

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

(43) Date of publication:
26.02.2014 Bulletin 2014/09

(51) Int Cl.: **B25D 11/04** (2006.01) **B25D 17/00** (2006.01)
B25D 17/04 (2006.01)

(21) Application number: **12774797.0**

(86) International application number:
PCT/JP2012/060635

(22) Date of filing: **19.04.2012**

(87) International publication number:
WO 2012/144568 (26.10.2012 Gazette 2012/43)

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

(72) Inventor: **KONISHI Takuro**
Anjo-shi, Aichi 446-8502 (JP)

(74) Representative: **Kramer - Barske - Schmidtchen**
Landsberger Strasse 300
80687 München (DE)

(30) Priority: **21.04.2011 JP 2011095090**

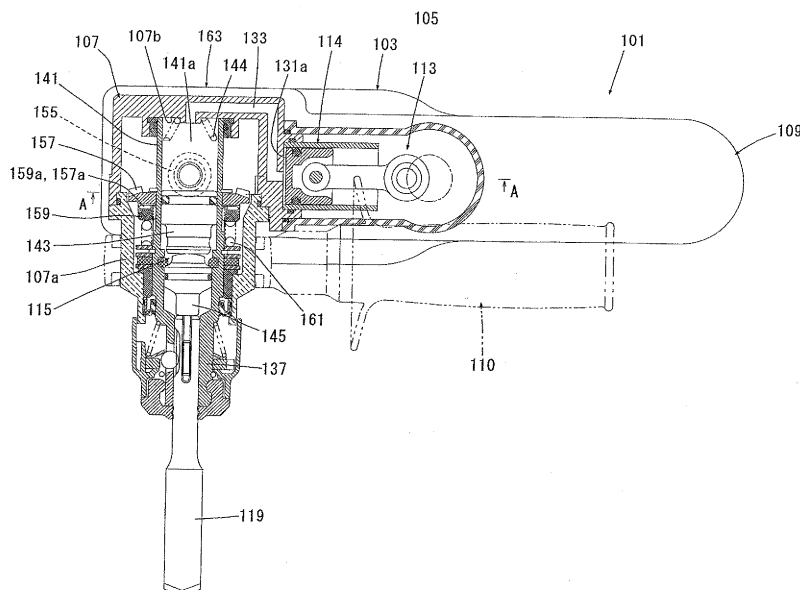
(71) Applicant: **Makita Corporation**
Anjo-shi, Aichi 446-8502 (JP)

(54) **IMPACT TOOL**

(57) [Problem] To provide an impact tool, the body of which is shortened in the direction of the long axis of a tool bit. [Solution] An impact tool in which a tool bit (119) moves linearly in at least the direction of the long axis thereof, thereby working a workpiece in a prescribed manner. Said impact tool has the following: a tool holder (137) that holds the tool bit (119) so as to allow relative movement in the direction of the long axis thereof; an impactor (143) that moves linearly in the direction of the

long axis of the tool bit (119) and applies an impact force thereto; and an impact cylinder (141) that is provided with an air chamber (141a) that causes compressed air to act upon the impactor (143), contains the impactor (143) so as to allow relative movement, and is coupled to the tool holder (137). The tool holder (137) and the impact cylinder (141) extend in the direction of the long axis of the tool bit (119), and the length of the body of the tool in the direction of the long axis of the tool bit (119) is determined by the tool holder (137) and the impact cylinder (141).

FIG. 1



Description

FIELD OF THE INVENTION

[0001] The invention relates to an impact tool which performs a predetermined operation on a workpiece by at least linear movement of a tool bit in an axial direction of the tool bit.

BACKGROUND OF THE INVENTION

[0002] US patent No. 4751970 discloses an angular attachment that is attached to a front end of a hammer drill and can transmit rotation and linear movement of a hammer drill body to a tool bit which is oriented at a different angle at an output of the attachment. The angular attachment is designed such that an output part of the tool bit intersects at 90 degrees with an output part of the hammer drill body. Therefore, in performing a drilling operation, for example, on an inner wall surface of a U-shaped drainage ditch (made of concrete), although a conventional hammer drill cannot be inserted into the U-shaped ditch since its body is much longer in its entire length in the axial direction of a tool bit than the inner width of the U-shaped ditch, the above-described known hammer drill can be inserted into the U-shaped ditch by using the angular attachment.

[0003] In the above-described known technique, although the length of the tool bit in the axial direction is shortened by attaching the angular attachment to the output part of the hammer drill, efficient transmission of rotation and linear movement to the tool bit is not realized and the length of the tool body in the axial direction of the tool bit is not shortened.

[0004] Prior Art Reference 1:

US patent No. 4751970

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] It is, accordingly, an object of the invention to provide an impact tool having a tool body of which length in an axial direction of a tool bit is downsized.

MEANS FOR SOLVING THE PROBLEMS

[0006] In order to solve the above-described problem, according to a preferred embodiment of the invention, an impact tool is provided which performs a predetermined operation on a workpiece by at least linear movement of a tool bit in an axial direction of the tool bit. The impact tool has a tool holder that holds the tool bit so as to allow relative movement in the axial direction, a striking element that moves linearly in the axial direction of the tool bit and applies an impact force to the tool bit, an impact cylinder that is connected to the tool holder, houses the

striking element so as to allow relative movement and has an air chamber that causes compressed air to act upon the striking element, and a tool body that houses the tool holder and the impact cylinder. The tool holder and the impact cylinder extend in the axial direction of the tool bit, and the length of the tool body in the axial direction of the tool bit is defined by the tool holder and the impact cylinder.

[0007] According to the preferred embodiment of the impact tool of the invention, the length of the tool body in the axial direction of the tool bit is defined by the tool holder and the impact cylinder. By provision of this construction, compared with the known impact tool in which the length of the tool body in the axial direction of the tool bit is defined not only by the tool holder and the impact cylinder but by a mechanism for fluctuating pressure of the air chamber, the length of the tool body in the axial direction of the tool bit can be shortened, so that it can be suitably used for an operation in a limited space. Further, unlike the known angular attachment, the impact force of the striking element can be directly transmitted to the tool bit, so that power transmission can be made without loss.

[0008] According to a further embodiment of the impact tool of the invention, the impact tool further has a compressed-air feeding cylinder for supplying compressed air to the air chamber of the cylinder. The compressed-air feeding cylinder extends in a different direction from an extending direction of the impact cylinder. Further, the manner of "extending in a different direction" here represents the manner in which the compressed-air feeding cylinder extends in a direction perpendicular or angled to the extending direction of the impact cylinder.

[0009] Generally, in an impact tool, a tool holder that holds a tool bit, an impact cylinder that houses a striking element for applying an impact force to the tool bit and has an air chamber for applying compressed air to the striking element, and a piston that generates compressed air in the air chamber and a driving mechanism for the piston are arranged in series in the axial direction of the tool bit. According to this embodiment, with the construction in which the compressed-air feeding cylinder for applying compressed air to the air chamber of the impact cylinder extends in a different direction from the extending direction of the impact cylinder, the length of the impact tool in the axial direction of the tool bit can be shortened.

[0010] According to a further embodiment of the impact tool of the invention, the impact tool has a handgrip which is connected to the tool body and designed to be held by a user in order to operate the impact tool, and a width direction of the handgrip coincides with the extending direction of the impact cylinder. Further, the "width direction of the handgrip" here represents a direction transverse to the extending direction of a grip part of the handgrip to be held by the user's hand, for example, in the case of the handgrip which has the grip part having a linearly extending region.

[0011] According to this embodiment, by provision of the construction in which the width direction of the handgrip coincides with the extending direction of the impact cylinder, when holding the handgrip with the user's hand, the user's arm (forearm) extends in the extending direction of the impact cylinder or in a direction transverse to the axial direction of the tool bit. Specifically, the extending direction of the arm intersects with the axial direction of the tool bit. Therefore, when performing an operation, for example, on an inner wall surface of a U-shaped drainage ditch (made of concrete), the arm of the user holding the handgrip does not get in the way of the operation.

[0012] According to a further embodiment of the impact tool of the invention, the axial direction of the tool bit, the extending direction of the compressed-air feeding cylinder and the extending direction of the handgrip intersect one another.

[0013] According to this embodiment, with the above-described construction, the impact tool can be compact as a whole.

[0014] According to a further embodiment of the impact tool of the invention, the impact tool further has a motion converting mechanism that converts rotation into linear motion and thereby generates compressed air in the air chamber of the impact cylinder. Further, a rotating shaft of the motion converting mechanism is disposed in parallel to the impact cylinder in a predetermined region along the extending direction of the impact cylinder. In this case, the rotating shaft of the motion converting mechanism preferably intersects with the extending direction of the impact cylinder.

[0015] According to this embodiment, the motion converting mechanism for generating compressed air in the air chamber is disposed in parallel to the impact cylinder. Therefore, the length of the impact tool in the axial direction of the tool bit can be shortened, compared with the known impact tool in which the motion converting mechanism is disposed outside a region of the impact cylinder in its longitudinal direction.

[0016] According to a further embodiment of the impact tool of the invention, the impact tool has a handgrip designed to be held by a user in order to operate the impact tool, and the extending directions of the impact cylinder and the handgrip are parallel to each other.

[0017] According to this embodiment, with the construction in which the extending direction of the handgrip coincides with the extending direction of the impact cylinder, when holding the handgrip with the user's hand, the user's arm (forearm) extends in the extending direction of the impact cylinder or in a direction transverse to the axial direction of the tool bit. Specifically, the extending direction of the arm intersects with the axial direction of the tool bit. Therefore, when performing an operation, for example, on an inner wall surface of a U-shaped ditch, the arm of the user holding the handgrip does not get in the way of the operation.

