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(54) **EXCAVATION TOOL AND EXCAVATION METHOD**

(57) A drilling tool of the invention includes an air supply pipe inserted through an inner circumference of a drilling pipe having a tip portion on which a tool main body is disposed. The air supply pipe being configured to supply compressed air. A supply channel is provided on an outer circumference of the drilling pipe. A discharge

channel is formed on the tip portion of the tool main body. The discharge channel is configured to discharge cuttings generated together with the drilling fluid into a space between the drilling pipe and the air supply pipe. An exhaust gas outlet opening into the space is formed at a tip portion of the air supply pipe.

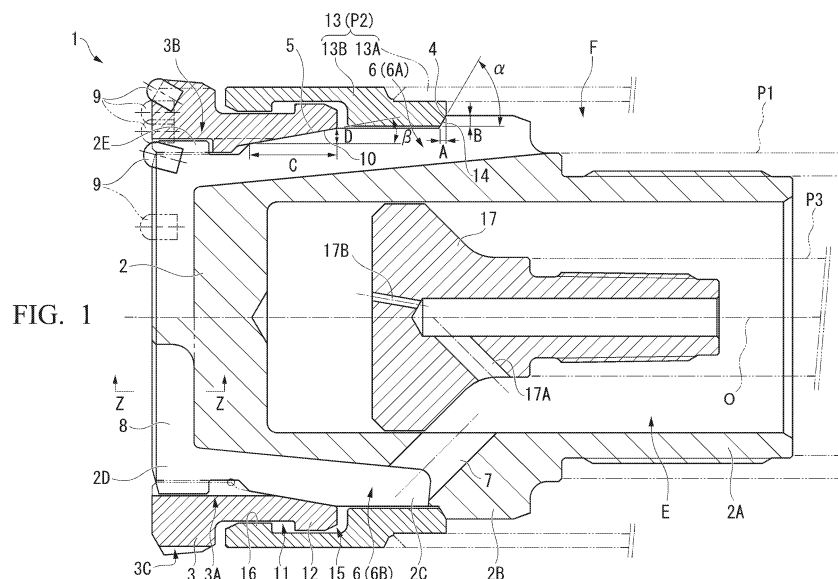


FIG. 1

Description

Technical Field

[0001] The present invention relates to a drilling tool used for a reverse circulation drilling method of taking in cuttings generated during drilling into a tool main body to discharge the cuttings through a drilling pipe, and a drilling method using this drilling tool.

[0002] Priority is claimed on Japanese Patent Application No. 2016-008874, filed January 20, 2016, the content of which is incorporated herein by reference.

Background Art

[0003] In a basic piling construction method using a casing pipe, generally, compressed air used for striking a drilling bit (tool main body) is ejected from a tip of the drilling bit, and cuttings, which are earth and sand generated by breaking a bedrock during drilling, are discharged toward a posterior end side through a space between the casing pipe and a drilling rod by this compressed air. However, if such a construction method is conducted in urban areas, there is a concern that the compressed air ejected from the tip of the drilling bit leaks out to a bedrock around a borehole to lower the strength of the surrounding bedrock and collapse of the surrounding bedrock is caused depending on the case.

[0004] In such a case, although it is effective to supply a slurry, with which bentonite is mixed, to the borehole, to prevent the compressed air from leaking out, the cuttings with which a slurry with high specific gravity is mixed have to be discharged. Thus, the pressure of the compressed air to be ejected has to be made high. Then, as a drilling tool used for such a construction method, for example, Patent Document 1 suggests a drilling tool that supplies pure water as conveyance water through a casing pipe and pumps and discharges cuttings, with which this conveyance water is mixed, using a vacuum pump.

Citation List

Patent Literature

[0005] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2007-170087

Summary of Invention

Technical Problem

[0006] However, in the drilling tool described in such Patent Document 1, not only the vacuum pump is required, but also the conveyance water with which the cuttings are mixed may pass through the vacuum pump. Therefore, there is a concern that damage may occur at an early stage in the vacuum pump, and it becomes difficult to stably perform drilling over a prolonged period of

time.

[0007] The invention has been made under such a background, and an object thereof is to provide a drilling tool capable of efficiently discharging water with which cuttings are mixed, without using a vacuum pump, and a drilling method using this drilling tool.

Solution to Problem

[0008] In order to solve the above problems to achieve such an object, a drilling tool of the invention includes a tool main body; a drilling pipe having a tip portion on which the tool main body is provided; and an air supply pipe configured to supply a compressed air and inserted through the drilling pipe. A supply channel is provided on an outer circumference of the drilling pipe, the supply channel being configured to supply drilling fluid to a tip portion of the tool main body. A discharge channel is formed on the tip portion of the tool main body, the discharge channel being configured to discharge cuttings generated during drilling together with the drilling fluid supplied from the supply channel into a space between the drilling pipe and the air supply pipe. An exhaust gas outlet opening into the space is formed on a tip portion of the air supply pipe.

[0009] Additionally, a drilling method of the invention is a drilling method using such a drilling tool. The method includes steps of forming a borehole using the tool main body while supplying the drilling fluid to the tip portion of the tool main body through the supply channel; discharging the cuttings generated during forming the borehole together with the drilling fluid through the discharge channel into the space between the drilling pipe and the air supply pipe; and discharging the cuttings and the drilling fluid discharged into the space toward a posterior end side of the tool main body using the compressed air discharged from the exhaust gas outlet.

[0010] In the drilling tool of the above configuration and the drilling methods using this drilling tool, the exhaust gas outlet opening into the space between the drilling pipe and the air supply pipe is formed on the tip portion of the air supply pipe. The compressed air used for striking, for example, the tool main body during drilling is supplied to the air supply pipe and is exhausted from the exhaust gas outlet. The cuttings and the drilling fluid discharged into the space between the drilling pipe and the air supply pipe is pushed out and discharged toward the posterior end side by the compressed air exhausted from the exhaust gas outlet.

[0011] Therefore, according to such drilling tool and drilling method, the compressed air supplied in order to apply the striking force to the tool main body in this way can be utilized for the discharge of the cuttings and the drilling fluid. In addition, since the drilling fluid is supplied to the tip portion of the tool main body via the supply channel during drilling, it is possible to prevent the compressed air from leaking out to a bedrock around the borehole to lower strength and causing collapse. Additionally,

since the drilling fluid is supplied to the tip portion of the tool main body via the supply channel, pure water can be used as the drilling fluid, and it is also not necessary to make the pressure of the compressed air higher than needed.

[0012] Since the cuttings and the drilling fluid can be discharged toward the posterior end side of the space between the drilling pipe and the air supply pipe using compressed air in this way, no vacuum pump is required, and damage resulting from the cuttings passing through the vacuum pump does not occur, either. Additionally, if the compressed air is exhausted and the cuttings and the drilling fluid are pushed out toward the posterior end side, the space closer to the tip side than the exhaust gas outlet has a negative pressure. Thus, new cuttings and drilling fluid can be suctioned into this space from the tip of the tool main body and can be continuously discharged.

[0013] Here, the exhaust gas outlet may extend toward the outer-peripheral side of the tool main body so as to incline toward a posterior end side of the tool main body and opens into the space. Accordingly, the cuttings and the drilling fluid discharged into this space can be pushed out toward the posterior end side and can be much more reliably discharged. Moreover, in a case where the drilling tool of the configuration is applied to a basic piling construction method using a casing pipe, the supply channel may be formed between the supply pipe and the drilling pipe by inserting the drilling pipe through the inner circumference of the supply pipe, using this casing pipe as the supply pipe. Accordingly, it is possible to reliably supply the drilling fluid to the tip portion of the tool main body.

[0014] Additionally, particularly in a case where such a casing pipe is inserted through the drilling pipe as the supply channel, a plurality of grooves may be formed on an outer circumference of the tip portion of the tool main body. The grooves may extend from a tip of the tool main body toward a posterior end side of the tool main body. Some of the plurality of grooves communicate with the supply channel. The remainder of the grooves may communicate with the discharge channel. Tip portions of the grooves which are communicated with the supply channel and tip portions of the grooves which are communicated with the discharge channel may communicate with each other via a communicating groove formed on a tip surface of the tool main body. Accordingly, while the drilling fluid is supplying from the some of the plurality of grooves flows into the tip portions of the remainder of the grooves via the communicating groove, the cuttings can be efficiently recovered and can be discharged into the space between the drilling pipe and the air supply pipe from the discharge channel.

[0015] Meanwhile, a groove may be formed on an outer circumference of the tip portion of the tool main body. The groove may extend from a tip of the tool main body toward a posterior end side of the tool main body to communicate with the supply channel. A hole may be formed in the tool main body inside than the groove as the dis-

charge channel. The hole may extend from the tip of the tool main body toward the posterior end side of the tool main body. A tip portion of the groove and a tip portion of the hole may communicate with each other via a communicating groove formed on a tip surface of the tool main body. Also by such a configuration, while the drilling fluid similarly is supplying from the groove flows into the tip portion of the hole via the communicating groove, the cuttings can be efficiently recovered. In addition, the drilling tool including the above configuration can be used for the drilling method of the invention.

