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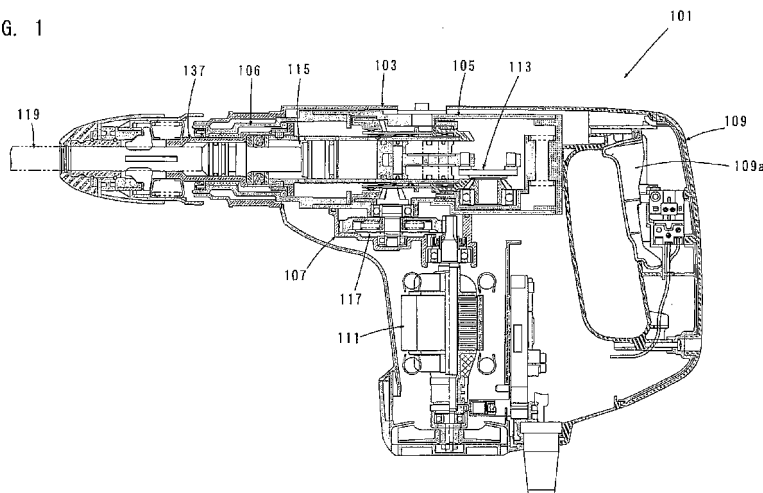
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(54) **IMPACT TOOL**

(57) A technique for further improving the effect of reducing vibration of a handle in an impact tool is provided. An impact tool, having a tool bit 119 which is caused to linearly move in an axial direction of the tool bit 119 and thereby perform a predetermined operation, includes a handle 109 to be held by a user, an outer housing 103 that is integrally formed with the handle 109, a motor 111 that is disposed in an outer housing 103 such that its rotation axis runs transversely to the axial direction of the tool bit 119, a gear 155 that is rotationally driven by re-

ceiving torque of the motor 111 in the outer housing 103, an impact driving part 113 that is driven by the gear 155 in the outer housing 103, and a striking element 133 that is driven by the impact driving part 113 and linearly moves the tool bit 119. The motor 111 is mounted to the outer housing 103, and the outer housing 103 is connected to the impact driving part 113 and the gear 155 via an elastic element 171 and can move in the axial direction of the tool bit 119 with respect to the impact driving part 113 and the gear 155.

FIG. 1



Description

FIELD OF THE INVENTION

[0001] The present invention relates to a technique for vibration-proofing an impact tool in which a tool bit is caused to perform a predetermined hammering operation by linearly moving in its axial direction.

BACKGROUND OF THE INVENTION

[0002] Japanese laid-open Patent Publication No. 2003-39344 discloses an electric hammer having a vibration-proof housing structure. According to the known electric hammer, a pot-shaped housing forms an outer shell of the electric hammer and is integrally formed with a handle to be held by a user, and this housing is connected via an elastic member to a striking mechanism unit which strikes a hammer bit.

[0003] In this electric hammer, transmission of vibration from the striking mechanism unit to the handle can be reduced by the elastic member, but a further improvement is desired in the effect of vibration-proofing the handle.

DISCLOSURE OF THE INVENTION

OBJECT OF THE THE INVENTION

[0004] Accordingly, it is an object of the present invention to further improve the effect of vibration-proofing a handle in an impact tool.

MEANS FOR ACHIEVING THE OBJECT

[0005] In order to solve the above-described problem, according to a preferred embodiment of the present invention, an impact tool is provided with a tool bit which is caused to linearly move in an axial direction of the tool bit and thereby perform a predetermined operation. The "impact tool" in this invention suitably includes a hammer in which a tool bit is caused to linearly move in the axial direction, and a hammer drill in which a tool bit is caused to linearly move in the axial direction and rotate around its axis.

The impact tool according to this invention is **characterized in that** it includes a handle to be held by a user, an outer housing that is integrally formed with the handle, a motor that is disposed in an outer housing such that its rotation axis runs transversely to the axial direction of the tool bit, a gear that is rotationally driven by receiving torque of the motor in the outer housing, an impact driving part that is driven by the gear in the outer housing, and a striking element that is driven by the impact driving part and linearly moves the tool bit. Further, the motor is mounted to the outer housing, and the outer housing is connected to the impact driving part and the gear via an elastic element and can move in the axial direction of the

tool bit with respect to the impact driving part and the gear.

[0006] According to this invention, the outer housing integrally formed with the handle is connected via the elastic element to the impact driving part and the gear which are sources of vibration such that it can move in the axial direction of the tool bit with respect to the impact driving part and the gear, and the motor is mounted to the outer housing. With such a construction in which the motor as a mass is mounted to the outer housing, the mass of the handle which is integrated with the outer housing can be made relatively large with respect to the impact driving part, so that the effect of vibration-proofing the handle can be enhanced. Particularly, in this invention, the outer housing is connected via the elastic element such that it can move with respect to the impact driving part and the gear in the axial direction of the tool bit. With this construction, the positional relation between the impact driving part and the gear which drives the impact driving part is held constant, so that stable and smooth movement can be ensured.

[0007] According to a further embodiment of the impact tool of the present invention, the motor is fixed to the outer housing and integrated with the handle. With such a construction, integration of the motor with the handle can be further enhanced.

[0008] According to a further embodiment of the impact tool of the present invention, the impact tool includes a torque transmitting member that is disposed on the outer housing side and rotates around an axis of the tool bit by receiving torque of the motor, and a power transmitting gear that rotates together with the torque transmitting member and transmits the torque to the gear. Further, the power transmitting gear can move together with the impact driving part in the axial direction of the tool bit with respect to the torque transmitting member while being held in engagement with the gear. The "torque transmitting member" in this invention typically comprises a cylindrical member, and it suitably includes a cylindrical member having an opening such as a slit or a hole in its circumferential surface.

According to this invention having the above-described construction, when the impact driving part and the outer housing move in the axial direction of the hammer bit with respect to each other due to vibration caused by driving of the impact driving part and the striking element, the torque transmitting member and the power transmitting gear correspondingly move with respect to each other. Thus, via the torque transmitting member and the power transmitting gear, torque can be transmitted from the motor to the gear with stability.

[0009] According to a further embodiment of the impact tool of the present invention, the impact tool further includes a bit driving gear that causes the tool bit to rotate in a circumferential direction by receiving the torque of the motor. Further, the power transmitting gear is rotationally driven by the bit driving gear via the torque transmitting member. According to this invention, with such a construction, the impact driving part can be driven by

power obtained from a rotary drive path of the tool bit.

[0010] According to a further embodiment of the impact tool of the present invention, an end of the motor which faces away from an axis of the tool bit in a direction of a rotation axis of the motor is mounted to the outer housing such that the motor can rotate in the axial direction of the tool bit.

According to this invention, by rotatably mounting the motor to the outer housing, the motor can be utilized as a mass of the handle, so that transmissibility of vibration from the impact driving part which is a source of vibration to the handle can be reduced. With such a construction, when the outer housing and the impact driving part move with respect to each other in the axial direction of the tool bit due to vibration, the impact tool can respond to such movement, while improving the effect of vibration-proofing the handle with respect to the impact driving part.

[0011] According to a further embodiment of the impact tool of the present invention, in the construction in which the end of the motor is rotatably mounted to the outer housing, the output shaft of the motor is split in its axial direction and the split shaft parts are coupled by a universal joint. The "universal joint" in this invention refers to a joint which does not affect torque transmission even if the positional relation and angle between the two split shaft parts change. With this construction, when the motor and the impact driving part move with respect to each other in the axial direction of the tool bit due to vibration, the impact tool can smoothly transmit torque of the motor to the impact driving part via the gear, while responding to such relative movement.

[0012] According to a further embodiment of the impact tool of the present invention, the impact tool has a dust-proof cover that covers at least the universal joint.

EFFECT OF THE INVENTION

[0013] According to this invention, a technique is provided for improving the effect of reducing vibration of a handle while securing stable movement in an impact tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a sectional view showing an entire structure of a hammer drill having a vibration-proof housing structure according to a first embodiment of the present invention.

FIG. 2 is also a sectional view showing the entire structure of the hammer drill, in the state in which a compression coil spring is deformed.

FIG. 3 is an enlarged sectional view showing the vibration-proof housing structure of the hammer drill.

FIG. 4 is a sectional view showing an entire structure of a hammer drill having a vibration-proof housing structure according to a second embodiment of the present invention.

FIG. 5 is also a sectional view showing the entire structure of the hammer drill, in the state in which a driving motor is rotated (tilted).

FIG. 6 is a sectional view taken along line A-A in FIG. 4.

FIG. 7 is a sectional view taken along line B-B in FIG. 4.

FIG. 8 is a sectional view taken along line C-C in FIG. 4.

FIG. 9 is a sectional view taken along line D-D in FIG. 4.

FIG. 10 is a sectional view taken along line E-E in FIG. 4.

