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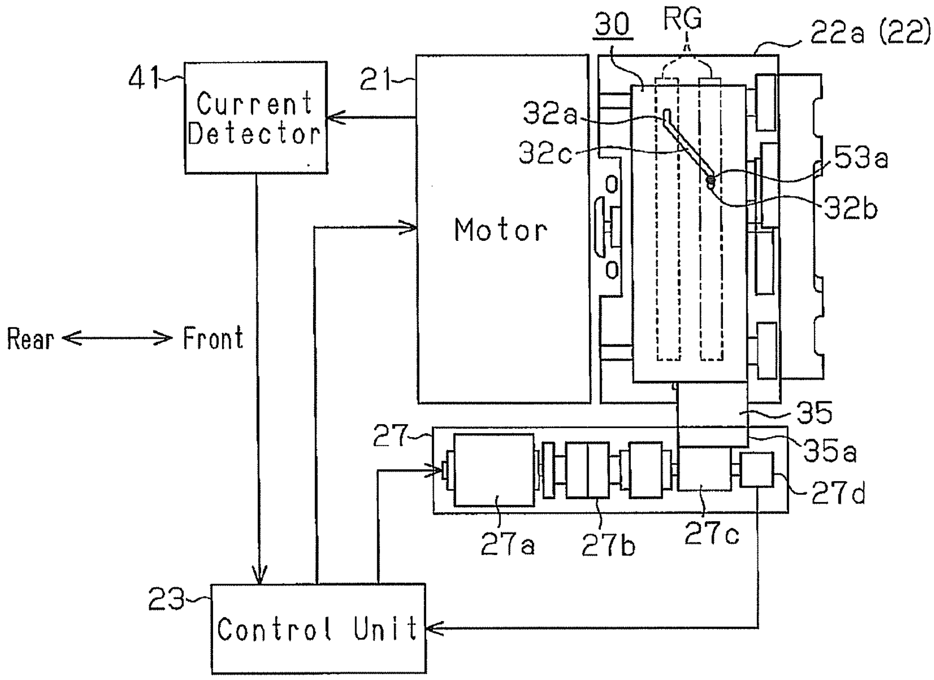
(54) Power tool

(57) A power tool that suppresses unexpected changes in the speed reduction ratio. A control unit (23) controls a gear shift actuator (27) to shift a speed reduction ratio of a power transmission unit (22) in accordance with the detected load torque. After shifting the speed reduction ratio, when a ring gear (RG) is not located at a target position corresponding to the shifted speed reduction ratio, that is, when a cam (30) is not located at a first engagement position or a second engagement position, the control unit (23) uses the gear shift actuator (27) to pivot the cam (30) again and move the ring gear (RG).

Fig.2



EP 2 708 329 A1

Description

[0001] The present invention relates to a power tool.

[0002] Japanese Laid-Open Patent Publication No. 2012-30347 describes an example of a power tool including a power transmission unit and a control unit. The power transmission unit reduces the rotation speed related to the rotational power produced by a motor. The control unit controls the power transmission unit to automatically shift the speed reduction ratio of the power transmission unit.

[0003] The power tool includes an output shaft and a tip tool (bit), which is coupled to the output shaft. The power tool detects the load torque applied to the output shaft and provides a gear shift actuator with a control signal for shifting the speed reduction ratio of the power transmission unit based on the detected load torque. When the speed reduction ratio is shifted to a predetermined value by the gear shift actuator, the control unit stops outputting the control signal and stops the gear shift actuator.

[0004] In such a power tool, the gear shift actuator stops operating after shifting the speed reduction ratio. This may result in deviation of the speed reduction ratio from the predetermined value due to displacement of a gear caused by operational vibration or wear of mechanical components. The displacement caused by inertial rotation until the motor of the actuator completely stops may also result in deviation of the speed reduction ratio from the predetermined value.

[0005] It is an object of the present invention to provide a power tool that suppresses unexpected changes in the speed reduction ratio.

[0006] One aspect of the present invention is a power tool including a motor and a power transmission unit that reduces a rotation speed related to rotational power of the motor in accordance with a speed reduction ratio that can be shifted and transmits the rotational power to an output shaft of the power tool. The power transmission unit includes a shifting member that is moved to shift the speed reduction ratio. A gear shift actuator moves the shifting member to shift the speed reduction ratio of the power transmission unit. A position detector detects a position of the shifting member and generates a detection signal. A torque detector detects a load torque applied to the output shaft. A control unit controls the gear shift actuator to shift the speed reduction ratio of the power transmission unit in accordance with the load torque detected by the torque detector. The control unit, after shifting the speed reduction ratio, determines with the detection signal generated by the position detector whether or not the shifting member is located at a target position corresponding to the speed reduction ratio. When determining that the shifting member is not located at the target position, the control unit controls the gear shift actuator to move the shifting member to the target position.

[0007] Preferably, in the above structure, when the control unit determines with the detection signal generated by the position detector that the shifting member is not located at the target position corresponding to the speed reduction ratio, the control unit controls the gear shift actuator to move the shifting member to the target position while decreasing an operational speed of the gear shift actuator.

[0008] Preferably, in the above structure, after shifting the speed reduction ratio, when the control unit determines with the detection signal generated by the position detector that the shifting member is not located at the target position corresponding to the speed reduction ratio, the control unit controls the gear shift actuator to move the shifting member to the target position. After a predetermined time elapses, when the control unit determines that the shifting member is not located at the target position, the control unit stops driving the gear shift actuator.

[0009] Preferably, in the above structure, after shifting the speed reduction ratio, when the control unit determines with the detection signal generated by the position detector that the shifting member is not located at the target position corresponding to the speed reduction ratio, the control unit controls the gear shift actuator to move the shifting member further away from the target position and then move the shifting member to the target position.

[0010] Preferably, in the above structure, the position detector detects the position of the shifting member and generates the detection signal in predetermined cycles.

[0011] Preferably, in the above structure, when controlling the gear shift actuator to move the shifting member, the control unit varies a speed at which the gear shift actuator moves the shifting member in accordance with the position of the shifting member using the detection signal generated by the position detector.