EFFECT OF THE INVENTION

[0018] According to the invention, an impact tool is provided with a tool body of which length in the axial direction of a tool bit is downsized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

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

FIG. 2 is a sectional view taken along line A-A in FIG. 1.

FIG. 3 is a sectional view taken along line B-B in FIG. 2.

FIG. 4 is a sectional view showing a modification to gear arrangement.

FIG. 5 is a sectional view showing a modification to feeding of compressed air.

FIG. 6 is a sectional view taken along line C-C in FIG. 5.

FIG. 7 is a sectional view showing a further modification to feeding of compressed air.

FIG. 8 is a sectional view taken along line D-D in FIG. 7.

FIG. 9 is a sectional view showing a further modification to feeding of compressed air.

FIG. 10 is a sectional view showing an entire hammer drill according to a second embodiment of the invention.

FIG. 11 is an enlarged sectional view showing a motion converting mechanism, in a state in which a piston is moved rearward.

FIG. 12 is a side view showing the motion converting mechanism.

FIG. 13 is a sectional view for showing a sectional shape of an impact cylinder taken along line F-F in FIG. 12.

FIG. 14 is a sectional view showing a modification to the second embodiment.

FIG. 15 is an enlarged sectional view showing the motion converting mechanism according to the modification of FIG. 14, in a state in which the piston is moved rearward.

REPRESENTATIVE EMBODIMENT OF THE INVENTION

(First Embodiment of the Invention)

[0020] A first embodiment of the invention is now described with reference to FIGS. 1 to 3. In this embodiment, an electric hammer drill is described as a representative example of a power tool. As shown in FIGS. 1 and 2, a hammer drill 101 of this embodiment mainly includes a body 103 that forms an outer shell of the ham-

mer drill 101, a hammer bit 119 detachably coupled to one end (front end region) of the body 103 in its longitudinal direction via a tool holder 137, and a handgrip 109 that is provided as a main handle on the opposite side of the body 103 from the hammer bit 119.

[0021] The hammer bit 119 is provided such that its axis extends in a direction transverse to the longitudinal direction of the body 103, and the hammer bit 119 is held by a tool holding member in the form of the hollow tool holder 137 such that it is allowed to linearly move in a longitudinal direction of the tool holder 137 with respect to the tool holder. Thus, the tool holder 137 extends in a direction transverse to the longitudinal direction of the body 103 or in a width direction of the body 103. The body 103 and the hammer bit 119 are features that correspond to the "tool body" and the "tool bit", respectively, according to the invention.

[0022] The body 103 mainly includes an outer housing 105 and an inner housing in the form of a gear housing 107 which is largely covered by the outer housing 105. The outer housing 105 includes a motor housing that houses a driving motor 111, and the gear housing 107 houses a motion converting mechanism 113, a compression device 114, a striking mechanism 115 and a power transmitting mechanism 117.

[0023] The handgrip 109 is configured as a D-shaped handle having a grip 109a which is designed to be held by a user. The grip 109a extends in a vertical direction transverse to the longitudinal direction of the body 103 and has upper and lower ends connected to the outer housing 105. An axis of the hammer bit 119 extends in a horizontal direction transverse to the longitudinal direction of the body 103 and to the extending direction of the handgrip 109.

[0024] Further, as shown in FIG. 1, the hammer drill 101 has an auxiliary handle in the form of a side grip 110 separately from the above-described handgrip 109. The side grip 110 is a rod-like member extending in a direction transverse to the axial direction of the hammer bit 119. One axial end of the side grip 110 is removably mounted on a generally cylindrical barrel 107a which houses the tool holder 137, and a fixed position of the side grip 110 to the barrel 107a can be adjusted in a circumferential direction around the axis of the hammer bit 119. The barrel 107a is provided as a region of the gear housing 107 which is exposed to the outside through the side surface of the outer housing 105.

[0025] As shown in FIG. 2, the driving motor 111 is disposed such that its axis of rotation runs vertically in a direction (a vertical direction in FIG. 2) generally perpendicular to the longitudinal direction of the body 103. Rotating power of the driving motor 111 is converted into linear motion via the motion converting mechanism 113 and then drives the compression device 114. Compressed air generated by the compression device 114 is led to an impact cylinder 141 and drives the striking mechanism 115. Thus, an impact force is generated in the axial direction (the vertical direction in FIG. 1) of the ham-

mer bit 119 via the striking mechanism 115.

[0026] The power transmitting mechanism 117 reduces the speed of the rotating output of the driving motor 111 and then transmits it to the hammer bit 119 via the tool holder 137, so that the hammer bit 119 is caused to rotate in the circumferential direction. Further, the driving motor 111 is driven by depressing an operating member in the form of a trigger 147 which is disposed on the handgrip 109, and the direction of rotation of the driving motor 111 can be changed by sliding a normal/reverse selector switch 149 disposed adjacent to the trigger 147. A direction in which the normal/reverse selector switch 149 is slid can be arbitrarily set.

[0027] As shown in FIG. 2, the motion converting mechanism 113 mainly includes a driving gear 121 that is formed on a motor shaft 111a of the driving motor 111 and rotationally driven in a horizontal plane, a driven gear 123 that is engaged with the driving gear 121, a crank shaft 125 that rotates together with the driven gear 123, a crank pin 126 that is eccentrically disposed on the crank shaft 125, a crank arm 127 that is loosely connected to the crank pin 126 and a driving element in the form of a piston 129 that is mounted to the crank arm 127 via a connecting shaft 128. The motor shaft 111a and the crank shaft 125 are disposed side by side in parallel to each other. The crank shaft 125, the crank pin 126, the crank arm 127 and the piston 129 which are described above, form the crank mechanism.

[0028] The piston 129 is slidably disposed within a bore of an air compression cylinder 131 and the piston 129 and the air compression cylinder 131 form the compression device 114. The air compression cylinder 131 is a feature that corresponds to the "compressed-air feeding cylinder" according to the invention. The air compression cylinder 131 has a compression chamber 131a partitioned by the gear housing 107 and the piston 129. The piston 129 generates compressed air by reducing (decreasing) a volume of the compression chamber 131a and supplies the compressed air to an air chamber 141a of the impact cylinder 141 through an air passage 133 formed in the gear housing 107. The air compression cylinder 131 extends in a same direction as the longitudinal direction of the body 103 and in a direction transverse to both the axial direction of the hammer bit 119 and the extending direction of the handgrip 109. Specifically, the axial direction of the hammer bit 119, the extending direction of the air compression cylinder 131 and the extending direction of the handgrip 109 intersect one another.

[0029] The striking mechanism 115 mainly includes a striking element in the form of a striker 143 that is slidably disposed within a bore of the impact cylinder 141, and an intermediate element in the form of an impact bolt 145 that is slidably disposed within the tool holder 137 and serves to transmit kinetic energy of the striker 143 to the hammer bit 119. The impact cylinder 141 has the air chamber 141a extending in the axial direction of the hammer bit 119 and partitioned by the striker 143 and an inner

wall surface 107b of the gear housing 107 which faces the striker 143. When compressed air is generated by movement of the piston 129 in a direction (to the left as viewed in FIGS. 1 and 2) that reduces the volume of the compression chamber 131a and supplied to the air chamber 141a of the impact cylinder 141, the striker 143 is moved forward by this compressed air and then collides with (strikes) the impact bolt 145 and transmits an impact force to the hammer bit 119 via the impact bolt 145.

[0030] When the piston 129 is moved in a direction that increases the volume of the compression chamber 131a, a negative pressure is formed in the air chamber 141a of the impact cylinder 141. Therefore, the striker 143 is sucked by this negative pressure, moved toward the inner wall surface 107b and returned to its retracted position. In order to avoid the striker 143 from colliding with the inner wall surface 107b facing the striker 143 during this return and to secure a predetermined space between the striker 143 and the inner wall surface 107b, a cushioning spring 144 is mounted on the inner wall surface 107b.

[0031] In this embodiment, one end of the air passage 133 is open at the bottom of the compression chamber 131a of the air compression cylinder 131 and the other end is open at a head (a part facing the striker 143) of the air chamber 141a of the impact cylinder 141. With such a construction, compressed air is fed in the longitudinal direction of the impact cylinder 141 through the air passage 133. Further, in this embodiment, the impact cylinder 141 is integrally formed by an extension of the tool holder 137 extending in its longitudinal direction. It may however be constructed such that the tool holder 137 and the impact cylinder 141 are separately formed and connected to each other.

[0032] The impact cylinder 141 and thus the tool holder 137 are caused to rotate via the power transmitting mechanism 117 by the driving motor 111. As shown in FIG. 2, the power transmitting mechanism 117 mainly includes a first intermediate gear 151 that engages with the driving gear 121 driven by the driving motor 111, a second intermediate gear 153 that engages with the first intermediate gear 151, a small bevel gear 155 that rotates together with the second intermediate gear 153 and a large bevel gear 157 that engages with the small bevel gear 155. A first intermediate shaft 152 having the first intermediate gear 151 fitted thereon and a second intermediate shaft 154 having the second intermediate gear 153 and the small bevel gear 155 fitted thereon are disposed in parallel to the motor shaft 111a of the driving motor 111 and rotatably supported on the gear housing 107. The large bevel gear 157 having a rotation axis perpendicular to that of the small bevel gear 155 is rotatably fitted on the impact cylinder 141 and connected to the impact cylinder 141 via a torque limiter 159 (see FIG. 1).