15 REPRESENTATIVE EMBODIMENT OF THE INVENTION

(First Embodiment of the Invention)

[0015] A first embodiment of the present invention is now described with reference to FIGS. 1 to 3. In this embodiment, an electric hammer drill is explained as a representative example of the impact tool. As shown in FIGS. 1 and 2, the hammer drill 101 according to this embodiment mainly includes an outer housing 103 that forms an outer shell of the hammer drill 101, a hammer bit 119 detachably coupled to a front end region (on the left as viewed in FIG. 1) of the outer housing 103 via a tool holder 137, and a handgrip 109 designed to be held by a user and connected to the outer housing 103 on the side opposite to the hammer bit 119. The hammer bit 119 is held by the hollow tool holder 137 such that it is allowed to linearly move with respect to the tool holder in its axial direction. The outer housing 103, the hammer bit 119 and the handgrip 109 are features that correspond to the "outer housing", the "tool bit" and the "handle", respectively, according to the present 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.

[0016] The outer housing 103 houses a driving motor 111, a crank housing 105 including a barrel 106 and a gear housing 107. The crank housing 105 including the barrel 106 and the gear housing 107 form an inner housing 103. The crank housing 105 houses a motion converting mechanism 113 and a striking mechanism 115 which move the hammer bit 119 linearly in an axial direction of the hammer bit. The gear housing 107 houses a power transmitting mechanism 117 which rotates the hammer bit 119 around its axis. The motion converting mechanism 113, the striking mechanism 115 and the power transmitting mechanism 117 form an internal actuating mechanism for driving the hammer bit 119. The driving motor 111 is fixed in a lower region of the outer housing 103 such that its rotation axis runs in a vertical direction (vertically as viewed in FIG. 1) substantially perpendicular to a longitudinal direction of the outer housing 103 (the axial direction of the hammer bit 119). The hand-

grip 109 is integrally formed with the outer housing 103, so that the driving motor 111 is substantially integrated with the handgrip 109.

[0017] The power transmitting mechanism 117 appropriately reduces the speed of torque of the driving motor 111 and transmits it to the motion converting mechanism 113, and the motion converting mechanism 113 appropriately converts torque of the driving motor 111 into linear motion and then transmits it to the striking mechanism 115. Then, an impact force is generated in the axial direction of the hammer bit 119 (the horizontal direction as viewed in FIG. 1) via the striking mechanism 115. The motion converting mechanism 113 is a feature that corresponds to the "impact driving part" according to this invention. Further, the speed of torque of the driving motor 111 is appropriately reduced by the power transmitting mechanism 117 and transmitted to the hammer bit 119 via a cylinder 131 and the tool holder 137, so that the hammer bit 119 is caused to rotate in its circumferential direction. The driving motor 111 is driven when a user depresses a trigger 109a disposed on the handgrip 109.

[0018] As shown in FIG. 3, the motion converting mechanism 113 mainly includes a crank shaft 121 that is rotationally driven in a horizontal plane via the power transmitting mechanism 117 for transmitting torque of the driving motor 111, a crank plate 123 that is caused to rotate together with the crank shaft 121, a crank arm 127 that is loosely connected to the crank plate 123 via an eccentric shaft 125, and a driving element in the form of a piston 129 which is mounted to the crank arm 127 via a connecting shaft 128. The piston 129 is slidably disposed within the cylinder 131. When the driving motor 111 is driven, the piston 129 is caused to linearly move in the axial direction of the hammer bit 119 within the cylinder 131.

[0019] The striking mechanism 115 mainly includes a striking element in the form of a striker 133 slidably disposed within the bore of the cylinder 131, and an intermediate element in the form of an impact bolt 135 that is slidably disposed within the tool holder 137 and serves to transmit kinetic energy of the striker 133 to the hammer bit 119. An air chamber 131a is formed between the piston 129 and the striker 133 in the cylinder 131. The striker 133 is driven via pressure fluctuations (air spring action) of the air chamber 131a by sliding movement of the piston 129. The striker 133 then collides with (strikes) the impact bolt 135 which is slidably disposed in the tool holder 137. As a result, a striking force caused by the collision is transmitted to the hammer bit 119 via the impact bolt 135.

[0020] The power transmitting mechanism 117 mainly includes a driving gear 141, a torque limiter 143, an intermediate shaft 145, a first bevel gear 147, a second bevel gear 149, a rotary sleeve 151, a third bevel gear 153 and a fourth bevel gear 155. The first bevel gear 147, the second bevel gear 149, the rotary sleeve 151, the third bevel gear 153 and the fourth bevel gear 155 of the power transmitting mechanism 117 are housed within the crank housing 105, and the other members of the

power transmitting mechanism 117 are housed within the gear housing 107.

[0021] Torque of the driving motor 111 is transmitted from the driving gear 141 formed on the output shaft 112 of the driving motor 111 to the intermediate shaft 145 via the torque limiter 143. The torque limiter 143 is provided on the intermediate shaft 145 as a safety device which interrupts power transmission from the driving gear 141 to the intermediate shaft 145 when an excessive load exceeding a set value predetermined by a spring 143a of the torque limiter 143 is exerted on the hammer bit 119. The torque transmitted to the intermediate shaft 145 is then transmitted from the first bevel gear 147 that rotates together with the intermediate shaft 145 in a horizontal plane, to the second bevel gear 149 that rotates in a vertical plane in engagement with the first bevel gear 147, and then further transmitted from the second bevel gear 149 to the rotary sleeve 151.

[0022] The rotary sleeve 151 is a cylindrical member which is coaxially disposed on the outside of the cylinder 131 and can move in the longitudinal direction with respect to the cylinder 131, the second bevel gear 149 that is disposed on the outside of a front end portion of the rotary sleeve 151, and the third bevel gear 153 that is disposed on the outside of a rear end portion of the rotary sleeve 151. The rotary sleeve 151 is splined to the second bevel gear 149 on its front end portion in the longitudinal direction, and also splined to the third bevel gear 153 on its rear end portion in the longitudinal direction. Therefore, when the driving motor 111 is driven, the three members, or the second bevel gear 149, the rotary sleeve 151 and the third bevel gear 153 are always caused to rotate together.

[0023] The third bevel gear 153 is engaged with the fourth bevel gear 155 fixed on the crank shaft 121. Therefore, torque of the rotary sleeve 151 is transmitted from the third bevel gear 153 that rotates in a vertical plane together with the rotary sleeve 151, to the crank shaft 121 via the fourth bevel gear 155, so that the crank shaft 121 rotates in a horizontal plane. Thus, the motion converting mechanism 113 and the striking mechanism 115 are driven. The rotary sleeve 151 and the fourth bevel gear 155 are features that correspond to the "torque transmitting member" and the "gear", respectively, according to this invention. The third bevel gear 153 is rotatably supported by a sliding bearing 169 which is housed within a bearing cover 163, and the crank shaft 121 is rotatably supported by a rolling bearing 167 which is housed within the bearing cover 163.

[0024] Further, clutch teeth 151a are formed on the inner circumferential surface of the rotary sleeve 151 and engage with clutch teeth 131b formed on the outer circumferential surface of the cylinder 131. Therefore, torque of the rotary sleeve 151 is transmitted to the cylinder 131 via the clutch teeth 151a, 131b and then to the hammer bit 119 via the tool holder 137 which is connected to the cylinder 131 by a connecting pin 132, so that the hammer bit 119 is caused to rotate.

[0025] An operation mode switching member in the form of an operation mode switching dial 175 is disposed in an upper surface region of the crank housing 105 and can be manually operated by a user. The operation mode switching dial 175 can be switched between hammer mode in which the hammer bit 119 is caused to perform at least a hammering operation only by striking movement and hammer drill mode in which the hammer bit 119 is caused to perform a hammer drill operation by striking movement and rotation. By switching the operation mode switching dial 175, the rotary sleeve 151 is slid in the axial direction of the hammer bit 119. The operation mode switching dial 175 is mounted to be rotatable around a vertical axis transverse to the axis of the hammer bit 119. The operation mode switching dial 175 has an eccentric shaft part 175a which is engaged with a circumferentially extending ring groove 151b formed in the outer surface of the rotary sleeve 151. When the user turns the operation mode switching dial 175, the rotary sleeve 151 is slid along the cylinder 131 in the axial direction of the hammer bit 119 via the eccentric shaft part 175a.

[0026] When the operation mode switching dial 175 is switched to hammer drill mode, the rotary sleeve 151 is slid rearward (toward the handgrip 109) and the clutch teeth 151a of the rotary sleeve 151 engage with the clutch teeth 131b of the cylinder 131 so that the torque is transmitted to the cylinder 131. Therefore, in this case, the motion converting mechanism 113 and the striking mechanism 115 are driven, and the torque of the rotary sleeve 151 is transmitted to the cylinder 131 and then transmitted to the hammer bit 119 via the tool holder 137 which is connected to the cylinder 131 by the connecting pin 132. Thus, the hammer bit 119 is caused to perform striking movement and rotation.

