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(54) DIRECTIONAL DRILLING APPARATUS USING WATER HAMMER UNIT

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(57) **ABSTRACT**

A directional drilling apparatus using a water hammer unit according to the present invention includes a hammer body in which a bit unit configured to perform boring work is installed to be movable upward and downward at an end portion of the hammer body, a piston slidably installed on the hammer body and including an operating fluid discharge part formed in a longitudinal direction, a drive unit installed between the hammer body and the piston to support an upper portion of the piston and configured to move the piston upward and downward using water supplied through a rod connected to the hammer body, a hammer unit including a rotary shaft coupled to a bit by a first coupling part so as to transmit a rotational force in a state in which the hammer unit passes through the piston installed on the hammer body and is moved upward or downward by the bit, and a mud motor unit coupled to the hammer body and configured to rotate the rotary shaft.

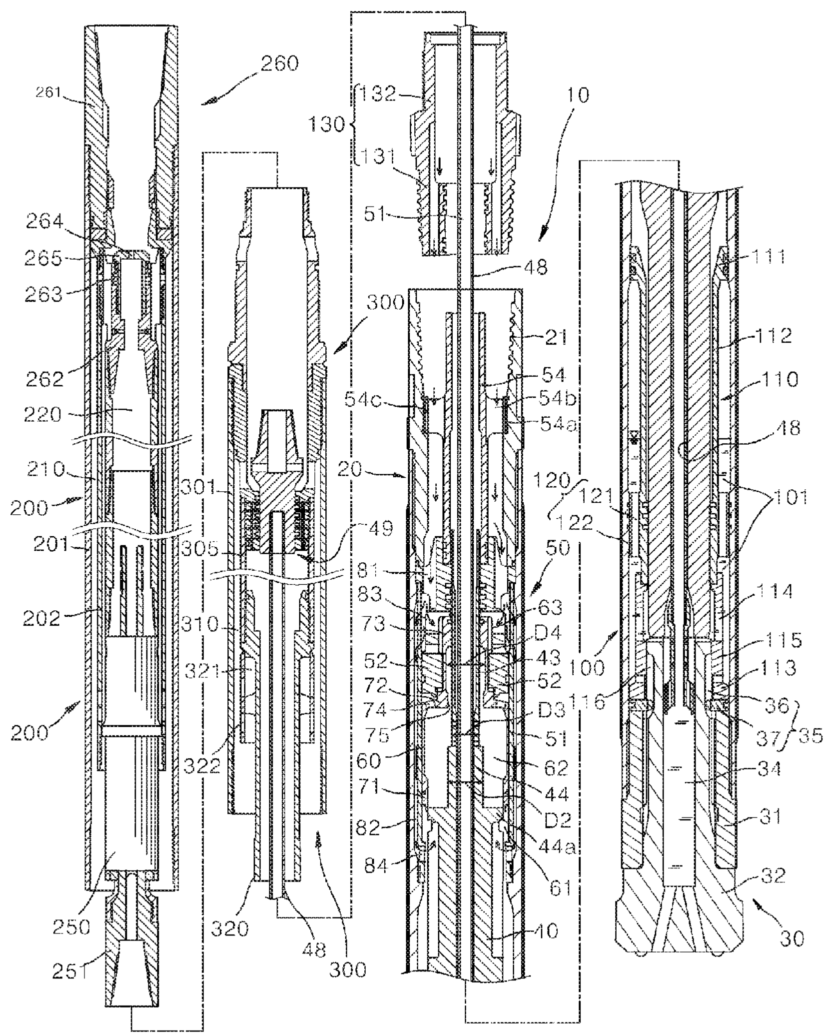

Fig. 1

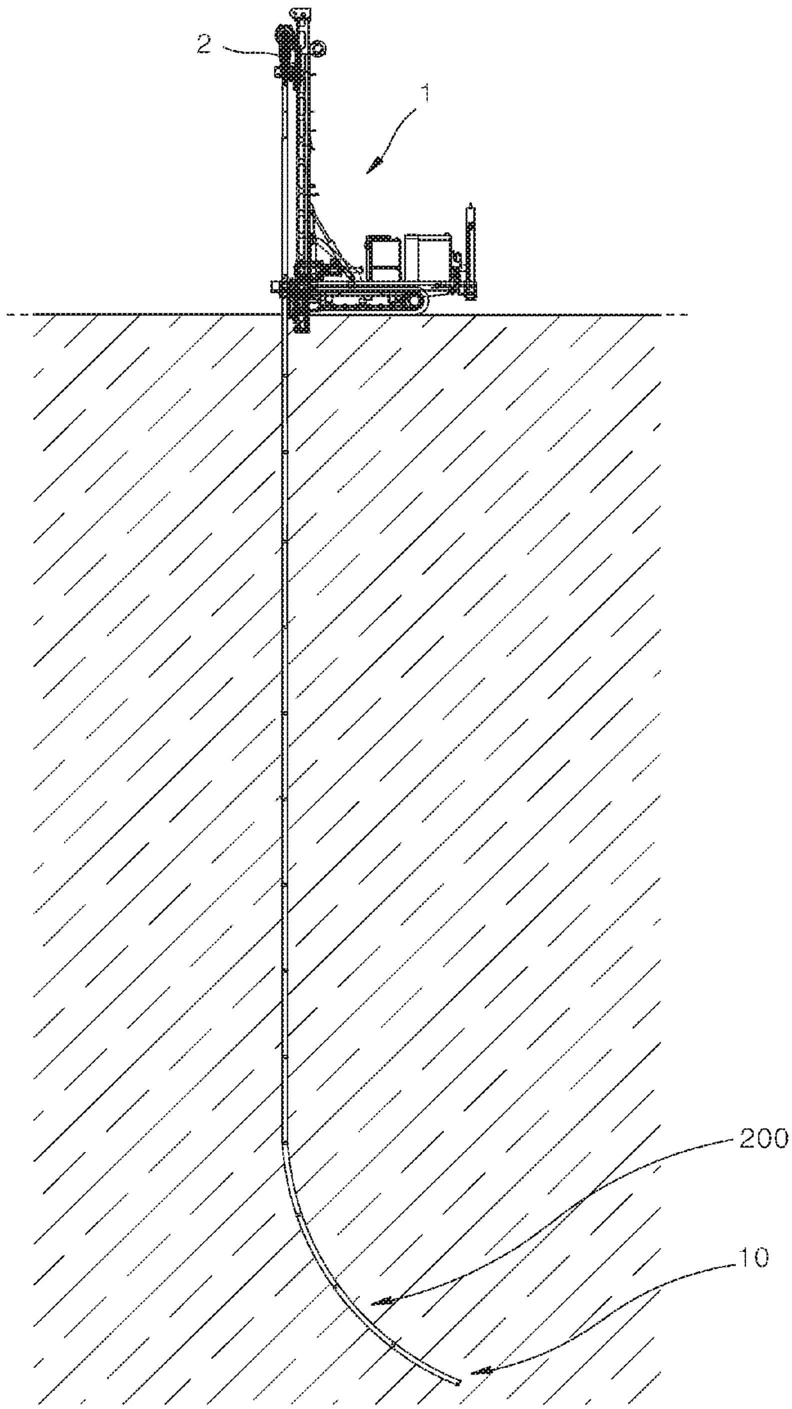

Fig. 2

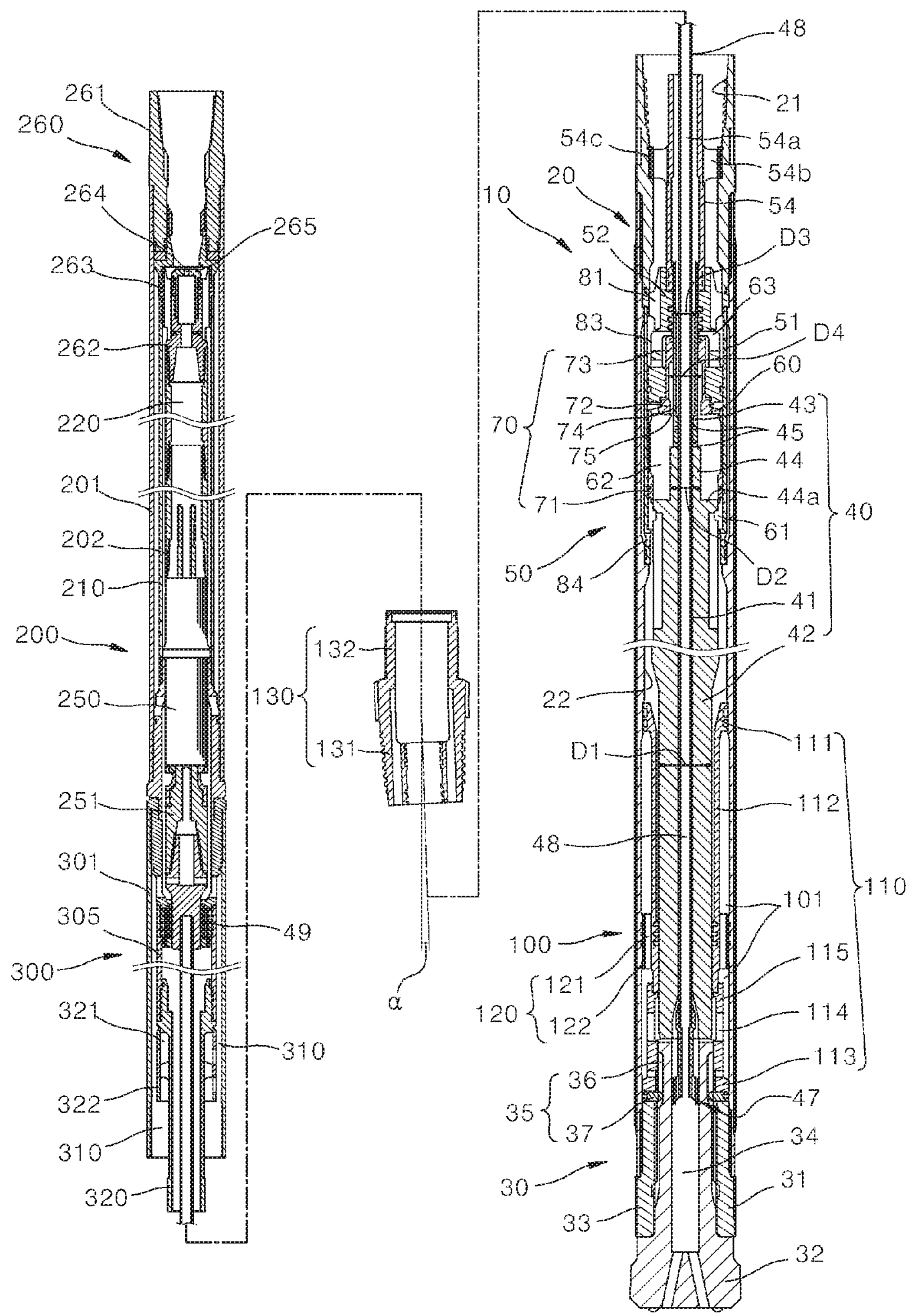
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Fig. 3