[0033] The torque limiter 159 has clutch teeth 159a which engage with clutch teeth 157a of the large bevel gear 157, and is normally biased in a direction of engagement between the clutch teeth 157a, 159a by a biasing

spring (compression coil spring) 161. When resistance torque on the hammer bit 119 reaches a set value, the torque limiter 159 moves in a direction away from the large bevel gear 157 against the biasing force of the biasing spring 161. Thus, the clutch teeth 157a, 159a are disengaged from each other, which results in interrupting transmission of rotation from the large bevel gear 157 to the impact cylinder 141. Further, as shown in FIG. 3, the motor shaft 111a, the crank shaft 125 and the first and second intermediate shafts 152, 154 are disposed on the same straight line P extending in the longitudinal direction of the body 103.

[0034] The hammer drill according to this embodiment is constructed as described above. Therefore, when the driving motor 111 is driven by depressing the trigger 147, the motion converting mechanism 113 is driven. Then, the piston 129 is rectilinearly slid within the air compression cylinder 131 and thus compresses the air in the compression chamber 131a and supplies the compressed air to the air chamber 141a of the impact cylinder 141 via the air passage 133. As a result, the striker 143 moves forward within the impact cylinder 141 and collides with the impact bolt 145, so that the kinetic energy of the striker 143 which is caused by the collision is transmitted to the hammer bit 119.

[0035] Further, the rotating output of the driving motor 111 is transmitted to the impact cylinder 141 via the power transmitting mechanism 117. Therefore, the impact cylinder 141, the tool holder 137 and the hammer bit 119 held by the tool holder 137 are caused to rotate together. In this manner, the hammer bit 119 performs a drilling operation on a workpiece by linear motion in the axial direction and rotation in the circumferential direction.

[0036] In this embodiment, in the hammer drill 101 constructed such that the striker 143 is driven by the compressed air in the air chamber 141a of the impact cylinder 141, the air compression cylinder 131 is provided separately from the impact cylinder 141 and the striker 143 is driven by supplying the compressed air generated in the compression chamber 131a of the air compression cylinder 131 to the air chamber 141a of the impact cylinder 141. Further, the air compression cylinder 131 is disposed such that it extends in a direction transverse to the extending direction of the impact cylinder 141. By provision of this construction, the length of the body 103 in the striking direction or the axial direction of the hammer bit 119 is defined by the extending lengths of the tool holder 137 for holding the hammer bit 119 and the impact cylinder 141. The impact cylinder 141 houses the striker 143 for applying the impact force to the hammer bit 119 and has the air chamber 141a for applying the compressed air to the striker 143.

[0037] According to this embodiment, compared with a known hammer drill having the construction in which the striker 143 is driven via pressure fluctuations of the air chamber 131a caused by linear movement of the piston 129 in the impact cylinder 141, the length of the body 103 in the striking direction of the hammer bit 119 can

be shortened. Therefore, in performing a drilling operation, for example, on an inner wall surface of a U-shaped drainage ditch (made of concrete), the tool body 103 can be inserted into the U-shaped ditch with the axis of the hammer bit 119 extending in the width direction of the ditch.

[0038] In the hammer drill 101 according to this embodiment, the impact force of the striker 143 is linearly transmitted to the hammer bit 119. With this construction, compared with a construction in which the impact force of the striker is transmitted to the hammer bit via an angular attachment attached to the front end of the hammer drill, the impact force of the striker 143 can be transmitted to the hammer bit 119 without loss.

[0039] During drilling operation, the user operates the hammer drill 101 while holding the main handle in the form of the handgrip 109 and the auxiliary handle in the form of the side grip 110. In this embodiment, the impact cylinder 141 is designed to extend in the width direction of the handgrip 109 or in a direction transverse to the extending direction of the grip 109a. With this construction, when holding the grip 109a of the handgrip 109 with the user's hand, the user's arm (forearm) extends in a direction transverse to the extending direction of the impact cylinder 141. Therefore, when performing an operation, for example, on an inner wall surface of a U-shaped ditch, the arm of the user holding the handgrip 109 does not get in the way of the operation.

[0040] In this embodiment, a rear end region of the outer housing 105 in the striking direction is designed as an auxiliary grip 163 (see FIG. 1) which can be pressed with a user's whole palm in case that the side grip 110 is found to be hard to use, or that the side grip 110 is not provided. By provision of this construction, when performing a drilling operation, the user can hold the handgrip 109 with one hand and press the auxiliary handle 163 in the striking direction with the other hand.

[0041] The size (outer diameter) of the driving motor 111 determines the external dimensions of the motor housing 105a of the outer housing 105 which covers the driving motor 111. In this embodiment, as shown in FIG. 3, the driving gear 121, the driven gear 123 of the motion converting mechanism 113 and the first intermediate gear 151 of the power transmitting mechanism 117 are disposed in series on a straight line P which extends in a radial direction through a center of the second intermediate gear 153 (the small bevel gear 155) and in parallel to a rear surface 105b of the outer housing 105 in the striking direction (to the longitudinal direction of the piston 129). By provision of such gear arrangement, if the size (outer diameter) of the driving motor 111 is relatively small, the motor housing 105a of the outer housing 105 can be prevented from bulging rearward of the rear surface 105b of the outer housing 105 in the striking direction. As a result, such gear arrangement doesn't interfere with shortening the length of the body 103 in the striking direction.

[0042] On the other hand, if the size (outer diameter)

of the driving motor 111 is relatively large, the motor housing 105a of the outer housing 105 may bulge rearward of the rear surface 105b of the outer housing 105 in the striking direction, so that such gear arrangement interferes with shortening the length of the body 103 in the striking direction. Therefore, a modification as shown in FIG. 4 is provided in order to avoid bulging of the motor housing 105a when the size (outer diameter) of the driving motor 111 is relatively large.

[0043] In this modification, the driving gear 121, the driven gear 123 of the motion converting mechanism 113 and the first intermediate gear 151 of the power transmitting mechanism 117 are disposed on a straight line P1 which is displaced a predetermined distance E in the striking direction from the straight line P extending in a radial direction through the center of the second intermediate gear 153 (the small bevel gear 155) and in parallel to the rear surface 105b of the outer housing 105 in the striking direction. With this construction, the motor housing 105a can be prevented from bulging rearward of the rear surface 105b of the outer housing 105 in the striking direction.

[0044] A modification to a feeding passage of compressed air in this embodiment is now described with reference to FIGS. 5 and 6. In the above-described embodiment, compressed air is supplied into the air chamber 141a through the head of the impact cylinder 141. In this modification, however, the air passage 133 for supplying compressed air is formed through a sidewall of the impact cylinder 141 such that the compressed air is supplied into the air chamber 141 a in the radial direction from the side or from a direction transverse to the longitudinal direction of the impact cylinder 141. With this construction, compared with the construction in which compressed air is supplied through the head of the impact cylinder 141, the length of the air passage 133 required can be shorter, and thus the length of the tool body 103 in the striking direction can be further shortened that much.

[0045] Further, in this modification, the air passage 133 is directly connected to the impact cylinder 141, so that the impact cylinder 141 cannot be rotated. Therefore, the impact cylinder 141 is formed separately from the tool holder 137 and fixed to the gear housing 107. Further, the tool holder 137 has an extension 137a which is fitted on the impact cylinder 141 and can rotate with respect to the impact cylinder 141, and the large bevel gear 157 is fitted on the extension 137a and can rotate together with the extension 137a. By provision of this construction, even though the impact cylinder 141 is fixed to the gear housing 107, the rotating output of the driving motor 111 can be transmitted to the tool holder 137 for holding the hammer bit 119.

[0046] A further modification to the feeding passage of compressed air in this embodiment is now described with reference to FIGS. 7 and 8. In this modification, a ring-like member 165 and a connecting pipe 167 form the air passage 133. The ring-like member 165 is fitted on the

impact cylinder 141 such that it can rotate with respect to the impact cylinder 141, and has an annular groove 165a formed in its inner circumferential surface and extending in its circumferential direction. The connecting pipe 167 serves to provide communication between the compression chamber 131a of the air compression chamber 131 and the annular groove 165a of the ring-like member 165. Further, the annular groove 165a communicates with the air chamber 141a via a plurality of vent holes 169 which are formed in the wall of the impact cylinder 141 and arranged in the circumferential direction. Therefore, according to this modification, in the construction in which the impact cylinder 141 rotates together (is integrally formed) with the tool holder 137, the compressed air of the air compression chamber 131 can be supplied to the air chamber 141a from the side or from a direction transverse to the longitudinal direction of the impact cylinder 141. Therefore, like the modification as viewed in FIG. 4, the length of the tool body 103 in the striking direction can be further shortened.

[0047] A further modification to the feeding passage of compressed air in this embodiment is now described with reference to FIG. 9. In this modification, the air compression cylinder 131 is obliquely disposed such that its longitudinal axis is inclined at a predetermined angle with respect to the longitudinal direction of the body 103. Further, a front end of a tubular part 171 protrudes from the bottom of the compression chamber 131a and is connected to the gear housing 107. Further, the head of the impact cylinder 141 is opposed to the inner wall surface of the gear housing 107 with a predetermined clearance such that the clearance forms an inner passage 173 to the air chamber 141a. The inner passage 173 communicates with the compression chamber 131a of the air compression cylinder 131 via the tubular part 171 connected to the gear housing 107.

[0048] According to this modification, like the modification as viewed in FIGS. 7 and 8, in the construction in which the impact cylinder 141 rotates together (is integrally formed) with the tool holder 137, the compressed air of the air compression chamber 131 can be supplied to the air chamber 141a from the side or from a direction transverse to the longitudinal direction of the impact cylinder 141. Therefore, the length of the tool body 103 in the striking direction can be further shortened.