[0012] The present invention provides a power tool that suppresses unexpected changes in the speed reduction ratio.

Fig. 1 is a schematic diagram of a power tool according to one embodiment;
Fig. 2 is a schematic diagram of the power tool shown in Fig. 1;
Fig. 3 is a plan view of an automatic gear shift device in the power tool of Fig. 1;
Fig. 4 is a diagram illustrating an example of the operation of the power tool shown in Fig. 1;
Fig. 5 is a diagram illustrating an example of the operation of a modified power tool;
Fig. 6 is a diagram illustrating an example of the operation of a modified power tool;
Fig. 7 is a diagram illustrating an example of the operation of a modified power tool; and
Fig. 8 is a diagram illustrating an example of the operation of a modified power tool.

[0013] Referring to Fig. 1, a power tool 10 of the present embodiment is used as, for example, a drill driver and includes a main body 11 and a battery pack 12, which is attached to the main body 11 in a removable manner.

The main body 11 includes a motor 21, which is driven when supplied with electric power from the battery pack 12, a power transmission unit 22, which reduces the rotation speed related to the rotational power from the motor 21, and a control unit 23, which controls the power tool 10. The battery pack 12 includes a rechargeable battery formed by a plurality of battery cells (e.g., lithium-ion cells).

[0014] The motor 21 includes a rotation shaft 24. The power transmission unit 22, which includes a speed reduction mechanism and a clutch mechanism, is coupled to the rotation shaft 24. The power transmission unit 22 reduces the rotation speed related to the rotational power obtained from the motor 21 and transmits the rotational power to an output shaft 25. The power transmission unit 22 includes two gears, namely, an H gear and an L gear, and a ring gear RG (refer to Fig. 2), which serves as a shifting member. The ring gear RG is moved in the axial direction of the output shaft 25 and engaged with one of the two gears. This allows for the speed reduction ratio to be shifted between two steps. In the present embodiment, the ring gear RG is engaged with the H gear at a first engagement position. Fig. 2 shows two engagement positions indicated by broken lines, and the first engagement position is the rear one. When the ring gear RG is located at the first engagement position, the speed reduction ratio is relatively low. Thus, the power tool 10 operates in a mode in which the rotation speed is high and the torque is low.

[0015] Further, when the ring gear RG is moved away from the first engagement position toward the front, the ring gear RG is disengaged from the H gear. As the ring gear RG moves to a second engagement position, which is the front engagement position indicated by the broken lines, the ring gear RG is engaged with the L gear. When the ring gear RG is located at the second engagement position, the speed reduction ratio is relatively high. Thus, the power tool 10 operates in a mode in which the rotation speed is low and the torque is high.

[0016] In this manner, when the ring gear RG moves from the first engagement position to the second engagement position, the power transmission unit 22 switches operation modes from the high rotation speed-low torque mode in which the speed reduction ratio is low to the low rotation speed-high torque mode in which the speed reduction ratio is high. In contrast, when the ring gear RG moves from the second engagement position to the first engagement position, the power transmission unit 22 switches operation modes from the low rotation speed-high torque mode in which the speed reduction ratio is high to the high rotation speed-low torque mode in which the speed reduction ratio is low.

[0017] A tip tool 26 (bit) is coupled to the tip of the output shaft 25. Accordingly, the tip tool 26 is rotated together with the output shaft 25 when the power transmission unit 22 transmits the rotational power from the motor 21 to the output shaft 25.

[0018] The power tool 10 includes a gear shift actuator 27 that shifts the speed reduction ratio by moving the ring gear RG of the power transmission unit 22. The gear shift actuator 27 includes a gear shift motor 27a, a speed reduction unit 27b, and an output unit 27c. The gear shift motor 27a produces rotation in forward and reverse directions. The speed reduction unit 27b reduces the rotation speed related to the drive power produced by the gear shift motor 27a. The output unit 27c is rotated by the drive power transmitted by the speed reduction unit 27b. The output unit 27c is an output gear as shown in Fig. 3 and is engaged with a cam 30 of the power transmission unit 22. The cam 30 includes a main body 31 and an engagement block 35. The main body 31 is arcuate and extends along the outer surface of the ring gear RG. The engagement block 35 projects in the radial direction from the main body 31 toward the outer side.

[0019] The main body 31 includes cam holes 31a and 31b extending in the circumferential direction near the two ends of the main body 31. The cams holes 31a and 31b each include first and second holding portions 32a and 32b, which are separated from each other in the axial direction of the output shaft 25 and in the circumferential direction of the main body 31, and a connection portion 32c, which connects the first and second holding portions 32a and 32b. The engagement block 35 includes an arcuate surface forming a rack 35a that is engaged with the output unit 27c.

[0020] As shown in Fig. 3, the power transmission unit 22 includes a gear case 22a that accommodates the cylindrical ring gear RG. The gear case 22a includes an outer wall that is opposed to and spaced apart by a predetermined distance from an inner surface of the main body 31 of the cam 30. A groove RGa extends along the outer surface of the ring gear RG in the circumferential direction. The ring gear RG includes a support member 51 that is fitted into the groove RGa and movable relative to the ring gear RG.

[0021] The support member 51 includes a semi-arcuate support body 52, which extends along the outer surface of the ring gear RG, and two insertion pins 53a and 53b, which extend straight toward the outer side in the radial direction from the two ends of the support body 52. The gear case 22a includes two insertion holes 22b. The insertion pins 53a and 53b of the support member 51 are received in two insertion holes 22b of the gear case 22a and the two cam holes 31a and 31b of the cam 30.

[0022] As shown in Fig. 3, when the output unit 27c is engaged with the teeth at one end of the rack 35a (right end as viewed in the drawing), the insertion pin 53a of the support member 51 is arranged at the second holding portion 32b in the cam hole 31a, and the insertion pin 53b of the support member 51 is arranged at the second holding portion 32b in the cam hole 31b. Under this situation, the ring gear RG is arranged at the second engagement position (front engagement position indicated by the broken lines in Fig. 2) and the speed reduction ratio is set at the low rotation speed mode.

