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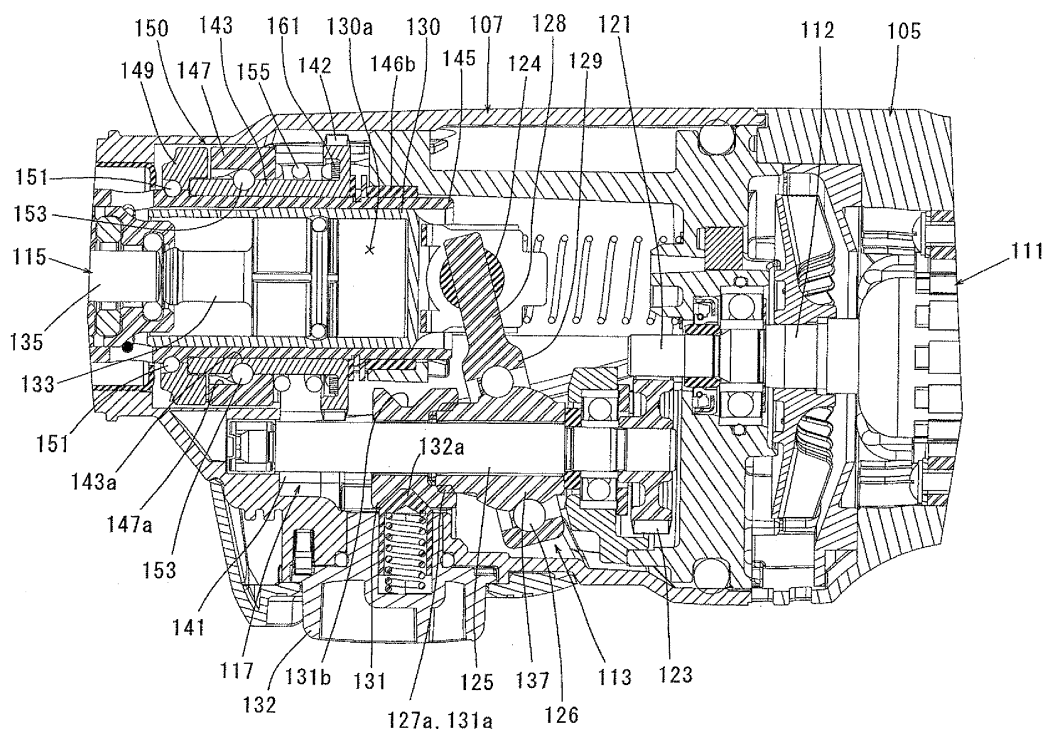
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(54) **HAMMER DRILL**

(57) [Problem] To provide a hammer drill improved for enhanced drilling performance. [Solution] A hammer drill having: a linear impact mechanism section (115) for applying an impact force in the longitudinal axis direction

to a tool bit (119); and a rotational drive mechanism section (117) for rotationally operating the tool bit (119) about the longitudinal axis. The hammer drill is configured so that a rotational impact can be applied to the tool bit (119) in the rotational direction.

FIG. 2



## Description

### FIELD OF THE INVENTION

**[0001]** The invention relates to a hammer drill in which a tool bit performs a predetermined operation on a workpiece by linear movement in its axial direction and rotation around its axis.

### BACKGROUND OF THE INVENTION

**[0002]** Japanese non-examined laid-open Patent Publication No. 1997-70771 discloses a hammer drill in which a tool bit performs a hammer drill operation (drilling operation) on a workpiece by linear movement in its axial direction and rotation around its axis.

**[0003]** According to the known hammer drill, a drilling operation can be rationally performed on a workpiece such as a concrete wall by causing the tool bit to linearly move in its axial direction and rotate around its axis. In order to efficiently perform a drilling operation, however, further improvement of drilling performance is required.

Prior art reference 1

**[0004]** Japanese non-examined laid-open Patent Publication No. 1997-70771

### DISCLOSURE OF THE INVENTION

### PROBLEMS TO BE SOLVED BY THE INVENTION

**[0005]** It is, accordingly, an object of the invention to provide an improved hammer drill which provides higher drilling performance.

### MEANS FOR SOLVING THE PROBLEMS

**[0006]** In order to solve the above-described problem, according to a preferred embodiment of the invention, a hammer drill has a linear impact mechanism section that applies an impact force to a tool bit in an axial direction of the tool bit, and a rotary drive mechanism section that rotates the tool bit around an axis of the tool bit. The hammer drill of the invention is characterized in that a rotary impact can be applied to the tool bit in a direction of rotation.

**[0007]** According to the invention, in the hammer drill in which the tool bit is caused to linearly move and rotate, a rotary impact can be applied to the tool bit in the direction of rotation during drilling operation on a workpiece. With such a construction, a drilling operation can be performed at higher torque, compared with a hammer drill having a construction in which a rotary impact is not applied.

**[0008]** According to a further embodiment of the hammer drill of the invention, the rotary drive mechanism section has a function of applying the rotary impact.

**[0009]** According to this embodiment, it is rational in that the rotary drive mechanism section rotationally drives the tool bit and applies the rotary impact thereto.

**[0010]** According to a further embodiment of the hammer drill of the invention, the rotary impact is applied when a resistance torque applied to the tool bit reaches a predetermined torque value.

**[0011]** According to this embodiment, during drilling operation, when load (rotational resistance) on the tool bit increases for any reason and the resistance torque reaches the predetermined torque value, an impact force can be applied to the tool bit in the direction of rotation. With this construction, when rotational resistance applied to the tool bit is low, unnecessary application of a rotary impact can be prevented.

**[0012]** According to a further embodiment of the hammer drill of the invention, the predetermined torque value can be adjusted.

**[0013]** According to this embodiment, it is rational in that, in performing a drilling operation, the predetermined torque value can be adjusted according to the kind or hardness of the workpiece.

**[0014]** According to a further embodiment of the hammer drill of the invention, the rotary drive mechanism section can be switched between an operating condition in which the rotary impact is applied to the tool bit and a non-operating condition in which the rotary impact is not applied to the tool bit.

**[0015]** According to this embodiment, for example, when the workpiece is hard, the hammer drill can be used in a manner in which the rotary impact is applied to the tool bit. Further, when the workpiece is relatively soft, the hammer drill can be used in a manner in which the rotary impact is not applied to the tool bit. Thus, this embodiment is rational.

**[0016]** According to a further embodiment of the hammer drill of the invention, the linear impact mechanism section has a cylinder that extends in the axial direction of the tool bit and a linear striking element that linearly moves within the cylinder and applies an impact force to the tool bit in the axial direction. Further, the rotary drive mechanism section has a rotary striking element that applies an impact force to the tool bit in the direction of rotation and is disposed on the outside of the cylinder.

**[0017]** According to this embodiment, by provision of the construction in which the rotary striking element is disposed on the outside of the cylinder, even though provided with a function of applying a rotary impact, the hammer drill can be prevented from increasing in the axial length of the tool bit.

**[0018]** According to a further embodiment of the hammer drill of the invention, the rotary striking element can be rotationally driven selectively either in one direction or the other of the circumferential direction of the cylinder, and the impact force can be applied to the tool bit both in the one direction and the other direction by changing the direction of rotation.