Advantageous Effects of Invention

[0016] As described above, according to the invention, there is no case where the strength of a bedrock around the borehole to cause collapse is lowered and collapse is caused, it is not necessary to make the pressure of compressed air higher than needed, and no vacuum pump is not required. Thus, stable drilling can be efficiently performed at low costs.

Brief Description of Drawings

[0017]

FIG. 1 is a side sectional view showing a first embodiment of a drilling tool of the invention.

FIG. 2 is a front view of a tool main body of the embodiment shown in FIG. 1.

FIG. 3 is a back view of a shank portion in the tool main body of the embodiment shown in FIG. 1.

FIG. 4 is a ZZ sectional view in FIG. 1.

FIG. 5 is a side sectional view showing a second embodiment of a drilling tool of the invention.

FIG. 6 is a front view of a tool main body of the embodiment shown in FIG. 5.

FIG. 7 is a back view of a shank portion in the tool main body of the embodiment shown in FIG. 5.

FIG. 8 is a ZZ sectional view in FIG. 5.

Description of Embodiments

[0018] FIGS. 1 to 4 show a first embodiment of the drilling tool of the invention. In the present embodiment, a tool main body 1 includes a bottomed substantially multi-stepped cylindrical pilot bit 2 that is formed of metallic materials, such as a steel material, is configured to have a one-step larger diameter on a tip side (a left side in FIG. 1) in a direction of an axis O, and is centered on the axis O, and a ring bit 3 that is detachably attached to an outer circumference of a tip portion of the pilot bit 2, is formed in an annular shape or a cylindrical shape, similarly, using metallic materials, such as a steel material, and is centered on the axis O. A smaller-diameter posterior end portion of the pilot bit 2 serves as a shank portion 2A having a male thread portion formed on an outer circumference thereof, and is attached to the shank

portion 2A by threadedly engaging a cylindrical drilling pipe P1 with the male thread portion of the shank portion 2A. A rotating force around the axis O and an impelling force and a striking force toward a tip side in the direction of the axis O are applied to the pilot bit 2 via the drilling pipe P1. In addition, in the present specification, a direction in which the axis O extends is referred to as the direction of the axis O, a direction toward the pilot bit 2 from the drilling pipe P1 in the direction of the axis O is referred to as the tip side (the left side of FIG. 1), and a direction toward the drilling pipe P1 from the pilot bit 2 is referred to as a posterior end side (a right side of FIG. 1). Additionally, a direction, which passes through the axis O and is orthogonal to the axis O, is referred to as a diametrical direction or a radial direction. In the radial direction, a direction (radial inner side) approaching the axis O is referred to as an inner-peripheral side, and a direction (radial outer side) separating from the axis O is referred to as outer-peripheral side. Moreover, a direction going around the axis O is referred to as a circumferential direction.

[0019] In the present embodiment, the tip portion of the pilot bit 2 closer to the tip side than this shank portion 2A is formed such that the diameter thereof is reduced approximately in three steps toward the tip side. That is, the tip portion of the pilot bit 2 has a larger-diameter part 2B with the largest external diameter, a middle-diameter part 2C with a smaller external diameter than the larger-diameter part 2B, and a smaller-diameter part 2D with a smaller external diameter than the middle-diameter part 2C, sequentially from the posterior end side. A conical-surface-shaped pilot-bit-side abutting surface 4, which is reduced in diameter gradually toward the tip side in the direction of the axis O and is centered on the axis O, is formed between an outer peripheral surface of the larger-diameter part 2B located on the most posterior end side among these diameter parts and an outer peripheral surface of the middle-diameter part 2C. A conical-surface-shaped pilot-bit-side contact surface 5, which is reduced in diameter gradually toward the tip side in the direction of the axis O and is centered on the axis O, is formed between the outer peripheral surface of the middle-diameter part 2C and an outer peripheral surface of the smaller-diameter part 2D located on the most tip end side.

[0020] Here, in a section along the axis O as shown in FIG. 1, an inclined angle β that the pilot-bit-side contact surface 5 makes with respect to the axis O is set to be smaller than an inclined angle α that the pilot-bit-side abutting surface 4 makes with respect to the axis O. In the present embodiment, as shown in FIG. 1, the pilot-bit-side abutting surface 4 is formed such that a length A thereof in a direction parallel to the axis O is equal to or less than a radius (the reduction amount of the radius) B that is reduced by the length A when being directed toward the tip side in the direction of the axis O, that is, is formed such that the inclined angle α thereof made with respect to the axis O is equal to or more than 45° . Contrary to this, the pilot-bit-side contact surface 5 is

formed such that a length C thereof in the direction parallel to the axis O is longer than a radius (the reduction amount of the radius) D that is reduced by the length C when being directed toward the tip side in the direction of the axis O, that is, is formed such that the inclined angle β thereof made with respect to the axis O is less than 45° .

[0021] In addition, the length C of the pilot-bit-side contact surface 5 is set to be sufficiently longer than the length A of the pilot-bit-side abutting surface 4, and the radius D of the pilot-bit-side contact surface 5 is set to be slightly larger than the radius B of the pilot-bit-side abutting surface 4. Additionally, the outer peripheral surfaces of the larger-diameter part 2B, the middle-diameter part 2C, and smaller-diameter part 2D are cylindrical surfaces having constant external diameters centered on the axis O, respectively. The length, in the direction of the axis O, of the middle-diameter part 2C among these, is set to be slightly longer than the larger-diameter part 2B or the smaller-diameter part 2D.

[0022] Moreover, a plurality of (three in the present embodiment) of grooves 6, which extend toward the posterior end side from a tip surface of the pilot bit 2, are formed substantially at equal intervals in the circumferential direction on the outer circumference of the tip portion of the pilot bit 2. Some of the grooves (on an upper side in FIG. 1 and one groove on a left side of FIG. 2) 6A among the plurality of grooves 6 penetrate from the tip surface of the pilot bit 2 to a posterior end surface of the larger-diameter part 2B. The remainder of the grooves 6B (on a lower side in FIG. 1 and two grooves on a right side in FIG. 2) among the plurality of grooves 6 extend from the tip surface of the pilot bit 2 to a position in front of the larger-diameter part 2B, and are formed in a cut-upward shape toward the outer-peripheral side. In other words, the remainder of the grooves 6B extend from the tip surface of the pilot bit 2 to a position near a posterior end of the middle-diameter part 2C. Holes, which extend toward the inner-peripheral side so as to face the posterior end side and have a circular cross-section, are formed as discharge channels 7 in the present embodiment from posterior end portions of the remainder of the grooves 6B. One end of each of the holes opens into an inner peripheral portion (inner peripheral surface) of the bottomed cylindrical pilot bit 2, and the other end thereof opens into a posterior end portion of each of the remainder of the grooves 6B.

[0023] Additionally, a communicating groove 8, which connects tip portions of the grooves 6A and tip portions of the remainder of the grooves 6B together to allow communication therebetween, is formed on the tip surface of the pilot bit 2. In the present embodiment, in a plan view as shown in FIG. 2, the communicating groove 8 is formed in a Y-shaped such that the communicating groove 8 extends to a position in front of the axis O in the radial direction with respect to the axis O from the tip portions of the grooves 6A, and then, reach the tip portions of the two remainder of the grooves 6B while being

branched into two and curved without reaching the axis O. In addition, each groove 6 has a substantially rectangular or substantially U-shaped cross-section, and a bottom surface of the groove that face the outer-peripheral side extends toward the posterior end side so as to slightly incline toward the outer-peripheral side with respect to the axis O as shown in FIG. 1. As shown in FIG. 4, the communicating groove 8 has a U-shaped cross-section and extends on a plane perpendicular to the axis O.

[0024] Moreover, a face surface on a planar central portion perpendicular to the axis O excluding the openings of the grooves 6 and the communicating groove 8, and a gauge surface of a conical-surface-shaped outer peripheral portion that inclines so as to extend toward the outer-peripheral side as going toward the posterior end side are formed on the tip surface of the pilot bit 2. Drilling tips 9, which are made of cemented carbide or the like harder than the pilot bit 2, are implanted on the face surface and the gauge surface perpendicularly to the face surface and the gauge surface so as to avoid the openings of the grooves 6 and the communicating groove 8.