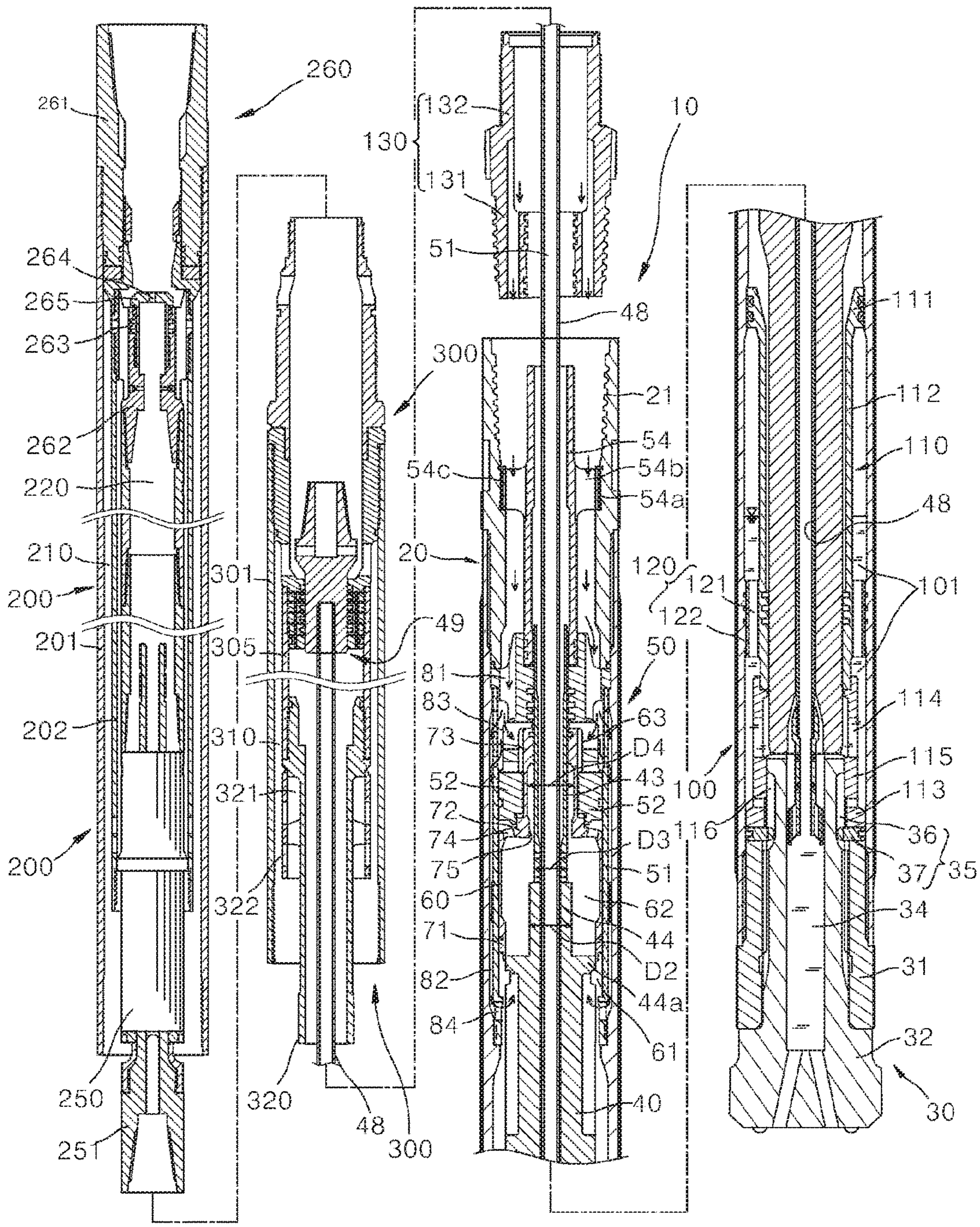

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Fig. 4

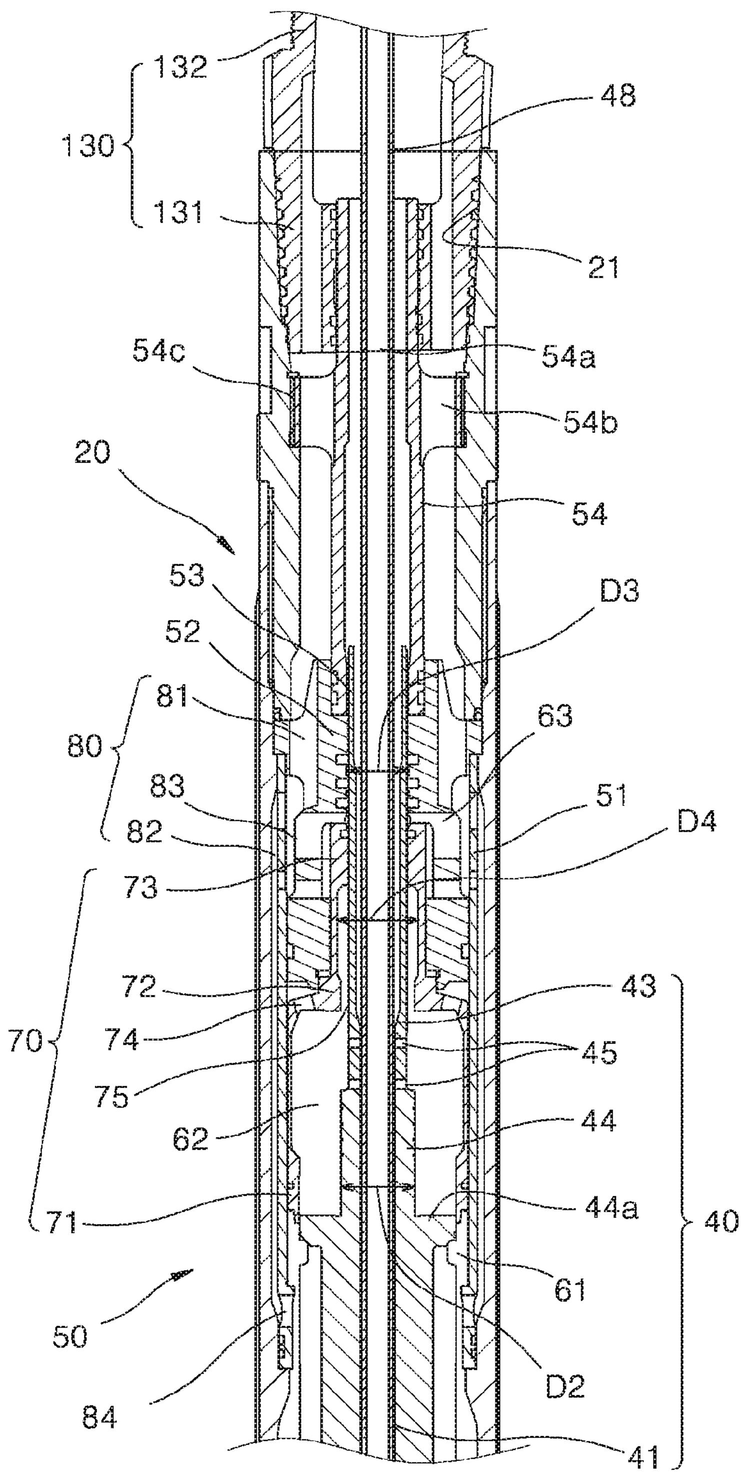
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Fig. 5