[0027] When the operation mode switching dial 175 is switched to hammer mode, the rotary sleeve 151 is slid forward (toward the hammer bit 119) and the clutch teeth 151a of the rotary sleeve 151 are disengaged from the clutch teeth 131b of the cylinder 131 so that the torque is no longer transmitted to the cylinder 131. Therefore, in this case, the hammer bit 119 is caused to perform only striking movement via the motion converting mechanism 113 and the striking mechanism 115. Thus, the rotary sleeve 151 according to this embodiment not only serves to transmit (distribute) the torque of the driving motor 111 as a rotational driving power to each of the motion converting mechanism 113 and the hammer bit 119, but also serves as a clutch member for switching the operation mode.

[0028] The tool holder 137 disposed in a front region of the crank housing 105 is mounted such that it can move in the axial direction of the hammer bit 119 and rotate in the circumferential direction with respect to the crank housing 105 via a front sliding bearing 161. The bearing cover 163 disposed in a rear region of the crank housing 105 is mounted such that it can move in the axial direction with respect to the crank housing 105 via a rear

sliding bearing 165. A rear end surface of the bearing cover 163 in the axial direction of the hammer bit is elastically connected to a front surface of a rear end part of the crank housing 105 via a compression coil spring 171 which contracts and extends in the axial direction of the hammer bit. The compression coil spring 171 is a feature that corresponds to the "elastic element" according to this invention. The compression coil spring 171 applies a biasing force in such a manner as to push the bearing cover 163 forward. This biasing force is received by a rubber ring 173 which is disposed between a rear end flange 137a of the tool holder 137 and an inner stepped part 106a of the barrel 106.

[0029] Specifically, in this embodiment, not only the tool holder 137, the cylinder 131, the motion converting mechanism 113 and the striking mechanism 115, but the third and fourth bevel gears 153, 155 of the power transmitting mechanism 117 which are supported by the bearing cover 163 are connected to the crank housing 105 such that they can move in the axial direction of the hammer bit 119 via the compression coil spring 171. The crank housing 105 is integrated with the outer housing 103. Therefore, the outer housing 103 integrally formed with the handgrip 109 is elastically connected via the compression coil spring 171 to the motion converting mechanism 113 and the striking mechanism 115 (which may also be hereinafter referred to as a striking mechanism part including both of the motion converting mechanism 113 and the striking mechanism 115) which are sources of vibration.

[0030] In the hammer drill 101 constructed as described above, when the user holds the handgrip 109 and depresses the trigger 109a in order to drive the driving motor 111, while applying a pressing force to the outer housing 103 in the axial direction of the hammer bit 119 and pressing the hammer bit 119 against the workpiece, the torque of the driving motor 111 is transmitted from the rotary sleeve 151 of the power transmitting mechanism 117 to the motion converting mechanism 113 via the third and fourth bevel gears 153, 155. Then the piston 129 is caused to linearly slide within the cylinder 131 via the motion converting mechanism 113. By this sliding movement, the striker 133 is caused to linearly move within the cylinder 131 via air pressure fluctuations or air spring action in the air chamber 131a of the cylinder 131. The striker 133 then collides with the impact bolt 135, so that the kinetic energy caused by this collision is transmitted to the hammer bit 119.

[0031] At this time, when the operation mode switching dial 175 is placed in the hammer mode, the rotary sleeve 151 is slid forward and the clutch teeth 151a of the rotary sleeve 151 are disengaged from the clutch teeth 131b of the cylinder 131 so that the torque is no longer transmitted to the cylinder 131. Therefore, the hammer bit 119 performs a hammering operation only by striking movement in its axial direction.

[0032] On the other hand, when the operation mode switching dial 175 is placed in the hammer drill mode,

the rotary sleeve 151 is slid rearward and the clutch teeth 151a of the rotary sleeve 151 are engaged with the clutch teeth 131b of the cylinder 131 so that the torque of the driving motor 111 is transmitted to the cylinder 131 via the rotary sleeve 151. Therefore, the cylinder 131 and the tool holder 137 are rotationally driven in a vertical plane and the hammer bit 119 is caused to rotate together with the tool holder 137. Thus, the hammer bit 119 performs a hammer drill operation (drilling operation) on a workpiece (concrete) by striking movement in the axial direction and rotation in the circumferential direction.

[0033] During hammering or hammer drill operation, impulsive and cyclic vibration is caused in the striking mechanism part (the motion converting mechanism 113 and the striking mechanism 115) in the axial direction of the hammer bit 119. By this vibration, the compression coil spring 171 elastically deforms, so that the motion converting mechanism 113 connected via the compression coil spring 171 is caused to move in the axial direction of the hammer bit 119 with respect to the crank housing 105. Thus, transmission of vibration from the motion converting mechanism 113 to the crank housing 105 can be reduced. FIG. 2 shows the state in which the compression coil spring 171 is deformed. Thus, the outer housing 103 to which the crank housing 105 is fixed, and the handgrip 109 which is integrally formed with the outer housing 103 are vibration-proofed.

[0034] In this case, in this embodiment, the driving motor 111 is fixed to the outer housing 103. With such a construction in which the driving motor 111 as a mass is fixed to the outer housing 103, the mass of the handgrip 109 which is integrated with the outer housing 103 can be made relatively large with respect to the motion converting mechanism 113 and the striking mechanism 115 which causes the hammer bit 119 to perform striking movement, so that the effect of vibration-proofing the handgrip 109 can be enhanced.

[0035] Further, in this embodiment, not only the driving motor 111, but the inner housing including the crank housing 105 and the gear housing 107 and most of the components or elements of the power transmitting mechanism 117 housed within the crank housing 105 and the gear housing 107 are fixed or disposed on the outer housing 103 side. Therefore, the mass of the outer housing 103 side is further increased by these members as well as the driving motor 111, so that the effect of vibration-proofing the handgrip 109 can be further enhanced.

[0036] Further, in this embodiment, the rotary sleeve 151 is connected such that it can move in the axial direction with respect to the cylinder 131 and the third bevel gear 153 and rotate together with the cylinder 131 and the third bevel gear 153. Therefore, the rotary sleeve 151 can transmit torque of the second bevel gear 149 to the cylinder 131 and the third bevel gear 153 without being affected by vibration caused in the axial direction of the hammer bit.

[0037] Further, in this embodiment, the torque of the driving motor 111 is distributed by the rotary sleeve 151

to a path for striking power of striking the hammer bit 119 and a path for rotating power of rotating the hammer bit 119. Therefore, components relating to power transmission between the rotary sleeve 151 and the driving gear 141, including the rotary sleeve 151, are used in common to the both paths. Thus, the number of parts for driving the hammer bit 119 can be rationally reduced.

[0038] Further, in this embodiment, in order to drive the motion converting mechanism 113, the third and fourth bevel gears 153, 155 supported via the bearings 167, 169 in the bearing cover 163 are connected such that they can move together with the motion converting mechanism 113 in the axial direction of the hammer bit with respect to the outer housing 103. Therefore, the positional relation between the motion converting mechanism 113 and the third and fourth bevel gears 153, 155 is held constant regardless of vibration, so that stable and smooth movement can be ensured.

[0039] Hammering or hammer drill operation by the hammer bit is performed while the user holding the handgrip 109 applies a pressing force to the outer housing 103 in the axial direction of the hammer bit 119 and presses the hammer bit 119 against the workpiece. In this embodiment, the tool holder 137 and the bearing cover 163 are supported via the front and rear sliding bearings 161, 165 with respect to the crank housing 105, or specifically they are allowed to move only in the axial direction with respect to the crank housing 105. With this construction, the hammer bit 119 can be pressed against the workpiece in stable condition.

(Second Embodiment of the Invention)

[0040] A hammer drill 201 according to a second embodiment of the present invention is now described with reference to FIGS. 4 to 10. An internal actuating mechanism for driving a hammer bit 219 (a motion converting mechanism 213 for causing the hammer bit 219 to perform striking movement and a striking mechanism (not shown)) and a power transmitting mechanism 217 for transmitting torque to the hammer bit 219 have substantially the same construction as those of the above-described first embodiment. In this embodiment, however, for the sake of convenience of explanation, part of the motion converting mechanism 213 is shown in FIG. 8, and part of the power transmitting mechanism 217 is shown in FIG. 7. The motion converting mechanism 213 is a feature that corresponds to the "impact driving part" according to this invention.

[0041] As shown in FIGS. 4 and 5, an outer housing 203 is integrally formed with a handgrip 209. The outer housing 203 and the handgrip 209 are features that correspond to the "outer housing" and the "handle", respectively, according to the present invention. As shown in FIGS. 4 to 6, the outer housing 203 houses a motor housing 208 which houses a driving motor 211, and an inner housing 205 which houses the motion converting mechanism 213, the striking mechanism and the power trans-

mitting mechanism 217. The driving motor 211 is driven when a user depresses a trigger 209a disposed on the handgrip 209. The driving motor 211 is disposed such that its rotation axis runs in a vertical direction (vertically as viewed in FIG. 4) substantially perpendicular to the axial direction of the hammer bit 219, and at an end (lower end) of the driving motor which faces away from the axis of the hammer bit 219, the motor housing 208 is mounted to the outer housing 203 such that it can rotate on a shaft 281 in the axial direction of the hammer bit.

