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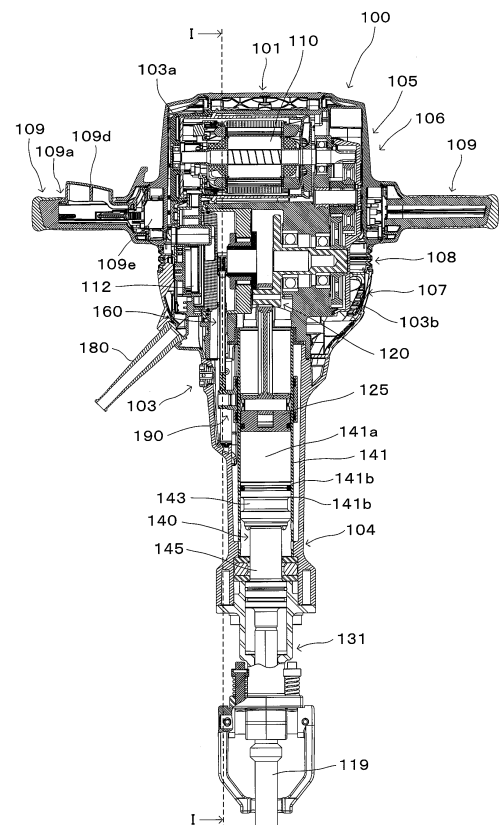
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(54) **IMPACT TOOL**

(57) It is an object of the invention to provide a further rational technique for reducing vibration in a non-pressed state for an impact tool. A representative electric hammer (100) has a driving mechanism (160) for driving a tool bit (119), a vibration suppressing mechanism (190) having a movable weight, and a controller (112) for controlling driving of an electric motor (110). In a pressed state that the tool bit (119) is pressed against a workpiece by a user, the controller (112) drives the electric motor (110) at a first rotation speed, and in a non-pressed state that the tool bit (119) is not pressed against the workpiece by the user, the controller (112) drives the electric motor (110) at a second rotation speed lower than the first rotation speed.

FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to an impact tool which performs a hammering operation on a workpiece by linearly driving a tool accessory along a prescribed hammering axis.

BACKGROUND ART

[0002] Japanese laid-open patent publication No. 2008-073836 A discloses an impact tool in which a counter weight is provided on a swinging member for reciprocally move a cylindrical piston. This impact tool is configured such that the swinging member reciprocally moves the cylindrical piston and thereby linearly drives a tool bit to perform a hammering operation, and is configured such that the counter weight reduces vibration caused during the hammering operation.

SUMMARY OF THE INVENTION

[0003] An impact tool of this type is configured such that, in a non-pressed state that a tool bit is not pressed against a workpiece, in order to secure user's safety and to promptly proceed to a hammering operation when the user switches to a pressed state by pressing the tool bit against the workpiece, a driving mechanism is placed in a driving state while impact driving of the tool bit is prevented when it is still in the non-pressed state in which the hammering operation is not yet started. Thus, the above-described impact tool is configured such that the swinging member is moved by driving of the driving mechanism even in the non-pressed state. Therefore, in the non-pressed state, unnecessary vibration may be caused by reciprocating movement of the counter weight. In view of this point, a countermeasure focusing on vibration of an impact tool in a non-pressed state is desired to be provided.

[0004] Accordingly, it is an object of the present invention to provide a further rational technique for reducing vibration in a non-pressed state.

[0005] The above-described problem is solved by the present invention. According to a preferred aspect of the present invention, an impact tool is provided which performs a hammering operation on a workpiece by linearly driving a tool accessory along a prescribed hammering axis. The impact tool has a brushless motor, a driving mechanism that drives the tool accessory by an output of the brushless motor, a vibration suppressing mechanism having a movable weight, and a controller that controls driving of the brushless motor. In a pressed state which is defined as a state that a prescribed pressing force is applied to the tool accessory, the controller drives the brushless motor at a first rotation speed. Further, in a non-pressed state which is defined as a state that the prescribed pressing force is not applied to the tool ac-

cessory, the controller drives the brushless motor at a second rotation speed lower than the first rotation speed.

[0006] In the impact tool according to this aspect, in the non-pressed state, since the brushless motor is driven at the second rotation speed, movement of the weight can be suppressed compared with in the pressed state. Thus, vibration caused by movement of the weight in the non-pressed state can be suppressed.

[0007] The impact tool may be configured to cause the tool accessory not only to perform hammering motion by linearly driving the tool accessory along the prescribed hammering axis, but to perform rotating motion by rotating the tool accessory around the hammering axis, or it may be configured to simultaneously perform the hammering motion and the rotating motion. The impact tool specifically includes an electric hammer and an electric hammer drill. The driving mechanism may typically consist of a piston which is caused to reciprocate by the output of the brushless motor, and a striking element which is moved via pressure fluctuations caused in the air chamber by reciprocating movement of the piston and collides with the tool accessory.

[0008] When performing a hammering operation with the impact tool, the user presses the tool accessory against a workpiece. By this user's operation, the impact tool is placed in the pressed state. Upon completion of the hammering operation, the user moves the tool accessory away from the workpiece. By this user's operation, the impact tool is placed in the non-pressed state.

[0009] The controller is typically formed by disposing a switching element for controlling a plurality of coils provided in the brushless motor, a central processing unit (CPU) and a condenser on a substrate. The controller is configured to determine whether the impact tool is placed in the pressed state or the non-pressed state and then switch the rotation speed of the brushless motor. As a structure for determining whether the impact tool is placed in the pressed state or the non-pressed state, a structure based on detection of a load on the brushless motor, or a structure using a sensor for detecting a region of the driving mechanism which is moved together with the tool accessory when it is switched to the pressed state may be appropriately used.

[0010] Further, the first rotation speed and the second rotation speed are preset in the controller, and the controller is configured to select the first rotation speed in the pressed state and to select the second rotation speed in the non-pressed state. The structure of switching between the first rotation speed and the second rotation speed may be a structure of instantaneously or gradually switching from one to the other speed. Further, the second rotation speed may be set to zero.

[0011] According to a further aspect of the impact tool of the present invention, the vibration suppressing mechanism is a counter weight which is configured such that the weight is mechanically connected to a prescribed region of the driving mechanism and the weight is caused to directly reciprocate by movement of the driving mech-

anism. Alternatively, the vibration suppressing mechanism is a dynamic vibration reducer which has a weight elastic member connected to the weight and is configured such that the weight is caused to reciprocate by movement of the driving mechanism.

[0012] In the impact tool according to this aspect, when the impact tool performs a hammering operation, vibration can be effectively suppressed by the counter weight or the dynamic vibration reducer.

[0013] The counter weight may be typically configured such that the weight is mechanically connected to a prescribed region of the driving mechanism via a cam mechanism or a link mechanism. Alternatively, the weight may be directly connected to part of the driving mechanism. With this structure, the weight can be caused to perform steady and periodic motion in a prescribed phase.

[0014] Further, the dynamic vibration reducer may be configured to vibrate the weight elastic member or the weight by movement of the driving mechanism. Typically, it may be configured to vibrate the weight elastic member by mechanically connecting the weight elastic member to a prescribed region of the driving mechanism via a cam mechanism or a link mechanism and to thereby vibrate the weight. Alternatively, it may be configured to vibrate the weight via fluctuations of air pressure by movement of the driving mechanism.

[0015] The weight elastic member may typically be a coil spring. The weight elastic member may consist of a single elastic body, or it may consist of a first elastic body connected to one side of the weight and a second elastic body connected to the other side of the weight.

[0016] According to a further aspect of the impact tool of the present invention, the weight may be configured to be moved linearly in the direction of the hammering axis. Alternatively, the weight may be configured to be rotated around the hammering axis. In the impact tool according to this aspect, a moving direction of the weight appropriate to the impact tool can be selected, so that the design freedom of the vibration suppressing mechanism can be ensured.

[0017] According to a further aspect of the impact tool of the present invention, the impact tool may further has a housing for housing at least part of the driving mechanism, a handle to be held by a user, and a handle elastic member. The handle is connected to the housing via the handle elastic member, so that the handle and the housing can be configured to be movable with respect to each other.

[0018] In the impact tool according to this aspect, vibration which is caused in the housing during hammering operation and transmitted to the handle can be suppressed.

[0019] Further, typically, the handle elastic member may be a coil spring or rubber. The handle and the housing are only enough to be movable with respect to each other via the handle elastic member. For example, another component may be disposed between the handle and the handle elastic member or between the housing

and the handle elastic member.

[0020] According to a further aspect of the impact tool of the present invention, the controller may be disposed within the handle. In the impact tool according to this aspect, the weight can be distributed to the handle with the controller, so that the vibration proofing effect can be enhanced.

[0021] According to a further aspect of the impact tool of the present invention, the impact tool may further have a sensor that detects behavior of the impact tool during a prescribed operation. With this structure, the controller can control driving of the brushless motor based on a detection result of the sensor. In the impact tool according to this aspect, the controller for controlling driving of the brushless motor is utilized to further control the driving of the brushless motor based on the detection result of the sensor, so that the controller can more finely control the brushless motor.

[0022] The sensor typically includes an acceleration sensor. When the acceleration sensor detects an inclined state of the impact tool, the controller can detect the behavior of the impact tool. For example, when the prescribed operation by the impact tool is a "drilling operation by rotating the tool accessory", the controller can detect behavior that the tool accessory is locked in a hole formed by the drilling operation and the impact tool is caused to rotate on the tool accessory. Upon detection of such behavior, the controller can control to stop the brushless motor.

[0023] According to a further aspect of the impact tool of the present invention, the brushless motor may be driven by a battery, and the handle may have a mounting part for the battery.

[0024] In the impact tool according to this aspect, the weight can be distributed to the handle with the battery, so that the vibration proofing effect can be enhanced. Particularly in the structure in which the handle and the housing are connected to each other via an elastic member, transmission of vibration to the handle is suppressed. Therefore, for example, a connection terminal of the mounting part and a connection terminal of the battery can be prevented from being welded with each other.

[0025] According to the invention, a further rational technique for reducing vibration in a non-pressed state can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

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

FIG. 2 is a sectional view showing a connecting mechanism according to the first embodiment.

FIG. 3 is an enlarged view showing a driving mech-

anism according to the first embodiment.

FIG. 4 is a sectional view showing an electric hammer according to a second embodiment of the invention.

FIG. 5 is an enlarged view showing a driving mechanism according to the second embodiment.

FIG. 6 is a sectional view showing an electric hammer drill according to a third embodiment of the invention.

FIG. 7 is a sectional view showing a vibration suppressing mechanism according to the third embodiment.

FIG. 8 is a sectional view showing an electric hammer drill according to a fourth embodiment of the invention.

DETAILED DESCRIPTION OF THE REPRESENTATIVE EMBODIMENT OF THE INVENTION

[0027] First to fourth embodiments of an impact tool according to the present invention are now described with reference to FIGS. 1 to 8. In the description of the second to fourth embodiments, components or mechanisms having structures or functions identical or similar to those of the first embodiment are given the same designations and reference signs and may not be described.

(First Embodiment)

[0028] The first embodiment of the present invention is now described with reference to FIGS. 1 to 3. FIG. 2 is a partially cutaway sectional view taken along line I-I in FIG. 1. An electric hammer 100 is explained as a representative example of the impact tool according to the present invention. As shown in FIG. 1, the electric hammer 101 is configured to perform a chipping operation on a workpiece (such as concrete) by causing a tool bit 119 coupled to a front end region of a body 101 to perform hammering motion in its longitudinal direction. Specifically, the tool bit 119 extends along its hammering axis.