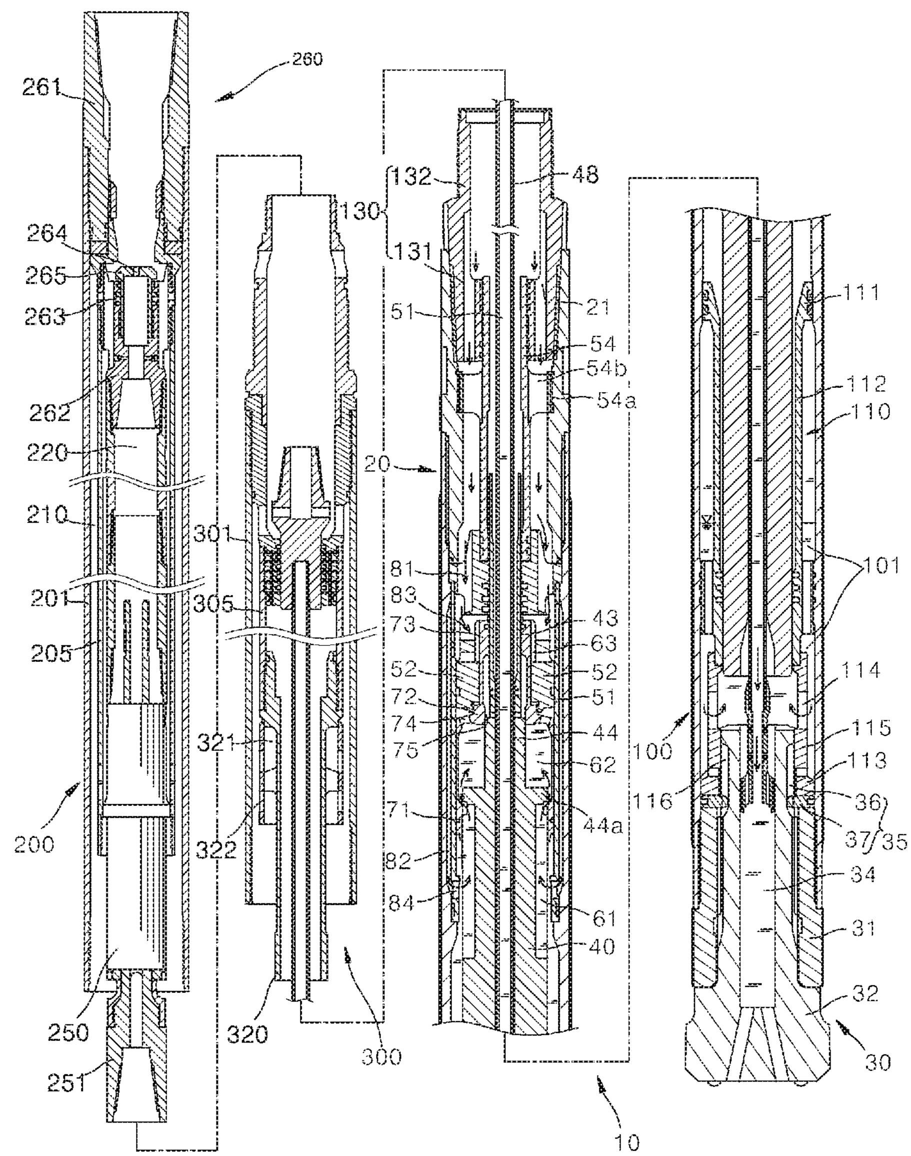

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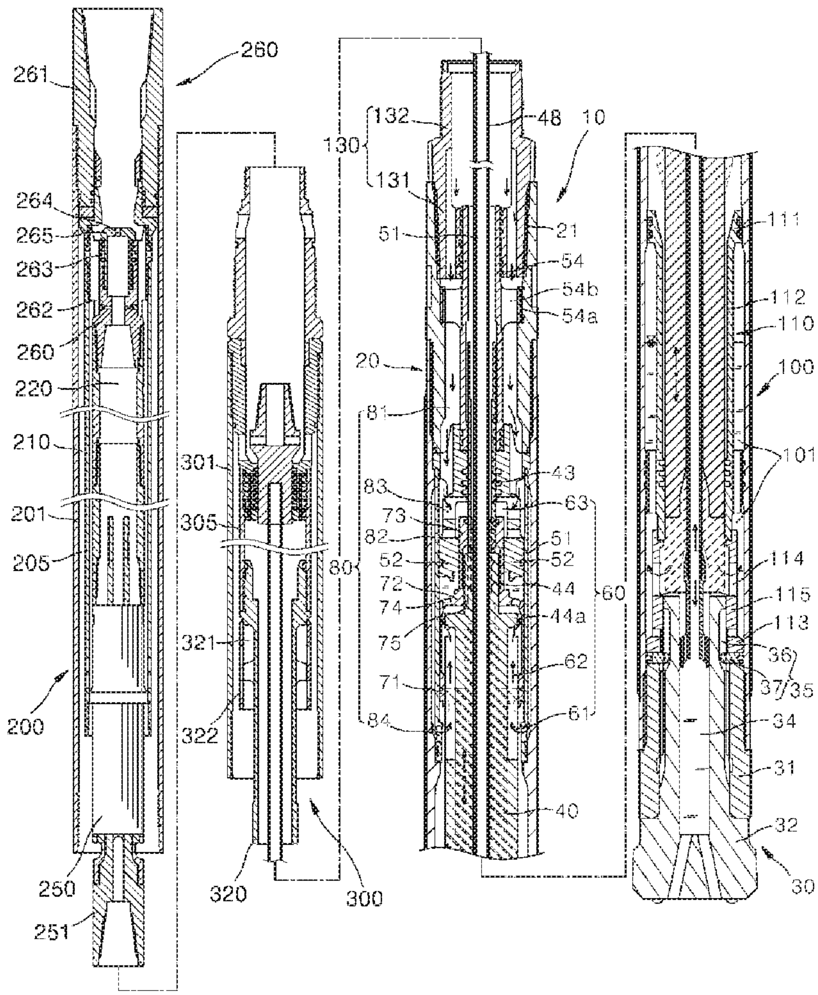
Fig. 6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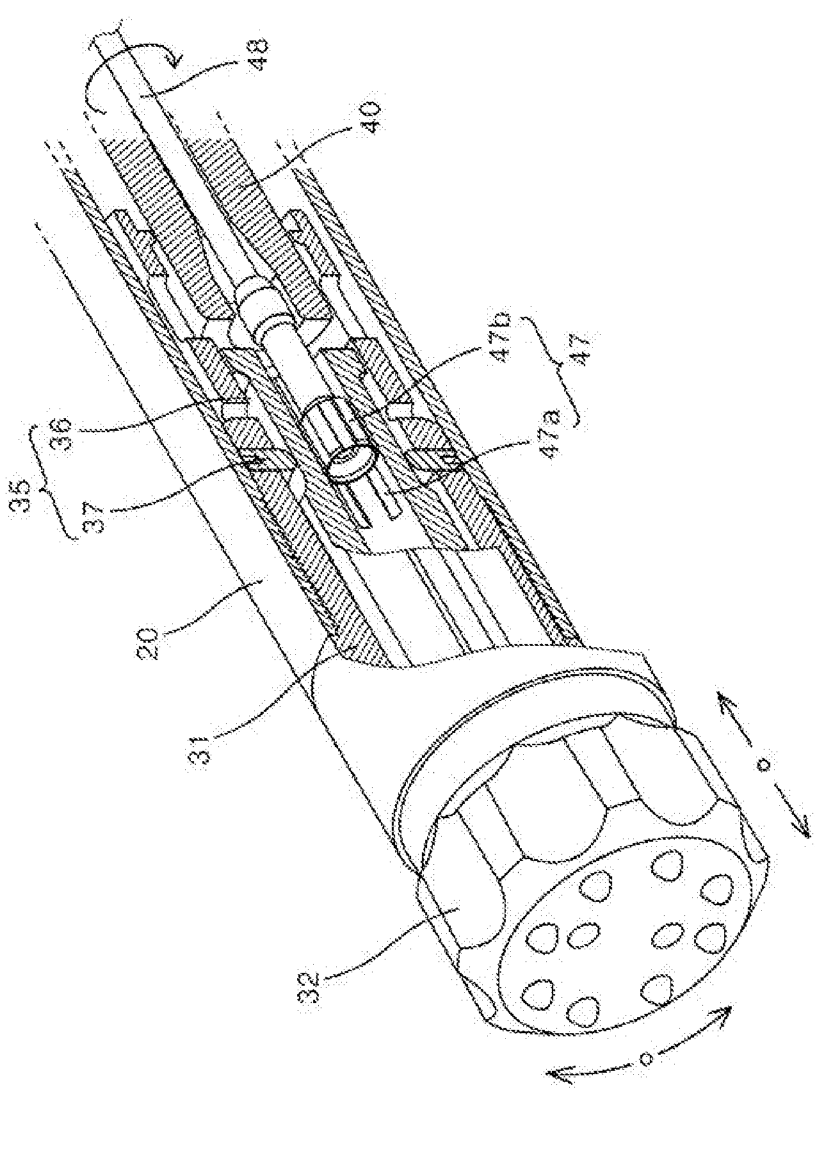

Fig. 7

DIRECTIONAL DRILLING APPARATUS USING WATER HAMMER UNIT

TECHNICAL FIELD

[0001] The present invention relates to a directional drilling apparatus using a water hammer unit, and more specifically, to a directional drilling apparatus using a water hammer unit capable of rotating a bit of a water hammer unit and performing drilling work from a kick off point (KOP) to a marked point in a predetermined orbital direction that is different from a vertical direction.

BACKGROUND ART

[0002] Generally, "drilling" means to drill a relatively small diameter hole in the earth's crust so as to understand a structure or characteristics of a stratum and is performed to acquire various knowledge or to obtain petroleum, natural gas, a hot spring, groundwater, or the like. The drilling depth and the diameter of a borehole vary according to the purpose of use.

[0003] According to drilling methods, drilling works are classified into a point-the-bit method in which a drilling direction is changed by changing a direction of a drill bit, a push-the-bit method in which a drilling direction is changed by pushing a housing of a drill part from a wall surface, a whipstock method in which a drilling direction is changed by inserting an auxiliary unit having an inclination in a specific direction, and a jetting method in which a drilling direction is changed by shooting muddy water only in a specific direction to weaken the ground. Such a method of changing a drilling direction is performed by applying a driving force in a lateral direction to provide directivity when an excavation is performed, by changing only a direction of a drill shaft to change the direction, or by adjusting a discharge direction of muddy water. Such a method facilitates precise control of a drilling direction.

[0004] Particularly, cable laying and ground survey of the construction industry and the mining sector and drilling investigation used for designing and constructing tunnels and various structures are performed by boring in a vertical or horizontal direction or at a preset and predetermined angle, and thus a drilling direction, a drilling angle, and a correct orientation need to be measured.

[0005] In a case in which a metal material having uniform isotropy is drilled during a drilling process, an error is not large, but in a case in which a rock including various materials and having anisotropy is drilled, an error and a deviation of a drilling direction are relatively large, and in a case in which a rock has cracks and joint fractures, an error and a deviation of a drilling direction are more serious.

[0006] In addition, when drilling is performed using the above-described conventional drilling methods, there is a problem in that a drilling speed for boring is relatively low.

[0007] In Japanese Patent Application Laid-Open No. 05-25998 (Feb. 2, 1993), a direction control method and a direction control apparatus for an excavator are disclosed. The disclosed method and apparatus use a shield body including a head and a tail flexibly connected to a rear portion thereof and control a drilling direction of an excavator using a light beam oriented along a reference line such as a projected line of a terminal to be built.

[0008] However, such a conventional direction control method for an excavator may perform direction control using a light beam oriented along a reference line, but, in a case in which the ground is weak and collapsed, excavation work may not be performed smoothly.

