(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 511 514 A1

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

(43) Date of publication:
17.07.2019 Bulletin 2019/29

(21) Application number: **17848900.1**

(22) Date of filing: **11.09.2017**

(51) Int Cl.:
E21B 10/32 *(2006.01)* ***E21B 6/00*** *(2006.01)*

(86) International application number:
PCT/JP2017/032645

(87) International publication number:
WO 2018/047962 (15.03.2018 Gazette 2018/11)

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

(30) Priority: **12.09.2016 JP 2016177490**

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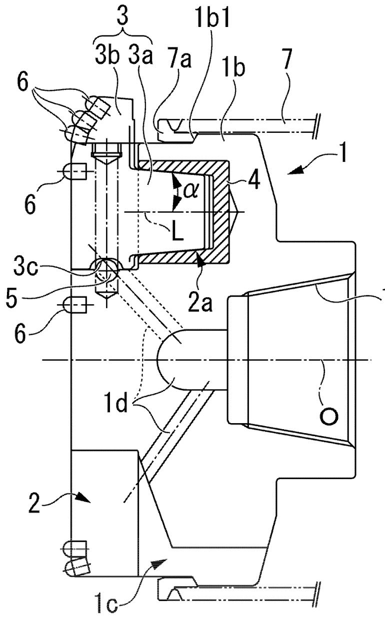
(54) DRILLING TOOL

(57) In this excavation tool, a bit head (3) which is rotatable about a bit center line (L) away from an axis (O) to an outer circumferential side is attached to a fore end part of a shank device (1) which is rotated about the axis (O) and to which a striking force is applied to a fore end side in the axis (O) direction, and the bit head (3) can be taper-fitted to the shank device (1) by an inclined surface inclined with respect to the bit center line (L).

FIG. 1C



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Description

[Technical Field]

[0001] The present invention relates to an excavation tool in which a bit head which is rotatable about a bit center line disposed away from an axis toward an outer circumferential side is attached to a fore end part of a shank device which is rotated about the axis and to which a striking force is applied to a fore end side in an axial direction.

[0002] Priority is claimed on Japanese Patent Application No. 2016-177490, filed in Japan on September 12, 2016, the content of which is incorporated herein by reference.

[Background Art]

[0003] As an excavation tool, for example, Patent Literature 1 and 2 disclose an excavation device in which a recess which opens to a fore end surface of a shank device is formed on an outer circumference of a fore end part of the shank device which is rotated about an axis and to which a striking force is applied toward a fore end side in the axial direction, and a diameter enlargement bit (bit head) is attached to the recess. The diameter enlargement bit can be accommodated in the recess in a reduced diameter state and can be rotated about a central axis eccentric with respect to the axis. When the diameter enlargement bit is enlarged and brought into contact with a wall surface of the recess, the diameter expansion bit is positioned, and an outer diameter of the tool from the axis enlarged to become larger than an outer diameter of the fore end part of the shank device.

[Citation List]

[Patent Literature]

[0004]

[Patent Literature 1]
Japanese Unexamined Patent Application, First Publication No. 2004-183471
[Patent Literature 2]
Japanese Unexamined Patent Application, First Publication No. 2006-037612

[Summary of Invention]

[Technical Problem]

[0005] In such an excavation tool, in order to enlarged and reduce the diameter of the bit head, a shaft of the bit head is fitted into a hole formed on a fore end surface of the shank device and a pin is inserted into a groove formed in the shaft to lock the bit head so that the bit head is not released. However, with this structure, it is difficult to secure a tool rigidity due to the increased number of components. Therefore, it is difficult to improve excavation efficiency, and there is a problem in that usage conditions are limited to drilling relatively soft bedrock.

[0006] The fitting between the hole and the shaft is formed as a clearance-fitting for rotating the bit head, and when a striking force applied to the shank device is transmitted to the bit head due to contact between a bottom surface of the hole and a rear end surface of the shaft or between a bottom surface of the recess and a rear end surface of a head part provided at a fore end of the shaft, and the shaft frequently moves back and forth inside the hole and vibrates even if the moving distance is slight. As a result, friction occurs on an outer circumferential surface of the shaft or an inner circumferential surface of the hole, and there is a likelihood that a mechanical seizure may occur on the shaft due to frictional heat.

[0007] When the fitting between the hole and the shaft is a clearance fitting, fine earth and sand enter this clearance and thus abrasion of the outer circumferential surface of the shaft or the inner circumferential surface of the hole may be also increased, causing backlash to occur in the bit head or further deterioration in tool rigidity, and in some cases, breakage of the shaft may occur. The problems of friction and abrasion are particularly significant in excavation with a high frequency hammer used in recent years when drilling is performed by shortening a striking cycle time while maintaining a small striking force because a frequency of the striking increases, for example, by about twice frequency.

[0008] The present invention has been made under such circumstances, and it is an objective of the present invention to provide an excavation tool which secures a tool rigidity to improve drilling efficiency and makes it possible to drill hard bedrock, prolongs a service life of the tool, and furthermore, can also be used for drilling using a high frequency hammer.

[Solution to Problem]

[0009] In order to solve the above problem, the excavation tool of the present invention includes a shank device which is rotated about an axis thereof and to which a striking force is applied to a fore end side in an axial direction, and a bit head attached to a fore end part of the shank device, in which the bit head is rotatable about a bit center line away from the axis to an outer circumferential side, and the bit head is able to be taper-fitted to the shank device by an inclined surface inclined with respect to the bit center line.

[0010] In the excavation tool having the above-described configuration, the bit head can be taper-fitted to the shank device by the inclined surface inclined with respect to the bit center line, and thereby the bit head and the shank device can be firmly integrated at the time of drilling and a tool rigidity can be improved. Therefore, excavation efficiency can also be improved and drilling can be performed even on hard bedrock. Further, the bit head does not vibrate due to a striking force applied to the shank device, friction and abrasion can be suppressed, and the tool can also be used for excavation using a high frequency hammer.

[0011] In order to enable the bit head to be taper-fitted to the shank device with the inclined surface, first, the bit head may be made able to be taper-fitted to the shank device toward a rear end side in the axial direction. For example, a shaft to be inserted into a hole of the shank device may be provided in the bit head, and an outer circumferential surface of the shaft may be formed as a tapered surface which is an inclined surface inclined with respect to the bit center line, and the inclined surface gradually reduces in diameter toward the rear end side. When resistance acts from bedrock toward the rear end side in the axial direction of the shank device at the time of drilling, the tapered surface is pressed against an inner circumferential surface of the hole of the shank device and taper-fitted, and the bit head and the shank device are firmly integrated.

[0012] When the bit head is made able to be taper-fitted to the shank device toward the rear end side in the axial direction by providing the inclined surface on the shaft of the bit head, the inner circumferential surface of the hole of the shank device is formed as a tapered hole in which a diameter thereof contracts toward the rear end side in accordance with an inclination of the outer circumferential surface of the shaft. The hole of the shank device may be formed in an intermediate member attached to the shank device. In this case, even when the tapered hole is damaged, a service life of the shank device can be prolonged by replacing the intermediate member.

[0013] A plurality of recesses may be formed at equal intervals in a circumferential direction on an outer circumferential part of the fore end of the shank device, and the bit head may be attached to each of these recesses such that the bit head is rotatable about the bit center line disposed away from the axis toward the outer circumferential side.

[0014] The hole centered on the bit center line may be formed on a side, opposite to the tool rotation direction, of a bottom surface of the recess facing the fore end side in the axial direction, and the inner circumferential surface of the hole may be formed in a concave circular truncated cone shape which gradually contracts in diameter toward the rear end side in the axial direction with the bit center line L as a center.

[0015] The bit center line may be parallel to the axis.

[0016] The bit head may include the columnar shaft and the head part provided at a fore end of the shaft, the shaft may be made to be coaxially inserted into the hole of the shank device, and the shaft may be made to be taper-fitted to the hole.

[0017] The head part may include a semicircular side surface centered on the bit center line, two extended side surfaces extending from both ends of the semicircular side surface, and an arcuate side surface having a radius of curvature larger than that of the semicircular side surface and connecting end parts of the extended side surfaces on a side opposite to the semicircular side surface.

[0018] When the bit head is rotated about the bit center line in a direction opposite to the tool rotation direction, the extended side surface of the head part is brought into contact with a wall surface of the recess facing in the tool rotation direction, and at this time, the arcuate side surface of the bit head is disposed on a virtual cylindrical surface having a larger radius than the fore end part of the shank device.

[0019] A locking pin may be detachably inserted in a plane perpendicular to the axis from the outer circumferential part of the shank device and the locking pin may be engaged with a recess formed on a circumferential surface of the bit head to prevent the bit head from falling off.

[0020] A second configuration may be provided in place of or in combination with the first configuration in which the bit head can be taper-fitted to the shank device toward the rear end side in the axial direction. In the second configuration, a bit head can be taper-fitted to a shank device toward a direction opposite to a rotation direction of the shank device at the time of drilling. For example, when the bit head includes a head part, a protruding part may be formed on a side surface of the head part facing a side opposite to the rotation direction of the shank device at the time of drilling. In the shank device, a recess for accommodating the protruding part is formed, and a rear end surface of the protruding part and a bottom surface of the recess are made to be perpendicular to a bit center line. A fore end surface of the protruding part and a ceiling face facing the bottom surface of the recess are formed as an inclined surface to be close to the rear end surface and the bottom surface toward a direction opposite to the rotation direction. As a result, in a state in which the head part is expanded in diameter, the fore end surface of the protruding part and the ceiling face of the recess are brought into contact with each other, and the bit head is taper-fitted to the shank device. When the bit center line is inclined toward a rotation direction side at the time of drilling toward the rear end side in the axial direction, the bit head can be taper-fitted to the shank device toward the rear end side in the axial direction and toward a direction opposite to the rotation direction.

[Advantageous Effects of Invention]

[0021] According to the present invention, excavation efficiency can be improved in accordance with improvement of the tool rigidity, a service life of the tool can be prolonged by suppressing friction and abrasion, and furthermore, the tool can also be used for drilling hard bedrock or excavation using a high frequency hammer.

[Brief Description of Drawings]

[0022]

Fig. 1A is a front view illustrating a state in which a bit head is expanded in diameter in an excavation tool according to a first embodiment of the present invention.
Fig. 1B is a plan view illustrating the same enlarged diameter state as in Fig. 1A.
Fig. 1C is a side sectional view illustrating the same enlarged diameter state as in Fig. 1A.
Fig. 2A is a front view of a state in which the bit head of the first embodiment is contracted in diameter.
Fig. 2B is a plan view illustrating the same reduced diameter state as in Fig. 2A.
Fig. 3A is a perspective view of a shank device of the first embodiment.
Fig. 3B is a perspective view of the bit head of the first embodiment when viewed from a fore end side.
Fig. 3C is a perspective view of the bit head of the first embodiment when viewed from a rear end side.
Fig. 4A is a front view illustrating a state in which the bit head is expanded in diameter in a first modified example of the first embodiment.
Fig. 4B is a plan view illustrating the same enlarged diameter state as in Fig. 4A.
Fig. 4C is a side sectional view illustrating the same enlarged diameter state as in Fig. 4A.
Fig. 5A is a front view illustrating a state in which the bit head of the first modified example illustrated in Fig. 4A is contracted in diameter.
Fig. 5B is a plan view illustrating the same state as in Fig. 5A.
Fig. 6A is a perspective view of a shank device of the modified example illustrated in Fig. 4A.
Fig. 6B is a perspective view of the bit head of the modified example illustrated in Fig. 4A when viewed from a fore end side.
Fig. 6C is a perspective view of the bit head of the modified example illustrated in Fig. 4A when viewed from a rear end side.
Fig. 7A is a front view illustrating a state in which a bit head is expanded in diameter in a second modified example of the embodiment illustrated in Fig. 1A.
Fig. 7B is a plan view illustrating the same state as in Fig 7A.
Fig. 7C is a side sectional view illustrating the same state as in Fig. 7A.
Fig. 8A is a front view illustrating a state in which the bit head of the second modified example illustrated in Fig. 7A is contracted in diameter.
Fig. 8B is a plan view illustrating the same state as in Fig. 8A.
Fig. 9A is a perspective view of a shank device of the modified example illustrated in Fig. 7A.
Fig. 9B is a perspective view of the bit head of the modified example illustrated in Fig. 7A when viewed from a fore end side.
Fig. 9C is a perspective view of the bit head of the modified example illustrated in Fig. 7A when viewed from a rear end side.
Fig. 10A is a front view illustrating a state in which a bit head is expanded in diameter in a third modified example of the embodiment illustrated in Fig. 1A.
Fig. 10B is a plan view illustrating the same state as in Fig. 10A.
Fig. 10C is a side sectional view illustrating the same state as in Fig. 10A.
Fig. 11A is a front view illustrating a state in which the bit head of the third modified example illustrated in Fig. 10A is contracted in diameter.
Fig. 11B is a plan view illustrating the same state as in Fig. 11A.
Fig. 12A is a perspective view of a shank device of the modified example illustrated in Fig. 10A.
Fig. 12B is a perspective view of the bit head of the modified example illustrated in Fig. 10A when viewed from a fore end side.
Fig. 12C is a perspective view of the bit head of the modified example illustrated in Fig. 10A when viewed from a rear end side.
Fig. 13A is a front view illustrating a state in which a bit head is expanded in diameter in an excavation tool according to a second embodiment of the present invention.
Fig. 13B is a plan view illustrating the same state as in Fig. 13A.
Fig. 13C is a side sectional view illustrating the same state as in Fig. 13A.
Fig. 13D is a perspective view illustrating the same state as in Fig. 13A.
Fig. 14A is a front view of a state in which the bit head of the embodiment illustrated in Fig. 13A is contracted in diameter.
Fig. 14B is a plan view illustrating the same state as in Fig. 14A.
Fig. 15A is a perspective view of a shank device of the second embodiment illustrated in Fig. 13A.
Fig. 15B is a perspective view of the bit head of the embodiment illustrated in Fig. 13A when viewed from a fore end side.
Fig. 15C is another perspective view of the bit head of the embodiment illustrated in Fig. 13A when viewed from a fore end side.
Fig. 15D is a perspective view of the bit head of the embodiment illustrated in Fig. 13A when viewed from a rear end side.
Fig. 16A is a front view illustrating a state in which a bit head is expanded in diameter in an excavation tool according to a third embodiment of the present invention.
Fig. 16B is a side sectional view illustrating the same state as in Fig. 16A.
Fig. 16C is a partial front view when viewed in a direction of an arrow X in Fig. 16B.

Fig. 16D is a perspective view of the same state as in Fig. 16A when viewed from a fore end side.

Fig. 16E is a perspective view of the same state as in Fig. 16A when viewed from a rear end side.

Fig. 17A is a front view of a state in which the bit head of the third embodiment illustrated in Fig. 16A is contracted in diameter.

Fig. 17B is a side view of the same state as in Fig. 17A.

Fig. 17C is a partial front view when viewed in a direction of an arrow X in Fig. 17B.

Fig. 17D is a perspective view of the same state as in Fig. 17A when viewed from a fore end side.

Fig. 18A is a perspective view of a shank device of the embodiment illustrated in Fig. 16A.

Fig. 18B is a perspective view of the bit head of the embodiment illustrated in Fig. 16A when viewed from a fore end side.

Fig. 18C is another perspective view of the bit head of the embodiment illustrated in Fig. 16A when viewed from a fore end side.

Fig. 18D is a perspective view of the bit head of the embodiment illustrated in Fig. 16A when viewed from a rear end side.

[Description of Embodiments]

[0023] Figs. 1A to 3C illustrate an excavation tool of a first embodiment of the present invention. The excavation tool of the present embodiment includes a shank device 1 and a plurality (three in this embodiment) of bit heads 3 attached to the shank device 1.

[0024] A main body of the shank device 1 is formed of a metal material such as steel and is formed in a multistage columnar shape or a disc shape in which a fore end part has a diameter larger than that of a rear end part with an axis O as a center. At the rear end part of the shank device 1 having a relatively small diameter, a tapered female screw 1a centered on the axis O which opens to a rear end surface of the shank device 1 and gradually contracts in diameter toward a fore end side is formed. The shank device 1 may be connected, for example, to a high frequency hammer (not illustrated) via a rod (not illustrated) screwed to the tapered female screw 1a so that a striking force directed toward the fore end side in an axis O direction and thrust as necessary is applied to the shank device 1 and the shank device 1 is rotated in a tool rotation direction T about the axis O at the time of drilling.

[0025] A plurality (three in the present embodiment) of recesses 2 are formed at equal intervals in a circumferential direction on an outer circumferential part of the fore end of the shank device 1, and the bit heads 3 are respectively attached to these recesses 2 to be rotatable about a bit center line L disposed away from the axis O to an outer circumferential side. When the shank device 1 is rotated in the tool rotation direction T at the time of drilling, as illustrated in Fig. 1A, each of the bit heads 3 rotates in a direction opposite to the tool rotation direction T, and an outer diameter of the bit head 3 from the axis O expands. After drilling has ended, when the shank device 1 is rotated in a direction opposite to the tool rotation direction T, as illustrated in Fig. 2A, the bit head 3 rotates in the tool rotation direction T so that the outer diameter of the bit head 3 from the axis O is contracted and is accommodated in the recess 2.

