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Waschmaschine

Machine à laver

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EP 2 009 169 B1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a washing machine capable of detecting the amount of a laundry.

BACKGROUND OF THE INVENTION

[0002] Fig. 8 is a sectional view of conventional washing machine 501. Washing tub 2 is suspended and supported with an anti-vibration suspension in cabinet 1. Drum 3 having bottom 3B and cylindrical side wall 3A is supported in washing tub 2. Drum 3 rotates on rotation shaft 3F about central axis 3C inclined downward from the front side of washing machine 501 toward its back side. Drum 3 has open end 3D opposite to bottom 3B along central axis 3. Laundry loading port 4 communicating with open end 3D of drum 3 is provided in the front side of washing tub 2. Opening 1A provided in an upward inclined surface at the front side of cabinet 1 is provided with door 5. Door 5 is opened to allow the laundry to be loaded in drum 3 through laundry loading port 4.

[0003] Side wall 3A of drum 3 has a lot of through-holes 6 provided therein communicating with the inside of washing tub 2. Inner circumferential surface 3E of side wall 3A is provided thereon with plural agitating projections 15 for agitating the laundry. Drum 3 rotates in forward and reverse directions by motor 7 mounted at the back side of washing tub 2. Feed pipe line 8 and drain pipe line 9 are connected to washing tub 2 to supply water to and discharge water from washing tub 2 by controlling a feed valve and drain valve.

[0004] An operation of washing machine 501 will be described below. Upon opening door 5, a user inputs laundry and detergent into drum 3. Upon the user operating operation panel 10 provided on the upper front surface of cabinet 1 to start the washing machine, a predetermined amount of water is supplied into washing tub 2 through feed pipe line 8, and controller 501A controls and rotates motor 7, thereby starting a wash cycle during which drum 3 rotates to wash the laundry. The rotation of drum 3 causes the laundry contained in drum 3 to be lifted in the rotating directions of drum 3 by agitating projections 15 provided on side wall 3A of drum 3. The lifted laundry drops from an appropriate height and collides against side wall 3A, thus being agitated. This agitation with the collision is repeated to wash the laundry by a beat washing effect. After the laundry is washed for a predetermined period of time, soiled washing liquid is discharged through drain pipe line 9. Then, a spin drying cycle is executed in which drum 3 rotates at a high speed to remove the washing liquid contained in the laundry. Then, a rinse cycle is executed in which water is supplied into washing tub 2 through feed pipe line 8 to rinse the laundry. In this rinse cycle, the agitating operation is repeated in which the laundry contained in drum 3 is lifted and drops by agitating projections 15 according to the rotation of drum 3. Then, air inside washing tub 2 is discharged to circulating duct 11, dehumidified, and heated to produce dry air. The dry air is sent to the inside of washing tub 2 through circulating duct 11 by blowing fan 12 to dry the laundry in drum 3.

[0005] Rotation detector 14, such as a position sensor for sensing the position of the rotor of motor 7, is provided behind motor 7.

[0006] In washing machine 501, controller 501A detects the amount of the laundry put into drum 3 to automatically determine the conditions of the washing, such as the periods of the wash and rinse cycles, the amount of the water, and the rotation speed of motor 7, based on the detected amount of laundry.

[0007] Upon starting the washing, controller 501A first starts motor 7, and rotation detector 14 inputs, to controller 501A, a signal having a frequency proportional to the rotation speed of motor 7. For example, in order to rotate motor 7 at a constant speed, controller 501A increases an average voltage applied to motor 7 by phase control when the frequency the signal from rotation detector 14 is low, and decreases the average voltage when the frequency is high.

[0008] A conventional method of detecting the amount of the laundry disclosed in Japanese Patent Laid-Open Publication No.5-168786 will be described. Fig. 9 shows the rotation speed of motor 7 for controller 501A to detect the amount of the laundry. Controller 501A gradually raises the average voltage applied to motor 7 to increase the rotation speed, accordingly attaching the laundry onto side wall 3A of drum 3 by a centrifugal force. At time point TP501, motor 7 is rotated at high constant rotation speed N501. After motor 7 rotates at the constant rotation speed N501 for predetermined period t501 of time, controller 501A stops energizing motor 7 at time point TP502. Upon stopping the energization, drum 3 rotates due to its inertia to cause motor 7 to rotate. Then, the rotation speed of drum 3 and motor 7 gradually decreases due to a friction torque at rotation shaft 3F, then stopping the rotation. Rotation detector 14 sends, to controller 501A, a signal having a frequency proportional to the rotation speed shown in Fig. 9. As shown in Fig. 9, period t503 of time from time point TP501 to the time point at which drum 3 (motor 7) containing a large amount of laundry stops is longer than period t502 of time from time point TP501 to the time point at which drum 3 (motor 7) containing a small amount of laundry stops. The period from time point TP501 to the time point at which drum 3 (motor 7) stops is proportional to the amount of the laundry, thus allowing controller 501A to detect the amount of the laundry according to the period of time.

[0009] Moment of inertia J which includes the laundry is determined by the weight M of the laundry, the average radius

R of the laundry distributed in drum 3, and the moment of inertia Jd of drum 3 and motor 7 as expression 1.

$$J = Jd + M \cdot R^2 \;\ldots\; \text{(expression 1)}$$

[0010] The relationship of torque T generated by motor 7, the friction torque Tb drum 3 and rotation shaft 3F, and the angular acceleration α of drum 3 is expressed by expression 2.

$$T = J \cdot \alpha + Tb \;\ldots\; \text{(expression 2)}$$

[0011] The angular acceleration α is determined by expression 3A as a function of angular velocity ω and period t of time. Period Ts of time (from time point TP502 to the time point at which motor 7 stops) is determined by expression 3B. As shown by expression 4A, the rotation speed, i.e., the angular velocity ω changes according to the weight M if the average radius R is constant.

$$\alpha = d\omega/dt \;\ldots\; \text{(expression 3A)}$$

$$Ts = N501/\alpha \;\ldots\; \text{(expression 3B)}$$

$$d\omega/dt = (T\text{-}Tb)/(Jd + M \cdot R^2) \;\ldots\; \text{(expression 4A)}$$

$$Ts = N501 \cdot (Jd + M \cdot R^2)/(T\text{-}Tb) \;\ldots\; \text{(expression 4B)}$$

[0012] The torque T is zero in periods t502 and t503, and the friction torque Td and moment of inertia Jd are constant for each washing machine, expression 4 indicates that $d\omega/dt$, i.e., the change of the rotation speed, is determined by the weight M of the laundry. Thus, controller 501A detects the weight M of the laundry based on the signal having the frequency proportional to the rotation speed of motor 7.

[0013] In the conventional method, the relationship between the weight M of the laundry and the period from time point TP502 to the time point at which motor 7 stops is preliminarily determined by experiments executed for a finite number of washing machines, and the determined values are applied to all washing machines.

[0014] The friction torque Tb of rotation shaft 3F of one of the washing machines is different from those of another of the washing machines, thus causing variation. As shown by expression 4, the relationship between the period Ts to the time point at which the drum stops and the weight M of each washing machine due to the variation of the friction torque Tb, accordingly preventing this method from detecting the amount of the laundry accurately.

[0015] According to expression 1, if the average radius R of the laundry is uniquely determined by the weight M of the laundry, the moment of inertia J is determined by the weight M, and thus, allows controller 501A to detect the weight M according to expression 4A. Actually, however, the laundry is unevenly distributed in drum 3, and causes the average radius R to change and to be determined not only by the weight M. This prevents controller 501A from detecting the weight M accurately.

[0016] In this method, the rotation speed of drum 3 is once raised regardless of the amount of the laundry. When the laundry is distributed drastically unevenly, washing tub 2 supporting drum 3 vibrates and collides against cabinet 1, hence generating an unusual noise. A washing machine having a rotation speed detector for the motor and a controller operating the motor according the detected speed is known from US 2005/028299.

SUMMARY OF THE INVENTION

[0017] A washing machine, according to the present invention, comprises the features of claim 1.