[0009] Meanwhile, in an excavation apparatus for drilling the ground, one rod among rods connected to each other is installed on a head of a boring apparatus and a hammer apparatus is installed on an end portion of the rod for oil drilling, gas drilling, tunnel boring, construction for underground cabling, underground heat source development, groundwater development, and the like.

[0010] The hammer apparatus includes an air hammer using an air pressure according to an operating fluid, a water hammer using high pressure water, or the like. The air hammer uses an air pressure to operate a piston so as to provide hitting power for boring the ground, and drilling a relatively deep hole is difficult. In addition, in the case of the water hammer, since water serving as an incompressible fluid is used as an operating fluid, there are advantages in that hitting power may be high, and soil and rock fragments generated during a boring process may be simultaneously discharged when the provided fluid is discharged. However, when drilling work is performed at a certain inclination, there is a problem in that direction control is not easy.

[0011] In Korean Patent Registration No. 876450 and Korean Patent Registration No. 1300243, hammers driven using water are disclosed.

DISCLOSURE

Technical Problem

[0012] The present invention is directed to providing a directional drilling apparatus using a water hammer unit capable of rotating a bit which provides hitting power and controlling a drilling direction.

[0013] The present invention is also directed to providing a directional drilling apparatus using a water hammer unit capable of preventing excavating power of a bit from being reduced by a piston due to an increase in water pressure inside a bored hole when a depth of the bored hole increases in the ground.

Technical Solution

[0014] One aspect of the present invention provides a directional drilling apparatus using a water hammer unit including a hammer body in which a bit unit configured to perform boring work is installed to be movable upward and downward at an end portion of the hammer body, a piston slidably installed on the hammer body and including an operating fluid discharge part formed in a longitudinal direction, a drive unit installed between the hammer body and the piston to support an upper portion of the piston and configured to move the piston upward and downward using water supplied through a rod connected to the hammer body, a hammer unit including a rotary shaft coupled to a bit by a first coupling part so as to transmit a rotational force in a state in which the hammer unit passes through the piston installed on the hammer body and is moved upward or downward by the bit, an outer pipe body coupled to the hammer body by a drilling direction angle adjusting unit, an inner pipe body installed inside the outer pipe body to form a first operating fluid supply path through which an operating fluid is supplied to an inner circumferential surface of the outer pipe body and the hammer unit and including a second operating fluid supply path, a mud motor installed at a lower end side of the inner pipe body and including a driving shaft connected to the rotary shaft so as to rotate the rotary shaft, and a mud motor unit including a pressure distribution unit installed on the outer pipe body and an end portion of the other side of the inner pipe body so as to distribute pressure to the first operating fluid supply path and the second operating fluid supply path.