[0025] Moreover, a plurality of (three in the present embodiment) circular-arc plate-shaped protruded streaks 2E (having outer peripheral surfaces that are arcuate surfaces centered on the axis O), which protrude toward the outer-peripheral side and are centered on the axis O, are formed at equal intervals in the circumferential direction at positions away at a slight distance from the pilot-bit-side contact surface 5 toward the tip side on the outer peripheral surface of the smaller-diameter part 2D of the pilot bit 2. In the present embodiment, each protruded streak 2E extends from one end (an end portion in the counterclockwise direction in the plan view as shown in FIG. 2) of the groove 6 in the circumferential direction, and the drilling tips 9 of the gauge surface are implanted over the protruded streaks 2E.

[0026] A conical-surface-shaped ring-bit-side contact surface 10, which is reduced in diameter gradually toward the tip side in the direction of the axis O and is centered on the axis O is formed on an inner peripheral surface of a posterior end portion of the annular or cylindrical ring bit 3 attached to the outer circumference of such a pilot bit 2. The ring-bit-side contact surface 10 makes the equal inclined angle β with the pilot-bit-side contact surface 5 with respect to the axis O in the section along the axis O.

[0027] That is, the ring-bit-side contact surface 10 is formed such that the length C thereof in the direction parallel to the axis O is longer than the radius D that is reduced by the length C when being directed toward the tip side in the direction of the axis O, similarly to the pilot-bit-side contact surface 5, that is, is formed at a inclined angle β of less than 45° with respect to the axis O. As shown in FIG. 1, the ring bit 3 brings the ring-bit-side contact surface 10 into close contact with the pilot-bit-side contact surface 5, and is attached from the tip surface of the pilot bit 2 to a posterior end of the pilot-bit-

side contact surface 5 in the direction of the axis O. In other words, in the present embodiment, the length of the ring bit 3 in the direction of the axis O is substantially the same as the length in the direction of the axis O from the tip surface of the pilot bit 2 to the posterior end of the pilot-bit-side contact surface 5. The ring bit 3 is attached to the outer circumference of the pilot bit 2 such that the position of the tip surface of the ring bit 3 is substantially the same as that of the tip surface of the pilot bit 2 in the direction of the axis O.

[0028] Additionally, an inner peripheral surface of a tip portion of the ring bit 3 has a slightly larger internal diameter than the smaller-diameter part 2D of the pilot bit 2. Recessed grooves 3A slightly wider in the circumferential direction than the protruded streaks 2E of the pilot bit 2 are formed by the same number as that of the protruded streaks 2E at regular intervals in the circumferential direction on the inner peripheral surface of the tip portion so as to penetrate from the tip surface of the ring bit 3 toward the ring-bit-side contact surface 10 in the direction of the axis O. The depth of each recessed groove 3A in the radial direction is set such that the internal diameter of the recessed groove 3A is slightly larger than the external diameter of the protruded streak 2E.

[0029] Moreover, an L-shaped engaging portion 3B, which is equal to the recessed groove 3A in depth in the radial direction, is slightly longer than the protruded streak 2E in length in the direction of the axis O, and has an L-shaped section in the direction of the axis O, is formed from one end (an end portion in the same direction as an end portion, extending in the circumferential direction from the groove 6, on the protruded streak 2E of the pilot bit 2, that is, from the end portion in the counterclockwise direction in FIG. 2) of the recessed groove 3A in the circumferential direction. An inner peripheral surface of the engaging portion 3B is smoothly continuous with the inner peripheral surface of the recessed groove 3A in the circumferential direction on a tip side thereof. By accommodating the protruded streaks 2E into the recessed grooves 3A to insert the ring bit 3 from the tip side of the tip of the pilot bit 2 and rotate the pilot bit 2 toward one end side (in the counterclockwise direction in FIG. 2) in the circumferential direction, the protruded streaks 2E are fitted to the engaging portions 3B so as to be engageable therewith. Therefore, the positions of the grooves 6 of the pilot bit 2 coincide with the recessed grooves 3A of the ring bit 3 in the circumferential direction in a state where the protruded streaks 2E are fitted to the engaging portions 3B in this way. In addition, the circumferential width of each engaging portion 3B is set such that the positions of each groove 6 of the pilot bit 2 overlap each recessed groove 3A of the ring bit 3 in the circumferential direction in a state where the protruded streak 2E is fitted to the engaging portion 3B. In the present embodiment, the circumferential width of the engaging portion 3B are set so as to be approximately equal to the circumferential width of the protruded streak 2E.

[0030] Moreover, the tip surface of the ring bit 3 also

includes a face surface of an inner peripheral portion perpendicular to the axis O, and a gauge surface of an outer peripheral portion that inclines so as to extend toward the outer-peripheral side as going toward the posterior end side. Drilling tips 9, which are made of cemented carbide or the like harder than the ring bit 3, are implanted in the face surface and the gauge surface perpendicularly to the face surface and the gauge surface. In addition, a plurality of recessed grooves 3C are formed at equal intervals in the circumferential direction between the drilling tips 9 implanted in the gauge surface on an outer peripheral surface of the tip portion of the ring bit 3.

[0031] Meanwhile, a ring-bit-side locking groove 11, which forms an oblong shape extending in the direction of the axis O in the section along the axis O and opens toward the outer-peripheral side, is formed over the entire circumference at a position with a distance in the direction of the axis O from the gauge surface of the tip surface and a posterior end surface in the ring bit 3, on the outer peripheral surface of the ring bit 3. Additionally, the outer peripheral portion of the ring bit 3 closer to the posterior end side than the ring-bit-side locking groove 11 serves as an annular ring-bit-side locking portion 12 that protrudes toward the outer-peripheral side with respect to the ring-bit-side locking groove 11. The external diameter of the ring-bit-side locking portion 12 is a smaller diameter than the tip portion of the ring bit 3, and the length of the ring-bit-side locking portion 12 in the direction of the axis O is set to be shorter than the ring-bit-side locking groove 11. In addition, chamfering is performed on an outer peripheral portion of a posterior end of the ring-bit-side locking portion 12.

[0032] Moreover, in the present embodiment, a cylindrical casing pipe 13 centered on the axis O is disposed as a supply pipe P2 in the present embodiment on the outer circumference of the pilot bit 2 to which the ring bit 3 is attached as described above. A supply channel F is formed between the outer circumference of the drilling pipe P1 and the casing pipe 13 (supply pipe P2). The casing pipe 13 is integrated by joining a cylindrical casing top 13B similarly centered on the axis O to a tip portion of a cylindrical pipe main body 13A centered on the axis O by welding or the like. The pipe main body 13A has a larger internal diameter than the external diameter of the larger-diameter part 2B of the pilot bit 2, and a plurality of the pipe main bodies 13A are sequentially joined to a posterior end of the pipe main body 13A by welding or the like in accordance with the depth of a borehole.

[0033] The casing top 13B is formed such that the external diameter of a posterior end portion thereof is one step smaller than a tip portion thereof, and is joined such that a tip portion of the pipe main body 13A at the foremost end is fitted into the stepped portion. In other words, the external diameter of a posterior end portion of the casing top 13B is substantially the same as the internal diameter of the tip portion of the pipe main body 13A, and the posterior end portion of the casing top 13B is joined so as to be fitted to the pipe main body 13A. Additionally, the

internal diameter of the posterior end portion of the casing top 13B is set to be smaller than the external diameter of the larger-diameter part 2B of the pilot bit 2 and to be larger than the external diameter of the middle-diameter part 2C. A casing-pipe-side abutting surface 14 capable of abutting against the pilot-bit-side abutting surface 4 formed at a position closer to the posterior end side than the pilot-bit-side contact surface 5 of the pilot bit 2 is formed on an inner peripheral portion of a posterior end surface of the casing top 13B.

[0034] That is, the casing-pipe-side abutting surface 14 is also formed in a conical surface shape that is reduced in diameter gradually toward the tip side in the direction of the axis O and is centered on the axis O. As shown in FIG. 1, in the section along the axis O, the inclined angle α made with respect to the axis O is an angle equal to the inclined angle α of the pilot-bit-side abutting surface 4 O and larger than the inclined angle β made between the pilot-bit-side contact surface 5 and the ring-bit-side contact surface 10. Moreover, in the present embodiment, the length A of the casing-pipe-side abutting surface 14 in the direction parallel to the axis O in the section along the axis O is set to be equal to or less than the radius B that is reduced in diameter by the length A when being directed toward the tip side in the direction of the axis O, and the inclined angle α is equal to or more than 45° .

[0035] Additionally, the external diameter of the tip portion of the casing top 13B is set to be equal to the external diameter of the pipe main body 13A and is set to be smaller than the external diameter of the tip portion that becomes the maximum external diameter of the ring bit 3. A casing-pipe-side locking groove 15, which forms an oblong shape extending in the direction of the axis O in the section along the axis O and opens toward the inner-peripheral side, and a casing-pipe-side locking portion 16, which protrudes toward the inner-peripheral side with respect to the casing-pipe-side locking groove 15, are formed over the entire circumference in order toward the tip side on an inner peripheral portion of the tip of the casing top 13B.