**[0019]** During drilling operation, for example, on a con-

crete wall, the tool bit may be locked against rotation by biting on a reinforcing rod or the like within the concrete wall. According to this embodiment, when such a problem occurs, the direction of rotation of the tool bit can be changed to the opposite direction, so that a rotary impact can be applied to the tool bit in the direction opposite to the biting direction. Thus, the tool bit can be released from the reinforcing rod or the like, so that it can be easily removed from the concrete wall.

**[0020]** According to a further embodiment of the hammer drill of the invention, a drive mode can be switched between a hammer drill mode in which the tool bit is caused to perform both striking movement in the axial direction and rotation around the axis and a drill mode in which the tool bit is caused to perform only rotation around the axis, and the rotary impact is applied to the tool bit via the rotary drive mechanism section in both the hammer drill mode and the drill mode.

**[0021]** According to this embodiment, the drilling operation can be performed by applying a rotary impact to the tool bit in both the hammer drill mode and the drill mode.

#### EFFECT OF THE INVENTION

**[0022]** According to this invention, an improved hammer drill with higher drilling performance is provided.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0023]**

FIG. 1 is a sectional view showing an entire hammer drill according to an embodiment of the invention.

FIG. 2 is a sectional view showing an essential part of the hammer drill, in a hammer drill mode in which clutch teeth are engaged with each other.

FIG. 3 is a sectional view showing the essential part of the hammer drill, in a drill mode in which the clutch teeth are disengaged from each other.

FIG. 4 is an illustration for explaining adjustment of a torque value setting by a compression coil spring.

FIG. 5 is an exploded perspective view showing components of a rotary impact mechanism and its surrounding parts.

#### REPRESENTATIVE EMBODIMENT FOR PERFORMING THE INVENTION

**[0024]** An embodiment of the invention is now described with reference to FIGS. 1 to 5. As shown in FIG. 1, a hammer drill 101 of this embodiment mainly includes a body 103 that forms an outer shell of the hammer drill 101, an elongate hammer bit 119 detachably coupled to one end (on the left side as viewed in FIG. 1) of the body 103 in a longitudinal direction of the hammer drill 101 via a tool holder 137, and a handgrip 109 that is connected to the other end of the body 103 in the longitudinal direc-

tion (on the side opposite to the hammer bit 119) and designed to be held by a user. The hammer bit 119 is held by the tool holder 137 such that it is allowed to reciprocate with respect to the tool holder in its longitudinal direction (the longitudinal direction of the body 103) and prevented from rotating with respect to the tool holder in its circumferential direction. The hammer bit 119 is a feature that corresponds to the "tool bit" according to the invention. In this embodiment, for the sake of convenience of explanation, the side of the hammer bit 119 is taken as the front and the side of the handgrip 109 as the rear.

**[0025]** The body 103 mainly includes a motor housing 105 that houses a driving motor 111, and a gear housing 107 that houses a motion converting mechanism 113, a striking mechanism 115 and a power transmitting part 117. The driving motor 111 is driven when a user depresses an operating member in the form of a trigger 109a on the handgrip 109. Further, a normal/reverse selector switch 109b is disposed close to the trigger 109a and designed and provided as an operating member for changing the direction of rotation of the motor, so that the direction of rotation of the driving motor 111 can be switched by sliding the normal/reverse selector switch 109b.

**[0026]** FIG. 2 shows the motion converting mechanism 113, the striking mechanism 115 and the power transmitting part 117 in enlarged sectional view. Rotating output of the driving motor 111 is appropriately converted into linear motion via the motion converting mechanism 113 and transmitted to the striking mechanism 115. Then, an impact force is generated in an axial direction of the hammer bit 119 (in a horizontal direction in FIG. 1) via the striking mechanism 115. Further, the power transmitting part 117 appropriately reduces the speed of the rotating output of the driving motor 111 and then transmits it as torque to the hammer bit 119 held by the tool holder 137, so that the hammer bit 119 is caused to rotate in its circumferential direction. The striking mechanism 115 and the power transmitting part 117 are features that correspond to the "linear impact mechanism section" and the "rotary drive mechanism section", respectively, according to the invention.

**[0027]** The motion converting mechanism 113 mainly includes a driving gear 121 that is provided on a motor output shaft 112 of the driving motor 111 extending in the axial direction of the hammer bit 119 and is rotationally driven in a vertical plane, a driven gear 123 that is engaged with the driving gear 121, an intermediate shaft 125 that rotates together with the driven gear 123, a rotating element 127 that is caused to rotate via an operation mode switching clutch member 131 which rotates together with the intermediate shaft 125, a swinging ring 129 that is caused to swing in the axial direction of the hammer bit 119 by rotation of the rotating element 127, and a cylindrical piston 130 which has a bottom and linearly reciprocates within a cylinder 145 by swinging movement of the swinging ring 129. The cylinder 145 is

disposed on the axis of the hammer bit 119 and the outer peripheries of both ends of the cylinder 145 in its longitudinal direction are rotatably supported on the gear housing 107 via bearings 146a, 146b (see FIG. 1).

**[0028]** The intermediate shaft 125 is disposed in parallel (horizontally) to the longitudinal direction of the cylinder 145 (the axial direction of the hammer bit 119) and the outer periphery of the rotating element 127 fitted onto the intermediate shaft 125 is inclined at a predetermined inclination with respect to an axis of the intermediate shaft 125. The swinging ring 129 is rotatably mounted on an inclined outer periphery of the rotating element 127 via a bearing 126 and configured as a swinging member that is caused to swing in the axial direction of the hammer bit 119 by rotation of the rotating element 127. The swinging ring 129 has a swinging rod 128 extending upward (in a radial direction) therefrom in a direction transverse to the axial direction of the hammer bit 119. The swinging rod 128 is connected to a driving element in the form of the cylindrical piston 130 via a cylindrical element 124 such that it can rotate with respect to the cylindrical piston. The rotating element 127, the swinging ring 129 and the cylindrical piston 130 form a swinging mechanism.

**[0029]** The rotating element 127 and the operation mode switching clutch member 131 are provided adjacent to each other on the intermediate shaft 125. The rotating element 127 is fitted onto the intermediate shaft 125 such that it can rotate with respect to the intermediate shaft 125, and has driven-side clutch teeth 127a on one axial end surface which faces the clutch member 131. The clutch member 131 is spline-fitted onto the intermediate shaft 125 such that it can move in the axial direction and cannot move in the circumferential direction with respect to the intermediate shaft. Further, the clutch member 131 has driving-side clutch teeth 131a on one axial end surface which faces the rotating element 127. When the clutch member 131 is moved toward the rotating element 127, the clutch teeth 131a, 127a are engaged with each other and rotation of the clutch member 131 is transmitted to the rotating element 127. When the clutch member 131 is moved away from the rotating element 127, the clutch teeth 131a, 127a are disengaged from each other and rotation transmission from the clutch member 131 to the rotating element 127 is interrupted.

**[0030]** The clutch member 131 has an annular groove 131b having a generally V-shaped cross section in its outer periphery. An engagement protrusion 132a of a mode switching operation member 132 is engaged with the annular groove 131b such that it can move with respect to the annular groove. The mode switching operation member 132 and the clutch member 131 are provided as a member for switching the operation mode of the hammer bit 119 between a hammer drill mode in which the hammer bit 119 is caused to perform a linear movement in the axial direction and rotation around the axis and a drilling mode in which the hammer bit 119 is caused to perform only rotation around the axis. The mode switching operation member 132 is mounted onto

the gear housing 107 such that it can rotate around an axis extending in a direction transverse to the axial direction of the hammer bit 119. The mode switching operation member 132 can be turned with user's fingers on the outside of the gear housing 107, and the engagement protrusion 132a is provided in a position displaced a predetermined distance from the center of rotation of the mode switching operation member 132.