[0015] The directional drilling apparatus using a water hammer unit may further including an operating fluid evacuating portion which is installed between the hammer body, which is disposed between the bit unit and the drive unit, and the piston to guide the piston, forms an evacuating space to which the water between the piston and the bit is evacuated when the piston hits the bit, separates bubbles from the water introduced into the evacuating space, and stores the water at an upper side of the evacuating space.

[0016] The operating fluid evacuating portion may include a sub-housing in which both end portions of the sub-housing are fixed to an inner circumferential surface of an interior of the hammer body to support a lower portion of the piston and an upper portion of the bit, an evacuating space to which the water serving as an operating fluid between the piston and the bit is evacuated when the piston hits the bit is formed between an inner circumferential surface of the hammer body and the sub-housing, and an operating fluid evacuating hole through which the water between the piston and the bit is introduced or discharged, and an air-water separating part formed between the sub-housing adjacent to the piston and a hitting part of the bit and the hammer body and configured to separate the bubbles from the water evacuated when the piston hits the bit and to store the water at an upper portion of the evacuating space.

[0017] The air-water separating part may include a defining member which is installed between an outer circumferential surface of the piston guide part adjacent to the bit guide part and the inner circumferential surface of the hammer body and in which a plurality of gas passing holes are formed.

[0018] The first coupling part which connects the bit and the rotary shaft may be formed by forming a hollow portion in the bit in the longitudinal direction and forming a female spline and a male spline an inner circumferential surface of the hollow portion and an inner circumferential surface of an end portion of the rotary shaft, respectively, to be coupled to each other.

[0019] The pressure distribution unit may include a socket installed at an end portion of the exterior to be coupled to the rod, an orifice main body member which has a hollow portion coupled to an end portion of the inner pipe body, having an end portion coupled to an inner circumferential surface of the socket, and communicating with the second operating fluid supply path and in which a plurality of air passing holes communicating with the hollow portion and the first operating fluid supply path are formed, and an orifice member inserted into the hollow portion of the orifice main body member to control a flow rate of the operating fluid passing through the air passing holes and the hollow portion so as to distribute pressure.

Advantageous Effects

[0020] A directional drilling apparatus using a water hammer unit according to the present invention can control directivity according to a design of a borehole to be bored and perform directional drilling work as well.

[0021] In addition, in the drilling apparatus using a water hammer unit, since an operating fluid evacuating portion is formed in a hammer body, when a piston moved upward or downward by a drive unit hits a bit, water serving as an operating fluid between the bit and an end portion of the piston can be introduced into or discharged from an evacuating space. In addition, the drilling apparatus using a water hammer unit can separate bubbles from the water introduced into the evacuating space and store air in an upper side of the evacuating space. Since reduction of hitting power of the bit and ascending power of the piston due to interference of the water between the piston and the bit when the piston moves upward or downward can be prevented by the operating fluid evacuating portion, and the bit can be simultaneously hit and rotated, flexibility can be improved.

[0022] Particularly, the drilling apparatus according to the present invention can perform directional drilling work and straight drilling work as well.

DESCRIPTION OF DRAWINGS

[0023] FIG. **1** is a schematic side cross-sectional view illustrating a state in which a directional drilling apparatus using a water hammer unit according to the present invention is installed in a boring apparatus and drilling is performed.

[0024] FIG. **2** is an exploded cross-sectional view illustrating the directional drilling apparatus using a water hammer unit according to the present invention.

[0025] FIG. **3** is a cross-sectional view illustrating the directional drilling apparatus using a water hammer unit according to the present invention.

[0026] FIG. **4** is an enlarged cross-sectional view illustrating a drive unit of the directional drilling apparatus using a water hammer unit according to the present invention.

[0027] FIGS. **5** and **6** are cross-sectional views illustrating an operating state of the directional drilling apparatus using a water hammer unit according to the present invention.

[0028] FIG. **7** is a perspective view illustrating a bit portion separated from the directional drilling apparatus using a water hammer unit according to the present invention.

MODES OF THE INVENTION

[0029] A directional drilling apparatus using a water hammer unit according to the present invention and a directional indentation method are for performing directional drilling work for geothermal power generation, oil and natural gas, hot springs, groundwater, core samples for knowledge in the earth's crust, cable laying, and the like, and one embodiment thereof is illustrated in FIGS. **1** to **7**.

[0030] Referring to the drawings, the directional drilling apparatus using a water hammer unit according to the present invention is installed in a boring apparatus **1** to drill the ground and includes a water hammer unit **10** using a bit to drill the ground and a mud motor unit **200** coupled to the water hammer unit **10** by a drilling angle adjusting unit **130** and configured to rotate the bit, that is, a bit **32** hit by a piston, of the water hammer unit **10**. An accumulating unit **300** for buffering may be further provided between the mud motor unit **200** and the drilling angle adjusting unit **130**.

[0031] The directional drilling apparatus **10** using a water hammer unit formed as described above according to the present invention will be described in more detail below.

[0032] The water hammer unit **10** and the water hammer unit **10** of the directional drilling apparatus using the same are moved downward by a head **2** of a boring apparatus **1** and are operated by an operating fluid supplied through rods **3** connected to each other and the mud motor unit **200** to bore the ground.

[0033] The water hammer unit **10** includes a hammer body **20** which has a coupling part **21** coupled to the drilling angle adjusting unit **130** at an upper side thereof and in which a bit unit **30** configured to perform boring work is installed at a lower side thereof. In addition, the water hammer unit **10** includes a piston **40** slidably installed in the hammer body **20** and including an operating fluid discharge part **41** in a longitudinal direction.

[0034] In addition, the water hammer unit **10** includes a rotary shaft **48** coupled to the bit **32** by a first coupling part **47** to transmit a rotational force in a state in which the rotary shaft **48** passes through the piston **40** installed in the hammer body **20** and moves the bit **32** upward or downward.

[0035] One side of the rotary shaft **48** is coupled to the bit by the first coupling part **47** so as to transmit the rotational force in the state in which the rotary shaft **48** passes through the piston installed in the hammer body and moves the bit upward or downward, and a second coupling part **49** coupled to a driving shaft of the mud motor unit **200** which will be described below is formed on an end portion of the other side of the rotary shaft **48**.

[0036] A female spline **47***a* formed on an inner circumferential surface of a hollow portion **34** formed in the bit **32** in a longitudinal direction and a male spline **47***b* formed at an end portion of the rotary shaft **48** may be coupled so that the first coupling part **47** which couples the bit **32** to the rotary shaft **48** may be formed (see FIGS. **2**, **3**, and **7**).

[0037] The water hammer unit **10** includes a drive unit **50** installed between an inner circumferential surface of the hammer body **20** and an outer circumferential surface of an upper portion of the piston **40** to support the upper portion of the piston **40** and configured to move the piston **40** upward or downward using water supplied through the mud motor unit **200** or the accumulating unit **300** connected to the hammer body **20**. The water hammer unit **10** further includes an operating fluid evacuating portion **100** which is installed between an inner surface of the hammer body **20** between the bit unit **30** installed at a lower end portion of the hammer body **20** and the drive unit **50** and an outer surface of the piston **40** to guide the piston **40**, forms an evacuating space for water between the piston **40** and the bit when the piston **40** hits the bit using bit unit **30**, separates bubbles from the water introduced into the evacuating space and stores the bubbles therein. In the present invention, the operating fluid evacuating portion **100** does not necessarily need to be installed.

[0038] In addition, an operating fluid supplied through the rod connected to the water hammer unit **10** may include a plurality of bubbles. That is, the operating fluid may include the bubbles because bubbles (air) permeate water due to a pump and the water is pumped at high pressure using the pump.

