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(71) Applicant: **Kabushiki Kaisha Toshiba**
Minato-ku, Tokyo 105 (JP)

(72) Inventors:
- **Hisano, Koji**
  Seto, Aichi (JP)
- **Hirano, Takayuki**
  Seto, Aichi (JP)
- **Nishiwaki, Satoru**
  Seto, Aichi (JP)
- **Tazawa, Takako**
  Ama-gun, Aichi (JP)

(74) Representative:
O'Connell, David Christopher et al
Haseltine Lake & Co.,
Imperial House,
15-19 Kingsway
London WC2B 6UD (GB)

(54) Automatic washing machine

(57) A washing machine includes a water tub (7), a rotating tub (9) rotatably mounted in the water tub (7) so that laundry is put into the rotating tub, a water supply (38, 45) for supplying water into the water tub (7), a driver (16, 86) for rotating the rotating tub (9), and a control device (86) for controlling the water supply (38, 45) and the driver (16, 86) so that a washing operation is carried out for the laundry. The control device (86) carries out the washing operation under a non-low-foaming detergent mode suitable for a case where a detergent used is a non-low-foaming detergent.

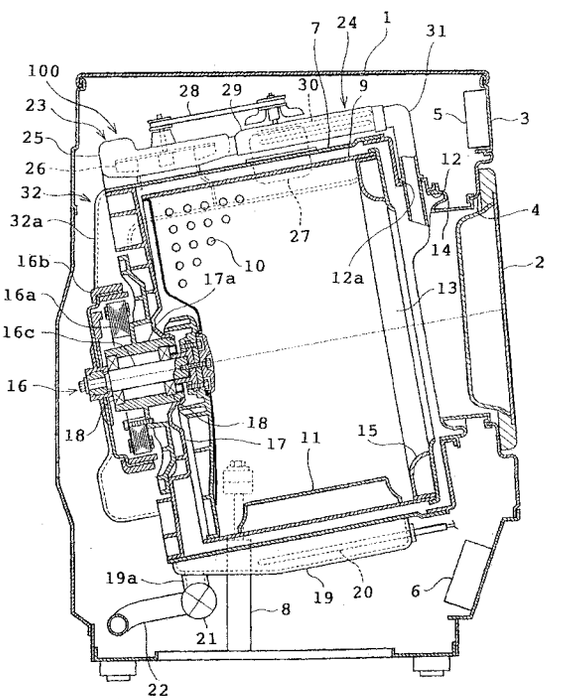

FIG. 1

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Description

[0001] This invention relates generally to automatic washing machines comprising a water tub and a rotating tub rotatably mounted in the water tub, and more particularly to drum type washing machines.

[0002] Low foaming detergents have been recommended for use with conventional drum type washing machines. An amount of foam produced in a wash step is relatively smaller in the case of low foaming detergents. A rotating tub is rotated at a relatively low speed in the wash step so that laundry falls from an upper interior of the rotating tub to a lower interior of the rotating tub in the wash step. In this case, a large amount of foam produced in the rotating tub moderates an impact due to fall of laundry, thereby reducing a washing effect.

[0003] Furthermore, when a large amount of foam is produced in the wash step, the foam enters a space between the rotating tub and a water tub during a dehydration step, thereby preventing the rotating tub from rotation. As a result, since the rotational speed of the rotating tub is not sufficiently increased, the laundry is insufficiently dehydrated or rotation of the rotating tub is interrupted.

[0004] Non-low-foaming detergents or ordinary synthetic detergents are more available and less expensive and have more types than the aforesaid low foaming detergents. Accordingly, a drum type washing machine with which the ordinary synthetic detergents can be used have been desired.

[0005] Therefore, an object of the present invention is to provide a washing machine from which a desired washing effect can be achieved without interruption of rotation of the rotating tub even when a non-low-foaming detergent is used.

[0006] The invention provides a washing machine including a water tub, a rotating tub rotatably mounted in the water tub so that laundry is put into the rotating tub, water supplying means for supplying water into the water tub, drive means for rotating the rotating tub, and control means for controlling the water supplying means and the drive means so that a washing operation is carried out for the laundry, characterized in that the control means carries out the washing operation under a non-low-foaming detergent mode suitable for a case where a detergent used is a non-low-foaming detergent.

[0007] An amount of water supplied into the water tub is preferably smaller under the low foaming detergent mode than under the non-low-foaming detergent mode. Furthermore, the rotational speed of the rotating tub is preferably lower under the low foaming detergent mode than under the non-low-foaming detergent mode. Consequently, production of a large amount of foam can be prevented even when the non-low-foaming detergent is used for the washing operation.

[0008] Furthermore, the number of times of a rinsing operation carried out subsequently to the washing operation under the non-low-foaming detergent mode is preferably larger than the number of times of the rinsing operation carried out subsequently to the washing operation under the low foaming detergent mode. Additionally, the control means preferably carries out a foam discharging operation in which the drive means is caused to rotate the rotating tub while the water supplying means is being caused to supply water into the water tub, so that foam is discharged from the rotating tub. Consequently, interruption of the dehydrating operation by the foam produced in the washing operation can be prevented.

[0009] The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a longitudinally sectional side view of a drum type washer-drier of a first embodiment in accordance with the present invention;
FIG. 2 is a front view of the drum type washer-drier;
FIG. 3 illustrates an operation panel;
FIG. 4 is a rear view of the drum type washer-drier with a rear panel of the outer cabinet being eliminated;
FIG. 5 is a plan view of the drum type washer-drier with an upper panel of the outer cabinet being eliminated;
FIG. 6 is a plan view of a detergent case;
FIG. 7 is a front view of an upper portion of the washer-drier with the detergent case being eliminated from a water supply case;
FIG. 8 is a block diagram showing an electrical arrangement of the washer-drier;
FIG. 9 is a flowchart showing processing of a standard course;
FIG. 10 shows differences in the water level between a low foaming detergent mode and an ordinary synthetic detergent mode;
FIG. 11A shows an amount of detergent displayed on a display when the low foaming detergent mode has been set;
FIG. 11B shows an amount of detergent displayed on a display when the ordinary synthetic detergent mode has been set;
FIG. 12 is a flowchart showing a process for determining whether a detergent case has been set in the water supply case;
FIG. 13 is a graph showing rotation of a rotating tub in the washing operation under the low foaming detergent mode;
FIG. 14 a graph showing rotation of the rotating tub in the washing operation under the ordinary synthetic detergent mode;
FIG. 15 is a flowchart showing a process for determining a water level and an amount of detergent in the wash step in the washer-drier of a second embodiment in accordance with the invention;
FIG. 16 is a view similar to FIG. 12, showing the washer-drier of a third embodiment in accordance

with the invention;

FIG. 17 is a view similar to FIG. 1, showing the washer-drier of a fourth embodiment in accordance with the invention;

FIG. 18 is a view similar to FIG. 4;

FIG. 19 is a flowchart showing a process for the wash step;

FIG. 20 schematically shows a condition where a large amount of foam is produced in the rotating tub;

FIG. 21 is a graph showing changes in the pressure in an air trap;

FIG. 22 is a graph showing differences in the pressure changes due to differences in the foam density in the washer-drier of a fifth embodiment in accordance with the invention; and

FIG. 23 shows thresholds changed with lapse of time in the washing operation.

[0010] A first embodiment of the present invention will be described with reference to FIGS. 1 to 13. In the first embodiment, the invention is applied to a drum type washer-drier. Referring to FIGS. 1 and 2, an overall construction of the washer-drier is shown. A generally rectangular box-shaped outer cabinet 1 has a front formed with a circular access opening 4. A door 2 is hingedly mounted on the front of the cabinet 1 for opening and closing the access opening 4. An operation panel 3 is provided on an upper front of the cabinet 1. An operation circuit unit 5 is provided in the cabinet 1 so as to be located in the rear of the operation panel 3. A control circuit unit 6 is also provided in the cabinet 1 so as to be located in the rear of a lower front of the cabinet 1.

[0011] A drum-like water tub 7 is mounted in the cabinet 1 so as to be inclined rearwardly downward. The water tub 7 is supported by a two suspension mechanisms 8 and has a front formed with a circular opening 12. An elastic member such as a rubber bellows 14 connects the opening 12 to the access opening 4 of the cabinet 1 with watertightness. A drum-like rotating tub 9 is rotatably mounted in the water tub 7. The rotating tub 9 is also inclined rearwardly downward so as to be substantially coaxial with the water tub 7. The rotating tub 9 serves as a dehydration tub, wash tub and drying tub. The rotating tub 9 includes a circumferential wall and a rear end panel each formed with a number of through holes 10 serving to cause water or air to pass therethrough. The rotating tub 9 has a front formed with a circular opening 13. A balancing ring 15 is mounted along a circumferential edge of the opening 13.

[0012] An electric motor 16 is mounted on a generally central part of the rear end panel of the water tub 7 for driving the rotating tub 9. The motor 16 is of the outer rotor type in which a rotor is disposed outside a stator. The motor 16 includes a stator 16a, a rotor 16b and a rotational shaft 16c. A bearing housing 17 having a cylindrical bearing support 17a is fixed on a generally central part of the rear end panel of the water tub 7. The stator 16a is mounted on an outer circumference of the bearing support 17a. The rotational shaft 16c is rotatably mounted on a bearing 18 supported by the bearing support 17a. The rotational shaft 16c has a front end extending through the rear end panel of the water tub 7, being secured to a generally central portion of the rear end panel of the rotating tub 9. The rotating tub 9 is thus directly rotated by the motor 16.

[0013] An outwardly protruding water reservoir 19 is formed on a lowermost portion of the circumferential wall of the water tub 7 so as to be integral with the circumferential wall. A heating element 20 for heating washing liquid is enclosed in the water reservoir 19. A drain hole 19a is formed in a rear end of the bottom of the water reservoir 19. A drain valve 21 and a drain hose 22 both serving as draining means are connected to the drain hole 19a.

[0014] Referring to FIGS. 1 and 4, a drier 100 serving as drying means is provided over the rear, upper and upper front portions of the water tub 7. More specifically, a heater 24 and blower 23 are disposed before and behind on the upper portion of the water tub 7. The blower 23 includes a casing 25, a blowing blade 26 provided in the casing 25, and an electric motor 27 fixed to an outer part of the casing 25 for driving the blowing blade 26. A belt transmission mechanism 7 connects the motor 27 to the blowing blade 26. The heater 24 includes a casing 29 and a heating element 30 disposed in the casing. The casing 29 has a rear end connected to a discharge side of the casing 25. A warm wind discharge hole 12a is formed over the opening 12 of the water tub 7. A duct 31 has one of two ends connected to the warm wind discharge hole 12a. The other end of the duct 31 is connected to a front end of the case 29 of the heater 24.

[0015] A heat exchanger 32 is provided in the rear of the water tub 7 in the casing 1. The heat exchanger 32 comprises a duct 32a provided on the left hand of the rear end panel of the water tub 7 as viewed in FIG. 4. The duct 32a is curved along the outer circumference of the rear end panel. A plurality of walls 33 are formed in the duct 32a to define a zigzag passage therein. The rear end panel of the water tub 7 has an air inlet 34 formed to correspond to a lower portion of the duct 32a. The air inlet 34 also serves as a water inlet. The duct 32 has an air outlet 35 and a water inlet 36 both formed in an upper portion thereof. The duct 32a is connected through the air outlet 35 to a suction side of the casing 25. Heat exchange is caused between air in the duct 32a and water supplied through the water inlet 36 in the above-described heat exchanger 32. The air in the duct 32a is thus cooled to be dehumidified. Accordingly, the heat exchanger 32 is of the water cooling type. The above-described blower 23, heater 24 and heat exchanger 32 constitute a drier 100.

[0016] Referring now to FIG. 5, a pump mount 37 is provided in the left-hand rear interior of the outer cabinet 1. A pump 38 is mounted on the mount 37 to supply bathwater. The pump 38 includes a priming supply opening 39, a suction opening 40 and a discharge opening 41.

A suction hose (not shown) is connected to the suction opening 40 so that bathwater is sucked up from a bathtub.

[0017] A water supply case 42 is provided in an upper left-hand front interior of the outer cabinet 1. The discharge opening 41 and supply opening 39 of the pump 38 are connected through respective hoses 44 to the water supply case 42. A detergent container 80 as shown in FIG. 6 is enclosed in the water supply case 42. The detergent container 80 includes a front panel 80a and a container body 80b having a powdered synthetic detergent container 83, a liquid detergent or bleach container 84 and a softener container 85. A magnet 103 is embedded in a left-hand portion of the front panel 80a.

[0018] Returning to FIG. 2, the front panel 80a having a front generally planar with the front of the outer casing 2. The front of the panel 80a has a hand hook 81 covered with a turnable lid 82. When pressed by fingers, the lid 82 is turned such that the front of the hand hook 81 is opened. When the hand hook 81 is drawn, the detergent container 80 is drawn outward to be drawn out from the water supply case 42.

[0019] Referring now to FIG. 7, the upper portion of the outer cabinet 1 is shown with the detergent container 80 having been removed from the water supply case 42. As shown, a reed switch 102 is mounted on an upper inner wall of the cabinet 1 so as to be located in the left of the water supply case 42. When the detergent container 80 has been set in the water supply case 42, the magnet 103 is located in proximity to the reed switch 102 such that the reed switch is turned on. Thus, the reed switch 102 and the magnet 103 serve as detecting means for detecting attachment or detachment of the detergent container 80 to or from the water supply case 42.

[0020] Referring now to FIG. 5, a water supply unit 45 is provided on the right of the pump 38 in the outer cabinet 1. The pump 38 and the water supply unit 45 constitute water supplying means in the invention. The water supply unit 45 includes a single water input section 46 and three water output sections 47 to 49. The water input section 46 is connected through a hose (not shown) to a faucet of a water service. Three valves 50 to 52 are mounted on the water output sections 47 to 49 respectively. The valves 50 and 51 are connected through hoses 53 and 54 to the water supply case 42 respectively. The valve 52 is connected through a hose 55 to the water inlet 36 of the duct 32a. Thus, the water supply unit 45 serves as heat exchanger water supplying means.