[0026] The recess 2 is formed in a substantially rectangular shape extending in the circumferential direction of the shank device 1 when viewed from the fore end side in the axis O direction, and a hole 2a centered on the bit center line L is formed on a side, opposite to the tool rotation direction T, of a bottom surface facing the fore end side in the axis O direction. In the first embodiment, a cylindrical hole having a constant inner diameter centered on the bit center line L is formed on the bottom surface of the recess 2, an intermediate member 4 in a bottomed cylindrical shape is inserted into the hole and attached by press-fitting, shrink-fitting, cold-fitting, adhesion, screw-fitting, or the like, and the inside of the intermediate member 4 serves as the hole 2a. The intermediate member 4 may be formed of, for example, a steel harder than a metal material such as the steel forming a main body of the bit head 3 or the like.

[0027] In the present embodiment, an inner circumferential surface of the hole 2a is formed in a concave circular truncated cone shape which gradually contracts in diameter toward the rear end side in the axis O direction with the bit center line L as the center. In other words, the inner circumferential surface of the hole 2a is formed as an inclined surface inclined at a constant inclination angle α with respect to the bit center line L. The bit center line L is parallel to the axis O in the first embodiment including first to third modified examples to be described below. A bottom surface of the hole 2a facing the fore end side in the axis O direction and the bottom surface of the recess 2 at a portion at which the hole 2a opens are perpendicular to the axis O.

[0028] A corner part at which a wall surface of the recess 2 facing in the tool rotation direction T and a wall surface facing the outer circumferential side of the shank device 1 intersect is formed in a concave cylindrical surface shape with the bit center line L as a center. A locking pin 5 is inserted and fixed in a plane perpendicular to the axis O from the outer circumferential part of the shank device 1 towards the corner part. As illustrated in Fig. 1A, a body part of the locking pin 5 partially protrudes into the corner part and is exposed, and the exposed portion engages with a locking groove 3c formed on a circumferential surface of the bit head 3, thereby preventing the bit head 3 from falling off.

[0029] An annular step part 1b having an larger diameter is formed at a rear end of the outer circumferential surface of the fore end part with a relatively large diameter in the shank device 1, and a fore end surface 1b1 of the step part 1b facing the fore end side in the axis O direction is formed in a convex circular truncated cone shape which is inclined to be directed toward the rear end side in the axis O direction toward the outer circumferential side.

[0030] On the bottom surface of the recess 2 on a front side with respect to the tool rotation direction T, a sludge discharge groove 1c, a depth of which extends toward the outer circumferential side, is formed, and as illustrated in Fig. 1C, the discharge groove 1c extends parallel to the axis O at the outer circumference of the fore end part of the shank device 1 and opens to a rear end surface of the fore end part.

[0031] A blow hole 1d is formed on a bottom surface of the tapered female screw 1a facing the rear end side in the axis O direction and extends toward the fore end side along the axis O. The blow hole 1d branches off into a plurality of portions to be directed toward the outer circumference side toward the fore end side in the axis O direction in the fore end part of the shank device 1, and opens to a bottom surface of the discharge groove 1c facing the fore end side in the axis O direction and to a corner part of the recess 2 at which a wall surface facing a side opposite to the tool rotation direction T and the wall surface facing the outer circumferential side intersect.

[0032] An outer circumferential part of the fore end surface of the shank device 1 is formed as a gauge surface 1f in a circular truncated cone shape which is directed toward the rear end side in the axis O direction toward the outer circumferential side, and a central part of the fore end surface of the shank device 1 is formed as a face surface 1g perpendicular to the axis O. An excavation tip 6 made of a hard material such as cemented carbide having a higher hardness than the main body of the shank device 1 is vertically implanted on these gauge surface 1f and the face surface 1g. A rear end of the excavation tip 6 has a columnar shape, and a fore end thereof has a hemispherical shape.

[0033] The main body of the bit head 3 attached to the shank device 1 is formed of a metal material such as steel as described above and includes a columnar shaft 3a and a rectangular parallelepiped head part 3b provided at a fore end of the shaft 3a. The shaft 3a can be inserted into the hole 2a of the shank device 1 coaxially with the bit center line L. That is, an outer circumferential surface of the shaft 3a is formed in a convex circular truncated cone shape with the bit center line L as a center which gradually contracts in diameter toward the rear end side in the axis O direction, and is formed as an inclined surface inclined at a constant inclination angle α with respect to the bit center line L. The inclination angle α is equal to an inclination angle α formed by the inner circumferential surface of the hole 2a with respect to the bit center line L, and the shaft 3a can be taper-fitted to the hole 2a.

[0034] The head part 3b is provided at a fore end part of the shaft 3a and has a thick plate shape, and has a side surface parallel to the bit center line L. When viewed from the fore end side in the axis O direction, a side surface of the head part 3b includes a semicircular side surface centered on the bit center line L, two extended side surfaces extending from both ends of the semicircular side surface, and an arcuate side surface having a radius of curvature larger than that of the semicircular side surface and connecting end parts of these extended side surfaces on a side opposite to the semicircular side surface.

[0035] In a state in which the shaft 3a is inserted into the hole 2a to be coaxial with the bit center line L as described above, the semicircular side surface of the head part 3b has a radius of curvature equal to or slightly smaller than that of the concave cylindrical surface of the corner part at which the wall surface of the recess 2 facing in the tool rotation direction T and the wall surface facing the outer circumferential side of the shank device 1 intersect each other, and is slidable on the concave cylindrical surface.

[0036] On the semicircular side surface, in a state in which the shaft 3a is inserted into the hole 2a, a locking groove 3c having an arcuate cross section is formed along a plane perpendicular to the bit center line L at a position corresponding to the locking pin 5 exposed to the corner part of the recess 2. A width of the locking groove 3c in a direction of the bit center line L is slightly larger than a width of the exposed locking pin 5 in the direction of the bit center line L.

[0037] In a state in which the shaft 3a of the bit head 3 is inserted into the hole 2a of the shank device 1 in which the locking pin 5 is not inserted, the bit head 3 can rotate about the bit center line L as described above while the outer circumferential surface of the shaft 3a is in sliding contact with the inner circumferential surface of the hole 2a, and the shaft 3a can be pulled out of the hole 2a. In this state, when the locking pin 5 is inserted, the body part of the locking pin 5 exposed in the recess 2 engages with the locking groove 3c, and movement of the shaft 3a in the axis O direction is hindered and the bit head 3 is prevented from coming out while being rotatable.

[0038] A rear end surface of the head part 3b facing the rear end side in the axis O direction is in a plane perpendicular to the bit center line L, and, in a state in which the shaft 3a is inserted into the hole 2a and tapered fitted, a slight clearance is formed between a rear end surface of the shaft 3a and the bottom surface of the hole 2a and between the rear end surface of the head part 3b and the bottom surface of the recess 2 at which the hole 2a opens.

[0039] The bit head 3 locked by the locking pin 5 is rotated about the bit center line L in a direction opposite to the tool rotation direction T as described above while the semicircular side surface of the head part 3b is in sliding contact with the concave cylindrical surface shaped corner part of the recess 2, and in a state in which an outer diameter of the head part 3b from the axis O is expanded, as illustrated in Fig. 1A, the extended side surface of the head part 3b facing a side opposite to the tool rotation direction T comes into contact with the wall surface of the recess 2 facing in the tool rotation direction T and is positioned. At this time, the arcuate side surface of the bit head 3 is disposed on a virtual cylindrical surface centered on the axis O having a larger radius than the fore end part of the shank device 1.

[0040] From this state, the bit head 3 is rotated in the tool rotation direction T about the bit center line L, and when the outer diameter of the head part 3b from the axis O is contracted in diameter, the extended side surface of the head part 3b, which has been facing in the tool rotation direction T, with the diameter expanded is brought into contact with the wall surface of the recess 2 facing the outer circumferential side of the shank device 1 and is positioned as illustrated in Fig. 2A. At this time, the bit head 3 is accommodated in the recess 2 such that the outer diameter of the head part 3b from the axis O is positioned within a virtual cylindrical surface having an outer diameter equal to or less than an outer diameter of a portion 1b2 on a fore end side of the step part 1b of the shank device 1.

[0041] In a state in which the bit head 3 is expanded in diameter, a fore end surface of the head part 3b of the bit head 3 is formed as a gauge portion in a circular truncated cone shape in which an outer circumferential part thereof is directed toward the rear end side in the axis O direction toward the outer circumferential side and an inner circumferential side of the outer circumferential part is formed as a face surface perpendicular to the axis O. The face surface of the fore end surface of the bit head 3 and the face surface of the fore end surface of the shank device 1 are positioned on the same plane in a state in which the shaft 3a of the bit head 3 is taper-fitted to the hole 2a of the shank device 1 as will be described below.

[0042] With the bit head 3 expanded in diameter, a boundary between the gauge surface and the face surface of the fore end surface of the head part 3b is disposed to form an arc continuous to an outer circumference of the portion 1b2 on the fore end side of the step part 1b of the shank device 1 when viewed from the fore end side in the axis O direction as illustrated in Fig. 1A. On these gauge surface and the face surface, the excavation tip 6 made of a hard material such as cemented carbide having a higher hardness than a main body of the bit head 3 is vertically implanted on the gauge surface and the face surface.

[0043] With the head part 3b of the bit head 3 contracted in diameter, the excavation tool configured as above is inserted into a cylindrical casing pipe 7 centered on the axis O from the rear end side in the axis O direction, and the fore end surface of the shank device 1 and the bit head 3 protrude toward the fore end side in the axis O direction from an inner circumferential part of a cylindrical casing top 7a centered on the axis O attached to a fore end part of the casing pipe 7. The casing pipe 7 has an inner diameter slightly larger than an outer diameter of the step part 1b of the fore end part of the shank device 1 and an outer diameter smaller than the outer diameter of the head part 3b of the bit head 3 with the diameter expanded.

[0044] The casing top 7a has an inner diameter smaller than the outer diameter of the step part 1b and slightly larger than an outer diameter of the shank device 1 on the fore end side further than the step part 1b and an outer diameter equal to an outer diameter of the casing pipe 7, and is joined and fixed to the fore end part of the casing pipe 7 by welding or the like. Therefore, the inner circumferential part of the casing top 7a extends to an inner circumferential side at the fore end part of the casing pipe 7, and a rear end surface of the extended portion facing the rear end side in the axis O direction is formed in a circular truncated cone shape which is inclined to be directed toward the rear end side in the axis O direction toward the outer circumferential side at an inclination angle equal to an inclination angle formed by the fore end surface 1b1 of the step part 1b of the shank device 1 with respect to the axis O.

[0045] Therefore, when the excavation tool is coaxially inserted into the casing pipe 7 in a state in which the head part 3b of the bit head 3 is contracted in diameter as described above, the fore end surface of the step part 1b of the shank device 1 comes into contact with the rear end surface of the casing top 7a, and thereby the casing top 7a and the casing pipe 7 can move forward integrally with the shank device 1 toward the fore end side in the axis O direction. In this state, the fore end surface of the shank device 1 and the bit head 3 protrude from the casing top 7a toward the fore end side in the axis O direction. In regards to a circumferential direction, since the fore end surface 1b1 of the step part 1b is in sliding contact with the rear end surface of the casing top 7a, the casing top 7a and the casing pipe 7 do not rotate integrally with the shank device 1.

[0046] In a state in which the fore end of the shank device 1 and the bit head 3 with a contracted diameter protrude from the casing top 7a, when a rotating force in the tool rotation direction T is applied to the shank device 1 while pressing the fore end surfaces of the shank device 1 and the head part 3b of the bit head 3 against bedrock, the bit head 3 rotates in a direction opposite to the tool rotation direction T due to resistance with the bedrock and is positioned, and as illustrated in Fig 1C, the outer diameter of the head part 3b from the axis O expands to be larger than the outer diameter of the casing pipe 7.

[0047] When a striking force directed toward the fore end side in the axis O direction and a thrust as necessary are applied from a high frequency hammer to the shank device 1, the bit head 3 is pushed into the rear end side in the axis O direction, the outer circumferential surface of the shaft 3a is firmly brought into close contact with the inner circumferential surface of the hole 2a of the shank device 1, and the bit head 3 is taper-fitted to and integrated with the shank device 1. That is, in the present embodiment, the bit head 3 can be taper-fitted to the shank device 1 toward the rear end side in the axis O direction. Therefore, the striking force is transmitted from the shank device 1 to the bit head 3 which are integrated with each other, an excavation hole is formed in bedrock by the excavation tip 6 implanted on the fore end surfaces of the shank device 1 and the bit head 3 together with the rotational force, and the casing pipe 7 which can move forward integrally with the shank device 1 to the fore end side in the direction of the axis O is inserted into the excavation hole.

[0048] When the excavation hole is formed in this manner, compressed air or the like is supplied to the blow hole 1d to eject air or the like to the discharge groove 1c and the recess 2, and sludge which is fine earth and sand generated by the excavation tip 6 is discharged. When an excavation hole is formed to a predetermined depth and the drilling has ended, first, the shank device 1 and the bit head 3 are moved back and the rear end surface of the head part 3b is brought into contact with the fore end of the casing top 7a, and thereby the bit head 3 is pushed out toward the fore end side in the axis O direction to release the tapered fitting with the shank device 1.

[0049] Next, when the shank device 1 is rotated in a direction opposite to the tool rotation direction T at the time of drilling while the rear end surface of the head part 3b is pressed against the fore end of the casing top 7a, due to friction with the casing top 7a, the bit head 3 rotates in a direction opposite to the tool rotation direction T and is positioned. When the head part 3b is accommodated in the recess 2 and the outer diameter from the axis O becomes smaller than an outer diameter of the portion on the fore end side of the step part 1b of the shank device 1, the excavation tool can be recovered by moving back the shank device 1 in this state. The casing pipe 7 may be left as it is in the excavation hole to be used for preventing the excavation hole from collapsing or may be recovered by being pulled out of the excavation hole after inserting a reinforcing material into the inner circumferential portion.

[0050] As described above, in the excavation tool having the above-described configuration, the bit head 3 can be taper-fitted to the shank device 1 by the inclined surface (the convex circular truncated cone shaped outer circumferential surface of the shaft 3a in the first embodiment) of the bit head 3 inclined with respect to the bit center line L, and thereby the bit head 3 is firmly integrated with the shank device 1 and a tool rigidity can be improved at the time of drilling. Therefore, a striking force from the shank device 1 can be efficiently transmitted to the bit head 3, and thereby excavation efficiency can be improved and, for example, even hard bedrock can be drilled.

[0051] The bit head 3 does not vibrate due to a striking force transmitted from the shank device 1 to the bit head 3, and damage to a service life of the tool due to friction and abrasion of a striking force transmission surface can be prevented. By suppressing friction and abrasion due to such vibration, a striking force from the high frequency hammer as described above can be transmitted and thus more efficient drilling can be promoted.

[0052] Further, in the present embodiment, the outer circumferential surface of the shaft 3a of the bit head 3 inserted into the hole 2a of the shank device 1 is formed as an inclined surface inclined with respect to the bit center line L in a convex circular truncated cone shape in which the outer diameter gradually contracts toward the rear end side in the axis O direction, the shaft 3a is in close contact with the inner circumferential surface of the hole 2a in a concave circular truncated cone shape on the shank device 1 side in which the inner diameter gradually contracts toward the rear end side in the direction of the axis O in the same manner, and thereby the bit head 3 is taper-fitted to the shank device 1. Therefore, transmission of a striking force applied to the shank device 1 to the bit head 3 via the bottom surface of the hole 2a and the rear end surface of the shaft 3a or the bottom surface of the recess 2 and the rear end surface of the head part 3b as in the conventional case is eliminated, and since a clearance can be formed between these bottom surfaces and the rear end surfaces as described above, damage due to friction can be more reliably prevented.

[0053] When the outer circumferential surface of the shaft 3a of the bit head 3 is brought into close contact with the inner circumferential surface of the hole 2a on the shank device 1 side and the bit head 3 is taper-fitted to the shank device 1, it is preferable that the inclination angle (single angle) α with respect to the bit center line L of these inner and outer circumferential surfaces be in a range of 3° to 10°. When the inclination angle α is larger than the above-described range, the tapered fitting tends to be released due to a striking force, and there is a likelihood that vibration of the bit head 3 cannot be prevented and a tool rigidity cannot be improved, and when the inclination angle α is smaller than the above-described range, the tapered fitting becomes too strong, and there is a likelihood that the bit head 3 cannot be easily expanded and contracted in diameter.

[0054] In the present embodiment, since the hole 2a is formed in the intermediate member 4 attached to a hole with a constant inner diameter formed on the bottom surface of the recess 2 of the shank device 1, when abrasion occurs in the hole 2a or the shaft 3a while the bit head 3 repeats expansion and contraction in diameter, the bit head 3 or the intermediate member 4 may be replaced, and the main body of the shank device 1 itself can be used over a longer period of time. Particularly, in the present embodiment, since the intermediate member 4 is made of a material having a hardness higher than that of the main body of the bit head 3, abrasion due to expansion and contraction in diameter occurs only in the bit head 3, and thus a service life of the shank device 1 including the intermediate member 4 can be prolonged. In the present embodiment, the intermediate member 4 is formed in a bottomed cylindrical shape but may have a cylindrical shape with no bottom, a ring shape, or a C-shaped cross section.