[0029] As shown in FIG. 1, the tool bit 119 is removably coupled to the body 101 via a cylindrical tool holder 131. The tool bit 119 is inserted into a bit insertion hole of the tool holder 131 and held such that it is prevented from rotating around an axis of the tool holder 131 with respect to the tool holder 131. The tool bit 119 is an example embodiment that corresponds to the "tool accessory" according to the present invention.

[0030] As shown in FIG. 1, the body 101 mainly includes a body housing 103, a barrel 104 and an outer housing 105. The body housing 103 mainly includes a motor housing 103a that houses an electric motor 110, and a gear housing 103b that houses a first motion con-

verting mechanism 120 and a second motion converting mechanism 160. The barrel 104 is configured as a cylindrical member for housing a striking mechanism 140 and part of the tool holder 131 and connected to the body housing 103. The motor housing 103a, the gear housing 103b and the barrel 104 are made of aluminum. The barrel 104, the gear housing 103b and the motor housing 103a are arranged in this order in the longitudinal direction of the tool bit 119 and joined to each other to be fixedly assembled together. The barrel 104 is arranged closest to the tool bit 119 and the motor housing 103a is arranged farthest from the tool bit 119 in the longitudinal direction of the tool bit 119. The motor housing 103a and the gear housing 103b may be formed in one piece. The body housing 103 is an example embodiment that corresponds to the "housing" according to the present invention.

[0031] The outer housing 105 is arranged on the outside of the body housing 103 as shown in FIG. 1. The outer housing 105 has a cylindrical shape extending in the longitudinal direction of the tool bit 119 and is arranged to entirely cover the body housing 103. The outer housing 105 has an upper housing 106 and a lower housing 107. A pair of handgrips 109 for operating the electric hammer 100 in chipping operation are provided on the upper housing 106. The handgrips 109 are symmetrically arranged with respect to an axis extending in the longitudinal direction of the tool bit 119 and extend straight in a direction crossing the axis. Each of the handgrips 109 has one end fixed to the upper housing 106 in a cantilever form. The handgrip 109 is an example embodiment that corresponds to the "handle" according to the present invention. In use of the electric hammer 100, the user performs a chipping operation while holding the handgrips 109 with hands and pointing the tool bit 119 downward. Therefore, for the sake of convenience, in the longitudinal direction of the tool bit 119 (the longitudinal direction of the body 101), the tool bit 119 side is defined as the lower side and the handgrip 109 side is defined as the upper side. The handgrip 109 is an example embodiment that corresponds to the "handle" according to the present invention.

[0032] The lower housing 107 is integrally connected to the body housing 103.

[0033] As shown in FIG. 2, a guide shaft 108A is disposed between the upper housing 106 and the motor housing 103a. The guide shaft 108A has a shaft support part 106a which is integrally connected to the upper housing 106. An upper end of the guide shaft 108A is fitted in a recess 106b of the shaft support part 106a, and a lower end of the guide shaft 108A is fitted in a recess 103a1 of the motor housing 103a. Further, a middle region of the guide shaft 108A is inserted through an annular part 106c of the shaft support part 106a. The guide shaft 108A has a flange 108A1 in a region below the annular part 106c. A coil spring 108b is disposed between the flange 108A1 and the recess 103a1 of the motor housing 103a. In the electric hammer 100, four such guide shafts 108A and

four such coil springs 108b are provided.

[0034] Thus, the upper housing 106 and the motor housing 103a are connected via the coil springs 108b. The coil spring 108b is an example embodiment that corresponds to the "handle elastic member" according to the present invention. With this structure, the handgrip 109 and the body housing 103 are configured to be movable with respect to each other.

[0035] The upper housing 106 and the lower housing 107 are connected via an annular bellows 108a. The bellows 108a is made of vinyl or rubber and configured to be expandable and contractable. The bellows 108a prevents entry of dust into the handgrips 109 and the body housing 103. The coil springs 108b and the bellows 108a form a connecting mechanism 108.

[0036] An electric switch 109e for driving and stopping the electric motor 110 and an operation part 109d for switching on and off the electric switch 109e are provided in one of the handgrips 109 as shown in FIG. 1. The operation part 109d of the electric hammer 100 is formed by a switch lever. The operation part 109d is provided to be turned in a direction crossing the longitudinal direction of the handgrip 109. When the operation part 109d is not operated, the operation part 109d is held in a position to protrude outward (upward) from an outer surface of the handgrip 109 by a biasing force of a built-in spring (not shown) provided in the electric switch 109e. When the operation part 109d is pressed with a user's finger, the operation part 109d is turned inward into the handgrip 109 and the electric switch 109e is switched on, so that the electric motor 110 is driven.

[0037] The electric motor 110 is formed by a brushless motor. As shown in FIG. 3, a controller 112 for controlling driving of the electric motor 110 is disposed between an outer surface of the body housing 103 and an inner surface of the outer housing 105. The controller 112 is formed by disposing a switching element for controlling a plurality of coils provided in the electric motor 110, a central processing unit (CPU) and a condenser on a substrate. The electric motor 110 and the controller 112 are example embodiments that correspond to the "brushless motor" and the "controller", respectively, according to the present invention.

[0038] The user performs a hammering operation on a workpiece while pressing the tool bit 119 against the workpiece. This state that a prescribed pressing force is applied to the tool bit 119 is defined as a pressed state of the electric hammer 100. After performing a hammering operation on a prescribed workpiece, the user may move the electric hammer 100 toward other workpiece. In such a case, while the user is moving the electric hammer 100, the electric motor 110 is kept on, but the tool bit 119 is not pressed against the workpiece. This state that the prescribed pressing force is not applied to the tool bit 119 is defined as a non-pressed state of the electric hammer 100. Thus, the user can perform a hammering operation on a plurality of workpieces by switching the electric hammer 100 between the pressed state and

the non-pressed state. The pressed state and the non-pressed state are example embodiments that correspond to the "pressed state" and the "non-pressed state", respectively, according to the present invention.

[0039] When the user performs a hammering operation while pressing the electric hammer 100, the controller 112 controls the electric motor 110 to be driven in a prescribed range of rotation speed. Specifically, the controller 112 controls the electric motor 110 to rotate in the prescribed range of rotation speed such that the rotation speed of the electric motor 110 does not significantly fluctuate by load on the electric motor 110 during hammering operation. The prescribed range of rotation speed at which the electric motor 110 is driven in the pressed state is defined as a first rotation speed. The first rotation speed is an example embodiment that corresponds to the "first rotation speed" according to the present invention.

[0040] When the user places the electric hammer 100 in the non-pressed state, the controller 112 controls the electric motor 110 to be driven at lower rotation speed than the first rotation speed. This lower rotation speed than the first rotation speed, at which the electric motor 110 is driven in the non-pressed state, is defined as a second rotation speed. The second rotation speed is an example embodiment that corresponds to the "second rotation speed" according to the present invention.

[0041] The controller 112 is configured to detect load on the electric motor 110 and thereby determine whether the electric hammer 100 is placed in the pressed state or the non-pressed state. More specifically, a threshold is set for a current to be supplied to the electric motor 110, and the controller 112 is configured to determine that the electric hammer 100 is placed in the non-pressed state when the current does not exceed the threshold and to determine that the electric hammer 100 is placed in the pressed state when the current exceeds the threshold.

[0042] The electric motor 110 is driven by alternate current supplied via a feeding part 180 as shown in FIG. 1. The feeding part 180 is formed by a power cable. As shown in FIG. 2, the electric motor 110 is arranged such that a motor shaft 111 of the electric motor 110 extends in a direction crossing a longitudinal axis of the tool bit 119 and parallel to a longitudinal axis of the handgrip 109. Rotation of the electric motor 110 is converted into linear motion by the first motion converting mechanism 120 and transmitted to the striking mechanism 140, and the tool bit 119 is struck in the longitudinal direction (downward as viewed in FIG. 1) via the striking mechanism 140. Further, rotation of the electric motor 110 is converted into linear motion by the second motion converting mechanism 160 and transmitted to a counter weight 190. The counter weight 190 is configured to linearly move in the longitudinal direction of the tool bit 119 at a timing when an impact force is generated by striking of the tool bit 119. With this structure, the counter weight 190 suppresses vibration caused in the electric hammer 100. The motor shaft 111, the first motion converting

mechanism 120 and the second motion converting mechanism 160 are example embodiments that correspond to the "rotary shaft", the "driving mechanism" and the "vibration suppressing mechanism", respectively, according to the present invention. The counter weight 190 is an example embodiment that corresponds to the "weight" and the "counter weight" according to the present invention.

[0043] As shown in FIG. 3, the first motion converting mechanism 120 is formed by a first crank mechanism disposed below the electric motor 110 and including a first crank shaft 121, a first connecting rod 123 and a piston 125. The first motion converting mechanism 120 is driven by the electric motor 110 via a gear speed reducing device 113 having a plurality of gears. The piston 125 forms a driving element for driving the striking mechanism 140 (see FIG. 1). The piston 125 is arranged to slide within a cylinder 141 in the longitudinal direction of the tool bit 119. The first crank shaft 121 is arranged in parallel to the motor shaft 111 of the electric motor 110. An eccentric shaft part 121a is integrally formed with the first crank shaft 121 and rotatably connected to the first connecting rod 123.

[0044] As shown in FIG. 1, the striking mechanism 140 mainly includes a cylinder 141, a striking element in the form of a striker 143, and an intermediate element in the form of an impact bolt 145. The striker 143 is slidably disposed within the cylinder 141. The impact bolt 145 is slidably disposed within the tool holder 131 and transmits kinetic energy of the striker 143 to the tool bit 119. The cylinder 141 is coaxially arranged with the tool holder 131 above the tool holder 131. An air chamber 141a is formed between the piston 125 and the striker 143 within the cylinder 141. The striker 143 is driven via pressure fluctuations caused in the air chamber 141a by sliding movement of the piston 125. Then the striker 143 collides with the impact bolt 145 and strikes the tool bit 119 via the impact bolt 145.

[0045] The cylinder 141 has a vent 141b as shown in FIG. 1. The vent 141b is configured to provide communication between the inside of the cylinder 141 and the inside of the barrel 104.

[0046] When the electric hammer 100 is in the pressed state, the striker 143 is placed in an upper position via the tool bit 119 and the impact bolt 145 and blocks communication between the air chamber 141a and the vent 141b. Thus, when the piston 125 is driven, the pressure of the air chamber 141a fluctuates, so that the striker 143 can be driven.

[0047] Immediately after the electric hammer 100 is switched from the pressed state to the non-pressed state, first, the striker 143 moves the tool bit 119 and the impact bolt 145 downward. In this state, the air chamber 141a is expanded to a region of the cylinder 141 having the vent 141b. Thus, the air chamber 141a communicates with the inside of the barrel 104 via the vent 141b. Therefore, when the piston 125 moves in a direction of compressing air of the air chamber 141a (downward), the air

is released into the barrel 104 via the vent 141b. On the other hand, when the piston 125 moves in a direction of expanding air of the air chamber 141a (upward), the air is led from the inside of the barrel 104 into the air chamber 141a via the vent 141b. Specifically, even if the piston 125 is driven, pressure fluctuations enough to lift the striker 143 from the lower position are not caused in the air chamber 141a. Thus, in the unloaded state, the tool bit 119 is prevented from being driven.