[0021] Bathwater is supplied via the hose 43 into the water supply case 42. Water from the water service is supplied via the hose 53 into the water supply case 42. The bathwater and the water from the water service are caused to pass through the containers 83 and 84 and thereafter supplied into the water tub 7. On the other hand, water from the water service is supplied via the hose 54 into the water supply case 42. The water is then caused to pass through the container 85 and thereafter supplied into the water tub 7.

[0022] The operation panel 3 will be described in detail with reference to FIG. 3. The operation panel 3 includes a power supply switch 56, start switch 57 serving also as an interrupt switch, various switches 58 to 63, and display sections 64 to 70 displaying contents set by the respective switches 58-63. The operation panel 3 further includes switches 72 to 75 and display sections 76 to 79 displaying contents set by the respective switches 72-75. For example, a COURSE switch 60 is provided for setting a washing course. A DETERGENT switch 63 is provided for setting a used detergent between an ordinary synthetic detergent (corresponding to a non-low-foaming detergent) and a low foaming detergent. When the ordinary synthetic detergent is set, the display section 70 comprising LEDs is turned on. In the following description, a mode in which an ordinary synthetic detergent is used in a washing operation will be referred to as "ordinary synthetic detergent mode." A mode in which a low foaming detergent is used in a washing operation will be referred to as "low foaming detergent mode." Furthermore, the display section 69 displays an amount of detergent according to an amount of laundry put into the rotating tub 9. In particular, the display section 69 displays an amount of detergent according to a type of the set detergent in the embodiment. Thus, the display section 69 serves as detergent amount display means.

[0023] Referring to FIG. 8, an electrical arrangement of the washer-drier is shown. A control circuit 86 serving as control means comprises a microcomputer and stores a control program for controlling an overall washing operation and an overall drying operation. An input circuit 87 delivers an operation signal to the control circuit 86. The reed switch 102 also delivers the operation signal to the control circuit 86. A water level sensor 88, a rotational position sensor 89, a turbidity sensor 90 and a dryness sensor 91 deliver respective signals to the control circuit 87. The input circuit 87 outputs operation signals delivered in response to the switches 57 to 63 and 72 to 75 except for the power switch 56 on the operation panel 3. The water level sensor 88 detects a water level in the water tub 7. The rotational position sensor 89 delivers a rotational position signal according to a rotational position of the motor 16. The turbidity sensor 90 comprises a photosensor detecting transmittance of washing liquid in the water tub 7 and delivers a signal according to turbidity of the washing liquid. The dryness sensor 91 delivers a signal according to a dryness factor of the laundry. For example, the dryness sensor 91 comprises a thermistor detecting a temperature in the duct 32a of the heat exchanger 32 and another thermistor detecting a temperature in the water tub 7.

[0024] The motor 16 is electrically connected via an inverter circuit 92 to the control circuit 86. A buzzer 93, a display circuit 94 and the heating element 20 are connected via a drive circuit 95 to the control circuit 86. The

drain valve 21, motor 27, heating element 30, pump 38 and valves 50 to 52 are also connected via the drive circuit 95 to the control circuit 20. The display circuit 94 is connected to the display sections 64 to 70 and 76 to 79 of the operation panel 3. The control circuit 86 and the motor 16 constitute drive means and laundry amount detecting means. Furthermore, the control circuit 86 and the display circuit 94 constitute detergent amount display means. The control circuit 86 further serves as supplied water amount determining means.

[0025] The operation of the washer-drier will now be described with reference to FIGS. 9 to 14. The following mainly described the differences between the ordinary synthetic detergent mode and the low foaming detergent mode under a STANDARD course. FIG. 9 shows processing steps carried out when the STANDARD course has been set. In the STANDARD course, wash, intermediate dehydration, rinse, final dehydration and drying steps are sequentially carried out upon operation of the start switch 57. In the wash step, a water supplying operation (step S1), a washing operation (step S2) and a dehydrating operation (step S3) are sequentially carried out. In the water supplying operation, a water level in the water tub 7 in the wash step is firstly determined. Four water levels, that is, EXTREMELY LOW, LOW, MIDDLE and HIGH, are previously set according to an amount of laundry put into the rotating tub 9. An amount of laundry in the rotating tub 9 is detected on the basis of a rotational speed of the motor 16 and accordingly a rotational speed of the rotating tub 9 in a case where a predetermined input current is supplied to the motor 16 so that the motor is driven. FIG. 10 shows water levels in the water tub 7 according to an amount of laundry. As shown, all the water levels in an ordinary synthetic detergent mode except the EXTREMELY LOW are lower by 20 mm than those in a low foaming detergent mode respectively. The water level of EXTREMELY LOW is set at 40 mm in each detergent mode.

[0026] The control circuit 86 stores data of amounts of detergent according to the water levels. When a water level has been determined, an amount of detergent according to the determined water level is displayed on the display section 69. FIGS. 11A and 11B illustrate examples of displayed detergent amounts corresponding to the HIGHs in the low foaming and ordinary synthetic detergent modes respectively. A pictograph 69a similar to the character of U and displayed on the right-hand part of the display section 69 designates a measuring cup representative of a unit of detergent amount. An amount of detergent corresponding to the HIGH in the low foaming detergent mode is displayed as 0.8 cups. An amount of detergent corresponding to the HIGH in the ordinary synthetic detergent mode is displayed as 1 cup. All the water levels in the ordinary synthetic detergent mode except the EXTREMELY LOW are lower by 20 mm than those in the low foaming detergent mode respectively as described above. Accordingly, detergent amounts in the low foaming detergent mode are larger by 0.2 cups than those in the ordinary synthetic detergent mode respectively. Based on the detergent amount displayed on the display section 69, the user puts a suitable amount of detergent into the container 83 or 84 of the detergent container 80.

[0027] When the water level has been determined and the detergent amount has been displayed, the water supply unit 45 or the pump 38 is driven so that water is supplied into the water tub 7. In this case, the control circuit 86 determines whether the detergent container 80 is attached to the water supply case 42, based on the signal from the reed switch 102. Based on the determination, the control circuit 68 starts driving the water supply unit 45 or the pump 38. FIG. 12 shows a determining process on the basis of the signal delivered from the reed switch 102. At step A1, the control circuit 68 determines whether the reed switch 102 has been turned on, namely, whether the detergent container 80 has been detached from the water supply case 42 and re-attached to the water supply case 42 with detergent in the container 83 or 84. When determining in the affirmative at step A1, the control circuit 68 determines at step A2 that the detergent container 80 has been set, finishing the process and starting the water supply.

[0028] On the other hand, when determining in the negative at step A1, the control circuit 68 advances to step A3 to determine whether the reed switch 80 is in an OFF-state. When the reed switch 102 is in the OFF-state (YES), that is, when the detergent container 80 has not been attached to the water supply case 42, the control circuit 68 advances to step A4 to determine whether a time t1 has elapsed after the detergent amount has been displayed on the display section 69. When the time t1 has not elapsed (NO), the control circuit 68 returns to step A1. When the time t1 has elapsed (YES), the control circuit 68 operates the buzzer 93 so that an error is informed of (step A5). Thereafter, the control circuit 68 returns to step A1 when the start switch 57 is operated (YES at step A6). Accordingly, when finding occurrence of the error by activation of the buzzer 93, the user attaches the detergent container 80 to the water supply case 42. As a result, water supply starts.

[0029] On the other hand, when determining in the negative (NO) at step A3 or when the detergent container 80 has been attached to the water supply case 42, the control circuit 68 advances to step A7 to determine whether a time t2 has elapsed after the detergent amount was displayed on the display section 69. When the time t2 has not expired (NO), the control circuit 68 returns to step A1. When the time t2 has expired (YES), the control circuit 68 determines that the detergent container 80 has been attached to the water supply case 42, finishing the processing. Thus, when the time t2 has expired at step A7, the control circuit 68 determines that the detergent container 80 has been set. This determination takes it into consideration that the user puts detergent into the detergent container 80 and attaches the detergent container to the water supply case 42 before

a detergent amount is displayed on the display section 69 or that the washing operation is carried out without use of a detergent. Accordingly, the water supply is not carried out without the detergent container 80 attached to the water supply case 42 in the washer-drier of the embodiment.

[0030] When a predetermined water level is reached in the water tub 7 such that water supply is finished, the rotating tub 9 is driven so that the washing operation is carried out (step S2). In this case, under the low foaming detergent mode, the motor 16 is controlled so that states of a low speed ranging from 40 to 50 rpm, a high speed ranging from 60 to 80 rpm and stop are sequentially repeated, as shown in FIG. 13. In the low speed state, the laundry in the rotating tub 9 is pushed by a baffle 11 thereby to be moved upward and thereafter falls down, so that the laundry is washed. In the high speed state, the laundry in the rotating tub 9 is rotated while adhering to a circumferential wall of the rotating tub 9 by a centrifugal force, so that the laundry is washed.

[0031] Under the ordinary synthetic detergent mode, the motor 16 is controlled so that two states, that is, a low speed ranging from 40 to 50 rpm and stop are alternately repeated as shown in FIG. 14. Accordingly, in the ordinary synthetic detergent mode, the laundry in the rotating tub 9 is pushed by the baffle 11 thereby to be moved upward and thereafter falls down, so that the laundry is washed. As a result, an amount of foam produced during the washing operation under the ordinary synthetic detergent mode can be reduced.

[0032] Upon completion of the washing operation, the drain valve 21 is opened so that the water tub 7 is drained (step S3). Under the ordinary synthetic detergent mode, while the drain valve 21 is open, water is supplied by the water supply unit 45 and the rotating tub 9 is rotated in one direction at high speeds so that a foam discharging operation is carried out at predetermined intervals.

[0033] Upon completion of the wash step, the control circuit 86 opens the valve 52 of the water supply unit 45 to supply water from the water service into the duct 32a of the heat exchanger 32 (step S4), advancing to the subsequent intermediate dehydration step (step S5). Thus, the water is supplied into the duct 32a so that foam and lint having entered the duct 32a until start of the drying step are discharged through the air inlet 34. In the intermediate dehydration step, the rotating tub 9 is rotated while the drain valve 21 is open.

[0034] In the rinse step, the rotating tub 9 is rotated while water is being supplied into the water tub 7 (step S6), and the water tub 7 is drained while the drain valve 21 is open (step S7). These steps are carried out in turn. At step S8, the control circuit 86 determines whether the rinsing and draining operations have been carried out N times. The control circuit 86 returns to step S6 when the operations has not been carried out N times.

[0035] The number of times N under the low foaming detergent mode is set at one or three on the basis of a result of detection by the turbidity sensor 90. On the other hand, the number of times N is set at four in the ordinary synthetic detergent mode.

[0036] Upon completion of the rinse step, the control circuit 86 advances to step S9 to determine whether the drying step is carried out. When determining that the rinse step is carried out (YES) , the control circuit 86 advances to step S10 to energize the heating element 30. When the final dehydration step (step S11) and the drying step (step S12) have been carried out, the valve 52 of the water supply unit 45 is closed so that the water supply into the duct 32a of the heat exchanger 32 is stopped, whereby the washing operation is completed. Under either low foaming detergent mode or ordinary synthetic detergent mode, the rotating tub 9 is rotated in one direction at high speeds with the drain valve 21 being open in the final dehydration step.

[0037] In the drying step, the rotating tub 9 is rotated at low speeds in both directions alternately, and the blower 23 is driven. Prior to the drying step, the heating element 30 is energized, and water is supplied from the water supply unit 45 into the duct 32a. As a result, moist air in the rotating tub 9 is sucked via the holes 10 and air inlet 34 into the duct 32a. The air sucked into the duct 32a is condensed by the water supplied through the water inlet 36 to be dehumidified. The dehumidified air flows through the air outlet 35 into the casing 25 of the blower 23. The dehumidified air then flows through the casing 29 of the heater 24 and the duct 31 in turn to be returned via the warm air discharge hole 12a into the water tub 7 and the rotating tub 9. As the result of the above-described air circulation, air in the rotating tub 9 is warmed and dehumidified, whereupon the laundry is dried. In particular, the heating element 30 is energized prior to the drying step in the embodiment and accordingly, a drying time can be reduced.

[0038] The control circuit 86 determines in the negative at step S9 in the case of the STANDARD course including only the washing operation. The final dehydration step is carried out at step S14, and all the steps have been completed.

[0039] According to the foregoing embodiment, the water level in the wash step in the ordinary synthetic detergent mode is lower than that in the low foaming detergent mode. Further, an amount of detergent in the wash step under the ordinary synthetic detergent mode is smaller than that under the low foaming detergent mode. Consequently, an amount of foam produced in the wash step can be reduced since the ordinary synthetic detergent is used. Furthermore, a capacity of the rotating tub 9 accommodating the foam produced in the wash step can be increased since the water level is reduced. Accordingly, the foam produced in the wash step can be prevented from entering a space between the tubs 9 and 7 to obstruct rotation of the rotating tub 9.

[0040] Under the ordinary synthetic detergent mode, the rotating tub 9 is rotated at low speeds in the washing operation. Consequently, an amount of foam produced

can be reduced. In the conventional drum type washing machines, a large amount of foam is produced in the rotating tub when an ordinary synthetic detergent is used, whereupon the cleaning effect is reduced and rotation of the rotating tub is obstructed. In the foregoing embodiment, however, the wash step can be carried out desirably even when an ordinary synthetic detergent is used.

[0041] Under the ordinary synthetic detergent mode, the foam discharging operation is carried out between the draining operation and the dehydrating operation in the intermediate dehydration step. Consequently, the rotation of the rotating tub 9 in the dehydrating operation can be prevented from being obstructed by the foam produced during the wash step. Furthermore, the rinsing operation is carried out in the rinse step under the ordinary synthetic detergent mode more frequently than the rinsing operation in the rinse step under the low foaming detergent mode. Consequently, the foam discharge can be enhanced even when the use of an ordinary synthetic detergent results in a large amount of foam.