**[0031]** Therefore, when the mode switching operation member 132 is turned and the engagement protrusion 132a rotates around the center of rotation of the mode switching operation member 132, the clutch member 131 is slid forward or rearward in the axial direction on the intermediate shaft 125, so that the driving-side and driven-side clutch teeth 131a, 127a are engaged with or disengaged from each other. Specifically, when the hammer drill mode is selected with the mode switching operation member 132 and the clutch teeth 131a, 127a are engaged with each other (see FIG. 2), the striking mechanism 115 is driven. However, when the drill mode is selected with the mode switching operation member 132 and the clutch teeth 131a, 127a are disengaged from each other (see FIG. 3), the striking mechanism 115 is not driven.

**[0032]** The striking mechanism 115 mainly includes a striker 133 that is slidably disposed within the bore of the cylindrical piston 130 and an intermediate element in the form of an impact bolt 135 that is slidably disposed within the cylinder 145 and serves to transmit kinetic energy of the striker 133 to the hammer bit 119. An air spring chamber 130a is defined by a bore inner wall of the cylindrical piston 130 and an axial rear end surface of the striker 133 which is slidably fitted into the bore. The striker 133 is configured as a striking element that is caused to move forward via the air spring chamber 130a by linear movement of the cylindrical piston 130 and strikes the hammer bit 119. The striker 133 is a feature that corresponds to the "linear striking element" according to the invention.

**[0033]** The power transmitting part 117 mainly includes a first transmission gear 141 that is fitted onto the other axial end (front end) of the intermediate shaft 125, a second transmission gear 142 that is engaged with the first transmission gear 141 and caused to rotate around the axis of the hammer bit 119, a hammer member 147 that rotates together with the second transmission gear 142, an anvil 149 that is rotated by the hammer member 147, the cylinder 145 that is caused to rotate together with the anvil 149, and a tool holder 137 that is caused to rotate together with the cylinder 145. The second transmission gear 142 has a sleeve 143 extending in its axial direction with a predetermined length therefrom, and the sleeve 143 is fitted onto the cylinder 145 such that it can rotate with respect to the cylinder. Further, the axial front end surface of the sleeve 143 is held in contact with a stepped end surface of the cylinder 145 in a direction transverse to the axial direction of the sleeve 143 and the axial rear end surface of the sleeve 143 is held in contact with a retaining ring 144 mounted on the cylinder 145. With such

a construction, the sleeve 143 is locked against movement in its axial direction. The cylinder 145 and the tool holder 137 are coaxially disposed on the axis of the hammer bit 119 and form a final axis of the power transmitting part 117.

**[0034]** The hammer member 147 and the anvil 149 form a rotary impact mechanism 150 that serves to apply a rotary impact to the hammer bit 119 around the axis (in the direction of rotation). The hammer member 147 is provided as a rotary impact member for applying a rotary impact to the anvil 149 in the direction of rotation, and the anvil 149 is provided as a rotary-impact receiving member for transmitting the rotary impact received from the hammer member 147 to the hammer bit 119. Specifically, the power transmitting part 117 has the rotary impact mechanism 150 in a rotation transmission path and is provided with a function of rotationally driving the hammer bit 119 by transmitting the rotating output of the driving motor 111 to the hammer bit 119 and a function of applying an impact force in the direction of rotation of the hammer bit 119. In other words, the rotary impact mechanism 150 also serves as a component of the power transmitting part 117 for transmitting the rotating output of the driving motor 111 to the hammer bit 119. The hammer member 147 is a feature that corresponds to the "rotary striking element" according to the invention.

**[0035]** The rotary impact mechanism 150 is now described with reference to FIGS. 2, 3 and 5. The hammer member 147 and the anvil 149 are opposed to each other on the axis of the cylinder 145 (the axis of the hammer bit 119). The hammer member 147 is a cylindrical or ring-like member and fitted onto the sleeve 143 such that it can rotate and move in the longitudinal direction with respect to the sleeve 143. The anvil 149 is a cylindrical or ring-like member which is fitted onto the cylinder 145, and a front end region of the anvil 149 in the longitudinal direction is connected to the cylinder 145 via a connecting member in the form of a plurality of first steel balls 151 disposed between the anvil 149 and the cylinder 145, such that the anvil 149 rotates together with the cylinder 145. Further, part of the rear end surface of the anvil 149 in the longitudinal direction is held in contact with the front end surface of the sleeve 143, so that the anvil 149 is locked against movement with respect to the cylinder 145 in the longitudinal direction.

**[0036]** In a fitting region in which the hammer member 147 is fitted on the sleeve 143, a second steel ball 153 is disposed between a guide groove 143a formed in an outer surface of the sleeve 143 and an engagement groove 147a formed in an inner surface of the hammer member 147. With such a construction, rotation of the sleeve 143 is transmitted to the hammer member 147 via the second steel ball 153. The sleeve 143 forms the "rotary drive element". As shown in FIG. 5, the guide groove 143a having a semicircular section is formed in the outer surface of the sleeve 143 and has a V-shape as viewed from the side and extending obliquely with respect to the axis of the hammer bit 119. The V-shape

of the guide groove 143a is tapered toward the hammer bit 119 (the front) and two such guide grooves 143a are provided with a phase difference of 180 degrees in the circumferential direction of the sleeve 143. In the inner surface of the hammer member 147, the engagement groove 147a is formed to be matched with the guide groove 143a. The engagement groove 147a has a V-shape having opposed inclined surfaces which extend rearward toward each other from the front end surface of the hammer member 147. The second steel ball 153 is disposed in between the V-shaped guide groove 143 and the engagement groove 147a. Therefore, when the hammer member 147 and the sleeve 143 rotate with respect to each other, the hammer member 147 is caused to move toward or away from the anvil 149 by the second steel ball 153 rolling along the V-shaped or obliquely extending guide groove 143a. When the hammer bit 119 is rotated in a direction of normal rotation (drilling direction), the second steel ball 153 rolls along one side of the V-shaped guide groove 143a. On the other hand, when the hammer bit 119 is rotated in the opposite direction (direction of reverse rotation), the second steel ball 153 rolls along the other side of the guide groove 143a. The guide groove 143a, the engagement groove 147a and the second steel ball 153 form the "guide part" which causes the hammer member 147 to move in its longitudinal direction when the hammer member 147 rotates with respect to the sleeve 143.

**[0037]** The hammer member 147 is biased toward the anvil 149 by a biasing member in the form of a biasing spring 155 (a compression coil spring). Therefore, the hammer member 147 is moved away from the anvil 149 against the biasing force of the biasing spring 155. As shown in FIG. 5, a plurality of driving-side engagement parts 157 are formed at predetermined intervals in the circumferential direction on the front end surface of the hammer member 147 (facing the anvil 149) and protrude toward the anvil 149. On the rear end surface of the anvil 149, a plurality of driven-side engagement parts 159 are formed to be matched with the driving-side engagement parts 157 and protrude toward the hammer member 147. Each of circumferential end surfaces of the driving-side engagement parts 157 and the driven-side engagement parts 159 is formed by a flat surface parallel to the axial direction of the hammer bit 119. With such a construction, when the hammer member 147 is moved toward the anvil 149 by the biasing force of the biasing spring 155 and the driving-side engagement parts 157 are engaged with the driven-side engagement parts 159 of the anvil 149 in the circumferential direction (the direction of rotation), this engagement is maintained. Thus, rotation of the hammer member 147 is normally transmitted as-is to the anvil 149.