[0042] One (rear) end of the inner housing 205 in the axial direction is connected to the outer housing 203 via ball-like vibration-proofing elastic rubbers 283, 284 (two each on its upper and lower ends in this embodiment) such that it can move in the axial direction of the hammer bit 219 with respect to the outer housing 203. The other end of the inner housing 205 in the axial direction is supported via a rubber ring 285 having a circular section with respect to the outer housing 203 such that it can move in the axial direction of the hammer bit 219 with respect to the outer housing 203. Specifically, in this embodiment, the inner housing 205 which houses the motion converting mechanism 213 and the striking mechanism which are sources of vibration and the power transmitting mechanism 217 is connected to the outer housing 203 which is integrally formed with the handgrip 209, via the elastic rubbers 283, 284 such that it can move in the axial direction of the hammer bit with respect to the outer housing 203. The elastic rubbers 283, 284 are features that correspond to the "elastic element" according to this invention.

[0043] FIG. 9 shows the upper two elastic rubbers 283, and FIG. 10 shows the lower two elastic rubbers 284. As shown in the drawings, the upper and lower elastic rubbers 283, 284 are arranged on the right and left sides of the axis of the hammer bit 219. The upper and lower elastic rubbers 283, 284 are held between a generally semispherical concave surface 286a of an outer rubber support 286 formed on the outer housing 203 and a generally semispherical concave surface 287a of an inner rubber support 287 formed on the inner housing 205.

[0044] In this embodiment, in the connecting structure of the outer and inner housings 203, 205 with respect to the upper and lower elastic rubbers 283, 284, as for the upper right and left parts, the mating surfaces of the outer and inner rubber supports 286, 287 which face each other are formed in a generally inverted V configuration as viewed from the handgrip 209 side, and as for the lower right and left parts, the mating surfaces of the outer and inner rubber supports 286, 287 which face each other are formed in a generally V configuration as viewed from the handgrip 209 side. Specifically, the mating surfaces of the outer and inner rubber supports 286, 287 which face each other are parallel in the axial direction of the hammer bit 119 and inclined at an angle of about 45 degrees in the horizontal direction and the vertical direction transverse to the axial direction. With this construction, in the axial direction, a force in a shearing direction

mainly acts upon the elastic rubbers 283, 284, and in a direction transverse to the axial direction, a force in a compressing direction mainly acts upon the elastic rubbers.

[0045] The rubber ring 285 is provided as a guide member for guiding movement of the inner housing 205 with respect to the outer housing 203 in the axial direction of the hammer bit. The rubber ring 285 is disposed in a ring-shaped space which is defined between an outer surface of the inner housing 205 and a front surface of a ring-shaped outer flange 205a formed on the outer surface of the inner housing 205, and an inner surface of the outer housing 203 and a ring-shaped inner flange 203a formed on the inner surface of the outer housing 203. Thus, the rubber ring 285 prevents the inner housing 205 from uselessly moving in a direction transverse to the axial direction of the hammer bit with respect to the outer housing 103. Therefore, when performing a hammering or hammer drill operation while pressing the hammer bit 219 against a workpiece, the hammer bit 219 can be prevented from uselessly moving in a direction transverse to the axial direction of the hammer bit with respect to the outer housing 103, so that operation can be performed in stable condition.

[0046] As shown in FIG. 6, an output shaft 212 of the driving motor 211 extends into the inner housing 205 and a driving gear 241 is formed on the extending end of the output shaft 212, so that the motion converting mechanism 213 is driven by a driven gear 242 which is engaged with the driving gear 241. The driven gear 242 is a feature that corresponds to the "gear" according to this invention. In FIG. 8, a crank shaft 221 to which the driven gear 242 is fixed, a crank plate 223, an eccentric shaft 225 and a crank arm 227 of the motion converting mechanism 213 are shown.

[0047] In FIG. 7, a torque limiter 243, an intermediate shaft 245 and a first bevel gear 247 of the power transmitting mechanism 217 are shown. In this embodiment, the torque limiter 243 is driven by the driven gear 242, and torque is transmitted from the first bevel gear 247 to a tool holder (not shown) directly or via a second bevel gear (not shown) and a cylinder (not shown).

[0048] The motor housing 208 which houses the driving motor 211 rotates on the shaft 281 in the axial direction of the hammer bit when the inner and outer housings 205, 203 move in the axial direction of the hammer bit with respect to each other. In order to respond to such rotation, the output shaft 212 of the driving motor 211 is split in its axial direction into a body-side shaft part 212a and a tip-side shaft part 212b on which the driving gear 241 is formed. An axially extending hexagonal hole 291 is formed in an end portion of the body-side shaft part 212a, and a spherical element 292 having a hexagonal section is formed on the tip-side shaft part 212b. The spherical element 292 is fitted in the hexagonal hole 291 such that it can move in the extending direction of the hole (in the axial direction of the shaft) with respect to the hole. Thus, the body-side shaft part 212a and the tip-

side shaft part 212b are connected such that torque can be transmitted therebetween and can flex at the joint. The hexagonal hole 291 and the spherical element 292 form the "universal joint" according to this invention. Further, axial ends of the tip-side shaft part 212b are rotatably supported by the inner housing 205 via bearings.

[0049] Further, the body-side shaft part 212a is supported by the inner housing 205 via a spherical bearing 295 such that it can move in all directions with respect to the inner housing. The spherical bearing 295 includes a spherical concave part 293 which is mounted to the inner housing 205, and a spherical element 294 which is fitted in the spherical concave part 293. The spherical element 294 is mounted on an outer surface of an end portion of the body-side shaft part 212a such that it can slide in the axial direction of the shaft. In FIG. 5, the inner housing 205 is shown moved rearward (toward the handgrip 209) in the axial direction of the hammer bit with respect to the outer housing 203, so that the driving motor 211 rotates rearward and the output shaft 212 flexes into a generally dogleg form.

[0050] Further, a flexible (rubber) dust-proof cover 297 covers regions of the motor housing 208 and the inner housing 205 which include a joint between the body-side shaft part 212a and the tip-side shaft part 212b.

[0051] The hammer drill 201 according to this embodiment is constructed as described above. Therefore, during operation, impulsive and cyclic vibration is caused in the inner housing 205 in the axial direction of the hammer bit 219 by driving of the striking mechanism part. However, transmission of vibration from the inner housing 205 to the outer housing 203 and the handgrip 209 side is reduced by elastic deformation of the elastic rubbers 283, 284. In this case, in this embodiment, the driving motor 211 is mounted to the outer housing 203 such that it can rotate in the axial direction of the hammer bit. With such a construction in which the driving motor 211 as a mass is mounted to the outer housing 203, the mass of the handgrip 209 which is integrated with the outer housing 203 can be made relatively large with respect to the inner housing 205 which houses the striking mechanism part, so that the effect of vibration-proofing the handgrip 109 can be enhanced.

[0052] Further, the elastic rubbers 283, 284 have lower shearing stiffness compared with their compressive stiffness, or in other words, a higher vibration reducing effect can be obtained by shearing deformation than by compressive deformation. In this embodiment, in order to utilize this property, it is designed such that the elastic rubbers 283, 284 undergo shearing deformation in the axial direction of the hammer bit. With this construction, the effect of reducing vibration of the handgrip 209 by shearing deformation of the elastic rubbers 283, 284 can be enhanced.

[0053] Further, the elastic rubbers 283, 284 undergo compressive deformation in the horizontal direction and the vertical direction transverse to the axial direction of the hammer bit 219. With this construction, the outer and

inner housings 203, 205 can be prevented from uselessly moving with respect to each other in the horizontal direction and the vertical direction, so that the hammer bit 219 can be pressed against the workpiece in stable condition.

[0054] Further, in this embodiment, the driving gear 241 and the driven gear 242 which drive the motion converting mechanism 213 are disposed in the inner housing 205 and connected to the outer housing 203 together with the motion converting mechanism 213 such that they can move in the axial direction of the hammer bit with respect to the outer housing 203. Therefore, the positional relation between the motion converting mechanism 213, the driving gear 241 and the driven gear 242 is held constant regardless of vibration, so that stable and smooth movement can be ensured.

[0055] In the second embodiment, the elastic rubbers 283 284 are described as being spherical, but they may be cylindrical. Further, the joint structure of the split output shaft 212 is described as being constructed such that the hexagonal hole 291 is formed in the body-side shaft part 212a and the spherical element 292 having a hexagonal section is formed in the tip-side shaft part 212b, but they may be formed vice versa. The universal joint is not limited to the structure comprising the hexagonal hole 291 and the spherical element 292 having a hexagonal section.

Further, in the above-described first and second embodiments, a hammer drill is described as a representative example of the impact tool, but the present invention may also be applied to a hammer in which the hammer bit 119 or 219 is caused to perform only striking movement in the axial direction.

[0056] In view of the above-described invention, the following aspects can be provided. Aspect 1

"The impact tool as defined in any one of claims 1 to 3, comprising an inner housing that houses the impact driving part, wherein the inner housing is fixed to the outer housing."

Aspect 2

[0057] "The impact tool as defined in aspect 1, wherein the impact driving part is supported via front and rear sliding bearings in the inner housing and can slide in the axial direction of the tool bit with respect to the inner housing."