[0042] FIG. 15 illustrates a second embodiment of the invention. FIG. 15 is a flowchart showing a process for determining a water level and an amount of detergent in the wash step. More specifically, the control circuit 86 firstly carries out a first detection of laundry amount (step B1) and determines an amount of detergent on the basis of a result of the detection (step B2). In the first detection of laundry amount, a predetermined input current is supplied to the motor 16 so that the rotating tub 9 is driven for a short period of time, for example, 15 seconds. Accordingly, a rough amount of laundry is obtained in the first detection. Upon determination of a detergent amount, the control circuit 86 displays the determined detergent amount on the display section 69. Thus, since the user finds a necessary amount of detergent at an initial stage of the wash step, the detergent can quickly be put into the detergent container 80.

[0043] The control circuit 86 then carries out a second detection of laundry amount (step B3) and determines a water level in the water tub 7 in the wash step on the basis of a result of the detection (step B4). In the second detection of laundry amount, the predetermined input current is supplied to the motor 16 so that the rotating tub 9 is driven for a longer period of time than in the first detection, for example, 40 seconds. Accordingly, a more accurate laundry amount can be obtained in the second detection than in the first detection. Based on the result of laundry amount detection, the control circuit 86 determines any water level between a minimum water level and a maximum water level. A suitable amount of water is supplied into the water tub 7 according to the laundry amount by the water supply unit 45 or pump 38.

[0044] When putting detergent into the detergent container 80, the user measures a necessary amount of detergent with a measuring cup or the like. The detergent amount may sometimes involve an accidental error. Accordingly, no problem arouses even when a laundry amount is determined on the basis of the rough first detection.

[0045] FIG. 16 illustrates a third embodiment of the invention. FIG. 16 is a flowchart showing a process for determining whether a detergent container 80 has been set in the water supply case 42. In the third embodiment, when determining at step A7 that the time t2 has expired since a detergent amount was displayed on the display section 69 (YES), the control circuit 68 advances to step A71 to turn on the buzzer 93 to inform of an error. Thereafter, upon operation of the start switch 57 (YES at step A72), the control circuit 86 advances to step A2. Alternatively, when a time t3 has expired (YES at step A73) without operation of the start switch 57 (NO at step A72), the control circuit 86 advances to step A2. Consequently, the user can remember to put the detergent into the detergent container 80.

[0046] FIG. 17 to 21 illustrate a fourth embodiment of the invention. A generally rectangular box shaped air trap 111 is mounted on the rear of the duct 32a of the heat exchanger 32. The duct 32a is formed with an overflow hole 112 through which water in the duct 32a is caused to overflow under an abnormal condition. The air trap 111 is located lower than the overflow hole 112. The rear of the duct 32a has a small through hole 111a corresponding to a lower portion of the air trap 111. The air trap 111 communicates via the hole 111a with the duct 32a.

[0047] A pressure sensor 113 is mounted on an inner wall of the top of the outer casing 1. The pressure sensor 113 is connected via a tube 114 to the air trap 111. Pressure in the air trap 111 is detected by the pressure sensor 113. The pressure sensor 113 is of a high sensitive type and can detect a very small pressure of about several hundreds [Pa]. The pressure sensor 113 delivers a signal to the control circuit 86.

[0048] The control circuit 86 determines a condition of foam in the rotating tub 9 on the basis of the signal delivered by the pressure sensor 113 when the wash step is carried out. Thus, the control circuit 86, air trap 111 and pressure sensor 113 constitute foam detecting means. Accordingly, a test is conducted prior to shipment of products. In the test, water is supplied into the water tub 7, and whether a detected value of the pressure sensor varies approximately when a water level reaches the small hole 111a.

[0049] FIG. 19 is a flowchart showing a process for the wash step. The control circuit 86 firstly inputs a detected value P of the pressure sensor 113, storing it as a reference P0 (step C1). The control circuit 86 further stores data of an upper limit value PA and a lower limit value PB of the detected value P. When the detected value P obtained at step C1 is smaller than the lower limit value PB, the control circuit 86 determines that the detection is erroneous. In this case, the lower limit value PB is stored as the reference P0. Water is then supplied into the water tub 7. (step C2). Water supply is carried out until a water level according to a laundry amount is

reached, and the rotating tub 9 is rotated at low speeds so that the laundry and wash liquid in the rotating tub 9 are agitated.

[0050] Upon completion of the water supply, the control circuit 86 starts the washing operation (step C3). The rotating tub 9 is rotated in opposite directions alternately (as in the directions of arrows X and Y in FIG. 18) either under the low foaming detergent mode or under the ordinary synthetic detergent mode. Upon start of the washing operation, the control circuit 86 inputs the detected value P of the pressure sensor 113 in synchronization with rotation of the tub 9 in the direction of arrow X (step C4). The control circuit 86 then obtains the difference ΔP between the reference P0 and the input detected value P by calculation (step C5). When the detected value P is without the range between the lower limit value PB and the upper limit value PA, the control circuit 86 determines that the detection is erroneous, reinputting the detected value P. Additionally, when the detected value P is smaller than the reference P0, the reference P0 is renewed to the detected value P.

[0051] Foam is produced in the rotating tub 9 when the washing operation is carried out. In this case, a large amount of foam is produced as shown in FIG. 20 when an ordinary synthetic detergent has been used although the low foaming detergent mode has been set, or when a large amount of detergent exceeding an amount displayed on the display section 69 has been put into the detergent container 80. The foam enters a space between the tubs 7 and 9 through the holes 10. The foam further enters the duct 32a through the air inlet 34. Pressure in the air trap 111 is increased when the foam in the duct 32a has reached the small hole 111a. FIG. 21 shows changes in the pressure in the air trap 111. The foam does not reach the small hole 111a until a short period of time expires from start of the washing operation and accordingly, pressure in the air trap 111 is maintained at a low value. However, the pressure in the air trap 111 is suddenly increased when the foam has reached the small hole 111a.

[0052] The duct 32a is disposed on a left-hand portion of the rear end plate of the water tub 7 as shown in FIG. 18. Accordingly, when the rotating tub 9 is rotated in the direction of arrow X, water in the water tub 7 tends to easily enter the duct 32a with rotation of the rotating tub 9. As a result, the foam in the duct 32a is forced upward such that the pressure in the air trap 111 is changed to a large extent. Accordingly, the control circuit 86 inputs the detected value P of the pressure sensor 113 in synchronization with rotation of the tub 9 in the direction of arrow X.

[0053] The above-mentioned difference ΔP is compared with a threshold KP at step C6. The threshold KP was experimentally obtained from the pressure changes in the air trap 111 as shown in FIG. 21. When the difference ΔP is smaller than the threshold KP (NO), the control circuit 86 determines that the condition of the foam is normal (step C7), advancing to step C8. On the other hand, when the difference ΔP is larger than the threshold KP (YES), the control circuit 86 determines that the condition of the foam is abnormal (step C9). Successively, the control circuit 86 determines whether the determination that the condition of the foam is abnormal has taken place at a predetermined number of times, for example, three times (step C10). When the determination has taken place once or twice, the drain valve 21 is opened for 12 seconds, for example so that part (about 2 lit.) of the water in the water tub 7 is discharged (step C11). The control circuit 86 then advances to step C8. When the determination has taken place three times, the drain valve 21 is opened (step C12), advancing to step C8.

[0054] At step C8, the control circuit 86 determines whether the washing operation is finished. When the washing operation is to be continued (NO), the control circuit 86 returns to step C4 to repeat the above processing. Accordingly, when the drain valve 21 is opened at step C12, the washing operation is carried out with all the wash liquid in the water tub 7 discharged. In this case, wash liquid having permeated the laundry is utilized for the washing operation. On the other hand, when the washing operation has been finished (YES at step C8), the control circuit 86 advances to step C13 to determine whether the determination of abnormal condition has taken place at least once. When determining that the determination of abnormal condition has taken place at least once (YES), the wash liquid discharging operation is carried out together with the aforesaid foam discharging operation (step C14). When determining that the determination of abnormal condition has never taken place (NO), a normal draining operation is carried out (step C15).

[0055] According to the fourth embodiment, the pressure in the air trap 111 is detected by the pressure sensor 113. Based on the detected pressure, the control circuit 86 determines whether the condition of foam in the tub 9 is abnormal. Consequently, the control circuit 86 can detect production of a large amount of foam in the tub 9 due to an error in the type of detergent used or an error in an amount of detergent.

[0056] When the determination of abnormal foam condition has taken place once or twice, part of the wash liquid in the water tub 7 is discharged. As a result, a space accommodating the foam in the water tub 7 is increased and accordingly, the height of the foam is reduced. Consequently, an adverse effect of the foam on the washing operation can be reduced. Furthermore, an amount of wash liquid in the water tub 7 is reduced such that an amount of foam produced after the determination by the control circuit 86 can be reduced. Additionally, when the determination of abnormal foam condition has taken place three times, all the wash liquid is discharged from the water tub 7. Consequently, little foam is produced after the determination.

[0057] FIGS. 22 and 23 illustrate a fifth embodiment of the invention. Only the difference between the fourth

and fifth embodiments will be described. In the fifth embodiment, the value of the threshold KP is changed by stages according to a time expired from start of the washing operation for the following reason: an adverse effect of the foam on the washing operation is small if the foam density is small even when a large amount of foam is produced in the rotating tub 9. Differences in the foam density result from the type of detergent and a detergent amount. Even when the foam having entered the duct 32a reaches the small hole 111a of the air trap 111, the pressure in the air trap 111 differs depending upon the foam density. FIG. 22 shows pressure changes (difference ΔP from the reference P0) with lapse of time during the washing operation. Curve D1 represents a lowest density and curve D4 represents a highest density. As shown, the pressure is increased upon start of the washing operation in the case of the foam with a high density. On the other hand, the pressure does not almost change in the case of the foam with a low density.

[0058] In the fifth embodiment, the threshold is set at a large value in an initial stage of the washing operation so as to correspond to a high-density foam, as shown in FIG. 23. Even when foam has reached the small hole 111a of the air trap 111 in the case where a foam density is low, the control circuit 86 is arranged not to determine that the foam condition is abnormal. Further, the threshold is rendered smaller with lapse of time from initial occurrence of foam so that a low-density foam is coped with. Consequently, the determination that the foam condition is abnormal can be made with a suitable timing irrespective of a foam density.

[0059] In the first embodiment, the water level under the ordinary synthetic detergent mode is set so that an amount of water is smaller by 20 ml than that under the low foaming detergent mode. However, the water level under the ordinary synthetic detergent mode may be set to be about 80% of that under the low foaming detergent mode, instead.

[0060] The time period of the washing operation may be increased when the rotational speed of the rotating tub 9 during the washing operation under the ordinary synthetic detergent mode is rendered lower than that under the low foaming detergent mode. In this case, the time period of the washing operation under the ordinary synthetic detergent mode may be rendered longer by 5 minutes than that under the low foaming detergent mode or by 30%.

[0061] The detecting means for detecting the detergent container set in the water supply case 42 may comprise a microswtich or a photoelectric switch.

[0062] In the fourth embodiment, the rotational speed of the rotating tub 9 may be reduced when the determination that the condition of the foam is abnormal has taken place once or at a plurality of times. In this case, too, an amount of foam produced after the determination by the control circuit 86 can be reduced.

[0063] The air trap 111 may be disposed at any location where a large amount of foam produced in the rotating tub 9 changes the pressure in the air trap.

[0064] The present invention may be applied to drum type washing machines without a drying function. The invention may further be applied to full automatic washing machines of the vertical axis type with or without a drying function.

[0065] The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the invention as defined by the appended claims.

Claims

1. A washing machine including a water tub (7), a rotating tub (9) rotatably mounted in the water tub (7) so that laundry is put into the rotating tub (9), water supplying means (38, 45) for supplying water into the water tub (7), drive means (16, 86) for rotating the rotating tub (9), and control means (86) for controlling the water supplying means (38, 45) and the drive means (16, 86) so that a washing operation is carried out for the laundry, **characterized in that** the control means (86) carries out the washing operation under a non-low-foaming detergent mode suitable for a case where a detergent used is a non-low-foaming detergent.

2. A washing machine according to claim 1, **characterized in that** the control means (86) carries out the washing operation selectively under a low foaming detergent mode suitable for a case where the detergent used is the low foaming detergent or under the non-low-foaming detergent mode.

3. A washing machine according to claim 2, **characterized in that** the control means (86) controls the water supplying means (38, 45) so that an amount of water supplied is smaller when the washing operation is carried out under the non-low-foaming detergent mode than when the washing operation is carried out under the low foaming detergent mode.

4. A washing machine according to claim 2, **characterized in that** the control means (86) controls the drive means (16, 86) so that a rotational speed of the rotating tub (9) is lower when the washing operation is carried out under the non-low-foaming detergent mode than when the washing operation is carried out under the low foaming detergent mode.

5. A washing machine according to claim 2, **characterized in that** the control means (86) controls the water supplying means (38, 45) and the drive means (16, 86) subsequently to the washing oper-

ation so that a rinsing operation is carried out for the laundry, and a number of times of the rinsing operation carried out subsequently to the washing operation under the non-low-foaming detergent mode is larger than a number of times of the rinsing operation carried out subsequently to the washing operation under the low foaming detergent mode.

6. A washing machine according to claim 1 or 2, **characterized in that** subsequently to the washing operation under the non-low-foaming detergent mode, the control means (86) carries out a foam discharging operation in which the drive means (16, 86) is caused to rotate the rotating tub (9) while the water supplying means (38, 45) is being caused to supply water into the water tub (9), so that foam is discharged from the rotating tub (9).

7. A washing machine according to claim 1 or 2, **characterized in that** the rotating tub is rotated about a horizontal axis and the control means (86) controls the drive means (16, 86) so that in a case where the washing operation is carried out under the non-low foaming detergent mode, the laundry falls without adhering to an inner wall of the rotating tub (9) when moved to an upper interior of the rotating tub (9).

8. A washing machine according to claim 2, further **characterized by** detergent amount display means (69, 86, 94) for displaying an amount of detergent according to a mode of the washing operation.