[0018] In the washing machine, the controller can detect the amount of the laundry accurately.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

Fig. 1 is a sectional view of a washing machine according to an exemplary embodiment of the present invention.
Fig. 2 is a circuit diagram of the washing machine according to the embodiment.
Fig. 3 illustrates an operation of the washing machine according to the embodiment.
Fig. 4 illustrates the relationship between the amount of laundry and an acceleration of a drum of the washing machine according to the embodiment.
Fig. 5 is a flowchart illustrating the operation of the washing machine according to the embodiment.
Fig. 6 is a circuit block diagram of the washing machine according to the embodiment.
Figs. 7A and 7B illustrate the operation of the washing machine according to the embodiment.
Fig. 8 is a sectional view of a conventional washing machine.
Fig. 9 illustrates an operation of the conventional washing machine.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0020] Fig. 1 is a sectional view of washing machine 1001 according to an exemplary embodiment of the present invention. Washing tub 2 is suspended and supported with an anti-vibration suspension in cabinet 1. Drum 3 having bottom 3B and cylindrical side wall 3A is supported in washing tub 2. Drum 3 rotates with rotation shaft 3F about central axis 3C inclined downward from the front side of washing machine 1001 toward its back side. Drum 3 has open end 3D opposite to bottom 3B along central axis 3. Laundry loading port 4 communicating with open end 3D of drum 3 is provided in the front side of washing tub 2. Opening 1A provided in an upward inclined surface at the front side of cabinet 1 is provided with door 5. Door 5 is opened to allow the laundry to be loaded in drum 3 through laundry loading port 4.

[0021] Side wall 3A of drum 3 has a lot of through-holes 6 provided therein communicating with the inside of washing tub 2. Inner circumferential surface 3E of side wall 3A is provided thereon with plural agitating projections 15 for agitating the laundry. Drum 3 rotates in forward and reverse directions by motor 7 mounted at the back side of washing tub 2. Feed pipe line 8 and drain pipe line 9 are connected to washing tub 2 to supply water to and discharge water from washing tub 2 by controlling a feed valve and drain valve.

[0022] An operation of washing machine 1001 will be described below. Upon opening door 5, a user inputs laundry and detergent into drum 3. Upon the user operating operation panel 10 provided on the upper front surface of cabinet 1 to start the washing machine, a predetermined amount of water is supplied into washing tub 2 through feed pipe line 8, and controller 31 controls and rotates motor 7, thereby starting a wash cycle during which drum 3 rotates to wash the laundry. The rotation of drum 3 causes the laundry contained in drum 3 to be lifted in the rotating directions of drum 3 by agitating projections 15 provided on side wall 3A of drum 3. The lifted laundry drops from an appropriate height and collides against side wall 3A, thus being agitated. This agitation with the collision is repeated to wash the laundry by a beat washing effect. After the laundry is washed for a predetermined period of time, soiled washing liquid is discharged through drain pipe line 9. Then, a spin drying cycle is executed in which drum 3 rotates at a high speed to remove the washing liquid contained in the laundry. Then, a rinse cycle is executed in which water is supplied into washing tub 2 through feed pipe line 8 to rinse the laundry. In this rinse cycle, the agitating operation is repeated in which the laundry contained in drum 3 is lifted and drops by agitating projections 15 according to the rotation of drum 3. Then, air inside washing tub 2 is discharged to circulating duct 11, dehumidified, and heated to produce dry air. The dry air is sent to the inside of washing tub 2 through circulating duct 11 by blowing fan 12 to dry the laundry in drum 3.

[0023] Rotation detector 14, such as a position sensor for sensing the position of the rotor of motor 7, is provided behind motor 7.

[0024] In washing machine 1001, controller 31 detects the amount of the laundry put into drum 3 to automatically determine the conditions of the washing, such as the periods of the wash and rinse cycles, the amount of the water, and the rotation speed of motor 7, based on the detected amount of laundry.

[0025] Fig. 2 is a circuit diagram of washing machine 1001. An alternating-current voltage from commercial power supply 20 is rectified by rectifier 21 and smoothed by a smoothing circuit including choke coil 22 and smoothing capacitor 23 so as to generate a direct-current (DC) voltage. The DC voltage rotates motor 7 via inverter circuit 24. Controller 31 controls inverter circuit 24 via driving circuit 32 to control the rotation of motor 7. Controller 31 controls feed valve 27, drain valve 28, blowing fan 12, and heater 29 via load driver 26 according to operation instructions input through input setting unit 25 and monitoring information on operations detected by sensors.

[0026] Motor 7 is a brushless DC motor and includes a stator including three-phase coils 7A, 7B, and 7C, a rotor including two-pole magnets, and position sensors 30A, 30B, and 30C for detecting the angular position of the rotor. Inverter circuit 24 includes switching elements 24A to 24F and controls the rotation of motor 7 by a pulse-width modulation (PWM) method. Position sensors 30A, 30B, and 30C input detection signals corresponding to the angular position of the rotor to controller 31 implemented by a computer. Each of the detection signals has a frequency changing according to the rotation speed of the rotor. Controller 31 controls the turning on and off of switching elements 24A to 24F by the PWM method via driving circuit 32 according to the angular position of the rotor so as to control energization of three-phase coils 7A, 7B, and 7C of the stator, thereby rotating the rotor at a predetermined rotation speed.

[0027] Controller 31 includes rotation speed detector 33 has the detection signals from position sensors 30A, 30B, and 30C input thereto. Rotation speed detector 33 detects the frequency of the detection signals from position sensors 30A, 30B, and 30C whenever any one of the signals changes so as to calculate the rotation speed of the rotor from the frequency. Laundry amount detector 34 detects the amount of the laundry according to the detected rotation speed of the rotor.

[0028] The rotation speed of the rotor of motor 7 detected by rotation speed detector 33 corresponds to the rotation speed of drum 3, thus allowing controller 31 to detect the rotation speed of drum 3 from the rotation speed of the rotor detected by rotation speed detector 33.

[0029] A method for controller 31 to detect the amount of the laundry will be described below. Fig. 3 illustrates the rotation speed N of drum 3.

[0030] Upon starting detecting the amount of the laundry, controller 31 allows motor 7 to generate start-up accelerating torque Ta to start up drum 3 from a stationary state, and raises the rotation speed N at a start-up angular acceleration $\alpha a(t)$ depending on time t. After rotation speed N changing at the start-up angular acceleration $\alpha a(t)$ reaches a predetermined rotation speed Na, controller 31 allows motor 7 to generate a predetermined accelerating torque T1 to raise the rotation speed N from a first predetermined rotation speed N1 to a second predetermined rotation speed N2 by a difference $\Delta N1$ of the rotation speed during period t1. Then, at time point tb, controller 31 allows motor 7 to generate a predetermined decelerating torque T2 so as to decelerate drum 3. The decelerating torque T2 reduces the rotation speed N from a third predetermined rotation speed N3 to fourth predetermined rotation speed N4 by a difference $\Delta N2$ of the rotation speed at second angular acceleration $\alpha 2$ during period t2. Controller 31 detects angular acceleration $\alpha 1$ during the period t1 and angular acceleration $\alpha 2$ by the following method.

[0031] The angular acceleration $\alpha 1$ is defined as expression 5.

$$\alpha 1 = \Delta N1/t1 \ldots \text{(expression 5)}$$

[0032] The accelerating torque T1 is determined by the weight M of the laundry, the average radius R of the laundry distributed in drum 3, the moment of inertia Jd of drum 3 and motor 7, and the friction torque Tb of drum 3 and rotation shaft 3F from expressions 1 and 2, and is determined as expression 6.

$$T1 = \alpha 1 \cdot (Jd + M \cdot R^2) + Tb \ldots \text{(expression 6)}$$

[0033] Similarly, the angular acceleration $\alpha 2$ and the decelerating torque T2 during period t2 are expressed as expressions 7 and 8, respectively.

$$\alpha 2 = \Delta N2/t2 \ldots \text{(expression 7)}$$

$$T2 = \alpha 2 \cdot (Jd + M \cdot R^2) + Tb \ldots \text{(expression 8)}$$

[0034] The friction torque Tb is deleted from expressions 6 and 8, providing expression 9.

$$\alpha 1 - \alpha 2 = (T1 - T2)/(Jd + M \cdot R^2) \ldots \text{(expression 9)}$$

[0035] Fig. 4 shows the relationship between the weight M of the laundry and the acceleration difference ($\alpha 1$-$\alpha 2$). Expression 9 shows that the difference ($\alpha 1$-$\alpha 2$) changes according to the weight M of the laundry as shown in Fig. 4 if the average radius R of the laundry in drum 3, the accelerating torque T1, and the decelerating torque T2 are constant.

[0036] The accelerations $\alpha 1$ and $\alpha 2$ are easily calculated by measuring difference ΔN of the rotation speed of drum 3 and the periods t1 and t2 as shown by expressions 5 and 7. Laundry amount detector 34 of controller 31 stores the relationship between the weight M of the laundry and the difference ($\alpha 1$-$\alpha 2$) of the angular accelerations expressed by expression 9 and Fig. 4 as an operation table or an operation program, thereby easily detecting the weight M of the laundry accurately regardless of the friction torque Tb. Controller 31 may store the relationship between weight M of the laundry and moment $M \cdot R^2$ corresponding to weight M.