[0048] As shown in FIG. 3, the second motion converting mechanism 160 is formed by a second crank mechanism including a second crank shaft 161, an eccentric shaft 163 and a second connecting rod 165. The second crank shaft 161 is arranged on an extension of an axis of the first crank shaft 121 of the first crank mechanism and rotated by the eccentric shaft part 121a of the first crank shaft 121. The eccentric shaft 163 is arranged in parallel to the second crank shaft 161 in a position displaced a prescribed distance in a radial direction from the center of rotation of the second crank shaft 161. One end of the second connecting rod 165 is connected to the eccentric shaft 163 so as to be rotatable around the eccentric shaft 163. The other end of the second connecting rod 165 is connected to a connecting shaft 166 provided on the counter weight 190 so as to be rotatable around the connecting shaft 166. The connecting shaft 166 is arranged in parallel to the eccentric shaft 163. The counter weight 190 is configured as a cylindrical member which is slidably fitted onto the cylinder 141. The counter weight 190 reciprocates between a front position closest to the tool bit 119 and a rear position farthest from the tool bit 119. The cylindrical counter weight 190 may be shaped to partially surround the cylinder 141.

[0049] When performing a hammering operation on a workpiece with the electric hammer 100 having the above-described structure, the user holds a pair of the handgrips 109 with hands and presses the tool bit 119 pointed downward against a workpiece. Specifically, the user performs a hammering operation while keeping the electric hammer 100 in the pressed state. When the user presses the operation part 109d with a finger of the hand holding the one handgrip 109 to turn on the electric switch 109e, the electric motor 110 is driven. Then the tool bit 119 is linearly driven via the first motion converting mechanism 120 and the striking mechanism 140 and can perform a hammering operation on the workpiece. At this time, the controller 112 determines that the electric hammer 100 is placed in the pressed state and controls the electric motor 110 to rotate at the first rotation speed.

[0050] The counter weight 190 is caused to reciprocate in the longitudinal direction of the tool bit 119 via the second motion converting mechanism 160. The counter weight 190 is set to move substantially in opposite phase to movement of the striker 143. Specifically, the counter weight 190 moves upward when the striker 143 moves downward, while the counter weight 190 moves downward when the striker 143 moves upward. By this movement, the counter weight 190 suppresses vibration

caused in the electric hammer 100 during operation.

[0051] During hammering operation, the handgrips 109 (the upper housing 106) and the body housing 103 (the motor housing 103a) are moved in the longitudinal direction of the tool bit 119 with respect to each other while being guided by the guide shafts 108A under the biasing force of the coil springs 108b. Specifically, the coil springs 108b are expanded and contracted by the kinetic energy of vibration caused during hammering operation, so that transmission of vibration from the body housing 103 to the handgrips 109 is suppressed. Thus, in the electric hammer 100 having two vibration proofing devices, or the vibration-proof handle and the counter weight 190, vibration which is caused during hammering operation and transmitted to the user holding the handgrips 109 is suppressed. As a result, the operability of the electric hammer 100 is improved.

[0052] When the user switches the electric hammer 100 from the pressed state to the non-pressed state, the controller 112 detects that the current supplied to the electric motor 110 is below a threshold and controls the electric motor 110 to rotate at the second rotation speed.

[0053] In the non-pressed state, where the electric motor 110 is rotationally driven at the second rotation speed, the first crank shaft 121 and the second crank shaft 161 are driven. Immediately after the electric hammer 100 is switched from the pressed state to the non-pressed state, the striker 143 is driven by driving of the piston 125. In the non-pressed state, however, the tool bit 119 and the impact bolt 145 are located in a lower position. Therefore, the striker 143 moves down to the impact bolt 145 located in this lower position. As a result, the striker 143 moves down to below the vent 141b. Thus, the air chamber 141a communicates with the inside of the barrel 104, so that the tool bit 119 is prevented from being driven by driving of the first crank shaft 121.

[0054] Further, although the counter weight 190 is caused to reciprocate by driving of the second crank shaft 161, the electric motor 110 is driven at the second rotation speed, so that vibration caused by the reciprocating movement of the counter weight 190 can be reduced.

[0055] As described above, in the pressed state, the electric hammer 100 can suppress vibration related to hammering operation by the second motion converting mechanism 160 and the coil springs 108b. Further, in the non-pressed state, the electric motor 110 is driven at the second rotation speed, so that vibration caused by the reciprocating movement of the counter weight 190 can be reduced. Specifically, the electric hammer 100 can effectively suppress vibrations caused in the pressed state and the non-pressed state.

(Second Embodiment)

[0056] The second embodiment of the present invention is now described with reference to FIGS. 4 and 5. An electric hammer 200 of the second embodiment is different from the electric hammer 100 of the first embod-

iment mainly in the structures of the handle and the vibration suppressing mechanism. The electric hammer 200 is an example embodiment that corresponds to the "impact tool" according to the present invention.

[0057] As shown in FIG. 4, the body 101 mainly includes a body housing 203 and a handgrip 109 connected to the body housing 203. The body housing 203 is an example embodiment that corresponds to the "housing" according to the present invention. A barrel 104 is connected to the body housing 203 and houses a striking mechanism 140. A side grip 109A to be held by a user can be removably attached onto the barrel 104. The structure of the side grip 109A is not described here for convenience sake.

[0058] The handgrip 109 to be held by a user is arranged on a side opposite from the tool bit 119 in the longitudinal direction of the tool bit 119 as shown in FIG. 4. In the second embodiment, for convenience sake, the tool bit 119 side is defined as a lower side and the handgrip 109 side is defined as an upper side in the longitudinal direction of the tool bit 119 (the longitudinal direction of the body 101). Further, in the electric hammer 200 shown in FIG. 4, a direction crossing the vertical direction is defined as a transverse direction, and a direction crossing the vertical direction and the transverse direction is defined as a thickness direction.

[0059] An operation part 109d is provided in the handgrip 109 as shown in FIG. 4. The operation part 109d of the electric hammer 200 is configured to be slidable in the thickness direction to switch on and off an electric switch 109e. When the electric switch 109e is switched on, a controller 112 drives the electric motor 110.

[0060] The body housing 203 and the handgrip 109 are connected by a connecting mechanism 108 as shown in FIG. 5. The connecting mechanism 108 has a bellows 108a and a coil spring 108b. With this structure, the body housing 203 and the handgrip 109 can move with respect to each other.

[0061] As shown in FIG. 5, the electric motor 110 is a brushless motor and is arranged such that the motor shaft 111 extends in a direction crossing the longitudinal axis of the tool bit 119. The electric motor 110 and the handgrip 109 are arranged on the longitudinal axis of the tool bit 119. Like in the first embodiment, the controller 112 is configured to drive the electric motor 110 at the first rotation speed in the pressed state and to drive the electric motor 110 at the second rotation speed in the non-pressed state. The controller 112 is housed in the handgrip 109. By this arrangement, in the electric hammer 200, the weight can be distributed to the handgrip 109, so that the vibration proofing effect can be enhanced. A cable for electrically connecting the controller 112 and the electric motor 110 is wired between the controller 112 and the electric motor 110 through the inside of the bellows 108a. In FIGS. 4 and 5, the cable is not shown for convenience sake.

[0062] As shown in FIGS. 4 and 5, rotation of the electric motor 110 is transmitted to a first motion converting

mechanism 120 via a gear speed reducing device 113, and thereafter converted into linear motion by the first motion converting mechanism 120 and transmitted to the striking mechanism 140. Then the tool bit 119 is struck in the longitudinal direction via the striking mechanism 140. Further, rotation of the electric motor 110 is transmitted to a second motion converting mechanism 160 via the first motion converting mechanism 120, and thereafter converted into linear motion by the second motion converting mechanism 160 and transmitted to a dynamic vibration reducer 290. The first motion converting mechanism 120, the gear speed reducing device 113 and the striking mechanism 140 have the same structures as those of the first embodiment, respectively, and are not described.

[0063] As shown in FIG. 5, the second motion converting mechanism 160 mainly includes a second crank shaft 161 which is rotated by an eccentric shaft part 121a of a first crank shaft 121 of the first motion converting mechanism 120, an eccentric shaft 163 integrally formed with the second crank shaft 161, and a second connecting rod 165 which is linearly moved in the longitudinal direction of the tool bit 119 by rotation of the eccentric shaft 163. The second connecting rod 165 drives the dynamic vibration reducer 290.

[0064] As shown in FIG. 5, the dynamic vibration reducer 290 mainly includes an annular weight 291 configured to surround the outer circumferential surface of the cylinder 141 entirely in the circumferential direction, and biasing springs 292, 293 disposed on the upper and lower sides of the weight 291. The biasing springs 292, 293 apply respective spring forces to the weight 291 in the longitudinal direction of the tool bit 119 when the weight 291 moves in the longitudinal direction of the tool bit 119. The weight 291, the dynamic vibration reducer 290 and the biasing spring 292 or 293 are example embodiments that correspond to the "weight", the "dynamic vibration reducer" and the "weight elastic member", respectively, according to the present invention.

[0065] The weight 291 is arranged to slide with its periphery in contact with an inner wall surface (cylindrical surface) of the barrel 104. The upper and lower biasing springs 292, 293 are compression coil springs. The upper spring 293 is configured such that its one end is held in contact with a flange of a slide sleeve 210 and the other end is held in contact with the weight 291. The lower spring 292 is configured such that its one end is held in contact with the weight 291 and the other end is held in contact with a ring-like member 211 fixed to the barrel 104. Thus, the slide sleeve 210 and the ring-like member 211 form spring receiving members.

[0066] The slide sleeve 210 can slide in the longitudinal direction of the tool bit 119 with respect to the periphery of the cylinder 141 and is held in contact with the second connecting rod 165. Thus, the slide sleeve 210 is slid by the second motion converting mechanism 160.

[0067] When the second connecting rod 165 moves downward, the slide sleeve 210 is pushed downward by

the second connecting rod 165 and compresses the biasing springs 292, 293. When the second connecting rod 165 moves upward, the slide sleeve 210 is pushed upward by the spring forces of the biasing springs 292, 293. Specifically, during hammering operation, the second motion converting mechanism 160 forcibly vibrates the biasing springs 292, 293 and thereby the weight 291 is driven. With this structure, vibration caused in the body housing 203 is effectively suppressed. The dynamic vibration reducer 290 is configured such that the weight 291 is driven in opposite phase to the striker 143.

[0068] When performing a hammering operation on a workpiece with the electric hammer 200 having the above-described structure, the user holds the handgrip 109 and presses the electric hammer 200. When the user slides the operation part 109d with a finger of the hand holding the handgrip 109 to turn on the electric switch 109e, the electric motor 110 is driven. Then the tool bit 119 is linearly driven via the first motion converting mechanism 120 and the striking mechanism 140 and can perform a hammering operation on the workpiece. At this time, the controller 112 determines that the electric hammer 200 is placed in the pressed state and controls the electric motor 110 to rotate at the first rotation speed.

