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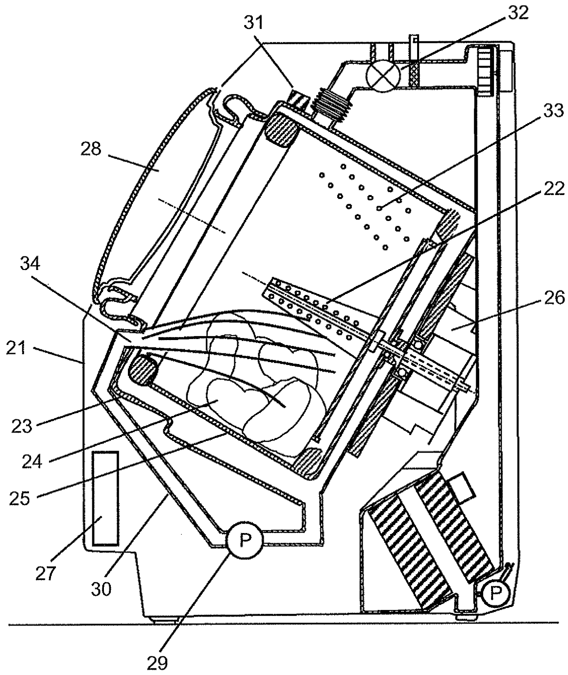
(54) **Drum-type washing machine**

(57) A controller of a drum-type washing machine controls rotation of a drum by controlling a driver while intermittently operating a circulating pump during a washing operation. While the circulating pump is stopped, the controller controls a drum rotating speed at a speed lower than a drum rotating speed while the circulating pump is operated.

FIG. 1



EP 2 113 600 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a drum-type washing machine employing a circulating pump which discharges washing water at the bottom of a washing tub toward laundries during washing.

BACKGROUND ART

[0002] A conventional drum-type washing machine agitates laundries by rotation of a drum in a washing step. In addition, the washing machine may be equipped with a circulating pump for discharging washing water at the bottom of a washing tub toward the laundries in the drum so as to enhance the washing effect. Fig. 4 is a sectional view of the conventional drum-type washing machine equipped with the circulating pump. Cylindrical washing tub 3 is disposed inside casing 1. Motor 6 is fixed to a left external side face of washing tub 3. Motor 6 rotatably supports cylindrical drum 5 with a bottom inside washing tub 3.

[0003] Water supply valve 12 for supplying washing water, water-level sensor 13 for detecting a water level of washing water, circulating pump 9 for circulating washing water, and circulating water passage 10 are connected to washing tub 3. Controller 7 receives a signal from water-level sensor 13, and controls the operation of motor 6 and circulating pump 9 so as to execute a series of operations, including washing, rinsing, and dehydration.

[0004] In this drum-type washing machine, baffle 14 provided on an inner side portion of drum 5 lifts up the laundry when drum 5 rotates, and lets the laundry fall due to its own weight. While the laundry is agitated and washed by beat-washing in this way, circulating pump 9 sprays washing water to the laundry from opening 15 created at an upper part of circulating water passage 10. This enhances the washing effect. However, if air bubbles enter circulating pump 9, they generate noise, or degrades washing performance due to generation of excessive foam.

[0005] This washing machine prevents generation of excessive foam by controlling circulating pump 9 in a way described next. First, washing starts at water level A required in a washing step. However, when the laundry absorbs water and the water level in washing tub 3 lowers, air is likely to enter circulating pump 9. Therefore, water-level sensor 13 detects the water level inside washing tub 3, and controller 7 stops the operation of circulating pump 9 when the water level decreases to predetermined first threshold B. Then, when the water level increases to predetermined second threshold C, controller 7 drives circulating pump 9 again.

[0006] In this control, however, a laundry load becomes large when the laundry absorbs large quantities of water by driving circulating pump 9, and thus the rotating number of drum 5 per unit time (rotating speed) also decreases. This results in insufficient lifting of the laundry by baffle 14, and the beat-washing effect degrades. Contrarily, if the laundry contains less amount of water by stopping circulating pump 9, the laundry load is small. In this case, baffle 14 can sufficiently lift up the laundry, and an effective beat-washing effect is achievable.

[0007] On the other hand, the rotating speed of drum 5 may be set to be obtain the beat-washing effect on the assumption that load becomes large due to absorbing large quantities of water in the laundry by driving circulating pump 9. However, if circulating pump 9 is stopped to prevent generation of foam, the laundry may stick to the drum and rotate together with the drum due to small laundry load and too fast rotating speed of drum 5. This degrades the washing effect. As described above, whether lifting of laundry by baffle 14 is sufficient or insufficient changes in line with the operation state of circulating pump 9. This changes the washing performance.

