



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**06.10.2010 Bulletin 2010/40**

(51) Int Cl.:  
**B25D 16/00 (2006.01)**

(21) Application number: **10002955.2**

(22) Date of filing: **19.03.2010**

(84) Designated Contracting States:  
**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 SE SI SK SM TR**  
Designated Extension States:  
**AL BA ME RS**

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(30) Priority: **01.04.2009 JP 2009089461**

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(54) **Hammer drill**

(57) In a hammer drill (1), a torque limiter includes: a cam ring (14) adjacent to a gear (13), and configured to be provided onto a tool holder (6) so as to be unitarily rotatable with the tool holder (6) and to have cam projections (18) on a surface facing to the gear (13); rollers (21) received in corresponding through-holes (20) formed in the gear (13) and engageable with the cam projections (18) in their rotational directions; and urging means

(washer (16) and coil spring (17)) configured to urge the rollers (21) toward the cam ring (14) so that the rollers (21) are brought into engagement with the cam projections (18), and when a torque applied to the tool holder (6) exceeds a setting torque, the rollers (21) pass the cam projections (18) within the through-holes (20) against the urging means and roll on the cam ring (14), so that the gear (13) slips on the cam ring (14) to thereby uncouple the torque transmission to the cam ring (14).

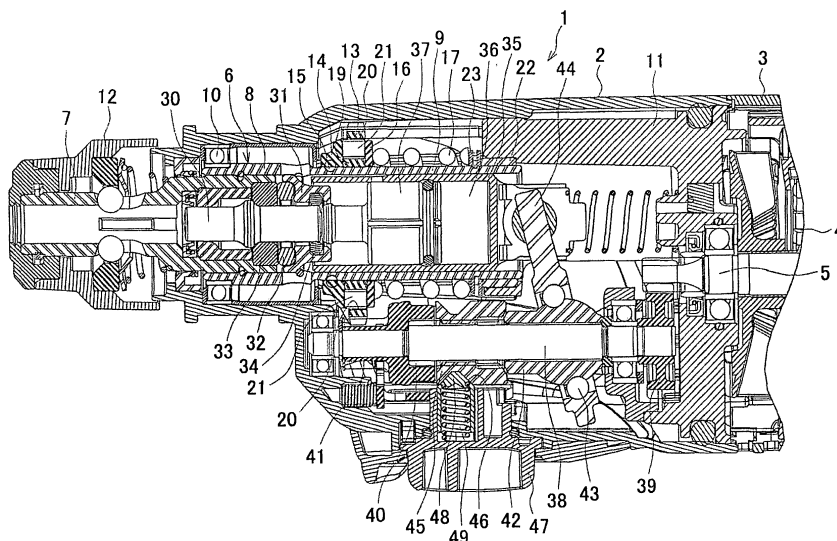


FIG. 1

## Description

### TECHNICAL FIELD

**[0001]** This invention relates to a hammer drill which can impart a rotation and/or an impact to a bit at a front end of the hammer drill.

### BACKGROUND ART

**[0002]** As a hammer drill, for example, an apparatus such as disclosed in Patent Document 1 is known. In this apparatus, a tool holder having a bit-installable front end and functioning as a final output shaft is rotatably supported at a front side of a housing, and at a rear side of the tool holder in the housing there is provided an impact mechanism configured to indirectly impact a bit through an interjacent element by a reciprocating movement of an impactor. An intermediate shaft to which a rotation is transmitted from an output shaft of a motor is disposed in the housing below the impact mechanism and parallel to the tool holder. The intermediate shaft is rotatably supported, and a gear on the intermediate shaft is in mesh with a gear on the tool holder so that a rotation of the intermediate shaft can be transmitted to the tool holder.

**[0003]** Further, a torque limiter is provided on the tool holder. The torque limiter uncouples a torque transmission from the intermediate shaft when a mechanical overload or a torque exceeding a setting torque is applied to the tool holder. The torque limiter comprises a rotatable and axially movable gear fitted on the tool holder, a coil spring for urging the gear toward a cam ring fixed to the tool holder, and rollers positioned between the gear and cam ring and engageable with opposite surfaces thereof. The torque limiter operates such that when a torque applied to the tool holder does not exceed the setting torque, a rotation of the gear is constrained so that the torque is transmitted to the cam ring and the tool holder, whereas when the torque applied to the tool holder exceeds the setting torque because of a rotation load to the bit, the gear advances forward against the urging force of the coil spring and slips to thereby uncouple the torque transmission to the cam ring.

