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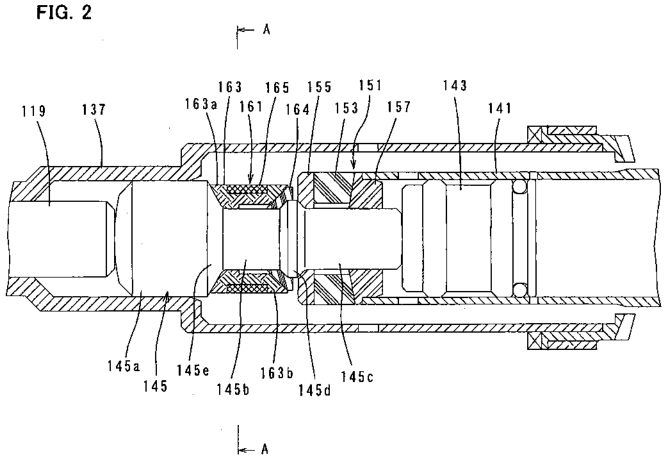
(54) **IMPACT TOOL**

(57) An impact tool is provided which is improved in its structure for absorbing an impact force caused by rebound of a tool bit after its striking movement. The impact tool of this invention includes a tool body (103), a hammer actuating member (119, 145), a striking element (143), a weight part (163) to which a reaction force is transmitted from the hammer actuating member in a reaction force transmitting position when the hammer actuating member performs a hammering operation on the workpiece and which moves from the reaction force transmitting position in a direction different from the axial direction of the hammer actuating member by the transmitted reaction force, and an elastically deformable elastic element (165). The weight part (163) changes in its state between a first state in which the reaction force is not yet transmitted to the weight part and a second state in which the weight part is caused to move by the transmission of the reaction force in the direction different from the axial direction of the hammer actuating member. Further, the elastic element (165) exerts a biasing force such that the weight part (163) is placed in the first state, and when the weight part (163) changes from the first state to the second state by the reaction force, the elastic element (165) elastically deforms by being pushed by the weight part (163) and thereby absorbs the reaction force transmitted to the weight part (163).

FIG. 2



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Description

FIELD OF THE INVENTION

[0001] The invention relates to an impact tool for performing a linear hammering operation on a workpiece, and more particularly to a technique for cushioning a reaction force received from the workpiece during hammering operation.

BACKGROUND OF THE INVENTION

[0002] Japanese non-examined laid-open Patent Publication No. 2007-50495 discloses a technique for cushioning an impact force (reaction force) caused by rebound of a tool bit after its striking movement in an impact tool. This impact tool has an impact absorbing mechanism which includes a weight that is placed in contact with the impact bolt during hammering operation and a coil spring that biases the weight in a direction that holds the weight in contact with the impact bolt. The impact absorbing mechanism is designed such that, when a rearward reaction force acts upon the impact bolt by rebound of the tool bit after striking movement of the tool bit, the weight is caused to move rearward by the reaction force transmitted from the impact bolt and the coil spring elastically deforms rearward by the movement of the weight.

[0003] With this known impact absorbing mechanism, the impact force caused by rebound of the tool bit after its striking movement can be absorbed by the rearward movement of the weight and by the elastic deformation of the coil spring which is caused by the movement of the weight, so that vibration of the impact tool can be reduced. In this known impact absorbing mechanism, however, further improvement of the impact force absorbing structure is required.

SUMMARY OF THE INVENTION

[0004] Accordingly, it is an object of the invention to provide an impact tool which is improved in its structure for absorbing an impact force caused by rebound of a tool bit after its striking movement.

[0005] Above described object can be achieved by the claimed invention. Representative impact tool according to the invention includes a tool body, a hammer actuating member that is disposed in a tip end region of the tool body and performs a predetermined hammering operation on a workpiece by linear movement in its axial direction, and a striking element that linearly moves in the axial direction of the hammer actuating member and thereby strikes the hammer actuating member. The "predetermined hammering operation" in this invention includes not only a hammering operation in which the hammer actuating member performs only a linear striking movement, but a hammer drill operation in which it performs a linear striking movement and a rotation in the circumferential direction. Further, the "hammer actuating member" in this invention typically represents a tool bit and an impact bolt that transmits a striking force in the state of contact with the tool bit.

[0006] The impact tool according to the invention further includes a weight part and an elastically deformable elastic element. When the hammer actuating member performs the hammering operation on the workpiece, a reaction force is transmitted from the hammer actuating member to the weight part in a reaction force transmitting position in which the weight part is placed in direct contact with the hammer actuating member or in which the weight part is placed in contact with the hammer actuating member via a hard metal intervening member. The weight part moves from the reaction force transmitting position in a direction different from the axial direction of the hammer actuating member by the transmitted reaction force. Further, the weight part changes in its state between a first state in which the reaction force is not yet transmitted to the weight part and a second state in which the weight part is caused to move by the transmission of the reaction force in the direction different from the axial direction of the hammer actuating member. The elastic element exerts a biasing force such that the weight part is placed in the first state, and when the weight part changes from the first state to the second state by the reaction force, the elastic element elastically deforms by being pushed by the weight part and thereby absorbs the reaction force transmitted to the weight part. The "different direction" in this invention includes not only a radial direction of the hammer actuating member or an obliquely rearward direction including a radial component, but all directions other than the axial direction of the hammer actuating member. Further, the "elastic element" in this invention typically comprises a spring, but it may comprise a rubber.

[0007] During hammering operation, the hammer actuating member is caused to rebound by receiving the reaction force from the workpiece after its striking movement. According to this invention, with the construction in which the reaction force received by the hammer actuating member from the workpiece is transmitted to the weight part in a reaction force transmitting position in which the weight part is placed in direct contact with the hammer actuating member or in which the weight part is placed in contact with the hammer actuating member via a hard metal intervening member, the reaction force is almost 100% transmitted. In other words, the reaction force is transmitted by exchange of momentum between the hammer actuating member and the weight part. By this transmission of the reaction force, the weight part is caused to move in a direction different from the axial direction of the hammer actuating member. The weight moving in this direction elastically deforms the elastic element, and the reaction force of the weight is absorbed by such elastic deformation. Specifically, according to this invention, the reaction force caused by rebound of the hammer actuating member can be absorbed by the movement of the weight part in a direction different from the axial direction of the hammer actuating member and by the elastic deformation of the elastic element which is caused by the movement of the weight part. As a result, vibration of the impact power tool can be reduced.