[0036] The lengths of the casing-pipe-side locking groove 15 and the casing-pipe-side locking portion 16 in the direction of the axis O are set to be equal to those of the ring-bit-side locking groove 11 and the ring-bit-side locking portion 12, respectively. The internal diameter of the casing-pipe-side locking groove 15 is set to be slightly larger than the external diameter of the ring-bit-side locking portion 12. Additionally, the internal diameter of the casing-pipe-side locking portion 16 is set to be slightly larger than the external diameter of the ring-bit-side locking groove 11 and smaller than the external diameter of the ring-bit-side locking portion 12, and chamfering is performed on an inner peripheral portion of the tip of the casing-pipe-side locking portion 16.

[0037] By accommodating the casing-pipe-side locking portion 16 in the ring-bit-side locking groove 11 and accommodating the ring-bit-side locking portion 12 in the

casing-pipe-side locking groove 15, the ring bit 3 is attached to the casing top 13B in a state where the ring bit 3 is rotatable around the axis O and is locked toward the tip side and the posterior end side in the direction of the axis O within a range in which the ring-bit-side locking groove 11 and the casing-pipe-side locking groove 15 are formed.

[0038] In addition, in order to attach the ring bit 3 to the casing top 13B in this way, for example, by making the chamfered portion of the outer peripheral portion of the posterior end of the ring-bit-side locking portion 12 coincide with (abut against) the chamfered portion of the inner peripheral portion of the tip end of the casing-pipe-side locking portion 16 and then pressing at least one of the casing top 13B and the ring bit 3 toward the other thereof in the direction of the axis O, thereby elastically reducing the diameter of the posterior end portion of the ring bit 3 and elastically increasing the diameter of the tip portion of the casing top 13B, the casing-pipe-side locking portion 16 is may be accommodated to be fitted into the ring-bit-side locking groove 11 and the ring-bit-side locking portion 12 may be accommodated to be fitted into the casing-pipe-side locking groove 15. After the ring bit 3 is attached in this way, the casing top 13B is joined to the pipe main body 13A, and the ring bit 3 is disposed on the tip portion of the casing pipe 13.

[0039] As described above, after the ring bit 3 is disposed on the casing top 13B of the tip portion of the casing pipe 13, the pilot bit 2 attached to the tip portion of the drilling pipe P1 is inserted into the casing pipe 13 from the posterior end side. After, by rotating the pilot bit 2 toward the one end side in the circumferential direction after the protruded streaks 2E are accommodated into the recessed grooves 3A, the engaging portions 3B are fitted to and engaged with the protruded streaks 2E. Drilling pipes P1 are sequentially joined and coupled together in accordance with the depth of a borehole. The drill pipe P1 located at the most posterior end is connected to a drilling unit. In this way, the pilot bit 2 inserted into the casing pipe 13 is positioned at a location where the pilot-bit-side abutting surface 4 abuts against the casing-pipe-side abutting surface 14 of the casing top 13B.

[0040] Moreover, if drilling is performed by making the tip portion of the pilot bit 2 and the ring bit 3 abut against a bedrock or the like from this state to apply a rotating force around the axis O and an impelling force and a striking force toward the tip side in the direction of the axis O from the drilling unit via the drilling pipe P1 to the pilot bit 2, the ring bit 3 is pressed toward the posterior end side due to resistance from the bedrock or the like, and the ring-bit-side contact surface 10 is brought into close contact with the pilot-bit-side contact surface 5. In addition, the ring bit 3 may be pressed toward the posterior end side before drilling to bring the ring-bit-side contact surface 10 close contact with the pilot-bit-side contact surface 5.

[0041] Here, the ring-bit-side locking portion 12 and the casing-pipe-side locking portion 16 are formed so as

to be disposed at positions with a distance from both ends, in the direction of the axis O, of the casing-pipe-side locking groove 15 and the ring-bit-side locking groove 11, respectively, as shown in FIG. 1, in a state where the pilot-bit-side abutting surface 4 abuts against the casing-pipe-side abutting surface 14 and the ring-bit-side contact surface 10 is brought into the pilot-bit-side contact surface 5, in this way.

[0042] The air supply pipe P3 is inserted through an inner circumference of the cylindrical drilling pipe P1 from the posterior end side, and a tip portion of the air supply pipe P3 is inserted into an inner peripheral portion of the pilot bit 2 in the tool main body 1. Moreover, an exhaust plug 17 is attached to a tip portion of the air supply pipe P3, and the exhaust plug 17 is accommodated in the inner peripheral portion of the pilot bit 2. The air supply pipe P3 is formed in a cylindrical shape that has an external diameter smaller than the internal diameter of the drilling pipe P1 and is centered on the axis O, and a space E having an annular section is formed between the air supply pipe P3 and the drilling pipe P1. For example, the compressed air used for driving of a pneumatic hammer when the striking force is applied to the pilot bit 2 as described above is supplied to an inner peripheral portion of the air supply pipe P3.

[0043] The exhaust plug 17 is formed in a bottomed multi-stepped cylindrical shape. Specifically, the exhaust plug 17 includes a tip portion having a larger external diameter, a posterior end portion having a smaller external diameter, and an intermediate portion having a smaller external diameter than the tip portion and larger than the posterior end portion, and an outer peripheral surface of any of these portions has a cylindrical surface shape having a substantially constant external diameter. A male thread portion screwed into an inner circumference of the tip portion of the air supply pipe P3 is formed on an outer circumference of the smaller-diameter posterior end portion of the exhaust plug 17. The larger-diameter tip portion of the exhaust plug 17 is an external diameter that makes it possible to be fitted into the inner peripheral portion of the pilot bit 2 with a slight space therefrom. Additionally, a posterior end surface of the tip portion of the exhaust plug 17 is formed in a conical surface shape that extends toward the inner-peripheral side as going toward the posterior end side. That is, the posterior end surface of the tip portion of the exhaust plug 17 connecting the outer peripheral surface of the tip portion of the exhaust plug 17 and the outer peripheral surface of the intermediate portion of the exhaust plug 17 together is formed in a conical surface shape. The inclined angle of the posterior end surface of the tip portion of the exhaust plug 17 with respect to the axis O is set to be equal to the inclined angle of each discharge channel 7 of the pilot bit 2, which similarly extends toward the inner-peripheral side as going the posterior end side, with respect to the axis O. Such an exhaust plug 17 is disposed such that the conical-surface-shaped tip portion posterior end surface is located at the tip edge of the opening of the dis-

charge channel 7 on the inner peripheral portion of the pilot bit 2, as shown in FIG. 1, in a state where the exhaust plug 17 is attached to the tip portion of the air supply pipe P3 and is inserted into the inner peripheral portion of the pilot bit 2. In other words, the exhaust plug 17 is disposed such that the position of an outer peripheral end (a posterior end of the tip portion) of the conical-surface-shaped tip portion posterior end surface thereof coincides with the position of the tip edge of the opening of the discharge channel 7 on the inner peripheral portion of the pilot bit 2 in the direction of the axis O.

[0044] An inner peripheral portion of the bottomed cylindrical exhaust plug 17 communicates with the inner peripheral portion of the cylindrical air supply pipe P3. A plurality of (three) the exhaust gas outlets 17A, which open into the space E from the inner peripheral portion of the exhaust plug 17 to the outer peripheral surface closer to the tip side than the posterior end surface of the tip portion, are formed at equal intervals in the circumferential direction in the present embodiment. That is, one end of each of the exhaust gas outlets 17A opens into an inner circumference of the exhaust plug 17, and the other end thereof opens into a connecting position between the posterior end surface of the tip portion of the exhaust plug 17 and the outer peripheral surface of the intermediate portion. The exhaust gas outlet 17A of the present embodiment inclines so as to extend toward the posterior end side as going toward the outer-peripheral side of the tool main body 1. In addition, an exhaust gas outlet 17B having a smaller diameter than the exhaust gas outlet 17A is formed even from the inner peripheral portion of the exhaust plug 17 to a tip surface of the exhaust plug 17 perpendicular to the axis O. That is, one end of the exhaust gas outlet 17B opens into the inner circumference of the exhaust plug 17, and the other end thereof opens into the tip surface of the exhaust plug 17. Additionally, the exhaust gas outlet 17B inclines so as to extend toward the tip side as going toward the outer-peripheral side of the tool main body 1. The exhaust gas outlet 17B has a function of discharging residual earth and sand on the inner peripheral portion of the pilot bit 2.