Patent Document 1: U.S. Patent No. 5,373,905

### DISCLOSURE OF INVENTION

#### Problems to be solved by the invention

**[0004]** According to this hammer drill, when the torque limiter is in operation, the gear on the tool holder slides in an axial direction while meshing with the gear on the intermediate shaft. This may disadvantageously cause wear of teeth at regions where the gears mesh with each other, which leads to a deterioration in durability. Further, it is necessary to take into consideration the stroke of the gear to determine the shape of the housing, which becomes an obstacle to reducing the size of the hammer

drill.

**[0005]** In view of the above, it is an object of the present invention to provide a hammer drill in which, even if a torque limiter is employed, an improved and desired durability of the gears can be achieved while realizing a reduction in the size without causing any problem.

#### Means for solving the problems

**[0006]** In order to achieve the above object, according to the present invention, a torque limiter comprises: a cam ring adjacent to a gear, and configured to be provided onto a final output shaft so as to be unitarily rotatable with the final output shaft and to have cam projections on a surface facing to the gear; rolling elements received in corresponding through-holes formed in the gear at positions concentrically with the cam projections, and engageable with the cam projections in their rotational directions; and urging means configured to urge the rolling elements toward the cam ring so that when a torque applied to the final output shaft does not exceed a setting torque, the rolling elements are engaged with the cam projections, and when the torque exceeds the setting torque, the rolling elements pass the cam projections within the through-holes against the urging means and roll on the cam ring, so that the gear slips on the cam ring to thereby uncouple the torque transmission to the cam ring.

**[0007]** According to one embodiment of the present invention, the rolling elements are rollers and an axis of each roller lies in conformity with a radial direction of the gear.

**[0008]** With the configuration of the present invention, even if the hammer drill is provided with the torque limiter, an improved and desired durability of the gears can be achieved. Further, because the gear does not move in an axial direction, it is not necessary to keep a space in the housing for a movement stroke of the gear, which can facilitate a reduction in the size of the hammer drill.

**[0009]** With the configuration of one embodiment of the present invention, in addition to the above advantageous effects of the present invention, the contacting area between the rolling element and the cam ring can be increased by the use of the rollers, when compared with the use of balls. This can enhance the reliability of the engagement between the cam projections and the rolling elements, as well as restrict a load applied to the cam projections to thereby improve the durability of the cam ring.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** The above aspect, other advantages and further features of the present invention will become more apparent by describing in detail illustrative, non-limiting embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 is a partially illustrated vertical section of a hammer drill during a normal operation of the hammer drill; and

FIG. 2 is a partially illustrated vertical section of the hammer drill during the time that a torque limiter is in operation.

## DETAILED DESCRIPTION OF THE INVENTION

**[0011]** One preferred embodiment of the present invention will be described below with reference to the accompanying drawings.

**[0012]** As seen in FIG. 1, a hammer drill 1 includes a gear housing 2 in which a rotation mechanism and an impact mechanism are accommodated, a motor housing 3 at the rear of the gear housing 2 (at a right-hand side of FIG. 1) and configured to accommodate a motor 4, and a tool holder 6 as a final output shaft which is rotatably supported in the gear housing 2 at a front side of the gear housing 2 and to which a bit can be installed at the front end thereof.

**[0013]** The tool holder 6 is a tubular member having an intermediate portion 8 which is rotatably supported at a front end of the gear housing 2 through a ball bearing 10, and a rear portion 9 which is rotatably supported in an inner housing 11 assembled with the gear housing 2 at a rear side of the gear housing 2. A manipulation sleeve 12 for attachment or detachment of a bit (not shown) to be inserted into the front end of the tool holder 6 is provided at a front end portion 7 of the tool holder 6 protruding from the gear housing 2.

**[0014]** A gear 13 is rotatably provided onto the tool holder 6 at a periphery of the rear portion 9, and at a front side of the gear 13, a cam ring 14 is unitarily provided onto the tool holder 6 through stopper balls 15. A washer 16 and a coil spring 17 are provided onto the tool holder 6 at a rear side of the gear 13.