SUMMARY OF THE INVENTION

[0008] The present invention offers a drum-type washing machine that demonstrates stable washing power by making a drum lift up laundry satisfactorily so as to produce a beat-washing effect, regardless of an operation state of a circulating pump.

[0009] The drum-type washing machine of the present invention includes a washing tub, a cylindrical drum with a bottom, a driver, a baffle, a circulating water passage, a circulating pump, a vibration sensor, and a controller. The washing tub holds washing water. The drum is rotatably disposed inside the washing tub. The driver for rotating the drum is disposed outside the washing tub. The baffle for agitating laundry is provided on an inner peripheral side wall of the drum. The circulating water passage is connected to the washing tub. The circulating pump is provided in the circulating water passage and takes in washing water in the washing tub, and discharges it into the drum via the circulating water passage. The vibration sensor detects vibration of the washing tub. The controller receives a signal from the vibration sensor, and controls the operation of the driver and the circulating pump. In the washing operation, the controller intermittently operates the circulating pump. While the circulating pump is stopped, the controller controls the driver to rotate the drum in a first rotating speed. On the other hand, while the circulating pump is operated, the controller controls the driver to rotate the drum at a second rotating speed which is faster than the first rotating speed.

[0010] With this structure, the laundry can be lifted up well by rotating the drum at high speed, even when a load applied to lifting of the laundry by the baffle increases due to the laundry becoming heavy by operating the circulating pump. This improves the washing power. The washing power can thus be improved by selecting a drum rotating speed that satisfactorily lifts the laundry by the baffle, regardless of the operation state of the circulating pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a sectional view of a drum-type washing machine in accordance with an exemplary embodiment of the present invention.

Fig. 2 illustrates the relationship among movement of cloth (laundry), washing power, and shaking of washing tub in the drum-type washing machine shown in Fig. 1.

Fig. 3 illustrates how a washing step is controlled in the drum-type washing machine shown in Fig. 1.

Fig. 4 is a sectional view of a conventional drum-type washing machine.

DETAILED DESCRIPTION OF THE INVENTION

[0012] An exemplary embodiment of the present invention is described with reference to drawings. It is apparent that the present invention is not limited to this exemplary embodiment.

[0013] Fig. 1 is a vertical sectional view of a drum-type washing machine in this exemplary embodiment of the present invention. This washing machine includes casing 21, washing tub 23, cylindrical drum 25 with a bottom, driver 26, baffle 22, circulating water passage 30, circulating pump 29, vibration sensor 31, and controller 27.

[0014] Washing tub 23 holding washing water is disposed inside casing 21, and supported by multiple suspensions (not illustrated). Washing tub 23 has a substantially cylindrical shape that is axisymmetric to a rotating axis. In addition, the rotating axis of washing tub 23 is tilted upward to the front relative to the horizontal direction, with its bottom on the downside. An opening in washing tub 23 is openably covered with cover 28.

[0015] Drum 25 is rotatably disposed in washing tub 23. Baffle 22 for agitating laundry is provided on an inner peripheral side wall of drum 25. The peripheral side wall of drum 25 is provided with holes 33 for passing water. Driver 26 is disposed outside washing tub 23, and rotates drum 25. In other words, drum 25 is disposed inside washing tub 23, and is rotated by driver 26, such as a motor, provided on the bottom of washing tub 23. Driver 26 is configured typically with a brushless motor, and controller 27 variably controls its rotating speed (number of revolutions per unit time).

[0016] Circulating pump 29 and circulating water passage 30 are provided under washing tub 23. Circulating water passage 30 is connected to washing tub 23, and circulating pump 29 is provided in circulating water passage 30. Circulating pump 29 takes in washing water (or rinsing water) held in washing tub 23, and discharges it into drum 25 from opening 34 provided on the front face of washing tub 23 via circulating water passage 30.

[0017] Vibration sensor 31 configured typically with an acceleration sensor is provided on a top part of washing tub 23. Vibration sensor 31 detects vibration of washing tub 23. Vibration sensor 31 continuously send an output signal to controller 27. Therefore, controller 27 can continuously monitor the vibration state of washing tub 23 during drum 25 is rotated.

[0018] As described above, controller 27 receives a signal from vibration sensor 31, and controls the operation of driver 26 and circulating pump 29 so as to control a series of washing steps. Controller 27 executes forward-reverse continuous pivot drive of drum 25 using driver 26. Controller 27 also controls a dehydration step, and so on.

[0019] In the drum-type washing machine as configured above, driver 26 is activated by an instruction from controller 27 and drum 25 rotates when a user operates a control panel (not illustrated) to start the washing operation. Controller 27 determines a quantity and quality of laundry based on a value of current traveling to driver 26 at this point. Based on this determination result, controller 27 opens water supply valve 32 so as to supply water to washing tub 23 until a predetermined water level. A known water-level sensor (not illustrated) detects the water level, and sends a signal on water level to controller 27.

