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(54) **WASHING MACHINE**

(57) A washing machine including an exterior housing, a tub disposed inside the exterior housing, a rotary tub driven in rotation within the tub, a suspension elastically supporting the tub inside the exterior housing and being provided with a damper that is capable of exerting variable damping force and that reduces oscillation of the tub, and a controller that executes a control that keeps the damping force of the damper constant while a predetermined detecting operation is ongoing or a controller that controls the damping force of the damper based on a result of detection of the laundry weight detector such that the damping force of the damper becomes greater as the detected laundry weight becomes smaller.

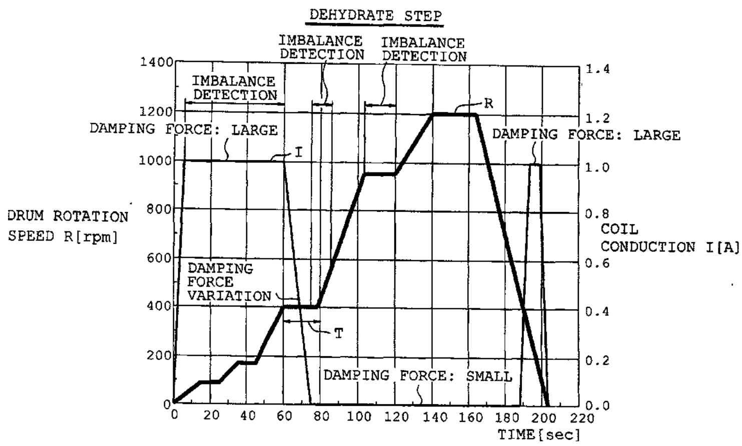

FIG.1

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Description

TECHNICAL FIELD

[0001] The embodiments of the present invention relates to a washing machine.

BACKGROUND

[0002] Washing machines have been typically configured by an exterior housing containing a tub which further contains a drum. The drum is driven in rotation by a motor provided outside the tub. The tub is disposed above the bottom panel of the exterior housing by way of an elastic support of a suspension. The suspension is provided with a damper configured to reduce the oscillation of the tub caused by the oscillation of the drum. Damping force of such dampers is normally configured to be invariable. New challenges are being made in the industry to employ a damper exerting variable damping force. One example of such dampers exerting variable damping force employs a functional a fluid as its working fluid.

[0003] A functional fluid is a fluid which functionally varies its rheological properties such as viscosity through control of external physical quantities applied to it. Examples of functional fluid include magnetic viscous fluid and electric viscous fluid in which viscosity varies by application of electric energy. Magnetic viscous fluid comprises, for example, a mixture of ferromagnetic particles such as iron and carbonyl iron dispersed in oil. Application of magnetic field to magnetic viscous fluid causes the ferromagnetic particles to form a chain of clusters that results in an increase in viscosity. Electric viscous fluid, on the other hand, increases its viscosity by application of electric field as may be learned through reference to, for instance, patent documents 1 to 4.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0004]

Patent Document 1: JP 2002-502942 A
Patent Document 2: JP 2005-291284 A
Patent Document 3: JP 2008-183297 A
Patent Document 4: JP 2008-295906 A

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE OVERCOME BY THE INVENTION

[0005] A damper employing the above described functional fluid is capable of exerting varying damping force by varying its viscosity. For instance, in a drum washer, the damper may be controlled to exert relatively high damping force at the start of dehydrate step up to a rotational speed in which sympathetic oscillation of the tub is encountered. The run-up performance of drum rotation can be improved by preventing the sympathetic oscillation of the tub. The damper is controlled to exert relatively low damping force while the dehydrate step is running steadily with the drum rotating at high speed. This prevents tub oscillation from being transmitted to the exterior housing and to the floor of the room in which the washer is installed.

[0006] Further, the drum washer may be configured to detect imbalance of drum rotation caused by uneven distribution of laundry load and to gradually accelerate the drum rotation provided that the imbalance is equal to or less than a predetermined level. Still further, the drum washer may be configured to detect the weight of laundry at the beginning of the wash step based upon which the wash water level, duration of wash, etc. are determined. Yet further, the drum washer may be configured to further detect the weight of laundry at the beginning of the dry step based upon which the duration of dry is determined.

[0007] A favorable or optimal scheme for controlling the variation of damping force is yet to be designed for a washer operation involving imbalance detection and laundry weight detection while the drum is in rotation.

[0008] It is thus, a first object of the present invention to provide a washing machine configured to favorably control the variation of damping force of the damper while certain detections are being made during drum rotation.