According to this invention, with the construction in which the weight part is moved in a direction different from the axial direction of the hammer actuating member or from the striking direction, the impact absorbing mechanism formed by the weight part and the elastic element can be reduced in size in the axial direction of the hammer actuating member.

[0008] According to a further embodiment of the invention, the weight part comprises at least two weights disposed side by side along a circumferential direction on the hammer actuating member, and when the reaction force is transmitted from the hammer actuating member to the weights, the weights are moved by the reaction force in a direction transverse to the axial direction of the hammer actuating member. The "transverse direction" typically represents a radially outward direction of the hammer actuating member, but it is only necessary to include a component of the radially outward direction. Therefore, the "elastic element" in this invention preferably comprises a generally C-shaped plate spring that is disposed on the outside of the at least two weights and biases the weights radially inward at the same time. The elastic element may however be designed to bias the weights individually. Further, in this invention, the movement of the weights in a direction transverse to the axial direction of the hammer actuating member can be effected by direct contact of the weight with the hammer actuating member, or by contact of the weight with the hammer actuating member via an intervening member, via their tapered surfaces.

According to this embodiment, the weights disposed on the outside of the hammer actuating member can be moved by utilizing a space on the outside (the radially outer side) of the hammer actuating member. Therefore, the impact absorbing mechanism can be further reduced in size in the axial direction of the hammer actuating member.

[0009] According to a further embodiment of the invention, the weight part comprises a large number of bead-like weights disposed in circumferential and axial directions of the hammer actuating member. The large number of the weights can be biased by the hammer actuating member such that adjacent ones of the weights are held in contact with each other while some of the weights are held in contact with the hammer actuating member. When the reaction force is transmitted from the hammer actuating member to the some weights, the reaction force is successively transmitted starting from the some weights to the adjacent weights. As a result, the weights are moved as a whole in a direction that elastically deforms the elastic member while each moving in random directions. The "bead-like weights" in this invention typically represent steel balls, but their shape is not limited to a spherical shape and widely includes polyhedral, fusiform and other shapes. Further, the direction of deformation of the "elastic element" in this invention is typically the axial direction of the hammer actuating member.

According to this embodiment, with the construction in which the weight part comprises a large number of bead-like weights, the reaction force transmitted from the hammer actuating member can be dispersed over the weights, and loss of the reaction force is increased by transmission of the reaction force between the adjacent weights. Therefore, the effect of damping the reaction force is increased, so that the reaction force upon the elastic element can be reduced. As a result, durability of the elastic element can be increased.

[0010] According to the invention, an impact tool is provided which is improved in its structure for absorbing an impact force caused by rebound of a tool bit after its striking movement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a sectional side view schematically showing an entire electric hammer drill according to a first embodiment of this invention, under loaded conditions in which a hammer bit is pressed against a workpiece.

FIG. 2 is a sectional view showing an essential part of this invention.

FIG. 3 is a sectional view taken along line A-A in FIG. 2, in the state in which an impact absorbing mechanism is not yet actuated.

FIG. 4 is a sectional view taken along line A-A in FIG. 2, in the state in which the impact absorbing mechanism is being actuated.

FIG. 5 is a sectional view showing an impact absorbing mechanism according to a second embodiment of this invention.

FIG. 6 is a schematic view for illustrating propagation of a stress wave between a large number of steel balls.

REPRESENTATIVE EMBODIMENT OF THE INVENTION

(First Embodiment of the Invention)

[0012] A first embodiment of the invention is now described with reference to FIGS. 1 to 4. FIG. 1 is a sectional side view showing an entire electric hammer drill 101 as a representative example of an impact tool according to the invention, under loaded conditions in which a hammer bit is pressed against a workpiece. As shown in FIG. 1, the hammer drill 101 of this embodiment includes a body 103 that forms an outer shell of the hammer drill 101, a hammer bit 119 detachably coupled to the tip end region (on the left side as viewed in FIG. 1) of the body 103 via a tool holder 137, and a handgrip 109 that is connected to the body 103 on the side opposite the hammer bit 119 and designed to be held by a user. The body 103 is a feature that corresponds to the "tool body" according to the invention. The hammer bit 119 is held by the tool holder 137 such that it is allowed to reciprocate with respect to the tool holder 137 in its axial direction and prevented from rotating with respect to the tool holder 137 in its circumferential direction. In the present embodiment, for the sake of convenience of explanation, the side of the hammer bit 119 is taken as the front and the side of the handgrip 109 as the rear.

[0013] The body 103 includes a motor housing 105 that houses a driving motor 111, and a gear housing 107 that houses a motion converting mechanism 113, a striking mechanism 115 and a power transmitting mechanism 117 which form a driving mechanism. The rotating output of the driving motor 111 is appropriately converted to linear motion by the motion converting mechanism 113 and then transmitted to the striking mechanism 115. As a result, an impact force is generated in the axial direction of the hammer bit 119 via the striking mechanism 115. Further, the speed of the rotating output of the driving motor 111 is appropriately reduced by the power transmitting mechanism 117 and then transmitted to the hammer bit 119. As a result, the hammer bit 119 is caused to rotate in the circumferential direction. The handgrip 109 is generally U-shaped in side view, having a lower end and an upper end. The lower end of the handgrip 109 is rotatably connected to the rear end lower portion of the motor housing 105 via a pivot 109a, and the upper end is connected to the rear end upper portion of the motor housing 105 via an elastic spring 109b for absorbing vibration. Thus, transmission of vibration from the body 103 to the handgrip 109 is reduced.

[0014] The motion converting mechanism 113 mainly includes a crank mechanism. The crank mechanism is designed such that, when the crank mechanism is rotationally driven by the driving motor 111, a driving element in the form of a piston 129 forming a final movable member of the crank mechanism linearly moves in the axial direction of the hammer bit. The power transmitting mechanism 117 mainly includes a gear speed reducing mechanism formed by a plurality of gears and serves to transmit rotation of the driving motor 111 to the tool holder 137. Thus the tool holder 137 is caused to rotate in the vertical plane, and the hammer bit 119 held by the tool holder 137 rotates.