(Second Embodiment of the Invention)

[0049] A second embodiment of the invention is now described with reference to FIGS. 10 to 13. Further, the description of the second embodiment is focused on the points of difference in order to avoid overlapping descriptions with the first embodiment, and components in this embodiment which are substantially identical to those in the first embodiment are given like numerals as in the first embodiment. As shown in the drawings, in this embodiment, the piston 129 which is one of components forming the motion converting mechanism 113 and per-

forms linear movement is slidably disposed within the bore of the impact cylinder 141. Therefore, the striker 143 is driven via pressure fluctuations of the air chamber 141a which are caused by sliding movement of the piston 129, collides with (strikes) the impact bolt 145 which is slidably fitted in the tool holder 137 and transmits the impact force to the hammer bit 119 via the impact bolt 145. Thus, the air compression cylinder in the first embodiment is not provided. The impact cylinder 141 is separately formed from the tool holder 137. The impact cylinder 141 is fitted in the tool holder 137 such that it can coaxially rotate with respect to the tool holder 137, and fixed to the gear housing 107.

[0050] The driving motor 111 is disposed such that the motor shaft 101a extends in the same direction as the longitudinal direction of the body 103 or in a direction transverse to the axial direction of the hammer bit 119 (the extending directions of the tool holder 137 and the impact cylinder 141). In this embodiment, the motion converting mechanism 113 for converting the rotating output of the driving motor 111 into linear motion is disposed in parallel to the impact cylinder 141 in a predetermined region along the longitudinal direction of the impact cylinder 141. In other words, the motion converting mechanism 113 and the impact cylinder 141 are disposed to overlap each other when viewed from a direction (the longitudinal direction of the body 103) transverse to the axial direction of the hammer bit 119. Further, the rotation axis of the crank shaft 125 intersects with the extending direction of the impact cylinder 141. The crank shaft 125 is a feature that corresponds to the "rotation axis" in claim 5 of the invention.

[0051] The motion converting mechanism 113 has a crank arm 181 formed by a generally U-shaped member. An escape groove 183 is formed in a peripheral wall (side wall) of the impact cylinder 141 in order to install the crank arm 181. A bottom region 181a of the U-shaped crank arm 181 (shown by a two-dot chain line in FIG. 12) has a circular section. The crank arm 181 is installed with the bottom region 181a through the escape groove 183, and in this state, one end of the crank arm 181 is connected to a connecting shaft 128 of the piston 129 and the other end is connected to the crank pin 126. The escape groove 183 has such a width and an axial length that the crank arm 181 is allowed to move in the longitudinal direction of the impact cylinder 141 while swinging on the connecting shaft 128.

[0052] As described above, in this embodiment, the crank arm 181 is U-shaped and allowed to move in the escape groove 183 formed in the peripheral wall of the impact cylinder 141. By provision of this construction, the motion converting mechanism 113 can be disposed in parallel to the impact cylinder 141 in a region along the extending direction (the longitudinal direction) of the impact cylinder 141. As a result, the length of the tool body 103 in the striking direction or the axial direction of the hammer bit 119 is defined by the extending lengths of the tool holder 137 for holding the hammer bit 119 and

the impact cylinder 141 for housing the piston 129 and the striker 143. Therefore, the length of the tool body 103 in the striking direction can be shortened, compared with a known hammer drill in which the motion converting mechanism 113 is disposed in a rear position outside a region along the longitudinal direction of the impact cylinder 141.

[0053] When performing a drilling operation with the hammer drill 101 constructed as described above, for example, on an inner wall surface of a U-shaped ditch, like the first embodiment, the tool body 103 can be inserted into the U-shaped ditch with the axis of the hammer bit 119 extending in the width direction of the ditch. In this case, the impact force of the striker 143 is linearly transmitted to the hammer bit 119. With this construction, compared with the construction in which the impact force of the striker is transmitted to the hammer bit via an angular attachment attached to the front end of the hammer drill, the impact force of the striker 143 can be transmitted to the hammer bit 119 without loss.

[0054] The handgrip 109 is configured as a D-shaped handle having the grip 109a designed to be held by a user. The grip 109a extends in a direction transverse to the longitudinal direction of the body 103 and in parallel to the extending direction of the impact cylinder 141, and has upper and lower ends connected to the outer housing 105. With this construction, the handgrip 109 can be configured to extend within the length of the hammer drill 101 in the striking direction.

[0055] The trigger 147 for starting and stopping the driving motor 111 and the normal/reverse selector switch 149 are disposed on the handgrip 109. In this embodiment, the trigger 147 and the normal/reverse selector switch 149 are disposed in a front region (a lower region as viewed in FIG. 10) of the handgrip 109 in the striking direction (along the extending direction of the handgrip 109). Specifically, in this embodiment, the handgrip 109 is designed and configured to be held such that the user's thumb and index finger are set on the front region of the handgrip 109 in the striking direction.

[0056] Further, a rear end region of the outer housing 105 in the striking direction is designed as an auxiliary grip 163 which can be pressed with a user's whole palm. By provision of this construction, when performing a drilling operation, the user can hold the handgrip 109 with one hand and press the auxiliary handle 163 in the striking direction with the other hand.

[0057] In this embodiment, as for the power transmitting mechanism 117 for transmitting the rotating output of the driving motor 111 to the hammer bit 119, rotation of an intermediate gear 185 which engages with the driving gear 121 driven by the driving motor 111 is transmitted to an intermediate shaft 186 via a torque limiter 187, and this rotation of the intermediate shaft 186 is transmitted from a small bevel gear 188 to the tool holder 137 via a large bevel gear 189 which engages with the small bevel gear 188. The small bevel gear 188 is integrally formed with an axial end of the intermediate shaft 186. The large

bevel gear 189 is spline-fitted onto the tool holder 137 and rotates together with the tool holder 137. Specifically, the power transmitting mechanism 117 according to this embodiment has a single intermediate shaft, so that it is made simpler in structure compared with the power transmitting mechanism 117 of the first embodiment which has two intermediate shafts.

[0058] A modification to the second embodiment is now described with reference to FIGS. 14 and 15. In this modification, a crank arm 191 is formed by a linear rod-like member or a plate-like member. Further, the connecting shaft 128 of the piston 129 has an extension 128a which extends outward of the impact cylinder 141 through the escape groove 183, and the extension 128a is connected to a crank arm 191. Therefore, according to this modification, like in the second embodiment, the length of the tool body 103 in the striking direction can be shortened compared with the known hammer drill.

[0059] In this modification, the trigger 147 for starting and stopping the driving motor 111 and the normal/reverse selector switch 149 are disposed in a rear region (an upper region as viewed in FIG. 14) of the handgrip 109 in the striking direction (along the extending direction of the handgrip 109). Specifically, in this embodiment, the handgrip 109 is designed and configured to be held such that the user's thumb and index finger are set on the rear region of the handgrip 109 in the striking direction.

[0060] In the above-described embodiment, the hammer drill 101 is described as a representative example of an impact tool, but the invention can be applied to a hammer in which the hammer bit 119 is caused to perform only linear movement in the axial direction.

[0061] In view of the aspect of the above-described invention, the following features can be provided.

(1) "An impact tool which performs a predetermined operation on a workpiece by at least linear movement of a tool bit in an axial direction of the tool bit, comprising:

a tool holder that holds the tool bit so as to allow relative movement in the axial direction, a striking element that moves linearly in the axial direction of the tool bit and applies an impact force to the tool bit, an impact cylinder that is connected to the tool holder, houses the striking element so as to allow relative movement and has an air chamber which causes compressed air to act upon the striking element, and a tool body that houses the tool holder and the impact cylinder, wherein:

both the tool holder and the impact cylinder extend in the axial direction of the tool bit and the length of the impact tool in the axial direction of the tool bit is defined by the tool holder and the impact cylinder."

(2)

"The impact tool as defined in (1), further comprising a compressed-air feeding cylinder for supplying compressed air to the air chamber of the impact cylinder, wherein the compressed-air feeding cylinder extends in a different direction from an extending direction of the impact cylinder."

(3)

"The impact tool as defined in (1) or (2), comprising a handgrip that is connected to the tool body and designed to be held by a user in order to operate the impact tool, wherein a width direction of the handgrip coincides with the extending direction of the impact cylinder."

(4)

"The impact tool as defined in (3), wherein the axial direction of the tool bit, the extending direction of the compressed-air feeding cylinder and the extending direction of the handgrip intersect one another."

(5)

"The impact tool as defined in (1), further comprising a motion converting mechanism that converts rotation into linear motion and thereby generates compressed air in the air chamber of the impact cylinder, wherein a rotating shaft of the motion converting mechanism is disposed in parallel to the impact cylinder in a predetermined region along the extending direction of the impact cylinder."

(6)

"The impact tool as defined in (5), wherein the rotating shaft intersects with the extending direction of the impact cylinder."

(7)

"The impact tool as defined in (5) or (6), comprising a handgrip that is connected to the tool body and designed to be held by a user in order to operate the impact tool, wherein the extending directions of the impact cylinder and the handgrip are parallel to each other."

(8)

"The impact tool as defined in (2), comprising an air passage that supplies compressed air generated in the compressed-air feeding cylinder to the air chamber of the impact cylinder, wherein the air passage is provided and configured to supply the compressed air in a longitudinal direction of the air chamber through a head of the impact cylinder."

(9)

"The impact tool as defined in (2), comprising an air passage that supplies compressed air generated in the compressed-air feeding cylinder to the air chamber of the impact cylinder, wherein the air passage is provided and configured to supply the compressed air in a radial direction of the air chamber through a sidewall region of the impact cylinder."