9. A washing machine according to claim 1 or 2, further **characterized by** laundry amount detecting means (16, 86) for executing a first detecting operation in which a rough amount of the laundry in the rotating tub (9) is detected and a second detecting operation in which an accurate amount of the laundry is detected, the first and second detecting operations being executed in turn in this order, detergent amount display means (69, 86, 94) for displaying an amount of a detergent on the basis of a result of the first detecting operation, and water amount determining means (86) for determining an amount of water supplied into the water tub (7) on the basis of a result of the second detecting operation.

10. A washing machine according to claim 1 or 2, further **characterized by** drying means (100) provided for drying the laundry in the rotating tub (9) and including a heat exchanger (32) mounted on the water tub (7) and heat exchanger water supply means (45) for supplying water to the heat exchanger (32), and
characterized in that the control means (86) causes the heat exchanger water supply means (45) to supply water to the heat exchanger (32) at least one of a rinse step and a dehydration step.

11. A washing machine according to claim 1, further **characterized by** foam detecting means (86, 111, 113) for detecting an amount of foam produced in the rotating tub (9) during the washing operation.

12. A washing machine according to claim 11, further **characterized by** draining means (21) for draining the water tub (7), and **characterized in that** when determining that an amount of foam produced is excessive, based on a result of detection by the foam detecting means (86, 111, 113), the control means (86) drives the draining means (21) so that the water tub (7) is partly drained.

13. A washing machine according to claim 11, further **characterized by** draining means (21) for draining the water tub (7), and **characterized in that** when determining that an amount of foam produced is excessive, based on a result of detection by the foam detecting means (86, 111, 113), the control means (86) drives the draining means (21) so that the water tub (7) is completely drained.

14. A washing machine according to claim 11, **characterized in that** when determining that an amount of foam produced is excessive, based on a result of detection by the foam detecting means (86, 111, 113), the control means (86) controls the drive means (16, 86) so that a rotational speed of the rotating tub (9) is reduced.

15. A washing machine according to claim 11, **characterized in that** the control means (86) compares an output value of the foam detecting means (86, 111, 113) with a threshold thereby to determine whether an amount of foam produced is excessive and that the threshold is varied according to a period of time expiring from start of the washing operation.

16. A washing machine according to claim 11, **characterized in that** the rotating tub is rotated in two directions about a horizontal axis, that the foam detecting means (86, 111, 113) includes an air trap (111) mounted on a portion of a wall of the water tub (7) circumferentially spaced from a lowermost portion thereof and a pressure sensor (113) for detecting pressure in the air trap (111), and that the control means (86) determines whether an amount of foam produced is excessive, based on an output value of the pressure sensor (113) in a case where the rotating tub (9) is rotated in a direction in which the air trap (111) is spaced from the lowermost portion of the water tub (7).

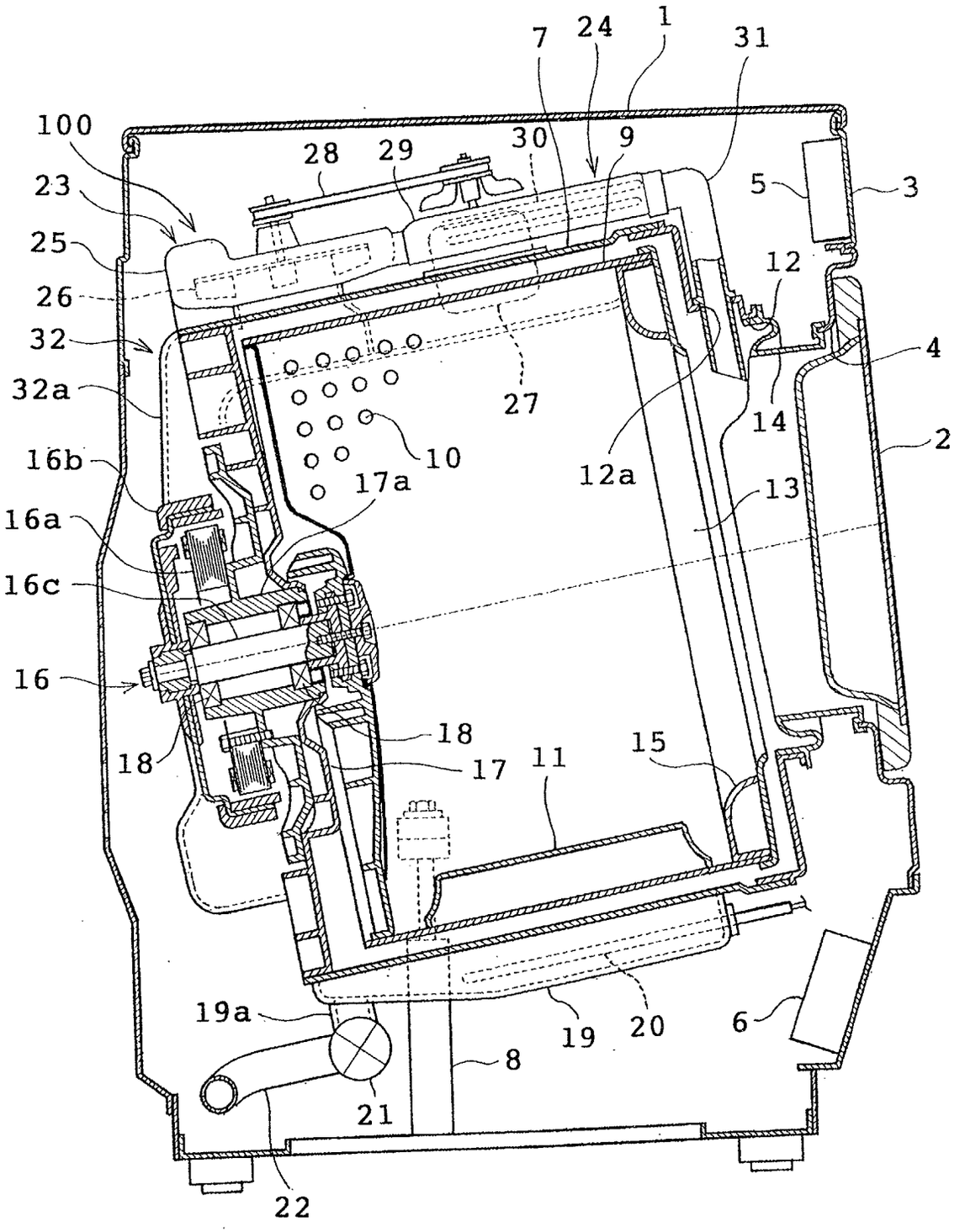
100
23
25
26
32
32a
16b
16a
16c
16
18
18
28
29
30
7
24
1
31
9
5
3
12
4
14
2
27
10
17a
12a
13
18
17
11
15
19a
19
20
6
8
21
22

FIG. 1

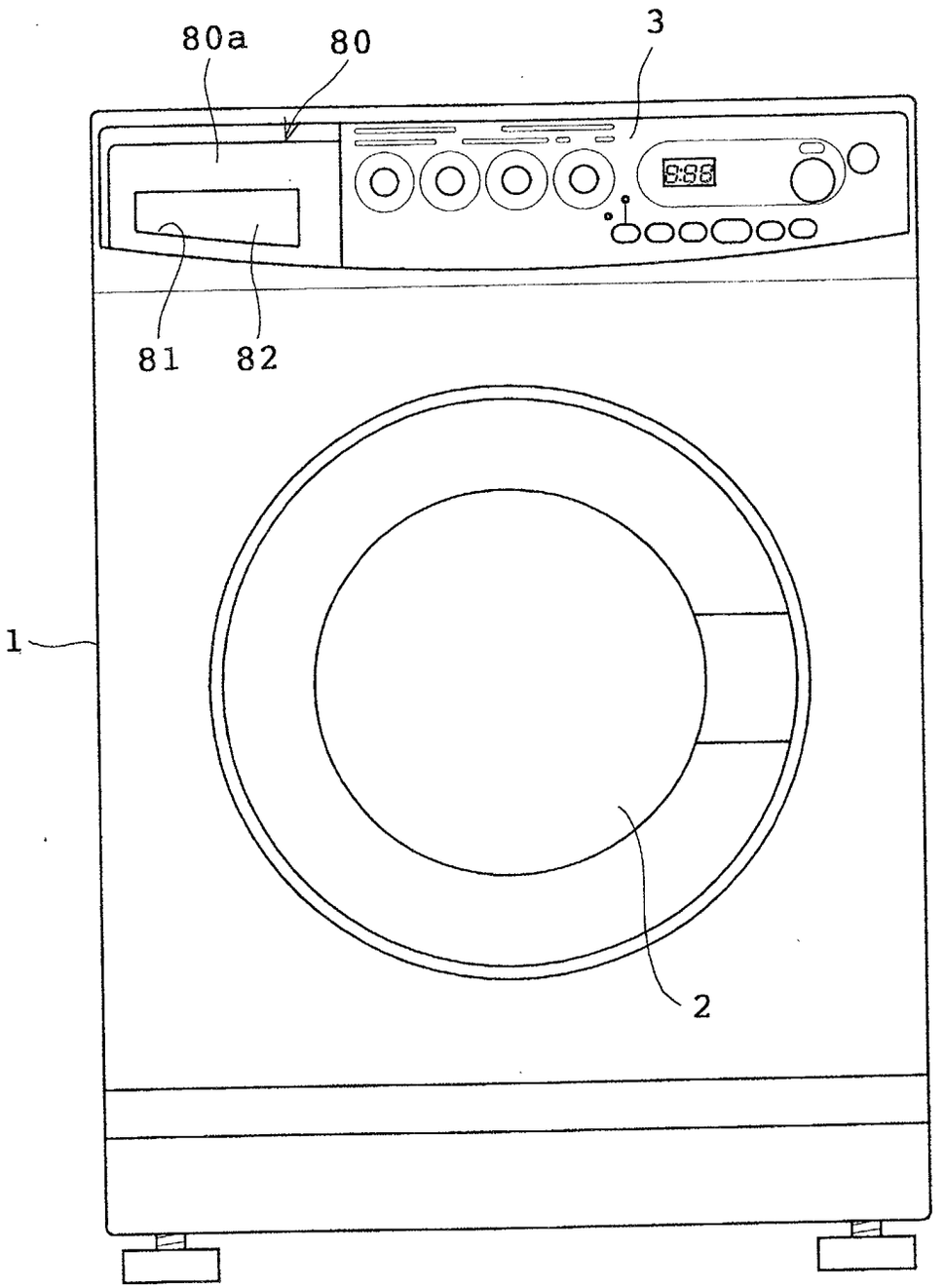

FIG.2

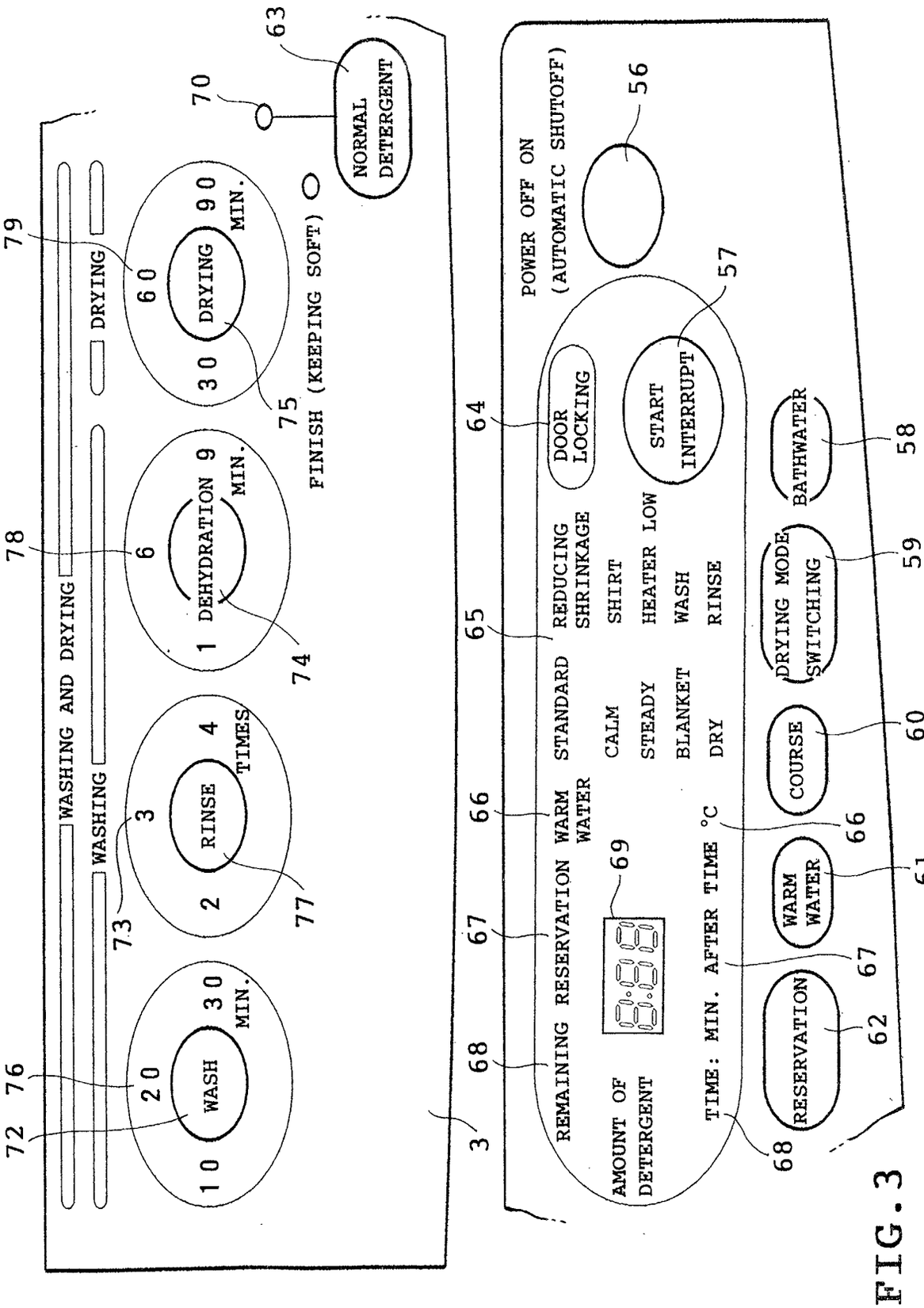
WASHING AND DRYING
WASHING
DRYING
WASH
RINSE
DEHYDRATION
DRYING
FINISH (KEEPING SOFT)
NORMAL DETERGENT
POWER OFF ON
(AUTOMATIC SHUTOFF)
DOOR LOCKING
START INTERRUPT
BATHWATER
REDUCING SHRINKAGE
SHIRT
HEATER LOW
WASH
RINSE
STANDARD
CALM
STEADY
BLANKET
DRY
WARM WATER
COURSE
DRYING MODE SWITCHING
RESERVATION
REMAINING RESERVATION
AMOUNT OF DETERGENT
TIME: MIN. AFTER TIME °C
TIMES
MIN.