[0045] In one embodiment of a drilling method of the invention of performing drilling with such a drilling tool, the striking force and the impelling force applied from the drilling unit via the drilling pipe P1 to the pilot bit 2 toward the tip side in the direction of the axis O are transmitted from the pilot-bit-side abutting surface 4 via the casing-pipe-side abutting surface 14 of the casing top 13B to the casing pipe 13, and are transmitted from the pilot-bit-side contact surface 5 via the ring-bit-side contact surface 10 to the ring bit 3. Accordingly, a borehole is formed by of the drilling tips 9 implanted in the tip surfaces of the pilot bit 2 and the ring bit 3, and the casing pipe 13 is inserted into this borehole. Additionally, the rotating force around the axis O applied to the pilot bit 2 is also transmitted from the pilot-bit-side contact surface 5 via the ring-bit-side contact surface 10 to the ring bit 3.

[0046] Additionally, the borehole is formed in this way,

and simultaneously, drilling fluid is supplied to the supply channel F between the drilling pipe P1 and the casing pipe 13, which is the supply pipe P2, from the posterior end side. The drilling fluid in the present embodiment is pure water, such as tap water. In the present embodiment, the drilling fluid supplied this way flows into a bottom portion of the borehole from the grooves 6A of the pilot bit 2 opening into a tip of the supply channel F to fill this bottom portion, and reaches the remainder of the grooves 6B while flowing through the communicating groove 8 communicating with the tip portions of the grooves 6A and entraining cuttings with the rotation of the pilot bit 2, flows into the space E closer to the posterior end side than the posterior end surface of the tip portion of the exhaust plug 17 of the inner peripheral portion of the pilot bit 2 through the discharge channels 7 communicates with the remainder of the grooves 6B, and is charged up to the posterior end side from the exhaust gas outlets 17A.

[0047] The drilling fluid mixed with the cuttings charged up to the posterior end sides of the exhaust gas outlets 17A in this way is delivered and discharged toward the posterior end side as the compressed air supplied into the air supply pipe P3 is jetted from the exhaust gas outlets 17A through the inner peripheral portion of the exhaust plug 17. Additionally, since the tip portion of the space E to which the drilling fluid is discharged in this way has a negative pressure, the drilling fluid remaining within the discharge channels 7 from the remainder of the grooves 6B is sucked into the tip portion of Space E together with the cuttings. In this way, the drilling fluid and the cuttings are continuously discharged due to the jetting of the compressed air from the exhaust gas outlets 17A.

[0048] In this way, according to the drilling tool and the drilling method of the above configuration, the drilling fluid with which the cuttings are mixed can be discharged using the compressed air for applying the striking force or the like to the pilot bit 2 and the ring bit 3 of the tool main body 1 without requiring a vacuum pump or the like. Since the drilling fluid to be discharged passes through the space E between the drilling pipe P1 and the air supply pipe P3, the drilling fluid does not interfere with the discharge even if the cuttings are mixed therewith. For this reason, low-cost drilling and discharge of the cuttings can be stably and efficiently discharged over a long period of time.

[0049] Additionally, since the compressed air for applying the striking force is exhausted to the above space E toward the posterior end side and is used for the discharge of the drilling fluid with which the cuttings are mixed, the compressed air does not leak out to the periphery of a borehole. Moreover, since the drilling fluid is charged into the bottom portion of a borehole, there is no case where a surrounding bedrock collapses due to strength reduction. Moreover, since the drilling fluid is also supplied through the supply channel F between the drilling pipe P1 and the casing pipe 13 that is the supply

pipe P2, the pure water as described above, having a lower specific gravity than a slurry or the like, can be used as the drilling fluid, and a pressure more than needed is not required for the compressed air jetted from the exhaust gas outlets 17A.

[0050] Additionally, in the present embodiment, since the exhaust gas outlets 17A inclines so as to extend toward the posterior end side as going toward the outer-peripheral side of the tool main body 1, the cuttings and the drilling fluid within the space E can be much more reliably discharged toward the posterior end side by the compressed air exhausted from the exhaust gas outlets 17A. Moreover, in the present embodiment, the drilling pipe P1 is inserted through the casing pipe 13 serving as the supply pipe P2 in this way, and the supply channel F is formed between the drilling pipe P1 and the casing pipe 13 (supply pipe P2). Thus, the present embodiment can be applied to a basic piling construction method of building the casing pipe 13 in a borehole while forming the borehole. In other words, the drilling fluid is supplied only to the tip side of the tool main body 1 via the supply channel F. For this reason, it is possible to reliably supply the drilling fluid to the bottom portion of the borehole on the tip portion of the tool main body 1 to discharge the cuttings, while preventing collapse of the borehole itself.

[0051] Additionally, in this way, combine with inserting the drilling pipe P1 into the casing pipe 13 in this way to supply the drilling fluid to the supply channel F during that time. In conjunction with this, in the present embodiment, the plurality of grooves 6, which extend toward the posterior end side from the tip surface of the pilot bit 2, are formed at intervals in the circumferential direction on the outer circumference of the tip portion of the pilot bit 2 of the tool main body 1 attached to the tip portion of the drilling pipe P1. The grooves 6A among these grooves are made to communicate with the supply channel F, and the remainder of the grooves 6B are made to communicate with the space E to which the drilling fluid is discharged via the discharge channels 7. Since the tip portions of the grooves 6A and the remainder of the grooves 6B communicate with the communicating groove 8 formed on the tip surface of the pilot bit 2, the cuttings generated by the drilling tips 9 implanted on the tip surface of the pilot bit 2 or the ring bit 3 can be uniformly taken into the communicating groove 8, and can be reliably discharged together with the drilling fluid.

[0052] Moreover, in the present embodiment, the pilot bit 2 and the ring bit 3 are configured so as to rotate integrally around the axis O due to the close contact between the conical-surface-shaped pilot-bit-side contact surface 5 and ring-bit-side contact surface 10. For this reason, between the pilot bit 2 and the ring bit 3, it is possible to prevent the drilling fluid from being supplied to the borehole from locations other than of the grooves 6A or the drilling fluid including the cuttings from being discharged from locations other than the above remainder of the grooves 6B. As a result, it is possible to much more reliably discharge the drilling fluid including the cut-

tings taken in by the communicating groove 8 as described above.

[0053] In addition, in the first embodiment, the tip portions of the some of the grooves 6A communicating with the supply channel F among the plurality of grooves 6 formed on the outer circumference of the tip portion of the pilot bit 2 as described above are made to communicate with the tip portions of the remainder of the grooves 6B communicating with the space E via the discharge channels 7 by the communicating groove 8. However, as in the second embodiment shown in FIGS. 5 to 8, holes 18 may be formed on the inner-peripheral sides of the grooves 6 of the outer circumference the tip portion of the pilot bit 2 of the tool main body 1 as a discharge channels 7, and tip portions of the holes 18 and the grooves 6 may be made to communicate with each other by communicating grooves 19. In addition, in these FIGS. 5 to 8, portions that are the same as those of the first embodiment shown in FIGS. 1 to 4 will be designated by the same reference signs, and the description thereof will be omitted.

[0054] That is, in the second embodiment, the plurality of grooves 6 (three also in the present embodiment) formed on the outer circumference of the tip portion of the pilot bit 2 all open into the posterior end surface of the tip portion of the pilot bit 2 to communicate with the supply channel F between the drilling pipe P1 and the casing pipe 13 (supply pipe P2), similar to some of the grooves 6A of the first embodiment. Meanwhile, the holes 18 passing through the inner peripheral portion of the pilot bit 2 from the tip surface of the pilot bit 2 and having a circular section are formed at positions away from the axis O on the inner-peripheral sides of the respective grooves 6 on the tip portion of the pilot bit 2. The holes 18 extends parallel to the axis O, tip-side end portions thereof open to the tip surface of the pilot bit 2, and posterior-end-side end portions thereof open to the inner peripheral surface of the pilot bit 2.

[0055] The tip portions of the holes 18 and the tip portions of the grooves 6 communicate with each other via the communicating grooves 19 that extends radially in the radial direction with respect to the axis O on a plane perpendicular to the axis O. Additionally, notches 17C, which pass through an outer circumference of the larger-diameter tip portion in the direction of the axis O, are respectively formed between the plurality of (three) exhaust gas outlets 17A in the circumferential direction on the larger-diameter tip portion of the exhaust plug 17 accommodated in the inner peripheral portion of the pilot bit 2.

[0056] Also in such a second embodiment, the drilling fluid supplied from the supply channel F flows to the tip side of the pilot bit 2 of the tool main body 1 through the respective grooves 6. Next, while the drilling fluid flows through the communicating grooves 19, the drilling fluid entrain the cuttings and reaches the tips of the holes 18, flows into the inner peripheral portion of the pilot bit 2 from the holes 18, and is charged from the exhaust gas

outlets 17A of the exhaust plug 17 to positions closer to the posterior end side than the notches 17C. Then, by exhausting compressed air from the exhaust gas outlets 17A, the drilling fluid with which the cuttings are mixed is pushed out and discharged toward the posterior end side, and the drilling fluid with which new cuttings are mixed is sucked from the holes 18.