[0015] As shown in FIG. 2 which shows an essential part of the invention, the striking mechanism 115 mainly includes a striker 143 that is slidably disposed within the bore of the cylinder 141. The striker 143 is a feature that corresponds to the "striking element" according to this invention. The striker 143 is driven via the action of an air spring of an air chamber 141a of the cylinder 141 which is caused by sliding movement of the piston 129. The striker 143 then collides with (strikes) an intermediate element in the form of an impact bolt 145 that is slidably disposed within the tool holder 137 and transmits the striking force to the hammer bit 119 via the impact bolt 145. The impact bolt 145 and the hammer bit 119 are features that correspond to the "hammer actuating member" according to this invention. The impact bolt 145 includes a large-diameter portion 145a which is formed in the front in the longitudinal direction and fitted in close contact with the inner surface of the tool holder 137, a first small-diameter portion 145b provided for defining a predetermined extent of a space between the small-diameter portion 145b and the inner circumferential surface of the tool holder 137, and a second small-diameter portion 145c on which a positioning member 151 which is described below is loosely fitted and which is struck by the striker 143. Further, a medium-diameter portion 145d having a larger diameter than the first small-diameter portion 145b and the second small-diameter portion 145c is formed between the small-diameter portions and has a tapered surface on its front and rear surfaces. Further, a tapered surface 145e is formed between the large-diameter portion 145a and the first small-diameter portion 145b. A contact surface of the large-diameter portion 145a which is placed in contact with a rear end surface of the hammer bit 119 is spherically convex.

[0016] The hammer drill 101 includes a positioning member 151 that is disposed between the impact bolt 145 and the cylinder 141 and serves to position the body 103 with respect to the workpiece under loaded conditions shown in FIG. 1 in which the hammer bit 119 is pressed against the workpiece by the user's pressing force applied forward to the body 103. The positioning member 151 positions the body 103 with respect to the workpiece by contact with the impact bolt 145 and the cylinder 141, between the impact bolt 145 and the cylinder 141 which is held prevented at least from rearward movement with respect to the gear housing 107, when the positioning member 151 is pushed rearward (to the piston 129 side) together with the hammer bit 119. The positioning member 151 is a unit part including a rubber ring 153, a front hard metal washer 155 joined to the axially front surface of the rubber ring 153, and a rear hard metal washer 157 joined to the axially rear surface of the rubber ring 153. The positioning member 151 is loosely fitted onto the second small-diameter portion 145c of the impact bolt 145.

[0017] In order to absorb the impact force (reaction force) that is caused by rebound of the hammer bit 119 after the striking movement of the hammer bit 119 during hammering operation on the workpiece, the hammer drill 101 according to this embodiment includes a weight part 163 that contacts the impact bolt 145 and a plate spring 165 that exerts a biasing force in such a manner as to cause the weight part 163 to contact the impact bolt 145 and thereby allow transmission of the reaction force from the impact bolt 145. The weight part 163 and the plate spring 165 are features that correspond to the "weight part" and the "elastic element", respectively, according to this invention. The weight part 163 and the plate spring 165 form an impact absorbing mechanism 161, and the impact absorbing mechanism 161 is disposed on the first small-diameter portion 145b of the impact bolt 145.

[0018] The weight part 163 is formed by two hard metal weights 163a, 163b shaped like two halves of a cylindrical body. The two weights 163a, 163b are disposed side by side in the circumferential direction on the first small-diameter portion 145b of the impact bolt 145 in such a manner as to surround the first small-diameter portion 145b and thereby forms the generally cylindrical weight part 163. The plate spring 165 is shaped like a generally C-shaped ring having a slit in the longitudinal direction and fitted on the two weights 163a, 163b under a predetermined initial load so as to bias the two weights 163a, 163b radially inward. Thus, the two weights 163a, 163b forming the weight part 163 can move radially outward under a biasing force of the plate spring 165. This radially outward direction corresponds to the "direction different from the axial direction" according to this invention. Further, the plate spring 165 is fitted in a circumferential groove formed in the outer circumferential surface of each of the weights 163a, 163b and thereby prevented from moving in the longitudinal direction with respect to the weights 163a, 163b. Therefore, the relative positions of the two weights 163a, 163b in the longitudinal direction are held constant with respect to each other.

[0019] Further, both end surfaces of each of the weights 163a,163b in the longitudinal direction are tapered. The front tapered end surface of each weight is held in contact with the tapered surface 145e of the impact bolt 145, and the rear tapered end surface is held in surface contact with the front tapered surface of the medium-diameter portion 145d of the impact bolt 145 via the rubber ring 164. Thus, the two weights 163a, 163b are placed in an initial state in which a reaction force can be transmitted, with their end surfaces in the longitudinal direction held in contact with the impact bolt 145 under the radially inward biasing force of the plate spring 165. This initial state corresponds to the "first state" in this invention. The position at which the front end surfaces of the weights 163a, 163b contact the tapered surface 145e of the impact bolt 145 corresponds to the "reaction force transmitting position" in this invention. Further, the rubber ring 164 is provided as a viscoelastic member that absorbs transmission of a stress wave from the weight part 163 to the impact bolt 145 during transmission of a reaction force from the impact bolt 145 to the weight part 163, while absorbing transmission of a stress wave from the impact bolt 145 to the weight part 163 during striking movement.

[0020] Operation of the hammer drill 101 constructed as described above is now explained. When the trigger 109c mounted on the handgrip 109 is depressed and the driving motor 111 is driven, the piston 129 of the crank mechanism which forms the motion converting mechanism 113 is caused to linearly slide within the cylinder 141 by the rotating output of the driving motor 111. The striker 143 reciprocates within the cylinder 141 by the action of an air spring within the cylinder 141 as a result of the sliding movement of the piston 129. At this time, the striker 143 collides with (strikes) the impact bolt 145 and transmits the kinetic energy caused by the collision to the hammer bit 119. The rotating output of the driving motor 111 is transmitted to the tool holder 137 via the gear speed reducing mechanism forming the power transmitting mechanism 117. As a result, the tool holder 137 and the hammer bit 119 held by the tool holder 137 rotate together. Thus, the hammer bit 119 performs a striking movement in its axial direction and a rotary movement in its circumferential direction, so that a hammer drill operation is performed on a workpiece.