[0020] Then, drum 25 rotates and agitates laundry 24 to start the washing operation. In order to make laundry 24 soaked with washing water quickly to enhance the washing power, controller 27 also starts the operation of circulating pump 29. Circulating pump 29 is intermittently operated to suppress generation of foam.

[0021] Next, the relationship among movement of laundry 24, washing power, and shaking of washing tub 23 is described with reference to Fig. 2. Fig. 2 illustrates movement of clothes (laundry), washing power, and shaking of washing tub in the drum-type washing machine in this exemplary embodiment.

[0022] In a state shown in Fig. 2(a), baffle 22 sufficiently lifts up laundry 24, and then lets it fall, making a substantially reverse-U shaped curve. This state includes a so-called beat-washing movement. In this state, drum 25 is operated at a rotating speed optimal for obtaining a high washing power. Since washing tub 23 shakes strongly, vibration sensor 31 detects a large level of vibration.

[0023] In a state shown in Fig. 2(b), laundry 24 is not caught by baffle 22, and is slipped off, due to low rotation of drum 25. Therefore, laundry 24 is rolling at the lower part of drum 25. In this state, the washing power applied to laundry 24 is low, and washing tub 23 also shakes (vibrates) weakly.

[0024] In a state shown in Fig. 2(c), the rotating speed of drum 25 is high. This makes laundry 24 pressed to an inner side wall of drum 25 by the centrifugal force, rather than being caught by baffle 22. Accordingly, the washing power is low and vibration of washing tub 23 also becomes weak.

[0025] In order to achieve movement of laundry 24 that causes strong shaking of washing tub 23 and high washing power, as described above, the rotating speed of drum 25 needs to be controlled optimally. In other words, the beat-washing state shown in Fig. 2(a) is needed. In the beat-washing state, optimal rotating speed delicately changes momentarily by type and quantity of laundry 24, moisture content in laundry24, and how clothes are entangled. In the beat-washing state, laundry 24 at the lower part of drum 25 moves together with the inner side wall of drum 25 as drum 25 rotates, and baffle 22 catches laundry 24 to lift it up. Then, laundry 24 falls when the dropping force surpasses the centrifugal force in a balance of the centrifugal force generated by rotation of drum 25 and a dropping force of wet laundry 24.

[0026] Wet laundry 24 discharges water outside at once when it falls and is beaten. This makes laundry 24 light. The balance of drum 25 changes by water coming in and out of laundry 24. Therefore, a cloth that absorbs large quantities of water causes stronger vibration in the beat-washing state. Moisture content in laundry 24 and a change in shape by dropping movement significantly vary depending on a material (wool, cotton, etc.), a texture of laundry 24, and entanglement of laundry 24 to each other. In addition, turning on and off of the operation of circulating pump 29 particularly and extremely changes the moisture content in laundry 24, and also changes movement of laundry 24. Accordingly, the rotating speed of drum 25 needs to be set corresponding to the activation and stoppage of circulating pump 29.

[0027] Next, how controller 27 controls is described with reference to Fig. 3. Fig. 3 illustrates how the washing step is controlled in the drum-type washing machine in this exemplary embodiment. More specifically, Fig. 3 illustrates the relationship of the rotating direction and rotating speed of drum 25, on and off of the operation of circulating pump 29, and output of vibration sensor 31 with respect to the elapse of time from start of the washing step.

[0028] When the washing step starts, controller 27 changes the rotating speed of drum 25 in a stepwise fashion, while driving circulating pump 29, so as to detect shaking of washing tub 23 by an output of vibration sensor 31 (S01). Through this operation, controller 27 determines an optimal rotating speed of drum 25 for satisfactorily lifting up laundry 24 in drum 25 by baffle 22.

[0029] In other words, controller 27 controls driver 26 to change the rotating speed of drum 25 stepwise at the beginning of washing operation, and compares outputs of vibration sensor 31 in each rotating speed. In this way, a reference rotating speed is determined so that an optimal rotating speed corresponding to each of a broad range of loads from no-load to rated load can be selected. In addition, an optimal rotating speed is selectable in a short time by not selecting a rotating speed at too fine intervals more than necessary.

[0030] In an example shown in Fig. 3, controller 27 changes the rotating speed of drum 25 in a stepwise fashion from 41 rpm to 53 rpm by 4 rpm each. A variation range and intervals are preferably set within a practically-selectable range and also within the minimum necessary, taking into consideration quantity and texture of laundry 24.