[0057] In this way, also in the drilling tool and the drilling method using this according to the second embodiment, similar to the first embodiment, it is possible stably and efficiently perform low-cost drilling while preventing collapse of a surrounding bedrock without requiring a vacuum pump or the like and without requiring high pressure for the compressed air. Additionally, in this second embodiment, even if the number of grooves 6 to be formed on the tip portion of the pilot bit 2 is the same as that of the first embodiment, more drilling fluid can be supplied to the tip side of the tool main body 1, and a distance at which the drilling fluid that has entrained cuttings flows through the communicating grooves 19 can be shortened. Thus, this is suitable also in a case where drilling is performed at a high speed.

Industrial Applicability

[0058] According to the drilling tool and the drilling method of the invention, the water with which the cuttings are mixed can be efficiently discharged without using a vacuum pump. Thus, the invention is suitable for a basic piling construction method.

Reference Signs List

[0059]

1: TOOL MAIN BODY
 2: PILOT BIT
 3: RING BIT
 4: PILOT-BIT-SIDE ABUTTING SURFACE
 5: PILOT-BIT-SIDE CONTACT SURFACE
 6: GROOVE
 6A: SOME GROOVES
 6B: REMAINDER OF THE GROOVES
 7: DISCHARGE CHANNEL
 8, 19: COMMUNICATING GROOVE
 9: DRILLING TIP
 10: RING-BIT-SIDE CONTACT SURFACE
 13: CASING PIPE
 14: CASING-PIPE-SIDE ABUTTING SURFACE
 17: EXHAUST PLUG
 17A: EXHAUST GAS OUTLET
 17C: NOTCH
 18: HOLE (DISCHARGE CHANNEL)
 P1: DRILLING PIPE
 P2: SUPPLY PIPE
 P3: AIR SUPPLY PIPE
 O: AXIS OF TOOL MAIN BODY 1
 F: SUPPLY CHANNEL

E: SPACE BETWEEN DRILLING PIPE P1 AND AIR SUPPLY PIPE P3

5 Claims

1. A drilling tool comprising:

a tool main body;
 a drilling pipe having a tip portion on which the tool main body is provided; and
 an air supply pipe configured to supply a compressed air and inserted through the drilling pipe, wherein
 a supply channel is provided on an outer circumference of the drilling pipe, the supply channel being configured to supply drilling fluid to a tip portion of the tool main body,
 a discharge channel is formed on the tip portion of the tool main body, the discharge channel being configured to discharge cuttings generated during drilling together with the drilling fluid supplied from the supply channel into a space between the drilling pipe and the air supply pipe, and
 an exhaust gas outlet opening into the space is formed on a tip portion of the air supply pipe.

2. The drilling tool according to Claim 1, wherein the exhaust gas outlet extends toward an outer peripheral side of the tool main body so as to incline toward a posterior end side of the tool main body and opens into the space.

3. The drilling tool according to Claim 1 or 2, further comprising a supply pipe through which the drilling pipe is inserted, wherein the supply channel is formed between the supply pipe and the drilling pipe.

4. The drilling tool according to any one of Claims 1 to 3, wherein a plurality of grooves are formed on an outer circumference of the tip portion of the tool main body, the grooves extending from a tip of the tool main body toward the posterior end side of the tool main body, some of the plurality of grooves communicate with the supply channel, the remainder of the grooves communicate with the discharge channel, and tip portions of the grooves which are communicated with the supply channel and tip portions of the grooves which are communicated with the discharge channel communicate with each other via a communicating groove formed on a tip surface of the tool main body.

5. The drilling tool according to any one of Claims 1 to

3, wherein

a groove is formed on an outer circumference of the tip portion of the tool main body, the groove extending from a tip of the tool main body toward the posterior end side of the tool main body to communicate with the supply channel,
a hole as the discharge channel is formed in the tool main body inside than the groove, the hole extending from the tip of the tool main body toward the posterior end side of the tool main body, and
a tip portion of the groove and a tip portion of the hole communicate with each other via a communicating groove formed on a tip surface of the tool main body.

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6. A drilling method using the drilling tool according to any one of Claims 1 to 5, the method comprising steps of:

forming a borehole using the tool main body while supplying the drilling fluid to the tip portion of the tool main body through the supply channel;
discharging the cuttings generated during forming the borehole together with the drilling fluid through the discharge channel into the space between the drilling pipe and the air supply pipe;
and
discharging the cuttings and the drilling fluid discharged into the space toward a posterior end side of the tool main body using the compressed air discharged from the exhaust gas outlet.

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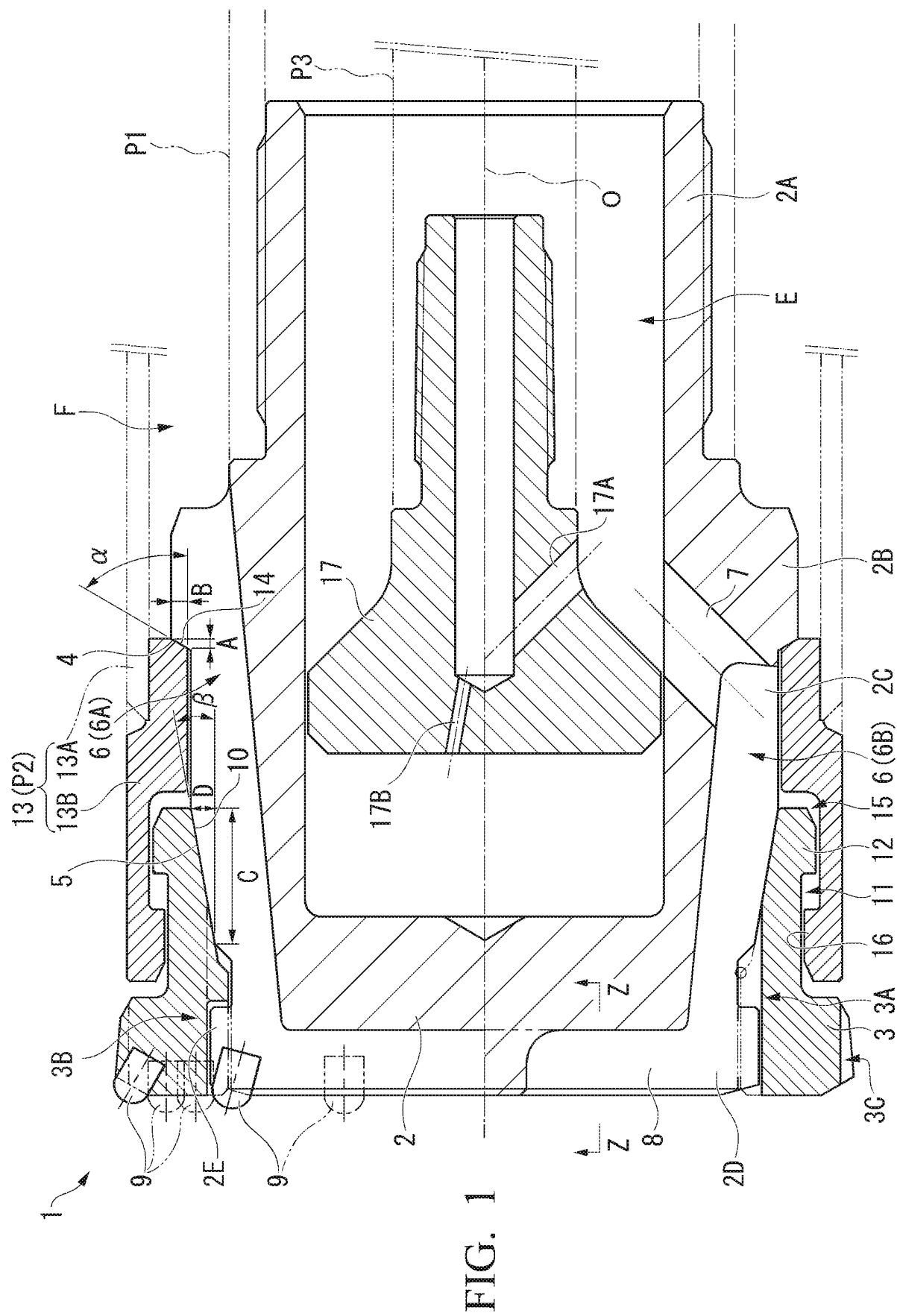