[0021] The above-described operation is performed with the hammer bit 119 pressed against the workpiece and with the hammer bit 119 and the tool holder 137 pushed rearward. This state is shown in FIGS. 1 and 2. When the tool holder 137 is pushed rearward, the impact bolt 145 is retracted and comes into contact with the front end of the cylinder 141 via the positioning member 151. Therefore, the cylinder 141 on the body 103 side receives the force of pushing in the hammer bit 119. Thus, the body 103 is positioned with respect to the workpiece, and in this state, a hammer drill operation is performed.

[0022] After striking movement of the hammer bit 119 upon the workpiece, the hammer bit 119 is caused to rebound by receiving the reaction force from the workpiece. This rebound causes the impact bolt 145 to be acted upon by a rearward reaction force. At this time, the weights 163a, 163b of the weight part 163 are in contact with the tapered surface 145e of the impact bolt 145. Therefore, the reaction force of the impact bolt 145 is transmitted to the weight part 163. In other words, momentum is exchanged between the impact bolt 145 and the weight part 163. By such transmission of the reaction force, the impact bolt 145 is held substantially at rest in the reaction force transmitting position, while the weights 163a, 163b of the weight part 163 are moved radially outward from the initial position shown in FIGS. 2 and 3. Specifically, the weights 163a, 163b are held in contact with the impact bolt 145 via their tapered surfaces inclined with respect the longitudinal direction of the impact bolt 145, so that the weights 163a, 163b are moved radially outward by radial components of the reaction force transmitted to the weights 163a, 163b. The state in which the weights 163a, 163b are moved radially outward corresponds to the "second state" in this invention. The radially outward movement of the weights 163a, 163b causes the plate spring 165 to elastically deform in such a manner as to expand radially outward. This state is shown in FIG. 4.

[0023] In this embodiment, the weight part 163 is designed to move radially by utilizing the property of the stress wave that spherically propagates. Specifically, when a rearward reaction force is applied to the front end of the impact bolt 145 by rebound of the hammer bit 119, a stress wave originating in the point of contact (axial center) of the impact bolt 145 with the hammer bit 119 spherically propagates rearward through the impact bolt, and then the stress wave is transmitted to the weights 163a, 163b which are held in contact with the tapered surface 145e inclined with respect the longitudinal direction of the impact bolt 145 via their tapered surfaces. By such transmission of the stress wave via the tapered surfaces, the stress wave smoothly propagates and the weights 163a, 163b are efficiently moved radially outward by the radial components of the transmitted stress wave.

[0024] In this manner, the reaction force caused by rebound of the hammer bit 119 and the impact bolt 145 can be efficiently absorbed by the radially outward movement of the weight part 163 and by the elastic deformation of the plate spring 165 which is caused by the movement of the weight part 163. As a result, vibration of the hammer drill 101 can be reduced.

During the above-described transmission of the reaction force, when the reaction force of the impact bolt 145 is transmitted to the weight part 163 via the tapered surfaces, longitudinal components of the reaction force act rearward upon the weight part 163. This rearward force is however absorbed by deformation of the rubber ring 164. Specifically, the rubber ring 164 can prevent the reaction force transmitted from the impact bolt 145 to the weight part 163 from being transmitted again to the impact bolt 145.

[0025] According to this embodiment, the weight part 163 is formed by the two weights 163a, 163b shaped like two halves of a cylindrical body, and the impact absorbing mechanism 161 is formed by biasing the weight part 163 radially inward by the generally C-shaped ring-like plate spring 165 fitted on the outer circumferential surface of the two weights 163a, 163b. Specifically, the impact absorbing mechanism 161 is designed to be moved in a radially outward direction transverse to the axial direction of the hammer bit, so that the impact absorbing mechanism 161 can be reduced in size in the axial direction of the hammer bit.

Further, in this embodiment, the impact bolt 145 has the second small-diameter portion 145b having a smaller diameter than its front end region (the large-diameter portion 145a) which is placed in contact with the hammer bit 119, and the impact absorbing mechanism 161 is disposed on the second small-diameter portion 145b. With this construction, the impact absorbing mechanism 161 can be disposed without need of radially increasing the size of the tool holder 137.

(Second Embodiment of the Invention)

[0026] A second embodiment of the invention is now described with reference to FIGS. 5 and 6. This embodiment is a modification to the impact absorbing mechanism 161. In the other points, it has the same construction as the first embodiment. As shown in FIG. 5, the impact absorbing mechanism 161 according to this embodiment mainly includes a weight part 173 formed by a large number of steel balls 173a made of hard metal, a case 174 that contains the steel balls 173a, and a coil spring 175 that exerts a biasing force such that the steel balls 173a within the case 174 are held in an initial state in which the adjacent steel balls 173a are allowed to transmit a reaction force by contact with each other. The large number of the steel balls 173a and the weight part 173 are features that correspond to the "large number of bead-like weights" and the "weight part", respectively, according to this invention. Further, the coil spring 175 and the initial state are features that correspond to the "elastic element" and the "first state", respectively, according to this invention.

[0027] The case 174 is, for example, a tubular body extending in the axial direction of the hammer bit and formed by two tubes having different diameters which are disposed concentrically to define an annular housing space between the inner and outer tubes. The two tubes are formed of a material having lower Young's modulus than the steel balls 173a, such as resin and rubber. Further, the two tubes are connected together at an appropriate region in the circumferential direction as necessary. The annular housing space have both ends open in the axial direction of the hammer bit.

[0028] The case 174 constructed as described above is disposed within an annular space between the cylinder 141 and the tool holder 137. The steel balls 173a disposed within the housing space of the case 174 face a rear end surface of the front metal washer 155 of the positioning member 151 via the front opening of the housing space. Specifically, the front metal washer 155 has a larger outside diameter than the rubber ring 153 and the rear metal washer 157 which are also components forming the positioning member 151. The front metal washer 155 thus has a protruding region that contacts some steel balls 173a located in the front opening of the housing space. A cover plate 177 made of hard metal is disposed in the rear opening of the housing space. The cover plate 177 is provided as an intermediary member for transmitting the movement of the steel balls 173a in the axial direction of the hammer bit to the coil spring 175. The cover plate 177 is fitted in the case 74 such that it can move in the longitudinal direction of the case 174 (the axial direction of the hammer bit) with respect to the case 174 and the inner surface (front surface) of the cover plate 177 is held in contact with some steel balls 173a located in the rear opening.