(10)

"The impact tool as defined in any one of (1) to (9), comprising a tool body, a motor that is housed in the

tool body, and an intermediate gear that is housed in the tool body and transmits a rotating output of the motor to the tool bit, wherein:

the motor and the intermediate gear are disposed such that their rotation axes extend in parallel to each other and intersect with an axis of the tool bit,

a rear surface of the tool body in a striking direction of the striking element extends generally transverse to the striking direction, and a rotation axis of the motor is displaced forward in the striking direction of the striking element with respect to a straight line extending through the center of the intermediate gear and in parallel to the rear surface in the striking direction."

(11)

"The impact tool as defined in (7), comprising a motor that drives the tool bit, and an operation member that is formed on the handgrip and operated to start and stop the motor, wherein the operation member is disposed on a rear part of an extending region of the handgrip in the striking direction of the striking element."

(12)

"The impact tool as defined in (7), comprising a motor that drives the tool bit, and an operation member that is formed on the handgrip and operated to start and stop the motor, wherein the operation member is disposed on a front part of the extending region of the handgrip in the striking direction of the striking element."

Description of Numerals

[0062]

101 hammer drill (impact tool)

103 body

105 outer housing

105a motor housing

105b rear surface in the striking direction

107 gear housing

107a barrel

107b inner wall surface

109 handgrip

109a grip

110 side grip

111 driving motor

111a motor shaft

113 motion converting mechanism

114 compression device

115 striking mechanism

117 power transmitting mechanism

119 hammer bit (tool bit)

121 driving gear

123 driven gear

125 crank shaft
 126 crank pin
 127 crank arm
 128 connecting shaft
 128a extension
 129 piston
 131 air compression cylinder
 131 a compression chamber
 133 air passage
 137 tool holder
 137a extension
 141 impact cylinder
 141a air chamber
 143 striker (striking element)
 144 cushioning spring
 145 impact bolt
 147 trigger
 149 normal/reverse selector switch
 151 first intermediate gear
 152 first intermediate shaft
 153 second intermediate gear
 154 second intermediate shaft
 155 small bevel gear
 157 large bevel gear
 157a clutch teeth
 159 torque limiter
 159a clutch teeth
 161 biasing spring
 163 auxiliary grip
 165 ring-like member
 165a annular groove
 167 connecting pipe
 169 vent hole
 171 tubular part
 173 inner passage
 181 crank arm
 181a U-shaped bottom region
 183 escape groove
 185 intermediate gear
 186 intermediate shaft
 187 torque limiter
 188 small bevel gear
 189 large bevel gear
 191 crank arm

Claims

1. An impact tool which performs a predetermined operation on a workpiece by at least linear movement of a tool bit in an axial direction of the tool bit comprising:

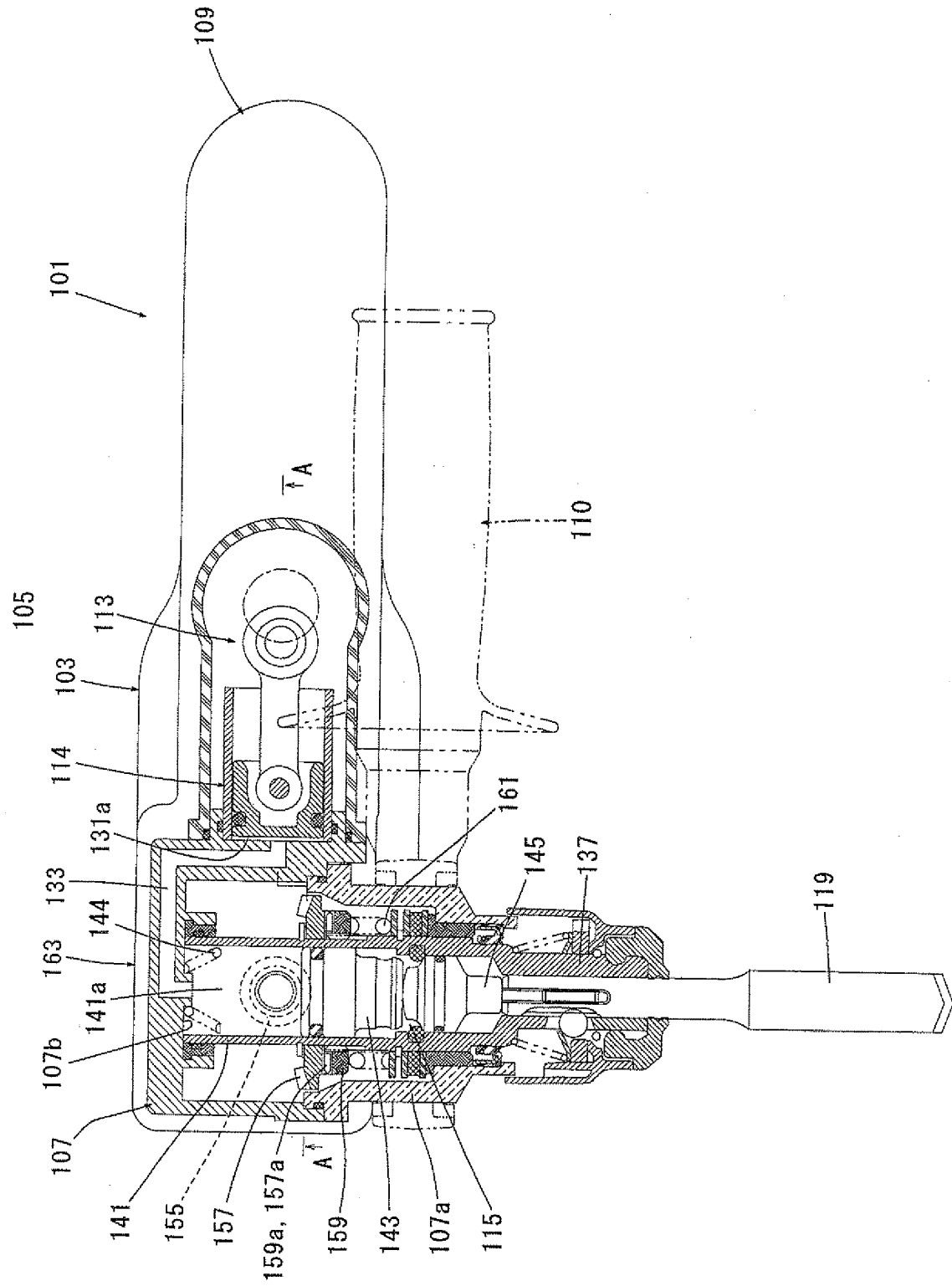
a tool holder that holds the tool bit so as to allow relative movement in the axial direction,
 a striking element that moves linearly in the axial direction of the tool bit and applies an impact force to the tool bit,

an impact cylinder that is connected to the tool holder, the impact cylinder housing the striking element to allow relative movement, wherein the impact cylinder has an air chamber that causes compressed air to act upon the striking element, and
 a tool body that houses the tool holder and the impact cylinder,
characterized in that
 both the tool holder and the impact cylinder extend in the axial direction of the tool bit, and the length of the tool body in the axial direction of the tool bit is defined by the tool holder and the impact cylinder.

2. The impact tool as defined in claim 1, further comprising a compressed-air feeding cylinder for supplying compressed air to the air chamber of the impact cylinder, wherein the compressed-air feeding cylinder extends in a different direction from an extending direction of the impact cylinder.
3. The impact tool as defined in claim 2, comprising a handgrip that is connected to the tool body and designed to be held by a user in order to operate the impact tool, wherein a width direction of the handgrip coincides with the extending direction of the impact cylinder.
4. The impact tool as defined in claim 3, wherein the axial direction of the tool bit, the extending direction of the compressed-air feeding cylinder and the extending direction of the handgrip intersect one another.
5. The impact tool as defined in claim 1, further comprising a motion converting mechanism that converts rotation into linear motion and thereby generates compressed air in the air chamber of the impact cylinder, wherein a rotating shaft of the motion converting mechanism is disposed in parallel to the impact cylinder in a predetermined region along the extending direction of the impact cylinder.
6. The impact tool as defined in claim 5, wherein the rotating shaft intersects with the extending direction of the impact cylinder.

7. The impact tool as defined in claim 5 or 6, comprising a handgrip that is connected to the tool body and designed to be held by a user in order to operate the impact tool, wherein the extending directions of the impact cylinder and the handgrip are parallel to each other.