FIG. 2

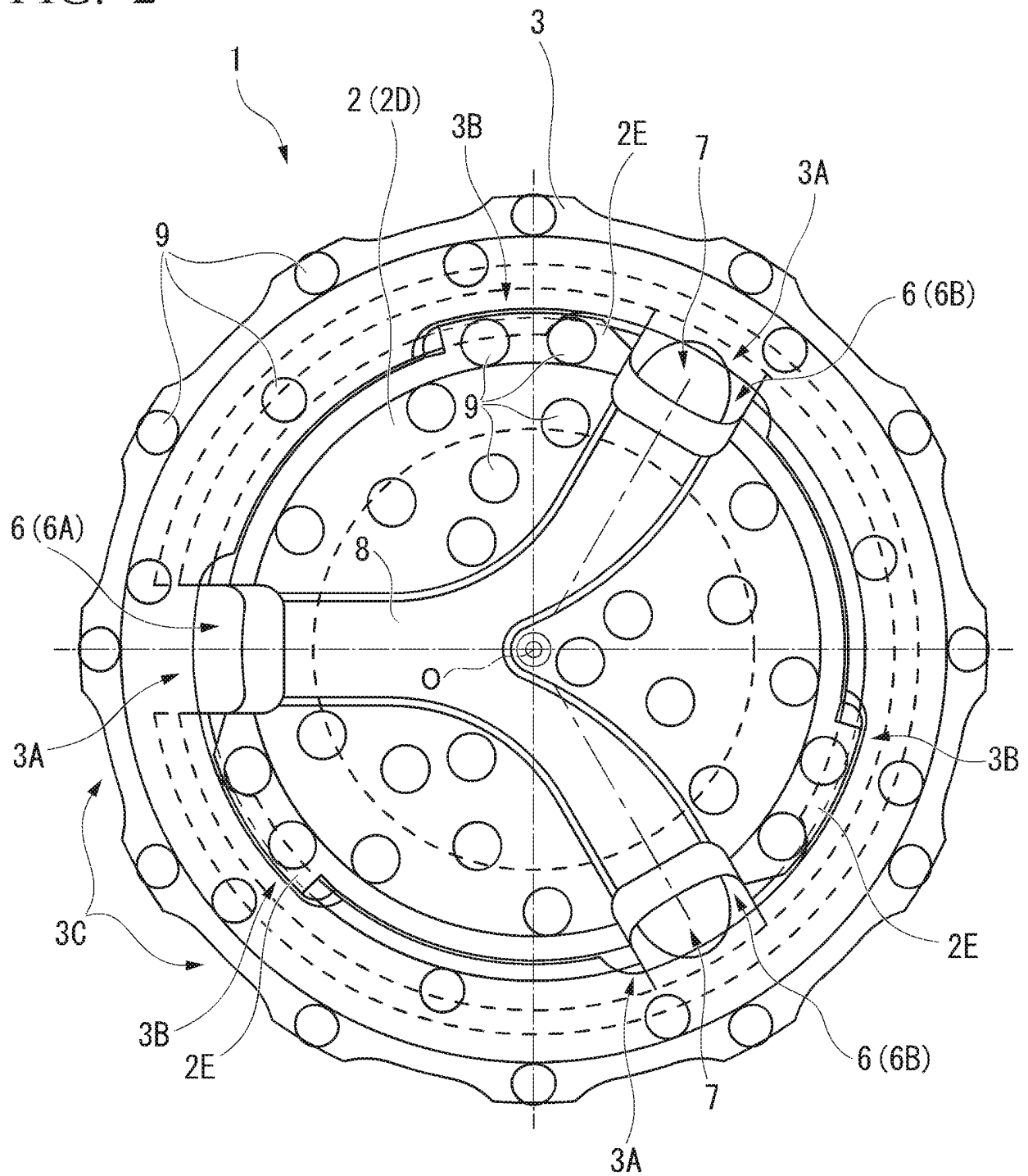


FIG. 3

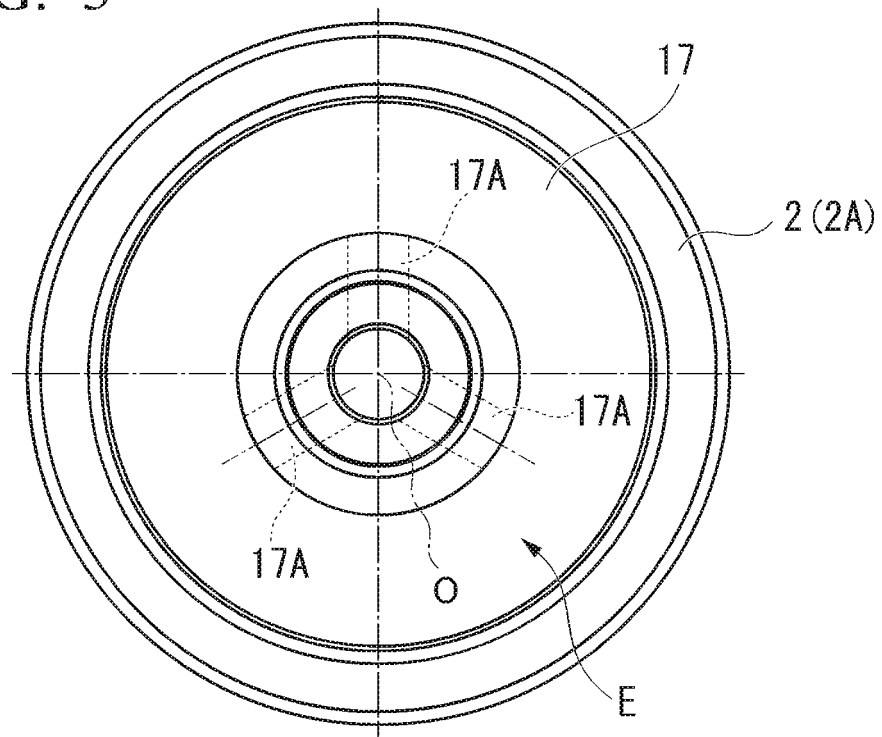
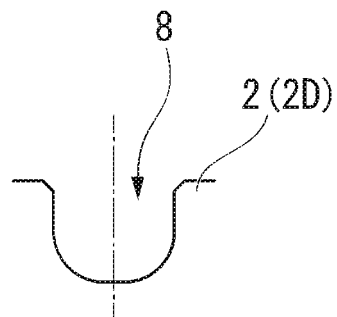