[0069] Further, during hammering operation, the dynamic vibration reducer 290 is forcibly driven by the second motion converting mechanism 160. Therefore, the dynamic vibration reducer 290 effectively suppresses vibration caused in the body housing 203 during hammering operation. Furthermore, the handgrip 109 moves with respect to the body housing 203 via the coil springs 108b, so that transmission of vibration to the handgrip 109 is further effectively suppressed.

[0070] When the user switches the electric hammer 200 from the pressed state to the non-pressed state, the controller 112 detects that the current supplied to the electric motor 110 is below a threshold and controls the electric motor 110 to rotate at the second rotation speed.

[0071] In the non-pressed state, where the electric motor 110 is rotationally driven at the second rotation speed, the first crank shaft 121 and the second crank shaft 161 are driven. Like in the first embodiment, as shown in FIG. 4, a vent 141b is formed in the cylinder 141, so that the tool bit 119 is prevented from being driven by driving of the piston 125.

[0072] Further, although the dynamic vibration reducer 290 is driven by driving of the second crank shaft 161, the electric motor 110 is driven at the second rotation speed, so that vibration caused by driving of the dynamic vibration reducer 290 can be reduced.

[0073] As described above, in the pressed state, the electric hammer 200 can suppress vibration related to hammering operation by the second motion converting mechanism 160 and the coil springs 108b. Further, in the non-pressed state, the electric motor 110 is driven at the second rotation speed, so that vibration caused by driving of the dynamic vibration reducer 290 can be reduced. Specifically, the electric hammer 200 can effectively sup-

press vibrations caused in the pressed state and the non-pressed state.

(Third Embodiment)

[0074] The third embodiment of the present invention is now described with reference to FIGS. 6 and 7. The structure of the impact tool according to the third embodiment is explained based on an electric hammer drill 300 which is capable of performing a hammering operation by linearly driving a tool bit along a prescribed hammering axis and a drilling operation of drilling a workpiece by rotating the tool bit around the hammering axis. The electric hammer drill 300 is an example embodiment that corresponds to the "impact tool" according to the present invention. The electric hammer drill 300 is configured to be switched by a user among a hammer mode for hammering operation, a drill mode for drilling operation and a hammer drill mode for simultaneously performing hammering and drilling operations. The structure for switching the operation mode is not described for convenience sake.

[0075] As shown in FIG. 6, the body 101 of the electric hammer drill 300 mainly includes a body housing 303 and a handgrip 109 connected to the body housing 303. The body housing 303 is an example embodiment that corresponds to the "housing" according to the present invention. The body housing 303 houses an electric motor 110, a controller 112, a first motion converting mechanism 120, a striking mechanism 140, and a rotation transmitting mechanism 151 and a dynamic vibration reducer 390 (see FIG. 7). The handgrip 109 is arranged on a side of the body housing 303 opposite from the tool bit 119 in the longitudinal direction of the tool bit 119. In the third embodiment, for convenience sake, the tool bit 119 side is defined as a front side and the handgrip 109 side is defined as a rear side in the longitudinal direction of the tool bit 119 (the longitudinal direction of the body 101).

[0076] The handgrip 109 has a grip part 109a extending in a vertical direction of the hammer drill 300 (a direction crossing the longitudinal direction of the tool bit 119) as shown in FIG. 6. The handgrip 109 is connected to the body housing 303 by a connecting mechanism 108 in an upper connecting region 109b. A coil spring 108b of the connecting mechanism 108 is arranged to extend between a spring receiving part 108c provided in the body housing 303 and a spring receiving part 108d provided in the handgrip 109. Further, the handgrip 109 is connected to the body housing 303 by a pivot 108e in a lower connecting region 109c.

[0077] With this structure, the handgrip 109 and the body housing 303 can rotate on the pivot 108e with respect to each other under the biasing force of the coil spring 108b. With this structure, transmission of vibration of the body housing 303 to the handgrip 109 can be suppressed.

[0078] An operation part 109d is provided in the handgrip 109 as shown in FIG. 6. When the operation part

109d is operated, the electric motor 110 is driven via the controller 112. The operation part 109d of the hammer drill 300 is a trigger which is depressed by a user. The electric motor 110 is a brushless motor and is arranged such that the motor shaft 111 extends in a direction crossing the longitudinal axis of the tool bit 119. The electric motor 110 is arranged in a position displaced from the longitudinal axis of the tool bit 119. Specifically, the electric motor 110 is disposed in a lower part of the hammer drill 300, and a cylinder 141 and a tool holder 131 which are coaxially arranged with the tool bit 119 are disposed in an upper part of the hammer drill 300.

[0079] As shown in FIG. 6, like in the first embodiment, the controller 112 is configured to drive the electric motor 110 at the first rotation speed in the pressed state and to drive the electric motor 110 at the second rotation speed in the non-pressed state. Further, the hammer drill 300 has an acceleration sensor 112a, and the controller 112 is configured to control driving of the electric motor 110 based on the detection result of the acceleration sensor 112a. The acceleration sensor 112a is an example embodiment that corresponds to the "sensor" according to the present invention. When the acceleration sensor 112a detects an inclined state of the hammer drill 300, the controller 112 can detect the behavior of the hammer drill 300. The hammer drill 300 is configured such that the controller 112 controls to stop driving of the electric motor 110 when the acceleration sensor 112a exhibits prescribed behavior in the drill mode or hammer drill mode of the hammer drill 300. This prescribed behavior includes such behavior that the tool bit 119 is locked in a hole formed by drilling operation and the hammer drill 300 is caused to rotate on the tool bit 119. The hammer drill 300 can be provided with a function of preventing specific behavior in drilling operation simply by providing the controller 112 for controlling driving of the brushless motor (the electric motor 110) with an additional function of controlling driving of the electric motor 110 based on the detection result of the acceleration sensor 112a.

[0080] The acceleration sensor 112a is disposed in the controller 112 as shown in FIG. 6. The acceleration sensor 112a may be disposed elsewhere in the body 101, and a plurality of acceleration sensors 112a may be provided.

[0081] As shown in FIG. 6, rotation of the electric motor 110 is transmitted to the first motion converting mechanism 120 disposed in the upper part of the hammer drill 300, and thereafter converted into linear motion by the first motion converting mechanism 120 and transmitted to the striking mechanism 140. Then the tool bit 119 is struck in the longitudinal direction via the striking mechanism 140. Further, rotation of the electric motor 110 is transmitted to the tool holder 131 via the rotation transmitting mechanism 151, and the tool bit 119 is rotated around its axis via the tool holder 131. The first motion converting mechanism 120 and the striking mechanism 140 have the same structures as those of the first embodiment, respectively, and are not described. A cylinder

side communication opening 141c is formed in the cylinder 141 of the hammer drill 300 as shown in FIG. 6. A barrel space (not shown) between the cylinder 141 and the barrel 104 communicates with the air chamber 141a via the cylinder side communication opening 141c. Further, a closed space which forms a crank chamber 121b is formed behind the piston 125. The first connecting rod 123 and the eccentric shaft part 121a of the first crank shaft 121 are disposed in the crank chamber 121b.

[0082] The rotation transmitting mechanism 151 mainly includes a driven gear 153, a mechanical torque limiter 155, an intermediate shaft 157 and a small bevel gear 159 as shown in FIG. 6. The driven gear 153 is engaged with a pinion gear provided on the motor shaft 111 and rotated. The driven gear 153 is connected to the intermediate shaft 157 via the mechanical torque limiter 155. The mechanical torque limiter 155 is configured to interrupt torque transmission between the driven gear 153 and the intermediate shaft 157 when acted upon by torque exceeding a prescribed value. The small bevel gear 159 is provided on an upper end of the intermediate shaft 157 and engages with a large bevel gear 132 provided on a rear end of the tool holder 131. With this structure, the rotation transmitting mechanism 151 transmits rotation of the electric motor 110 to the tool holder 131.

[0083] As shown in FIG. 7, the dynamic vibration reducer 390 has a weight 391, a biasing spring 392 disposed on the front side of the weight 391, and a biasing spring 393 disposed on the rear side of the weight 391. The weight 391, the dynamic vibration reducer 390 and the biasing springs 392, 393 are example embodiments that correspond to the "weight", the "dynamic vibration reducer" and the "weight elastic member", respectively, according to the present invention. Only one dynamic vibration reducer 390 is shown in FIG. 7, but another dynamic vibration reducer 390 is disposed on the opposite side of the hammering axis from the one dynamic vibration reducer 390.

[0084] The dynamic vibration reducer 390 is disposed in a dynamic vibration reducer arrangement space. The dynamic vibration reducer arrangement space includes a first space 394 in which the biasing spring 392 is disposed and a second space 395 in which the biasing spring 393 is disposed. The weight 391 is disposed in the dynamic vibration reducer arrangement space via a cylindrical member 396. More specifically, a large-diameter part of the weight 391 is held in contact with the cylindrical member 396 so as to be reciprocally slidable. The large-diameter part of the weight 391 prevents communication between the first space 394 and the second space 395.

[0085] The first space 394 has a dynamic vibration reducer side first communication opening 394a which communicates with the barrel space. Thus, the first space 394 communicates with the air chamber 141a via the dynamic vibration reducer side first communication opening 394a and the barrel space. The second space 395 has a dynamic vibration reducer side second com-

munication opening 395a which communicates with the crank chamber 121b. Thus, the second space 395 communicates with the crank chamber 121b via the dynamic vibration reducer side second communication opening 395a.

[0086] With this structure, the weight 391 reciprocates in the back and forth direction by driving of the piston 125.

[0087] Specifically, when the piston 125 moves forward and compresses air of the air chamber 141a, air is sent to the first space 394 via the cylinder side communication opening 141c, the barrel space and the dynamic vibration reducer side first communication opening 394a. As a result, the pressure of the first space 394 increases, so that the weight 391 is moved rearward. When the piston 125 moves rearward and compresses air of the crank chamber 121b, air is sent to the second space 395 via the crank chamber 121b and the dynamic vibration reducer side second communication opening 395a. As a result, the pressure of the second space 395 increases, so that the weight 391 is moved forward. Thus, the dynamic vibration reducer 390 is configured to move the weight 391 in a phase opposite to the moving direction of the piston 125. Based on this movement, the dynamic vibration reducer 390 is designed such that the weight 391 is driven in a phase opposite to the moving direction of the striker 143.

[0088] With this structure, vibration caused in the body housing 303 particularly during hammering operation can be suppressed.

[0089] When performing a hammering operation on a workpiece with the hammer drill 300 having the above-described structure, the user holds the handgrip 109 and presses the hammer drill 300. When the user operates the operation part 109d with a finger of the hand holding the handgrip 109, the electric motor 110 is driven. Then the tool bit 119 is linearly driven via the first motion converting mechanism 120 and the striking mechanism 140 and can perform a hammering operation on the workpiece. At this time, the controller 112 determines that the hammer drill 300 is placed in the pressed state and controls the electric motor 110 to rotate at the first rotation speed. The operation part 109d of the hammer drill 300 is a trigger.

[0090] Further, during hammering operation, the weight 391 of the dynamic vibration reducer 390 is moved in a phase opposite to the moving direction of the striker 143. Therefore, during hammering operation, the dynamic vibration reducer 390 effectively reduces vibration caused in the body housing 303. Furthermore, the handgrip 109 reciprocally rotates on the pivot 108e with respect to the body housing 303 via the coil spring 108b, so that transmission of vibration to the handgrip 109 is further effectively suppressed.