[0055] Next, Figs. 4A to 6C, Figs. 7A to 9C, and Figs. 10A to 12C respectively illustrate first to third modified examples of the first embodiment, and portions common to those in the first embodiment illustrated in Figs. 1A to 3C are denoted by the same reference signs, and description thereof will be omitted. The same applies to second and third embodiments to be described below.

[0056] The first modified example illustrated in Figs. 4A to 6C is an example in which the intermediate member 4 is not attached to the shank device 1 and the hole 2a is formed directly on the bottom surface of the recess 2.

[0057] The second modified example illustrated in Figs. 7A to 9C is an example in which the intermediate member 4 is not attached to the shank device 1, and the locking groove 3c of the bit head 3 is not formed on the side surface of the head part 3b but formed in an annular shape on the outer circumferential surface of the shaft 3a. In this case, the locking pin 5 is inserted into the shank device 1 and fixed so that a body part of the locking pin 5 of the shank device 1 partially protrudes to a position corresponding to the locking groove 3c of the hole 2a.

[0058] In the first embodiment and the first and second modified examples, the tapered female screw 1a is formed at the rear end part of the shank device 1 to transmit a striking force and a rotational force to the shank device 1. In contrast, in the third modified example illustrated in Figs. 10A to 12C, a shank part 1e extending toward a rear end side along the axis O is integrally formed at a rear end part of the shank device 1. In this case, a striking force and a rotational force from a down-the-hole hammer or the like attached to the shank part 1e are transmitted to the shank device 1. Grooves extending in the axis O direction are formed at regular intervals in the circumferential direction on an outer circumference of the shank part 1e and engaged with the down-the-hole hammer or the like to be relatively non-rotatable.

[0059] Figs. 13A to 15D illustrate a second embodiment of the present invention, and Figs. 16A to 18D illustrate a third embodiment of the present invention. In the first embodiment and the first to third modified examples described above, the outer circumferential surface of the shaft 3a of the bit head 3 is formed as an inclined surface inclined with respect to the bit center line L and is close contact with the inner circumferential surface of the hole 2a which is an inclined surface inclined with respect to the bit center line L in the same manner, and thereby the bit head 3 can be taper-fitted to the shank device 1. In contrast, in the second and third embodiments, a bit head 3 can be taper-fitted to a shank device 1 toward a direction opposite to a tool rotation direction T at the time of drilling.

[0060] In the second embodiment, a bit center line L is parallel to an axis O of the shank device 1, and a protruding part 3d is formed on a rear end side in an axis O direction of a side surface of a head part 3b facing a side opposite to the tool rotation direction T in an enlarged diameter state. A rear end surface of the protruding part 3d facing the rear end side in the axis O direction is on the same plane with a rear end surface of the head part 3b and is a flat surface perpendicular to the bit center line L. In the enlarged diameter state, a fore end surface 3e of the protruding part 3d facing a fore end side in the axis O direction is formed as an inclined surface inclined with respect to the bit center line L and extending toward the rear end side in the axis O direction (that is, on a rear end surface side of the protruding part 3d) toward a direction opposite to the tool rotation direction T.

[0061] A recess 2b capable of accommodating the protruding part 3d is formed in a recess 2 of the shank device 1 on the rear end side in the axis O direction of a wall surface facing in the tool rotation direction T. A bottom surface of the recess 2b facing the fore end side in the axis O direction is on the same plane with a bottom surface of the recess 2 facing the fore end side in the axis O direction and is a flat surface perpendicular to the bit center line L. On the other hand, a ceiling face 2c of the recess 2b facing the rear end side in the axis O direction to face the bottom surface is formed as an inclined surface inclined with respect to the bit center line L extending toward the rear end side in the axis O direction (that is, on a bottom surface side of the recess 2b) toward a direction opposite to the tool rotation direction T.

[0062] In the second embodiment, an inclination angle β formed by the fore end surface 3e of the protruding part 3d with respect to the rear end surface of the protruding part 3d and an inclination angle β formed by the ceiling face 2c of the recess 2b with respect to the bottom surface of the recess 2b are equal to each other, and are within, for example, a range of 6° to 20°. As illustrated in Fig. 13B and Fig. 13D, the fore end surface 3e and the ceiling face 2c are in close contact (surface contact) with each other in an enlarged diameter state. Thereby, the bit head 3 is taper-fitted to the shank device 1 toward a direction opposite to the tool rotation direction T at the time of drilling. That is, in the present embodiment, the bit head 3 can be taper-fitted to the shank device 1 toward a direction opposite to the tool rotation direction T at the time of drilling.

[0063] In the second embodiment and the third embodiment, the hole 2a of the shank device 1 has a constant inner diameter, and the shaft 3a of the bit head 3 has a columnar shape centered on the bit center line L that can be fitted into the hole 2a. A locking groove 3c is annularly formed on an outer circumferential surface of the shaft 3a, a locking pin 5 is inserted into the shank device 1 so that a body part of the locking pin 5 partially protrudes to a position corresponding to the locking groove 3c of the hole 2a, and thereby the bit head 3 is fixed. Even when the hole 2a of the shank device 1 has a constant inner diameter as described above, the hole 2a may be formed on a cylindrical intermediate member 4 attached to the shank device 1. In a reduced diameter state, the head part 3b of the bit head 3 is accommodated in the recess 2 including the protruding part 3d, and an outer diameter from the axis O is equal to or less than an outer diameter of a portion 1b2 on a fore end side of a step part 1b of the shank device 1.

[0064] In the second embodiment, when the shank device 1 is rotated in the tool rotation direction T and the bit head 3 is rotated in a direction opposite to the tool rotation direction T at the time of starting drilling, the protruding part 3d of the head part 3b is accommodated in the recess 2b of the recess 2 and the fore end surface 3e of the protruding part 3d is in close contact with the ceiling face 2c of the recess 2b. Thereby, the shank device 1 and the bit head 3 are taper-fitted. After drilling has ended, simply by rotating the shank device 1 in a direction opposite to the tool rotation direction T at the time of drilling, the bit head 3 rotates in the tool rotation direction T due to resistance from a bottom surface of an excavation hole. As a result, the fore end surface 3e is separated from the ceiling face 2c, the protruding part 3d is pulled out of the recess 2b, and the taper-fitting is released.

[0065] Accordingly, also in the second embodiment, similarly to the first embodiment, a tool rigidity can be improved by taper-fitting the bit head 3 to the shank device 1 at the time of drilling, and thereby a service life of the tool can be prolonged due to improvement in excavation efficiency and suppression of abrasion and friction and the tool can also be used for excavation using a high frequency hammer.

[0066] In the second embodiment, it is unnecessary to release the taper-fitting by bringing the rear end surface of the head part 3b of the bit head 3 into contact with the fore end of the casing top 7a as in the first embodiment, the shank device 1 need only be rotated in a direction opposite to the tool rotation direction T at the time of drilling similarly to a case in which a normal diameter expansion bit is contracted, and thereby damage to the bit head 3 can be more reliably prevented.

[0067] In the second embodiment, the inclination angle β formed by the fore end surface 3e of the protruding part 3d with respect to the rear end surface of the protruding part 3d and the inclination angle β formed by the ceiling face 2c of the recess 2b with respect to the bottom surface of the recess 2b are preferably within a range of 6° to 20° as described above. When the inclination angle β is larger than the above-described range, the tapered fitting tends to be released due to a striking force, and there is a likelihood that vibration of the bit head 3 cannot be prevented and a tool rigidity cannot be improved. When the inclination angle β is smaller than the above-described range, the tapered fitting becomes too strong, and there is a likelihood that the bit head 3 cannot be easily expanded and contracted in diameter.

[0068] On the other hand, in the third embodiment, similarly to the second embodiment, the protruding part 3d having the fore end surface 3e which is an inclined surface inclined with respect to the bit center line L is formed at the head part 3b of the bit head 3, the recess 2b having the ceiling face 2c is formed in the recess 2 of the shank device 1, and these fore end surface 3e and the ceiling face 2c are brought into close contact with each other as illustrated in Fig. 13B and Fig. 13D in an enlarged diameter state. Thereby, the bit head 3 can be taper-fitted to the shank device 1 toward a direction opposite to the tool rotation direction T.

[0069] However, in the third embodiment, as illustrated in Fig. 16B and Fig. 17B, the bit center line L is inclined with respect to a plane perpendicular to the axis O of the shank device 1. That is, in the third embodiment, the bit center line L is inclined to the tool rotation direction T at the time of drilling toward the rear end side in the axis O direction. In accordance with this, a wall surface of the recess 2 facing in the tool rotation direction T in which the hole 2a and the recess 2b of the shank device 1 are formed and the shaft 3a of the bit head are also inclined to face in the tool rotation direction T at the time of drilling toward the rear end side in the axis O direction. Further, the bottom surface of the recess 2 and the rear end surface of the head part 3b of the bit head 3 are inclined to face the rear end side in the axis O direction toward a direction opposite to the tool rotation direction T at the time of drilling.

[0070] In a state in which the head part 3b is rotated in a direction opposite to the tool rotation direction T and positioned at the time of drilling, the above-described arcuate side surface of the head part 3b of the bit head 3 is formed in a trapezoidal shape in which the tool rotation direction T side is narrow as illustrated in Fig. 16B so that a face surface of the fore end surface thereof is positioned on the same plane with a face surface of the shank device 1. In a reduced diameter state, as illustrated in Fig. 17B, the head part 3b is disposed so that the above-described arcuate side surface protrudes toward the fore end side in the axis O direction with respect to the fore end surface of the shank device 1. In the reduced diameter state, the fact that an outer diameter of the head part 3b from the axis O is smaller than an outer diameter of the portion 1b2 on a fore end side of the step part 1b of the shank device 1 is the same as in the second embodiment.

[0071] In the third embodiment, similarly to the second embodiment, by rotating the shank device 1 in the tool rotation direction T to rotate the bit head 3 in a direction opposite to the tool rotation direction T at the start of drilling, the fore end surface 3e of the protruding part 3d is brought into close contact with the ceiling face 2c of the recess 2b, and thereby the bit head 3 can be taper-fitted to the shank device 1 toward a direction opposite to the tool rotation direction T. Further, when resistance from bedrock is directed toward the rear end side in the axis O direction and acts on the bit head 3 at the time of drilling, the head part 3b is pushed along the bottom surface of the recess 2 in a direction opposite to the tool rotation direction T, and the fore end surface 3e is strongly brought into close contact with the ceiling face 2c. Therefore, the shank device 1 and the bit head 3 can be more firmly taper-fitted. That is, in the third embodiment, the bit head 3 can be taper-fitted to the shank device 1 toward a direction opposite to the tool rotation direction T at the time of drilling, and can also be taper-fitted to the shank device 1 toward the rear end side in the axis

O direction.

[0072] Therefore, according to the third embodiment, a tool rigidity can be further improved to increase a hole boring rate, friction and abrasion can be more reliably suppressed to prolong a service life of the tool, and the tool can cope with use of a higher frequency hammer. Also in the third embodiment, at the end of drilling, by rotating the shank device 1 in a direction opposite to the tool rotation direction T at the time of drilling, the head part 3b of the bit head 3 rotates in the tool rotation direction T to release the tapered fitting, the head part 3b is accommodated in the recess 2, and the excavation tool can be recovered.

[Industrial Applicability]

[0073] According to the present invention, it is possible to improve a tool rigidity, and thereby excavation efficiency can be improved. In addition, a service life of the tool can be prolonged by suppressing friction and abrasion, and the tool can also be used for drilling hard bedrock or for excavation using a high frequency hammer. Therefore, the present invention is industrially applicable.

[Reference Signs List]

[0074]

1 Shank device
1a Tapered female screw
1b Step part
1e Shank part
2 Recess
2a Hole
2b Recess
2c Ceiling face of recess 2b (inclined surface)
3 Bit head
3a Shaft
3b Head part
3d Protruding part
3e Fore end surface of protruding part 3d (inclined surface)
4 Intermediate member
6 Excavation tip
7 Casing pipe
7a Casing top
O Axis of shank device 1
L Bit center line
T Tool rotation direction (rotation direction of shank device 1 at the time of drilling)

Claims

1. An excavation tool comprising:

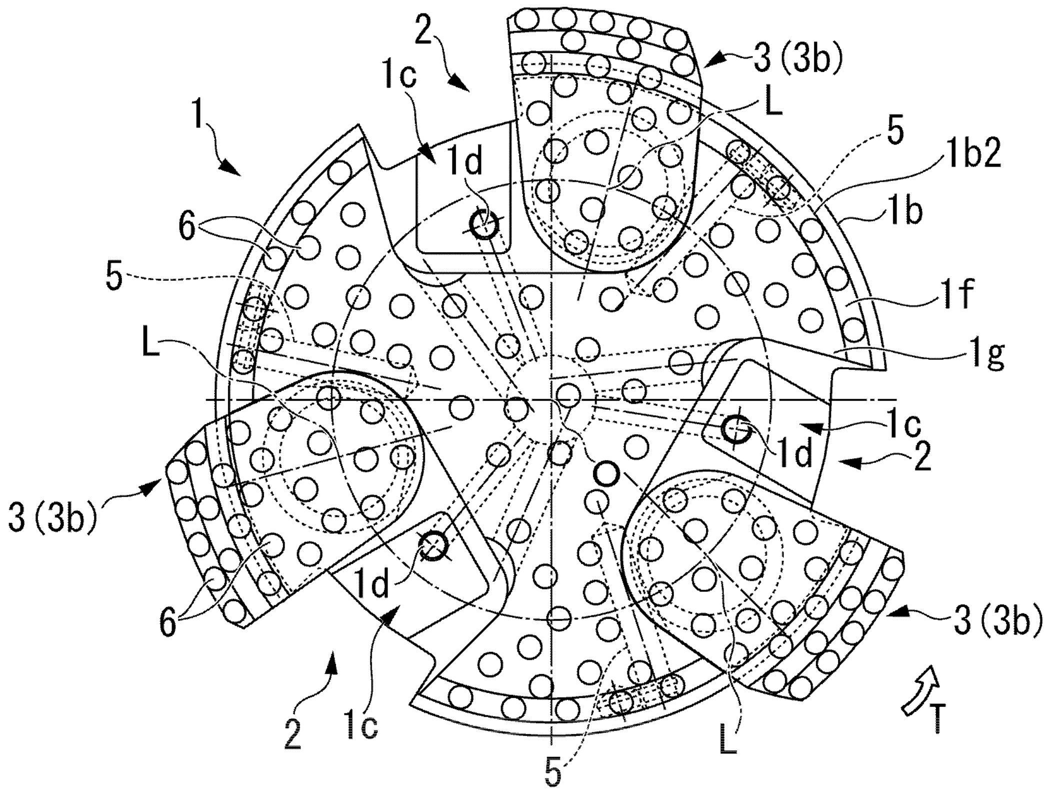
   a shank device which is rotated about an axis thereof and to which a striking force is applied to a fore end side in an axial direction; and
   a bit head attached to a fore end part of the shank device and rotatable about a bit center line disposed away from the axis toward an outer circumferential side, wherein
   the bit head which is able to be taper-fitted to the shank device by an inclined surface inclined with respect to the bit center line.

2. The excavation tool according to claim 1, wherein the bit head is able to be taper-fitted to the shank device toward a rear end side in the axial direction.

3. The excavation tool according to claim 2, wherein a shaft to be inserted into a hole of the shank device is provided in the bit head,
   an outer circumferential surface of the shaft is formed as an inclined surface inclined with respect to the bit center line, and the inclined surface gradually reduces in diameter toward the rear end side, and
   the hole of the shank device is formed in an intermediate member attached to the shank device.

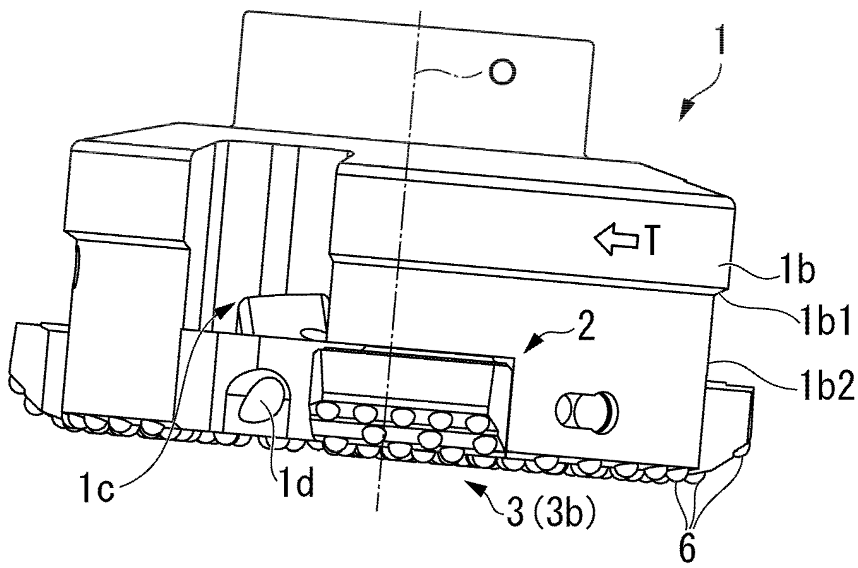
4. The excavation tool according to any one of claim 1 to 3, wherein
   the bit head is able to be taper-fitted to the shank device toward a direction opposite to a rotation direction of the shank device at the time of drilling.