FIG. 3

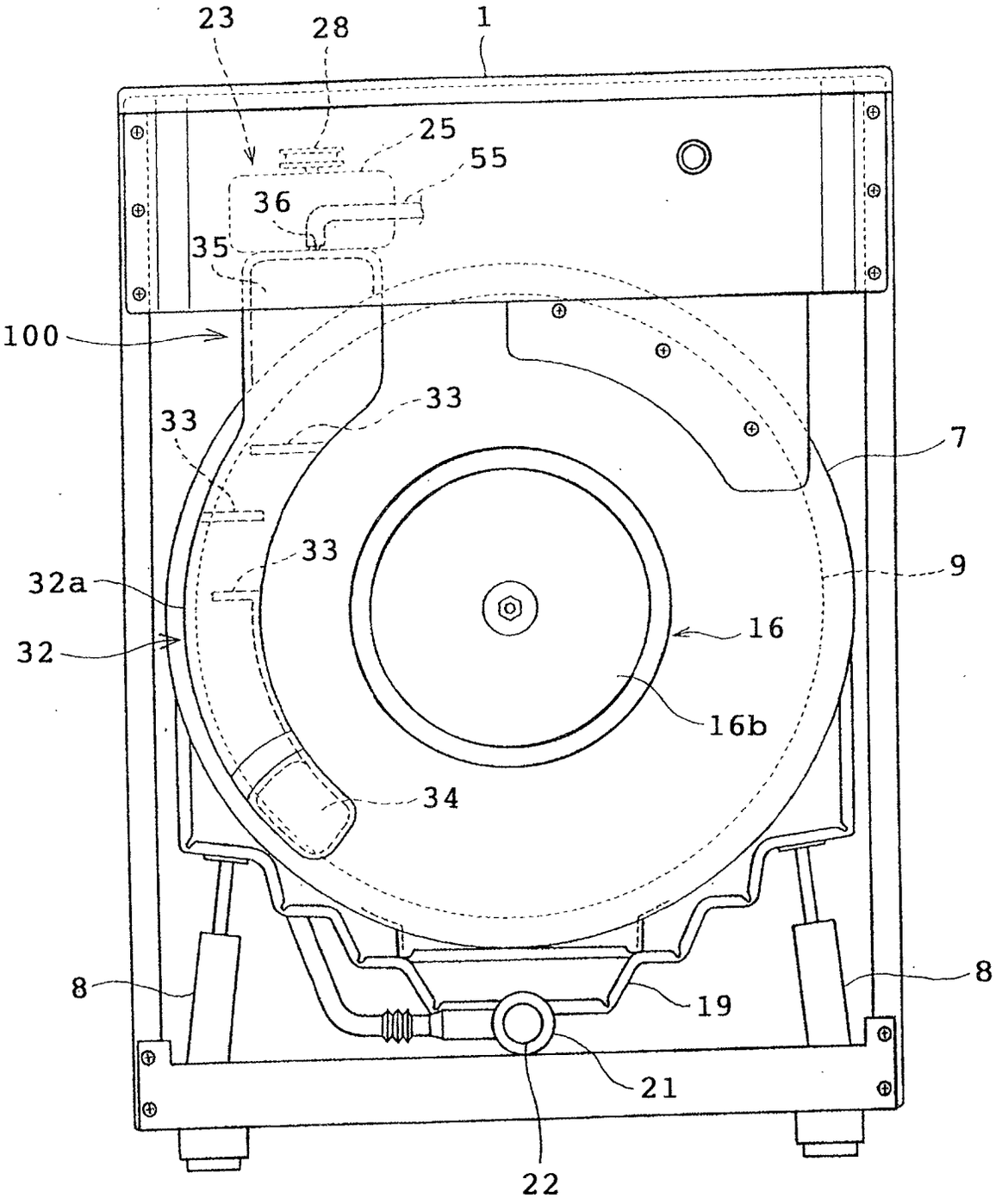

FIG. 4

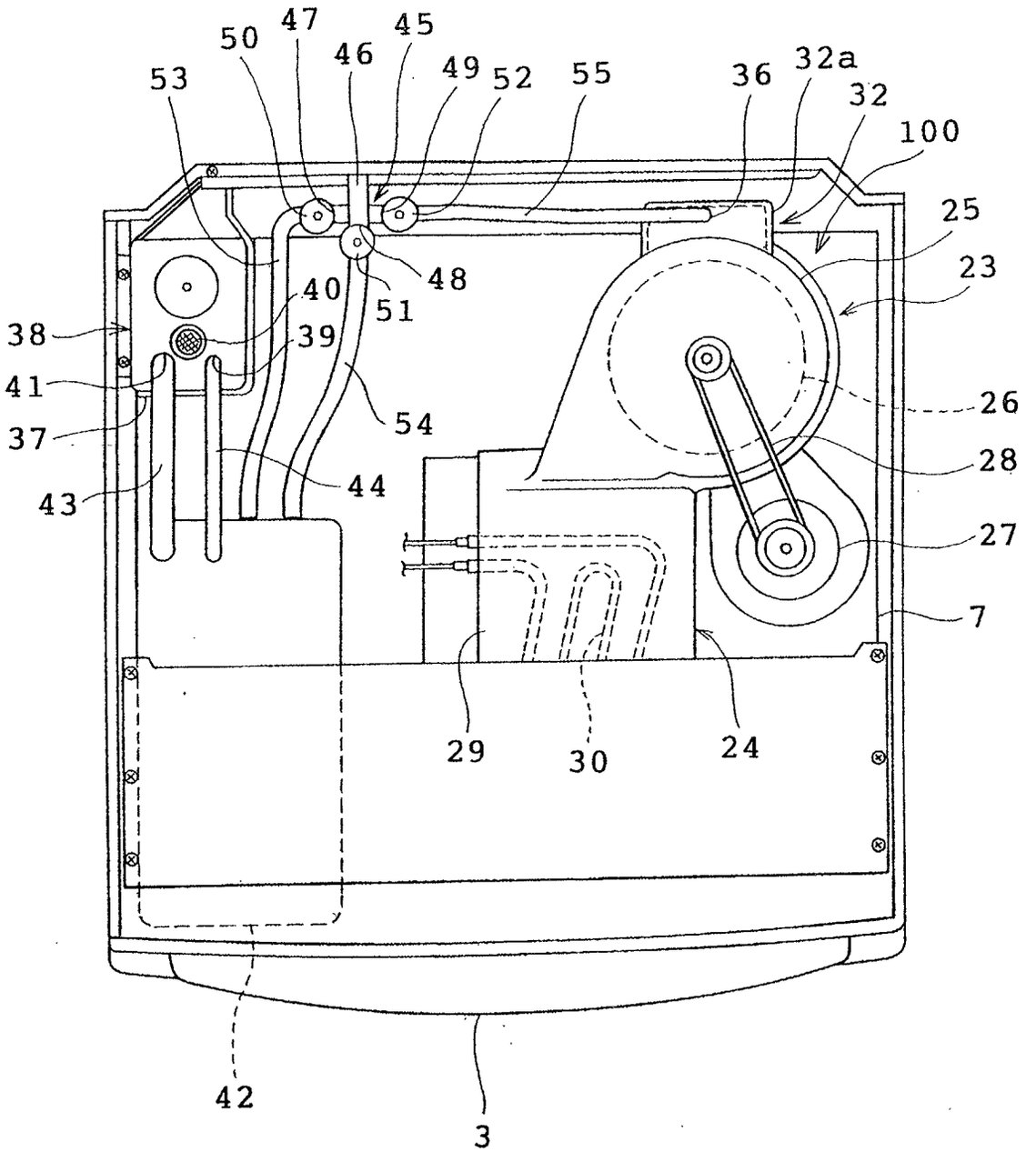
50
47
45
46
49
52
55
36
32a
32
100
53
25
23
48
40
51
38
39
41
54
26
37
28
44
43
27
7
29
30
24
42
3

FIG.5

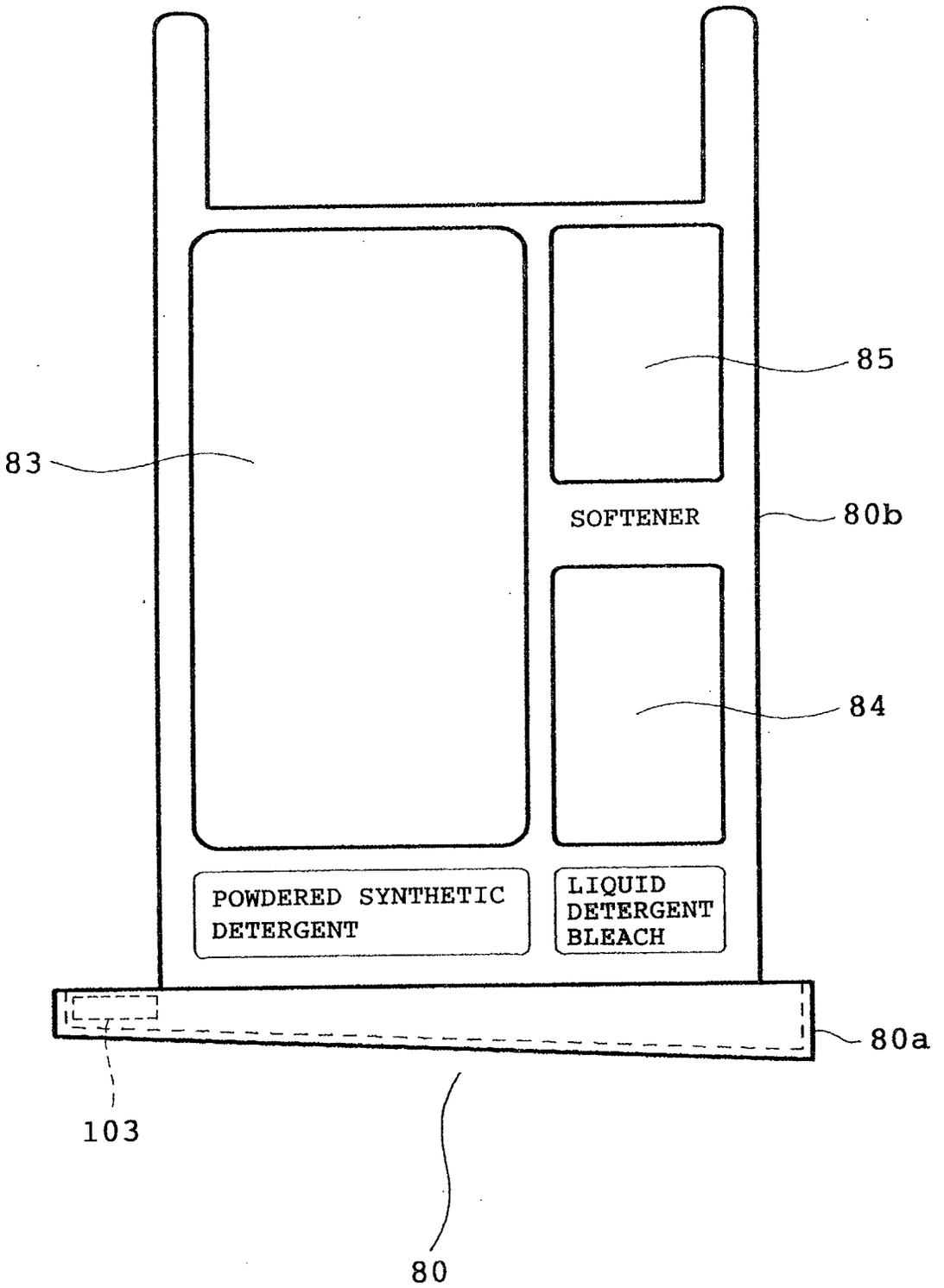
85
83
SOFTENER
80b
84
POWDERED SYNTHETIC DETERGENT
LIQUID DETERGENT BLEACH
80a
103
80

