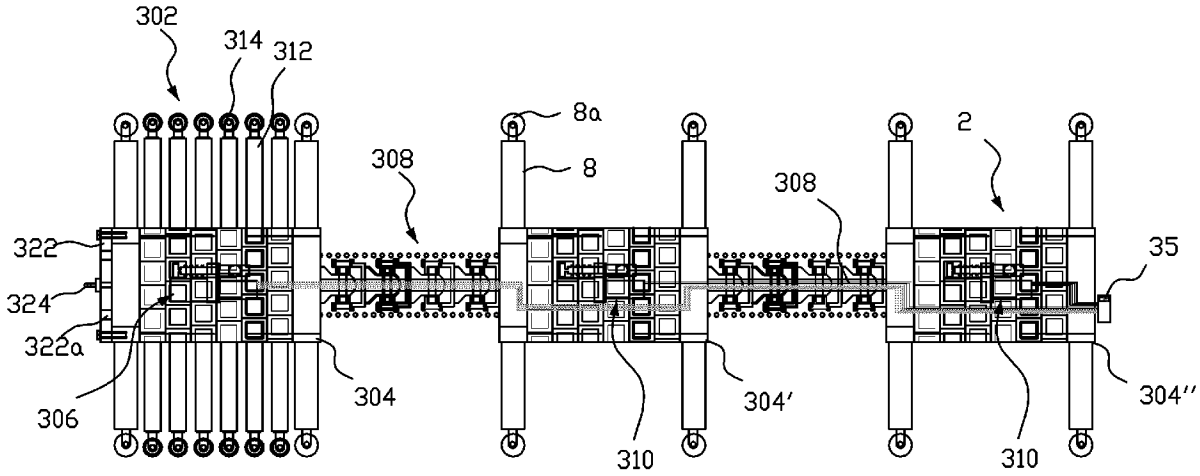
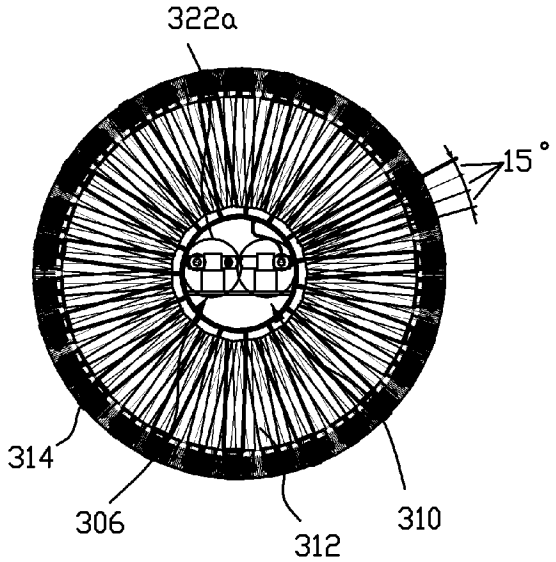
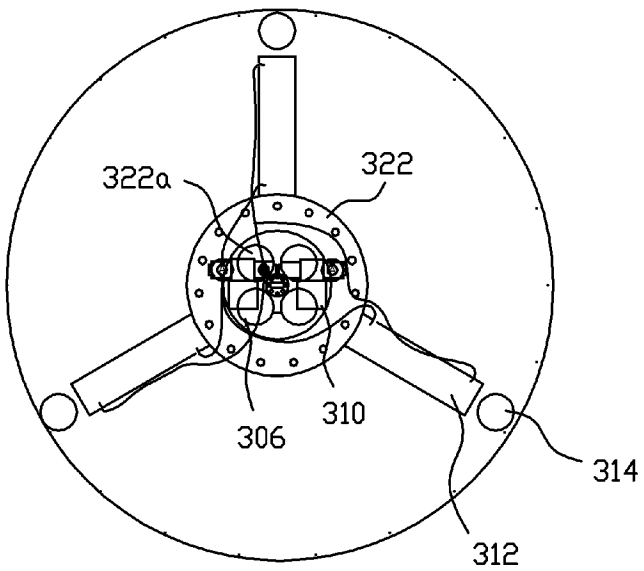
[Fig. 22]