[0039] The hammer body **20** of the water hammer unit **10** has a pipe form having a hollow portion **22** therein, and a coupling part **21** for being coupled to the rod is formed at an upper end side of the hammer body **20**. A screw may be formed on an inner circumferential surface of an end side of the hammer body **20** to form the coupling part **21**.

[0040] In addition, the piston **40** is installed in the hollow portion **22** of the hammer body **20** to be movable upward and downward, and the piston **40** is supported by a sub-housing **110** forming the operating fluid evacuating portion **100**, the inner circumferential surface of the hammer body **20**, and the drive unit **50** installed at an upper side of the piston **40** as described above. In addition, the piston **40** includes an operating fluid discharge path **41** passing through the piston **40** in the longitudinal direction as described above. The rotary shaft **48** passes through the operating fluid discharge path **41**.

[0041] In the bit unit **30** installed at a lower side of the water hammer body **20**, a collar member **31** is installed at the end portion of the hammer body **20**, the bit **32** including a hitting part **32** is rotatably installed in the collar member **31** to be movable upward and downward. In addition, in the bit **32** and the collar member **31**, a stroke distance restriction unit **35** configured to restrict a stroke distance according to upward or downward movement of the bit **32** is provided. In the stroke distance restriction unit **35**, bit guide grooves **36** having a predetermined length (corresponding to the stroke distance of the bit) are formed in an outer circumferential surface of the bit **32** in the longitudinal direction, and a bit locker **37** in which an inner end portion is coupled to the bit guide groove **36** is installed on the collar member **31**. The bit locker **37** guides the bit **32** along the bit guide groove **36** to restrict the stroke distance according to upward or downward movement of the bit **32** when the bit **32** moves upward or downward. A discharge path **34** communicating with the operating fluid discharge part **41** of the piston **40** is formed at a central portion of the bit **32**.

[0042] The drive unit **50** moves the piston **40** upward and downward using water serving as an operating fluid supplied through the rod, a piston housing **51** having a cylindrical form and coupled to the hollow portion **22** of the hammer body **20** is installed in the drive unit **50**, and the piston **40** is slidably installed in the piston housing **51** to hit the bit **32**.

[0043] The piston **40** includes a guide part **42** which guides the piston **40** to slide in the sub-housing **110**, and a pressing part **44** and a step portion **43** which are gradually stepped from the guide part **42** and define a valve installation space in which a valve member **70**, which will be described below, is installed between an inner circumferential surface of the piston housing **51** and the piston **40**, wherein a guide disc **44***a* configured to come into contact with a first stopper **71** of the valve member **70**, which will be described below, is formed on the pressing part **44**. In addition, a first communication hole **45** communicating with the operating fluid discharge part **41** is formed in the step portion **43** of the piston **40**. Here, a diameter D**1** of the guide part **42** of the piston **40** is greater than a diameter D**2** of the pressing part **44**, and a diameter D**3** of the step portion **43** of a portion in which the first communication hole **45** is formed is less than the diameter D**2**.

[0044] A sleeve member **52** inserted into and supported by the hammer body **20** and including an accommodation part **53** into which the step portion **43** is inserted and guided is installed at an upper side of the piston housing **51**.

[0045] In an upper end portion of the hammer body **20**, the sleeve member **52** is coupled to a first connecting pipe **54** including a hollow **54***a* communicating with the operating fluid discharge part **41**, and a flange **54***c* in which a plurality of first through holes **54***b*, through which a plurality of operating fluids flow, are formed is formed between an outer circumferential surface of the first connecting pipe **54** and the inner circumferential surface of the hammer body **20**.

[0046] Meanwhile, a valve installation space **60** defined by the piston **40** is formed inside the piston housing **51** and the sleeve member **52**. The piston housing **51**, the piston **40**, and a valve member **70**, which is installed to be slidable due to the sleeve member **52**, defines the valve installation space **60** into first, second, and third spaces **61**, **62**, and **63** (see FIGS. **2** and **3**), and moves the piston **40** upward or downward using water pressure supplied to a side of the space, are installed in the valve installation space **60**.

[0047] As illustrated in FIGS. **1** and **2** to **4**, the valve member **70** includes a first stopper **71** which is installed between an outer circumferential surface of the pressing part **44** and an inner circumferential surface of the piston housing **51** to have a predetermined width and defines the first space **61**, an extension **72** which extends from the first stopper **71** and forms the second space **62** connected to the first communication hole **45**, and a second stopper **73** which extends from an end portion of the extension **72**, slides to an end side of the piston **40**, and defines the third space **63** with the piston **40** and an inner circumferential surface of the sleeve member **52**. A through portion **74** which is formed from the second space **62** toward the sleeve member **52** and decreases a relative cross-sectional area on which water pressure is applied is formed at a side of the extension **72** of the valve member **70**. In addition, an insertion portion **75** having a diameter substantially the same as the diameter D2 of the pressing part **44** of the piston **40** is formed at the extension **72** of the valve member **70**. Since an inner surface of the extension **72** at an upper side of the insertion portion **75** is formed to have a diameter D4 greater than the diameter of the pressing part **44**, a difference between a cross-sectional area of the first stopper **71** and a cross-sectional area of the second stopper **72** exposed to the third space **63** may occur.

[0048] Here, a cross-sectional area of the piston **40** formed by the guide disc **44***a* formed at the pressing part **44** of the piston **40** and the first stopper **71** in a direction perpendicular to the longitudinal direction of the piston **40** is greater than a cross-sectional area of the step portion **43** exposed to the third space defined by an outer circumferential surface of the step portion **43** of the piston **40**, the sleeve member **52**, and the second stopper **73** of the valve member **70**. In addition, the first stopper **71** which comes into contact with the guide disc **44***a* has a length such that the first stopper **71** is not separated from the guide disc **44***a* even when the valve member **70** moves upward and the first stopper **71** is separated from the guide disc **44***a* to discharge water, which is supplied to the first space **61** so as to move the piston **40** upward, through the second space **62**, the first communication hole **45**, and the operating fluid discharge part **41** of the piston **40** when the piston **40** moves upward.

[0049] Here, at a time point at which the piston **40** initially moves upward, that is, the first stopper **71** and the guide disc **44***a* of the pressing part **44** are separated, the first communication hole **45** and the second space **62** are connected, and the piston **40** moves further upward, a portion, which has the diameter D2, of the pressing part **44** of the piston **40** is coupled to the insertion portion **75**, and thus the first communication hole **45** is disconnected from the second space **62**.

[0050] In addition, an operating fluid supply **80** configured to supply water serving as an operating fluid having a predetermined pressure is provided in the first space **61** and the third space **63** to move the valve member **70** and the piston **40** upward.

[0051] In addition, in the operating fluid supply **80**, a first water pressure path **81** is formed between the sleeve member **52** and an outer circumferential surface of the hammer body **20**, and a second water pressure path **82** communicates with the first water pressure path **81** and is formed between the inner circumferential surface of the hammer body **20** and the outer circumferential surface of the piston housing **51**. In addition, a second communication hole **83** is formed in the sleeve member **52** to communicate with the first water pressure path **81** and the third space **63**, and a third communication hole **84** communicating with the second water pressure path **82** for supplying an operating fluid to the first space **61** is formed in the piston housing **51**. The above-described drive unit of the water hammer apparatus is disclosed in Korea Patent Registration No. 0562954 which is invented and registered by the present inventor.

[0052] The operating fluid evacuating portion **100** of the water hammer unit **10** has a structure in which water serving as an operating fluid between the bit **32** and an end portion of the piston **40** is evacuated when the piston **40** hits the bit **32**, and the operating fluid is supplied between the bit **32** and the end portion of the piston **40** when the piston moves upward.

[0053] The operating fluid evacuating portion **100** includes the sub-housing **110**, which is installed at the inner surface of the hammer body **20** and supports a lower portion of the piston **40** and an upper portion of the bit **32**, and forms an evacuating space **101** which is formed between the inner circumferential surface of the hammer body and the sub-housing **110** and to which water serving as an operating fluid between the piston **40** and the bit **32** is evacuated when the piston hits the bit **32**, and an air-water separating part **120** which is disposed between the sub-housing **110** adjacent to the piston **40** and the bit **32** and the inner circumferential surface of the hammer body **20**, and separates bubbles from the water, which has been evacuated when the piston **40** hits the bit **32**, to store in an upper portion of the evacuating space.