[0009] Further, as described above, dehydration may progress with suppressed oscillation by gradually accelerating the drum rotation provided that each of the detected imbalances is equal to or less than a predetermined level.

However, the drum rotation imbalance varies with the amount of laundry measured by weight. Conventional damping force control schemes did not take into consideration the fact that the drum rotation imbalance varies with laundry weight.

[0010] It is thus, a second object of the present invention to control the damping force of the damper based on laundry weight.

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE OVERCOME BY THE INVENTION

[0011] The washer in one embodiment is provided with an exterior housing, a tub, a rotary tub, a suspension, and a controller.

The tub is disposed inside the exterior housing. The rotary tub is driven in rotation within the tub. The suspension elastically supports the tub inside the exterior housing and is provided with a damper that is capable of exerting variable damping force and that reduces oscillation of the tub. The controller executes a control to keep the damping force of the damper constant while a predetermined detecting operation is ongoing.

[0012] The washer in one embodiment is provided with an exterior housing, a tub, a rotary tub, a laundry weight detector, a suspension, and a controller. The tub is disposed inside the exterior housing. The rotary tub is driven in rotation within the tub. The laundry weight detector detects the weight of laundry inside the tub. The suspension elastically supports the tub inside the exterior housing and is provided with a damper that is capable of exerting variable damping force and that reduces oscillation of the tub. The controller controls the damping force of the damper based on a result of detection of the laundry weight detector such that the damping force of the damper becomes greater as the detected laundry weight becomes smaller.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0013]

FIG.1 is a time chart of a control executed in a dehydrate step in a first embodiment.
FIG.2 is a partially broken vertical cross sectional view of the entire washer.
FIG.3 is a vertical cross sectional view of a single suspension unit.
FIG.4 is a block diagram of an electrical arrangement.
FIG. 5 is a time chart of a control executed throughout the sequence of steps in a second embodiment.
FIG.6 corresponds to FIG.5 and illustrates a third embodiment.
FIG.7 is a chart indicating a specific relation between the damping force of the damper and the laundry weight detected during wash, rinse, and dehydrate operations.
FIG.8 is a chart indicating a linear relation between the detected laundry weight and the damping force of the damper.
FIG.9 is a chart indicating a specific relation between the damping force of the damper and the laundry weight detected during a dehydrate operation.
FIG.10 is a chart indicating a stepped relation between the damping force of the damper and the detected laundry weight and illustrates a fourth embodiment.
FIG.11 corresponds to FIG.3 and illustrates a fifth embodiment.

MODES FOR IMPLEMENTING THE INVENTION

[0014] Embodiments of a washing machine/washer will be described hereinafter with reference to the drawings. Elements that are substantially identical across the embodiments are identified with identical reference symbols and will not be redescribed.

[FIRST EMBODIMENT]

[0015] A description will be given hereinafter on a first embodiment with reference to FIGS.1 to 4.

FIG. 2 illustrates the entire structure of a drum washer also referred to as a washer dryer. Exterior housing 1 serves as the outermost structure of the washer. Exterior housing 1 has laundry inlet/outlet 2 at the central portion of its front side (right side as viewed in FIG. 2). Laundry inlet/outlet 2 is opened/closed by door 3 which is pivoted to exterior housing 1. On the upper front portion of exterior housing 1, control panel 4 is provided which has control unit 5 for controlling the operation of the washer on its bottom side so as to be located inside exterior housing 1.

[0016] Exterior housing 1 contains tub 6. Tub 6 is configured as a laterally oriented cylinder with its axis extending in the front and rear direction which is oriented in the left and right direction as viewed in FIG.2. Tub 6 is elastically supported so as to be inclined forwardly upward by a pair of left and right suspensions 7, only one of which is shown in FIG.2, so as to be located above bottom panel 1a of exterior housing 1. The structure of suspension 7 will be a later described in detail.

[0017] On the rear portion of tub 6, motor 8 is attached is as shown in FIG.2. Motor 8 comprises an outer rotor direct current brushless motor. A rotary shaft not shown attached to the central portion of rotor 8a is inserted into tub 6 through bearing housing 9.

[0018] Tub 6 contains drum 10. Drum 10 is also configured as a laterally oriented cylinder with its axis extending in the front and rear direction. The central rear portion of drum 10 is connected to the tip of the rotary shaft of motor 8 so as to be inclined forwardly upward. Drum 10 is driven in rotation by motor 8. Motor 8 serves as a drum driver that drives drum 10 in rotation.