FIG. 4



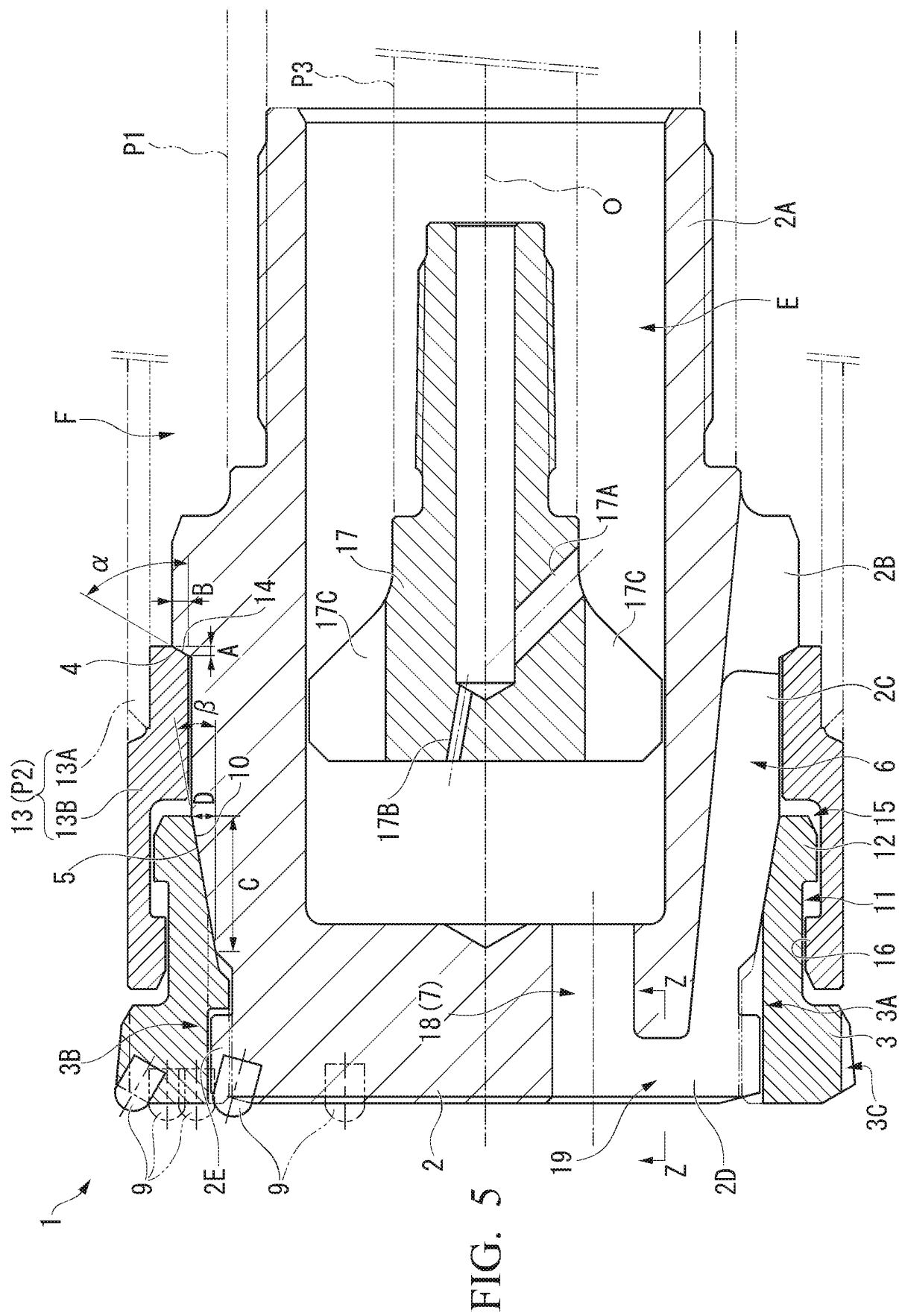


FIG. 6

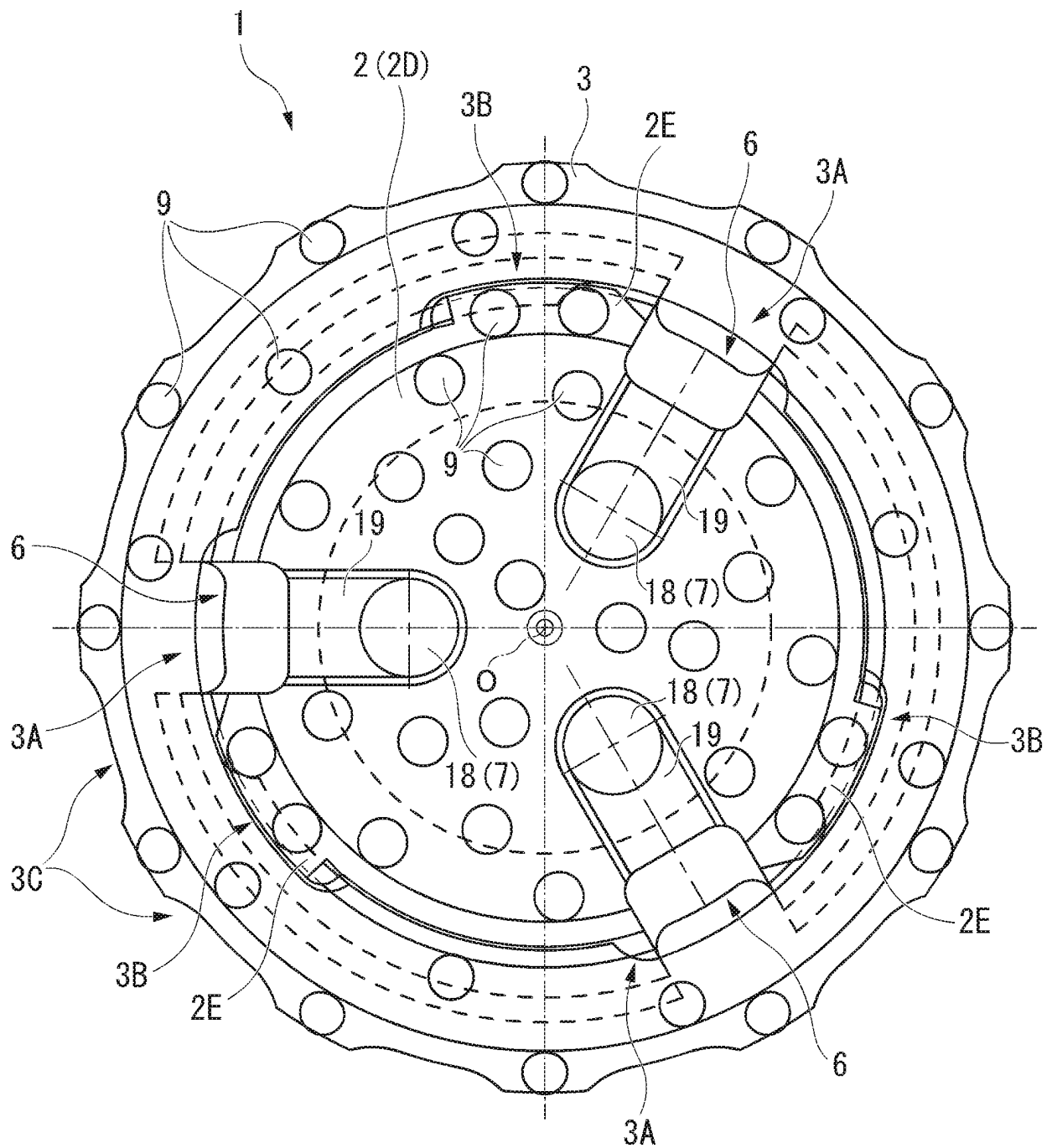


FIG. 7

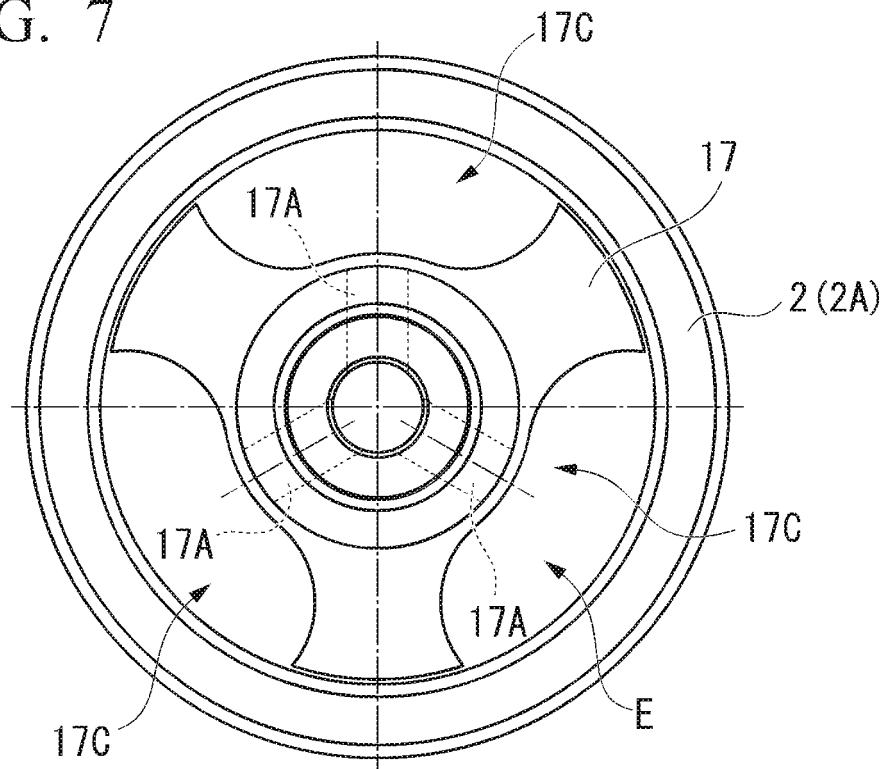
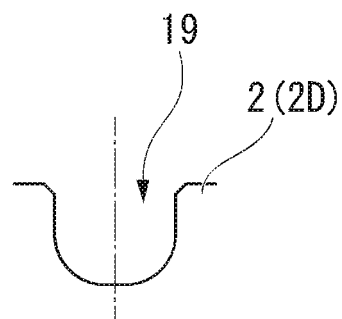


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/086558

A. CLASSIFICATION OF SUBJECT MATTER

E21B10/60(2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B1/00-E21B19/24, E21B21/12, E21B44/00-E21B44/10, F16L1/024, E02D17/13

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
 Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-028936 A (Chemical Grouting Co., Ltd.), 07 February 2013 (07.02.2013), (Family: none)	1-6
A	JP 2010-077699 A (Mitsubishi Materials Corp.), 08 April 2010 (08.04.2010), (Family: none)	1-6
A	JP 2003-161092 A (Sumiko Consultant Kabushiki Kaisha), 06 June 2003 (06.06.2003), (Family: none)	1-6
A	JP 07-217381 A (Tone Corp.), 15 August 1995 (15.08.1995), (Family: none)	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

06 February 2017 (06.02.17)

Date of mailing of the international search report

14 February 2017 (14.02.17)

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/086558

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-336266 A (Akira UENISHI), 14 December 2006 (14.12.2006), (Family: none)	1-6
A	WO 2015/151737 A1 (Mitsubishi Materials Corp.), 08 October 2015 (08.10.2015), & JP 2015-193994 A & CA 2942534 A & AU 2015241806 A & KR 10-2016-0138034 A	1-6
A	WO 2010/071563 A1 (SANDVIK INTELLECTUAL PROPERTY AB), 24 June 2010 (24.06.2010), & SE 802615 A	1-6

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2007170087 A [0005]