[0054] The sub-housing **110** includes a fixed portion **111** at which an upper end portion thereof is fixedly in contact with the inner circumferential surface of the hammer body **20** and an upper end side of the evacuating space **101** is blocked by the sub-housing and the hammer body **20**, a piston guide part **112** which extends downward from the fixed portion **111** to guide the lower portion of the piston **40** and forms the evacuating space **101** between the inner circumferential surface of the hammer body **20** and the piston guide part **112**, and a stopper **113** which extends from the piston guide part **112** to guide the outer circumferential surface of the bit **32** and blocks between the outer circumferential surface of the bit **32** and the inner circumferential surface of the hammer body **20** to seal and define a lower side of the evacuating space **101**.

[0055] In addition, the sub-housing **110** includes a bit guide part **115** in which an operating fluid evacuating hole **114** through which an operating fluid between the piston **40** and the bit **32** is introduced into or discharged from the evacuating space **101** when the piston **40** moves upward or downward for hitting the bit **32**. Here, the stopper **113** and the bit guide part **115**, in which the operating fluid evacuating hole **114** is formed, may be formed of different materials and coupled to the sub-housing **110**. In addition, an operating fluid moving space **116** communicating with the operating fluid evacuating hole **114** may be formed on an inner side of the bit guide part **115** around the bit **32** and the end portion of the piston **40**.

[0056] In addition, the air-water separating part **120** configured to separate bubbles from water serving as an operating fluid introduced into the evacuating space **101** through the operating fluid evacuating hole **114** to store the water at an upper side of the evacuating space **101** when the piston **40** moves upward or downward includes a defining member **122** which is installed between an outer circumferential surface of the piston guide part **112** adjacent to the bit guide part **115** and the inner circumferential surface of the hammer body **20** and in which a plurality of gas passing holes **121** are formed. The air-water separating part **120** may be formed at a side of the fixed portion **111** adjacent to the bit guide part **115** in which the operating fluid evacuating hole **114** is formed.

[0057] In addition, the coupling part **21** of the water hammer unit **10** is coupled to the drilling angle adjusting unit **130** by the accumulating unit **300**. In addition, the accumulating unit **300** is coupled to a mud hammer unit.

[0058] The drilling angle adjusting unit **130** includes a coupling member **135** having a first drilling angle coupling part **131** coupled to a coupling part of the hammer unit **10**, and a second drilling angle coupling part **132** coupled to the accumulating unit **300**.

[0059] The first drilling angle coupling part **131** and the second drilling angle coupling part **132** are inclined at an angle in the range of 1° to 1.5° for directional drilling (see FIGS. **2** and **3**). An inclination angle of the hammer unit **10** coupled to the first drilling angle coupling part **131** is in the range of 1° to 1.5° with respect to the mud motor unit **200** coupled to the second drilling angle coupling part **132** and the accumulating unit **300**.

[0060] In addition, in the accumulating unit **300**, a first outer pipe member **301** and a first inner pipe member **305** are coupled, and a lower end portion of the first outer pipe member **301** is coupled to the second drilling angle coupling part **132** of the drilling angle adjusting unit **130** and thus a third operating fluid supply path **310** is formed. The first inner pipe member **301** is coupled to a first core pipe member **320** through which the rotary shaft **48** passes and thus an air storing tank **321** is formed between an inner circumferential surface of the first inner pipe member **301** and an outer circumferential surface of the first core pipe member **320**. In addition, a connecting hole **322**, through which the third operating fluid supply path **310** communicates with the air storing tank **321** such that water flows through the third operating fluid supply path **310**, is formed at a lower end side of the first inner pipe member **301**, and thus an operating fluid is supplied to the water hammer unit through the air storing tank **321**. Accordingly, bubbles included in the operating fluid are moved upward and stored in the air storing tank **321**.

[0061] In addition, the mud motor unit **200** coupled to the accumulating unit **300** by the drilling direction angle adjusting unit **130** includes a second outer pipe body **201**, a second inner pipe body **202** which is installed in the second outer pipe body **201**, forms a first operating fluid supply path **210** through which, with an inner circumferential surface of the second outer pipe body **201**, water is supplied to the water hammer unit **10**, and includes a second operating fluid supply path **220**, a mud motor **250** which is installed at a lower end side of the second inner pipe body **202** and includes a driving shaft **251** connected to the rotary shaft **48** to rotate the rotary shaft **48**, and a pressure distribution unit **260** installed at the second outer pipe body **201** and an end portion of the other side of the second inner pipe body **202** and configured to distribute pressure to the first operating fluid supply path **210** and the second operating fluid supply path **220**.

[0062] The pressure distribution unit **260** includes a socket **261** installed at the end portion of the exterior to be coupled to the rod, an orifice main body member **262** which has a hollow portion coupled to an end portion of the second inner pipe body **202**, having an end portion connected to an inner circumferential surface of the socket **261**, and communicating with the second operating fluid supply path **220** and in which a plurality of air passing holes **263** through which the hollow portion communicates with the first operating fluid supply path **210** are formed, and an orifice member **265** which is inserted into the hollow portion of the orifice main body member **262** and in which an orifice hole **264** configured to control a flow rate of an operating fluid passing through the air passing holes **263** and the hollow portion and configured to distribute pressure is formed.

[0063] Operation according to boring of the boring apparatus according to the present invention formed as described above will be described with reference to FIGS. **5** and **6**.

[0064] First, drive rods (not shown) connected to each other of the boring apparatus **1**, the mud motor unit **200**, and the drilling angle adjusting unit **130** are coupled to perform directional boring work. According to the above coupling, the water hammer unit **10** is coupled at an inclination angle in the range of 1° to 1.5° with respect to the mud motor unit **200**.

[0065] In a state in which the coupling is completed, an operating fluid having a high pressure supplied by the rod is supplied. Then, the operating fluid is distributed and introduced through the air passing hole **263** of the pressure distribution unit **260** and the orifice hole **264** of the orifice member **265** as illustrated in FIGS. **2** and **3**. The pressure distribution may relatively decrease pressure of the operating fluid supplied to the mud motor **250** by considering a flow rate supplied to the mud motor **250** through the orifice hole **264**.

[0066] Accordingly, the operating fluid supplied through the orifice hole **264** operates the mud motor **250**, and since the driving shaft **251** of the mud motor **250** is connected to the rotary shaft **48**, the rotary shaft **48** is rotated, and thus the bit is rotated.

[0067] In addition, the operating fluid passing through the mud motor **250** is mixed with water passed through the first operating fluid supply path **210**, passes through the accumulating unit **300**, and is introduced into the first water pressure path **81** and the second water pressure path **82** of the operating fluid supply **80** of the water hammer unit **10**.

[0068] The operating fluid introduced as described above is supplied to the first space **61** and the third space **63** through the second communication hole **83** formed in the sleeve member **52** and the third communication hole **84** formed in the piston housing **51**.

[0069] Accordingly, since the cross-sectional area, to which a pressure of is applied, of the first stopper **71** in the longitudinal direction, of the piston **40** is greater than the cross-sectional area to which pressure is applied, of the second stopper **73**, a pressure difference occurs between the first and second stoppers **71** and **73** of the valve member **70** due to a difference between the cross-sectional areas. The valve member **70** moves upward due to the pressure difference. At this moment, since the first stopper **71** does not leave the guide disc **44***a* of the pressing part **44** of the piston **40**, the pressure applied to the first space **61** does not leak.

[0070] In addition, the piston **40** moves upward due to pressure, which is applied to the pressing part **44** of the piston **40**, that is, pressure applied to a lower surface of the guide disc **44***a*, of the pressure applied to the first space **61**.

[0071] As illustrated in FIG. **3**, when the piston **40** moves upward to a predetermined height, an outer circumferential surface of the guide disc **44***a* of the pressing part **44** is separated from the first stopper **71**, some water, which provides pressure to the first space **61**, in the second space **62** is discharged to the operating fluid discharge part **41** through a gap formed between the pressing part **44**, the guide disc **44***a*, and the first stopper **71**, the second space **62**, and the first communication hole **45** formed in the piston **40**.