[0037] Fig. 5 is a flowchart illustrating an operation for washing machine 1001 to detecting the amount of the laundry. Upon starting detecting the amount of the laundry (step S1), controller 31 drives motor 7 to allow motor 7 to generate start-up torque Ta to rotate drum 3 (step S2), accelerates the drum 3 to have the angular acceleration of drum 3 reach $\alpha a(t)$ (step S3), and has the rotation speed N reach predetermined rotation speed Na (step S4).

[0038] Then, controller 31 controls motor 7 to allow motor 7 to generate predetermined accelerating torque T1 to raise rotation speed N of drum 3 from first predetermined rotation speed N1 to second predetermined rotation speed N2 by difference $\Delta N1$ (step S5). When rotation speed N of drum 3 reaches rotation speed N2 (step S6), controller 31 calculates period t1 for which rotation speed N rises by difference $\Delta N1$ of the rotation speed (step S7).

[0039] Then, controller 31 allows motor 7 to generate predetermined decelerating torque T2 to start decreasing rotation speed N of motor 7 at time point tb (step S8). When rotation speed N of drum 3 decreases from third predetermined rotation speed N3 to fourth predetermined rotation speed N4 by difference $\Delta N2$ of the rotation speed (step S9), controller 31 calculates period t2 for which rotation speed N decreases by rotation speed difference $\Delta N2$ (step S10). Then, the difference ($\alpha 1$-$\alpha 2$) of the angular accelerations is determined by expressions 5 and 7 from rotation speed differences $\Delta N1$ and $\Delta N2$ and periods t1 and t2 (step S11). The weight M of the laundry is determined based on expression 9 including coefficients which have been experimentally predetermined (step S12).

[0040] In order to detect the amount of the laundry accurately by expression 9, controller 31 controls motor 7 to rotate drum 3 preferably with constant accelerating torque T1 during period t1 and with constant decelerating torque T2 during period T2. In order to control motor 7 to make torques T1 and T2 during periods t1 and t2, respectively, controller 31 may control the voltage applied to motor 7. Typically, controller 31 allows torques T1 and T2 to be constant by a vector control method described below.

[0041] Fig. 6 is a block diagram of washing machine 1001 for illustrating the vector control method. Signals corresponding to at least two phases of currents iu and iv out of three-phase currents flowing in motor 7 and to angular position θ of the rotor of motor 7 is obtained by sensors, such as a Hall ICs. Using these signals, controller 31 converts currents iu and iv in motor 7 to q-axis current Iq, i.e., a torque component, and d-axis current Id, i.e., a magnetic flux component. Currents Iq and Id are orthogonal to each other. Then, currents Iq, Id are compared with desired currents Iq* and Id* so as to maintain currents Iq and Id constant.

[0042] Torque T of motor 7 is expressed by expression 10.

$$T = P \cdot (\psi a \cdot Iq + (Ld \cdot Lq) \cdot Iq \cdot Id) \ldots \text{(expression 10)}$$

where P represents the number of pairs of poles of motor 7, ψa represents the density of interlinkage magnetic flux produced by the magnets, Ld represents a d-axis inductance, and Lq represents a q-axis inductance. Expression 10 indicates that q-axis current Iq and d-axis current Id are controlled to controlling torque T of motor 7.

[0043] The product $\psi a \cdot Iq$ in expression 10 represents a torque of the magnet. This torque is a main component of the torque generated by motor 7. Thus, the torque of motor 7 can be substantively controlled by q-axis current Iq. In the case that d-axis current Id is not zero, the change of inductances Ld and Lq due to the rotation causes torque T to fluctuates, or may produce an error of calculated torque T for calculating the amount of the laundry. Thus, torque T may not be constant even if q-axis current Iq and d-axis current Id are controlled to be constant. The q-axis current Iq is controlled to be constant while the d-axis current Id is controlled to be substantively zero for controlling the torque of motor 7 to be constant. This allows controller 31 to reduce an error in detecting the amount of the laundry.

[0044] In the start-up period during which rotation speed N rises at start-up angular acceleration $\alpha a(t)$ after startup, the angular acceleration changes according to a time elapsed in order to rotate drum 3 from a stationary state. In washing machine 1001 according to the embodiment, start-up angular acceleration $\alpha a(ta)$ at a certain time point ta in this start-up period is larger than first angular acceleration $\alpha 1$, thereby rapidly accelerating drum 3.

[0045] If start-up angular acceleration $\alpha a(t)$ is small, the laundry rotates about the axis near bottom 3B of drum 3, consequently being prevented from being attached onto side wall 3A of drum 3. If rotation speed N rises to rotation speed N1 in this situation, the laundry is unevenly distributed, and then, the elapsed time enters period t1. This prevents controller 3 from detecting the amount of the laundry accurately. The start-up angular acceleration $\alpha a(ta)$ is larger than first angular acceleration $\alpha 1$ at a certain time point ta in the start-up period not to change the relationship between laundry weight M and average radius R. This stabilizes the relationship between the weight M and moment of inertia $M \cdot R^2$, thereby allowing controller 31 to detect the weight M of the laundry accurately.

[0046] As described above, according to the embodiment, the laundry is attached onto drum 3 to be stabilized due to the large angular acceleration at startup, and additionally, the amount of the laundry is detected according to the angular accelerations at the rotation speed of drum 3 increases and decreases. This operation cancels friction torque Tb generated mainly at rotation shaft 3F of drum 3, thus reducing the influence of the variation of friction torque Tb. Therefore, controller 31 can detect the weight M, the amount of the laundry, stably and accurately.

[0047] Controller 31 may stop the rotation of drum 3 according to the change of rotation speed N when raising rotation speed N of drum 3 for detecting the amount of the laundry (weight M). Fig. 7A illustrates rotation speed N of drum 3 increasing with time. The horizontal axis represents an elapsed time when rotation speed N of drum 3 is raised by a predetermined torque produced by driving motor 7. The vertical axis represents rotation speed N of drum 3. Rotation speed N may increase not uniformly with time, but repeating up-and-down changes. This results from the fact that washing tub 1001 vibrates due to the imbalanced laundry contained in drum 3. An excessively large vibration causes washing tub 2 to collide against cabinet 1, thereby making a noise.

[0048] Controller 31 detects the difference P between local maximum rotation speed Nmax and local minimum rotation speed Nmin within a predetermined range of the angular position of drum 3 during accelerating the rotation of drum 3. If the difference P exceeds a predetermined value, controller 31 controls motor 7 so as to stop the rotation of drum 3. According to the embodiment, controller 31 detects rotation speed N four times during one rotation of drum 3 to obtain four values, and determines the local maximum rotation speed and the local minimum rotation speeds out of the four values as local maximum rotation speed Nmax and local minimum rotation speed Nmin, respectively.

[0049] When the difference P between speeds Nmax and Nmin increases, washing tub 2 vibrates and collides against cabinet 1. The upper limit of difference P for avoiding washing tub 2 to collide against cabinet 1 varies depending on rotation speed N. Fig. 7B illustrates the relationship between rotation speed N of drum 3 and the upper limit Pmax of the difference P. Rotation speed N and the upper limit Pmax corresponding to rotation speed N are determined based on an allowable range of vibration determined experimentally, and are stored in controller 31 as a table. In order to detect the amount of the laundry (weight M), controller 31 detects the rotation speed N and the difference P when raising rotation speed N of drum 3, and controls motor 7 so as to stop the rotation of drum 3 if the difference P exceeds the upper limit Pmax corresponding to rotation speed N. This operation prevents washing tub 2 from excessively vibrating and colliding against cabinet 1 due to the imbalanced laundry in drum 3, thereby stopping drum 3 safely.

[0050] After drum 3 once stops, the user can rearrange the laundry in drum 3 and start up washing machine 1001 again.

Claims

1. A washing machine comprising:

a drum (3) arranged to contain a laundry and to rotate;
a motor (7) rotating the drum (3);
a rotation speed detector (33) detecting a rotation speed of the motor (7); and
a controller (31) controlling the motor (7) according to the rotation speed (N) detected by the rotation speed detector (33), the controller (31) detecting an amount of the laundry,
wherein the controller (31) is operable to detect a first acceleration (α1) of the drum (3) while allowing the motor (7) to generate a predetermined accelerating torque (T1) to raise the rotation speed of the drum (3) from a first predetermined rotation speed (N1) to a second predetermined rotation speed (N2), detect a second acceleration of the drum (3) while allowing the motor (7) to generate a predetermined decelerating torque (T2) to decrease the rotation speed of the drum (3) from a third predetermined rotation speed (N3) to a fourth predetermined rotation speed (N4), and
detect the amount of the laundry according to the first angular acceleration (α1) and the second angular acceleration (α2),
wherein the controller (31) is operable to detect a local maximum rotation speed and a local minimum rotation speed within a predetermined range of an angular position of the drum (3) while allowing the motor (7) to generate the predetermined accelerating torque (T1) to raise the rotation speed of the drum (3) from said first predetermined rotation speed (N1) to said second predetermined rotation speed (N2), and
drive the motor (7) so as to stop the drum (3) if a difference between the local maximum rotation speed and the local minimum rotation speed exceeds a predetermined value.