**[0015]** As seen in FIG. 2, six cam projections 18 protrude from a rear surface (i.e., surface facing to the gear 13) of the cam ring 14 at positions proximate to the peripheral edge of the cam ring 14. The six cam projections 18 are equidistantly arranged around a peripheral direction of the cam ring 14. Each cam projection 18 has slant surfaces extending in a front-back direction along the peripheral direction of the cam ring 14 as seen in the rotating direction of the cam ring 14. The gear 13 has an annular projection 19 at a front surface (i.e., surface facing to the cam ring 14) thereof. The annular projection 19 contacts with the rear surface of the cam ring 14 at an inner side of the cam projections 18, and the annular projection 19 has a height that is slightly greater than that of the cam projection 18. Further, six through-holes 20 are formed in the gear 13 at positions concentrically with the cam projections 18, and the arrangement of the six through-holes 20 conforms to that of the six cam projections 18 (i.e., the cam projections 18 and the through-holes 20 are in phase with each other). A roller 21 is received in each through-hole 20, and an axis of rotation of the roller

21 lies in conformity with a radial direction of the gear 13.

**[0016]** The washer 16 has a diameter sufficient to cover the through-holes 20 of the gear 13 from the rear side of the gear 13. The washer 16 is urged forward by the coil spring 17 and pushes the gear 13. The washer 16 and the coil spring 17 correspond to the urging means according to the present invention. Reference numeral 22 indicates a bearing which is retained in the inner housing 11 and supports the rear portion 9 while allowing a rotation of the rear portion 9. Reference numeral 23 indicates a spring retainer which is provided onto the rear portion 9 between the bearing 22 and the coil spring 17 for receiving the rear end of the coil spring 17.

**[0017]** Because the gear 13 is urged by the washer 16 and the coil spring 17, a front-back movement of the gear 13 is constrained at a position where the annular projection 19 is brought into contact with the cam ring 14. In this position, the rollers 21 penetrating through the gear 13 are pressed by the washer 16 and protrude forward from the through-holes 20, and the rollers 21 do not protrude from the rear surface of the gear 13.

**[0018]** When a torque applied to the tool holder 6 does not exceed a setting torque that is determined by the urging force of the coil spring 17, the rollers 21 arranged in the through-holes 20 rotate as the gear 13 rotates, so that the rollers 21 roll on the rear surface of the cam ring 14 and engage with the cam projections 18. Therefore, the torque of the gear 13 is transmitted from the rollers 21 to the tool holder 6 via the cam ring 14. Meanwhile, when the torque applied to the tool holder 6 exceeds the setting torque, the rollers 21 pushes back the washer 16 against the urging force of the coil spring 17, so that the roller 21 pass the cam projections 18 and roll on the rear surface of the cam ring 14. Therefore, the gear 13 slips on the cam ring 13 to thereby uncouple the torque transmission to the tool holder 6. In other words, a torque limiter is provided.

**[0019]** An impact bolt (interjacent element) 30 is received in and reciprocates within the intermediate portion 8 of the tool holder 6. The retreating position (rear end position) of the impact bolt 30 is defined by an elastic ring 32 and a retaining ring 33, which are positioned by a tubular cap 31 assembled in the intermediate portion 8 at a rear side of the impact bolt 30. An O-ring 34 is received at the rear end of the cap 31. During the normal use, the rear end of the impact bolt 30 is engageable with the O-ring 34 to restrict the reciprocating movement of a striker 37 to be described later. On the contrary, at a blank shot, for example, when no bit is installed in the tool holder 6, the O-ring 34 holds the front end of the striker 37 and restricts the reciprocating movement of the striker 37.

**[0020]** Further, a tubular piston cylinder 35 which opens toward the front is loosely fitted into the rear portion 9 of the tool holder 6, and the striker (impactor) 37 is accommodated in the piston cylinder 35 through an air chamber 36 so as to reciprocate in the front-back direction.

**[0021]** An intermediate shaft 38 is rotatably supported in the gear housing 2 below the output shaft 5 of the motor 4. The intermediate shaft 38 is disposed parallel to the tool holder 6 and the output shaft 5, and a first gear 39 provided at the rear end of the intermediate shaft 38 is in mesh with the output shaft 5. A spline gear 40 is formed on the intermediate portion of the intermediate shaft 38. A second gear 41 is separately and rotatably provided onto the intermediate shaft 38 at the front of the spline gear 40, and the second gear 41 is in mesh with the gear 13 of the tool holder 6. Further, a boss sleeve 42 is separately and rotatably provided onto the intermediate shaft 38 at the rear of the spline gear 40, and a swash bearing 43 is rotatably provided onto the outer periphery of the boss sleeve 42. A connecting arm 44 is connected to the boss sleeve 42 via the swash bearing 43 with its axis inclined. The upper end of the connecting arm 44 protruding upward from the swash bearing 43 is rotatably connected to the rear end of the piston cylinder 35.