**[0038]** During drilling operation, when a load (rotational resistance) on the hammer bit 119 increases and a resistance torque applied to the hammer member 147 via the anvil 149 reaches a predetermined torque value set by the biasing spring 155, the second steel ball 153 rolls

along one side of the V-shaped guide groove 143a (in the direction of normal rotation), which causes the hammer member 147 to move away from the anvil 149. As a result, the driving-side engagement part 157 is disengaged from the driven-side engagement part 159. By this disengagement, the resistance torque is no longer applied to the hammer member 147, so that the hammer member 147 is moved toward the anvil 149 by the biasing force of the biasing spring 155 while rotating. Therefore, the driving-side engagement part 157 is engaged with the driven-side engagement part 159 in the direction of rotation, so that an impact force is intermittently applied to the anvil 149 and thus the hammer bit 119 in the direction of rotation. This condition is a feature that corresponds to the "operating condition" according to the invention.

**[0039]** As described above, in the rotary impact mechanism 150, when resistance torque applied to the hammer member 147 is lower than the predetermined torque value set by the biasing spring 155, engagement of the driving-side engagement parts 157 of the hammer member 147 with the driven-side engagement parts 159 of the anvil 149 is maintained so that rotation of the hammer member 147 is transmitted as-is to the anvil 149. However, when the resistance torque applied to the hammer member 147 reaches a predetermined torque value, the rotary impact is applied to the hammer bit 119. Further, as described above, in this embodiment, the guide groove 143a of the sleeve 143 is V-shaped. With this construction, when the hammer bit 119 is driven in the direction of normal rotation in order to perform a drilling operation, the second steel ball 153 rolls along one side of the V-shaped guide groove 143a. Further, when the hammer bit 119 is driven in the direction of reverse rotation or in the direction opposite to the direction of normal rotation, the second steel ball 153 rolls along the other side of the guide groove 143a. In this manner, the rotary impact mechanism 150 is configured and provided to be capable of applying a rotary impact whether the hammer bit 119 is driven in the direction of normal rotation or in the direction of reverse rotation.

**[0040]** The second transmission gear 142 is a flanged cylindrical member with which the sleeve 143 having a smaller diameter than the second transmission gear 142 is integrally formed, and a ring-like spring receiving member 161 is fitted on the sleeve 143. As shown in FIG. 4, the biasing spring 155 is disposed on the outside of the sleeve 143 and has a rear end held in contact with the front surface of the spring receiving member 161 and a front end held in contact with the rear end surface of the hammer member 147. The ring-like spring receiving member 161 is fitted on the sleeve 143 such that it can slide in the longitudinal direction. Thus, the position of the spring receiving member 161 can be adjusted in the longitudinal direction of the sleeve 143 by externally manually operating the spring receiving member 161, which is not shown. Therefore, initial load (initial deformation) of the biasing spring 155 can be changed, so that the

setting of the predetermined torque value can be adjusted. FIG. 4 shows a state in which the spring receiving member 161 is adjusted in position by moving it forward (toward the anvil 149) so that the predetermined torque value is increased. Further, when the biasing spring 155 is deformed or compressed to its maximum or nearly to the maximum at which its coils are pushed tightly one against the other, the hammer member 147 is prevented from moving away from the anvil 149. Thus, engagement between the driving-side engagement parts 157 and the driven-side engagement parts 159 is maintained and application of a rotary impact is stopped. This stopped condition is a feature that corresponds to the "non-operating condition" according to the invention.

**[0041]** In the hammer drill 101 constructed as described above, when the normal/reverse selector switch 109b is switched to normal rotation and the trigger 109a is depressed to drive the driving motor 111, the intermediate shaft 125 is rotationally driven via the driving gear 121 and the driven gear 123. At this time, when the hammer drill mode is selected with the mode switching operation member 132, the driving-side clutch teeth 131a of the clutch member 131 are engaged with the driven-side clutch teeth 127a of the rotating element 127, so that the motion converting mechanism 113 mainly including a swinging mechanism is driven. Thus, the cylindrical piston 130 is caused to linearly slide within the cylinder 145, which causes the striker 133 to linearly move within the cylindrical piston 130 via air pressure fluctuations or air spring action in the air spring chamber 130a of the cylindrical piston 130. The striker 133 then collides with the impact bolt 135 and the kinetic energy of the striker 133 which is caused by the collision is transmitted to the hammer bit 119.

**[0042]** When the first transmission gear 141 is rotated together with the intermediate shaft 125, the cylinder 145 is caused to rotate in a vertical plane via the second transmission gear 142 engaged with the first transmission gear 141 and via the rotary impact mechanism 150, and the tool holder 137 and the hammer bit 119 held by the tool holder 137 are rotated together with the cylinder 145. In this manner, the hammer bit 119 performs a drilling operation on a workpiece by linear movement in the axial direction and rotation in the circumferential direction. Further, when the drill mode is selected with the mode switching operation member 132, the driving-side clutch teeth 131a of the clutch member 131 are disengaged from the driven-side clutch teeth 127a of the rotating element 127, so that a drilling operation is performed solely by rotation of the hammer bit 119.

**[0043]** According to the hammer drill 101 of this embodiment, during the above-described drilling operation, when the load in the direction of rotation of the hammer bit 119 is low and the resistance torque applied to the hammer member 147 is lower than the predetermined torque value set by the biasing spring 155, engagement of the driving-side engagement parts 157 of the hammer member 147 with the driven-side engagement parts 159

of the anvil 149 is maintained and rotation of the hammer member 147 is transmitted as-is to the anvil 149. Specifically, the hammer member 147 and the anvil 149 serve as a component of the power transmitting part 117.

[0044] On the other hand, when the load in the direction of rotation of the hammer bit 119 is high and the resistance torque applied to the hammer member 147 reaches the predetermined torque value set by the biasing spring 155, as described above, the rotary impact mechanism 150 is operated to apply an impact force to the hammer bit 119 in the direction of rotation. Specifically, when the load torque applied to the hammer member 147 reaches the predetermined torque value, the hammer member 147 is caused to rotate with respect to the sleeve 143, so that the second steel ball 153 engaged with the engagement groove 147a of the hammer member 147 rolls along the V-shaped guide groove 143a of the sleeve 143. Thus, the hammer member 147 is caused to move rearward with respect to the sleeve 143 against the biasing force of the biasing spring 155. When the driving-side engagement parts 157 are disengaged from the driven-side engagement parts 159 by this rearward movement and thus the resistance torque is released from the hammer member 147, the hammer member 147 rotates while moving forward by the biasing force of the biasing spring 155. As a result, the driving-side engagement parts 157 of the hammer member 147 are engaged with the driven-side engagement parts 159 of the anvil 149 in the direction of rotation and the hammer member 147 applies an impact force to the anvil 149. Therefore, according to the hammer drill 101 of this embodiment, a drilling operation can be performed at higher torque, compared with a hammer drill having a construction in which the rotary impact is not applied.

[0045] Further, according to this embodiment, the rotary impact mechanism 150 is driven when the resistance torque applied to the hammer member 147 reaches a predetermined torque value. With such a construction, when rotational resistance applied to the hammer bit 119 is low and the drilling operation is performed in a torque range lower than the predetermined torque value, the rotary impact mechanism 150 is stopped and application of a rotary impact to the anvil 149 by the hammer member 147 is stopped, so that waste of energy can be reduced.