Aspect 3

[0058] "The impact tool as defined in claim 3, further comprising an operation mode switching member that is switched between hammer mode in which the tool bit is caused to perform an operation only by striking movement and hammer drill mode in which the tool bit is caused to perform an operation by striking movement and rotation, wherein the torque transmitting member also serves as a clutch member for switching operation mode which transmits torque of the motor to the tool bit

when the operation mode switching member is switched to hammer drill mode, and interrupts the torque transmission when the operation mode switching member is switched to hammer mode."	131a	air chamber
	131b	clutch teeth
	132	connecting pin
	133	striker
Aspect 4	5 135	impact bolt
	137	tool holder
	137a	rear end flange
[0059] "The impact tool as defined in any one of claims 1 to 6, comprising a motion converting mechanism that converts torque into linear motion, and a striking element that is linearly driven by the motion converting mechanism and applies a striking force to the tool bit."	141	driving gear
	143	torque limiter
	10 143a	spring
	145	intermediate shaft
	147	first bevel gear
	149	second bevel gear (bit driving gear)
Aspect 5	151	rotary sleeve (rotation power transmitting member)
	15	
[0060] "The impact tool as defined in any one of claims 4 to 6, wherein the elastic element comprises an elastic rubber, and the elastic element mainly undergoes shearing deformation in the axial direction of the hammer bit and mainly undergoes compressive deformation in a direction transverse to the axial direction of the hammer bit."	151a	clutch teeth
	151b	ring groove
	153	third bevel gear (power transmitting gear)
	155	fourth bevel gear (gear)
	20 161	front sliding bearing
	163	bearing cover
	165	rear sliding bearing
	167	rolling bearing
Aspect 6	169	sliding bearing
	25 171	compression coil spring (elastic element)
[0061] "The impact tool as defined in claim 6, wherein the universal joint for coupling the split shaft parts comprises a hexagonal hole formed in one of the split shaft parts and a spherical element having a hexagonal section which is formed on the other split shaft part and fitted in the hexagonal hole."	173	rubber ring
	175	operation mode switching dial (operation mode switching member)
	175a	eccentric shaft part
	30 201	hammer drill (impact tool)
	203	outer housing
	203 a	inner flange
Description of Numerals	205	inner housing
	205a	outer flange
[0062]	35 208	motor housing
	209	handgrip (handle)
101	209a	trigger
103	211	driving motor (motor)
105	212	output shaft
106	40 212a	body-side shaft part
106a	212b	tip-side shaft part
107	213	motion converting mechanism (impact driving part)
109		handgrip (handle)
109a	217	power transmitting mechanism
111	45 219	hammer bit (tool bit)
112	221	crank shaft
113	223	crank plate
	225	eccentric shaft
115	227	crank arm
117	50 241	driving gear
119	242	driven gear (gear)
121	243	torque limiter
123	245	intermediate shaft
125	247	first bevel gear
127	55 281	shaft
128	283, 284	elastic rubber (elastic element)
129	285	rubber ring
131	286	outer rubber support

286a spherical concave surface
 287 inner rubber support
 287a spherical concave surface
 291 hexagonal hole
 292 spherical element
 293 spherical concave part
 294 spherical element
 295 spherical bearing
 297 dust-proof cover

Claims

1. An impact tool that linearly move a tool bit in an axial direction of the tool bit to perform a predetermined operation, comprising:
 - a handle to be held by a user,
 - an outer housing that is integrally formed with the handle,
 - a motor that is disposed in an outer housing such that its rotation axis runs transversely to the axial direction of the tool bit,
 - a gear that is rotationally driven by receiving torque of the motor in the outer housing,
 - an impact driving part that is driven by the gear in the outer housing, and
 - a striking element that is driven by the impact driving part and linearly moves the tool bit,
 - characterized in that** the motor is mounted to the outer housing, and the outer housing is connected to the impact driving part and the gear via an elastic element and can move in the axial direction of the tool bit with respect to the impact driving part and the gear.
2. The impact tool as defined in claim 1, wherein the motor is fixed to the outer housing and integrated with the handle.
3. The impact tool as defined in claim 1 or 2, comprising a torque transmitting member that is disposed on the outer housing side and rotates around an axis of the tool bit by receiving torque of the motor, and a power transmitting gear that rotates together with the torque transmitting member and transmits the torque to the gear, wherein the power transmitting gear can move together with the impact driving part in the axial direction of the tool bit with respect to the torque transmitting member while being held in engagement with the gear.
4. The impact tool as defined in claim 3, further comprising a bit driving gear that causes the tool bit to rotate in a circumferential direction by receiving the torque of the motor, wherein the power transmitting gear is rotationally driven by the bit driving gear via the torque transmitting member.

5. The impact tool as defined in claim 1, wherein an end of the motor which faces away from an axis of the tool bit in a direction of a rotation axis of the motor is mounted to the outer housing such that the motor can rotate in the axial direction of the tool bit.
6. The impact tool as defined in claim 5, wherein the output shaft of the motor is split in its axial direction and the split shaft parts are coupled by a universal joint.
7. The impact tool as defined in claim 6, comprising a dust-proof cover that covers at least the universal joint.