[0031] In this example, the range is determined based on the size of drum 25, shape of baffle 22, setting for rotating speed, and so on of a commercially-available washing machine at present, regardless of the operation of circulating pump 29. In this case, laundry 24 just rolls at a lower part of drum 25 in any condition of laundry 24 when the rotating speed is below 41 rpm, which is an underwater oscillating state. On the other hand, when the rotating speed becomes higher than 53 rpm, the moisture content in laundry 24 is rapidly discharged, and drum 25 rotates with laundry 24 pressed to the inner side wall of drum 25. In other words, laundry 24 is washed in the state shown in Fig. 2(c), and thus the washing effect degrades.

[0032] Although driver 26 is rotated at a constant speed, the rotation is affected by changes in load due to a drop impact or a change in weight of laundry 24 when drum 25 rotates and laundry 24 moves. In other words, the rotation becomes inconsistent. For example, the rotation may vary for ± 2 rpm. With consideration to this variation in rotation, aforementioned 4 rpm is selected as a rotation variation range that can give effect even to a specific difference in movement of laundry 24. Controller 27 can preferably determine an optimal rotating speed by increasing the rotating speed in a stepwise fashion at this interval.

[0033] In step S01 in Fig. 3, outputs detected by vibration sensor 31 are small at the rotating speed of 41 rpm and 45 rpm. This is the state that laundry 24 rolls at the lower part of drum 25, as shown in Fig. 2(b). At this point, laundry 24 contains large quantities of water and the centrifugal force of drum 25 is also not so large. Therefore, laundry 24 slides down from the inner wall of drum 25, even if lifted, and laundry 24 always oscillates at the lower part of drum 25.

[0034] When the rotating speed of drum 25 is changed to 49 rpm at E, a shaking of washing tub 23 detected by vibration sensor 31 becomes strong at F. At this point, the beat-washing, as shown in Fig. 2(a), is effectively applied. In other words, the centrifugal force generated by the rotation of drum 25 becomes almost equivalent to the dropping force of laundry 24. Laundry 24 is thus caught by baffle 22 and lifted up, and then is fallen from above. This drop impact discharges moisture content in laundry 24 at once. The beat-washing effect is enhanced by repeating this movement.

[0035] When the rotating speed is further increased to 53 rpm, the output detected by vibration sensor 31 becomes small. In this state, the movement of washing tub 23 is small, and laundry 24 is pressed, as shown in Fig. 2(c). At this point, the centrifugal force of drum 25 surpasses the dropping force, and thus laundry 24 is always pressed to the inner side wall of drum 25. Since laundry 24 discharges moisture content in the pressed state, laundry 24 firmly sticks to the inner side wall of drum 25 and becomes more difficult to be removed as this state lasts longer.

[0036] Based on the above detection of vibrations, controller 27 sets the optimal rotating speed of rotating drum 25 to 49 rpm when circulating pump 29 is activated. This enables optimal washing.

[0037] The rotating direction of drum 25 in step S01, at which the optimal rotating speed is determined, is one direction (rightward in Fig. 3), and the rotation of drum 25 is kept turned ON during step S01. After step S01, controller 27 proceeds to a normal washing control of a drum-type washing machine, and repeats ON and OFF of the rotation of drum 25, and reverses the rotating direction of drum 25 to left and right to execute a washing step (S02). At this point, controller 27 rotates drum 25 at the rotating speed determined in step S01 using driver 26.

[0038] To suppress generation of foam while rotating drum 25 during the washing operation, only circulating pump 29 is stopped (S03). Step S03 is pre-programmed, taking into account factors including suppression of foam generated by operating circulating pump 29 and lowering of water level in washing tub 23. This program is also applied in the case requiring a sudden stop of the operation of circulating pump 29 if abnormal generation of foam or lowered water level is detected.

[0039] In any of the above cases, if circulating pump 29 is stopped, controller 27 operates drum 25 at a rotating speed lower than the rotating speed while circulating pump 29 is operated. In other words, controller 27 intermittently activates circulating pump 29. While circulating pump 29 is stopped, driver 26 is controlled to rotate drum 25 at the fist rotating speed. While circulating pump 29 is operated, driver 26 is controlled to rotate drum 25 at the second rotating speed faster than the first rotating speed.

[0040] In an example shown in Fig. 3, the first rotating speed is 45 rpm as shown by D, and the second rotating speed is 49 rpm. More specifically, controller 27 reduces the rotating speed of drum 25 by 4 rpm. In case of abnormal foam generation, an increase of foam is prevented by stopping circulating pump 29, without stopping the washing operation, so as to encourage elimination of foam. If the water level lowers, a problem related to foam is solved by returning the washing water into drum 25. When the problem is solved, the operation of circulating pump 29 is restarted, and the rotating speed of drum 25 is returned to the second rotating speed (S04).