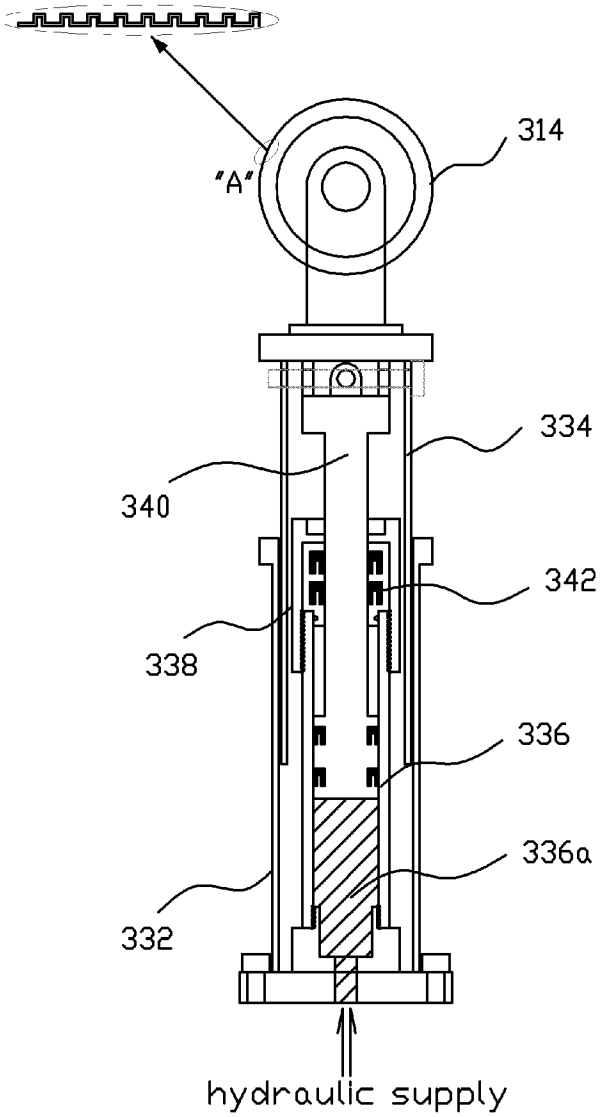
[Fig. 23]



[Fig. 24]



[Fig. 25]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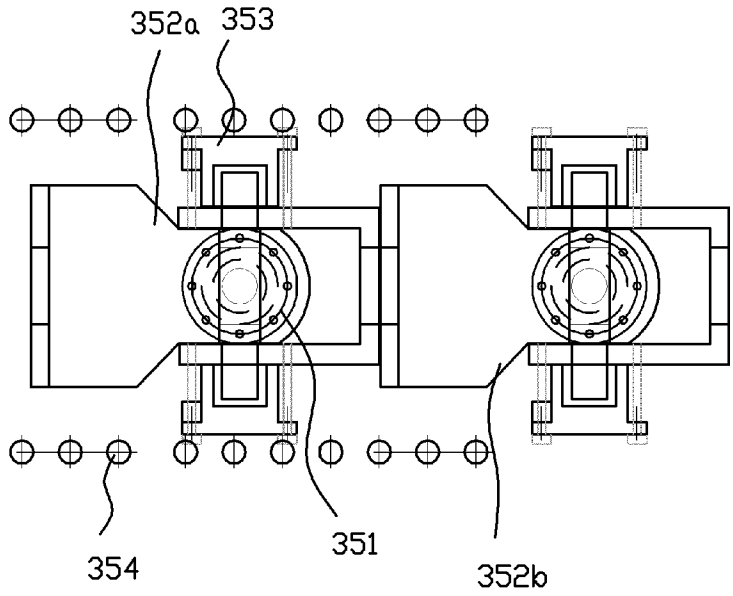
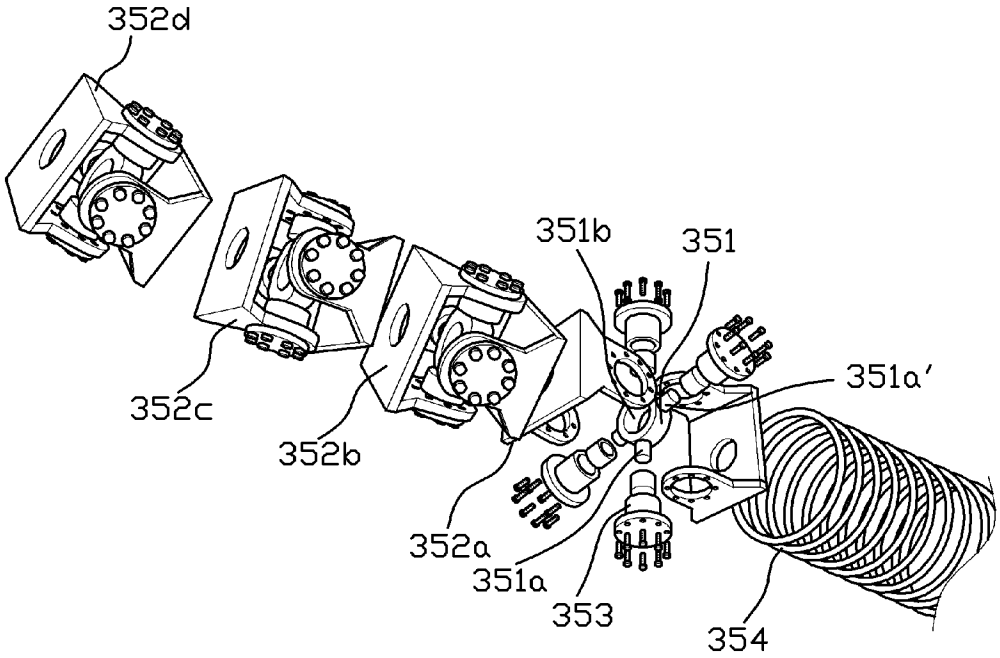
hydraulic supply