[0029] The coil spring 175 is elastically disposed under a predetermined initial load between the cover plate 177 and the tool holder 137, in the space between the cylinder 141 and the tool holder 137. Specifically, the coil spring 175 is disposed at the rear of the case 174. One end (rear end) of the coil spring 175 in the longitudinal direction is held in contact with a spring receiving ring 179 fastened to the tool holder 137, and the other end (front end) of the coil spring 175 in the longitudinal direction is held in contact with the cover plate 177. The coil spring 175 biases the large number of the steel balls 173a within the case 174 via the cover plate 177 under an initial load such that adjacent ones of the steel balls 173a are held in contact with each other and some of the steel balls 173a which are located in the front opening are held in contact with the tapered surface 145e of the impact bolt 145 via the front metal washer 155 of the positioning member 151. Thus, the steel balls 173a are placed in an initial state in which transmission of a reaction force is allowed. The position at which the steel balls 173a contact the impact bolt 145 via the front metal washer 155 corresponds to the "reaction force transmitting position" in this invention.

[0030] The hammer drill 101 according to this embodiment is constructed as described above. A hammer drill operation by the hammer drill 101 is performed with the hammer bit 119 pressed against the workpiece. When the tool holder 137 is pushed rearward, the impact bolt 145 is pushed rearward and comes into contact with the front metal washer 155 of the positioning member 151, and the rear metal washer 157 comes into contact with the front end of the cylinder 141. Therefore, the cylinder 141 on the body 103 side receives the force of pushing in the hammer bit 119. Thus, the body 103 is positioned with respect to the workpiece, and in this state, a hammer drill operation is performed. At this time, as described above, the steel balls 173 located in the front of the case 174 are held in contact with the rear surface of the front metal washer 155 of the positioning member 151. This state is shown in FIG. 5.

[0031] In this state, when the hammer bit 119 performs a striking movement on the workpiece and the hammer bit is caused to rebound by receiving a reaction force from the workpiece, this rebound causes the impact bolt 145 to be acted upon by a rearward reaction force. At this time, the steel balls 173a of the weight part 173 are held in contact with the impact bolt 145 via the front metal washer 155, so that the reaction force of the impact bolt 145 is transmitted to the steel balls 173a via the front metal washer 155. FIG. 6 schematically illustrates propagation of a stress wave caused in the steel balls 173a by this transmission of the reaction force. As shown in FIG. 6(I), a stress wave (shown by arcuate lines) which is caused in a steel ball A by transmission of the reaction force from the front metal washer 155 spherically propagates through the steel ball A, starting from the contact point (shown by a black dot) between the steel ball A and the front metal washer 155. Then, the stress wave propagates to steel balls B and C which are adjacent to and in contact with the steel ball A, and thereafter likewise propagates to the steel ball D adjacent to the steel balls B and C. By such successive propagation of the stress wave, the steel balls A to D move in a direction of propagation of the stress wave (in the direction shown by the arrow). This state is shown in FIG. 6(II).

[0032] Specifically, according to this embodiment, when a reaction force is transmitted from the impact bolt 145 side to the steel balls 173a within the case 174, the steel balls 173a are moved rearward as a whole while each moving in random directions within the case 174. Such movement of the steel balls 173a causes the cover plate 177 to move rearward, and then the cover plate 177 pushes and elastically deforms the coil spring 175. The random directions of movement of the steel balls 173a correspond to the "different direction" according to this invention, and the state of movement of the steel balls 173a in random directions correspond to the "second state" according to this invention.

In this manner, the reaction force caused by rebound of the hammer bit 119 and the impact bolt 145 can be efficiently absorbed by the movement of the large number of the steel balls 173a in random directions within the case 174 and by the rearward elastic deformation of the coil spring 175 which is caused by the movement of the steel balls 173a. As a result, vibration of the hammer drill 101 can be reduced.

[0033] According to this embodiment, by forming the weight part 163 using the large number of the steel balls 173a, loss of the reaction force (stress wave) is increased by propagation between the adjacent steel balls 173a, so that the damping effect is increased. Moreover, the stress wave propagates at random in many directions between the large number of the steel balls 173a, so that the reaction force upon the coil spring 175 is reduced. As a result, the life of the coil spring 175 can be increased. Further, the elastic deformation of the coil spring 175 is reduced by reduction of the reaction force upon the coil spring 175, so that the coil spring 175 can be reduced in size by reducing its length in the axial direction of the hammer bit by the reduction of the elastic deformation.

[0034] Further, in the above-described embodiments, the electric hammer 101 is described as a representative example of the impact tool. However, naturally, the invention is not limited to the hammer drill 101, but can also be applied to a hammer. Further, in the above embodiments, as for the path of transmission of the reaction force upon the weight part 163 or 171, the reaction force is described as being transmitted from the impact bolt 145, but it may be transmitted from the hammer bit 119.

[0035] Further, in the above-described embodiments, the motion converting mechanism 113 for converting the rotating output of the driving motor 111 to linear motion is described as being formed by a crank mechanism in order to linearly drive the hammer bit 119, but it is not limited to the crank mechanism. For example, a motion converting mechanism utilizing a swash plate that swings in the axial direction can also be used.