[0041] When circulating pump 29 is stopped, moisture content in laundry 24 decreases, and laundry 24 becomes light. If drum 25 is operated at a high rotating speed same as that while circulating pump 29 is operated, laundry 24 will thus be pressed to the inner side wall of drum 25 during operation, as shown in Fig. 2(c). Accordingly, as described above, degradation in the washing power is also preventable by reducing the rotating speed.

[0042] In other words, if baffle 22 hardly lifts up laundry 24 due to laundry 24 becoming heavy by operating circulating pump 29, controller 27 rotates drum 25 at the second rotating speed, which is a high speed. By this control, the centrifugal force of drum 25 surpasses the dropping force of laundry 24 soaked with water. Accordingly, laundry 24 is lifted up well, and laundry 24 falls and is beaten even when laundry 24 is soaked with water. As a result, the washing force is improved.

[0043] An optimal reduction range for the rotating speed of drum 25 is determined by an internal diameter of drum 25 and the shape and the number of baffles 22. In case of commercialized general household drum-type washing machines, the optimal range confirmed through experiments is around 5 rpm. Accordingly, the first rotating speed is preferably lower than the second rotating speed by between 4rpm and 6 rpm, inclusive.

[0044] As described above, the moisture content in laundry 24 changes, and in turn the load changes, by conditions related to activation and stoppage of circulating pump 29. In this exemplary embodiment, the rotating speed of drum 25 is changed to achieve the beat-washing state even if the load changes. Accordingly, the washing power can be improved.

[0045] In the above example, a rotating speed that increases the output of vibration sensor 31 in a state that circulating pump 29 is operated is set as a reference rotating speed. However, the maximum output of vibration sensor 31 in the state that circulating pump 29 is stopped may be larger than the maximum output of vibration sensor 31 in the state that circulating pump 29 is operated. In this case, circulating pump 29 is stopped in step S01, and a rotating speed that increases the output of vibration sensor 31 in this state may be set as a reference rotating speed. In other words, it is preferable that controller 27 selects the first rotating speed or the second rotating speed that causes a larger output of vibration sensor 31 as a reference rotating speed, while drum 25 is rotated.

[0046] More specifically, at the beginning of washing step, controller 27 sets the rotating speed in multiple steps under a condition that circulating pump 29 is activated or stopped, and then the rotating speed is sequentially increased. Based on detection results of vibration sensor 31 in each rotating speed, an optimal rotating speed of drum 25 that achieves strong shaking of washing tub 23 and high washing power is selected. If the operation state of circulating pump 29 is switched, controller 27 immediately changes the rotating speed of drum 25 so as to realize an optimal movement of laundry 24 that does not degrade the washing effect.

[0047] As described above, the rotating speed that causes an intense movement of lifting up laundry 24 by baffle 22 and dropping laundry 24 to drum 25 is selected. Accordingly, laundry 24 is lifted up and beat-washed well, improving the washing power. In other words, the rotating speed of drum 25 that causes a larger output of vibration sensor 31 when drum 25 is rotated may be selected as a reference in the rotating speeds of drum 25 while circulating pump 29 is operated or stopped during washing.

This control results in selecting the rotating speed that causes an intense movement of lifting up laundry 24 by baffle 22 and dropping laundry 24 to drum 25.

[0048] The above example describes the case that a ratio of circulating pump 29 in operation is higher to a ratio of circulating pump 29 in a stopped state during the washing step. Accordingly, the optimal rotating speed of drum 25 is determined in step S01 in the activated state of circulating pump 29.

[0049] Contrarily, if a ratio of stopped state of circulating pump 29 is set higher during the washing step, it is preferable to perform step S01 for determining the rotating speed of drum 25 at the beginning of the washing step in the stopped state of circulating pump 29. In other words, it is preferable that controller 27 determines the reference rotating speed in the activated or stopped state of circulating pump 29, whichever accounts for a larger proportion.

[0050] Accordingly, it is preferable to select the activated or stopped state, whichever accounts for a larger proportion in the intermittent operation of circulating pump 29. This enables determination of the reference rotating speed for controlling rotation of drum 25 in highly practical state, improving the washing effect.

[0051] As described above, the drum-type washing machine of the present invention rotates drum 25 at a high rotating speed while circulating pump 29 is operated, so as to satisfactorily lift up laundry 24. This enables improvement of washing power. Accordingly, the present invention is effectively applicable to a drum-type washing machine equipped with circulating pump 29.

Claims

1. A drum-type washing machine comprising:

   a washing tub for holding washing water;
   a cylindrical drum with a bottom, the drum being rotatably disposed in the washing tub;
   a driver for rotating the drum, the driver being disposed outside the washing tub;
   a baffle for agitating laundry, the baffle being provided on an inner peripheral side wall of the drum;
   a circulating water passage connected to the washing tub;
   a circulating pump for taking in the washing water held in the washing tub from the washing tub and discharging the washing water into the drum via the circulating water passage, the circulating pump being provided in the circulating water passage;
   a vibration sensor for detecting vibration of the washing tub; and
   a controller for receiving a signal from the vibration sensor and controlling an operation of the driver and the circulating pump;

   wherein the controller intermittently operates the circulating pump during a washing operation, controls the driver to rotate the drum at a first rotating speed when the circulating pump is stopped, and controls the driver to rotate the drum at a second rotating speed higher than the first rotating speed when the circulating pump is operated.