**[0022]** A sleeve-shaped clutch 45, in which a V-shaped fitting groove 46 is formed around a peripheral surface thereof, is provided on the spline gear 40 of the intermediate shaft 38. The clutch 45 is splined to the intermediate shaft 38 so as to be unitarily rotatable with the intermediate shaft 38 and slidable along the intermediate shaft 38 in the front-back direction. A mode-selecting knob 47 is rotatably mounted below the clutch 45 and at the lower surface of the gear housing 2, and an engagement pin 48 having a tapered upper end to be fitted into the fitting groove 46 of the clutch 45 is eccentrically provided on the upper surface of the mode-selecting knob 47. The engagement pin 48 is retained on the mode-selecting knob 47 in such a manner that it is movable in the vertical direction while being urged upward by a coil spring 49.

**[0023]** Accordingly, when a user rotates the mode-selecting knob 47, the engagement pin 48 undergoes an eccentric motion while being fitted into the fitting groove 46, so that the clutch 45 moves in the front-back direction in accordance with the travel distance of the engagement pin 48 in the front-back direction. According to the sliding position of the clutch 45, the clutch 45 is brought into engagement with either one of or both of the second gear 41 and the boss sleeve 42.

**[0024]** To be more specific, in an advanced position of the clutch 45, the clutch 45 merely engages with the second gear 41 to allow a unitary rotation of the second gear 41 and the intermediate shaft 38 in their rotational direction (i.e., drill mode). In a retreating position of the clutch 45, the clutch 45 merely engages with the boss sleeve 42 to allow a unitary rotation of the boss sleeve 42 and the intermediate shaft 38 (i.e., hammer mode). In an intermediate position of the clutch 45, the clutch 45 engages with both the second gear 41 and the boss sleeve 42 to allow a unitary rotation of the second gear 41 and the boss sleeve 42 with the intermediate shaft 38 in their rotational direction (i.e., hammer drill mode). Therefore, various modes of operation can be selected in accordance with the sliding positions of the clutch 45.

**[0025]** In the hammer drill 1 configured as described above, when the motor 4 is driven to rotate after the user turns the mode-selecting knob 47 to the drill mode, a rotation of the output shaft 5 is transmitted from the first gear 39 to the intermediate shaft 38, and via the clutch 45, further to the second gear 41 and the gear 13. As described previously, when a torque applied to the tool holder 6 does not exceed the setting torque, the torque limiter is not in operation, so that the rotation of the gear 13 is transmitted to the cam ring 14 via the rollers 21 and the tool holder 6 rotates. This results in the rotation of the bit that is attached to the front end of the tool holder 6. This mechanism from the output shaft 5 to the gear 13 corresponds to the rotation mechanism according to the present invention.

**[0026]** When the motor 4 is driven to rotate after the user selects the hammer mode, a rotation of the output shaft 5 is transmitted from the first gear 39 to the intermediate shaft 38, and via the clutch 45, further to the boss sleeve 42. Therefore, the rotation of the boss sleeve 42 is converted by the swash bearing 43 into a swinging motion of the connecting arm 44 in the front-back direction to thereby cause the piston cylinder 35 to reciprocate. This causes the striker 37 to reciprocate in synchronization with the reciprocating motion of the piston cylinder 35 by the action of an air spring, so that the striker 37 strikes the impact bolt 30 that has been pushed by the bit and positioned in the retreating position. Therefore, the bit is indirectly struck by the striker 37 through the impact bolt 30. This mechanism from the output shaft 5 to the bit corresponds to the impact mechanism according to the present invention.

**[0027]** When the motor is driven to rotate after the user selects the hammer drill mode, a rotation of the output shaft 5 is transmitted from the first gear 39 to the intermediate shaft 38, and via the clutch 45, further to both the second gear 41 and the boss sleeve 42. Therefore, a rotation of the tool holder 6 and a striking blow on the bit generate at the same time. In this case too, when a torque applied to the tool holder 6 does not exceed the setting torque, the torque limiter is not in operation, so that the rotation of the gear 13 is transmitted to the cam ring 14 via the rollers 21 and the tool holder 6 rotates.