[0023] When the output unit 27c is rotated in the clockwise direction at the location shown in Fig. 3, the cam 30 is pivoted in the counterclockwise direction. When the output unit 27c is rotated by a predetermined rotation angle $\alpha 1$, the teeth at the other side of the rack 35a of the cam 30 become engaged with the output unit 27c. Here, the insertion pin 53a of the support member 51 is arranged at the first holding portion 32a in the cam hole 31a, and the insertion pin 53b of the support member 51 is arranged at the first holding portion 32a in the cam hole 31b. Further, the ring gear RG is moved by the pivoting of the cam 30 from the second engagement position to the first engagement position (rear engagement position indicated by the broken lines in Fig. 2) and the speed reduction ratio is shifted from the low rotation speed mode to the high rotation speed mode.

[0024] The gear shift actuator 27 includes a position detector 27d that detects the rotated amount of the output unit 27c. The position detector 27d has a resistance that changes in accordance with the rotation angle (rotation amount) of the output unit 27c. Based on changes in the resistance, the position detector 27d detects the position of the ring gear RG with respect to the movement direction (axial direction of the output shaft 25).

[0025] The gear shift actuator 27 is supplied with electric power from a gear shift driver 28 that is controlled by the control unit 23. The gear shift actuator 27 shifts the gears of the power transmission unit 22 under the control of the control unit 23 via the gear shift driver 28. Further, the control unit 23 runs on voltage-regulated electric power supplied from the battery pack 12. The gear shift driver 28 is formed by, for example, an H-bridge circuit using a switching element (e.g., FET). The control unit 23 provides the gear shift driver 28 with a control signal. Based on the control signal, the gear shift driver 28 controls the rotational direction of the motor in the gear shift actuator 27 and performs PWM control on the electric power supplied to the gear shift actuator 27.

[0026] As shown in Fig. 1, the power tool 10 includes a switching drive circuit 29 that is connected to the control unit 23 and formed by, for example, an H-bridge circuit using a switching element (e.g., FET). The switching drive circuit 29 supplies the motor 21 with electric power to drive and generate rotation with the motor 21. The control unit 23 performs PWM control on the switching drive circuit 29 and controls the electric power supplied to the motor 21 from the battery pack 12. In other words, the control unit 23 controls the electric power supplied to the motor 21 via the switching drive circuit 29. This controls the rotation speed of the motor 21.

[0027] The power tool 10 includes a trigger switch Tr that may be operated by a user. The trigger switch Tr is activated and deactivated to start and stop the motor 21. Further, the trigger switch Tr provides the control unit 23 with an output signal that is in accordance with the operation amount of the trigger switch Tr (pulled amount of trigger). The control unit 23 controls the electric power supplied to the motor 21 from the switching drive circuit 29 based on the output signal from the trigger switch Tr to start and stop the motor 21 and adjust the rotation speed of the motor 21.

[0028] The power tool 10 includes a current detector 41 arranged between the switching drive circuit 29 and the motor 21 to detect the drive current supplied to the motor 21. The current detector 41 includes a detection resistor 42 and an amplification circuit 43 (operational amplifier). The detection resistor 42 is connected between the switching drive circuit 29 and the motor 21. The amplification circuit 43 amplifies the voltage across the terminals of the detection resistor 42 to generate a detection signal provided to the control unit 23. The current detector 41 provides the control unit 23 with detection signals in predetermined sampling cycles. The control unit 23 detects the drive current based on detection signals from the current detector 41. Further, the control unit 23 detects the load torque applied to the output shaft 25 (tip tool 26) based on the detected drive current and the gear to which the power transmission unit 22 is shifted when the drive current is detected. The control unit 23 also detects locking of the motor 21 based on the detected load torque and controls the motor 21 in accordance with the detection.

[0029] Preferably, the power tool 10 includes a rotation detector 61 arranged on the rotation shaft 24 of the motor 21 to detect the rotation speed of the motor 21. The rotation detector 61 includes a sensor magnet 62, which is provided with magnetic poles and fixed to and rotated integrally with the rotation shaft 24, and a Hall element 63, which is arranged opposing the sensor magnet 62. The Hall element 63 provides the control unit 23 with a detection signal corresponding to changes in the magnetic flux based on the rotation of the sensor magnet 62. The control unit 23 detects the rotation speed of the motor 21 based on the detection signal from the rotation detector 61. The control unit 23 also detects locking of the motor 21 from changes in the rotation speed.

[0030] In the power tool 10, the control unit 23 controls the gear shift actuator 27 and automatically shifts the gears of the power transmission unit 22 based on the load torque detected by the control unit 23. The speed reduction mechanism of the power transmission unit 22 is, for example, a planetary gear speed reduction mechanism that includes a sun gear rotated about the rotation shaft 24 of the motor 21, planet gears engaged with the sun gear, and the ring gear RG engaged with the planet gears. The gear shift actuator 27 moves the ring gear RG to change the planet gear engaged with the ring gear RG. This controls the gear of the power transmission unit 22. The control unit 23 determines whether or not the gear shift actuator 27 has moved the ring gear RG to the correct position based on the detection signal from the position detector 27d and controls the gear shift actuator 27 accordingly.

[0031] When the user pulls the trigger switch Tr, the control unit 23 is provided with an output signal that is in accordance with the pulled amount. The control unit 23 controls the switching drive circuit 29 based on the output signal from the trigger switch Tr to start and stop the motor 21 and control the rotation speed of the motor 21. The power transmission unit 22 reduces the rotation speed related to the rotational power from the motor 21 and transmits the rotational power to the output shaft 25 to rotate the tip tool 26. The control unit 23 shifts the gears of the power transmission unit 22 to the H gear or the L gear in accordance with the load torque. In this case, the H gear is selected in the power transmission unit 22 when the load torque is relatively low to drive the tip tool 26 at a high rotation speed with a low torque. When the power tool 10 is activated, the H gear is selected in the power transmission unit 22. When the load torque increases and exceeds a predetermined torque, the L gear is selected in the power transmission unit 22. This drives the tip tool 26 at a low rotation speed with a high torque. Further, the control unit 23 determines whether or not locking of the motor 21 is occurring based on the detection signals from the rotation detector 61 and the current detector 41 and stops the motor 21 when detecting locking.