[0046] In this embodiment, the initial load of the biasing spring 155 can be adjusted by adjusting the position of the ring-like spring receiving member 161 disposed outside the sleeve 143 in the longitudinal direction of the sleeve 143. With this construction, it is convenient in that the predetermined torque value set by the biasing spring 155 can be easily adjusted according to the kind or hardness of the workpiece.

[0047] When it is unnecessary to apply a rotary impact via the rotary impact mechanism 150, the rotary impact mechanism 150 can be switched to the non-operating condition by compressing the biasing spring 155 to its maximum or nearly to the maximum at which its coils are pushed tightly one against the other, and in this state,

the drilling operation can be performed. Thus, protection of the hammer bit 119 can also be realized.

[0048] Further, during drilling operation, for example, on a concrete wall, the hammer bit 119 may be locked against rotation by biting on a reinforcing rod or the like within the concrete wall. According to this embodiment, when such a problem occurs, the direction of rotation of the driving motor 111 can be changed to the opposite direction or the direction of reverse rotation with the normal/reverse selector switch 109b, so that the rotary impact can be applied to the hammer bit 119 in the opposite direction. Thus, the hammer bit 119 can be released from the reinforcing rod or the like and easily removed from the concrete wall.

[0049] In this embodiment, the hammer member 147 and the anvil 149 which are components of the rotary impact mechanism 150 are disposed on the outside of the cylinder 145 which is a component of the linear impact mechanism. With this construction, even though provided with the rotary impact mechanism 150, the hammer drill 101 doesn't have to be increased in the axial length of the hammer bit.

[0050] The rotary impact mechanism 150 according to this embodiment is constructed by utilizing a torque limiter. In the hammer drill 101, an overload protection device in the form of the torque limiter may be provided which serves to interrupt torque transmission when the resistance torque applied to a final shaft of the power transmitting part 117 exceeds a predetermined set value. In the rotary impact mechanism 150 of this embodiment, when the load on the hammer bit 119 increases up to the predetermined torque value, the hammer member 147 moves away from the anvil 149, so that torque transmission is temporarily interrupted. Thereafter, a rotary impact is applied to the anvil 149 by the hammer member 147. With such a construction, when this application of a rotary impact is started, the drilling operation is interrupted, so that the hammer bit 119 and the power transmitting part 117 can be protected.

[0051] In view of the above-described aspect of the invention, the following features can also be provided:

(1) "A hammer drill, including a linear impact mechanism section that applies an impact force to a tool bit in an axial direction of the tool bit and a rotary drive mechanism section that rotates the tool bit around an axis of the tool bit, wherein:

a rotary impact can be applied to the tool bit in a direction of rotation."

(2) "The hammer drill as defined in (1), wherein the rotary drive mechanism section has a function of applying the rotary impact."

(3) "The hammer drill as defined in (2), wherein the rotary impact is applied when a resistance torque applied to the tool bit reaches a predetermined torque value."

(4) "The hammer drill as defined in (3), wherein the predetermined torque value can be manually adjusted."

(5) "The hammer drill as defined in (3), wherein the rotary drive mechanism section can be switched between an operating condition in which the rotary impact is applied to the tool bit and a non-operating condition in which the rotary impact is not applied to the tool bit."

(6) "The hammer drill as defined in any one of (2) to (5), wherein the linear impact mechanism section has a cylinder that extends in the axial direction of the tool bit and a linear striking element that linearly moves within the cylinder and applies an impact force to the tool bit in the axial direction, and wherein the rotary drive mechanism section has a rotary striking element that applies an impact force to the tool bit in the direction of rotation, and the rotary striking element is disposed on the outside of the cylinder."

(7) "The hammer drill as defined in (6), wherein the rotary striking element can be rotationally driven selectively either in one direction or the other of the circumferential direction of the cylinder, and the impact force can be applied to the tool bit both in the one direction and the other direction by changing the direction of rotation."

(8) "The hammer drill as defined in any one of (2) to (7), wherein a drive mode can be switched between a hammer drill mode in which the tool bit is caused to perform both striking movement in the axial direction and rotation around the axis and a drill mode in which the tool bit is caused to perform only rotation around the axis, and the rotary impact is applied to the tool bit via the rotary drive mechanism section in both the hammer drill mode and the drill mode."

(9) "The hammer drill as defined in (1) or (2), wherein the rotary impact is intermittently applied."

(10) "The hammer drill as defined in (2), wherein the rotary drive mechanism section has a rotary impact mechanism that serves a function of applying the rotary impact and the rotary impact mechanism also serves as a member for transmitting rotation to the tool bit."

(11) "The hammer drill as defined in (10), comprising a rotary drive element that is rotationally driven on the axis of the tool bit, wherein:

the rotary impact mechanism includes a hammer member that is fitted on the rotary drive element in such a manner as to be allowed to rotate with respect to the rotary drive element and move in the axial direction, an anvil that is opposed to the hammer member in such a manner as to be allowed to rotate with respect to the hammer member and serves to transmit rotation to the tool bit, a driving-side engagement part that is formed in the hammer member, a driven-side engagement part that is formed in the anvil

and can be engaged with the driving-side engagement part in the circumferential direction, a biasing spring that biases the hammer member toward the anvil, and a guide part that moves the hammer member away from the anvil against the biasing spring when a resistance torque applied to the anvil reaches a predetermined torque value, rotation of the hammer member is transmitted to the anvil by engagement of the driving-side engagement part with the driven-side engagement part in the circumferential direction until the resistance torque applied to the anvil reaches the predetermined torque value, and the hammer member is disengaged from the anvil against the biasing member by the guide part when the resistance torque applied to the anvil reaches the predetermined torque value, and the resistance torque is released from the anvil by said disengagement, and at the same time, the hammer member moves toward the anvil while rotating and the driving-side engagement part is engaged with the driven-side engagement part in the circumferential direction, so that the rotary impact is applied."

(12) "The hammer drill as defined in (11), wherein the guide part includes a guide groove that is formed in an outer surface of the rotary drive element and extends obliquely with respect to the axis of the tool bit, an engagement groove that is formed in an inner surface of the hammer member, and a steel ball that is disposed between the guide groove and the engagement groove, and when the hammer member rotates with respect to the cylinder, the steel ball rolls along the guide groove, whereby the hammer member is moved away from or toward the anvil."

#### Description of Numerals

#### [0052]

101 hammer drill  
103 body  
105 motor housing  
107 gear housing  
109 handgrip  
109a trigger  
109b normal/reverse selector switch  
111 driving motor  
112 motor output shaft  
113 motion converting mechanism  
115 striking mechanism (linear impact mechanism section)  
117 power transmitting part (rotary drive mechanism section)  
119 hammer bit (tool bit)  
121 driving gear



123 driven gear  
 124 cylindrical element  
 125 intermediate shaft  
 126 bearing  
 127 rotating element  
 127a driven-side clutch teeth  
 128 swinging rod  
 129 swinging ring  
 130 cylindrical piston  
 130a air spring chamber  
 131 clutch member  
 131a driving-side clutch teeth  
 132 mode switching operation member  
 132a engagement protrusion  
 134 striker (linear striking element)  
 135 impact bolt  
 137 tool holder  
 141 first transmission gear  
 142 second transmission gear  
 143 sleeve (rotary drive element)  
 143a guide groove  
 145 cylinder  
 145a air spring chamber  
 146a, 146b bearing  
 147 hammer member (rotary striking element)  
 147a engagement groove  
 149 anvil  
 150 rotary impact mechanism  
 151 first steel ball  
 153 second steel ball  
 155 biasing spring (biasing member)  
 157 driving-side engagement part  
 159 driven-side engagement part  
 161 spring receiving member

## Claims

### 1. A hammer drill comprising:

a linear impact mechanism section that applies an impact force to a tool bit in an axial direction of the tool bit, and  
 a rotary drive mechanism section that rotates the tool bit around an axis of the tool bit, **characterized in that**  
 a rotary impact can be applied to the tool bit in a direction of rotation.