FIG. 1A



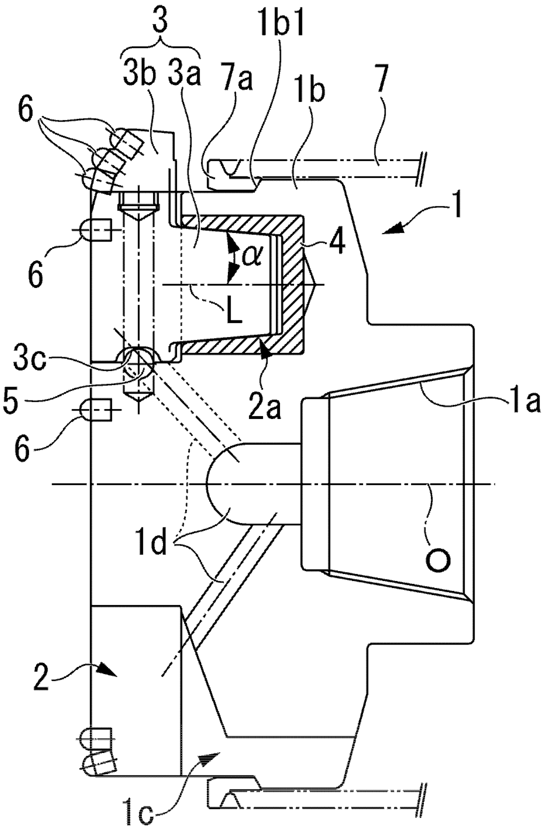
1
2
1c
1d
3 (3b)
L
5
1b2
1b
6
5
1f
1g
L
1c
1d
2
3 (3b)
1d
6
3 (3b)
2
1c
5
L
T

FIG. 1B



O
1
T
1b
1b1
2
1b2
1c
1d
3 (3b)
6

FIG. 1C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3a
1b1
7a
1b
7
6
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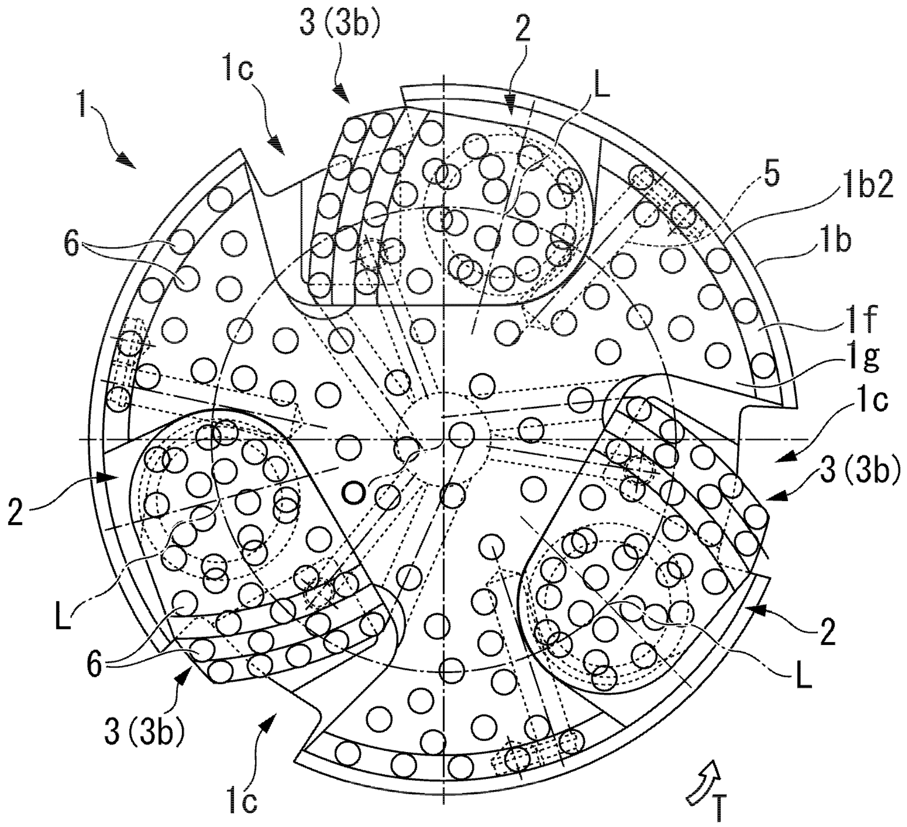
4
α
6
L
3c
2a
5
1a
6
1d
O
2
1c

FIG. 2A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1c
L
1
5
1b2
6
1b
1f
1g
1c
3 (3b)
2
O
L
2
6
L
3 (3b)
1c
T

FIG. 2B

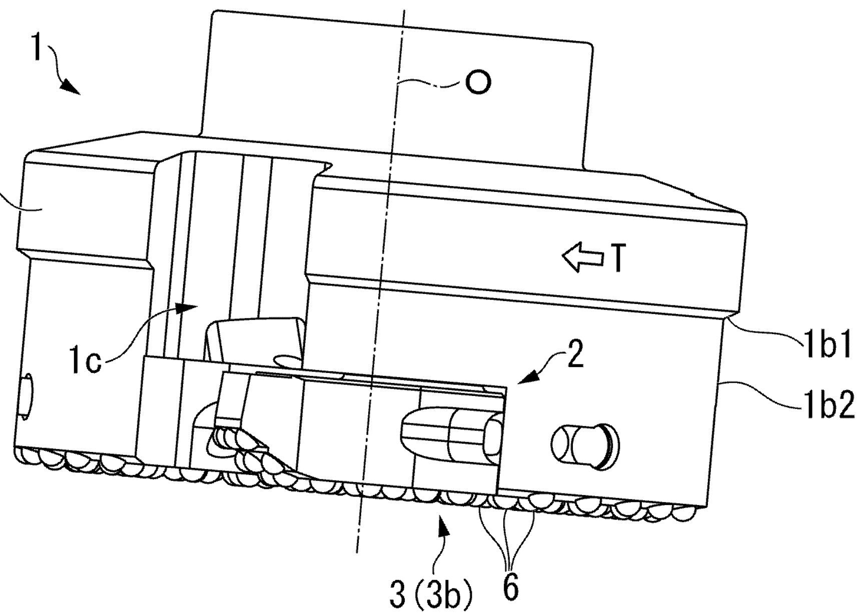


FIG. 3A

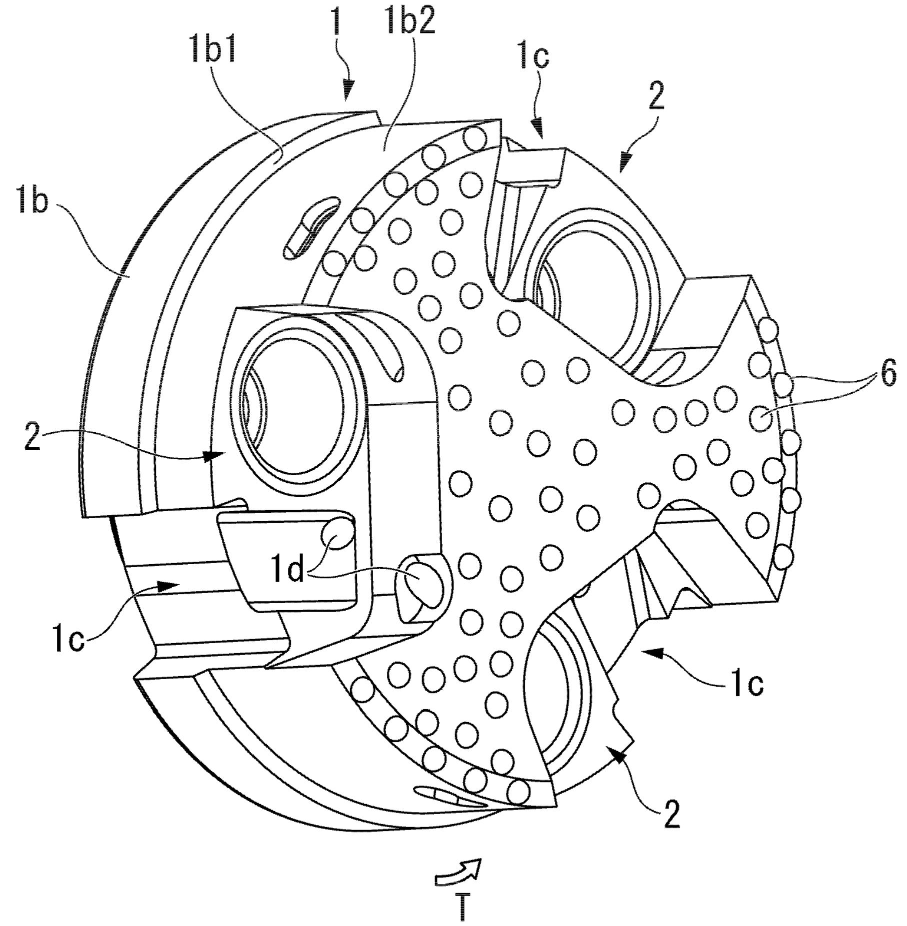


FIG. 3B

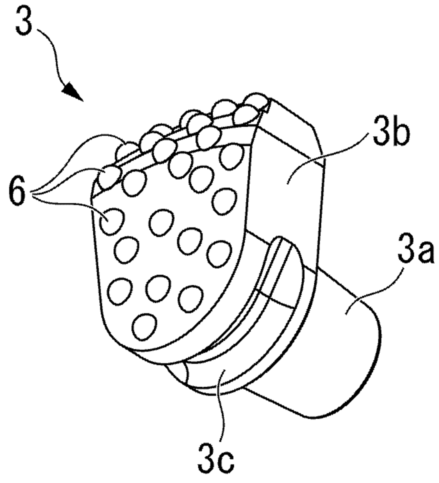


FIG. 3C

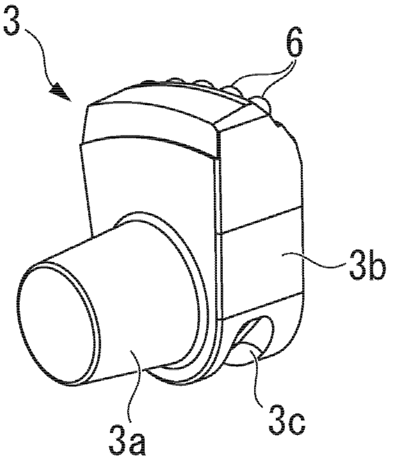
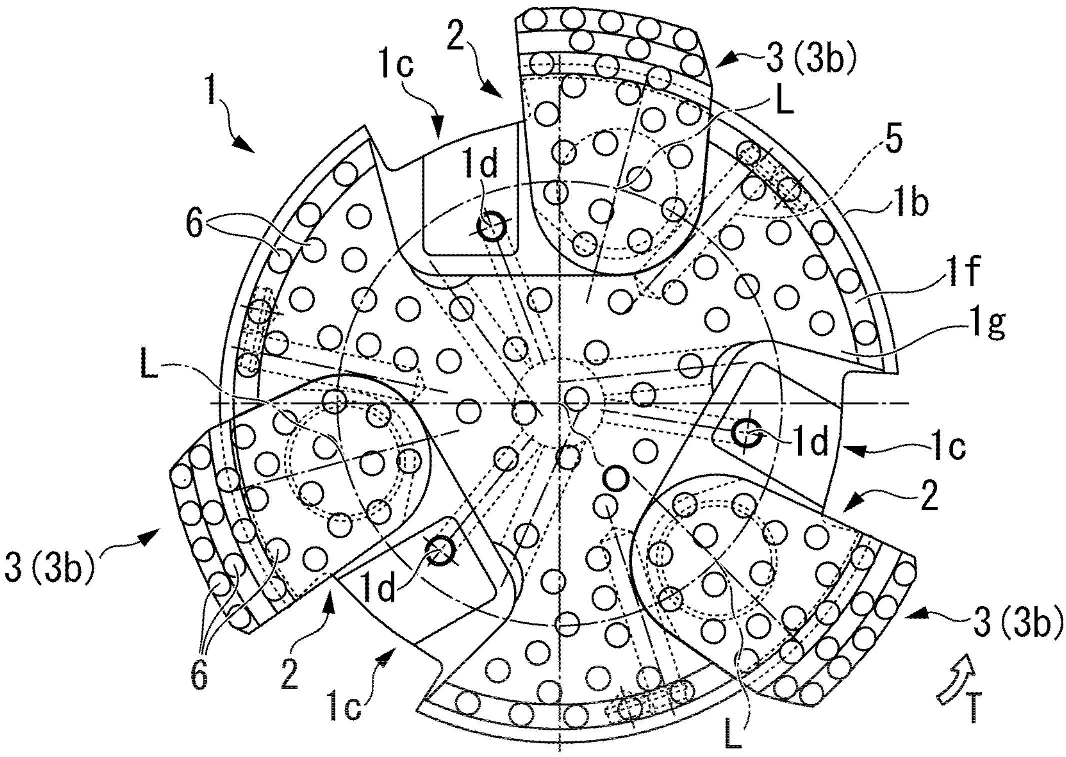
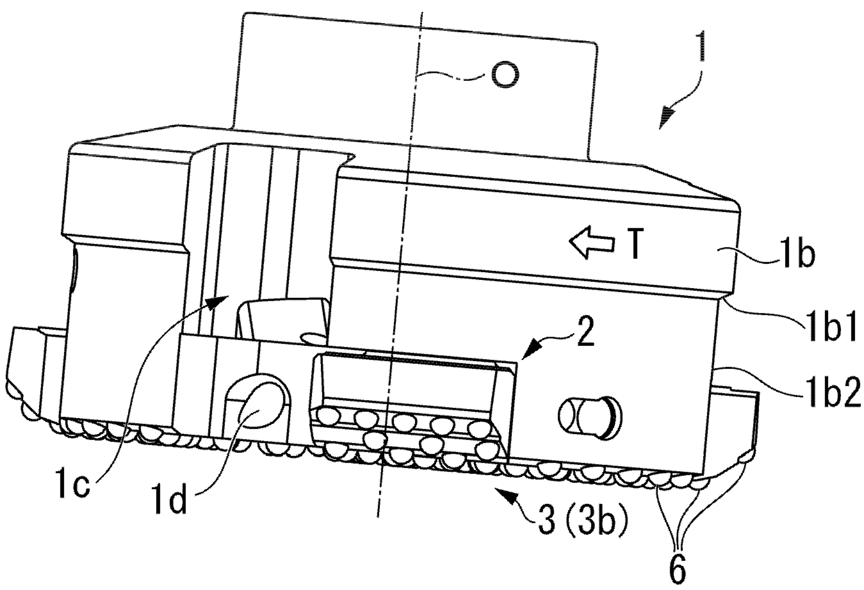


FIG. 4A



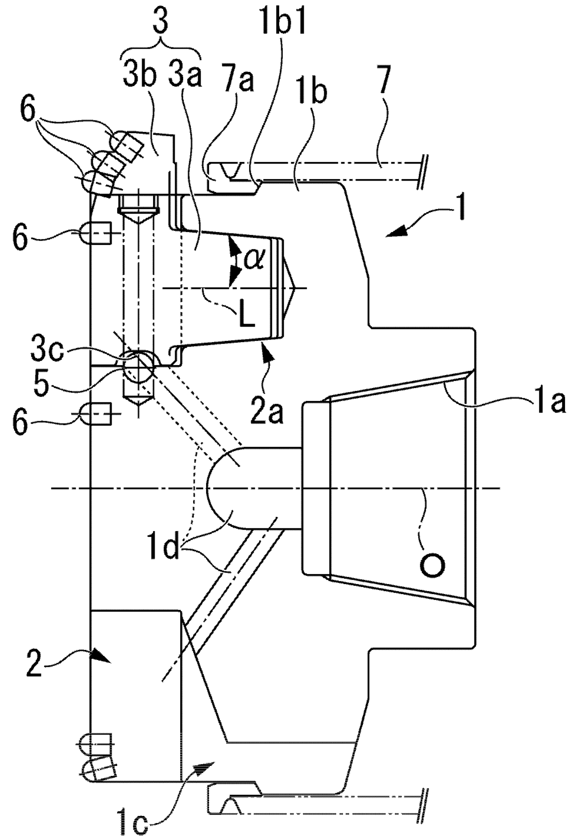
1
1c
2
3 (3b)
L
5
1b
1d
6
1f
1g
L
1d
1c
2
3 (3b)
1d
2
6
2
1c
L
3 (3b)
T

FIG. 4B



1
T
1b
1b1
2
1b2
1c
1d
3 (3b)
6

FIG. 4C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7a
1b1
1b
7
6
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6
α
L
3c
5
2a
6
1a
1d
O
2
1c