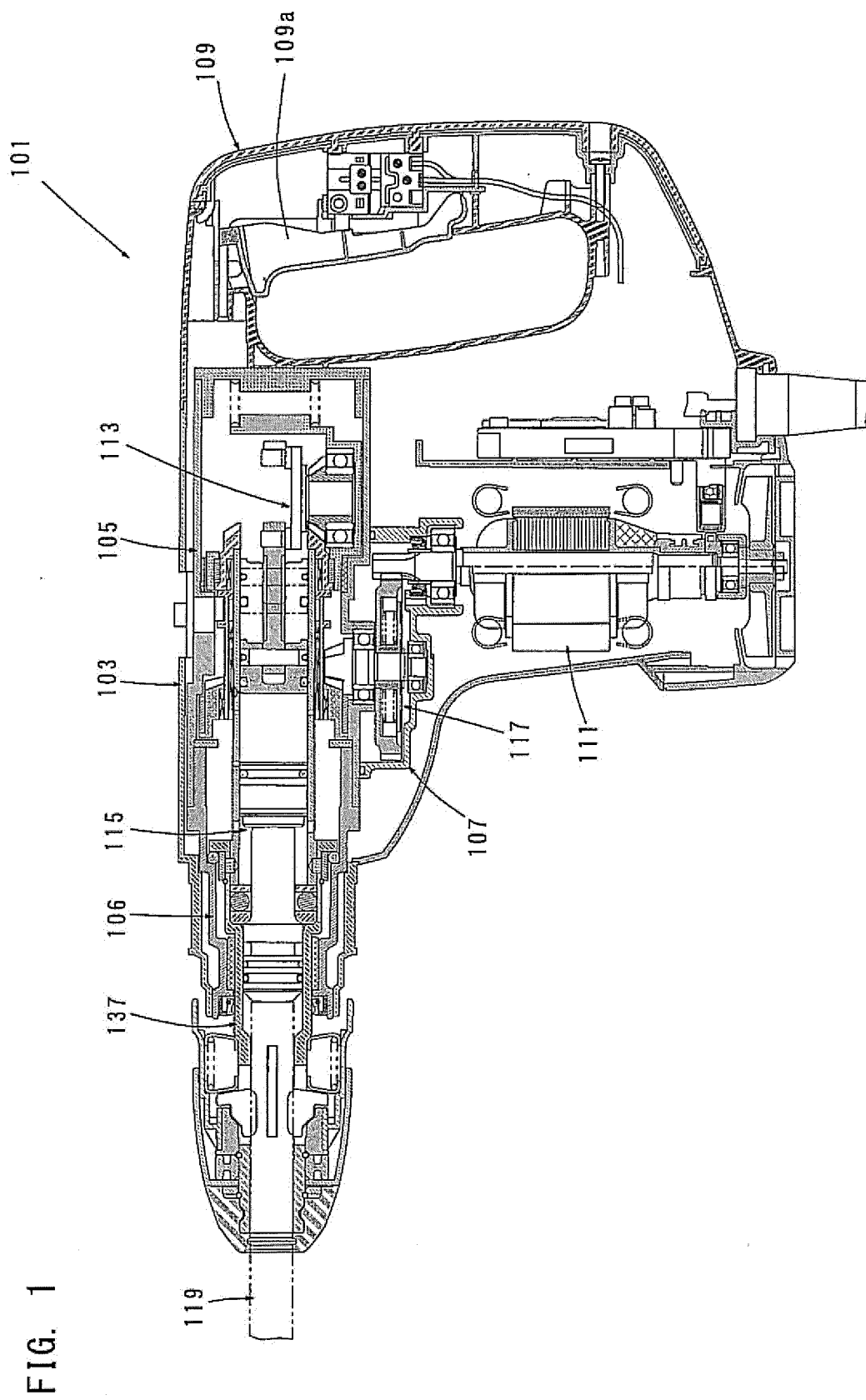


FIG. 2

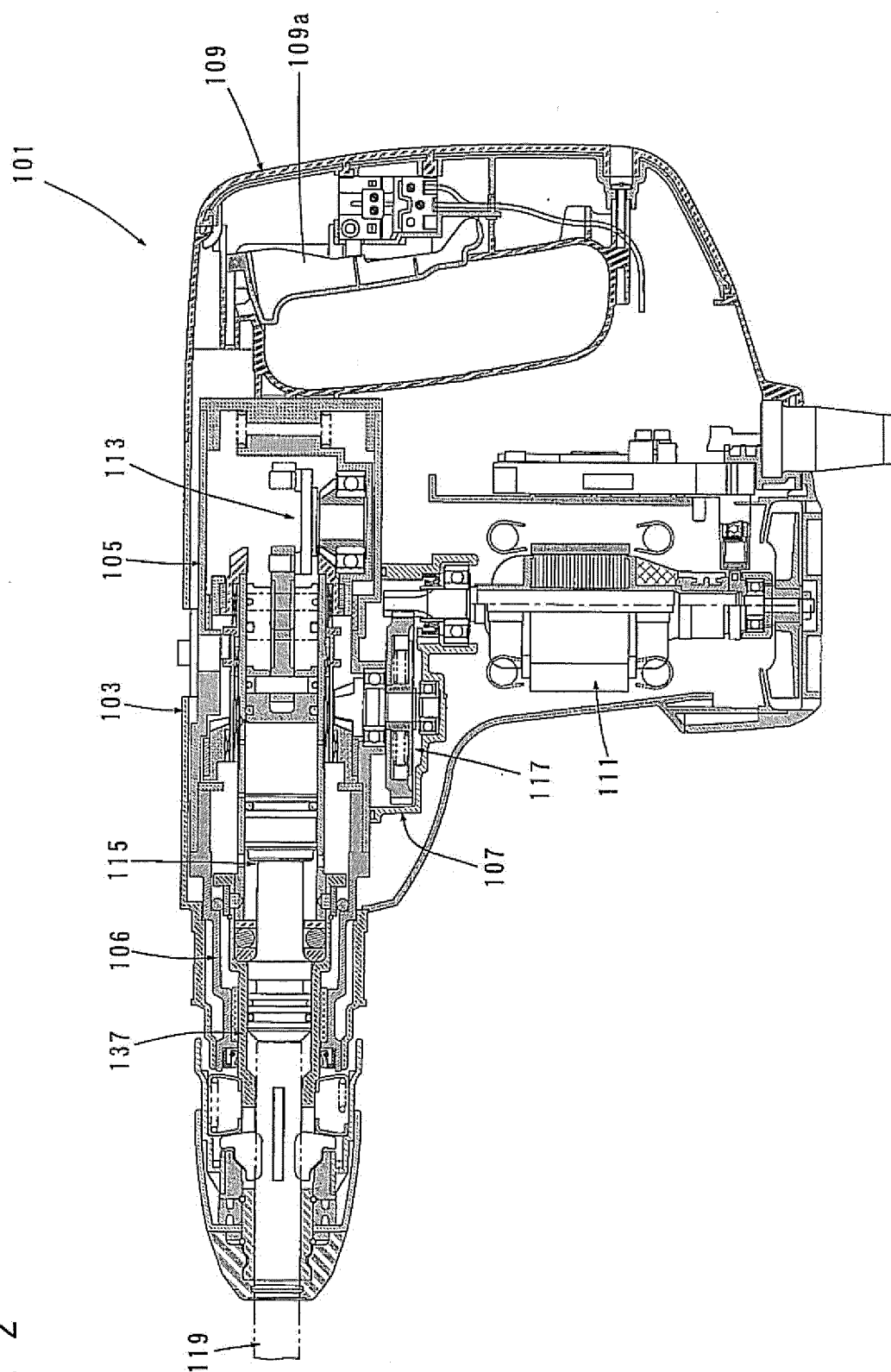


FIG. 3

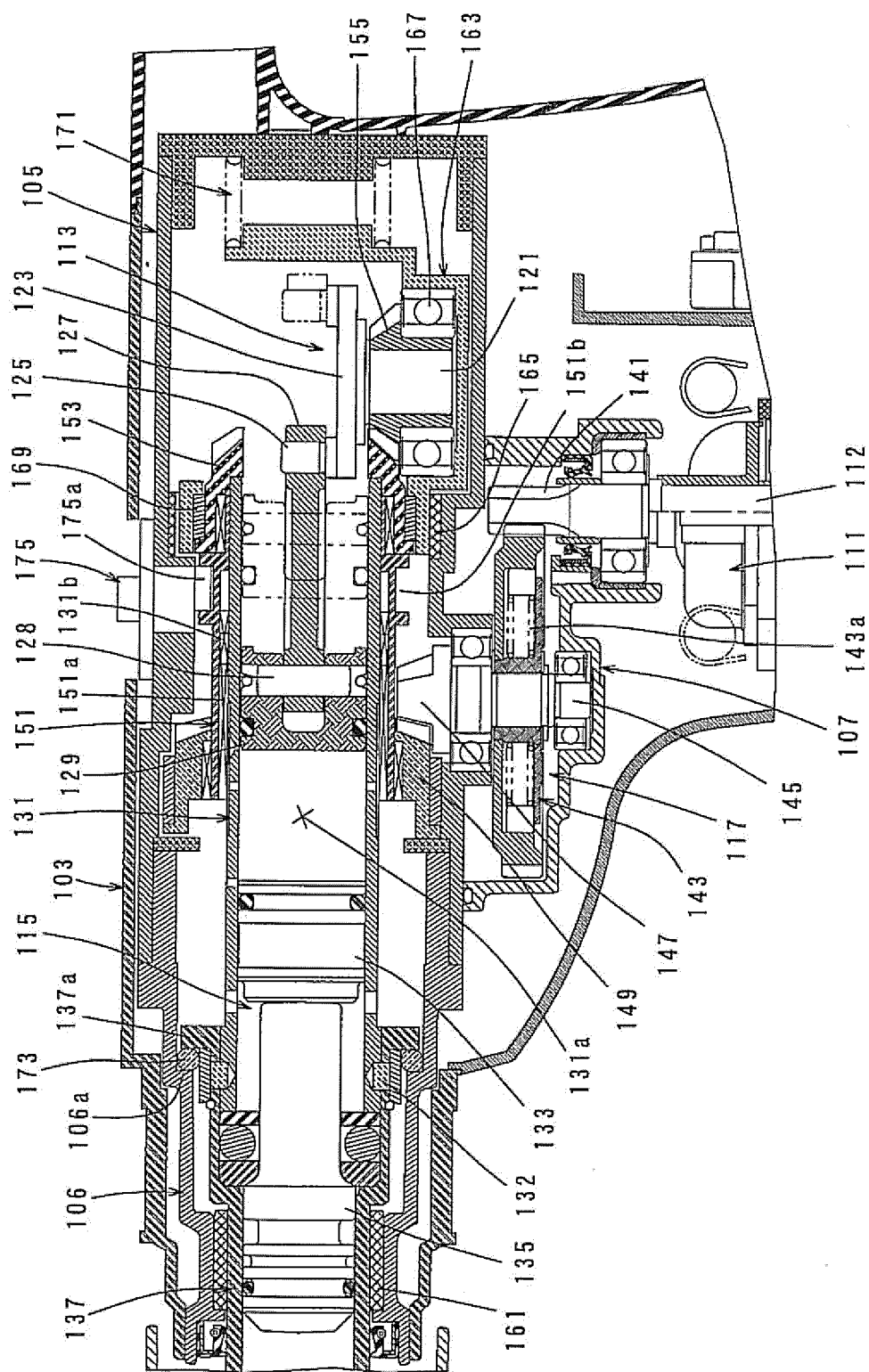


FIG. 4

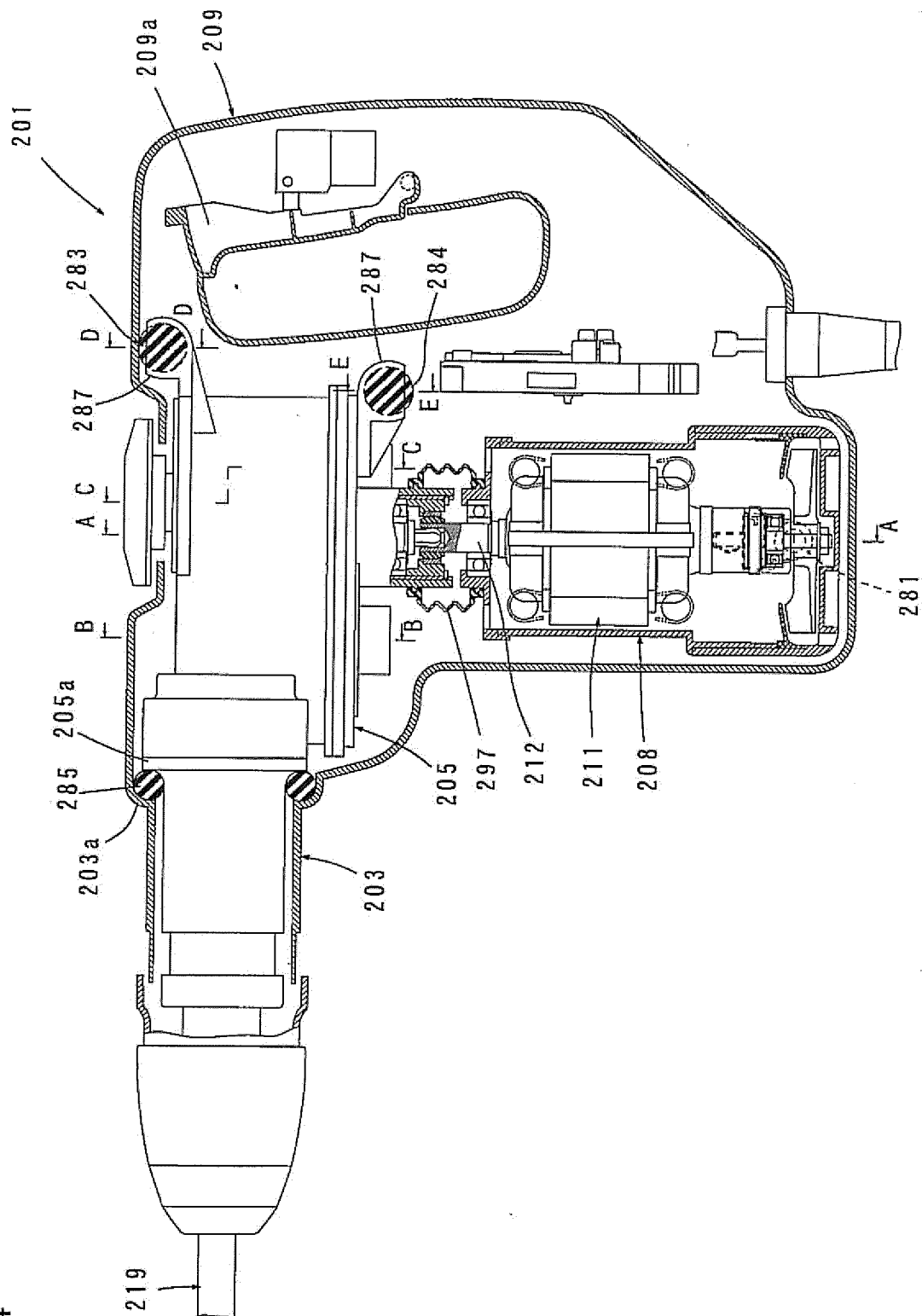


FIG. 5

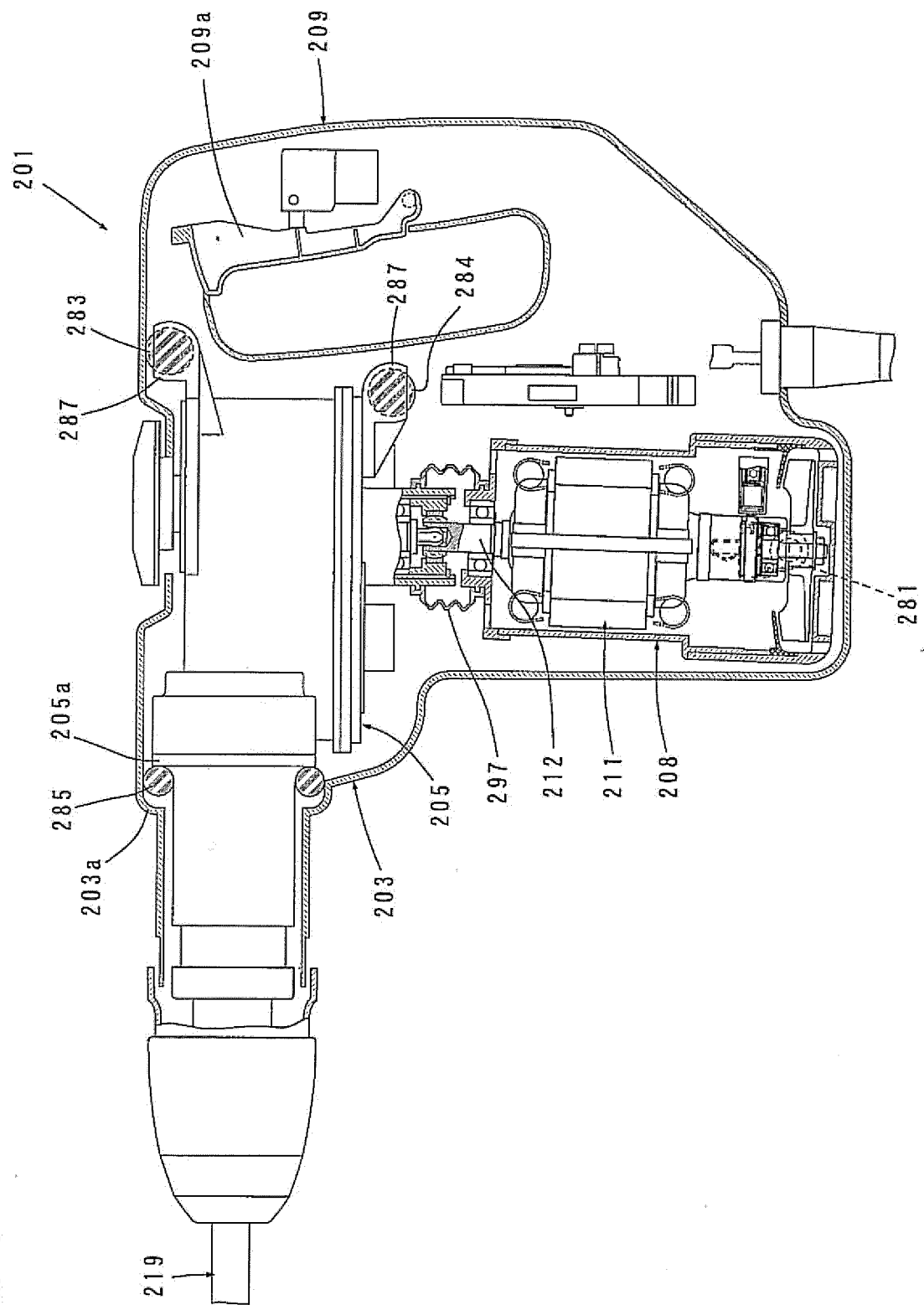


FIG. 6

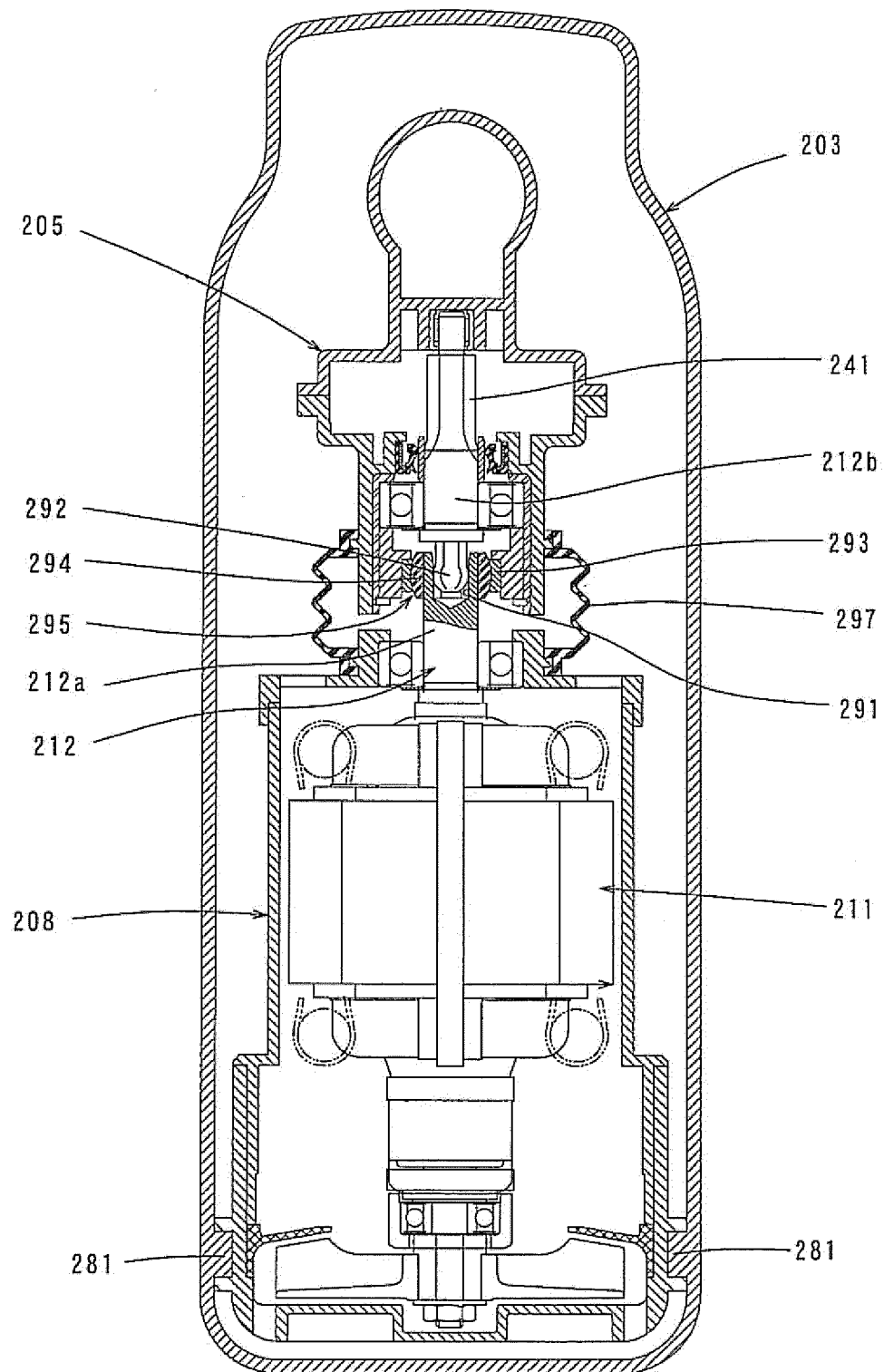


FIG. 7

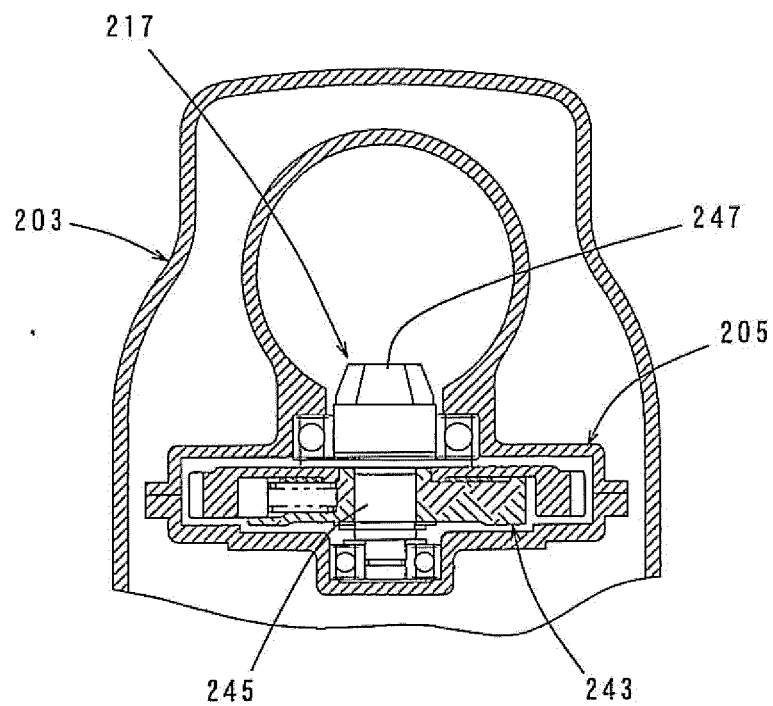


FIG. 8

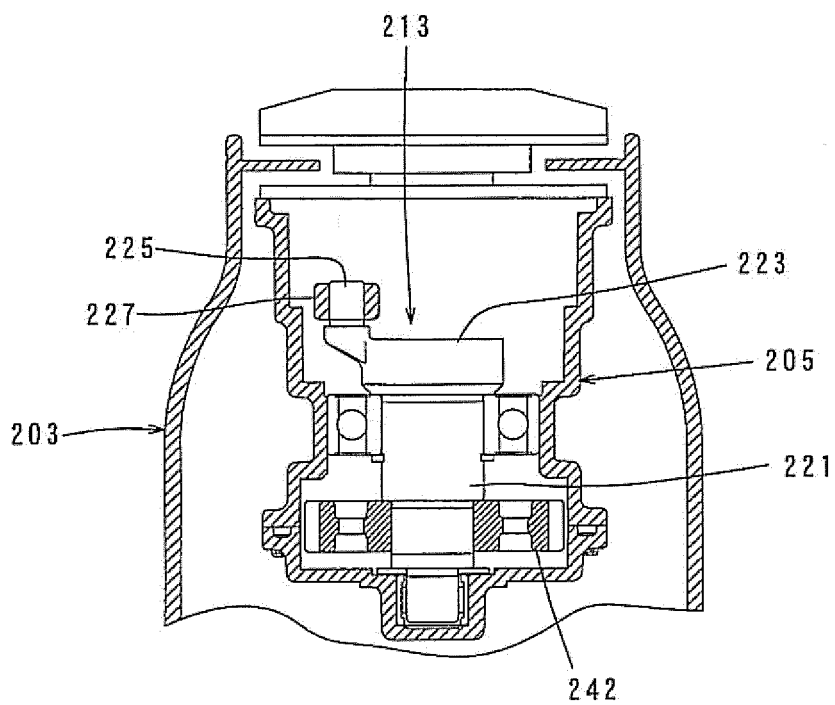


FIG. 9

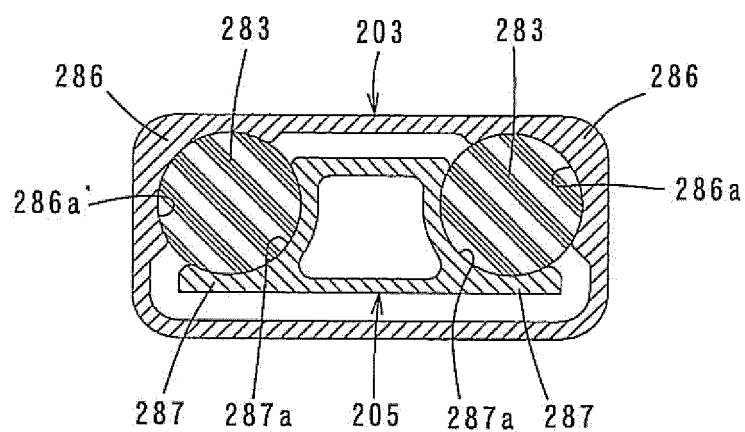
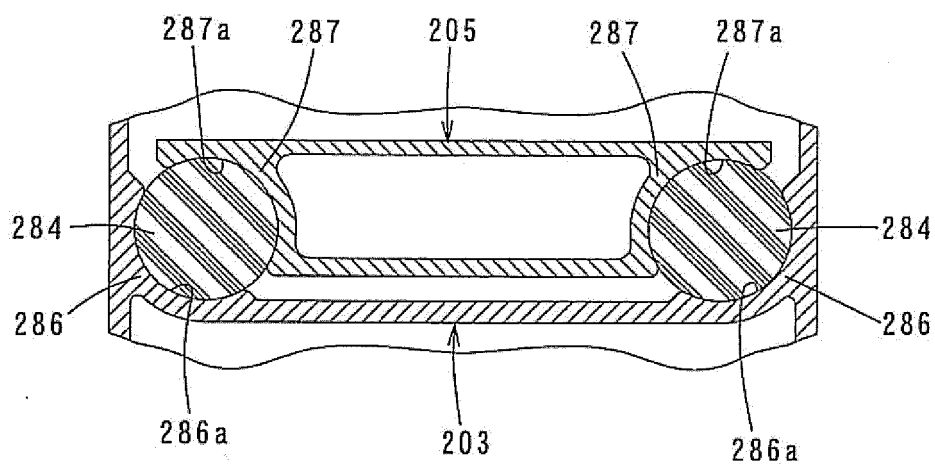


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/055923

A. CLASSIFICATION OF SUBJECT MATTER

B25D17/24(2006.01) i, 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)