FIG. 1



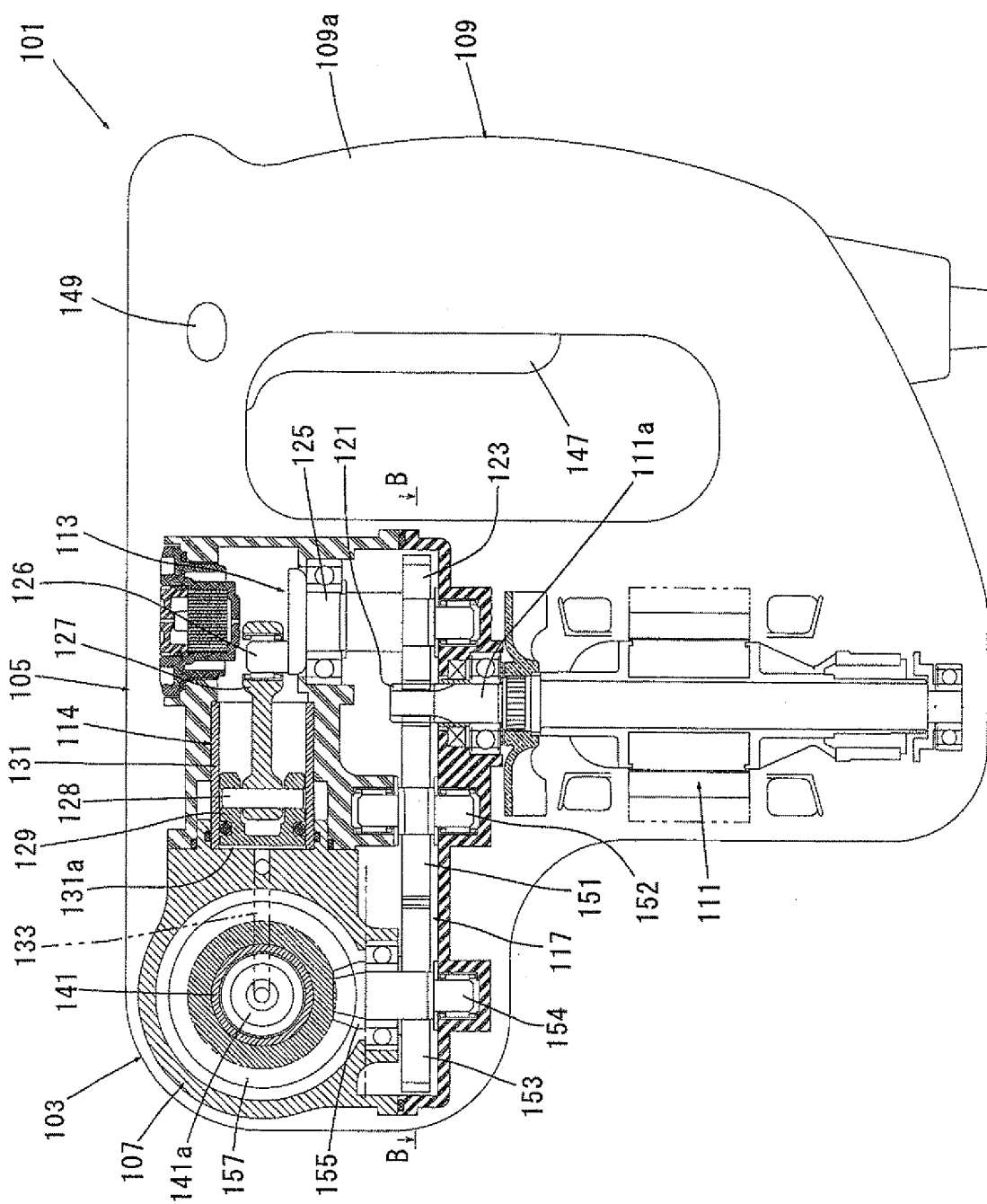


FIG. 2

FIG. 3

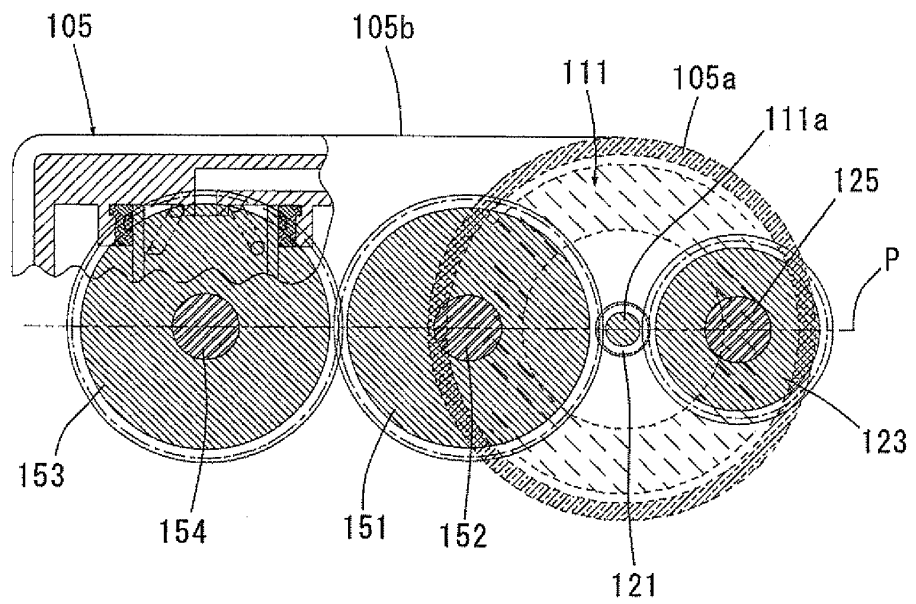


FIG. 4

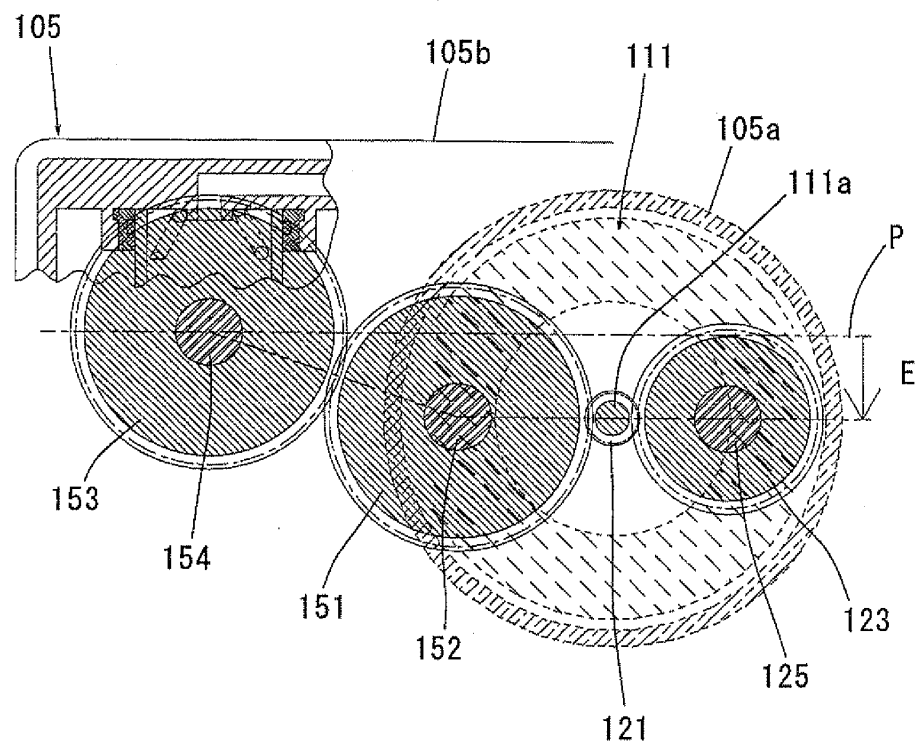


FIG. 5

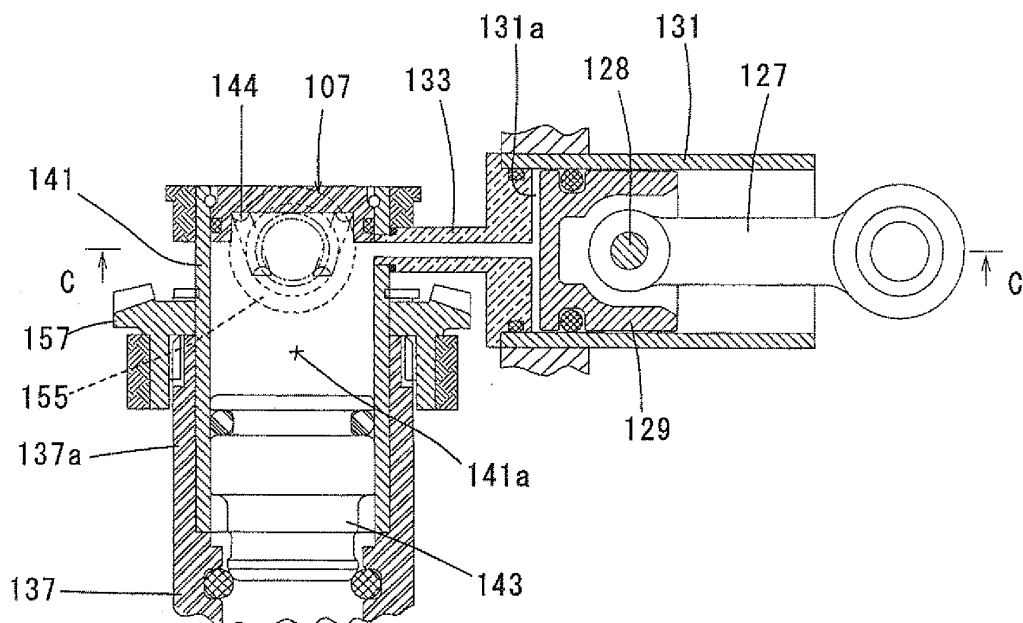