FIG. 5A

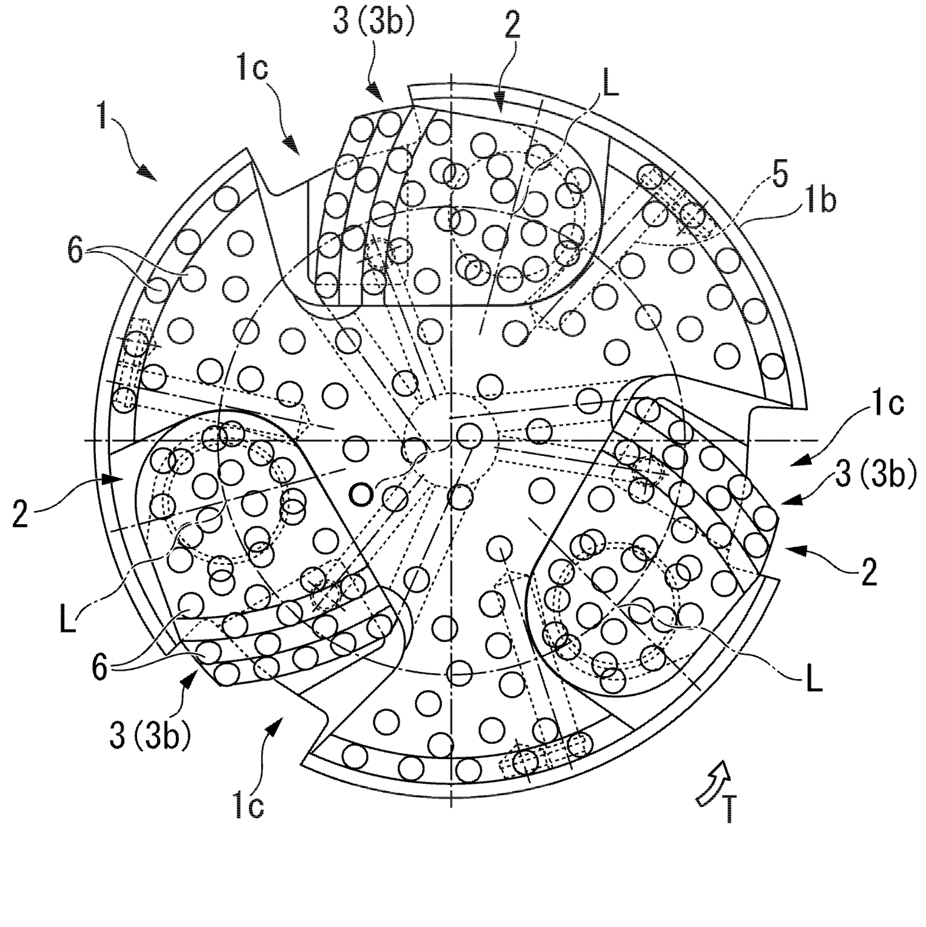

3 (3b)
2
1c
L
1
5
1b
6
1c
3 (3b)
2
O
2
L
6
L
3 (3b)
1c
T

FIG. 5B

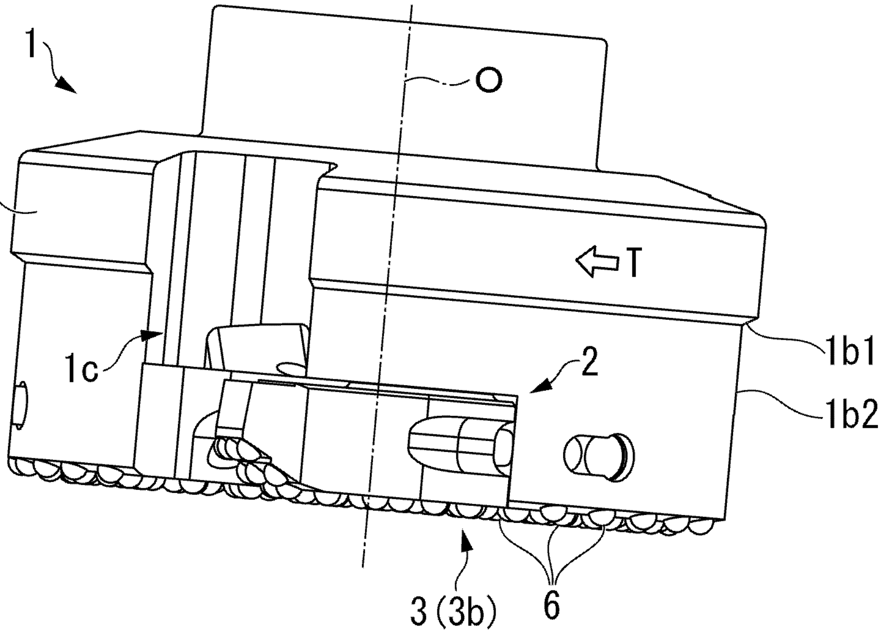


FIG. 6A

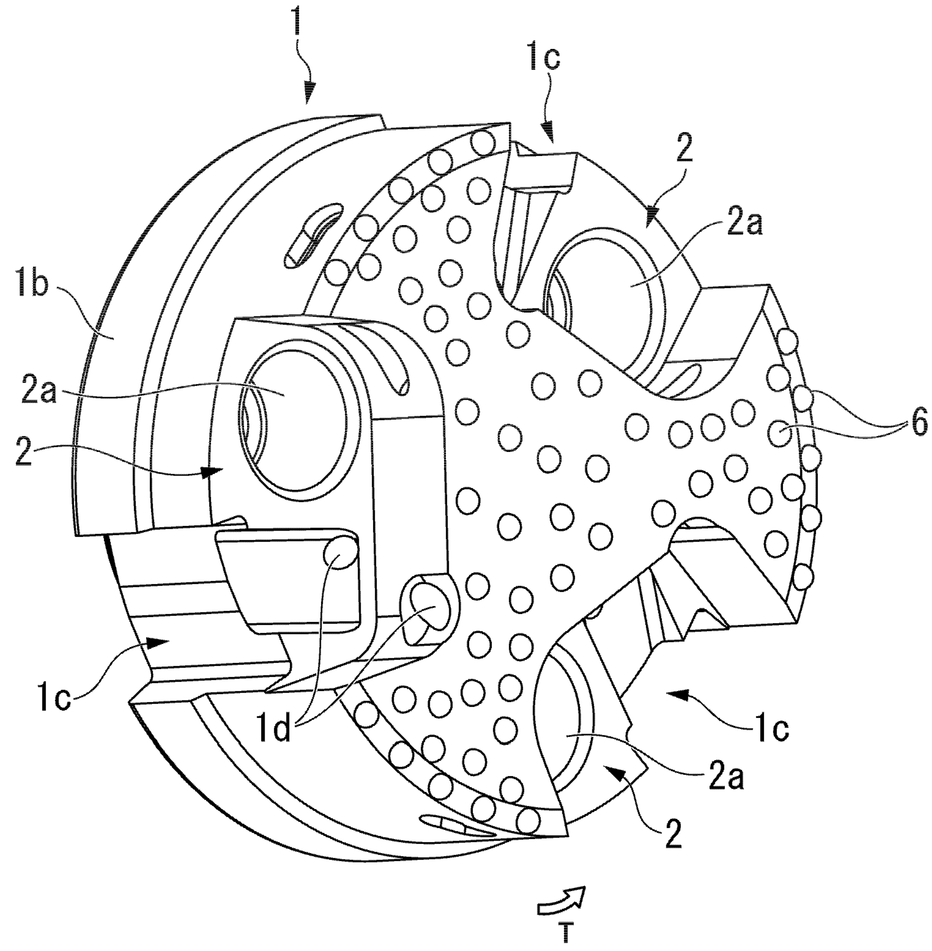


FIG. 6B

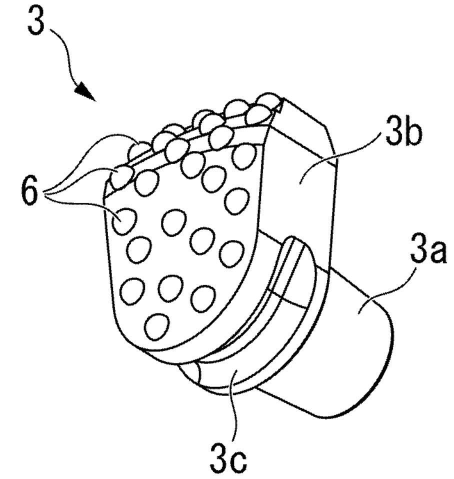


FIG. 6C

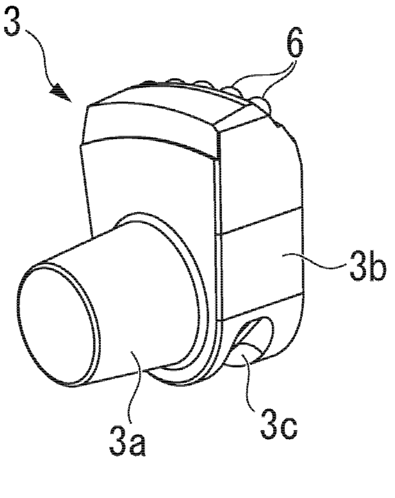


FIG. 7A

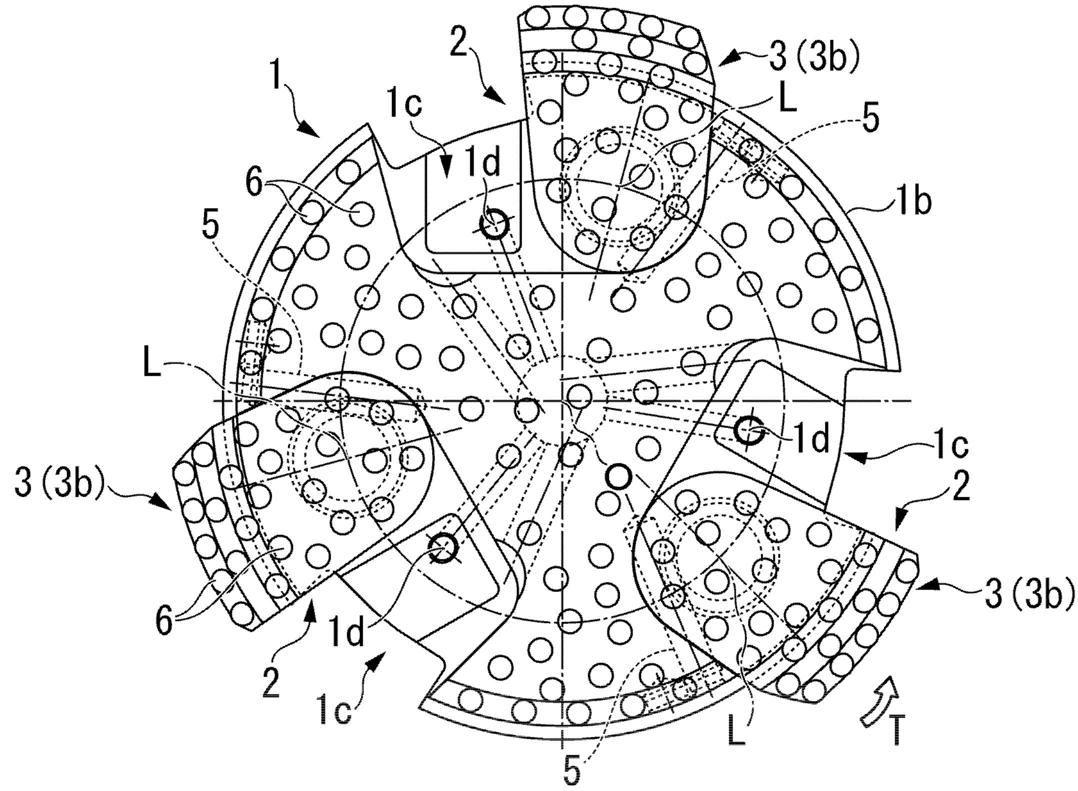

1
2
1c
1d
3 (3b)
L
5
6
1b
5
L
1d
1c
2
3 (3b)
3 (3b)
6
1d
2
1c
5
L
T

FIG. 7B

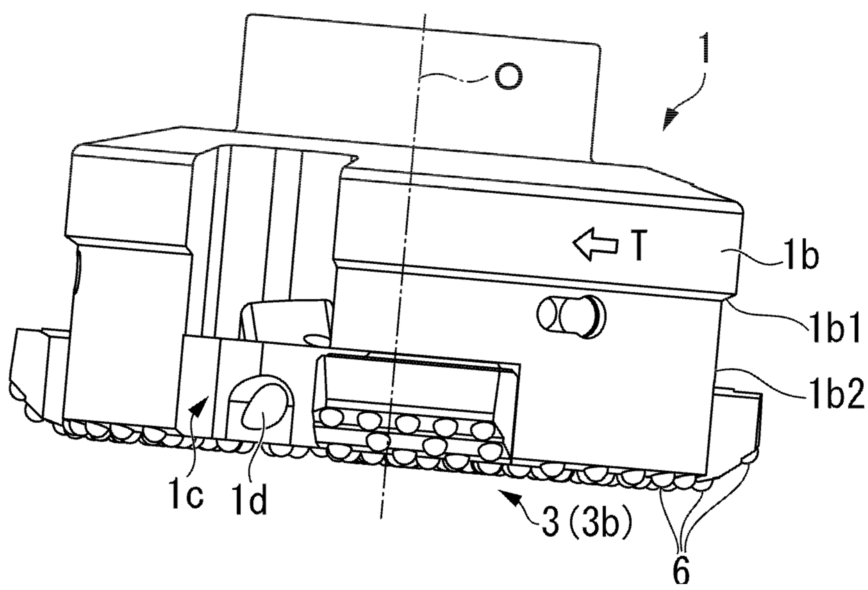

O
1
T
1b
1b1
1b2
1c
1d
3 (3b)
6

FIG. 7C

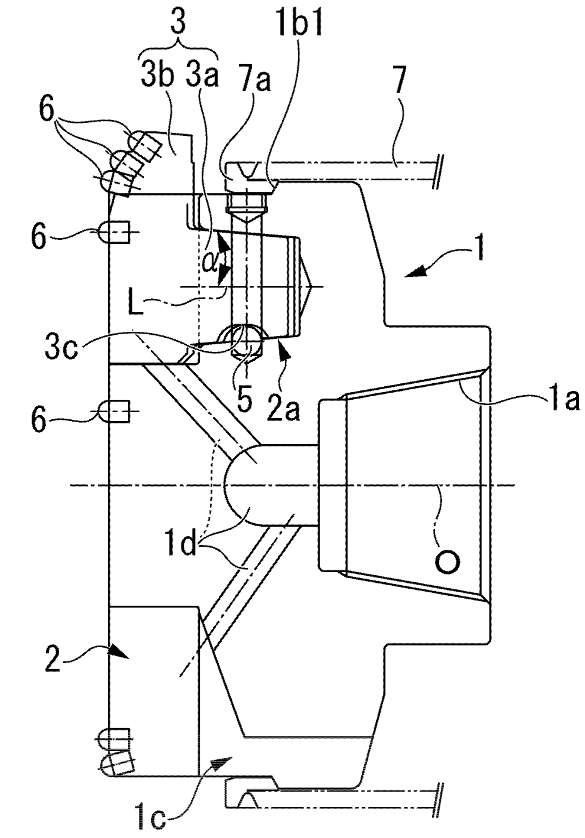

3
3b 3a
1b1
7a
7
6
6
α
L
1
3c
5
2a
6
1a
1d
O
2
1c

FIG. 8A

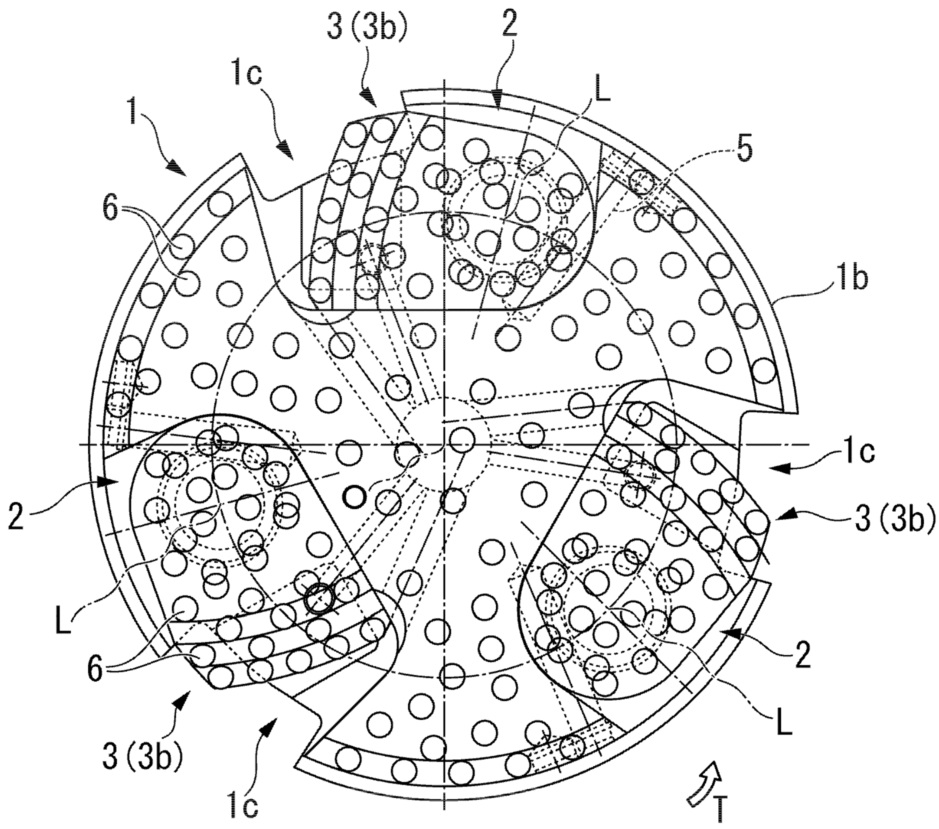

3 (3b)
2
1c
L
1
5
6
1b
1c
2
3 (3b)
O
L
2
6
L
3 (3b)
1c
T

FIG. 8B

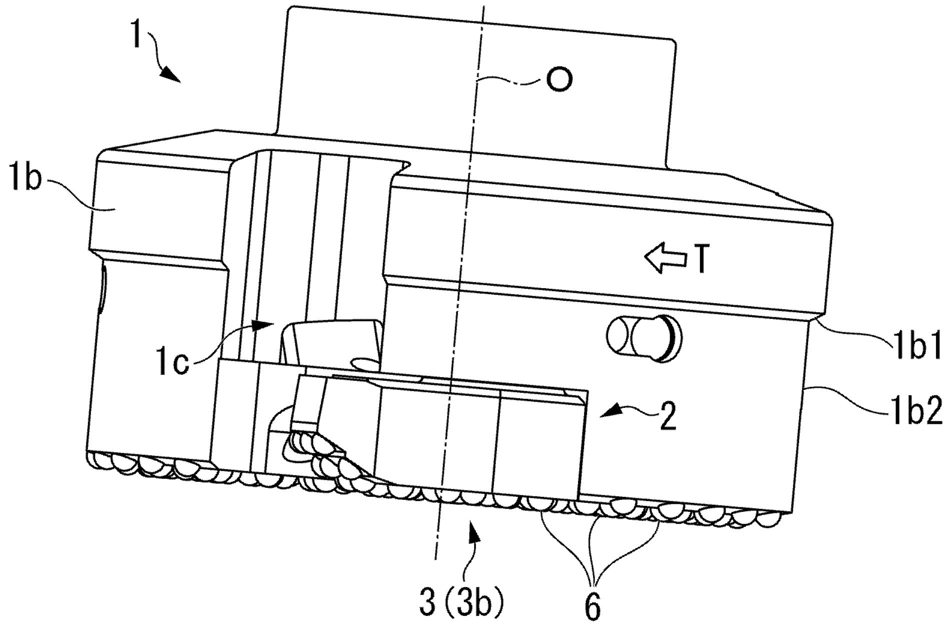


FIG. 9A

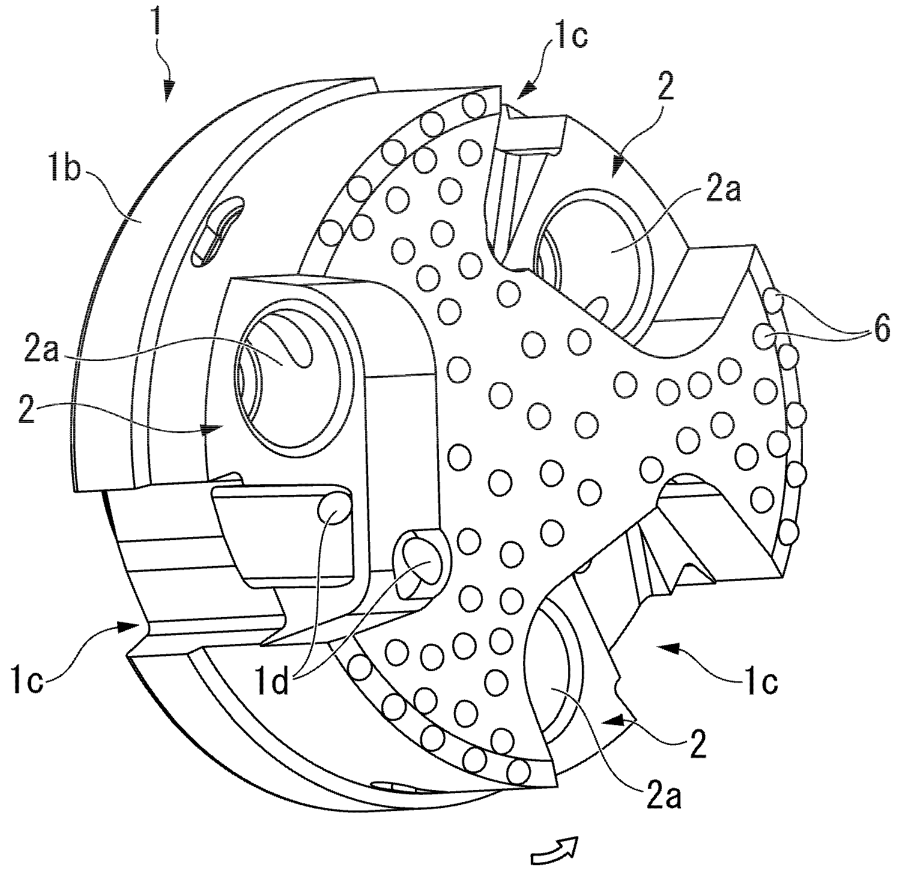


FIG. 9B

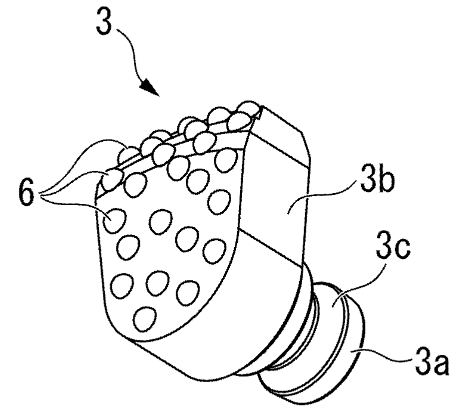