B25D17/24, 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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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 Y	EP 1674214 A1 (Black & Decker Inc.), 28 June 2006 (28.06.2006), fig. 4 & JP 2006-175586 A & JP 2006-175587 A & JP 2006-175588 A & JP 2006-175589 A & JP 2006-175590 A & JP 2006-175591 A & JP 2006-175592 A & JP 2006-175594 A & US 2006/0137888 A1 & US 2006/0144602 A1 & US 2006/0144603 A1 & US 2006/0144604 A1 & US 2006/0156858 A & US 2006/0156859 A1 & US 2006/0156860 A1 & US 2006/0159577 A1 & US 2007/0151081 A1 & GB 428210 D & GB 2421459 A & GB 2421460 A & GB 2421461 A & GB 2421462 A & GB 2421463 A & GB 2421699 A & GB 2421700 A & GB 2421464 A & GB 510930 D0 & DE 602005007166 D	1, 3-4 2, 5-7

☒ 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

08 June, 2010 (08.06.10)

Date of mailing of the international search report

22 June, 2010 (22.06.10)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/055923

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& DE 602005007167 D & DE 602005010037 D & DE 602005011562 D & CN 1792562 A & CN 1792563 A & CN 1792564 A & CN 1792565 A & CN 1792566 A & CN 1792567 A & CN 1807026 A & CN 1807027 A & AT 396838 T & AT 396841 T & AT 409554 T & AT 416889 T	

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