**[0028]** Of these modes of operation, in the drill mode and the hammer drill mode, if the torque applied to the tool holder 6 increases because of a rotational resistance to the bit or the like and exceeds the setting torque of the torque limiter, as seen in FIG. 2, the torque limiter operates so that the rollers 21 ride on the cam projections 18 of the cam ring 14 and pass the cam projections 18. Because the rollers 21 roll on the cam ring 14 and the gear 13 slips on the cam ring 14, the mechanical coupling between the cam ring 14 and the gear 13 is uncoupled. Therefore, the torque transmission from the gear 13 to the cam ring 14 and the tool holder 6 is disconnected. The gear 13 does not move in the axial direction during operation/non-operation of the torque limiter and only the rotation of the gear 13 is permitted, so that the teeth at

regions where the gear 13 and the second gear 41 mesh with each other are less likely to subject to wear.

**[0029]** As described previously, according to the hammer drill 1 disclosed in the above embodiment, the torque limiter includes: the cam ring 14 adjacent to the gear 13, and configured to be provided onto the tool holder 6 so as to be unitarily rotatable with the tool holder 6 and to have cam projections 18 on the surface facing to the gear 13; rollers 21 received in the corresponding through-holes 20 formed in the gear 13 at positions concentrically with the cam projections 18, and engageable with the cam projections 18 in their rotational directions; and the urging means (the washer 16 and the coil spring 17) configured to urge the rollers 21 toward the cam ring 14 so that when the torque applied to the tool holder 6 does not exceed the setting torque, the rollers 21 are brought into engagement with the cam projections 18; and when the torque applied to the tool holder 6 exceeds the setting torque, the rollers 21 pass the cam projections 18 within the through-holes 20 against the urging means and roll on the cam ring 14, so that the gear 13 slips on the cam ring 14 to thereby uncouple the torque transmission to the cam ring 14. Therefore, even if the hammer drill 1 is provided with the torque limiter, an improved and desired durability of the gear 13 and the second gear 41 can be achieved. Further, because the gear 13 does not move in the axial direction, it is not necessary to keep a space in the gear housing 2 for the movement stroke of the gear 13, which can facilitate a reduction in the size of the hammer drill 1.

**[0030]** Further, according to the hammer drill 1 disclosed in the above embodiment, the rolling elements are rollers 21 and an axis of each roller 21 lies in conformity with the radial direction of the gear 13. Therefore, the contacting area between the rolling element and the cam ring 14 can be increased by the use of the rollers 21, when compared with the use of balls. This can enhance the reliability of the engagement between the cam projections 18 and the rolling elements, as well as restrict a load applied to the cam projections 18 to thereby improve the durability of the cam ring 14.

**[0031]** Although the present invention has been described in detail with reference to the above preferred embodiment, the present invention is not limited to the above specific embodiment and various changes and modifications may be made without departing from the scope of the appended claims.

**[0032]** For example, the number of cam projections 18 of the cam ring 14 and the number of through-holes 20 of the gear 13 may vary where necessary, and the number of rollers 21 may vary in accordance with the number of the through-holes 20. The rolling elements are not limited to the rollers 21, and balls may be employed instead.

**[0033]** Further, another resilient member such as a coned disc spring may be employed as the urging means in place of the coil spring. The direction of the torque limiter is not limited to that disclosed in the above em-

bodiment, and it is possible to change the arrangement such that the cam ring 14 is disposed rearward of the gear 13 and the washer 16 and the resilient member are disposed forward of the gear 13.

**[0034]** Other than the above, the design of the hammer drill may also vary where necessary. For example, the impact mechanism may be configured such that a piston reciprocates in a stationary cylinder so as to cause an impactor to reciprocate in synchronization with the piston. The impactor may directly strike the bit without employing an interjacent element. Further, a crank mechanism may be employed for the reciprocating motion of the piston. Of course, other modifications may be made where necessary.