[0091] When the user switches the hammer drill 300 from the pressed state to the non-pressed state, the controller 112 detects that the current supplied to the electric motor 110 is below a threshold and controls the electric motor 110 to rotate at the second rotation speed.

[0092] In the non-pressed state, where the electric motor 110 is rotationally driven at the second rotation speed, the piston 125 is driven. Thus, the dynamic vibration reducer 390 is driven, but in this state where the electric motor 110 is rotationally driven at the second rotation speed, vibration caused by driving of the dynamic vibration reducer 390 is reduced, compared with the state where the electric motor 110 is driven at the first rotation speed.

[0093] Further, the hammer drill 300 is configured such that the ring-like member 141 d shown in FIG. 6 closes the vent 141b of the cylinder 141 in the pressed state and opens the vent 141b in the non-pressed state. With this structure, the tool bit 119 is prevented from being driven by driving of the piston 125. The structure relating to this function is not described for convenience sake.

[0094] As described above, in the pressed state, the hammer drill 300 can suppress vibration related to hammering operation by the dynamic vibration reducer 390 and the coil spring 108b. Further, in the non-pressed state, since the electric motor 110 is driven at the second rotation speed, vibration caused by driving of the dynamic vibration reducer 390 can be reduced. Specifically, the hammer drill 300 can effectively suppress vibrations caused in the pressed state and the non-pressed state.

(Fourth Embodiment)

[0095] The fourth embodiment of the present invention is now described with reference to FIG. 8. Like the electric hammer drill 300 of the third embodiment, an electric hammer drill 400 of the fourth embodiment is configured to be switched by a user among a hammer mode, a drill mode and a hammer drill mode.

[0096] As shown in FIG. 8, the body 101 of the electric hammer drill 400 mainly includes a body housing 403 and a handgrip 109 connected to the body housing 403. The body housing 403 houses an electric motor 110, a controller 112, a first motion converting mechanism 120, a striking mechanism 140, a rotation transmitting mechanism 151 and a counter weight 490. The handgrip 109 is arranged on a side of the body housing 403 opposite from the tool bit 119 in the longitudinal direction of the tool bit 119. In the fourth embodiment, for convenience sake, the tool bit 119 side is defined as a front side and the handgrip 109 side is defined as a rear side in the longitudinal direction of the tool bit 119 (the longitudinal direction of the body 101). Further, in a direction crossing the longitudinal direction of the tool bit 119, the side on which the tool bit 119 is arranged is defined as an upper side and the side on which the controller 112 is arranged is defined as a lower side.

[0097] The handgrip 109 has a grip part 109a extending in a vertical direction of the hammer drill 400 (a direction crossing the longitudinal direction of the tool bit 119). The handgrip 109 has an upper connecting region 109b and a lower connecting region 109c which are connected to the body housing 403 by respective connecting

mechanisms 108.

[0098] With this structure, the handgrip 109 and the body housing 403 can move with respect to each other under the biasing force of the coil spring 108b, so that transmission of vibration of the body housing 403 to the handgrip 109 can be suppressed.

[0099] A battery mounting part 109f for mounting a battery (a feeding part 180) is provided on the underside of the handgrip 109. By this arrangement, in the hammer drill 400, the weight can be distributed to the handgrip 109, so that the vibration proofing effect can be enhanced. The battery mounting part 109f is an example embodiment that corresponds to the "mounting part" according to the present invention. A cable for electrically connecting the feeding part 180 and the controller 112 is wired between the feeding part 180 and the electric motor 110 through the inside of a lower bellows 108a. In FIG. 8, the cable is not shown for convenience sake.

[0100] A trigger which forms an operation part 109d is provided in the handgrip 109. When the operation part 109d is depressed, the electric motor 110 is driven via the controller 112. The electric motor 110 is a brushless motor. Like in the first embodiment, the controller 112 is configured to drive the electric motor 110 at the first rotation speed in the pressed state and to drive the electric motor 110 at the second rotation speed in the non-pressed state.

[0101] The electric motor 110 is arranged such that the motor shaft 111 extends in a direction crossing the longitudinal axis of the tool bit 119. The electric motor 110 is arranged in a position displaced from the longitudinal axis of the tool bit 119. Rotation of the electric motor 110 is transmitted to the first motion converting mechanism 120 disposed above the electric motor 110, and thereafter converted into linear motion by the first motion converting mechanism 120 and transmitted to the striking mechanism 140. Then the tool bit 119 is struck in the longitudinal direction via the striking mechanism 140. Further, rotation of the electric motor 110 is transmitted to the tool holder 131 via the rotation transmitting mechanism 151, and the tool bit 119 is rotated around its axis via the tool holder 131. Furthermore, rotation of the electric motor 110 is transmitted to a counter weight 490 via the first motion converting mechanism 120.

[0102] The first motion converting mechanism 120 mainly includes a driven gear 117, an intermediate shaft 116, a swinging shaft 118, a movable cylinder 142 and a striking mechanism 140. The driven gear 123 is integrally formed with the intermediate shaft 116. The swinging shaft 118 is configured to rotate together with the intermediate shaft 116 and has a rotary member 118a and a shaft member 118b. The rotary member 118a has an outer surface inclined with respect to the extending direction of the intermediate shaft 116. The shaft member 118b has an annular region which is connected to the rotary member 118a via a steel ball, and a shaft-like region which protrudes upward from the annular region and is rotatably connected to the movable cylinder 142. The

movable cylinder 142 is a cylindrical member having a bottom and is disposed within the tool holder 131 so as to be reciprocally slidable. A striker 143 is disposed within the movable cylinder 142 so as to be reciprocally slidable, and an air chamber 142a is formed between the bottom of the movable cylinder 142 and the striker 143. In the tool holder 131, an impact bolt 145 is disposed in front of the striker 143 so as to be reciprocally slidable.

[0103] In the first motion converting mechanism 120 having the above-described structure, the swinging shaft 118 reciprocally moves the movable cylinder 142 when the intermediate shaft 116 is rotated by rotation of the motor 110. Then the striker 143 is caused to collide with the impact bolt 145 via pressure fluctuations of the air chamber 142a by the reciprocating movement of the movable cylinder 142, and the tool bit 119 is moved forward via the impact bolt 145.

[0104] The tool holder 131 has a striker holding part 131a and an O-ring 131b fitted in the striker holding part 131a. Further, the striker 143 has a front end large-diameter part.

[0105] When the hammer drill 400 is placed in the pressed state, the striker 143 is placed in a rear position via the tool bit 119 and the impact bolt 145. In this state, the impact bolt 145 is located in an inside region of the O-ring 131b of the striker holding part 131a.

[0106] Immediately after the hammer drill 400 is switched from the pressed state to the non-pressed state, first, the striker 143 moves the tool bit 119 and the impact bolt 145 forward. Thus, the impact bolt 145 is no longer located in the inside region of the O-ring 131b. In this state, when the striker 143 is moved forward by driving of the movable cylinder 142, the front end large-diameter part of the striker 143 moves over the O-ring 131b. In this state, even if the pressure of the air chamber 142a decreases by the movement of the movable cylinder 142, the front end large-diameter part is engaged with the O-ring 131b, so that the striker 143 is prevented from moving. Thus, in the unloaded state, the tool bit 119 is prevented from being driven.

[0107] The rotation transmitting mechanism 151 mainly includes a driven gear 154 which can rotate together with the intermediate shaft 116, and a tool holder gear 133 which engages with the driven gear 154 and can rotate together with the tool holder 131.

[0108] With the above-described structure, the driven gear 154 is rotated by the intermediate shaft 116 and rotationally drives the tool holder gear 133, so that the rotation transmitting mechanism 151 can rotate the tool bit 119 held by the tool holder 131.

[0109] The counter weight 490 has an upper end region 490a which is rotatably journaled to the body housing 403 and a lower end region 490b which is connected to a lower end of the annular region of the shaft member 118b. Thus, the counter weight 490 is reciprocally rotated in the back and forth direction by swinging of the shaft member 118b. The upper end region 490a and the lower end region 490b of the counter weight 490 are arranged

on the opposite sides of the swinging axis of the shaft member 118b. Thus, the counter weight 490 is moved in a phase opposite to the moving direction of the movable cylinder 142.

[0110] When performing a hammering operation on a workpiece with the hammer drill 400 having the above-described structure, the user holds the handgrip 109 and presses the hammer drill 400. When the user operates the operation part 109d with a finger of the hand holding the handgrip 109, the electric motor 110 is driven. Then the tool bit 119 is linearly driven via the first motion converting mechanism 120 and the striking mechanism 140 and can perform a hammering operation on the workpiece. At this time, the controller 112 determines that the hammer drill 400 is placed in the pressed state and controls the electric motor 110 to rotate at the first rotation speed.

[0111] Further, during hammering operation, the counter weight 490 is driven by movement of the swinging shaft 118. Therefore, during hammering operation, the counter weight 490 effectively reduces vibration caused in the body housing 403. Furthermore, the handgrip 109 reciprocally moves with respect to the body housing 403 via the coil spring 108b, so that transmission of vibration to the handgrip 109 is further effectively suppressed.

[0112] When the user switches the hammer drill 400 from the pressed state to the non-pressed state, the controller 112 detects that the current supplied to the electric motor 110 is below a threshold and controls the electric motor 110 to rotate at the second rotation speed.

[0113] In the non-pressed state, where the electric motor 110 is rotationally driven at the second rotation speed, the swinging shaft 118 is swung by the intermediate shaft 116. Thus, the counter weight 490 is driven, but in this state where the electric motor 110 is rotationally driven at the second rotation speed, vibration caused by driving of the counter weight 490 can be reduced.

[0114] As described above, in the pressed state, the hammer drill 400 can suppress vibration related to hammering operation by the counter weight 490 and the coil spring 108b. Further, in the non-pressed state, since the electric motor 110 is driven at the second rotation speed, vibration caused by driving of the counter weight 490 can be reduced. Specifically, the hammer drill 400 can effectively suppress vibrations caused in the pressed state and the non-pressed state.

[0115] Embodiments of the present invention are not limited to the above-described structures of the first to fourth embodiments, but may have other structures. Typically, the hammering axis of the tool bit 119 may be arranged in parallel to the output shaft of the electric motor 110.

[0116] Further, the structures of the first to fourth embodiments may be appropriately used in combination. For example, the structures relating to the counter weight 190 of the first embodiment, the dynamic vibration reducer 290 of the second embodiment, the dynamic vibration reducer 390 of the third embodiment and the counter

weight 490 of the fourth embodiment may be appropriately used in other embodiments.