FIG. 6

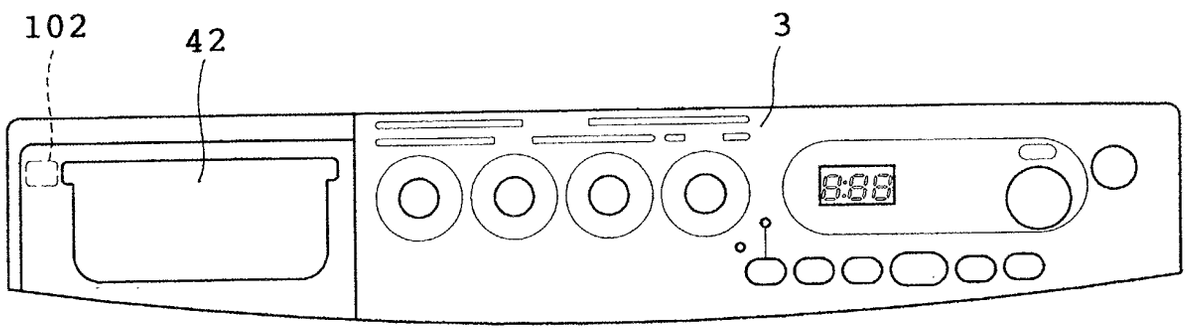

FIG. 7

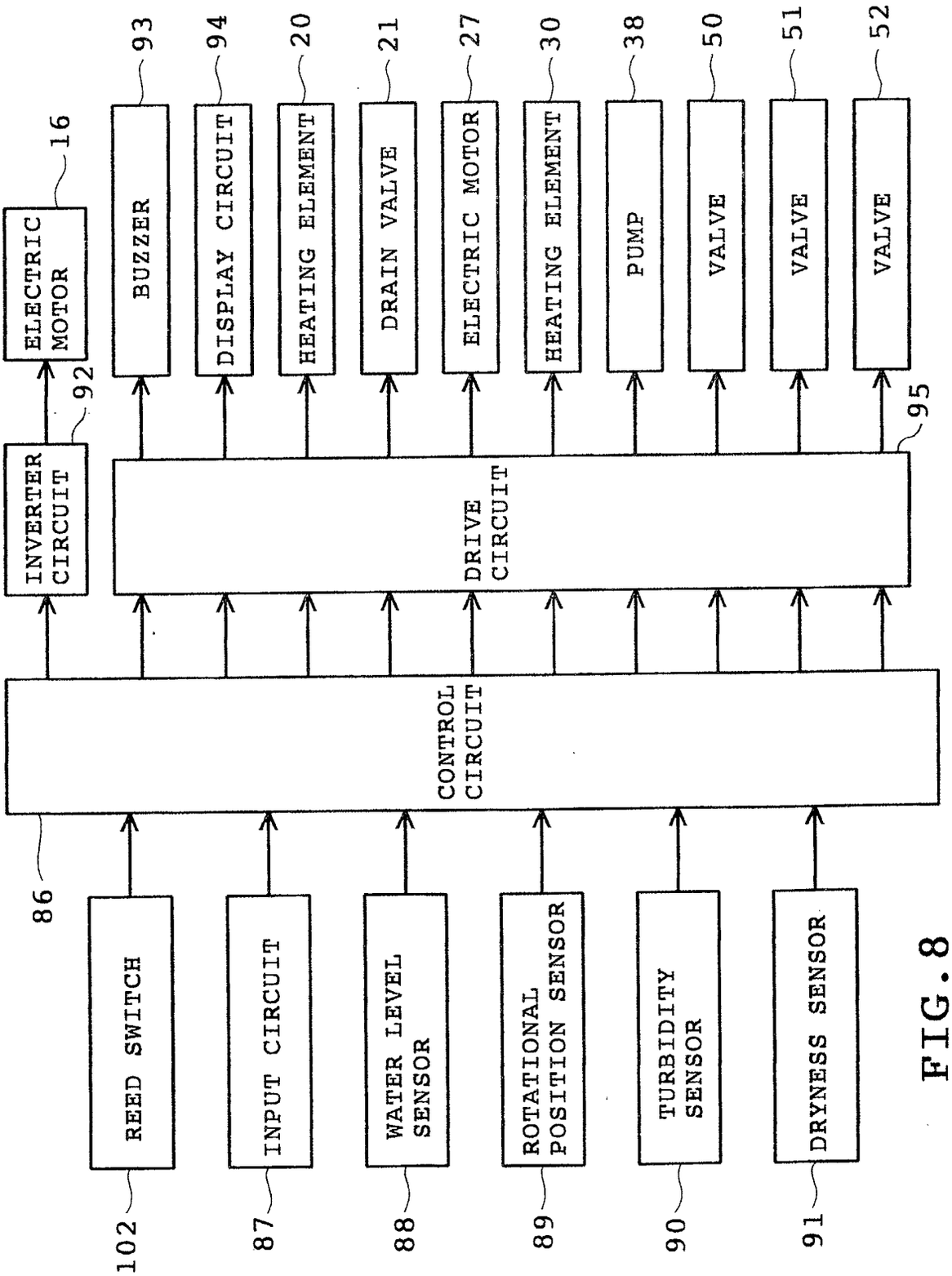
ELECTRIC MOTOR
16
BUZZER
93
DISPLAY CIRCUIT
94
HEATING ELEMENT
20
DRAIN VALVE
21
ELECTRIC MOTOR
27
HEATING ELEMENT
30
PUMP
38
VALVE
50
VALVE
51
VALVE
52
INVERTER CIRCUIT
92
DRIVE CIRCUIT
95
CONTROL CIRCUIT
86
REED SWITCH
102
INPUT CIRCUIT
87
WATER LEVEL SENSOR
88
ROTATIONAL POSITION SENSOR
89
TURBIDITY SENSOR
90
DRYNESS SENSOR
91

FIG. 8

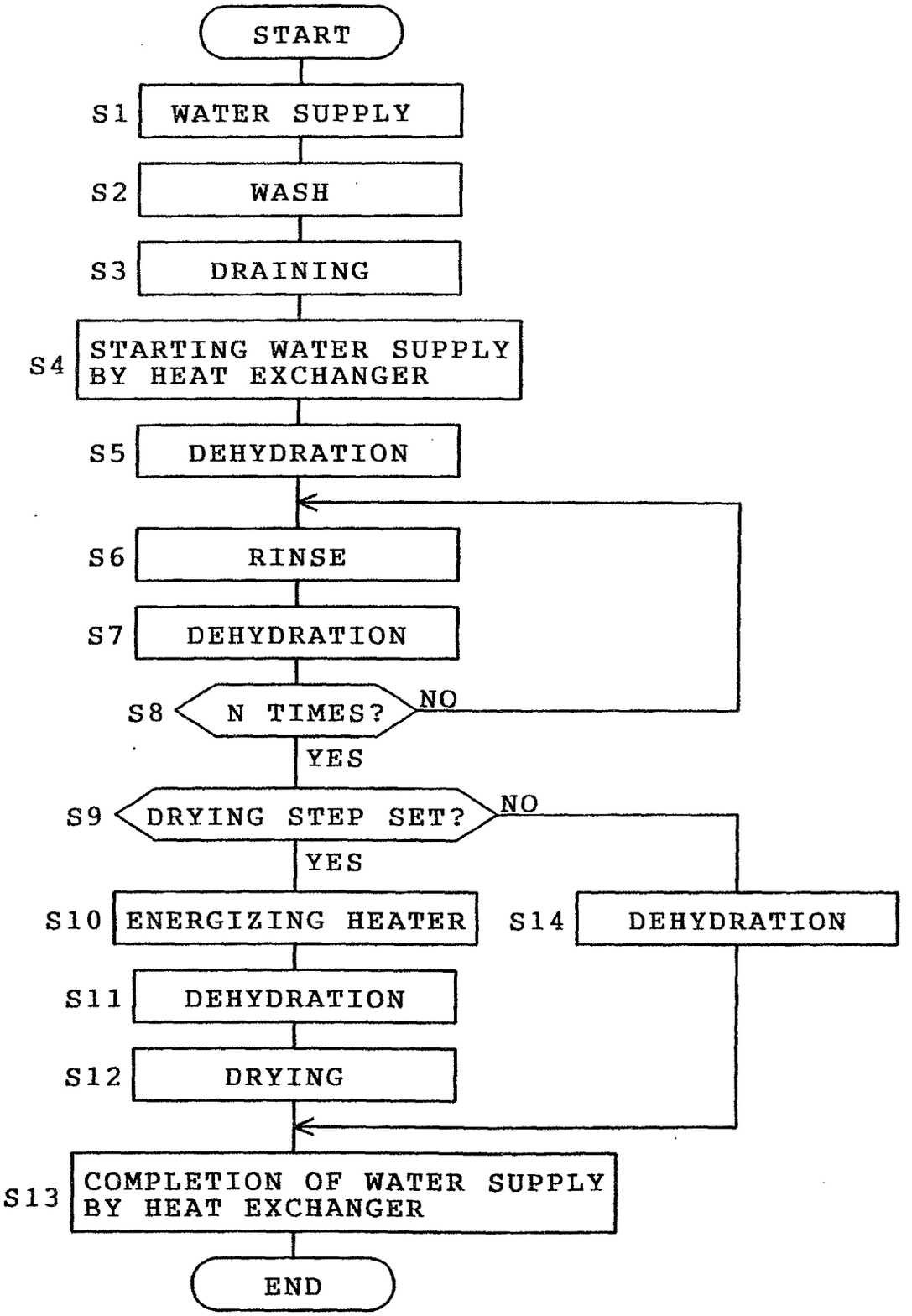
START
S1
WATER SUPPLY
S2
WASH
S3
DRAINING
S4
STARTING WATER SUPPLY BY HEAT EXCHANGER
S5
DEHYDRATION
S6
RINSE
S7
DEHYDRATION
S8
N TIMES?
NO
YES
S9
DRYING STEP SET?
NO
YES
S10
ENERGIZING HEATER
S11
DEHYDRATION
S12
DRYING
S14
DEHYDRATION
S13
COMPLETION OF WATER SUPPLY BY HEAT EXCHANGER
END

FIG. 9

		LOW FOAMING DETERGENT MODE	ORDINARY SYNTHETIC DETERGENT MODE
WATER LEVEL	HIGH	100mm	80mm
	MIDDLE	80mm	60mm
	LOW	60mm	40mm
	EXTREMELY LOW	40mm	40mm

FIG.10

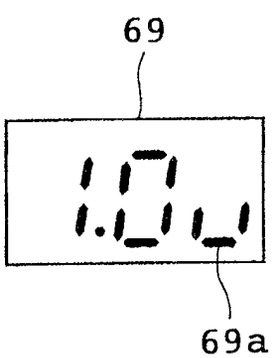

FIG.11A

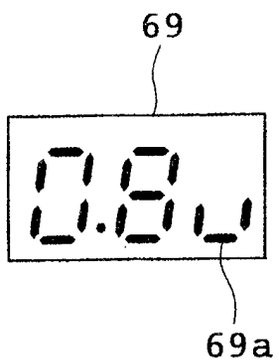

FIG.11B

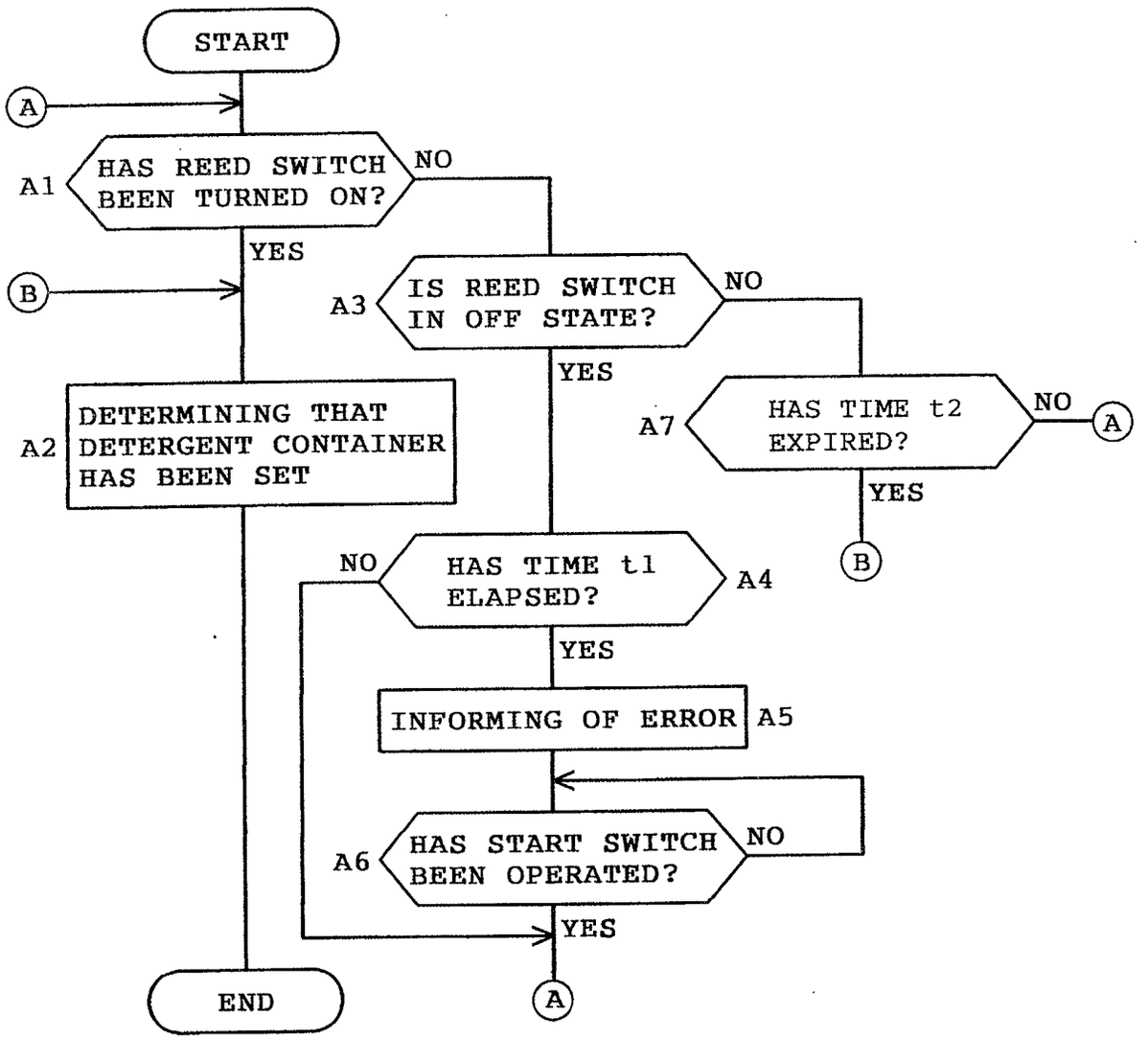
START
A
A1
HAS REED SWITCH BEEN TURNED ON?
NO
YES
B
A3
IS REED SWITCH IN OFF STATE?
NO
YES
A2
DETERMINING THAT DETERGENT CONTAINER HAS BEEN SET
A7
HAS TIME t2 EXPIRED?
NO
A
YES
B
NO
HAS TIME t1 ELAPSED?
A4
YES
INFORMING OF ERROR
A5
A6
HAS START SWITCH BEEN OPERATED?
NO
YES
END
A