### 2. The hammer drill as defined in claim 1, wherein:

the rotary drive mechanism section has a function of applying the rotary impact.

### 3. The hammer drill as defined in claim 2, wherein:

the rotary impact is applied when a resistance torque applied to the tool bit reaches a prede-

termined torque value.

### 4. The hammer drill as defined in claim 3, wherein:

the predetermined torque value can be manually adjusted.

### 5. The hammer drill as defined in claim 3, wherein:

the rotary drive mechanism section can be switched between an operating condition in which the rotary impact is applied to the tool bit and a non-operating condition in which the rotary impact is not applied to the tool bit.

### 6. The hammer drill as defined in any one of claims 2 to 5, wherein:

the linear impact mechanism section has a cylinder that extends in the axial direction of the tool bit and a linear striking element that linearly moves within the cylinder and applies an impact force to the tool bit in the axial direction, and  
 the rotary drive mechanism section has a rotary striking element that applies an impact force to the tool bit in the direction of rotation and the rotary striking element is disposed on the outside of the cylinder.

### 7. The hammer drill as defined in claim 6, wherein:

the rotary striking element can be rotationally driven selectively either in one direction or the other of the circumferential direction of the cylinder, and the impact force can be applied to the tool bit both in the one direction and the other direction by changing the direction of rotation.

### 8. The hammer drill as defined in any one of claims 2 to 7, wherein:

a drive mode can be switched between a hammer drill mode in which the tool bit is caused to perform both striking movement in the axial direction and rotation around the axis and a drill mode in which the tool bit is caused to perform only rotation around the axis, and the rotary impact is applied to the tool bit via the rotary drive mechanism section in both the hammer drill mode and the drill mode.