2. The drum-type washing machine according to claim 1, wherein
   the first rotating speed is lower than the second rotating speed by not less than 4 rpm and not greater than 6 rpm.

3. The drum-type washing machine according to claim 1 or 2, wherein
   the controller selects a reference rotating speed from the first rotating speed and the second rotating speed, whichever causes a greater output of the vibration sensor while the drum is operated.

4. The drum-type washing machine according to any one of claims 1 through 3, wherein
   the controller determines a reference rotating speed in one of activated and stopped states of the circulating pump, whichever accounts for a larger proportion in the washing operation.

5. The drum-type washing machine according to any one of claims 1 through 4, wherein
   the controller controls the driver at a beginning of the washing operation to change a rotating speed of the drum in a stepwise fashion, compares outputs of the vibration sensor at each rotating speed, and determines a reference rotating speed.

6. The drum-type washing machine according to claim 5, wherein the controller controls the driver at the beginning of the washing operation to change the rotating speed of the drum in a stepwise fashion by 4 rpms from 41 rpm to 53 rpm.

FIG. 1

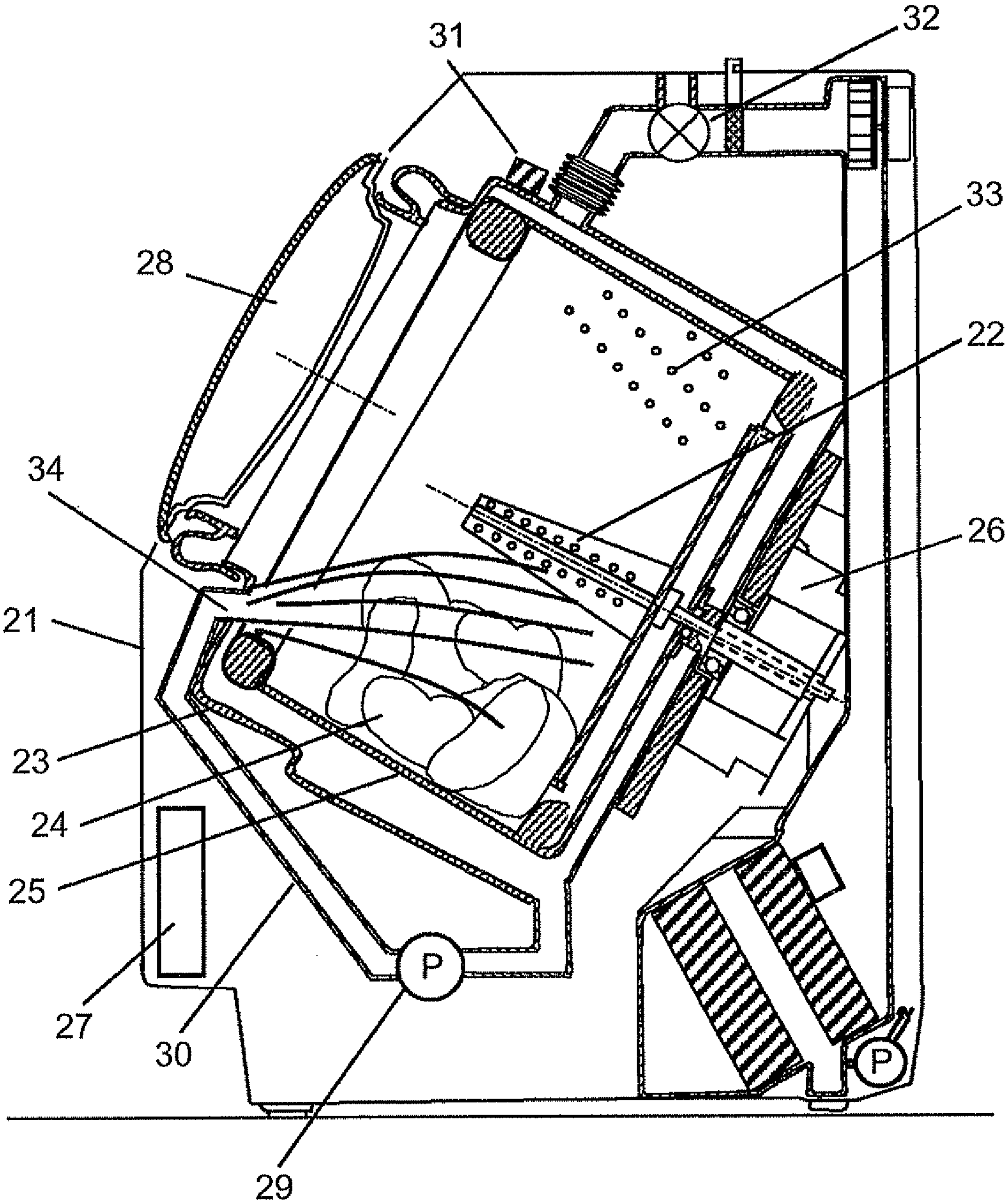


FIG. 2

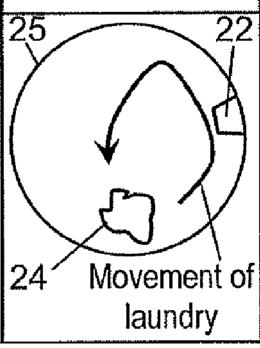
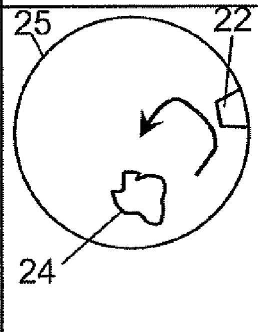
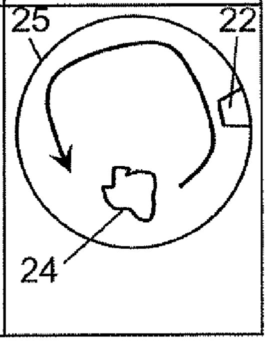
	(a)	(b)	(c)
Movement of laundry	Beaten	Rolling	Pressed
Drum Rotating speed	Optimal	Slow	Fast
Washing power	High	Low	Low
Shaking of washing tub	Large	Small	Small
Image			