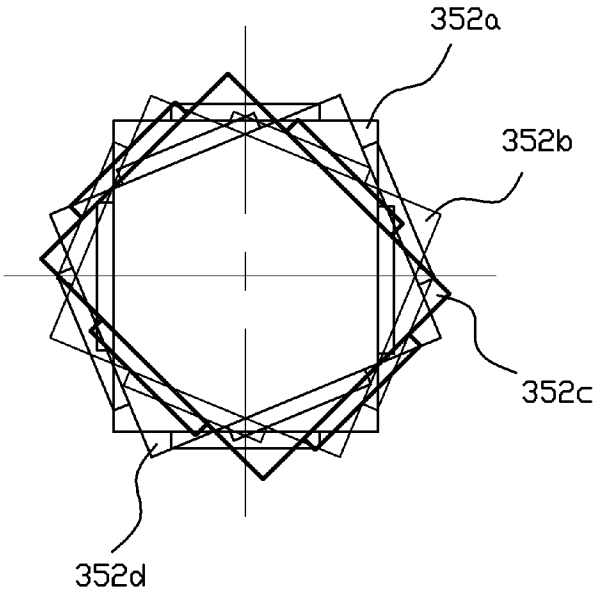
[Fig. 26]


352a
353
354
351
352b

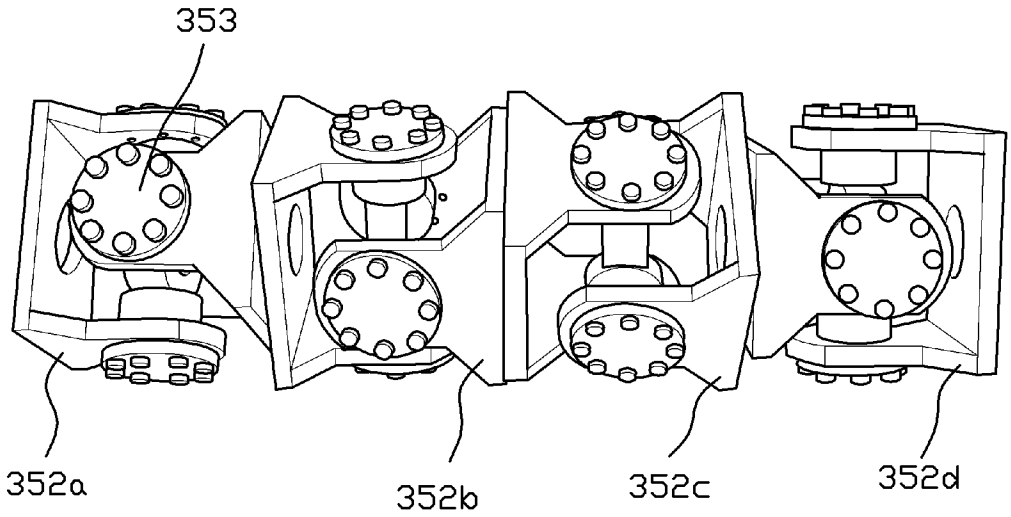
[Fig. 27]


352d
351b
351
351a'
352c
352b
352a
351a
353
354

[Fig. 28]


352a
352b
352c
352d

[Fig. 29]



[Fig. 30]