FIG. 9C

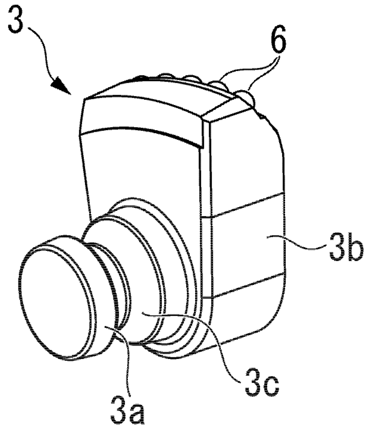


FIG. 10A

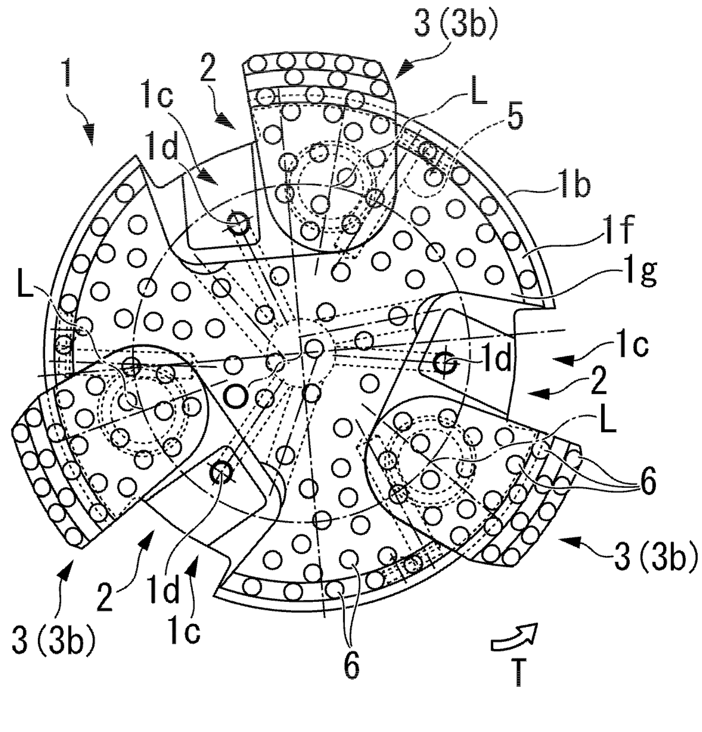


FIG. 10B

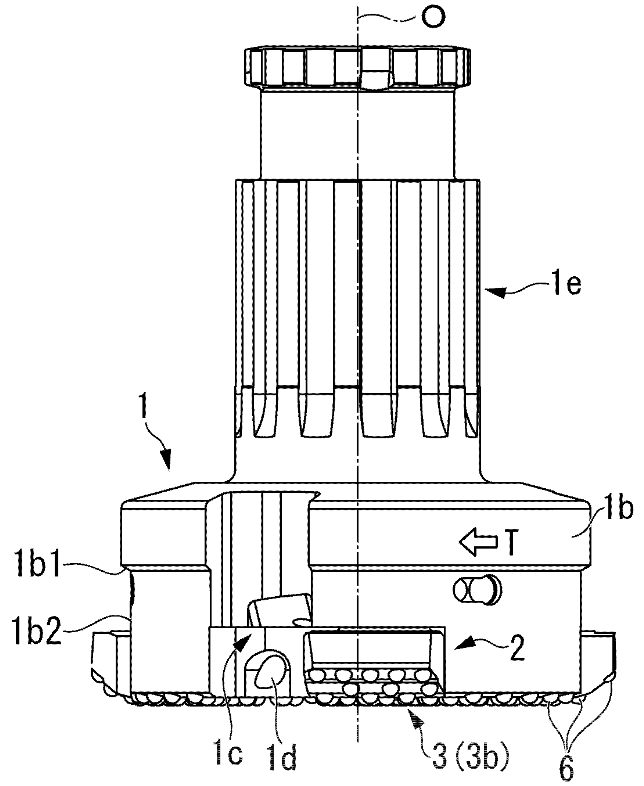


FIG. 10C

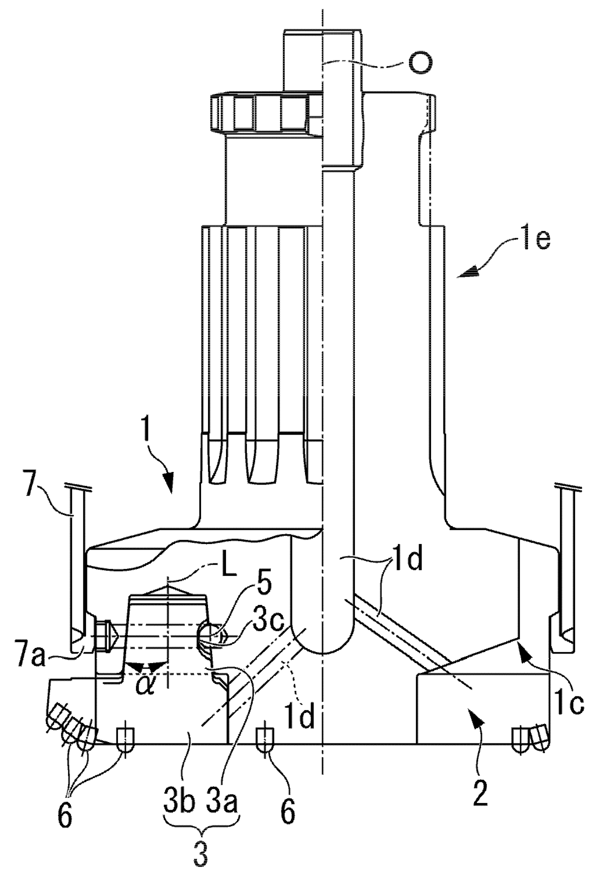


FIG. 11A

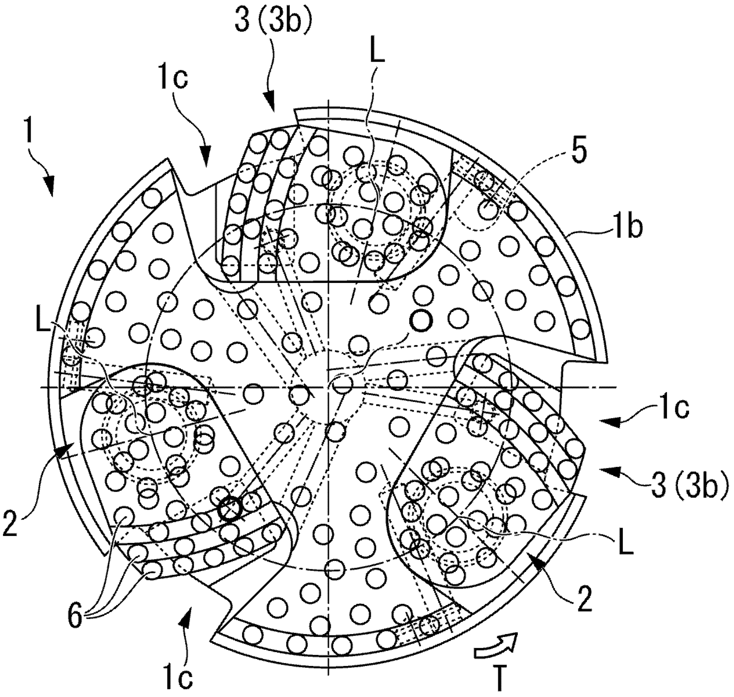


FIG. 11B

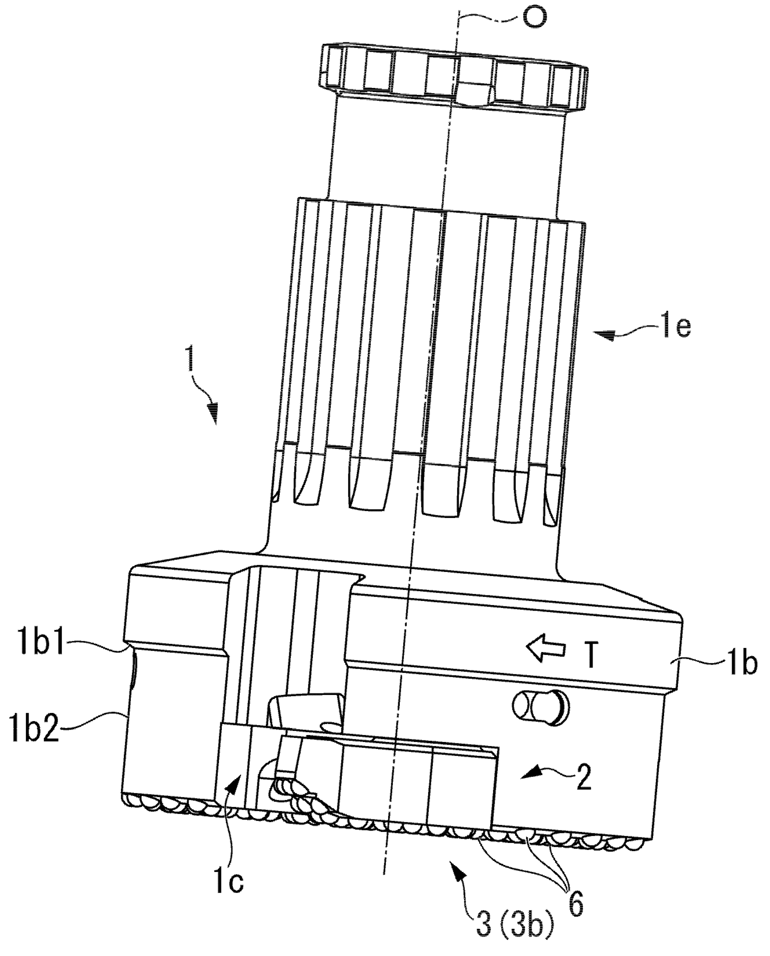


FIG. 12A

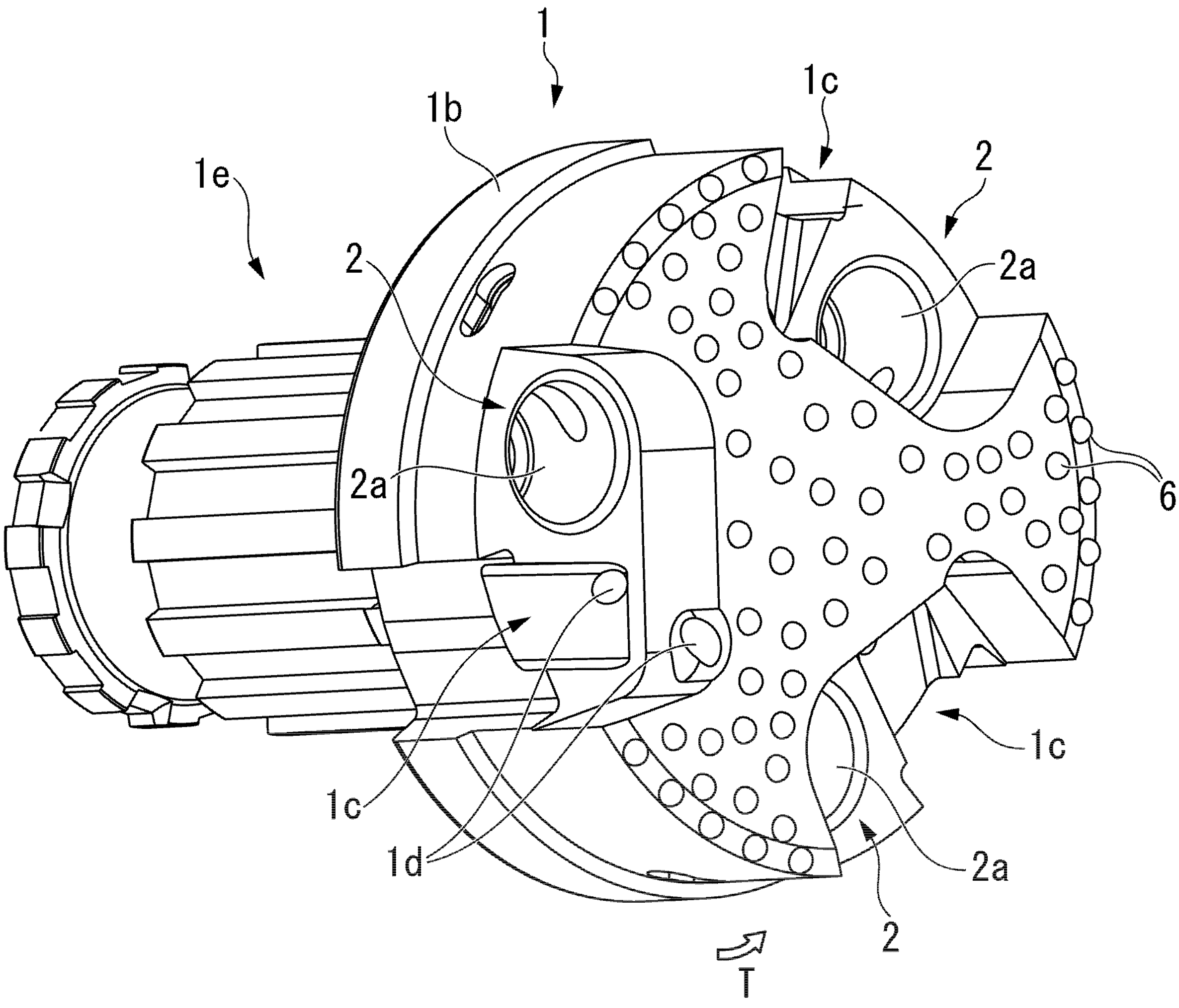


FIG. 12B

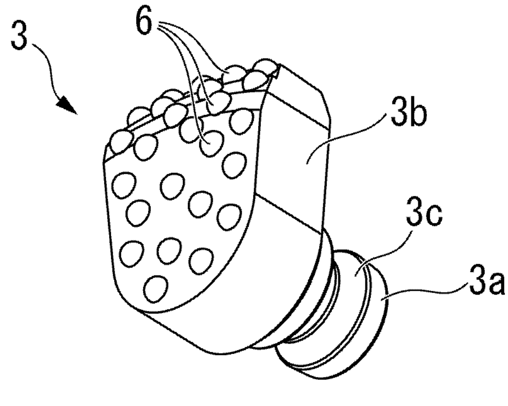


FIG. 12C

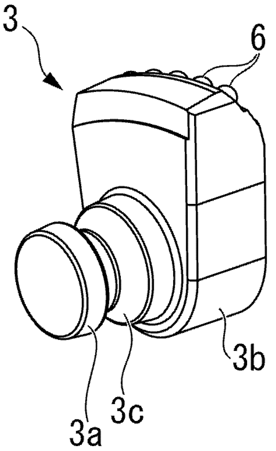


FIG. 13A

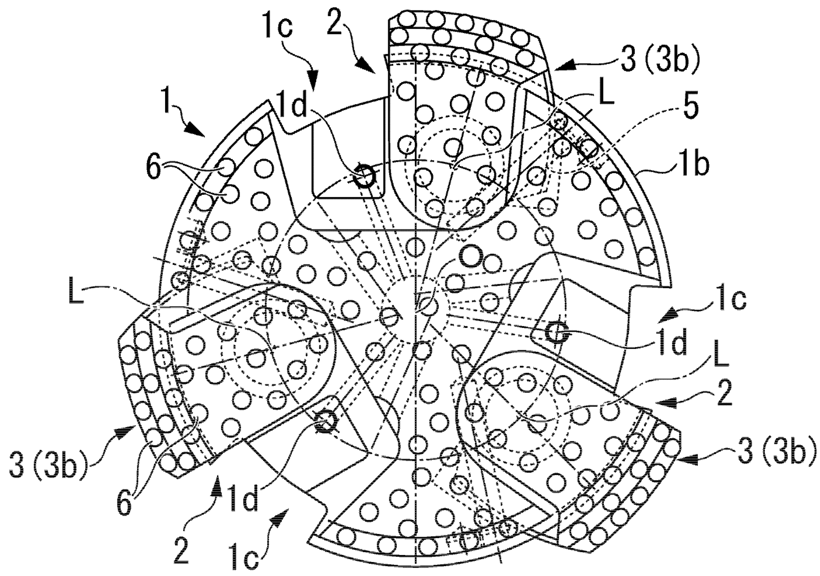


FIG. 13B

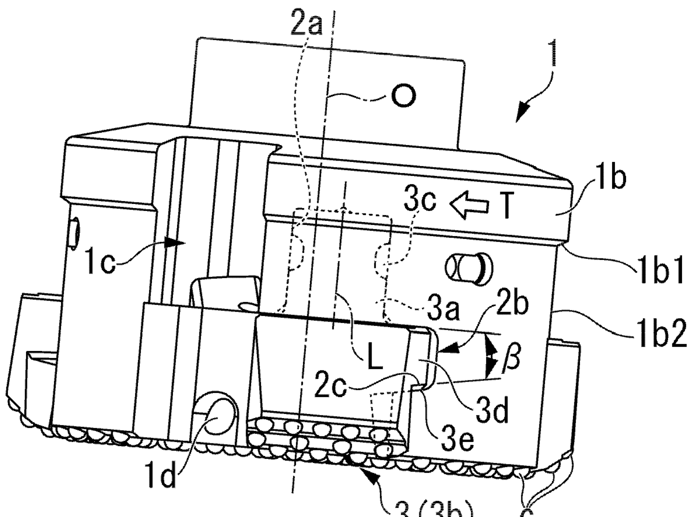


FIG. 13C

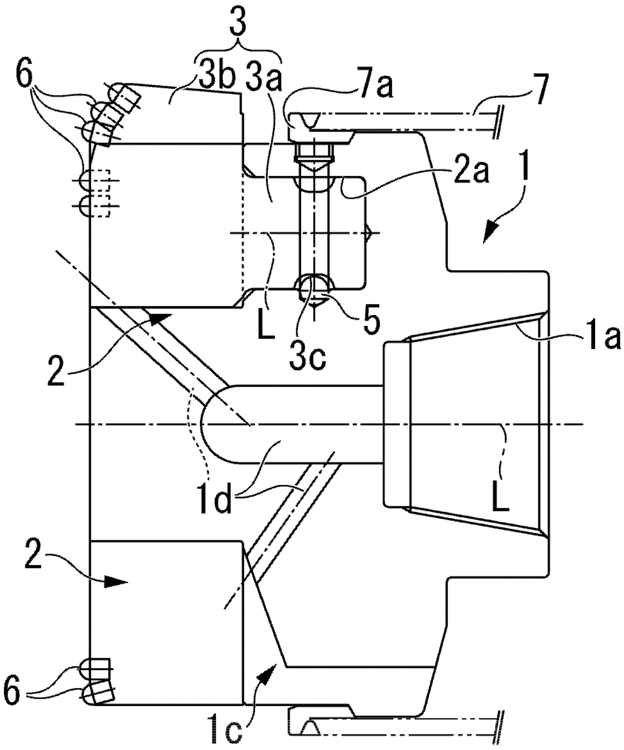


FIG. 13D

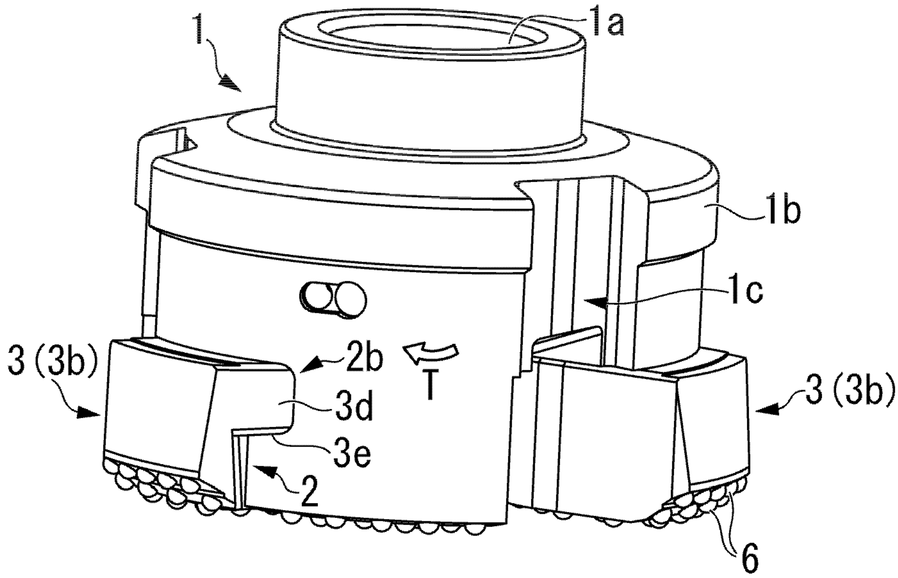


FIG. 14A

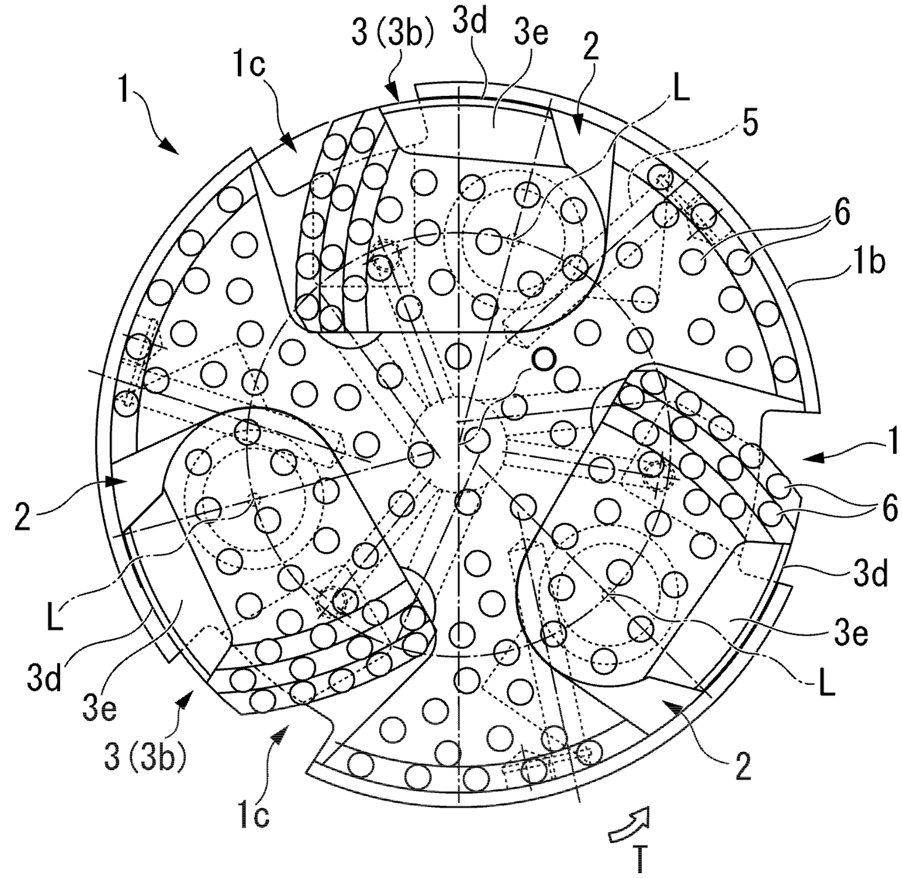


FIG. 14B

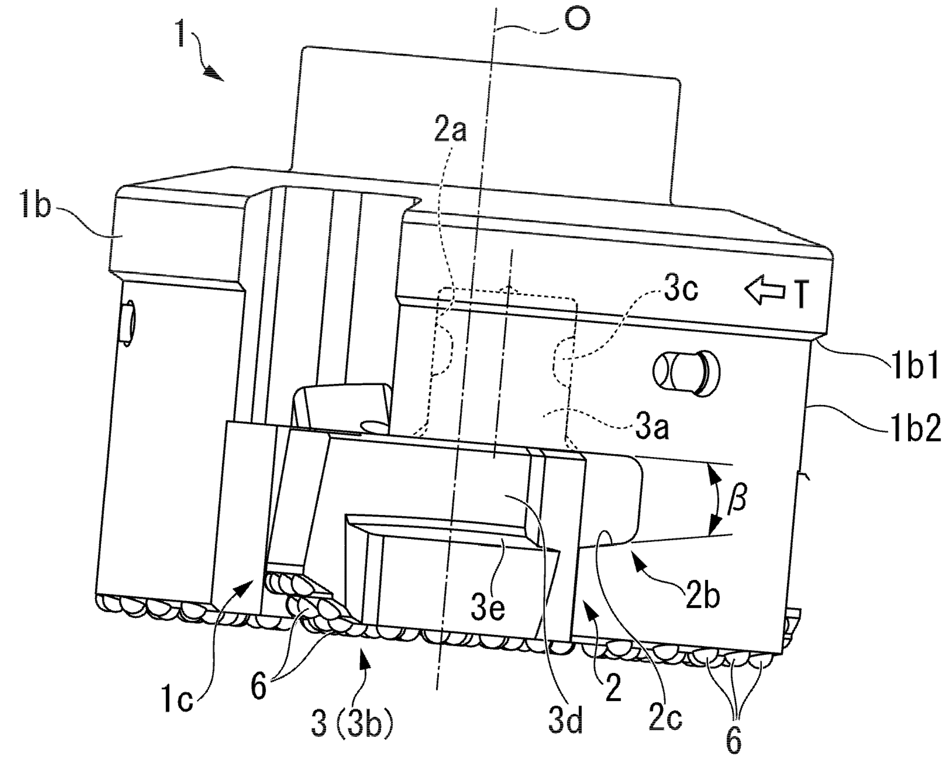


FIG. 15A

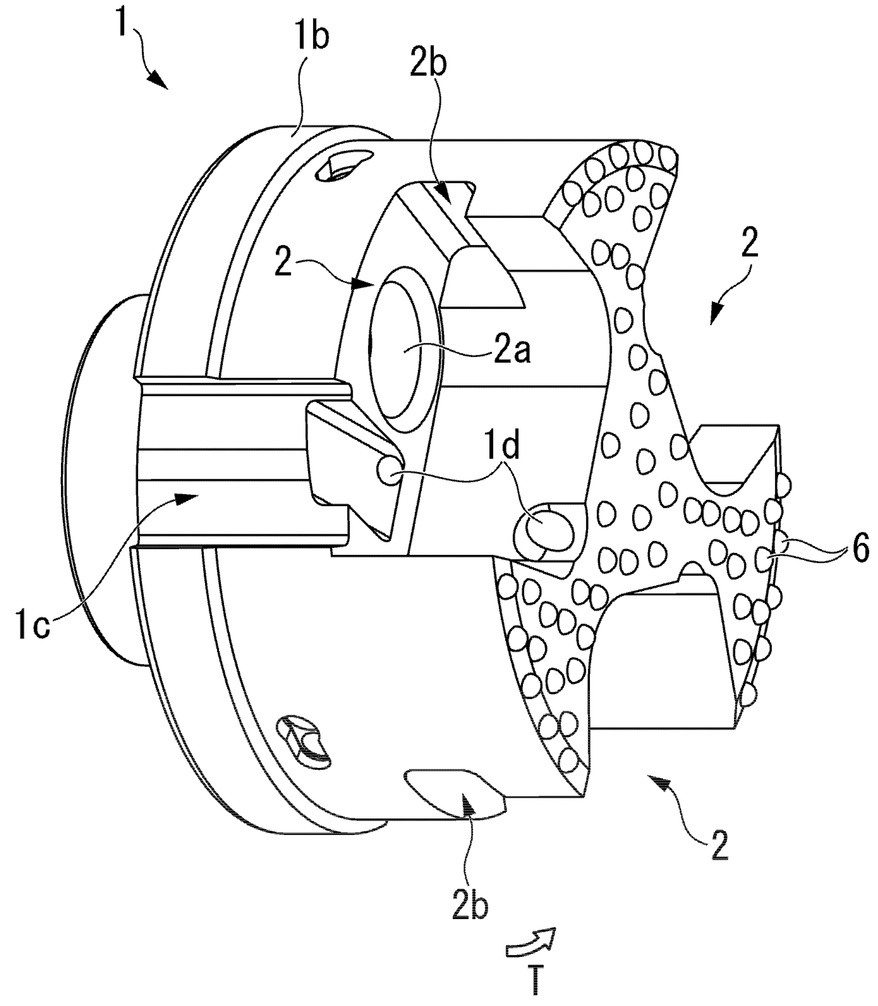


FIG. 15B

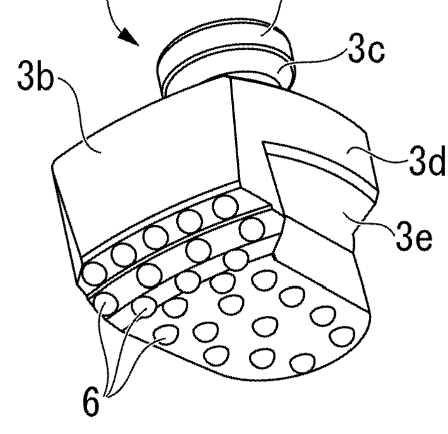