(Correspondences between the features of the embodiments and the features of the invention)

[0117] The above-described embodiments are representative examples for embodying the present invention, and the present invention is not limited to the structures of the representative embodiments. Correspondences between the features of the embodiments and the features of the invention are as follow:

The electric hammer 100, the electric hammer 200, the electric hammer drill 300 or the electric hammer drill 400 is an example embodiment that corresponds to the "impact tool" according to the present invention. The tool bit 119 is an example embodiment that corresponds to the "tool accessory" according to the present invention. The body housing 103, the body housing 203, the body housing 303 or the body housing 403 is an example embodiment that corresponds to the "housing" according to the present invention. The handgrip 109 is an example embodiment that corresponds to the "handle" according to the present invention. The coil spring 108b is an example embodiment that corresponds to the "handle elastic member" according to the present invention. The electric motor 110 and the controller 112 are example embodiments that correspond to the "brushless motor" and the "controller", respectively, according to the present invention. The pressed state and the non-pressed state are example embodiments that correspond to the "pressed state" and the "non-pressed state", respectively, according to the present invention. The first rotation speed is an example embodiment that corresponds to the "first rotation speed" according to the present invention. The second rotation speed is an example embodiment that corresponds to the "second rotation speed" according to the present invention. The motor shaft 111, the first motion converting mechanism 120 and the second motion converting mechanism 160 are example embodiments that correspond to the "rotary shaft", the "driving mechanism" and the "vibration suppressing mechanism", respectively, according to the present invention. The counter weight 190 is an example embodiment that corresponds to the "weight" and the "counter weight" according to the present invention. The weight 291 or the weight 391 is an example embodiment that corresponds to the "weight" according to the present invention. The dynamic vibration reducer 290 or the dynamic vibration reducer 390 is an example embodiment that corresponds to the "dynamic vibration reducer" according to the present invention. The biasing spring 292, the biasing spring 293, the biasing spring 392 or the biasing spring 393 is an example embodiment that cor-

respond to the "weight elastic member" according to the present invention. The counter weight 490 is an example embodiment that corresponds to the "weight" and the "counter weight" according to the present invention. The acceleration sensor 112a is an example embodiment that corresponds to the "sensor" according to the present invention. The battery mounting part 109f is an example embodiment that corresponds to the "mounting part" according to the present invention.

[0118] In view of the nature of the above-described invention, the impact tool according to this invention can be provided with the following features. Each of the features can be used separately or in combination with the other, or in combination with the claimed invention.

(Aspect 1)

[0119] The weight elastic member has a first elastic body connected to one side of the weight, and a second elastic body connected to the other side of the weight.

(Aspect 2)

[0120] The counter weight is configured such that one end region of the counter weight is rotatably journaled to the housing and the other end region is connected to the driving mechanism.

(Aspect 3)

[0121] The sensor for detecting behavior of the impact tool during the prescribed operation comprises an acceleration sensor.

[0122] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Description of the Numerals

[0123]

100	electric hammer
101	body
103	body housing
103a	motor housing
103a1	recess
103b	gear housing

104 barrel
 105 outer housing
 106 upper housing
 106a shaft support part
 106b recess
 106c annular part
 107 lower housing
 108 connecting mechanism
 108A guide shaft
 108A1 flange
 108a bellows
 108b coil spring (handle elastic member)
 108c spring receiving part
 108d spring receiving part
 108e pivot
 109 handgrip
 109A side grip
 109a grip part
 109b upper connecting region
 109c lower connecting region
 109d operation part
 109e electric switch
 109f battery mounting part
 110 electric motor
 111 motor shaft
 112 controller
 112a acceleration sensor
 113 gear speed reducing device
 116 intermediate shaft
 117 driven gear
 118 swinging shaft
 118a rotary member
 118b shaft member
 119 tool bit
 120 first motion converting mechanism
 121 first crank shaft
 121a eccentric shaft part
 121b crank chamber
 123 first connecting rod
 125 piston
 131 tool holder
 131a striker holding part
 131b O-ring
 132 large bevel gear
 133 tool holder gear
 140 striking mechanism
 141 cylinder
 141a air chamber
 141b vent
 141c cylinder side communication opening
 141d ring-like member
 142 movable cylinder
 142a air chamber
 143 striker
 145 impact bolt
 151 rotation transmitting mechanism
 153 driven gear
 154 driven gear

155 mechanical torque limiter
 157 intermediate shaft
 159 small bevel gear
 160 second motion converting mechanism
 5 161 second crank shaft
 163 eccentric shaft
 165 second connecting rod
 166 connecting shaft
 170 bearing holder
 10 170a needle bearing
 180 feeding part
 190 counter weight
 200 electric hammer
 203 body housing
 15 210 slide sleeve
 211 ring-like member
 290 dynamic vibration reducer
 291 weight
 292 biasing spring (weight elastic member)
 20 293 biasing spring (weight elastic member)
 300 electric hammer drill
 303 body housing
 390 dynamic vibration reducer
 391 weight
 25 392 biasing spring (weight elastic member)
 393 biasing spring (weight elastic member)
 394 first space
 394a dynamic vibration reducer side first communication opening
 30 395 second space
 395b dynamic vibration reducer side second communication opening
 396 cylindrical member
 400 electric hammer drill
 35 403 body housing
 490 counter weight
 490a upper end region
 490b lower end region

Claims

1. An impact tool, which performs a hammering operation on a workpiece by linearly driving a tool accessory (119) along a prescribed hammering axis, comprising:

45 a brushless motor (110),
 a driving mechanism (120) that drives the tool accessory by an output of the brushless motor (110),
 50 a vibration suppressing mechanism (160; 290; 390) having a movable weight (190; 291; 391; 490), and
 55 a controller (112) that controls driving of the brushless motor (110), wherein:

in a pressed state which is defined as a state

- that a prescribed pressing force is applied to the tool accessory (119), the controller (112) drives the brushless motor (110) at a first rotation speed, and
in a non-pressed state which is defined as a state that the prescribed pressing force is not applied to the tool accessory (119), the controller (112) drives the brushless motor (110) at a second rotation speed lower than the first rotation speed.
2. The impact tool as defined in claim 1, wherein the vibration suppressing mechanism (160; 290; 390) comprises a counter weight (190; 291; 391; 490) which is configured such that the weight (190; 490) is mechanically connected to a prescribed region of the driving mechanism (120) and the weight is caused to directly reciprocate by movement of the driving mechanism, or a dynamic vibration reducer (290; 390) which has a weight elastic member (292, 293; 392, 393) connected to the weight (291; 391) and is configured such that the weight (190; 291; 391; 490) is caused to reciprocate by movement of the driving mechanism (120).
3. The impact tool as defined in claim 1 or 2, wherein the weight (190; 291; 391; 490) is configured to be moved linearly or rotated with respect to the direction of the hammering axis.
4. The impact tool as defined in any one of claims 1 to 3, further comprising:
a housing (103; 203; 303; 403) for housing at least part of the driving mechanism (120),
a handle (109) to be held by a user, and
a handle elastic member (108b), wherein:
the handle (109) is connected to the housing (103; 203; 303; 403) via the handle elastic member (108b), so that the handle (109) and the housing (103; 203; 303; 403) can be configured to be movable with respect to each other.
5. The impact tool as defined in claim 4, wherein a connecting member (108a) is provided between the handle (109) and the housing (103; 203; 403), wherein the connecting member (108a) covers the handle elastic member (108b) and the connecting member (108a) is expandable and contractable.
6. The impact tool as defined in claim 4 or 5, wherein the controller (112) is disposed within the handle (109).
7. The impact tool as defined in any one of claims 1 to 6, further comprising:
a sensor (112a) that detects behavior of the impact tool during a prescribed operation, wherein:
the controller (112) controls driving of the brushless motor (110) based on a detection result of the sensor (112a).
8. The impact tool as defined in claim 7, wherein an acceleration sensor (112a) is provided as the sensor (112a).
9. The impact tool as defined in any one of claims 4 to 8, wherein the brushless motor (110) is driven by a battery, and the handle (109) has a mounting part (109f) for the battery.