2. The washing machine of claim 1, wherein the predetermined accelerating torque (T1) and the predetermined decelerating torque (T2) are constant.

3. The washing machine of claim 2, wherein the controller (31) is operable to drive the motor (7) so that a q-axis current flowing to the motor (7), representing a torque component, is constant in order to accelerate the drum (3) at, representing a torque component, predetermined accelerating torque (T1) and to decelerate the drum (3) at said predetermined decelerating torque (T2).

4. The washing machine of claim 2, wherein the controller (31) is operable to drive the motor (7) so that a d-axis current flowing to the motor (7), representing the magnetic flux coomponent, is substantively zero in order to accelerate the drum (3) at said predetermined accelerating torque (T1) and to decelerate the drum (3) at said predetermined decelerating torque (T2).

5. The washing machine of claim 1, wherein the controller (31) is operable to raise the rotation speed of the drum (3) from a stationary state of the drum (3) to said first predetermined rotation speed (N1) at an angular acceleration larger than said first acceleration before allowing the motor (7) to generate said predetermined accelerating torque (T1) to raise the rotation speed of the drum (3) from said first predetermined rotation speed (N1) to said second predetermined rotation speed (N2).

6. The washing machine of claim 1, wherein the controller (31) is operable to allow the motor (7) to generate said predetermined decelerating torque (T2) to decrease the rotation speed of the drum (3) from said third predetermined third rotation speed (N3) to said fourth predetermined rotation speed (N4) before allowing the motor (7) to generate said predetermined accelerating torque (T1) to raise the rotation speed of the drum (3) from said first predetermined rotation speed (N1) to said second predetermined rotation speed (N2).

Patentansprüche

1. Waschmaschine, die umfasst:

eine Trommel (3), die so eingerichtet ist, dass sie Wäsche aufnimmt und sich dreht;
einen Motor (7), der die Trommel (3) dreht;
einen Drehgeschwindigkeits-Detektor (33), der eine Drehgeschwindigkeit des Motors (7) erfasst; sowie
eine Steuereinrichtung (31), die den Motor (7) entsprechend der durch den Drehgeschwindigkeits-Detektor (33) erfassten Drehgeschwindigkeit (N) steuert, wobei die Steuereinrichtung (31) eine Menge der Wäsche erfasst, und die Steuereinrichtung (31) so betrieben werden kann, dass sie
eine erste Beschleunigung (α1) der Trommel (3) erfasst und zulässt, dass der Motor (7) ein vorgegebenes Beschleunigungsdrehmoment (T1) erzeugt, um die Drehgeschwindigkeit der Trommel (3) von einer ersten vorgegebenen Drehgeschwindigkeit (N1) auf eine zweite vorgegebene Drehgeschwindigkeit (N2) zu erhöhen,
eine zweite Beschleunigung der Trommel (3) erfasst und zulässt, dass der Motor (7) ein vorgegebenes Abbremsdrehmoment (T2) erzeugt, um die Drehgeschwindigkeit der Trommel (3) von einer dritten vorgegebenen Drehgeschwindigkeit (N3) auf eine vierte vorgegebene Drehgeschwindigkeit (N4) zu senken, und
eine Menge der Wäsche entsprechend der ersten Winkelbeschleunigung (α1) sowie der zweiten Winkelbeschleunigung (α2) erfasst,
wobei die Steuereinrichtung (31) so betrieben werden kann, dass sie eine lokale maximale Drehgeschwindigkeit und eine lokale minimale Drehgeschwindigkeit innerhalb eines vorgegebenen Bereiches einer Winkelposition der Trommel (3) erfasst und zulässt, dass der Motor (7) das vorgegebene Beschleunigungsdrehmoment (T1) erzeugt, um die Drehgeschwindigkeit der Trommel (3) von der ersten vorgegebenen Drehgeschwindigkeit (N1) auf die zweite vorgegebene Drehgeschwindigkeit (N2) zu erhöhen, und
den Motor (7) so ansteuert, dass die Trommel (3) angehalten wird, wenn eine Differenz zwischen der lokalen maximalen Drehgeschwindigkeit und der lokalen minimalen Drehgeschwindigkeit einen vorgegebenen Wert überschreitet.

2. Waschmaschine nach Anspruch 1, wobei das vorgegebene Beschleunigungsdrehmoment (T1) und das vorgegebene Abbremsdrehmoment (T2) konstant sind.

3. Waschmaschine nach Anspruch 2, wobei die Steuereinrichtung (31) so betrieben werden kann, dass sie den Motor (7) so ansteuert, dass ein q-Achsen-Strom, der zu dem Motor (7) fließt und eine Drehmoment-Komponente repräsentiert, konstant ist, um die Trommel (3) mit dem vorgegebenen Beschleunigungsdrehmoment (T1) zu beschleunigen und die Trommel (3) mit dem vorgegebenen Abbremsdrehmoment (T2) abzubremsen.

4. Waschmaschine nach Anspruch 2, wobei die Steuereinrichtung (31) so betrieben werden kann, dass sie den Motor (7) so ansteuert, dass ein d-Achsen-Strom, der zu dem Motor (7) fließt und die Magnetfluss-Komponente repräsentiert, im Wesentlichen Null ist, um die Trommel (3) mit dem vorgegebenen Beschleunigungsdrehmoment (T1) zu beschleunigen und die Trommel (3) mit dem vorgegebenen Abbremsdrehmoment (T2) abzubremsen.

5. Waschmaschine nach Anspruch 1, wobei die Steuereinrichtung (31) so betrieben werden kann, dass sie die Drehgeschwindigkeit der Trommel (3) von einem stationären Zustand der Trommel (3) mit einer Winkelbeschleunigung, die größer ist als die erste Beschleunigung, auf die erste vorgegebene Drehgeschwindigkeit (N1) erhöht, bevor zugelassen wird, dass der Motor (7) das vorgegebene Beschleunigungsdrehmoment (T1) zum Erhöhen der Drehgeschwindigkeit der Trommel (3) von der ersten vorgegebenen Drehgeschwindigkeit (N1) auf die zweite vorgegebene Drehgeschwindigkeit (N2) erzeugt.

6. Waschmaschine nach Anspruch 1, wobei die Steuereinrichtung (31) so betrieben werden kann, dass sie zulässt, dass der Motor (7) das vorgegebene Abbremsdrehmoment (T2) zum Absenken der Drehgeschwindigkeit der Trommel (3) von der dritten vorgegebenen Drehgeschwindigkeit (N3) auf die vierte vorgegebene Drehgeschwindigkeit (N4) erzeugt, bevor zugelassen wird, dass der Motor (7) das vorgegebene Beschleunigungsdrehmoment (T1) zum Erhöhen der Drehgeschwindigkeit der Trommel (3) von der ersten vorgegebenen Drehgeschwindigkeit (N1) auf die zweite vorgegebene Drehgeschwindigkeit (N2) erzeugt.

Revendications

1. Lave-linge comportant :

un tambour (3) conçu pour contenir du linge et pour tourner ;
un moteur (7) faisant tourner le tambour (3) ;
un détecteur de vitesse de rotation (33) détectant une vitesse de rotation du moteur (7) ; et
un dispositif de commande (31) commandant le moteur (7) selon la vitesse de rotation (N) détectée par le détecteur de vitesse de rotation (33), le dispositif de commande (31) détectant une quantité de linge,
où le dispositif de commande (31) est apte à exécuter la détection d'une première accélération (α1) du tambour (3) tout en permettant au moteur (7) de générer un couple d'accélération prédéterminé (T1) afin d'augmenter la vitesse de rotation du tambour (3) d'une première vitesse de rotation prédéterminée (N1) jusqu'à une deuxième vitesse de rotation prédéterminée (N2),
la détection d'une deuxième accélération du tambour (3) tout en permettant au moteur (7) de générer un couple de décélération prédéterminé (T2) afin de réduire la vitesse de rotation du tambour (3) d'une troisième vitesse de rotation prédéterminée (N3) jusqu'à une quatrième vitesse de rotation prédéterminée (N4), et
la détection de la quantité de linge en fonction de la première accélération angulaire (α1) et de la deuxième accélération angulaire (α2),
où le dispositif de contrôle (31) est apte à exécuter la détection d'une vitesse de rotation maximale locale et d'une vitesse de rotation minimale locale à l'intérieur d'une plage prédéterminée de positions angulaires du tambour (3) tout en permettant au moteur (7) de générer le couple d'accélération prédéterminé (T1) afin d'augmenter la vitesse de rotation du tambour (3) de ladite première vitesse de rotation prédéterminée (N1) à ladite deuxième vitesse de rotation prédéterminée (N2), et
commander au moteur (7) d'arrêter le tambour (3) si une différence entre la vitesse de rotation maximale locale et la vitesse de rotation minimale locale excède une valeur prédéterminée.