FIG. 6

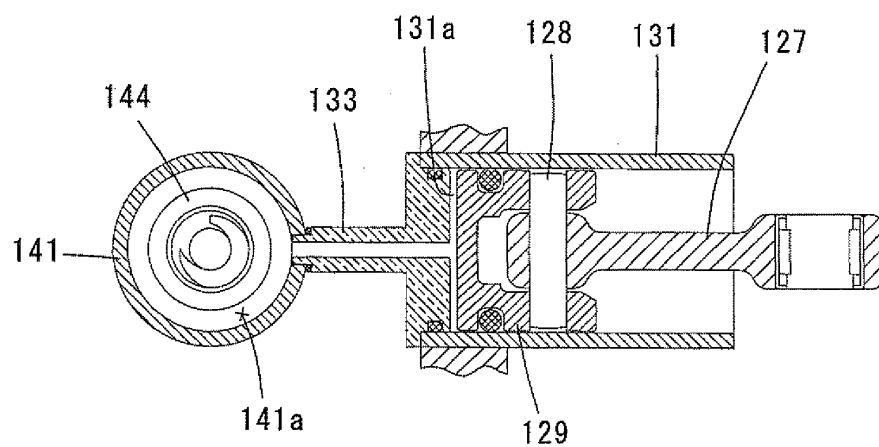


FIG. 7

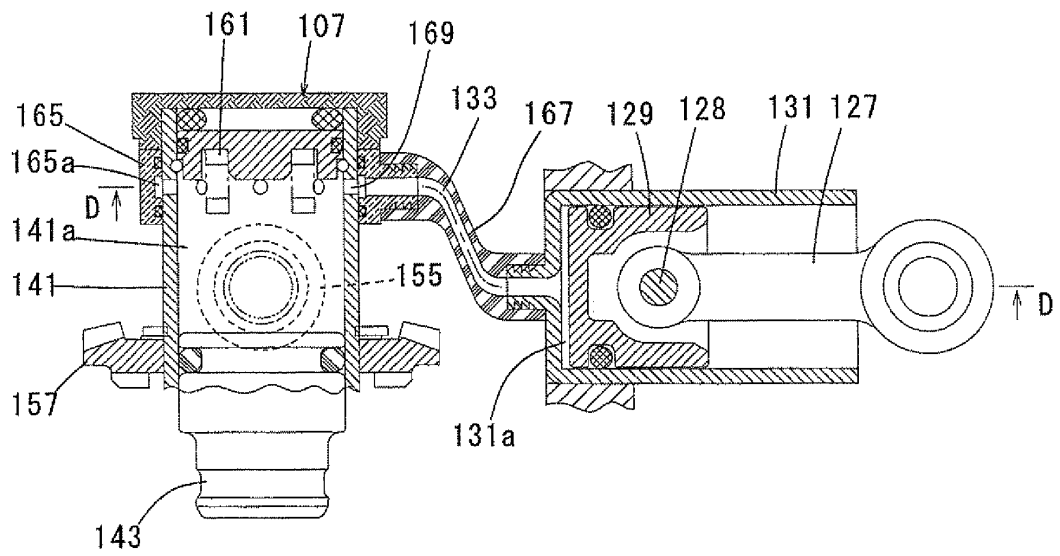


FIG. 8

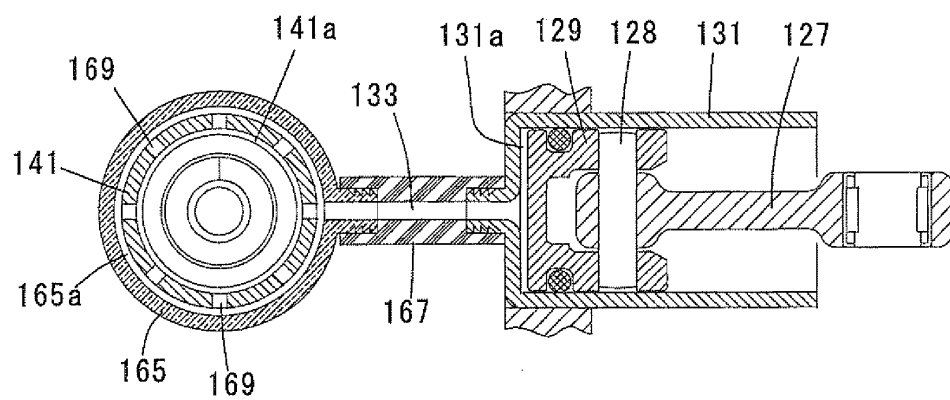
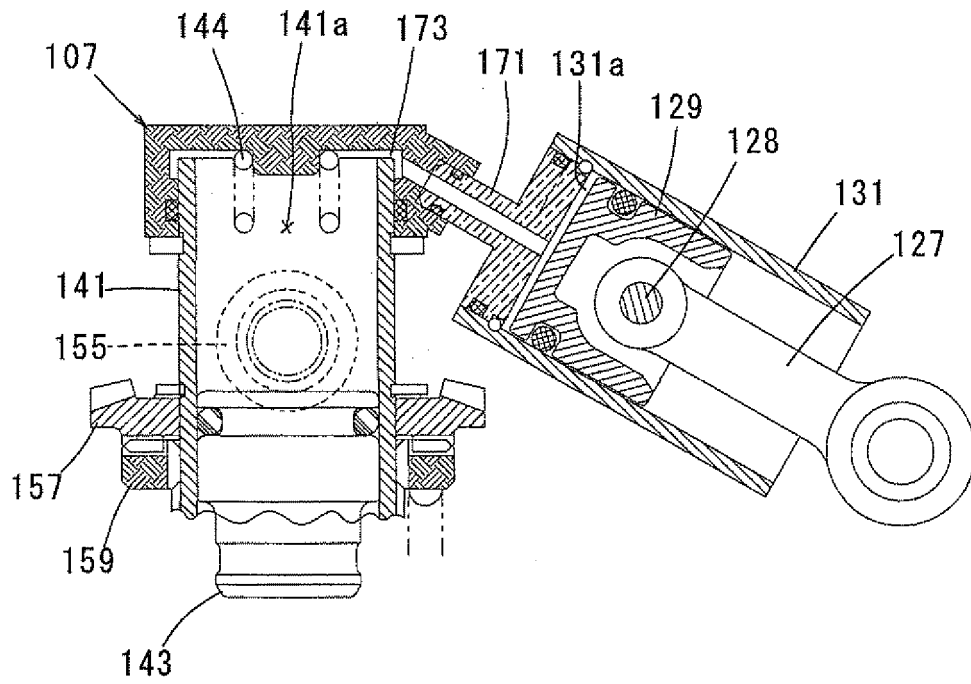