[0032] An example of the operation for shifting gears (speed reduction ratios) in the power tool 10 will now be described.

[0033] Referring to Figs. 1 to 4, when gear shifting conditions are satisfied at time t0, the control unit 23 drives the gear shift actuator 27 to pivot the cam 30 and move the ring gear RG. As a result, the ring gear RG switches from the H gear to the L gear and shifts the speed reduction ratio. Then, at time t1, when the control unit 23 determines that the output unit 27c has been rotated by the predetermined rotation angle $\alpha 1$ and that the output unit 27c has reached the target position based on the detection signal of the position detector 27d, the control unit 23 stops the motor 27a of the gear shift actuator 27 and ends the gear shifting operation.

[0034] The gear shift motor 27a of the present embodiment does not include a braking function, which is a function that immediately stops the motor with a regenerative diode when the power supply is cut. Thus, the gear shift motor 27a continues inertial rotation after the power supply is cut. The inertial rotation continuously pivots the cam 30. The pivoting of the cam 30 causes the second holding portions 32b of the cam 30 to strike the insertion pins 53a and 53b of the support member 51. The striking may result in a reaction that pivots the cam 30 in a direction opposite to the predetermined direction (time t2). Further, for example, operational vibration may displace the cam 30 (gear shift cam plate) from a predetermined position.

[0035] Thus, at time t3, when a predetermined time elapses from when the gear shifting operation ends (time t1) and the control unit 23 determines from the detection signal of the position detector 27d that the cam 30 is not located at the predetermined position, the control unit 23 drives the motor 27a of the gear shift actuator 27 and pivots the cam 30 to move the ring gear RG to the predetermined position (time t4). In this case, the control unit 23 changes the duty ratio of the motor 27a in the gear shift actuator 27 so that the rotation produced by the motor 27a is slower than that for a normal gear shifting operation. Then, as the control unit 23 pivots the cam 30 and determines from the detection signal of the position detector 27d that the output unit 27c (ring gear RG) has reached the target position, the control unit 23 stops driving the motor 27a of the gear shift actuator 27 and ends the control of the gear shift actuator 27.

[0036] The present embodiment has the advantages described below.

(1) The control unit 23 controls the gear shift actuator 27 to shift the speed reduction ratio of the power transmission unit 22 in accordance with the detected load torque. After shifting the speed reduction ratio, if the ring gear RG (cam 30 is not located at the target position (first engagement position or second engagement position) corresponding to the shifted speed reduction ratio, the control unit 23 pivots the cam 30 again with the gear shift actuator 27 to move the ring gear RG. Thus, after the speed reduction ratio is shifted, unexpected shifting of the speed reduction ratio may be suppressed.

(2) When determining with the detection signal of the position detector 27d that the ring gear RG is not located at the target position corresponding to the speed reduction ratio, the gear shift actuator 27 is operated at an operation speed that is slower than normal to move the ring gear RG to the target position corresponding to the shifted speed reduction ratio. Thus, for example, after the power supply for the gear shift motor 27a is cut, the inertial rotation amount of the gear shift motor 27a may be compensated for even when there is no braking function. More specifically, when the second holding portions 32b of the cam 30 strikes against the insertion pins 53a and 53b of the support member 51, the reaction moves the cam 30 in a direction opposite to the predetermined direction by an amount that is compensated for.

[0037] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

[0038] In the above embodiment, the control processes described below may be added.

[0039] Referring to Fig. 5, after shifting the speed reduction ratio, if the control unit 23 determines with the detection signal of the position detector 27d that the cam 30 is not located at the target position corresponding to the speed reduction ratio (t5), the control unit 23 controls the gear shift actuator 27 (motor 27a) to move the ring gear RG to the target position corresponding to the speed reduction ratio. Then, after a predetermined time elapses (time t6), if the control unit 23 determines that the cam 30 is not located at the target position corresponding to the speed reduction ratio, the control unit 23 stops driving the gear shift actuator 27 (motor 27a). By performing such a control, the operation of the gear shift actuator 27 may be stopped without forcibly moving the ring gear RG to the target position. This reduces the risk of damaging the gear shift actuator 27 and the power transmission unit 22.

[0040] Referring to Fig. 6, the control unit 23 may detect the position of the ring gear RG in predetermined cycles. In this manner, by detecting the position of the ring gear RG for a number of times, whenever the ring gear RG is separated from the target position, the ring gear RG may be moved to the target position.

[0041] Referring to Fig. 7, after shifting the speed reduction ratio, if the control unit 23 determines with the detection signal of the position detector 27d that the cam 30 is not located at the target position corresponding to the speed reduction ratio, the control unit 23 moves the ring gear RG further away from the target position (time t7). Then, the control unit 23 controls the gear shift actuator 27 to move the ring gear RG to the target position corresponding to the speed reduction ratio (time t8).

[0042] When moving the ring gear RG, the control unit 23 may use the detection signal of the position detector 27d to vary the speed at which the ring gear RG is moved in accordance with the position of the ring gear RG. For example, as shown in Fig. 8, when gear shift conditions are satisfied at time t10, the control unit 23 drives the gear shift actuator 27 (motor 27a) and pivots the cam 30. The control unit 23 drives the motor 27a with a duty ratio of 100% until time t11. Then, the control unit 23 drives the motor 27a with a duty ratio of 60%. Then, the control unit 23 drives the motor 27a with a duty ratio of 40% until gear shifting is completed at time t14. When the gear shifting is completed (time t14), the control unit 23 stops driving the motor 27a. In this manner, the control unit 23 gradually decreases the rotation speed of the motor 27a from when the gear shifting is started to decrease the movement speed of the ring gear RG. Such a control decreases the amount the cam 30 is moved in a direction opposite to the predetermined direction by the reaction produced when the cam 30 strikes the support member 51 due to inertia.