2. Lave-linge selon la revendication 1, où le couple d'accélération prédéterminé (T1) et le couple de décélération prédéterminé (T2) sont constants.

3. Lave-linge selon la revendication 2, où le dispositif de contrôle (31) est apte à actionner le moteur (7) de telle manière qu'un courant d'axe q passant dans le moteur (7), représentant une composante de couple, est constant afin d'accélérer le tambour (3) audit couple d'accélération prédéterminé (T1) et à décélérer le tambour audit couple de décélération prédéterminé (T2).

4. Lave-linge selon la revendication 2, où le dispositif de contrôle (31) est apte à actionner le moteur (7) de telle manière qu'un courant d'axe d passant dans le moteur (7), représentant la composante de flux magnétique, est substantiellement égal à zéro afin d'accélérer le tambour (3) audit couple d'accélération prédéterminé (T1) et de décélérer le tambour (3) audit couple de décélération (T2).

5. Lave-linge selon la revendication 1, où le dispositif de contrôle (31) est apte à augmenter la vitesse de rotation du tambour (3) d'un état stationnaire du tambour (3) à ladite première vitesse de rotation prédéterminée (N1) avec une accélération angulaire plus grande que ladite première accélération, avant de permettre au moteur (7) de générer ledit couple d'accélération prédéterminé (T1) afin d'augmenter la vitesse de rotation du tambour (3) de ladite première vitesse de rotation prédéterminée (N1) à ladite deuxième vitesse de rotation prédéterminée (N2).

6. Lave-linge selon la revendication 1, où le dispositif de contrôle (31) est apte à permettre au moteur (7) de générer ledit couple de décélération prédéterminé (T2) afin de réduire la vitesse de rotation du tambour (3) de ladite troisième vitesse de rotation prédéterminée (N3) à ladite quatrième vitesse de rotation prédéterminée (N4), avant de permettre au moteur (7) de générer le couple d'accélération prédéterminé (T1) afin d'augmenter la vitesse de rotation du tambour (3) de la première vitesse de rotation prédéterminée (N1) à la deuxième vitesse de rotation prédéterminée (N2).

Fig. 1

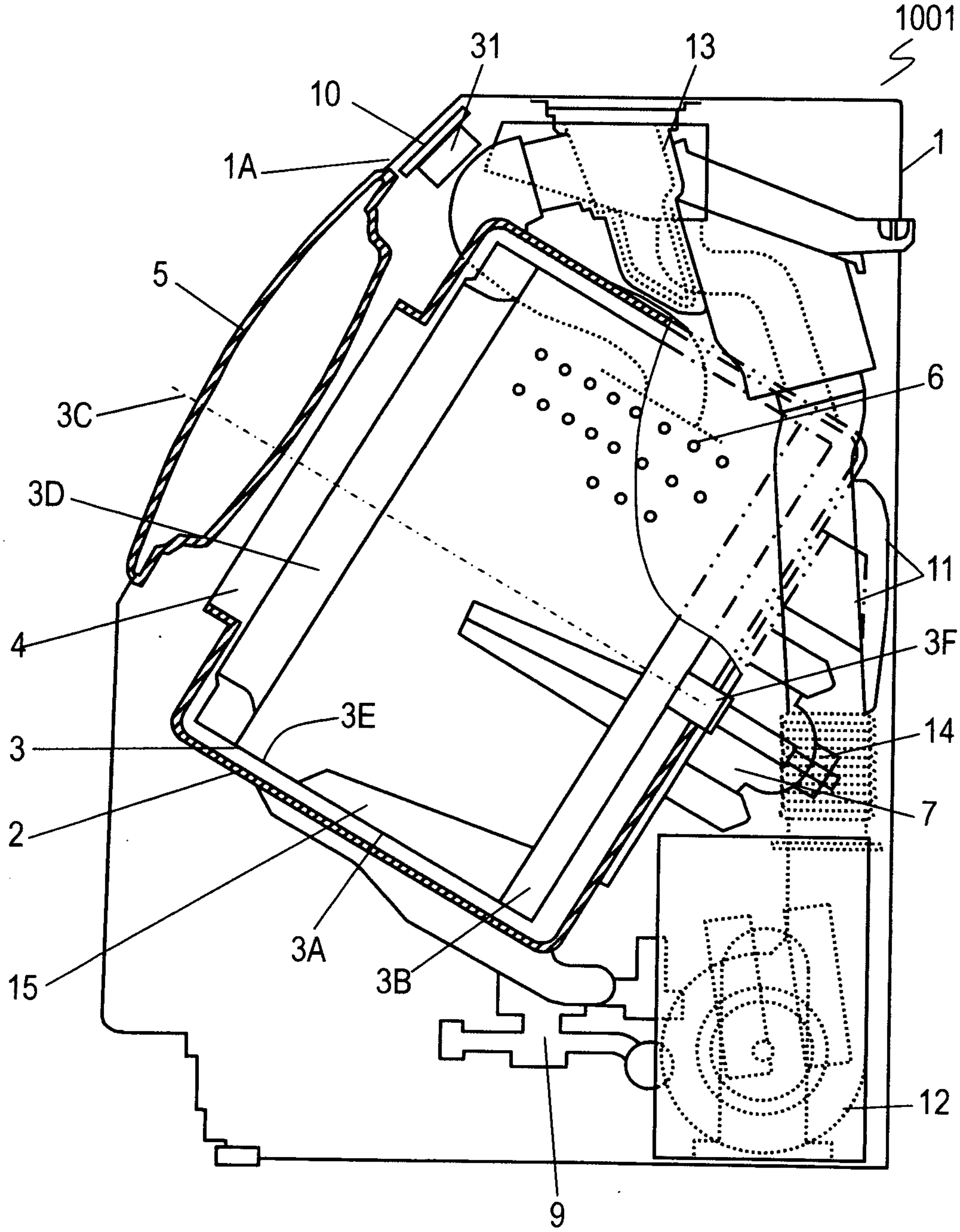
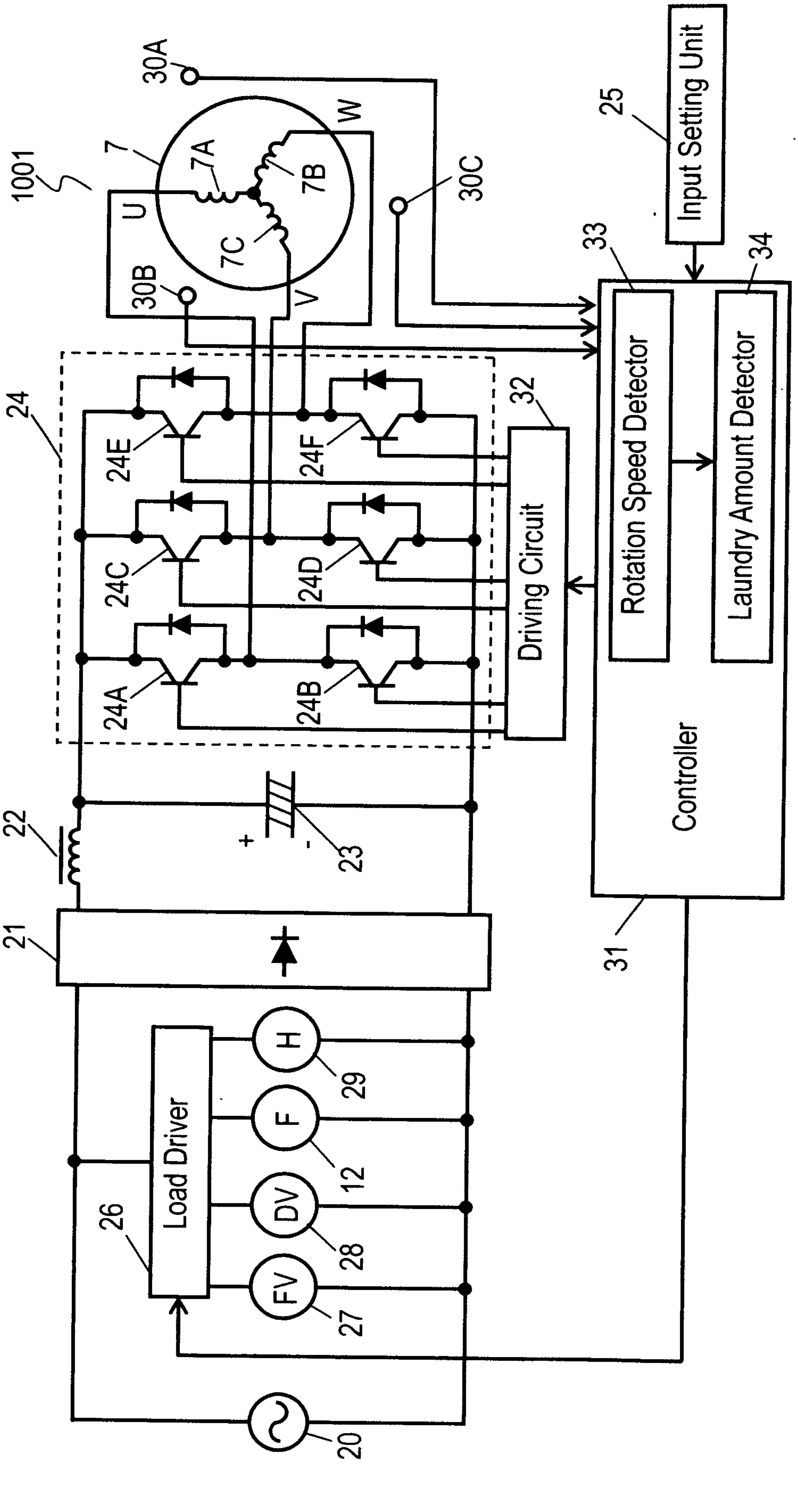