**[0035]** It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

## Claims

### 1. A hammer drill (1) comprising:

- a housing (2);
- a final output shaft rotatably supported in the housing (2) and adapted to have a bit attached thereto;
- a rotation mechanism disposed in the housing (2) and configured to transmit torque to a gear (13) which is rotatably provided on the final output shaft;
- an impact mechanism disposed in the housing (2) and configured to strike the bit; and
- a torque limiter provided on the final output shaft and configured such that when a torque applied to the final output shaft does not exceed a setting torque, a rotation of the gear (13) is constrained so as to allow the torque to be transmitted to the final output shaft, whereas when the torque applied to the final output shaft exceeds the setting torque, the gear (13) slips to thereby uncouple the torque transmission to the final output shaft,

**characterized in that** the torque limiter comprises:

- a cam ring (14) adjacent to the gear (13) and configured to be provided on the final output shaft so as to be unitarily rotatable with the final output shaft and to have cam projections (18)

on a surface facing to the gear (13);  
 rolling elements received in corresponding  
 through-holes (20) formed in the gear (13) at  
 positions concentric with the cam projections  
 (18) and engageable with the cam projections  
 (18) in their rotational directions; and  
 urging means configured to urge the rolling el-  
 ements toward the cam ring (14) so that when  
 the torque does not exceed the setting torque,  
 the rolling elements are engaged with the cam  
 projections (18),

wherein when the torque exceeds the setting torque,  
 the rolling elements pass the cam projections (18)  
 within the through-holes (20) against the urging  
 means and roll on the cam ring (14), so that the gear  
 (13) slips on the cam ring (14) to thereby uncouple  
 the torque transmission to the cam ring (14).

2. The hammer drill (1) according to claim 1, wherein  
 the rolling elements are rollers (21) and an axis of  
 each roller (21) lies in conformity with a radial direc-  
 tion of the gear (13).
3. The hammer drill (1) according to claim 1 or 2, where-  
 in the urging means comprises a washer (16) adja-  
 cent to the gear (13) and having a diameter for cov-  
 ering the through-holes (20) and a coil spring (17)  
 urging the washer (16) toward the gear (13).
4. The hammer drill (1) according to one of claims 1 to  
 3, wherein the gear (13) has an annular projection  
 at a surface facing to the cam ring (14), the annular  
 projection being configured to contact the cam ring  
 (14) at an inner side of the cam projections (18) and  
 to have a height greater than that of the cam projec-  
 tion (18).
5. The hammer drill (1) according to one of claims 1  
 to 4, wherein each of the cam projections (18) has  
 slant surfaces extending in a front-back direction  
 along a peripheral direction of the cam ring (14).
6. The hammer drill (1) according to one of claims 1 to  
 5, wherein the through-holes (20) are provided in the  
 same number as the number of the cam projections  
 (18), and the cam projections (18) and the through-  
 holes (20) are in phase with each other.
7. The hammer drill (1) according to one of claims 1 to  
 6, wherein the final output shaft is a tubular tool hold-  
 er (6) having a bit-installable front end.
8. The hammer drill (1) according to claim 7, wherein  
 the cam ring (14) is provided on the tool holder (6)  
 through stopper balls (15) provided between the cam  
 ring (14) and the tool holder (6).

9. The hammer drill (1) according to claim 7 or 8, where-  
 in the rotation mechanism is rotatably supported in  
 the housing (2), parallel to the tool holder (6), and  
 the rotation mechanism includes an intermediate  
 shaft (38) having a first gear (39) at a rear side thereof  
 which is in mesh with an output shaft of a motor and  
 a second gear (41) at a front side thereof which is in  
 mesh with the gear.
10. The hammer drill (1) according to claim 9, wherein  
 the impact mechanism comprises: an impact bolt  
 (30) received in the tool holder (6) at a rear of the  
 bit; a tubular piston cylinder (35) inserted into the  
 tool holder (6) from a rear side of the impact bolt (30)  
 and in which a striker (37) is accommodated through  
 an air chamber; a connecting arm (44) connected to  
 a rear end of the piston cylinder (35); and a boss  
 sleeve (42) provided on the intermediate shaft (38)  
 and on which the connecting arm (44) is positioned  
 via a swash bearing (43) in a state where an axis of  
 the connecting arm (44) is inclined.
11. The hammer drill (1) according to claim 10, wherein  
 a clutch (45) is splined to the intermediate shaft (38)  
 between the second gear (41) and the boss sleeve  
 (42), and wherein three modes of operation can be  
 selected by a sliding movement of the clutch (45),  
 which include a drill mode in which the clutch (45)  
 merely engages with the second gear (41) to allow  
 a unitary rotation of the second gear (41) and the  
 intermediate shaft (38), a hammer mode in which  
 the clutch (45) merely engages with the boss sleeve  
 (42) to allow a unitary rotation of the boss sleeve (42)  
 and the intermediate shaft (38), and a hammer drill  
 mode in which the clutch (45) engages with both the  
 second gear (41) and the boss sleeve (42) to allow  
 a unitary rotation of the second gear (41) and the  
 boss sleeve (42) with the intermediate shaft (38).
12. The hammer drill (1) according to claim 11, wherein  
 a V-shaped fitting groove is formed around a periph-  
 eral surface of the clutch (45), and an engagement  
 pin (48) eccentrically provided on a mode-selecting  
 knob (47) is fitted into the fitting groove, so that the  
 clutch (45) is slid along the intermediate shaft (38)  
 by an eccentric movement of the engagement pin  
 (48) due to a rotation of the mode-selecting knob  
 (47).