[0043] In the above embodiment, after shifting from the H gear to the L gear (after shifting the speed reduction gear), when the position of the ring gear RG is detected and the cam 30 is not located at the second engagement position that is the target position, the ring gear RG is moved to the second engagement position. However, there is no limit to such a control. For example, after shifting from the L gear to the H gear (after shifting the speed reduction gear), when the position of the ring gear RG is detected and the cam 30 is not located at the first engagement position that is the target position, the ring gear RG may be moved to the first engagement position.

[0044] In the above embodiment, the power transmission unit 22 shifts to two speed reduction ratios. Instead, the power transmission unit 22 may shift to three or more speed reduction ratios.

[0045] In the above embodiment, the gear shift actuator 27 is a motor actuator. However, the gear shift actuator 27 does not have to use a motor as a drive source and may use a solenoid or the like instead.

[0046] In the above embodiment, motor locking is detected. However, this detection may be omitted.

[0047] In the above embodiment, the power tool 10 is embodied in a drill driver but may be embodied in a different type of power tool such as an impact driver, an impact wrench, a hammer drill, a vibration drill, a jigsaw, and a sealing gun.

[0048] The present examples and embodiments are to be considered as illustrative and not restrictive.

Claims

1. A power tool (10) **characterized by** comprising:

   a motor (21);
   a power transmission unit (22) that reduces a rotation speed related to rotational power of the motor (21) in accordance with a speed reduction ratio that can be shifted and transmits the rotational power to an output shaft (25) of the power tool (10), wherein the power transmission unit (22) includes a shifting member (RG) that is moved to shift the speed reduction ratio;
   a gear shift actuator (27) that moves the shifting member (RG) to shift the speed reduction ratio of the power transmission unit (22);
   a position detector (27d) that detects a position of the shifting member (RG) and generates a detection signal;
   a torque detector (41) that detects a load torque applied to the output shaft; and
   a control unit (23) that controls the gear shift actuator to shift the speed reduction ratio of the power transmission unit in accordance with the load torque detected by the torque detector (41), wherein the control unit, after shifting the speed reduction ratio, determines with the detection signal generated by the position detector (27d) whether or not the shifting member (RG) is located at a target position corresponding to the speed reduction ratio; and
   when determining that the shifting member (RG) is not located at the target position, the control unit (23) controls the gear shift actuator to move the shifting member (RG) to the target position.

2. The power tool according to claim 1, being **characterized in that**:

   when the control unit (23) determines with the detection signal generated by the position detector (27d) that the shifting member (RG) is not located at the target position corresponding to the speed reduction ratio, the control unit (23) controls the gear shift actuator (27) to move the shifting member (RG) to the target position while decreasing an operational speed of the gear shift actuator (27).

3. The power tool according to claim 1 or 2, being **characterized in that**:

after shifting the speed reduction ratio, when the control unit (23) determines with the detection signal generated by the position detector (27d) that the shifting member (RG) is not located at the target position corresponding to the speed reduction ratio, the control unit (23) controls the gear shift actuator (27) to move the shifting member (RG) to the target position; and
after a predetermined time elapses, when the control unit (23) determines that the shifting member (RG) is not located at the target position, the control unit (23) stops driving the gear shift actuator (27).

4. The power tool according to any one of claims 1 to 3, being **characterized in that**:

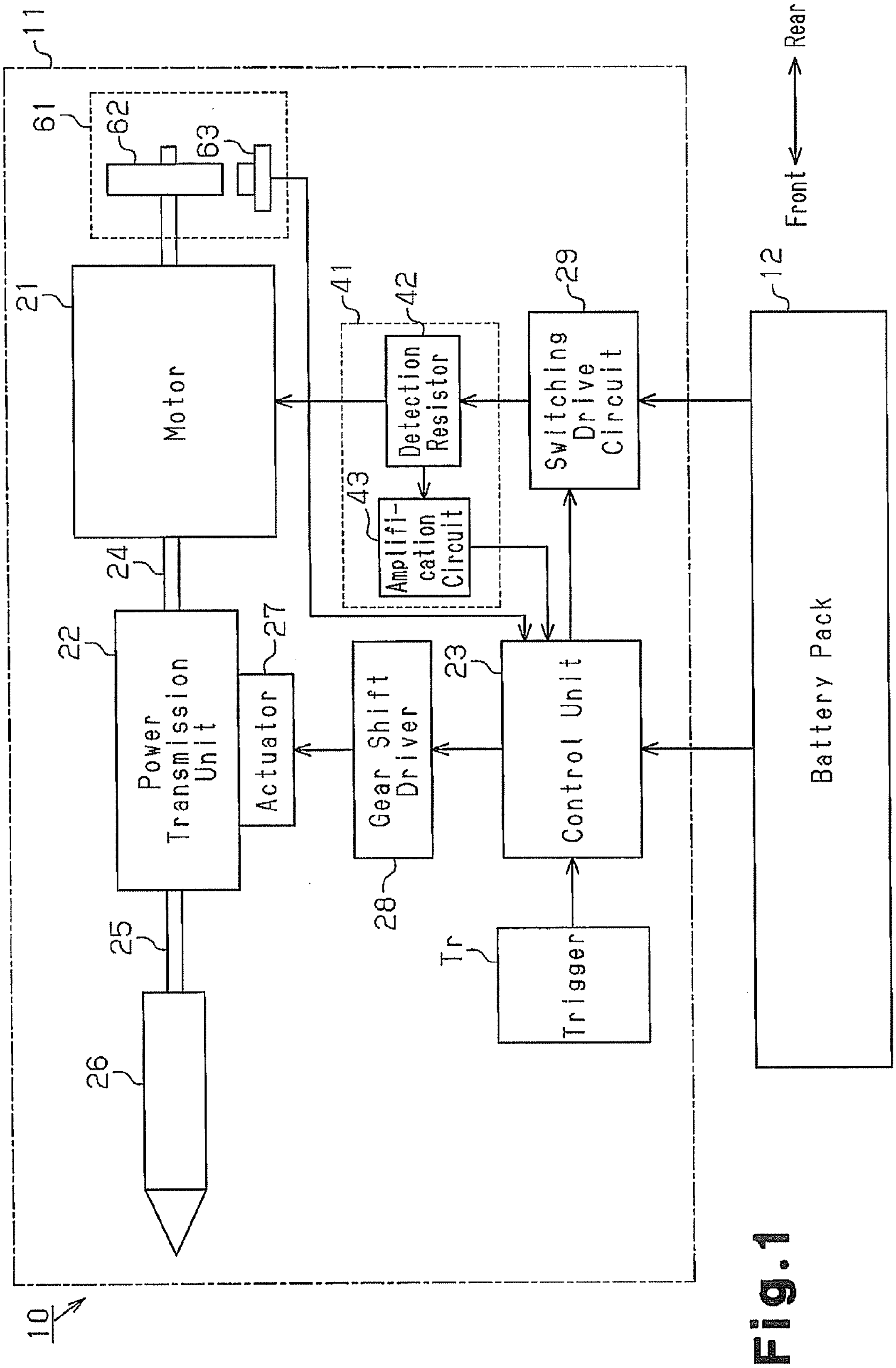
after shifting the speed reduction ratio, when the control unit (23) determines with the detection signal generated by the position detector (27d) that the shifting member (RG) is not located at the target position corresponding to the speed reduction ratio, the control unit (23) controls the gear shift actuator (27) to move the shifting member (RG) further away from the target position and then move the shifting member (RG) to the target position.