FIG. 1

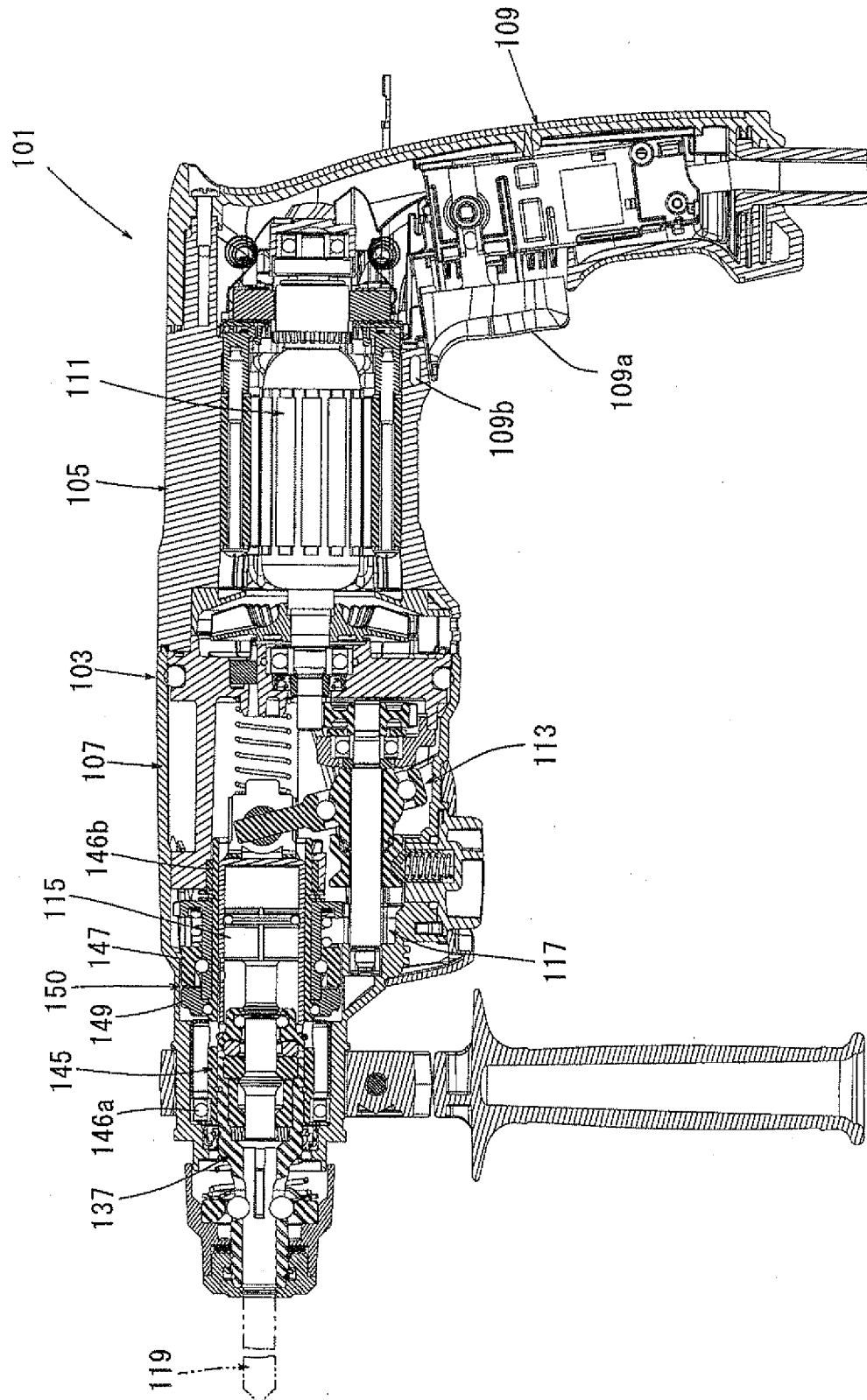


FIG. 2

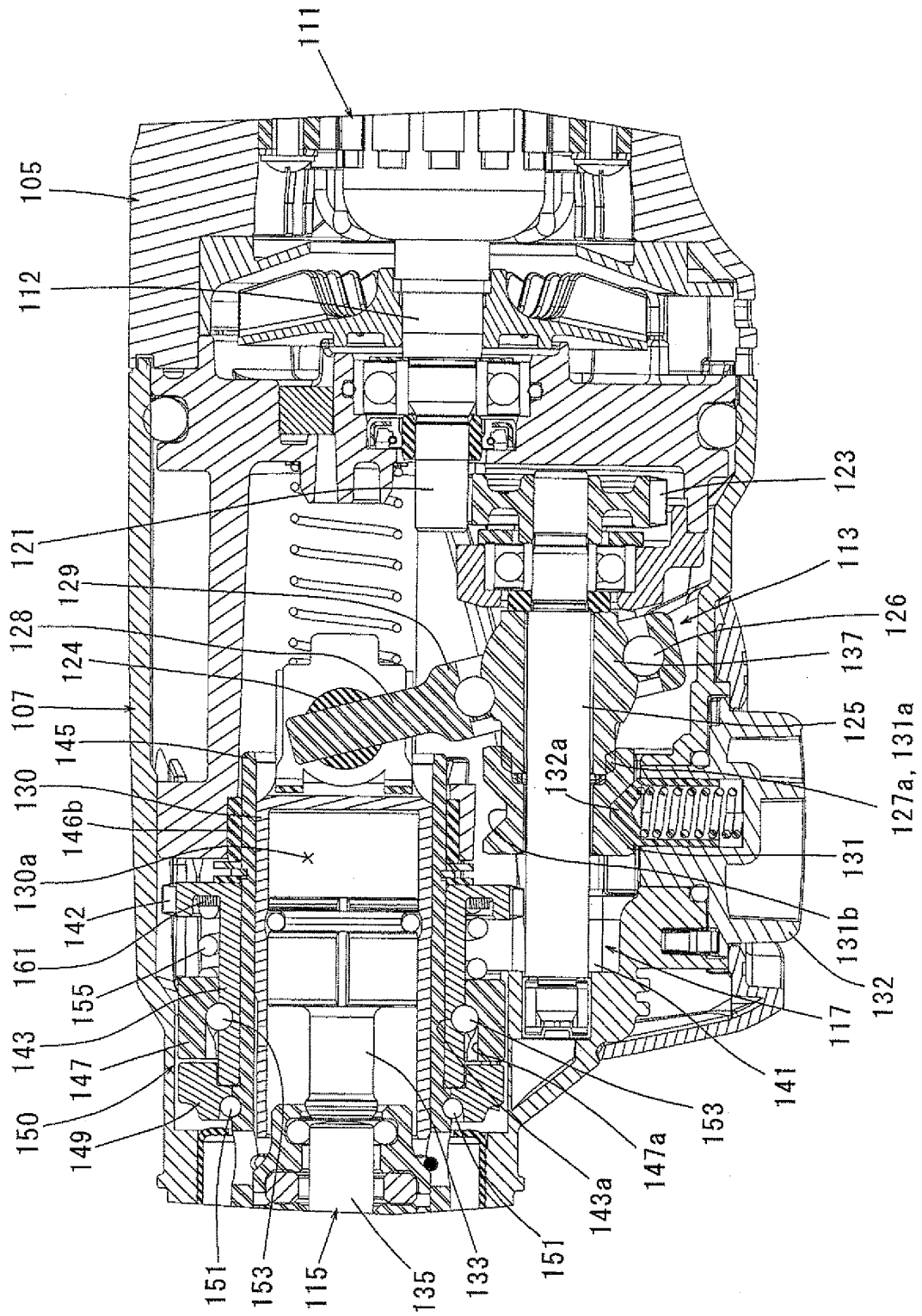
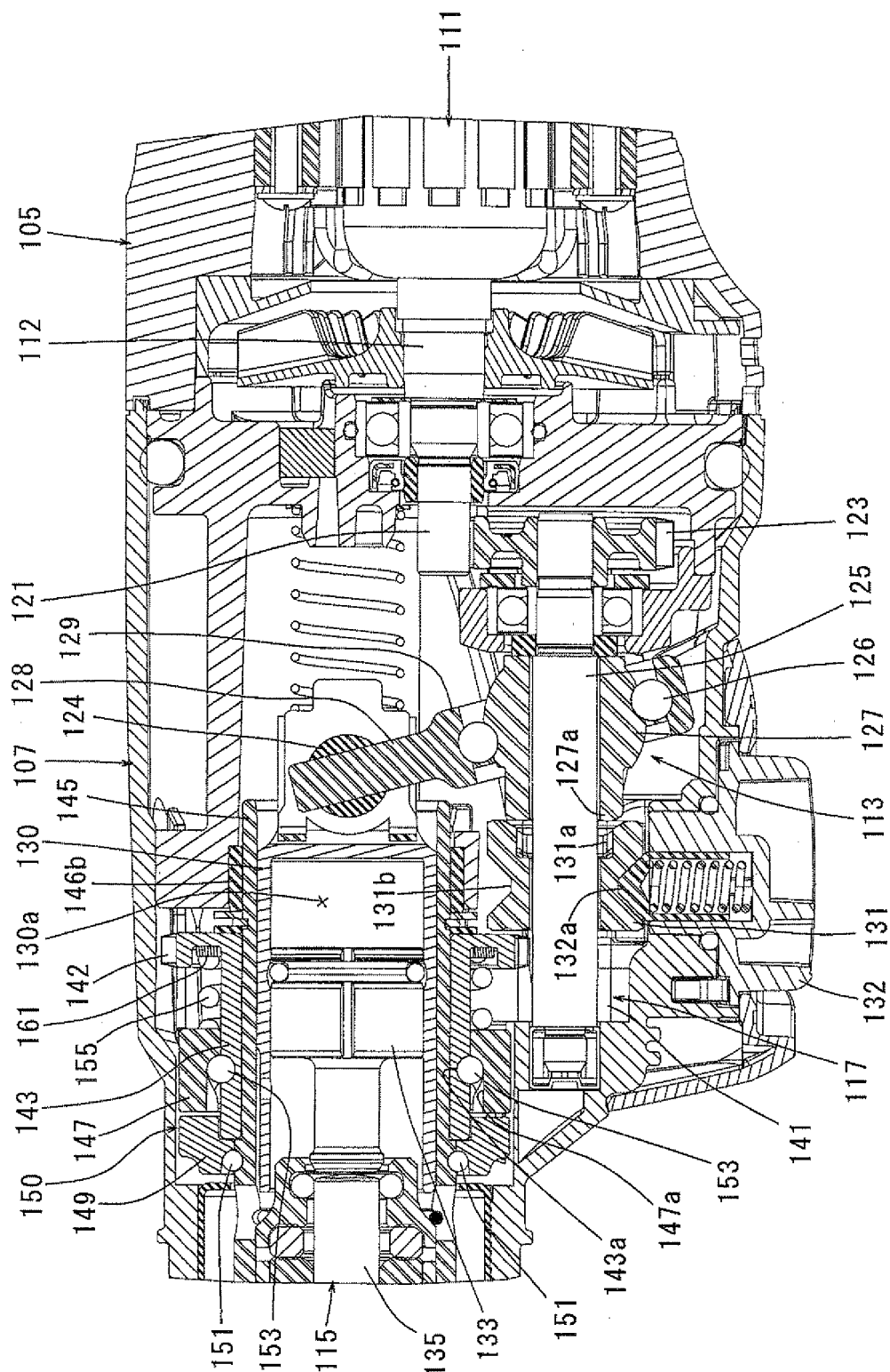