FIG. 1

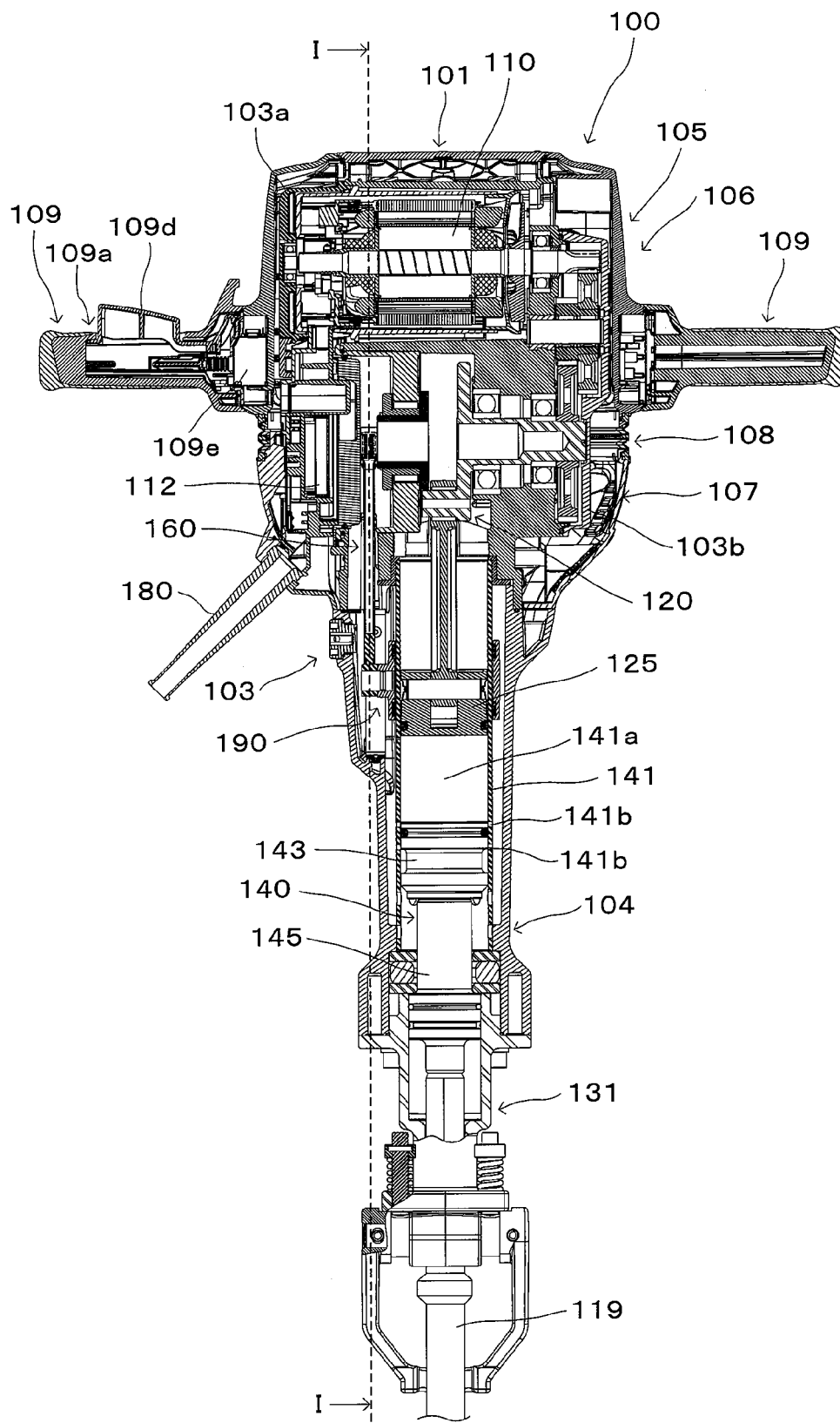


FIG. 2

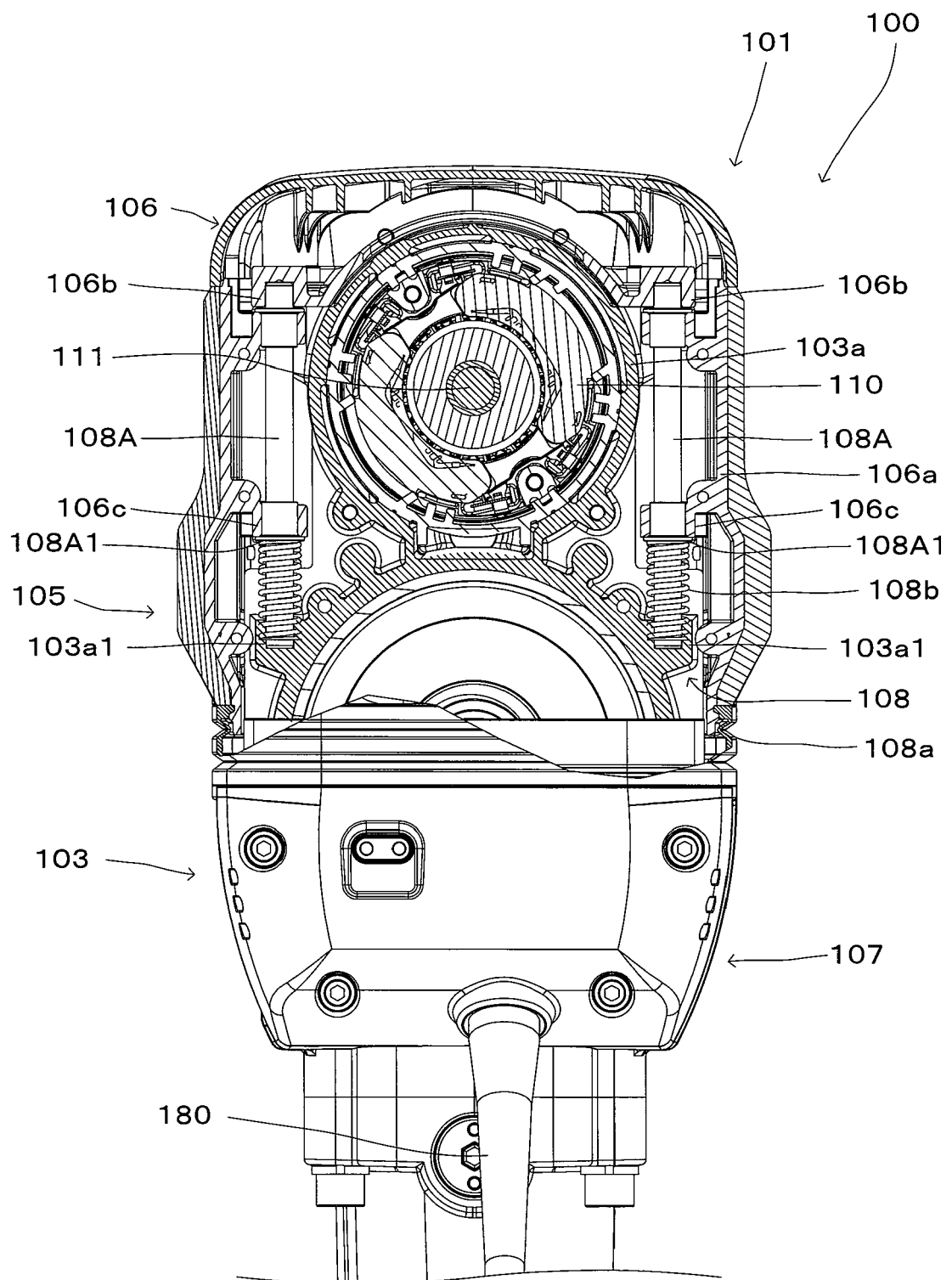


FIG. 3

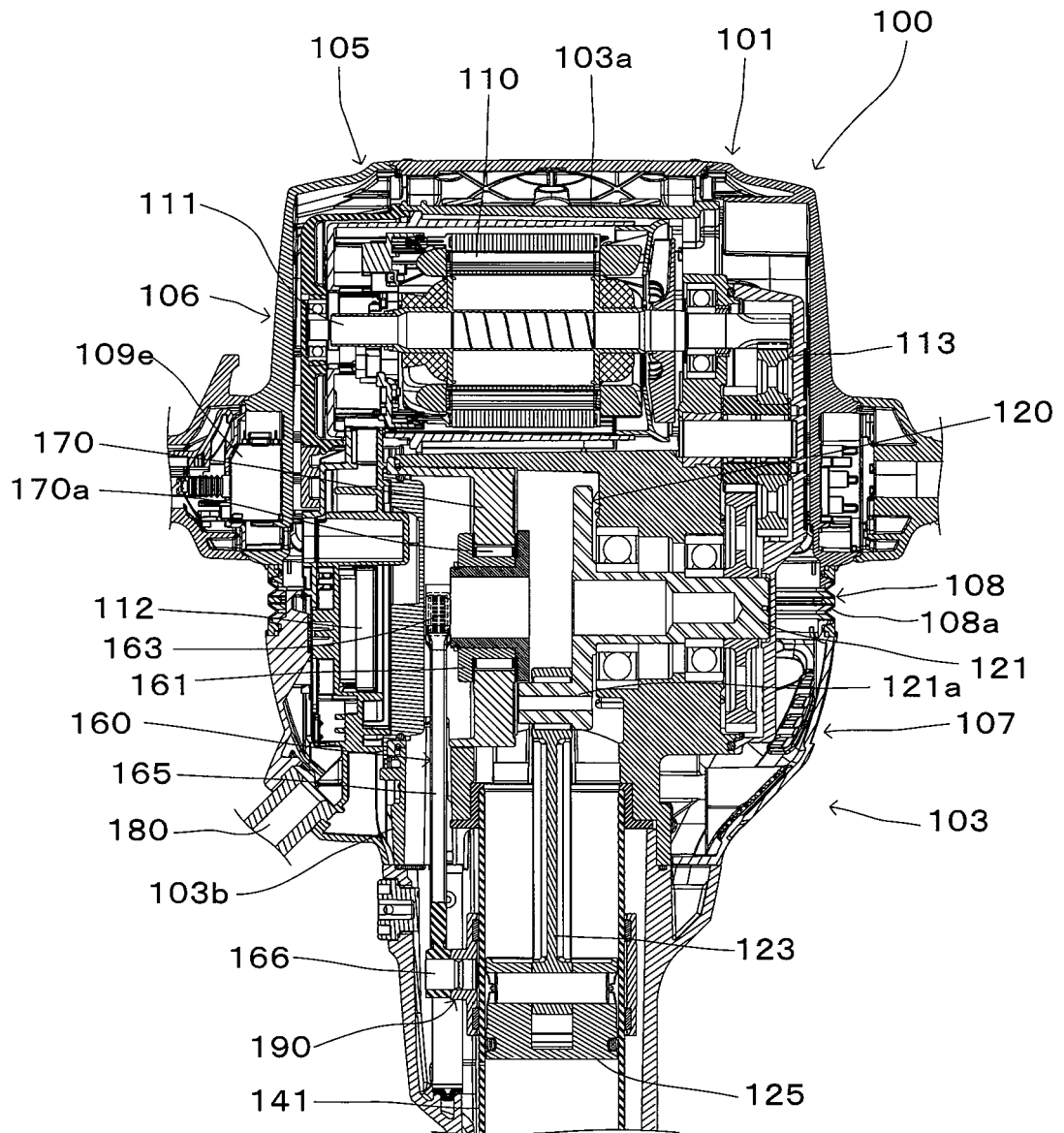


FIG. 4

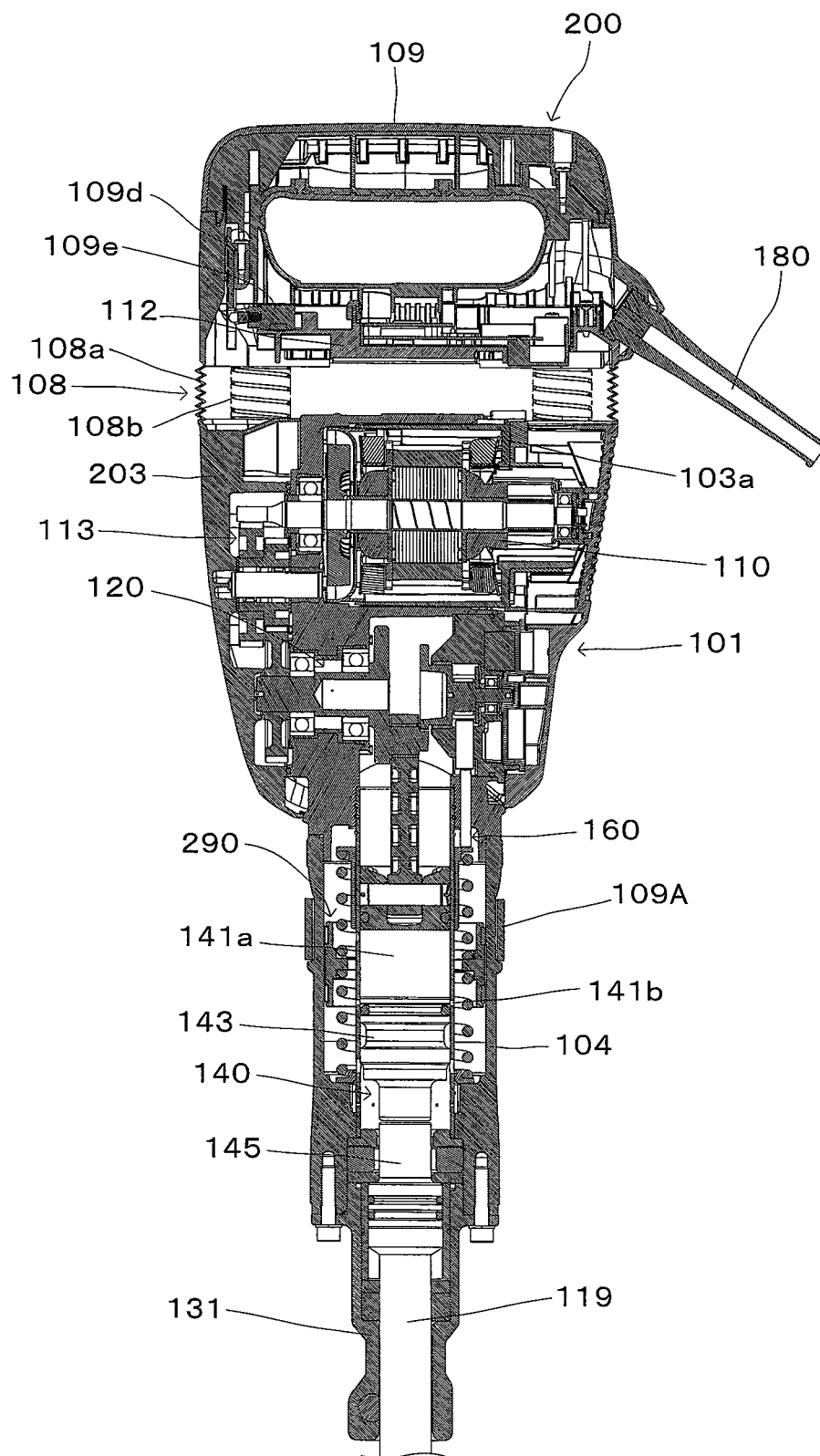


FIG. 5