5. The power tool according to any one of claims 1 to 4, being **characterized in that**:

the position detector detects the position of the shifting member (RG) and generates the detection signal in predetermined cycles.

6. The power tool according to any one of claims 1 to 5, being **characterized in that**:

when controlling the gear shift actuator (27) to move the shifting member, the control unit (23) varies a speed at which the gear shift actuator (27) moves the shifting member (RG) in accordance with the position of the shifting member (RG) using the detection signal generated by the position detector (27d).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Motor
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Switching Drive Circuit
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24
22
Power Transmission Unit
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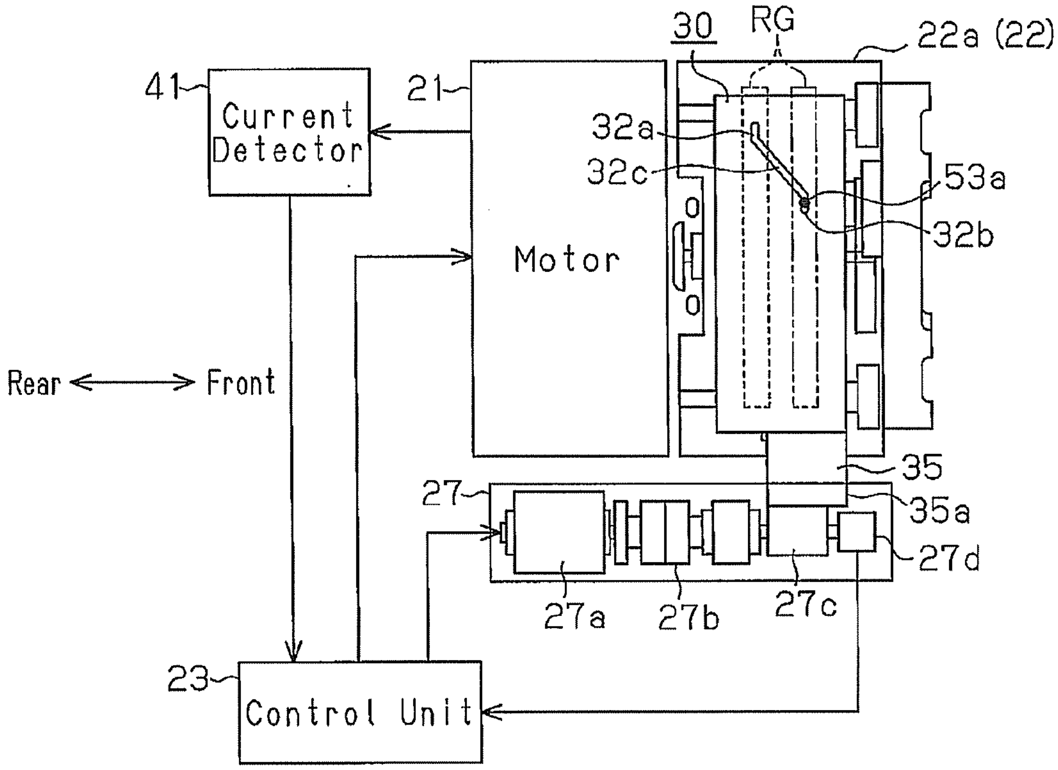
Actuator
Gear Shift Driver
23
Control Unit
Battery Pack
28
25
Tr
Trigger
26
10