FIG. 9



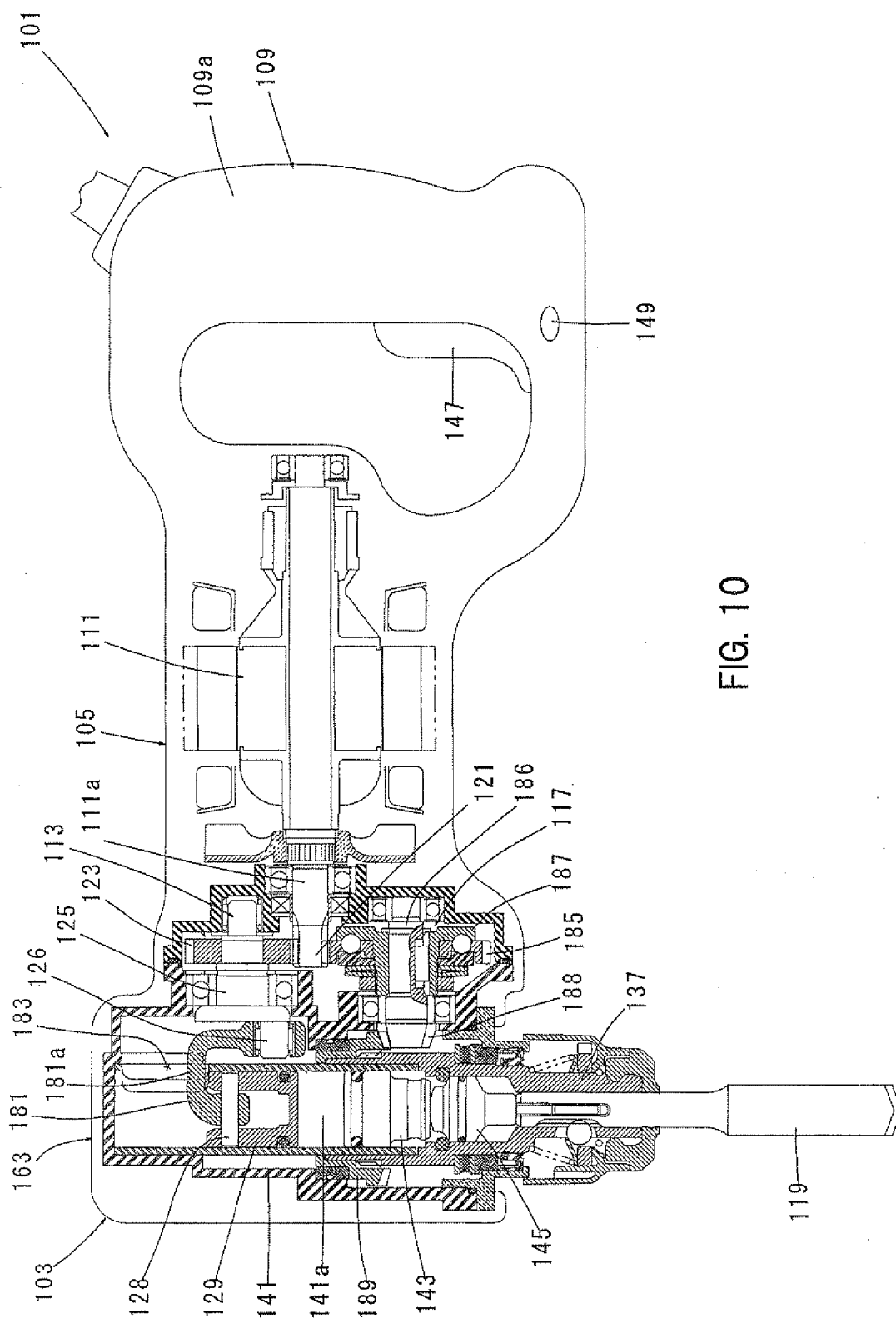


FIG. 10

FIG. 11

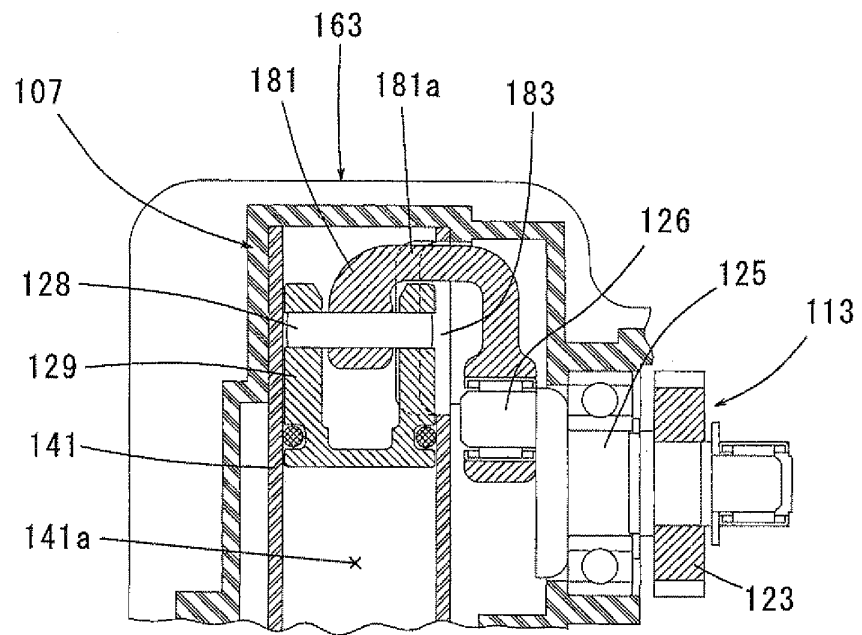


FIG. 12

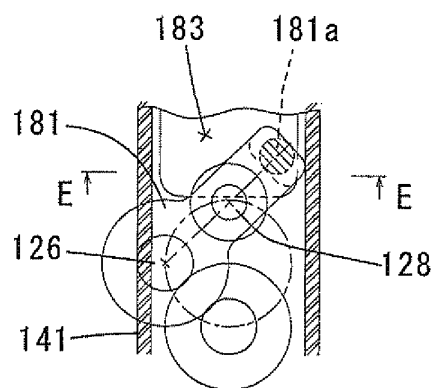
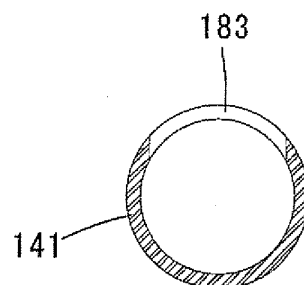


FIG. 13



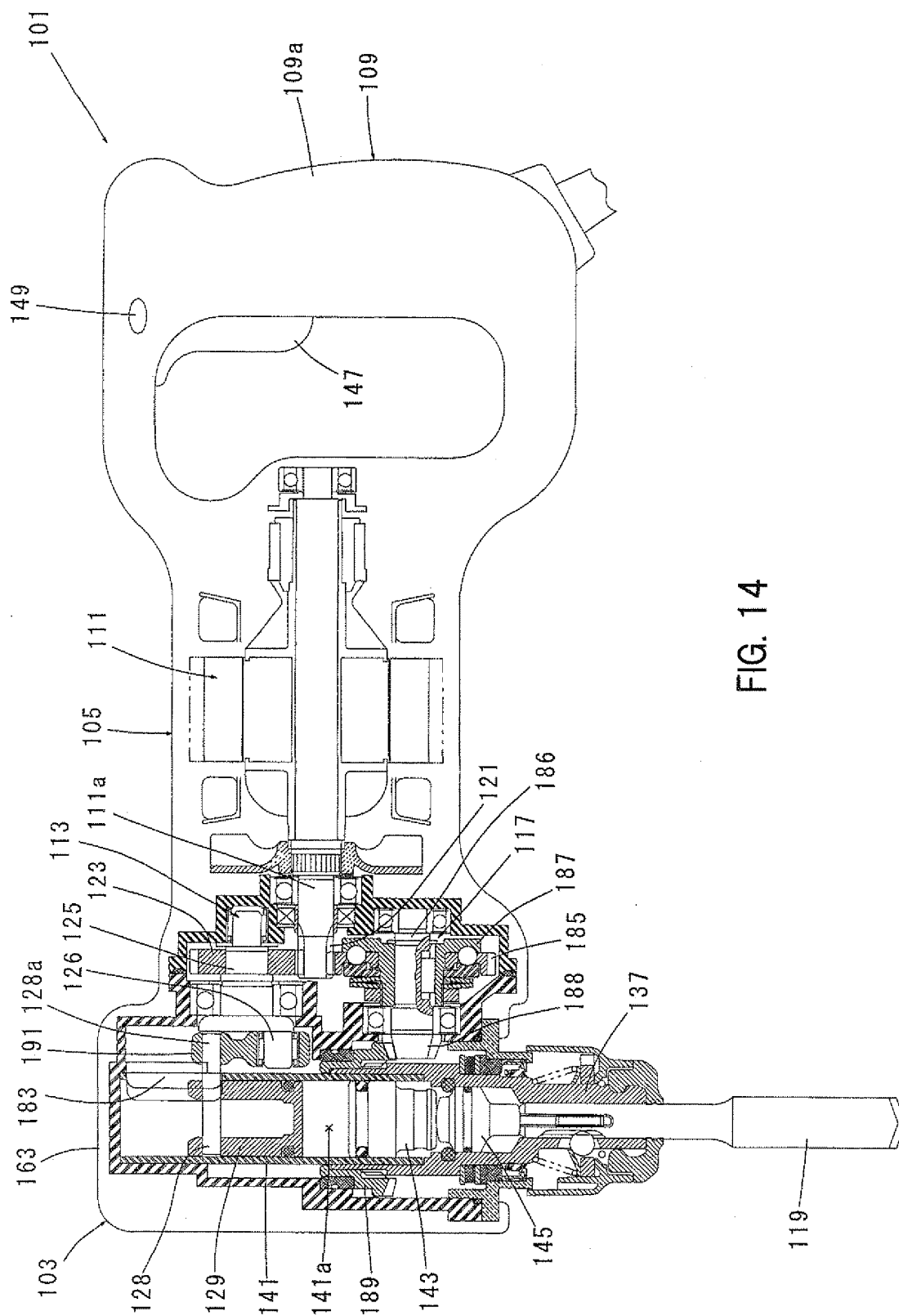
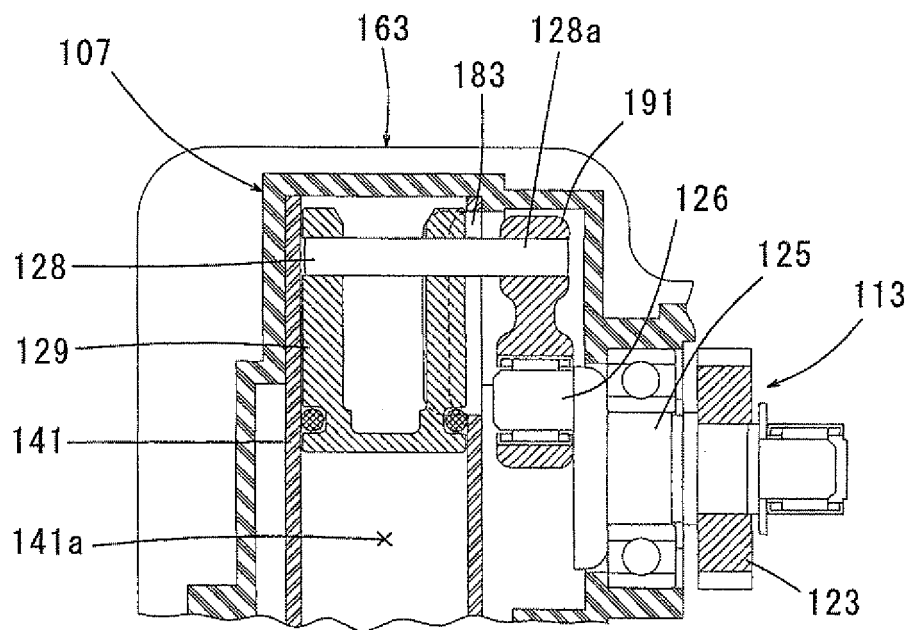


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/060635

A. CLASSIFICATION OF SUBJECT MATTER <i>B25D11/04 (2006.01) i, B25D17/00 (2006.01) i, B25D17/04 (2006.01) i</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) B25D1/00-17/32		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2012 Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2011-684 A (Makita Corp.), 06 January 2011 (06.01.2011), paragraphs [0019] to [0022]; fig. 1 & WO 2010/147153 A1	1 2-7
A	JP 61-103785 A (Robert Bosch GmbH), 22 May 1986 (22.05.1986), & US 4751970 A & GB 2166075 A & DE 3439475 A1 & CH 667838 A5	1-7
A	JP 2001-9746 A (Makita Corp.), 16 January 2001 (16.01.2001), (Family: none)	1-7
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 28 May, 2012 (28.05.12)		Date of mailing of the international search report 12 June, 2012 (12.06.12)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/060635

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 79829/1990 (Laid-open No. 38377/1992) (Hitachi Koki Co., Ltd.), 31 March 1992 (31.03.1992), (Family: none)	1-7
P, A	US 2011/0108298 A1 (CHERVON LTD.), 12 May 2011 (12.05.2011), & GB 2475160 A & DE 202010008946 U & CN 201565934 U & CA 2719984 A1	1-7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 21839/1980 (Laid-open No. 126381/1981) (Nissan Motor Co., Ltd.), 25 September 1981 (25.09.1981), (Family: none)	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4751970 A [0002] [0004]