FIG. 12

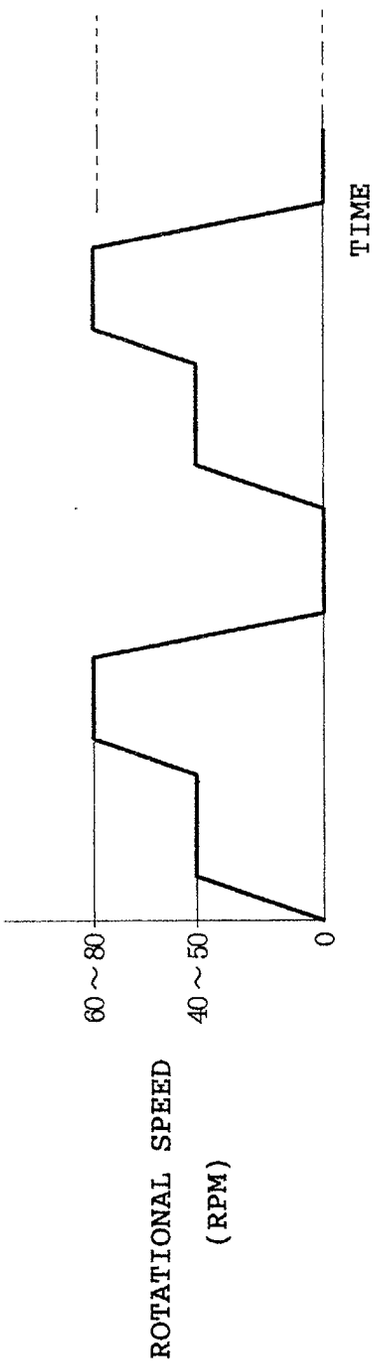
ROTATIONAL SPEED
(RPM)
60～80
40～50
0
TIME

FIG.13

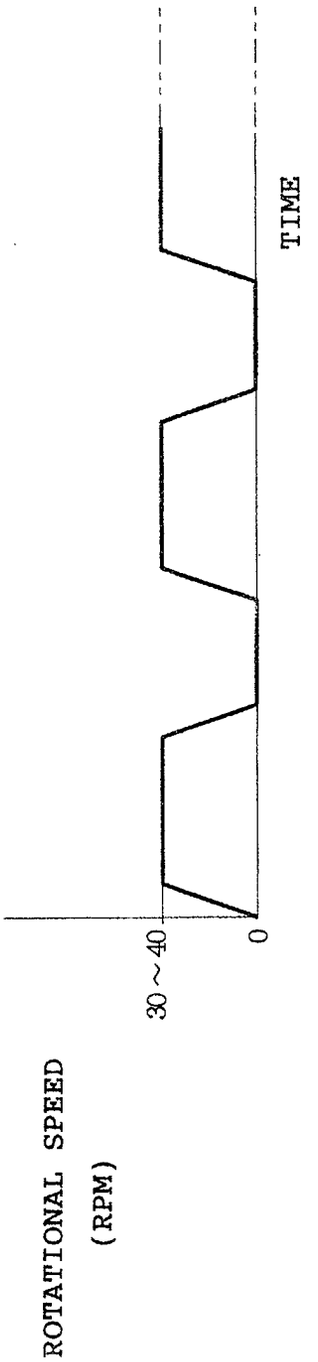
ROTATIONAL SPEED
(RPM)
30～40
0
TIME

FIG.14

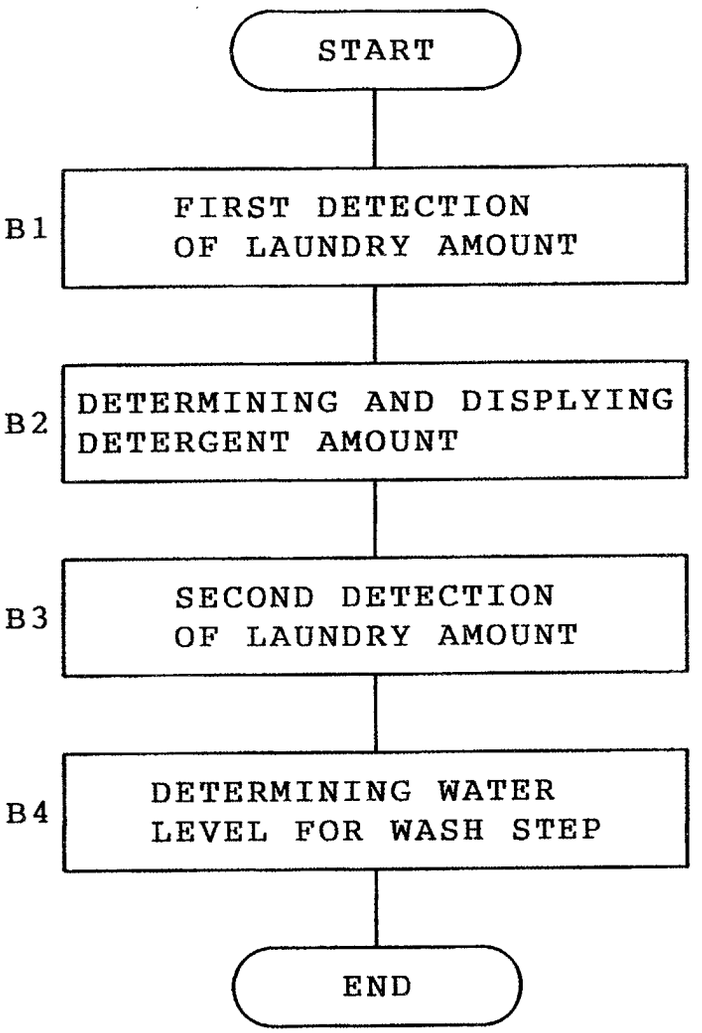
START
B1
FIRST DETECTION OF LAUNDRY AMOUNT
B2
DETERMINING AND DISPLYING DETERGENT AMOUNT
B3
SECOND DETECTION OF LAUNDRY AMOUNT
B4
DETERMINING WATER LEVEL FOR WASH STEP
END

FIG. 15

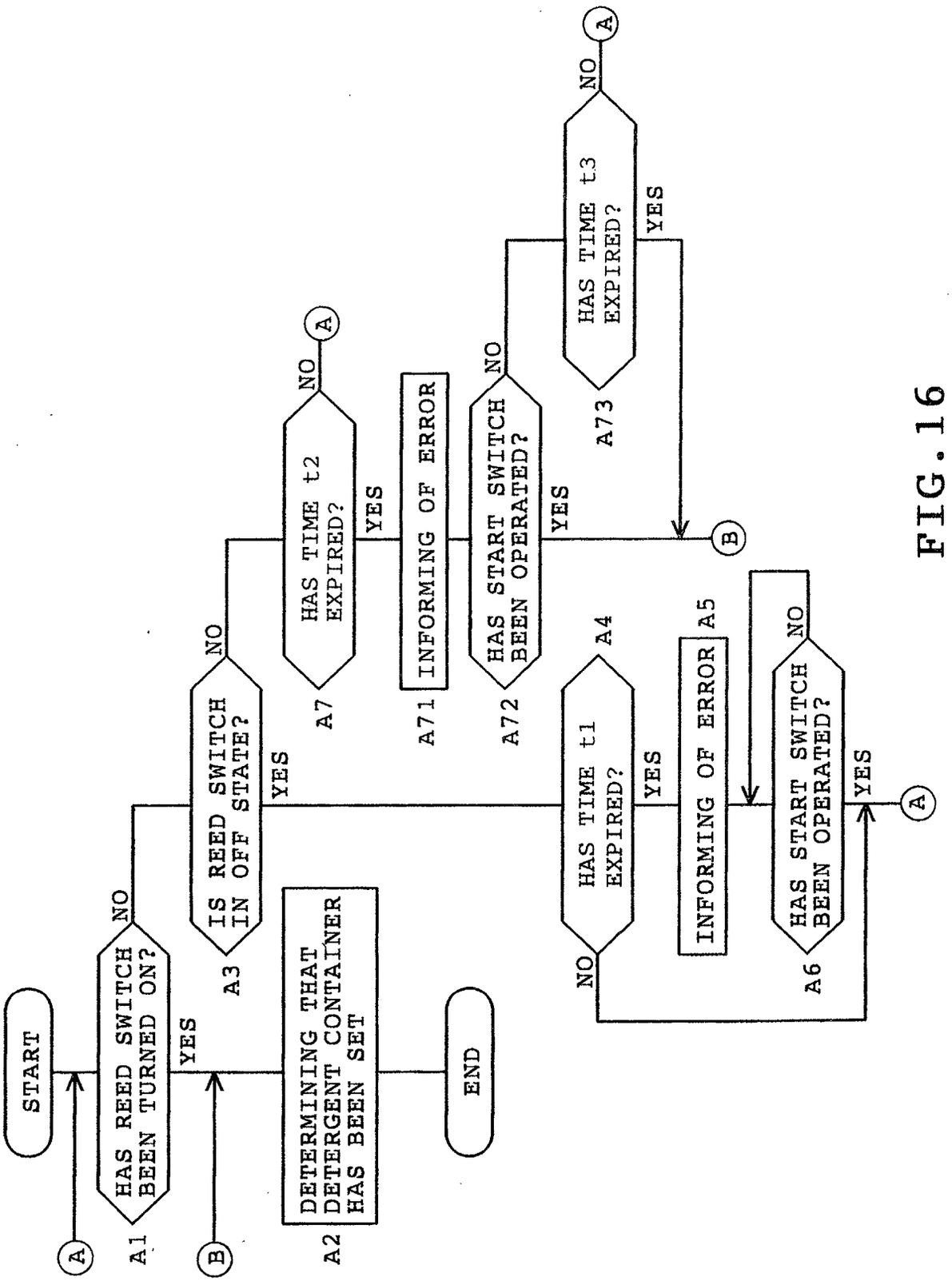
START
HAS REED SWITCH BEEN TURNED ON?
A1
NO
YES
IS REED SWITCH IN OFF STATE?
A3
NO
YES
HAS TIME t2 EXPIRED?
A7
NO
YES
INFORMING OF ERROR
A71
HAS START SWITCH BEEN OPERATED?
A72
NO
YES
HAS TIME t3 EXPIRED?
A73
NO
YES
HAS TIME t1 EXPIRED?
A4
NO
YES
INFORMING OF ERROR
A5
HAS START SWITCH BEEN OPERATED?
A6
NO
YES
DETERMINING THAT DETERGENT CONTAINER HAS BEEN SET
A2
END
A
B

FIG. 16

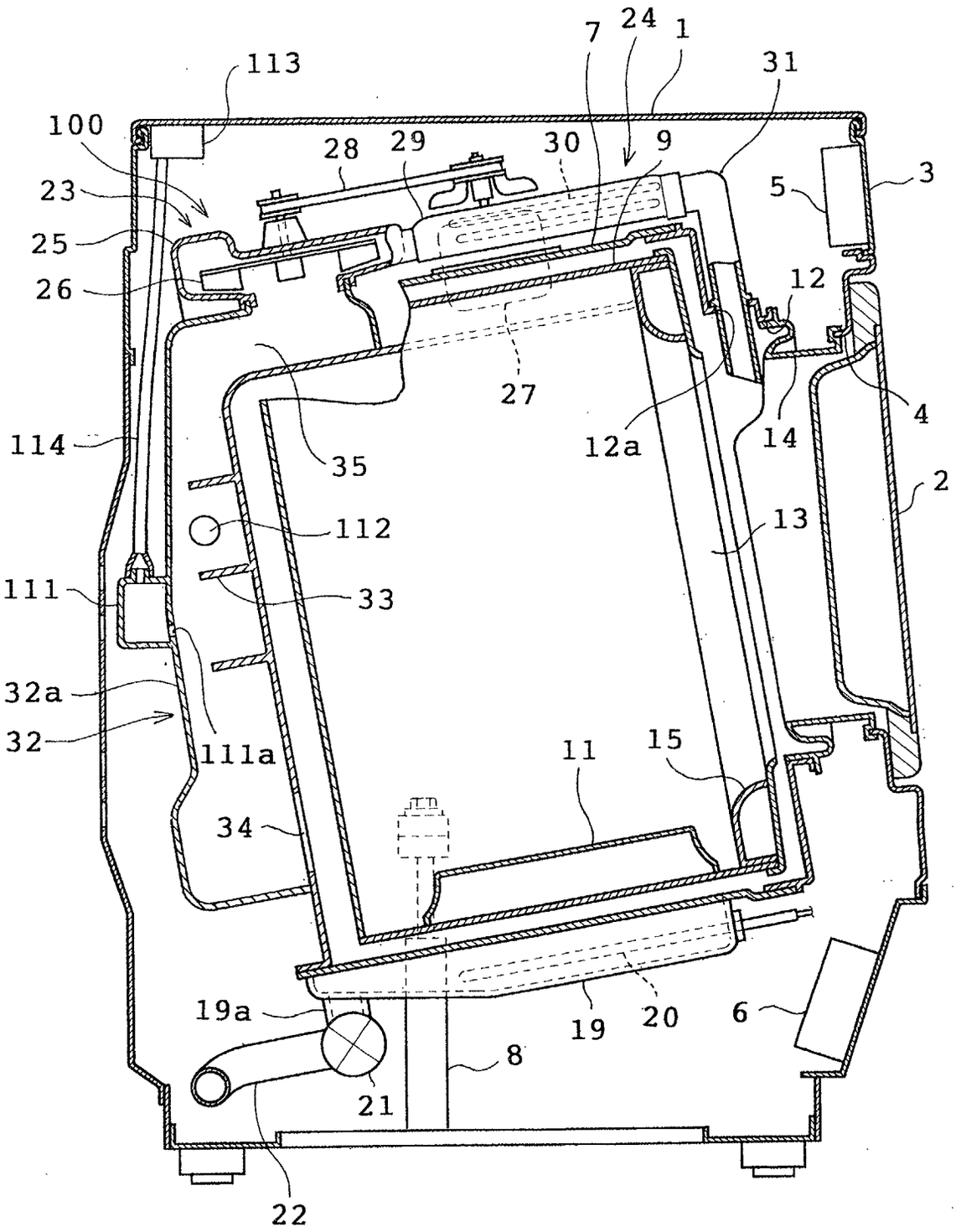
113
7
24
1
31
100
28
29
30
9
3
23
5
25
12
26
27
4
12a
14
114
35
2
112
13
111
33
32a
111a
11
15
32
34
19a
19
20
6
8
21
22