Fig.1

Fig.2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27c
23
Control Unit

Fig.3

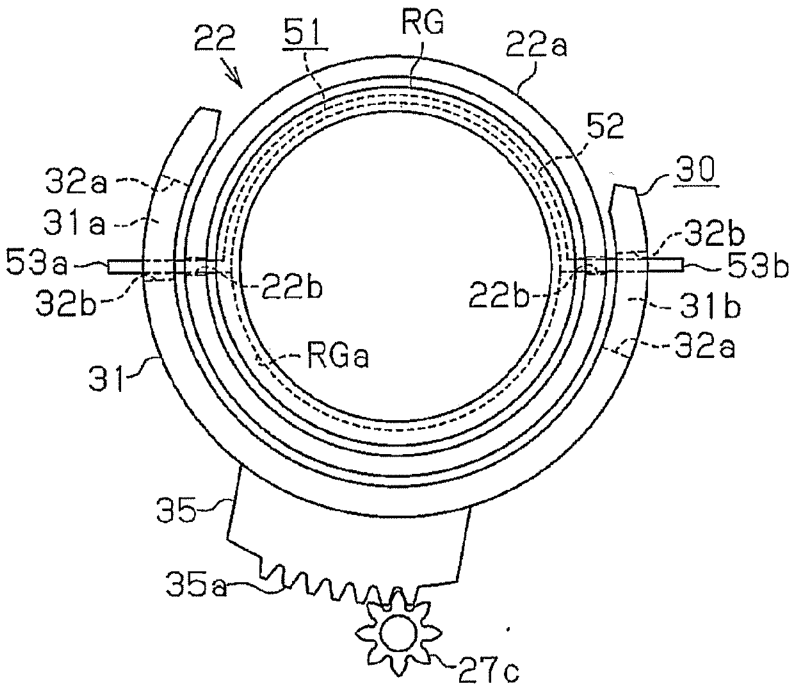
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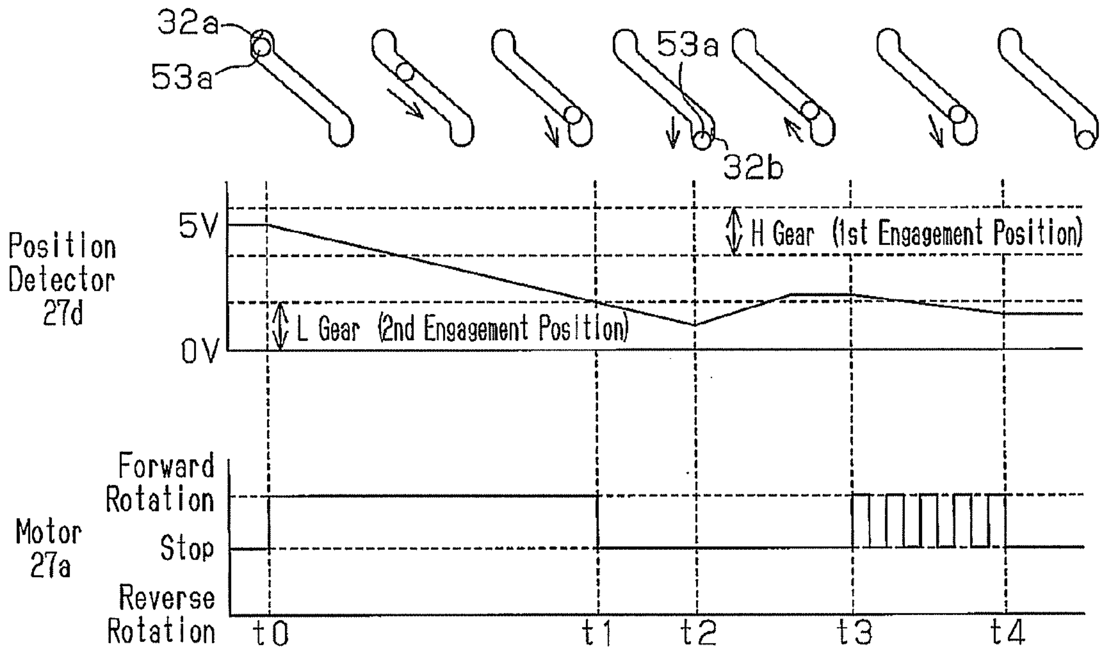
Fig.4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5V
0V
H Gear (1st Engagement Position)
L Gear (2nd Engagement Position)
Motor 27a
Forward Rotation
Stop
Reverse Rotation
t0
t1
t2
t3
t4

Fig.5

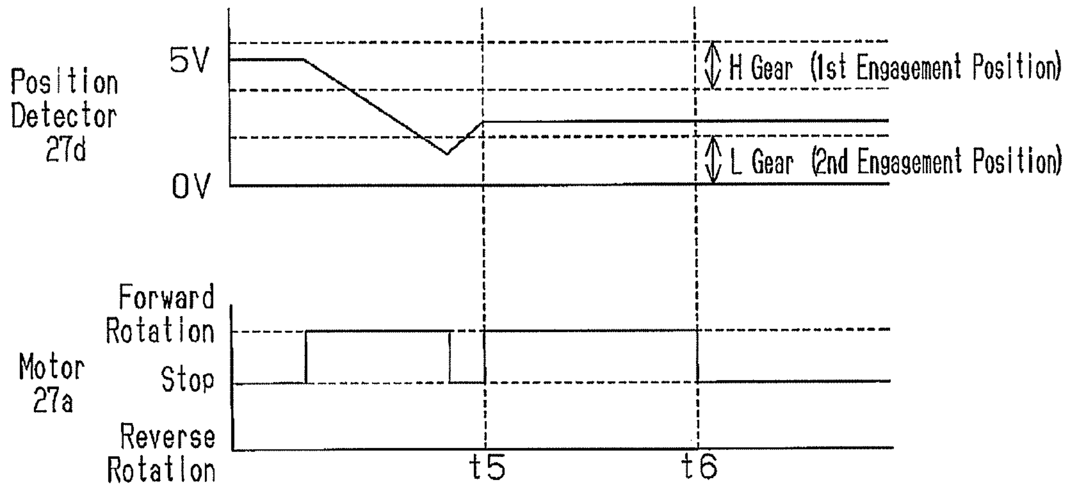

Position Detector 27d
5V
0V
H Gear (1st Engagement Position)
L Gear (2nd Engagement Position)
Motor 27a
Forward Rotation
Stop
Reverse Rotation
t5
t6