Description of Numerals

[0036]

101	hammer drill (impact tool)
103	body (tool body)
105	motor housing
107	gear housing
109	handgrip

109a	pivot
109b	elastic spring
109c	trigger
111	driving motor
113	motion converting mechanism
115	striking mechanism
117	power transmitting mechanism
119	hammer bit (hammer actuating member)
129	piston
137	tool holder
141	cylinder
141a	air chamber
143	striker (striking element)
145	impact bolt (hammer actuating member)
145a	large-diameter portion
145b	first small-diameter portion
145c	second small-diameter portion
145d	medium-diameter portion
145e	tapered surface
151	positioning member
153	rubber ring
155	front metal washer (intervening member)
157	rear metal washer
161	impact absorbing mechanism
163	weight part
163a	weight
164	rubber ring
165	plate spring (elastic element)
173	weight part
173a	steel ball (bead-like weight)
174	case
175	coil spring (elastic element)
177	cover plate
179	spring receiving ring

Claims

1. An impact tool comprising:

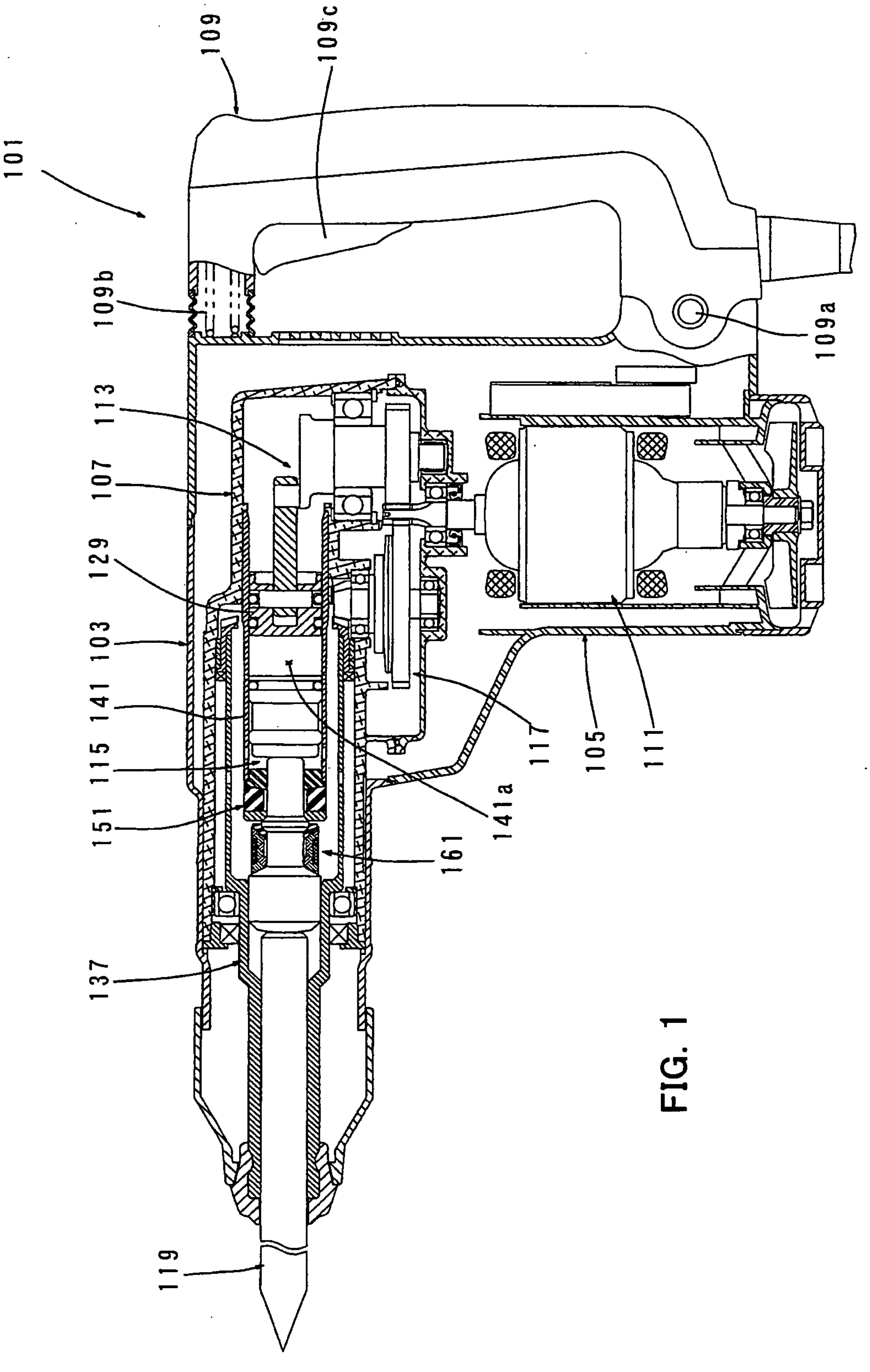
    a tool body,
    a hammer actuating member that is disposed in a tip end region of the tool body and performs a predetermined hammering operation on a workpiece by linear movement in its axial direction,
    a striking element that linearly moves in the axial direction of the hammer actuating member and thereby strikes the hammer actuating member,
    a weight part to which a reaction force is transmitted from the hammer actuating member in a reaction force transmitting position in which the weight part is placed in direct contact with the hammer actuating member or in which the weight part is placed in contact with the hammer actuating member via a hard metal intervening member, when the hammer actuating member performs the hammering operation on the workpiece, wherein the weight part moves from the reaction force transmitting position in a direction different from the axial direction of the hammer actuating member by the transmitted reaction force, and
    an elastically deformable elastic element, wherein:

        the weight part changes in its state between a first state in which the reaction force is not yet transmitted to the weight part and a second state in which the weight part is caused to move by the transmission of the reaction force in the direction different from the axial direction of the hammer actuating member, and
        the elastic element exerts a biasing force such that the weight part is placed in the first state, and when the weight part changes from the first state to the second state by the reaction force, the elastic element elastically deforms by being pushed by the weight part and thereby absorbs the reaction force transmitted to the weight part.

2. The impact tool as defined in claim 1, wherein the weight part comprises at least two weights disposed side by side along a circumferential direction on the hammer actuating member, and when the reaction force is transmitted from the hammer actuating member to the weights, the weights are moved by the reaction force in a direction transverse to the axial direction of the hammer actuating member.

3. The impact tool as defined in claim 2, wherein the elastic member comprises a plate spring which is disposed on the outside of the at least two weights and biases the weights radially inward.