[0072] In addition, when the piston **40** is moved upward further, the first communication hole **45** formed in the step portion **43** is blocked because an end side of the pressing part **44** having the diameter D**2** is coupled to the insertion portion **75** of the valve member **70** supported by the slide member **52** and the piston housing **51** (see FIGS. **3** and **4**).

[0073] Accordingly, since pressures in the first and third spaces **61** are **63** are the same and a pressure difference occurs between pressure applied to the cross-sectional area of the second stopper **73** of the valve member **70** exposed to the third space and pressure applied to the first stopper **71**, the valve member **70** is moved downward. That is, since the cross-sectional area of the second stopper **73** exposed to the third space **63** is relatively greater than the cross-sectional area of the first stopper **71** exposed to the second space **62**, the valve member **70** is moved downward.

[0074] Accordingly, one sealed space is formed in which the first and the second spaces **61** and **62** communicate with each other. In this state, since a cross-sectional area of a stopper **44** including the guide disc **44***a* is greater than cross-sectional area of the step portion **43** exposed to the third space and pressure applied to the pressing part **32***c* is relatively high, the piston **40** is moved downward to the guide disc **44***a* of the stopper **44** and hits the bit **32** rotated by the rotary shaft **48**.

[0075] Meanwhile, a hole bored by the hammer apparatus and the operating fluid discharge part **41** are filled with water serving as an operating fluid during the process operated as described above, and since the operating fluid evacuating portion **100** is formed in the hammer apparatus, reduction of hitting power and ascending power, which may occur because the water positioned between the piston **40** and the bit **32** interferes with the piston **40**, may be prevented.

[0076] More specifically, when the drive unit **50** operates to move the piston **40** downward so as to hit the rotating bit **32**, water serving as an operating fluid between the end portion of the piston **40** and the bit **32** is introduced into the evacuating space **101** through the operating fluid evacuating hole **114** to reduce resistance against downward movement of the piston **40**.

[0077] Since bubbles are included in the water which serves as the operating fluid and is evacuated to the evacuating space **101**, the bubbles are moved upward through the gas passing hole **121** formed in the defining member **122** which defines the evacuating space **101**, stored at the upper side of the evacuating space **101**, and compressed therein. In addition, when the piston **40** hits the bit **32** and moves upward, as illustrated in FIG. **4**, the compressed air stored at the upper side of the evacuating space **101** and the operating fluid positioned at a lower side of the evacuating space **101** are introduced and supplied between the piston **40** and the bit **32** through the operating fluid evacuating hole **114** positioned under the evacuating space **101**, and the introduced water acts as pressure for moving the piston **40** upward, and thus the piston **40** is easily moved upward.

[0078] Particularly, as a boring depth in the ground is increased, drive rods should be continuously connected, and in this case, air in an empty space of the drive rod permeates water when the water is introduced, moves with water, is separated from the water, and thus bubbles supplied to the evacuating space move upward. In order to increase pressure of the air stored in the evacuating space, the air also permeates an operating fluid for operating the water hammer apparatus and may be pumped with high pressure as described above.

[0079] As described above, while drilling work is performed by the directional drilling apparatus using a water hammer unit according to the present invention, the water hammer unit is installed in the mud motor unit **200** to be inclined at a predetermined angle (ranging from 1° to 1.5°) due to the drilling angle adjusting unit **130**, directional drilling can be performed. That is, since the bit is rotated by the mud motor unit **200** and the water hammer unit **10** is obliquely installed due to the mud motor unit **200**, directional drilling is performed with respect to a straight direction according to drilling.

[0080] The present invention has been described with reference to the embodiments illustrated in the drawings, but is only an example, and variously modified and equivalent embodiments may be made therefrom by those skilled in the art.

[0081] Accordingly, the scope of the present invention will be defined by only the appended claims.

1. A directional drilling apparatus using a water hammer unit, comprising:

a hammer body in which a bit unit configured to perform boring work is installed to be movable upward and downward at an end portion of the hammer body;

a piston slidably installed on the hammer body and including an operating fluid discharge part formed in a longitudinal direction;

a drive unit installed between the hammer body and the piston to support an upper portion of the piston and configured to move the piston upward and downward using water supplied through a rod connected to the hammer body;

a hammer unit including a rotary shaft coupled to a bit by a first coupling part so as to transmit a rotational force in a state in which the hammer unit passes through the piston installed on the hammer body and is moved upward or downward by the bit;

an outer pipe body coupled to the hammer body by a drilling direction angle adjusting unit;

an inner pipe body installed inside the outer pipe body to form a first operating fluid supply path through which an operating fluid is supplied to an inner circumferential surface of the outer pipe body and the hammer unit and including a second operating fluid supply path;

a mud motor installed at a lower end side of the inner pipe body and including a driving shaft connected to the rotary shaft so as to rotate the rotary shaft; and

a mud motor unit including a pressure distribution unit installed on the outer pipe body and an end portion of the other side of the inner pipe body so as to distribute pressure to the first operating fluid supply path and the second operating fluid supply path.

2. The directional drilling apparatus of claim **1**, further comprising an operating fluid evacuating portion which is installed between the hammer body, which is disposed between the bit unit and the drive unit, and the piston to guide the piston, forms an evacuating space to which the water between the piston and the bit is evacuated when the piston hits the bit, separates bubbles from the water introduced into the evacuating space, and stores the water at an upper side of the evacuating space.

3. The directional drilling apparatus of claim **2**, wherein the operating fluid evacuating portion includes:

a sub-housing in which both end portions of the sub-housing are fixed to an inner circumferential surface of an interior of the hammer body to support a lower portion of the piston and an upper portion of the bit, an evacuating space to which the water serving as an operating fluid between the piston and the bit is evacuated when the piston hits the bit is formed between an inner circumferential surface of the hammer body and the sub-housing, and an operating fluid evacuating hole through which the water between the piston and the bit is introduced or discharged; and

an air-water separating part formed between the sub-housing adjacent to the piston and a hitting part of the bit and the hammer body and configured to separate the bubbles from the water evacuated when the piston hits the bit and to store the water at an upper portion of the evacuating space.

4. The directional drilling apparatus of claim **3**, wherein the sub-housing includes:

a fixed portion of which an upper end portion is fixedly in contact with the inner circumferential surface of the hammer body;

a piston guide part which extends downward from the fixed portion to guide the lower portion of the piston and forms the evacuating space between the inner circumferential surface of the hammer body and the piston guide part;

a bit guide part which extends from the piston guide part and in which operating fluid evacuating holes, through which the operating fluid between the piston and the bit is introduced into or discharged from the evacuating space when the piston moves upward or downward to hit the bit, are formed; and

a stopper which extends from the bit guide part to guide the outer circumferential surface of the bit and blocks between the inner circumferential surface of the hammer body and the outer circumferential surface of the bit,

wherein an operating fluid moving space communicating with the operating fluid evacuating hole is formed in an inner surface of the bit guide part around the bit and an end portion of the piston.

5. The directional drilling apparatus of claim **3**, wherein the air-water separating part includes a defining member which is installed between an outer circumferential surface of the piston guide part adjacent to the bit guide part and the inner circumferential surface of the hammer body and in which a plurality of gas passing holes are formed.

6. The directional drilling apparatus of claim **1**, wherein, the first coupling part which connects the bit and the rotary shaft is formed by forming a hollow portion in the bit in the longitudinal direction and forming a female spline and a male spline in an inner circumferential surface of the hollow portion and an inner circumferential surface of an end portion of the rotary shaft, respectively, to be coupled to each other.

7. The directional drilling apparatus of claim **1**, wherein the pressure distribution unit includes:

a socket installed at an end portion of the exterior to be coupled to the rod;

an orifice main body member which has a hollow portion coupled to an end portion of the inner pipe body, having an end portion coupled to an inner circumferential surface of the socket, and communicating with the second operating fluid supply path and in which a plurality of air passing holes communicating with the hollow portion and the first operating fluid supply path are formed; and

an orifice member inserted into the hollow portion of the orifice main body member to control a flow rate of the operating fluid passing through the air passing holes and the hollow portion so as to distribute pressure.

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