Fig. 2



1001
7
7A
7B
7C
U
V
W
30A
30B
30C
25
Input Setting Unit
33
34
Rotation Speed Detector
Laundry Amount Detector
Controller
31
32
Driving Circuit
24
24A
24B
24C
24D
24E
24F
22
23
+
-
21
26
Load Driver
H
29
F
12
DV
28
FV
27
20

Fig. 3

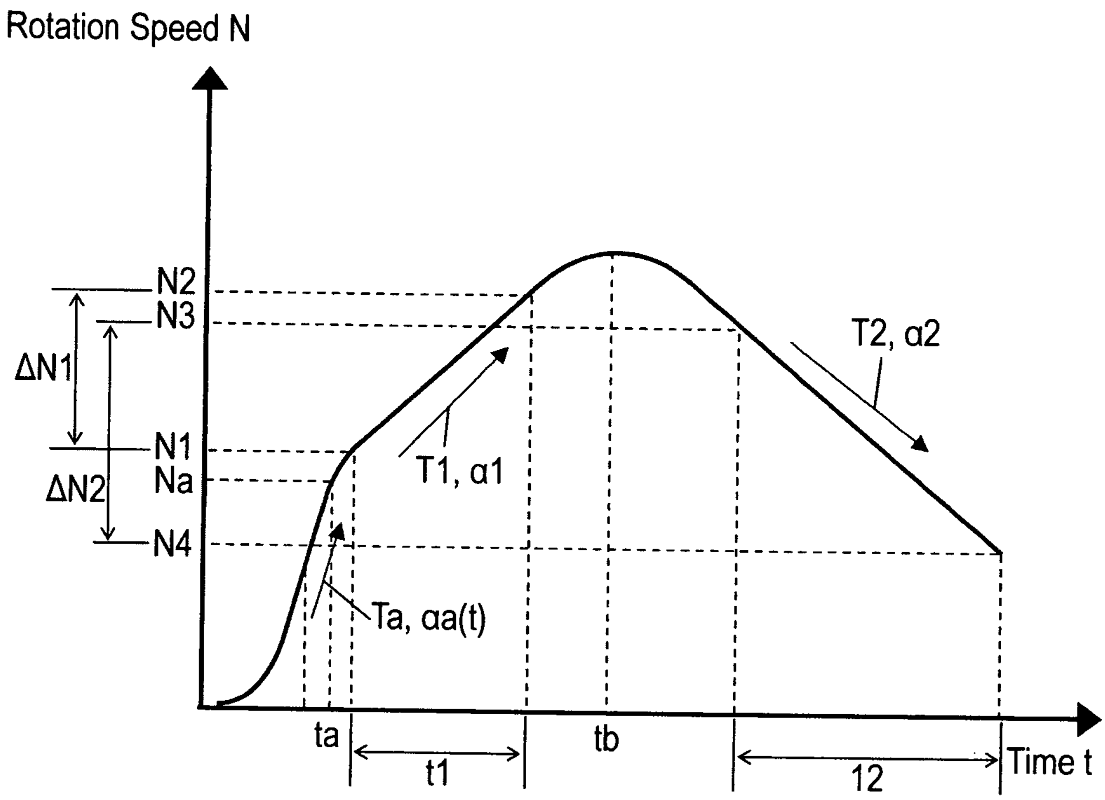

Rotation Speed N
N2
N3
ΔN1
N1
Na
ΔN2
N4
T1, α1
T2, α2
Ta, αa(t)
ta
t1
tb
12
Time t