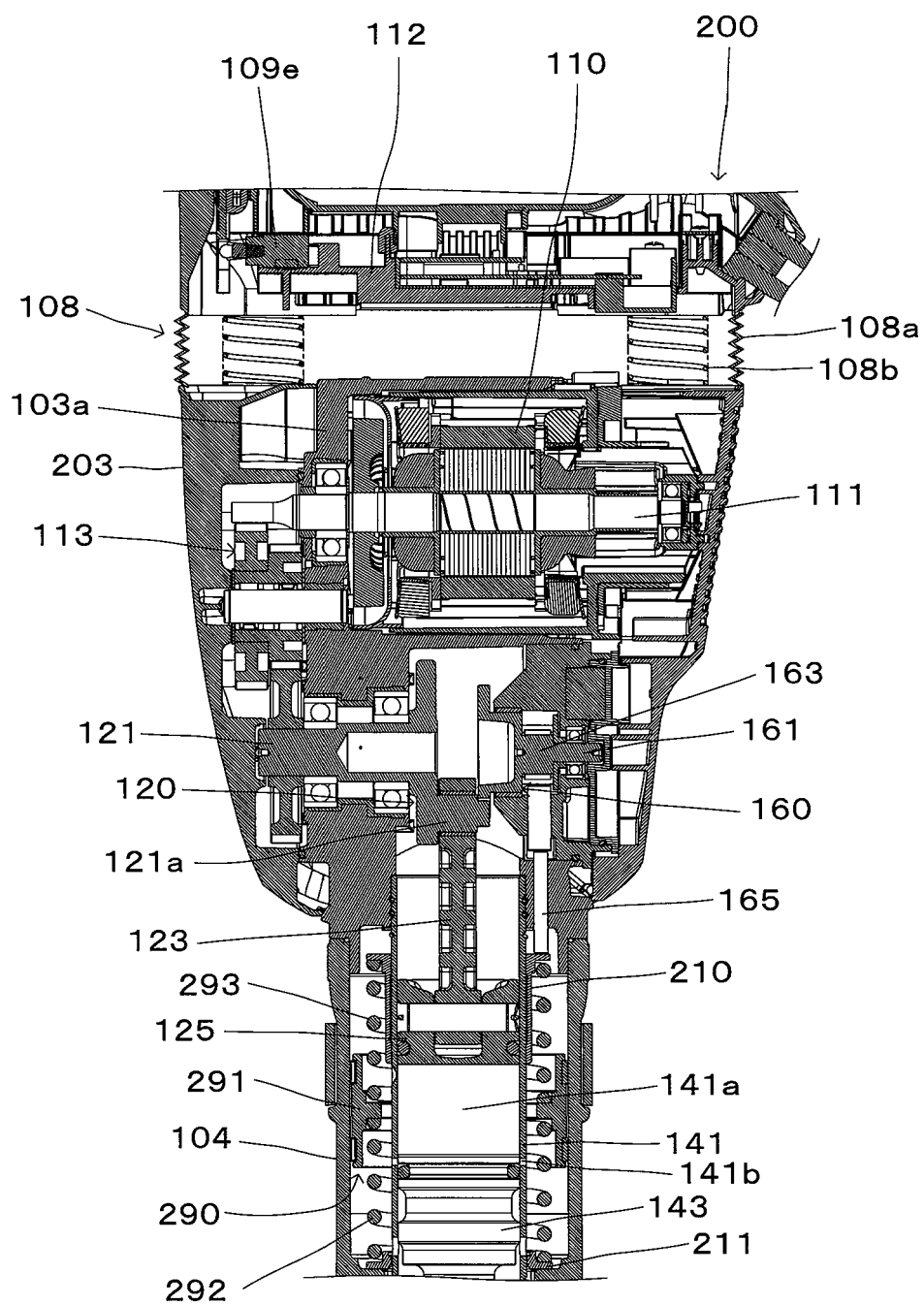


FIG. 6

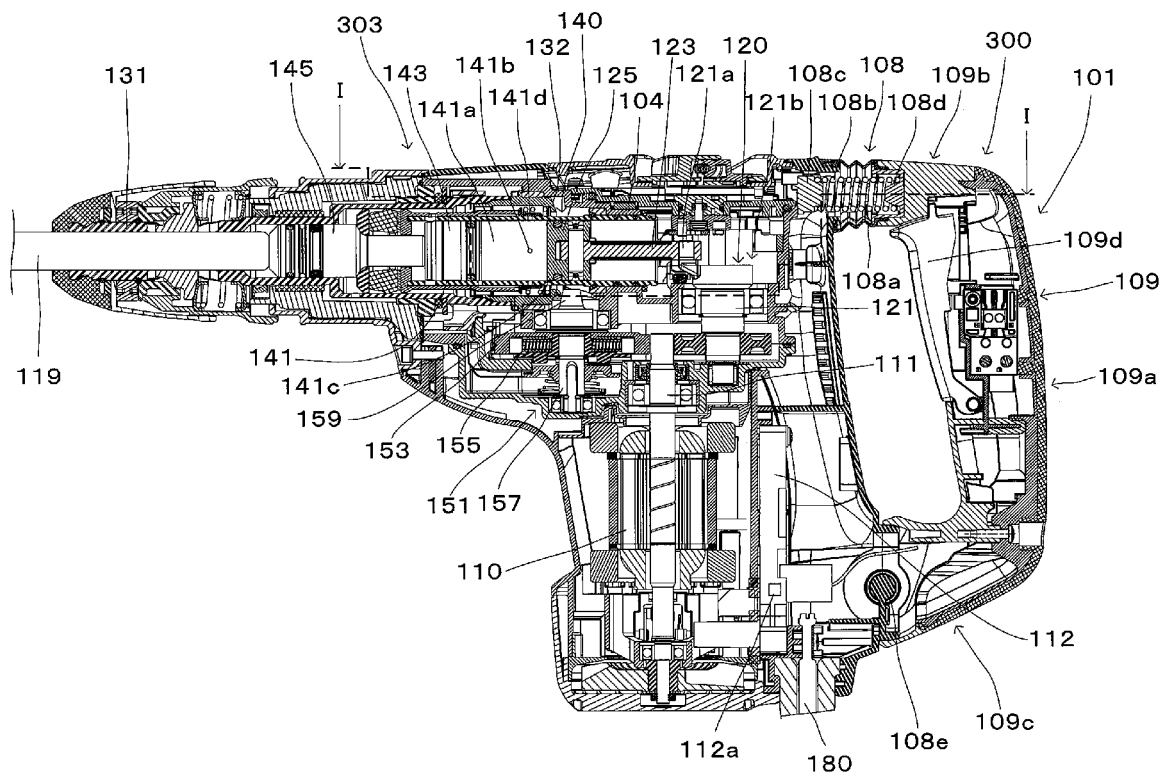


FIG. 7

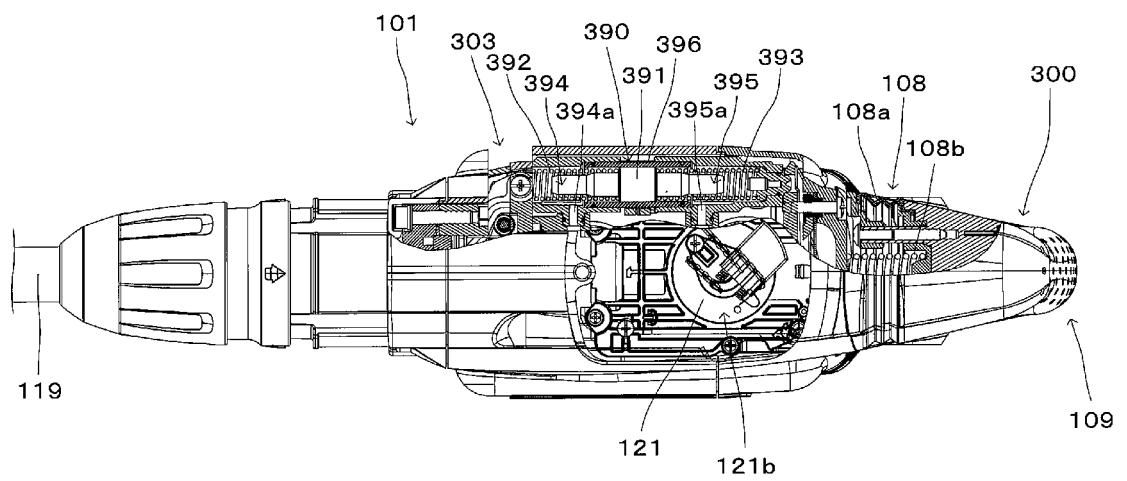
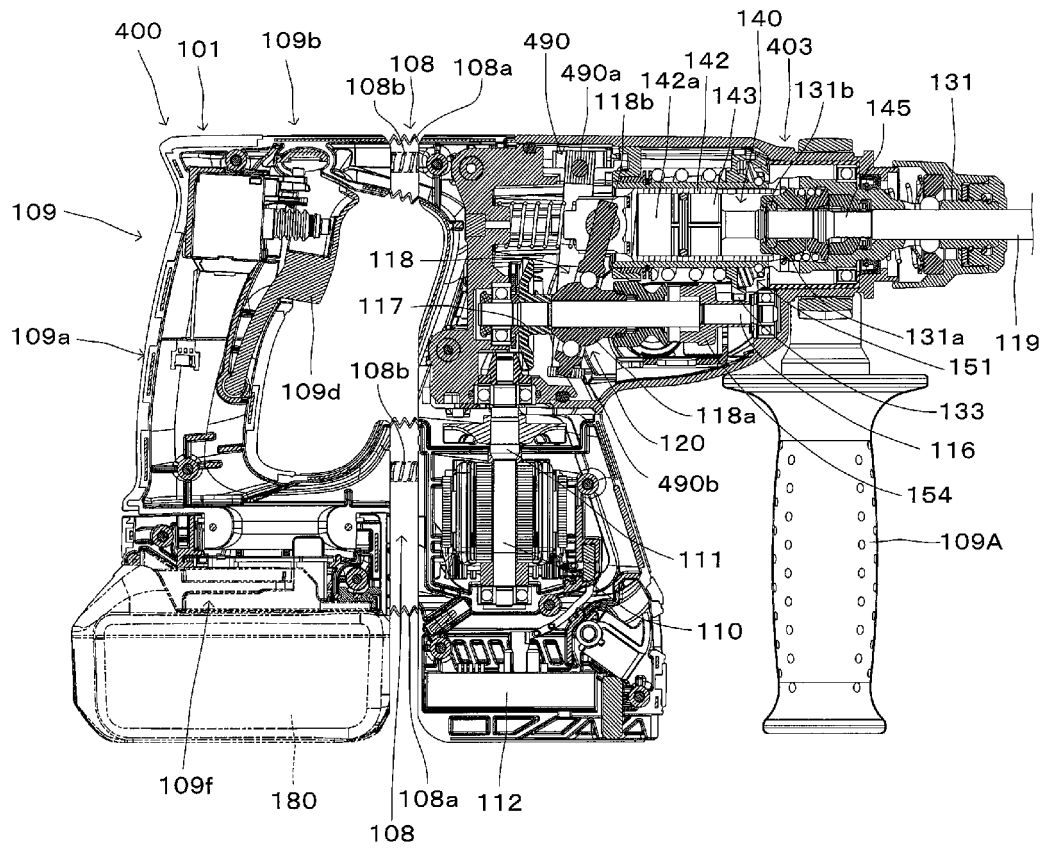


FIG. 8





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