4. The impact tool as defmed in claim 1, wherein the weight part comprises a large number of bead-like weights disposed in circumferential and axial directions of the hammer actuating member, wherein the large number of the weights are biased by the hammer actuating member such that adjacent ones of the weights are held in contact with each other while some of the weights are held in contact with the hammer actuating member, and when the reaction force is transmitted from the hammer actuating member to the some weights, the reaction force is successively transmitted starting from the some weights to the adjacent weights, whereby the weights are moved as a whole in a direction that elastically deforms the elastic member while each moving in random directions.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109c
109b
109a
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141a
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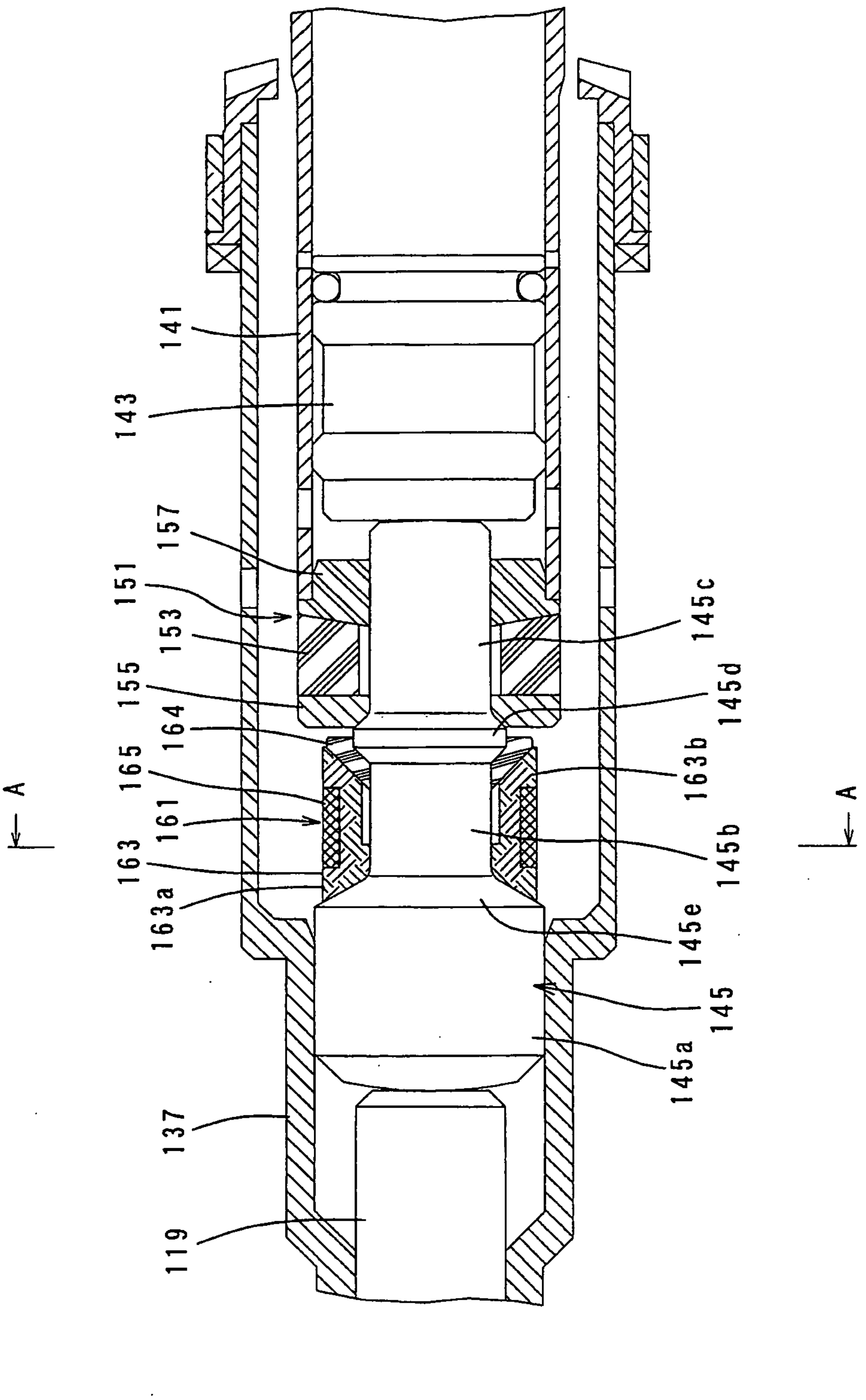
FIG. 1

FIG. 2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163a
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145c
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163b
145b
145e
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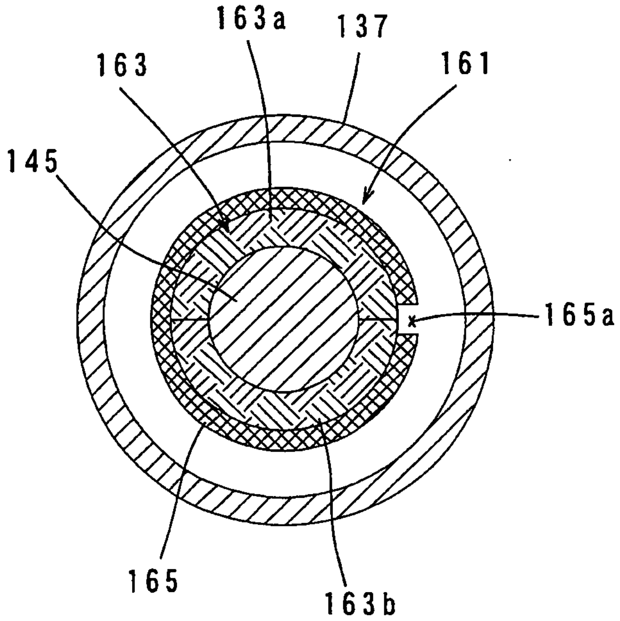
145a
A
A

FIG. 3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165a
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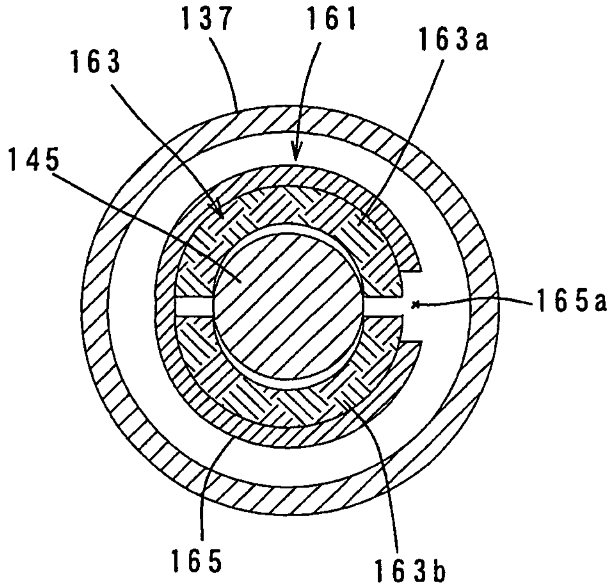
163b