Fig. 4

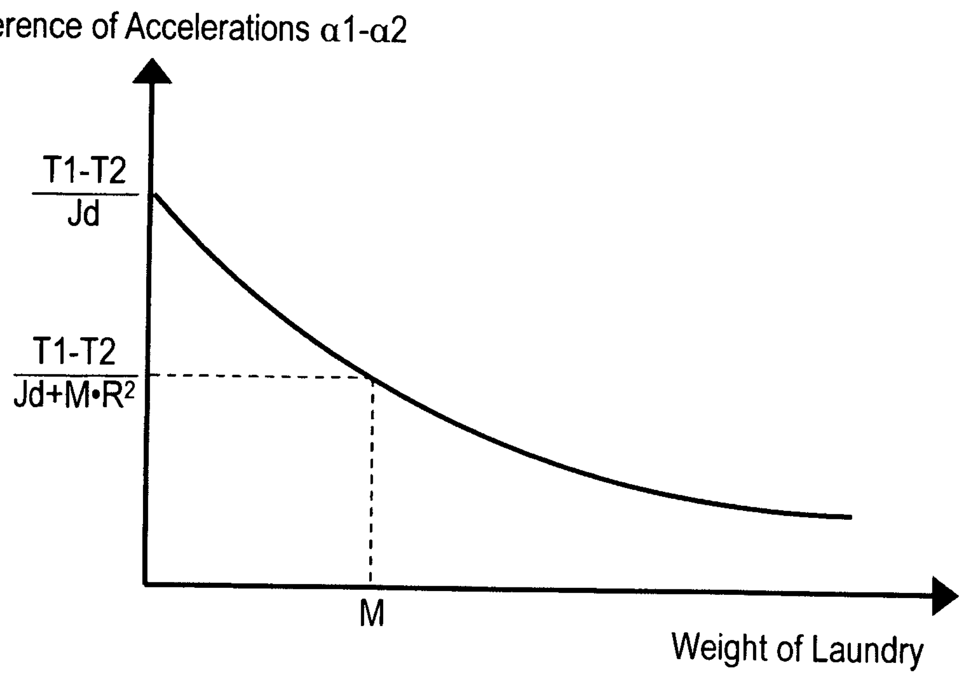

Difference of Accelerations α1-α2
T1-T2 / Jd
T1-T2 / Jd+M•R2
M
Weight of Laundry

Fig. 5

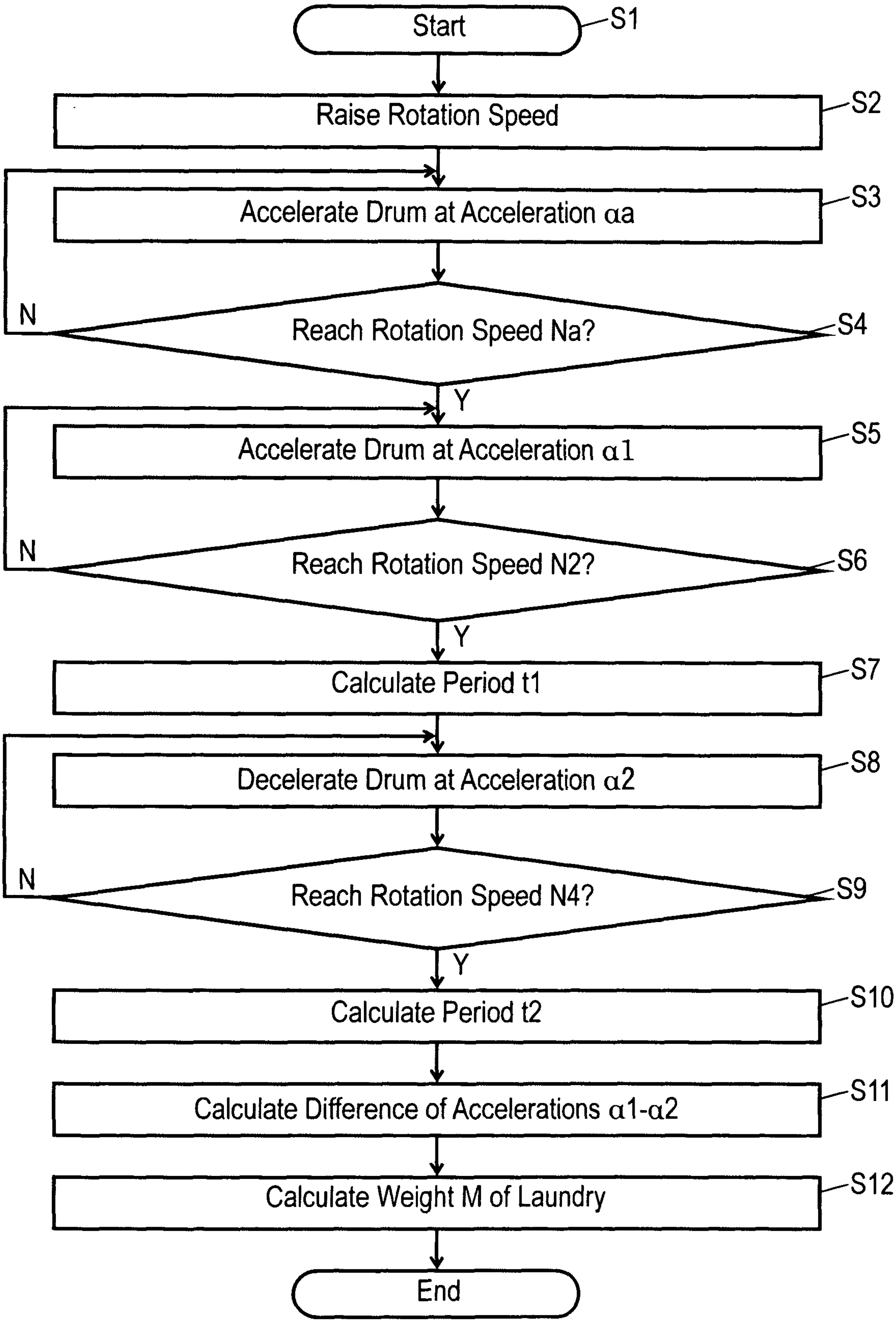

Start
S1
Raise Rotation Speed
S2
Accelerate Drum at Acceleration αa
S3
Reach Rotation Speed Na?
S4
N
Y
Accelerate Drum at Acceleration α1
S5
Reach Rotation Speed N2?
S6
N
Y
Calculate Period t1
S7
Decelerate Drum at Acceleration α2
S8
Reach Rotation Speed N4?
S9
N
Y
Calculate Period t2
S10
Calculate Difference of Accelerations α1-α2
S11
Calculate Weight M of Laundry
S12
End

Fig. 6

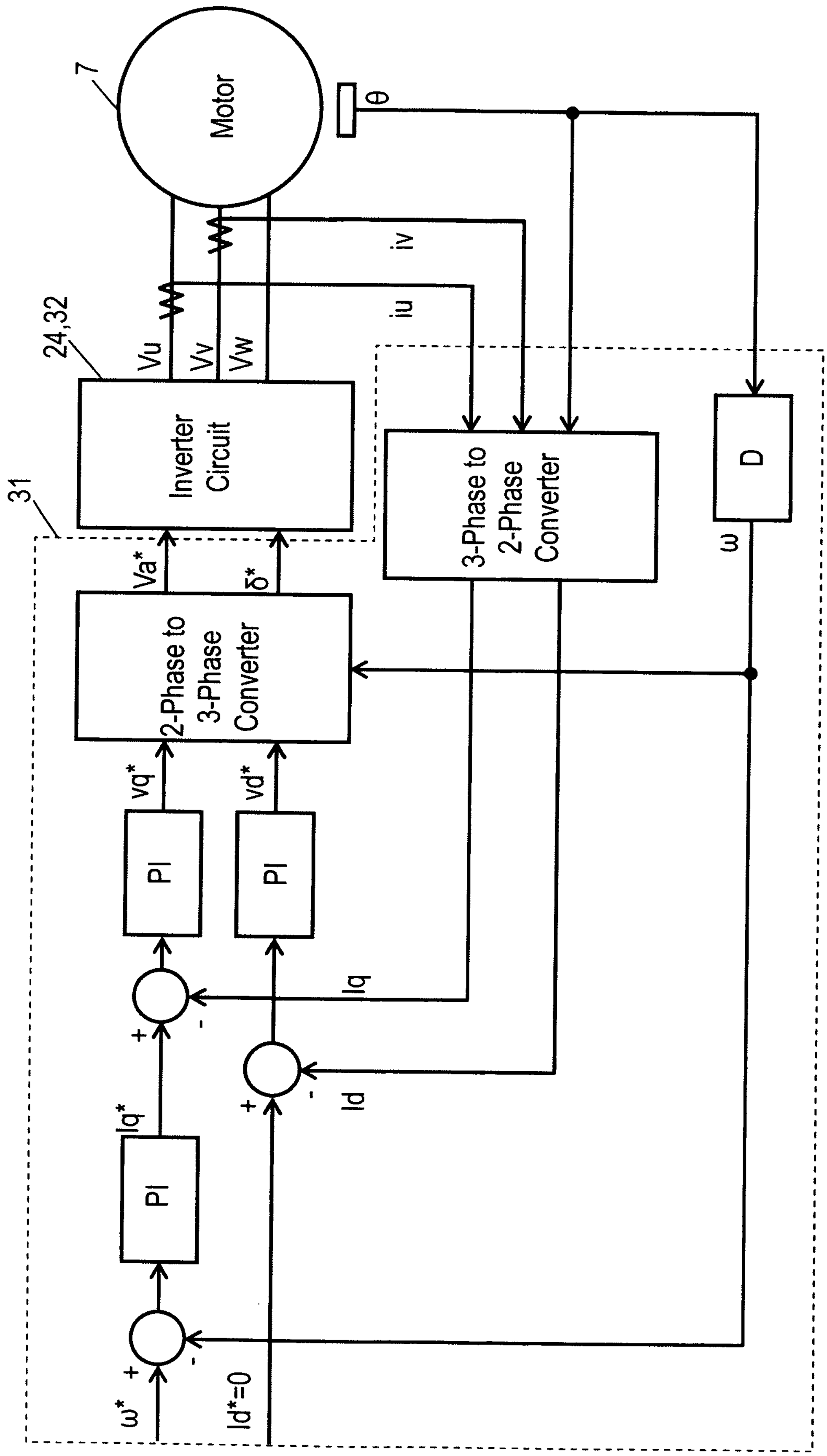

7
Motor
θ
24,32
Vu
Vv
Vw
iu
iv
31
Inverter Circuit
3-Phase to 2-Phase Converter
D
ω
Va*
δ*
2-Phase to 3-Phase Converter
vq*
vd*
PI
PI
Iq
Id
Iq*
PI
ω*
Id*=0
+
-