FIG. 3

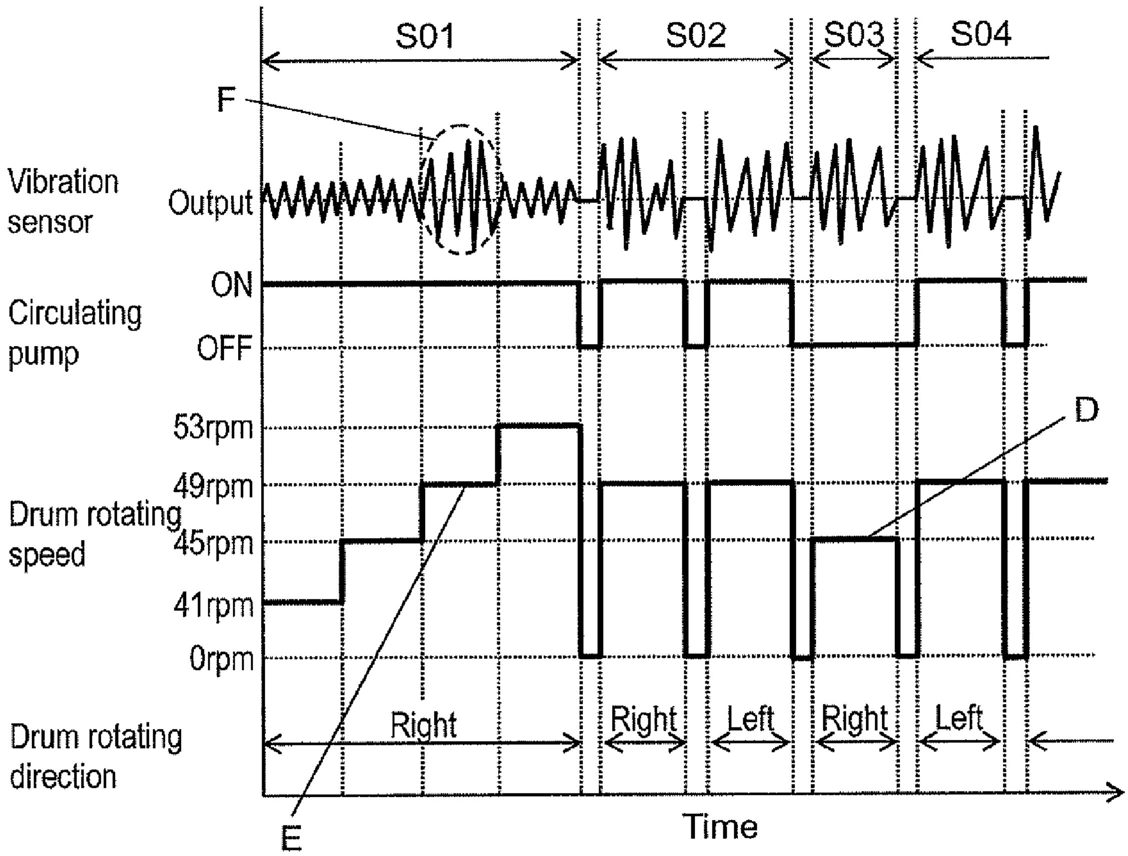
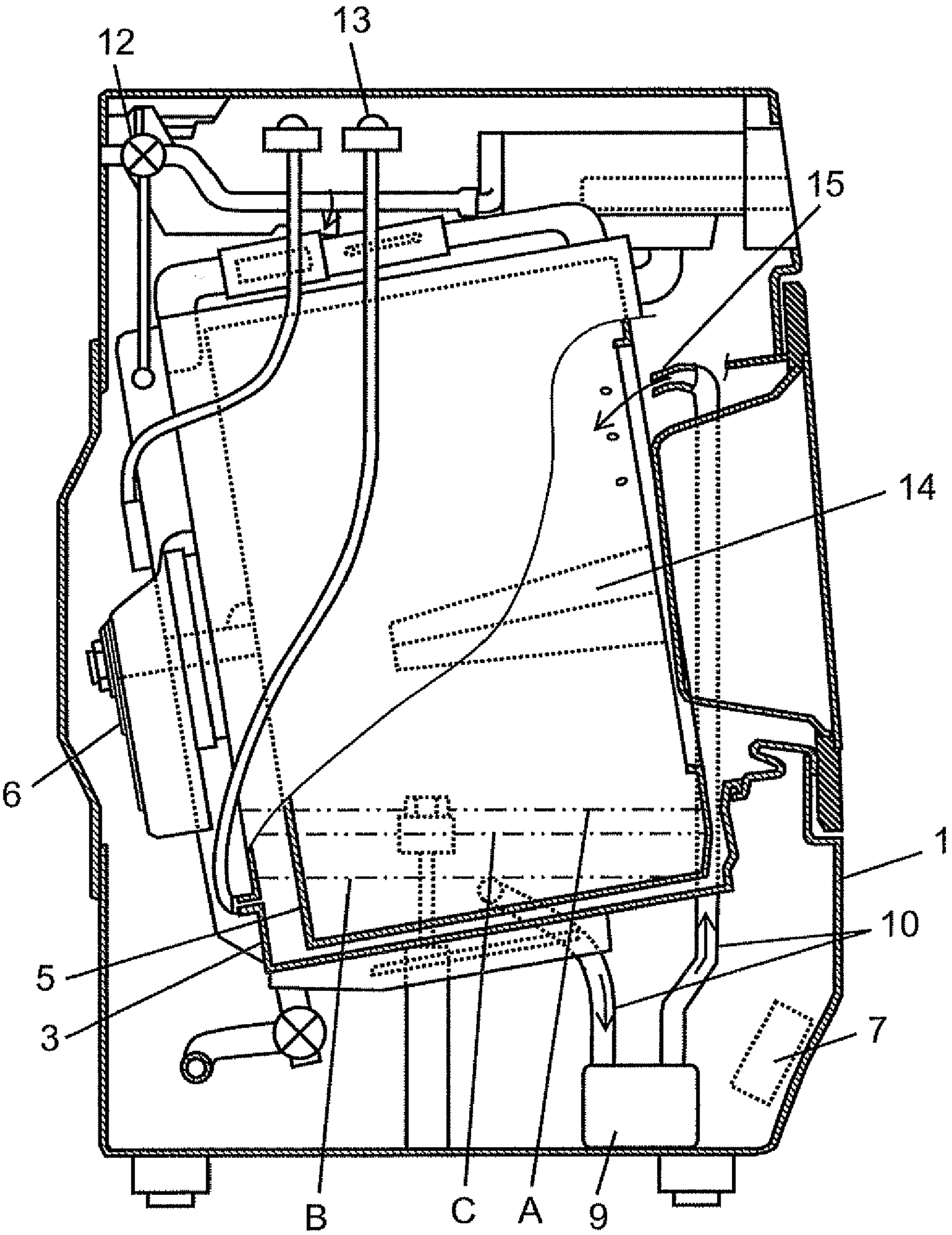


FIG. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 09 15 4605

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2004/139557 A1 (SEO HYUN-SEOK [KR] ET AL) 22 July 2004 (2004-07-22) * paragraphs [0035] - [0048]; figures 1,2 *	1-6	INV. D06F33/02 D06F37/20
A	JP 2003 334396 A (HITACHI HOME & LIFE SOLUTIONS) 25 November 2003 (2003-11-25) * abstract *	1	
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TECHNICAL FIELDS SEARCHED (IPC)
D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 July 2009	Kising, Axel

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CATEGORY OF CITED DOCUMENTS

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