FIG. 4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163a
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145
165a
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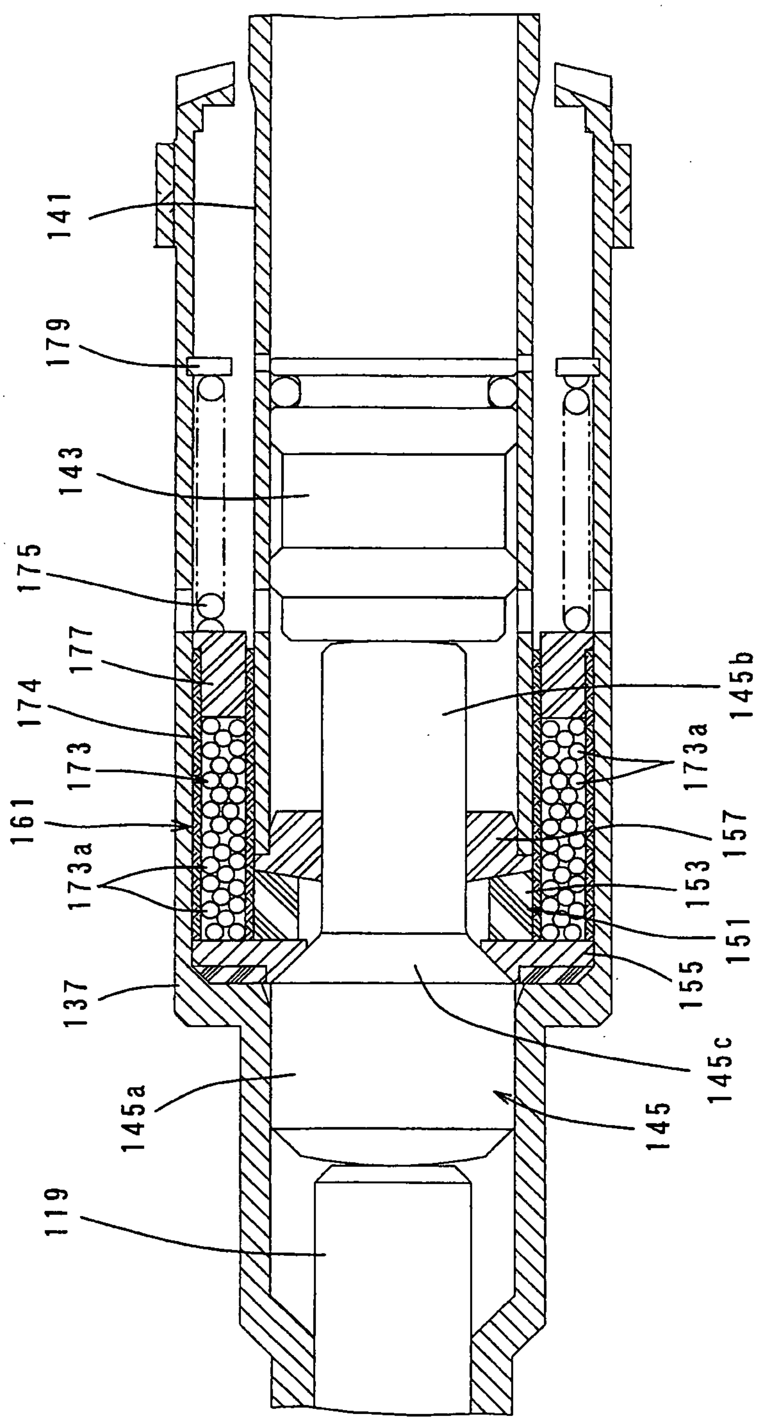
163b

FIG. 5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145c
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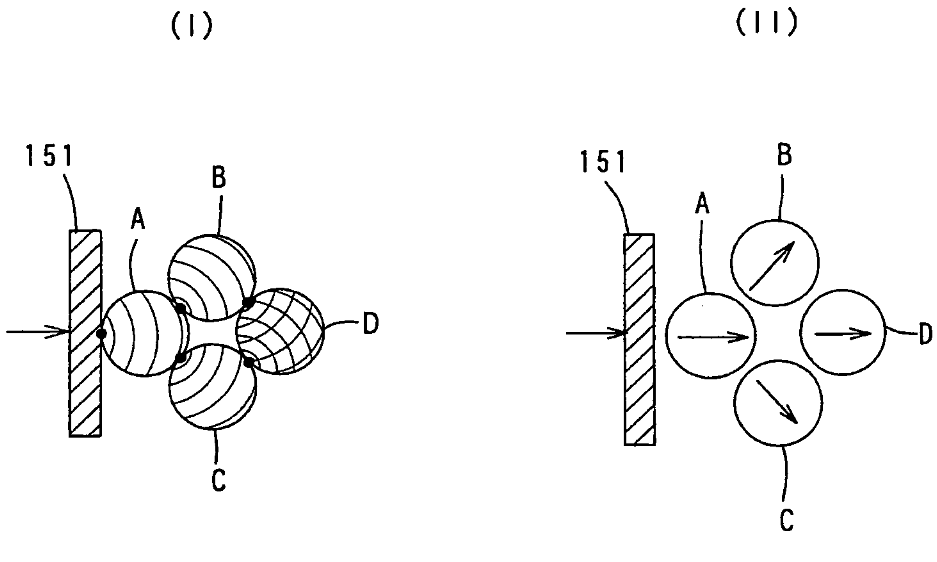
FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/066561

A. CLASSIFICATION OF SUBJECT MATTER
B25D17/24(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25D17/24

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	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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 X	JP 8-141939 A (Makita Corp.), 04 June, 1996 (04.06.96), Claim 1; Par. Nos. [0007] to [0008]; Figs. 2, 3 (Family: none)	1 2-3
A	JP 2003-175477 A (Ryobi Ltd.), 24 June, 2003 (24.06.03), Claim 1 (Family: none)	1-4

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 December, 2008 (05.12.08)	16 December, 2008 (16.12.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2007050495 A **[0002]**