Fig.6

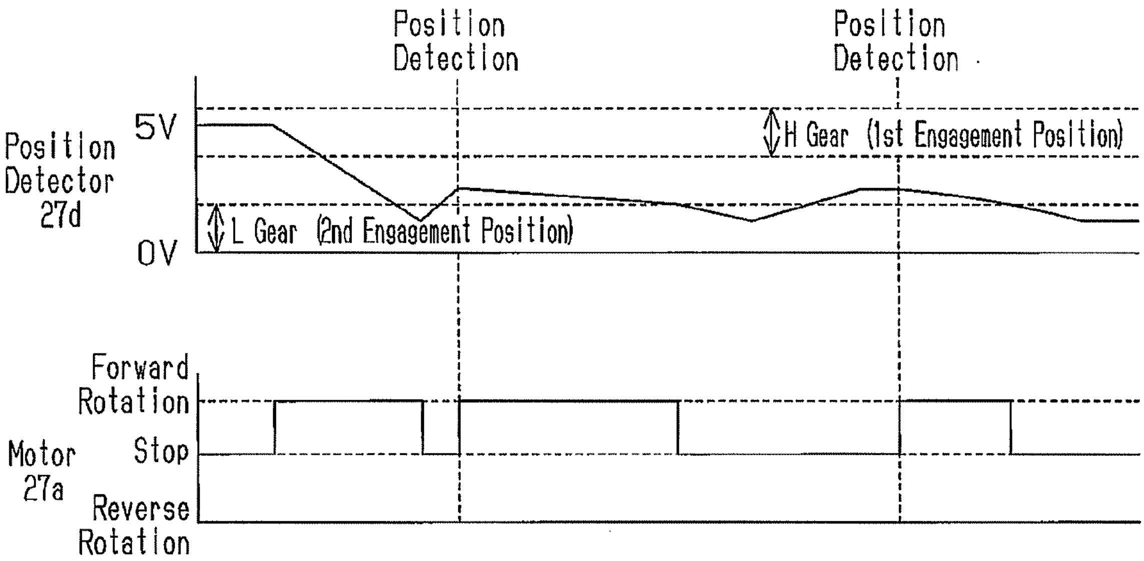

Position
Detection
Position
Detection
Position
Detector
27d
5V
0V
H Gear (1st Engagement Position)
L Gear (2nd Engagement Position)
Forward
Rotation
Motor
27a
Stop
Reverse
Rotation

Fig.7

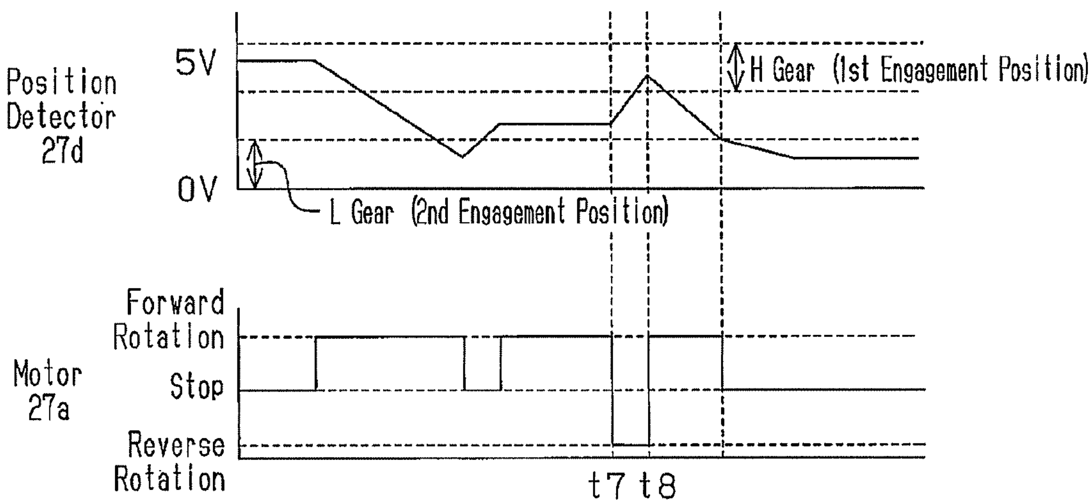
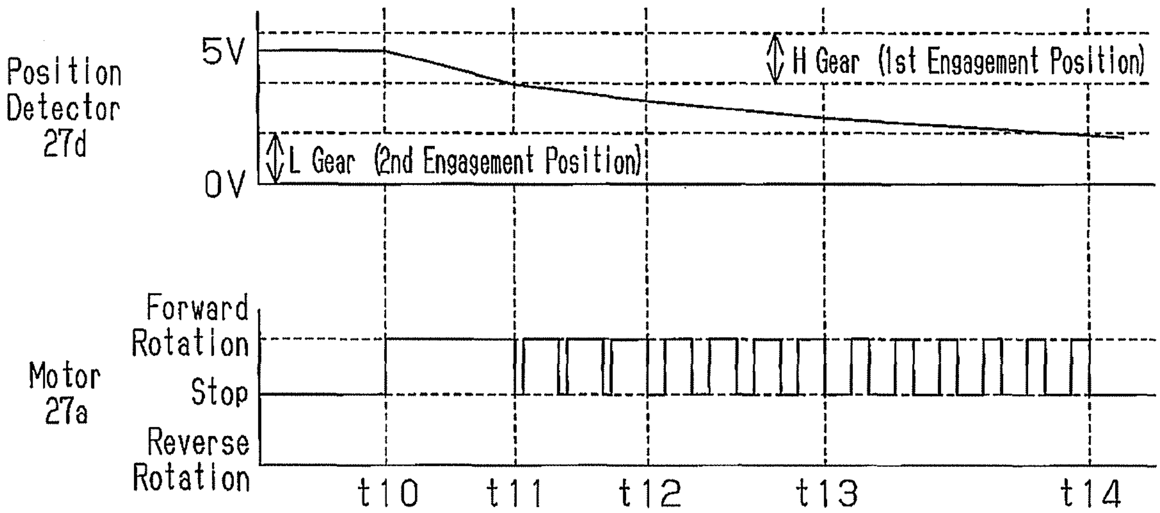

Position
Detector
27d
5V
0V
H Gear (1st Engagement Position)
L Gear (2nd Engagement Position)
Forward
Rotation
Motor
27a
Stop
Reverse
Rotation
t7 t8

Fig.8


Position
Detector
27d
5V
0V
H Gear (1st Engagement Position)
L Gear (2nd Engagement Position)
Motor
27a
Forward
Rotation
Stop
Reverse
Rotation
t10
t11
t12
t13
t14

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 3461

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	JP 2012 030347 A (PANASONIC ELECTRIC WORKS POWER) 16 February 2012 (2012-02-16) * the whole document * -----	1-6	INV. B25F5/00
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TECHNICAL FIELDS SEARCHED (IPC)
B25F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 January 2014	Gavaza, Bogdan

2

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