FIG. 15C

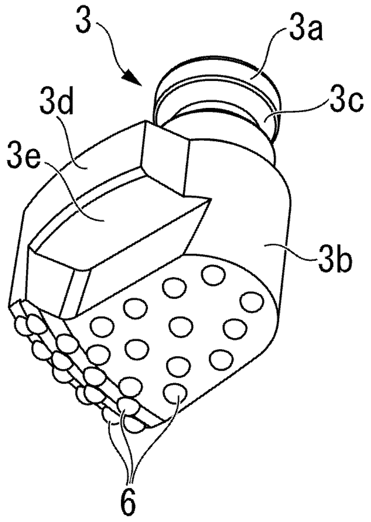


FIG. 15D

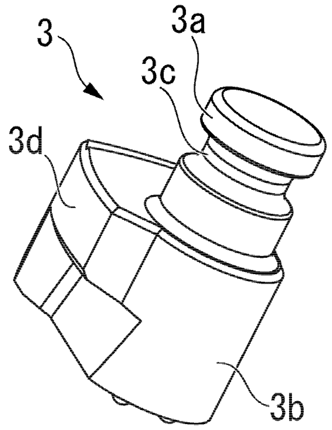


FIG. 16A

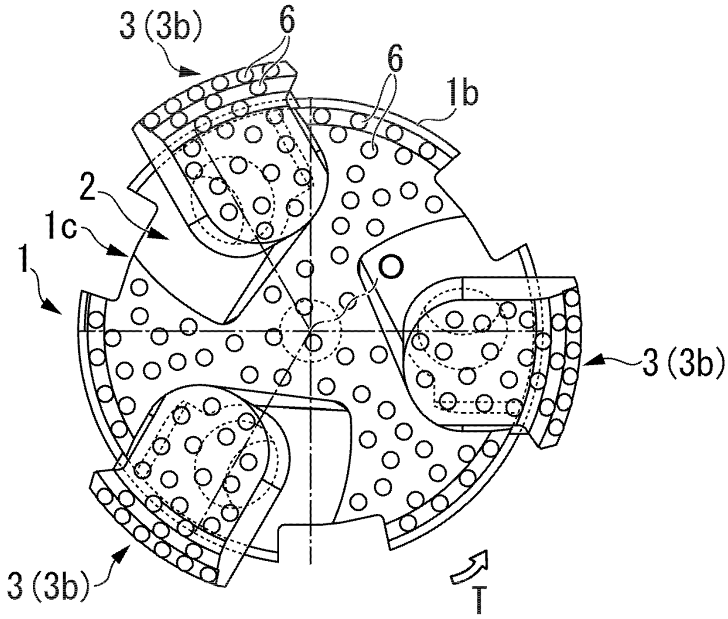


FIG. 16B

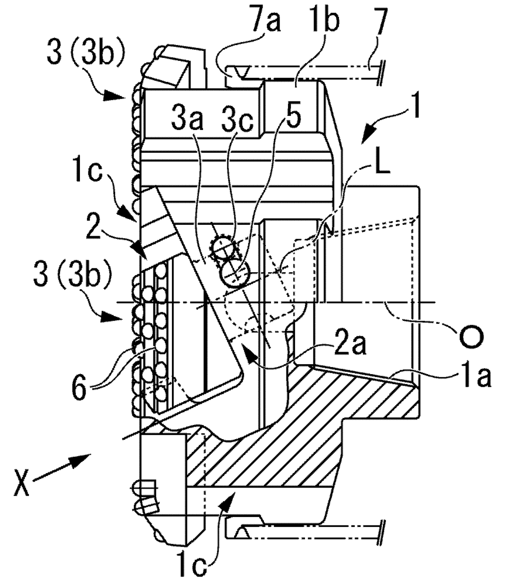


FIG. 16C

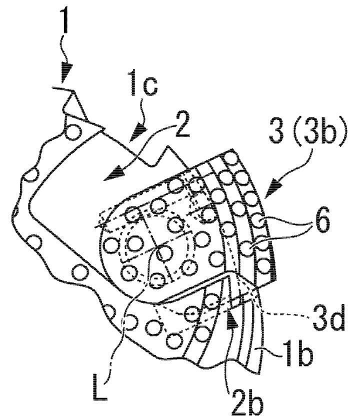


FIG. 16D

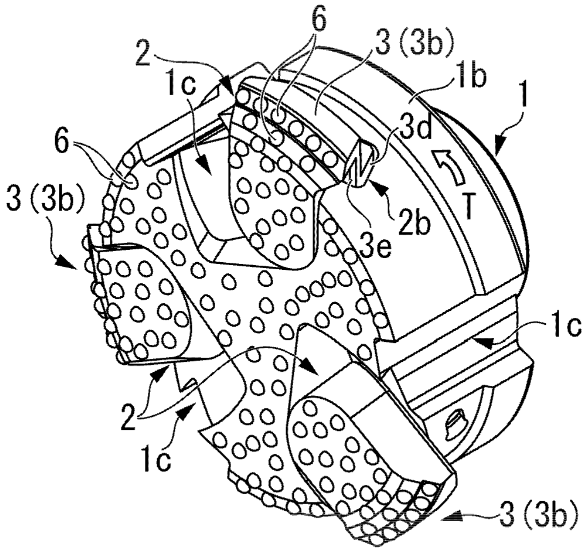


FIG. 16E

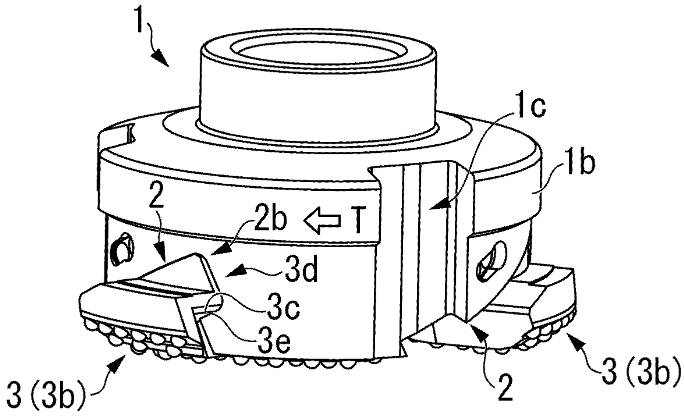


FIG. 17A

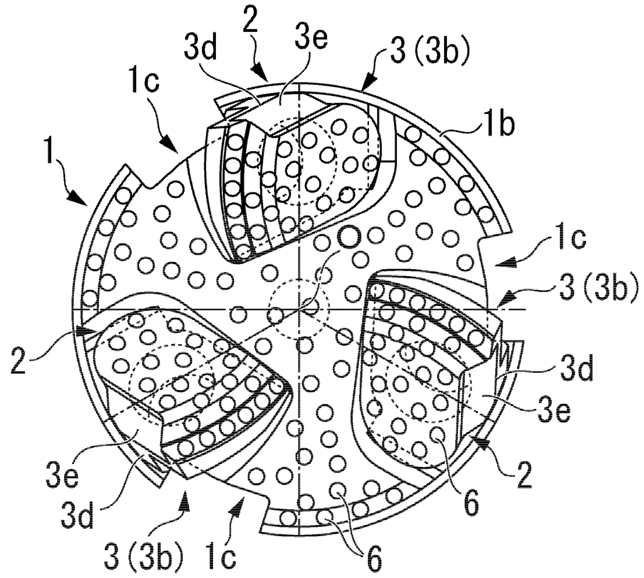


FIG. 17B

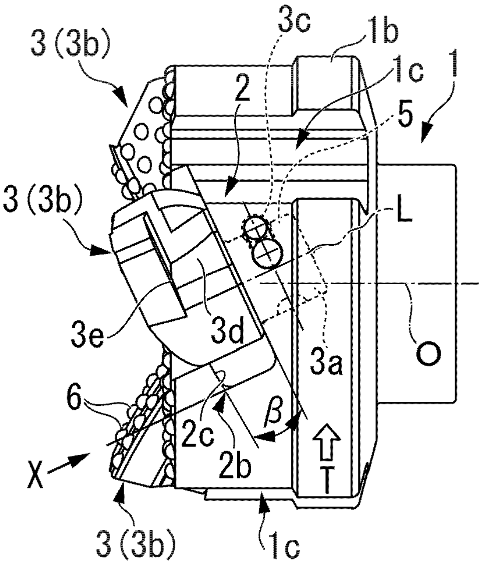


FIG. 17C

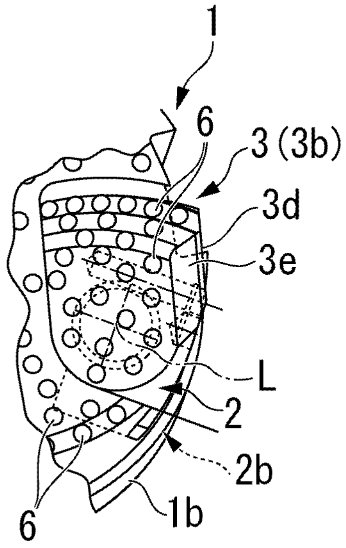


FIG. 17D

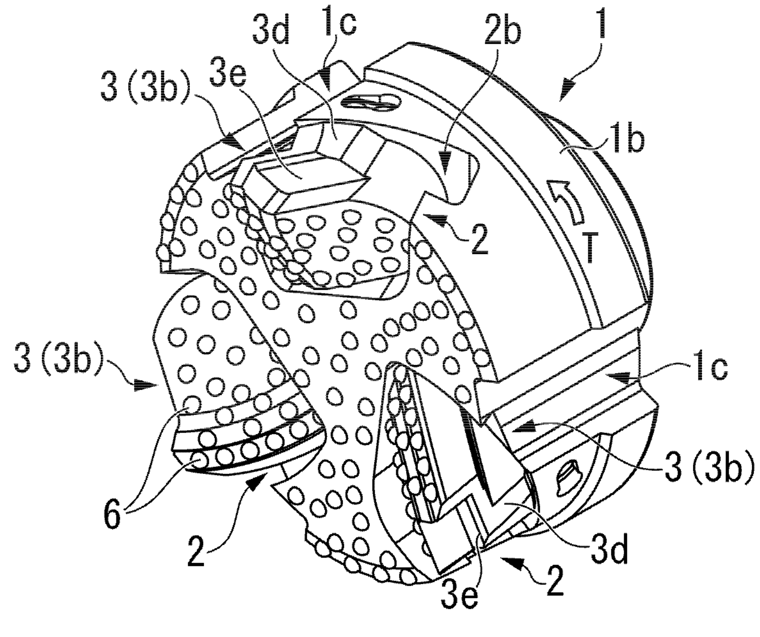


FIG. 18A

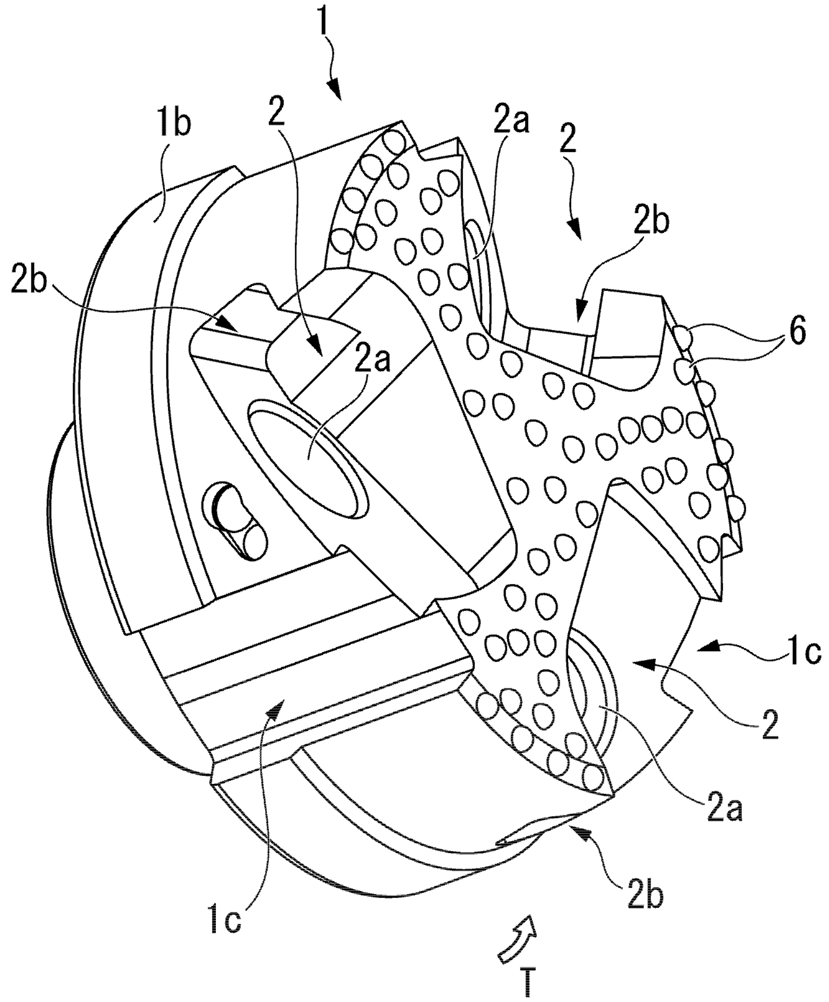


FIG. 18B

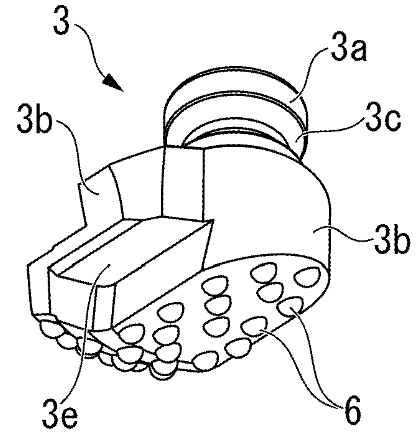


FIG. 18C

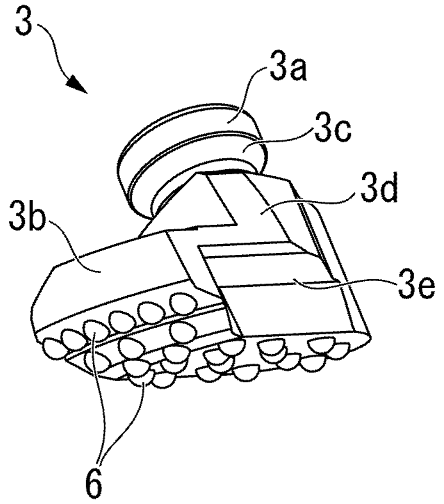
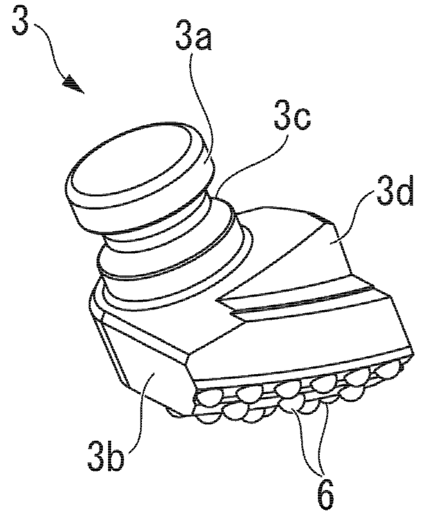


FIG. 18D



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/032645

A. CLASSIFICATION OF SUBJECT MATTER
E21B10/32(2006.01)i, *E21B6/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B10/32, E21B6/00

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.
X	JP 10-231677 A (Mitsubishi Materials Corp.), 02 September 1998 (02.09.1998), paragraphs [0001] to [0025]; fig. 1 to 4 (Family: none)	1-4
A	JP 2001-146886 A (Mitsubishi Materials Corp.), 29 May 2001 (29.05.2001), paragraphs [0013] to [0016] (Family: none)	1-4

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

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Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2017 (26.09.17)	10 October 2017 (10.10.17)

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

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Patent documents cited in the description

- JP 2016177490 A **[0002]**
- JP 2004183471 A **[0004]**
- JP 2006037612 A **[0004]**