FIG. 17

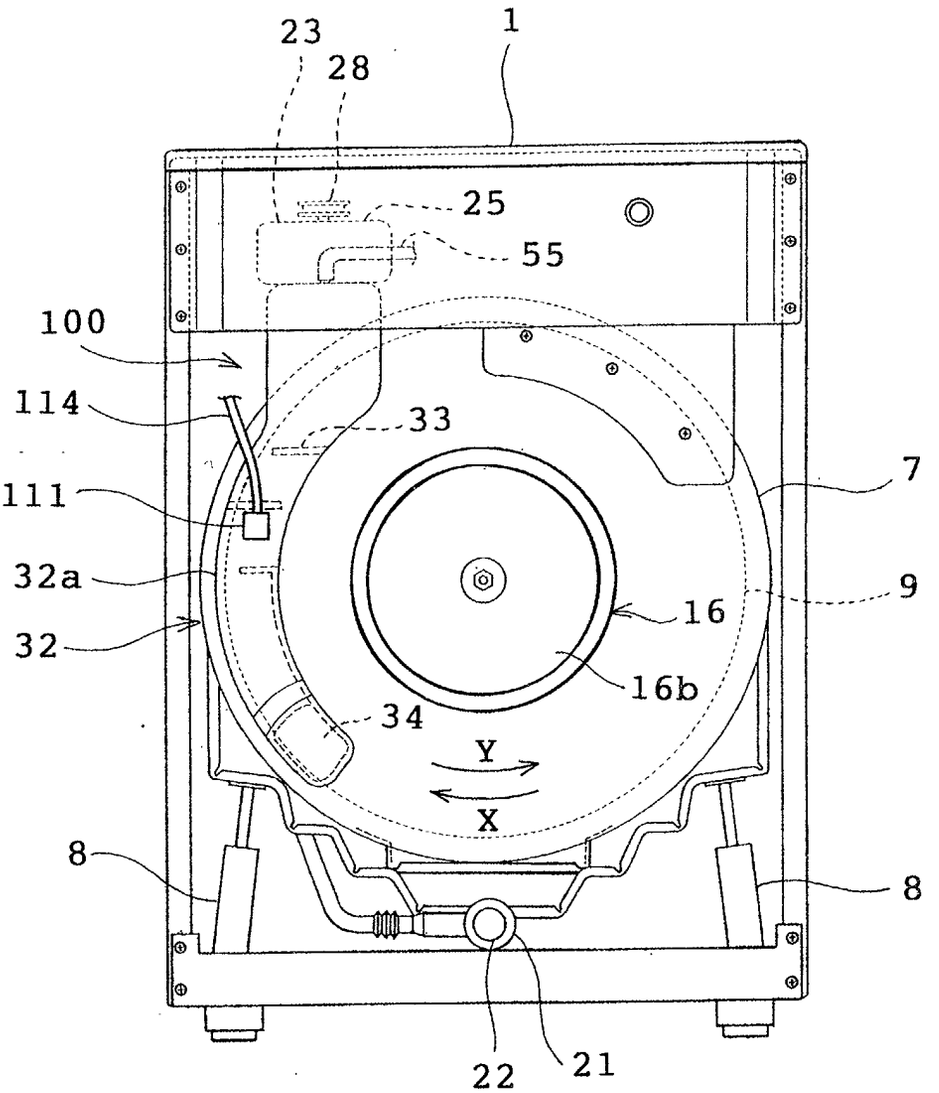

FIG.18

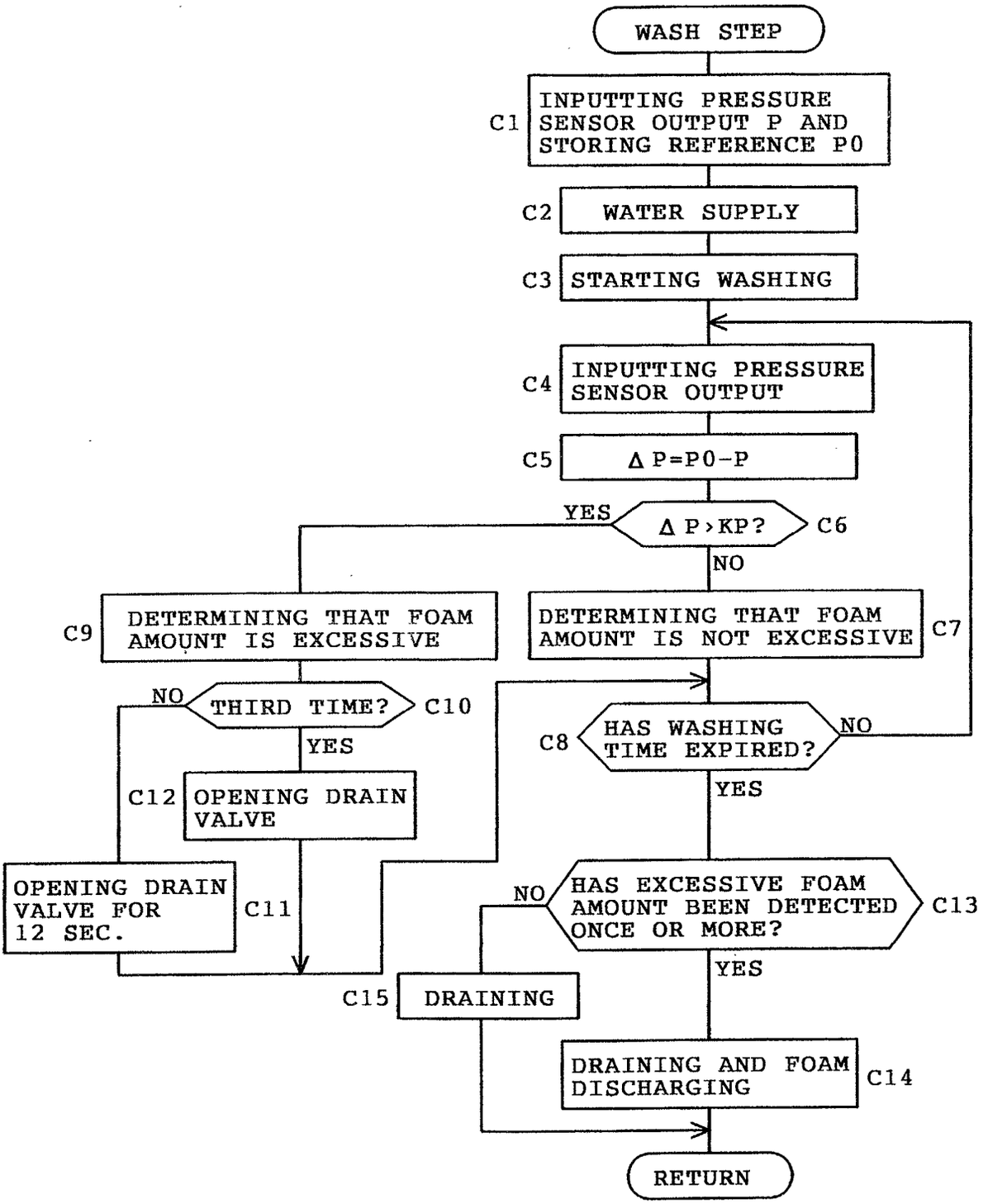
WASH STEP
C1
INPUTTING PRESSURE SENSOR OUTPUT P AND STORING REFERENCE P0
C2
WATER SUPPLY
C3
STARTING WASHING
C4
INPUTTING PRESSURE SENSOR OUTPUT
C5
Δ P=P0-P
YES
Δ P>KP?
C6
NO
C9
DETERMINING THAT FOAM AMOUNT IS EXCESSIVE
DETERMINING THAT FOAM AMOUNT IS NOT EXCESSIVE
C7
NO
THIRD TIME?
C10
YES
C12
OPENING DRAIN VALVE
OPENING DRAIN VALVE FOR 12 SEC.
C11
C8
HAS WASHING TIME EXPIRED?
NO
YES
NO
HAS EXCESSIVE FOAM AMOUNT BEEN DETECTED ONCE OR MORE?
C13
YES
C15
DRAINING
DRAINING AND FOAM DISCHARGING
C14
RETURN

FIG.19

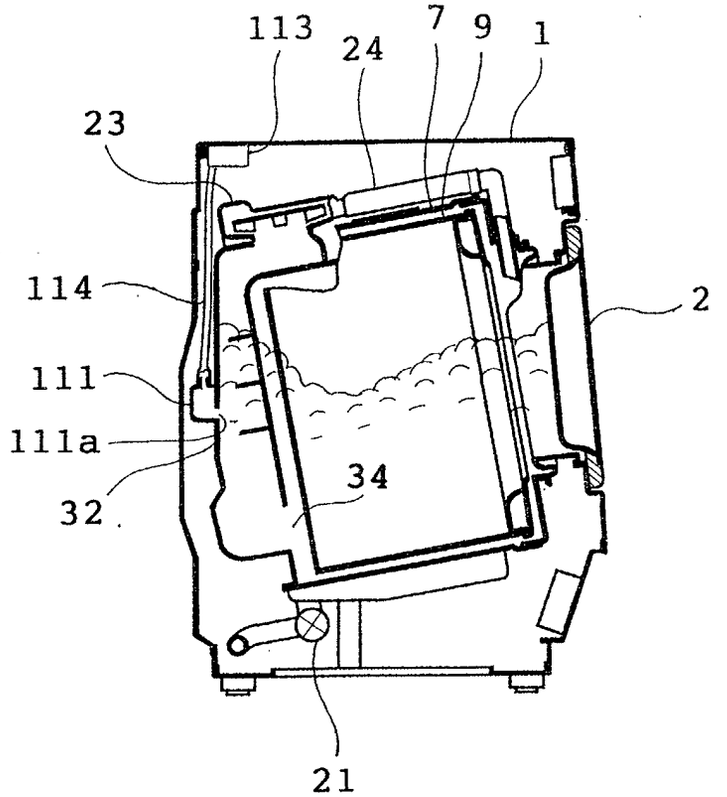

FIG. 20

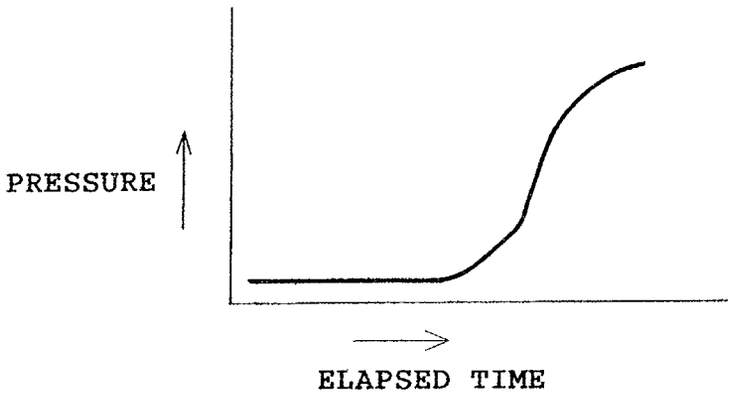
PRESSURE
ELAPSED TIME

FIG.21

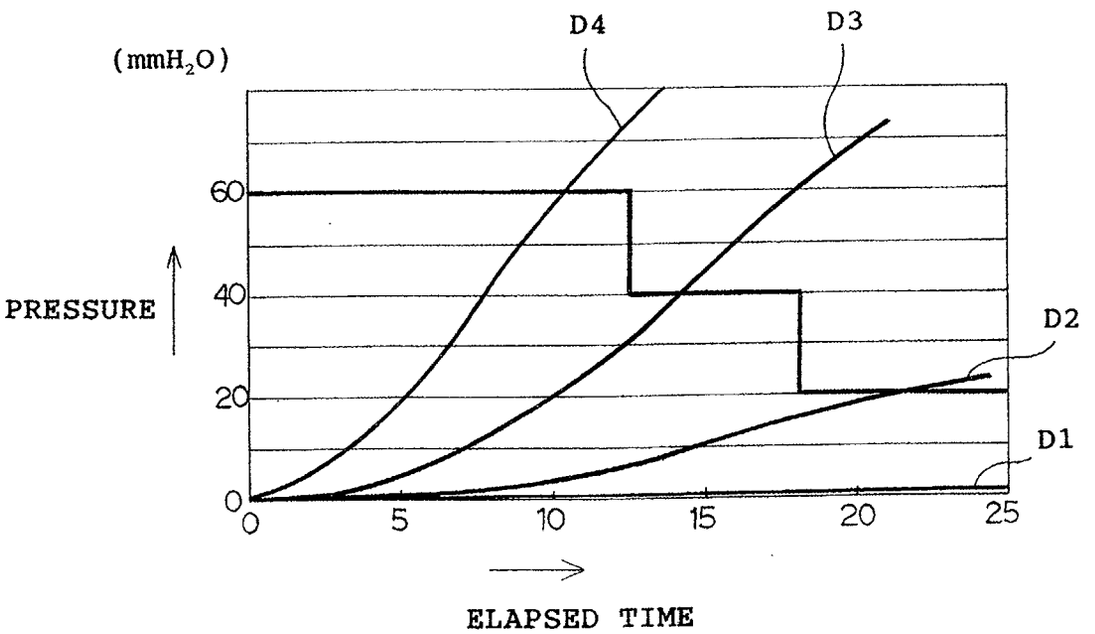
D4
D3
(mmH2O)
60
40
20
0
PRESSURE
D2
D1
0
5
10
15
20
25
ELAPSED TIME

FIG.22

ELAPSED TIME	1 TO 12 MIN.	12 TO 18 MIN.	18 MIN.OR MORE
THRESHOLD	60 mmH_2O	40 mmH_2O	20 mmH_2O

FIG. 23