FIG. 3



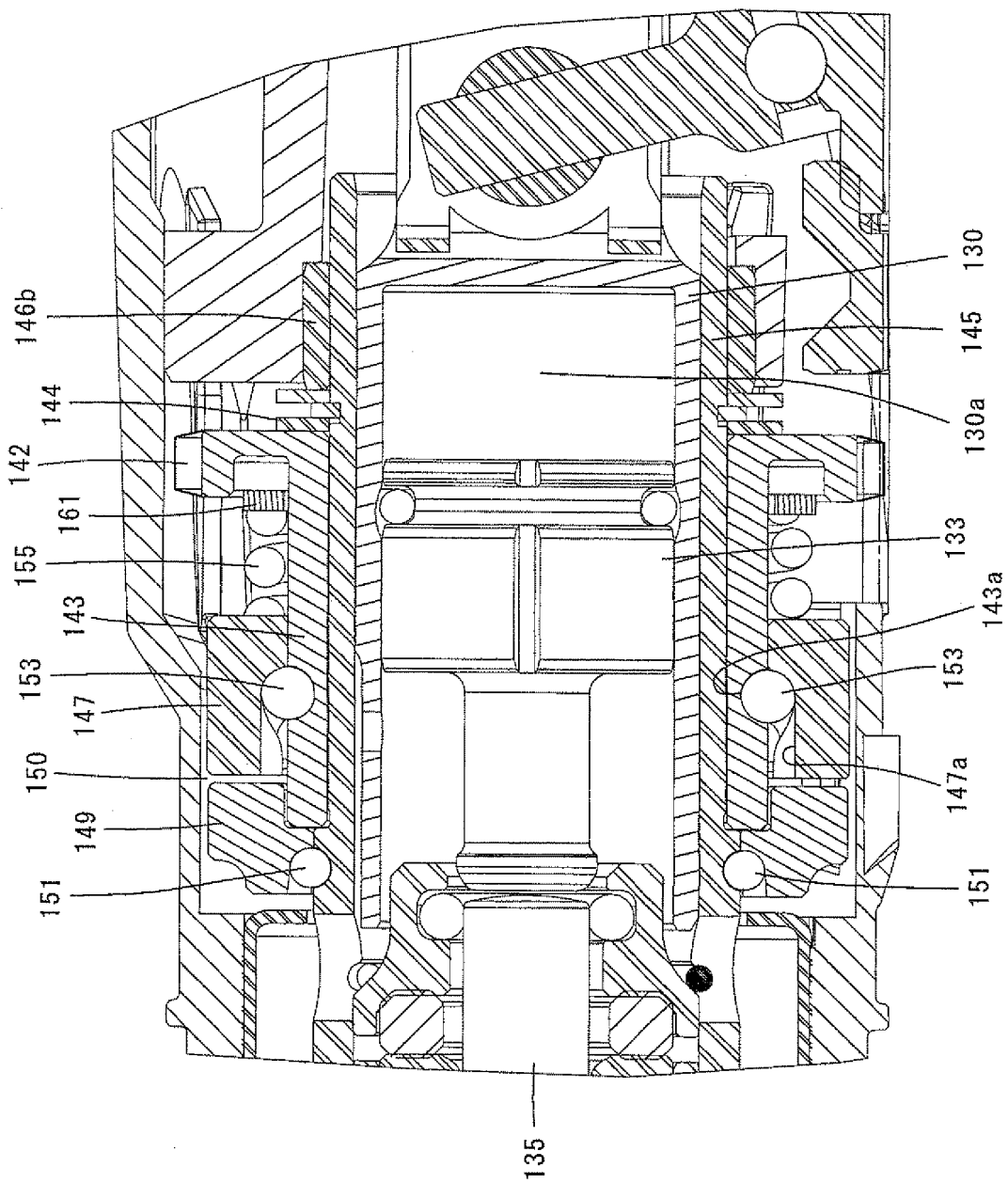
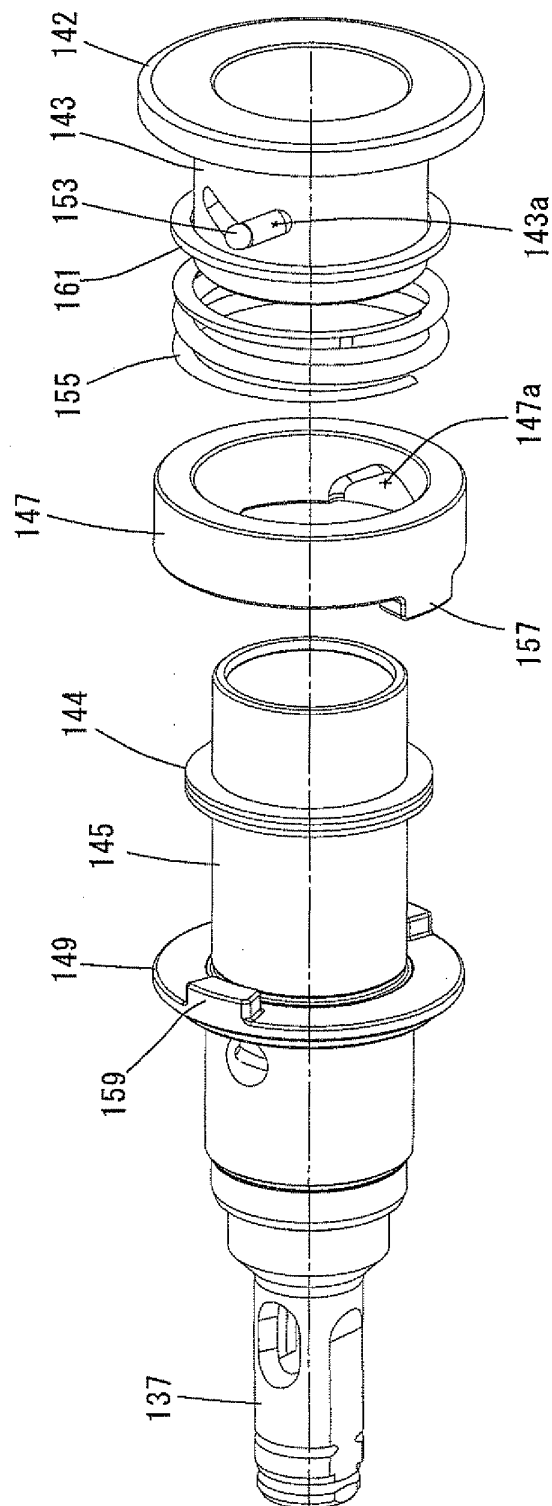


FIG. 4

FIG. 5



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/060386

## A. CLASSIFICATION OF SUBJECT MATTER

B25D16/00 (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)

B25D16/00

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 | 1996-2012 |
| Kokai Jitsuyo Shinan Koho | 1971-2012 | Toroku Jitsuyo Shinan Koho | 1994-2012 |

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. |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | JP 9-70771 A (Hitachi Koki Co., Ltd.),<br>18 March 1997 (18.03.1997),<br>paragraphs [0012] to [0013]; fig. 1 to 3<br>(Family: none) | 1-8                   |
| Y         | JP 2001-9746 A (Makita Corp.),<br>16 January 2001 (16.01.2001),<br>paragraphs [0006] to [0025]; fig. 1 to 8<br>& JP 6-182674 A      | 1-8                   |

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

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"&amp;" document member of the same patent family

Date of the actual completion of the international search  
06 June, 2012 (06.06.12)Date of mailing of the international search report  
19 June, 2012 (19.06.12)Name and mailing address of the ISA/  
Japanese Patent Office

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/060386

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                     | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 23803/1990 (Laid-open No. 113764/1991)<br>(Hitachi Koki Co., Ltd.),<br>21 November 1991 (21.11.1991),<br>page 3, line 8 to page 5, line 15; fig. 1 to 2<br>(Family: none) | 1-8                   |
| Y         | JP 3-49881 A (Matsushita Electric Works, Ltd.),<br>04 March 1991 (04.03.1991),<br>page 2, lower right column, line 9 to page 3,<br>left column, line 18; fig. 1 to 4<br>(Family: none)                                                                                                 | 1-8                   |

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 9070771 A [0002] [0004]