Fig. 7A

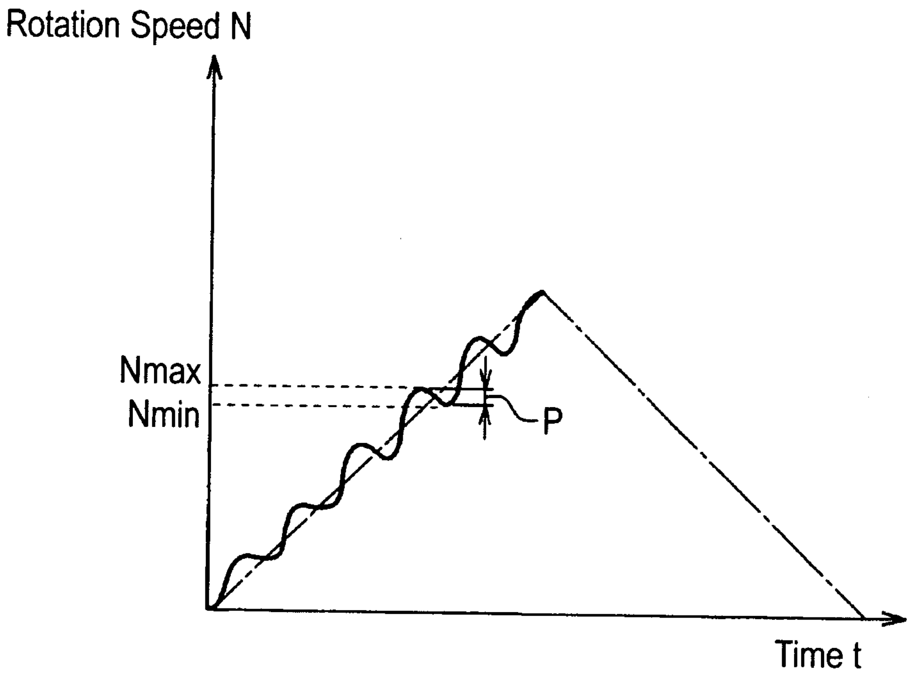

Rotation Speed N
Nmax
Nmin
P
Time t

Fig. 7B

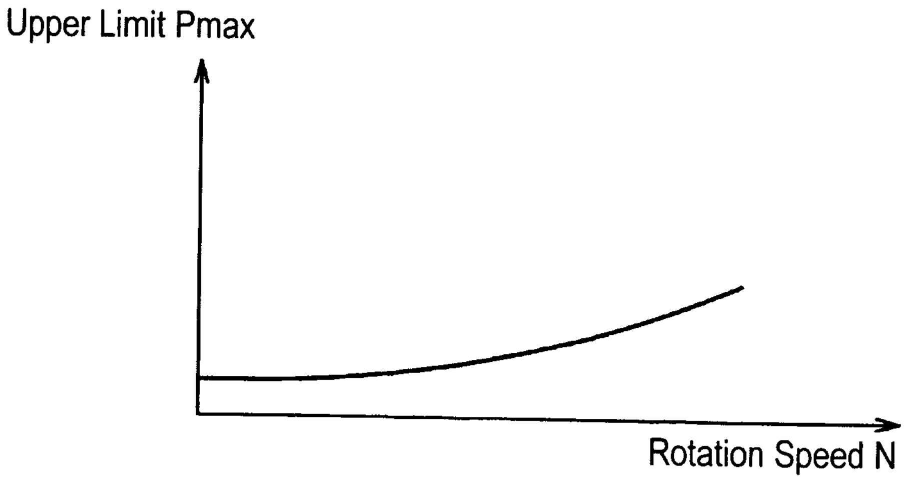

Upper Limit Pmax
Rotation Speed N

Fig. 8

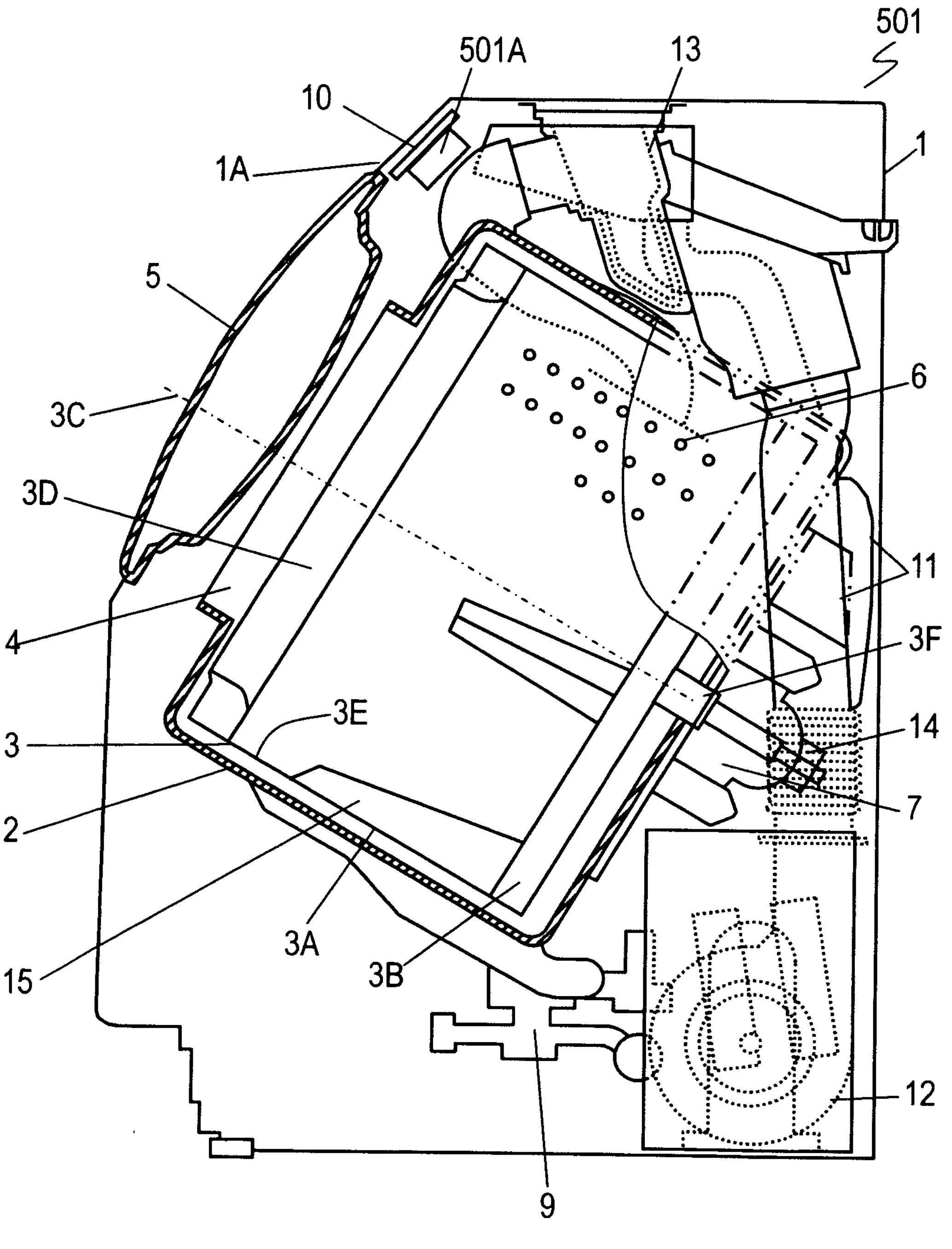
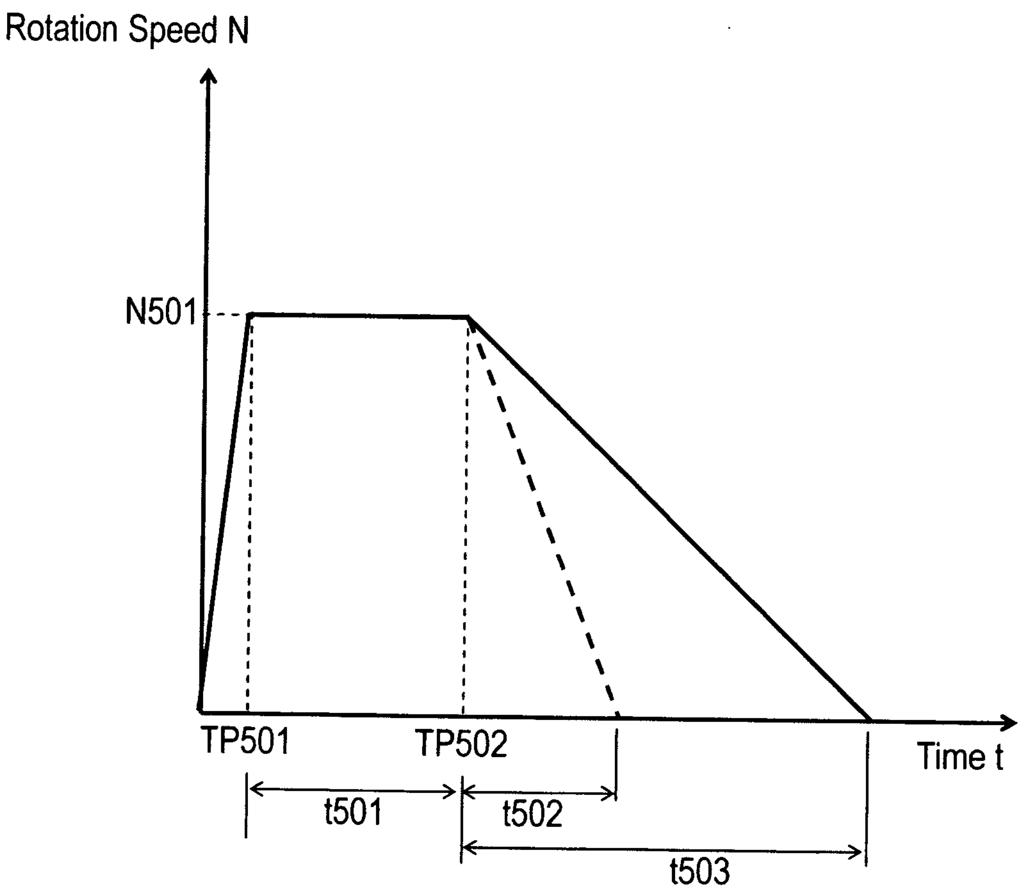


Fig. 9



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5168786 A **[0008]**
- US 2005028299 A **[0016]**