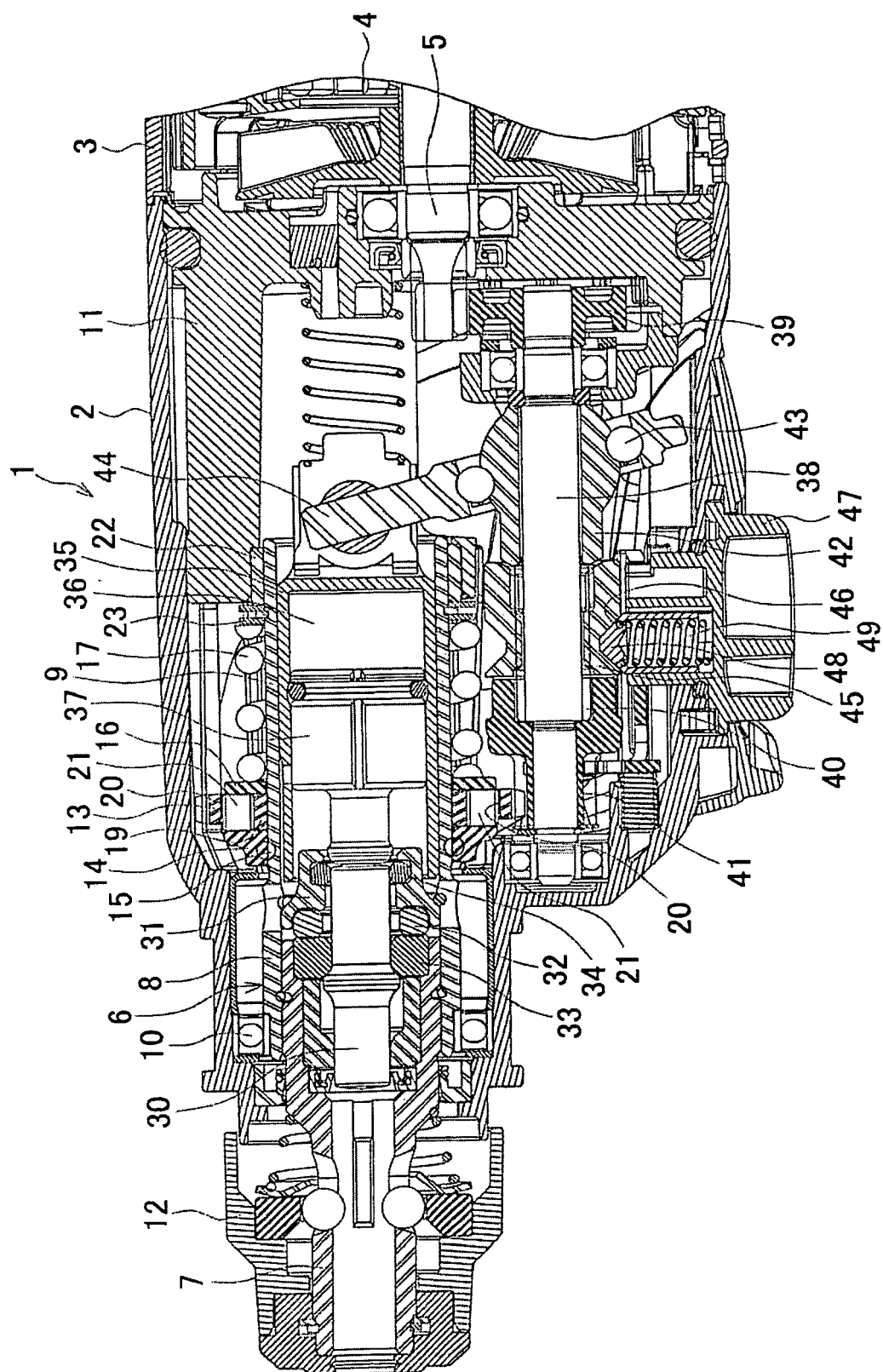


FIG. 1

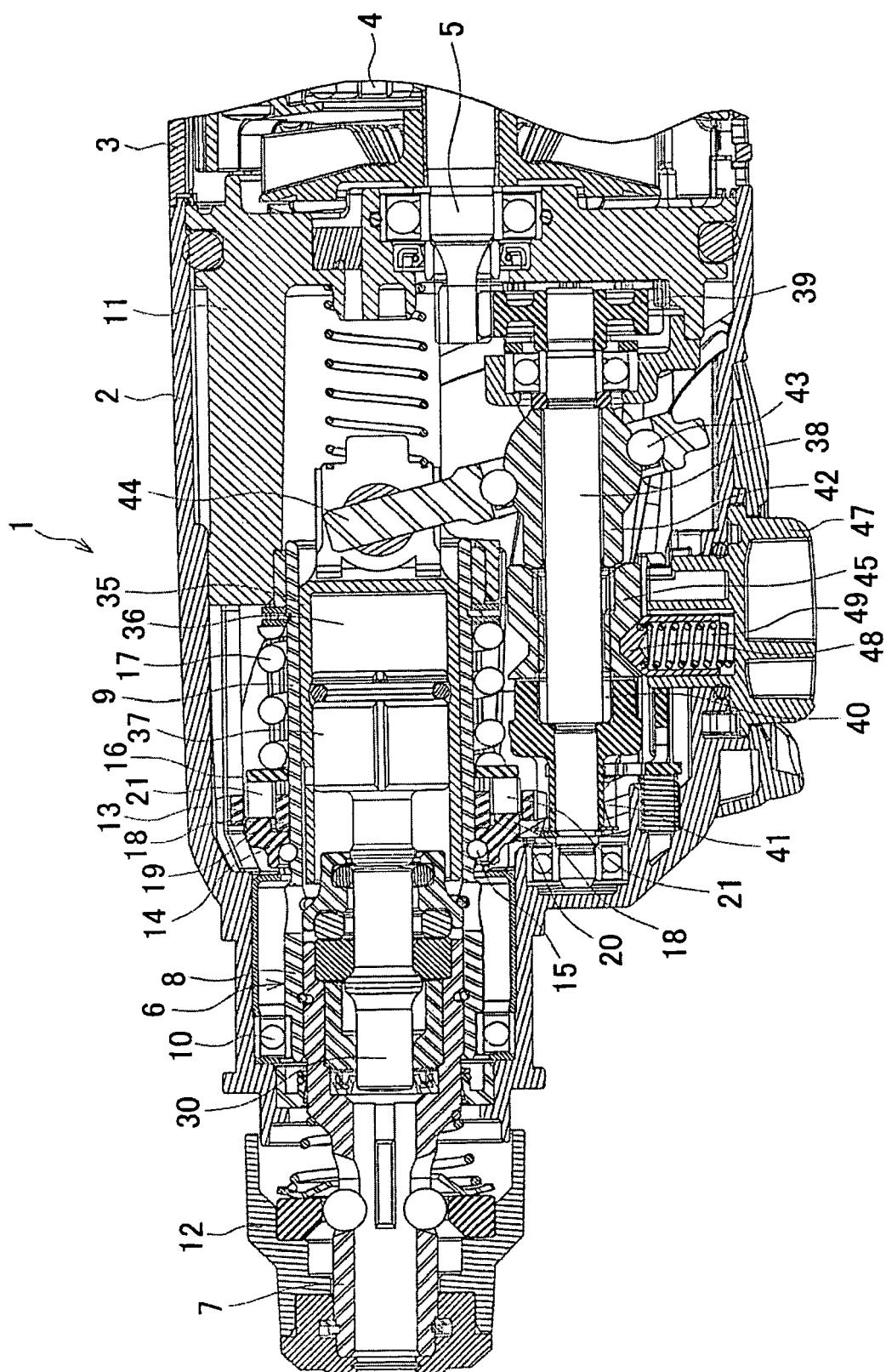


FIG. 2

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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