[0019] The peripheral portion or the waist of drum 10 has multiplicity of pores 11 formed all over it. Drum 10 has opening 12 on its front side, whereas tub 6 has opening 13 at its front side. Opening 13 of tub 6 communicates with laundry inlet/outlet 2 through annular bellows 14. As a result, laundry inlet/outlet 2 communicates with drum 10 interior through bellows 14, opening 13 of tub 6, and opening 12 of drum 10.

[0020] The bottom rear side portion of tub 6 is connected to drain tube 16 by way of drain valve 15. Dry unit 17 is disposed along the rear side portion, the upper portion, and forward portion of tub 6. Dry unit 17 comprises dehumidifier 18, blower 19, and heater 20. Dry unit 17 dries the laundry by dehumidifying the air inside tub 6, heating it, and returning the heated air back into tub 6.

[0021] Further, oscillation sensors 21 and 22 are attached to the upper front portion and the upper rear portion of tub 6. Oscillation sensors 21 and 22 each comprise an acceleration sensor. When there is an imbalance in drum rotation, originating from uneven distribution of laundry within drum 10, drum 10 is caused to oscillate, which in turn, oscillates tub 6. The oscillation is detected by oscillation sensors 21 and 22. To summarize, oscillation sensors 21 and 22 serve as an imbalance detector that detects rotation imbalance of drum 10 through the oscillation of tub 6.

[0022] The structure of suspension 7 will be described in detail hereinafter. Suspension 7 is provided with damper 23. As shown in FIG.3, damper 23 primarily comprises cylinder 24 and shaft 25 both being made of magnetic material. Cylinder 24 is provided with connecting member 26 on its upper end. As shown in FIG.2, connecting member 26 is passed upward through attachment plate 27 of tub 6 and fastened by nut 29 by way of resilient set plate 28 or the like. Cylinder 24 is thus, attached to tub 6.

[0023] On the other hand, the lower end of shaft 25 is provided with connecting portion 25a. Still referring to FIG.2, connecting portion 25a is passed upward through attachment plate 30 of bottom plate 1a of exterior housing 1 and fastened by nut 32 by way of resilient set plate 31 or the like. Shaft 25 is thus, attached to bottom plate 1a of exterior housing 1.

[0024] Referring again to FIG.3, Cylinder 24 contains upper yoke 33 which is pressed into its mid section. Upper yoke 33 is made of magnetic material and is shaped into a short cylinder having space 34 defined in its inner upper peripheral portion. Space 34 receives and holds a ring shaped upper bearing 35. Upper bearing 35 is made, for instance, of oil-impregnated sintered metal.

[0025] Cylinder 24 further contains upper coil 36 being wound on upper bobbin 37. Upper bobbin 37, being wound with upper coil 36, is inserted into cylinder 24 so as to be held at a position immediately below upper yoke 33. Cylinder 24 still further contains middle yoke 38. Middle yoke 38 is pressed into cylinder 24 so as to be secured at a position immediately below upper bobbin 37. Middle yoke 38 is made of magnetic material.

[0026] Provided further within cylinder 24 is lower coil 39 being wound on lower bobbin 40. Lower bobbin 40, being wound with lower coil 39 is inserted into cylinder 24 so as to be held at a position immediately below middle yoke 33. Cylinder 24 still further contains lower bracket 44 which is shaped into a short cylinder. Lower bracket 44 is inserted into cylinder 24 so as to be held at a position immediately below lower bobbin 40. Lower bracket 44 contains a ring shaped lower yoke 41, a lip-shaped seal 42, and a ring-shaped lower bearing 43 in its inner peripheral portion. Lower yoke 41 and bracket 44 are made of magnetic material and lower bearing 43 is made, for instance, of oil-impregnated sintered metal.

[0027] Between upper yoke 33 and upper bobbin 37, seal 45 is provided, whereas between upper bobbin 37 and middle yoke 38, seal 46 is provided, and between middle yoke 38 and lower bobbin 40, seal 47 is provided. Further, between lower bobbin 40 and lower yoke 41, seal 48 is provided. Seals 45 to 48 may comprise O-rings.

[0028] Shaft 25 is inserted into cylinder 24 from lower opening 49 and passes through lower bearing 43, seal 42, lower yoke 41, lower bobbin 40, middle yoke 38, upper bobbin 37, upper yoke 33, and upper bearing 35 in the listed sequence. The inserted shaft 25, being supported by lower bearing 43 and upper bearing 35, is allowed to relatively reciprocate in the axial direction with respect to lower bearing 43, seal 42, lower yoke 41, lower bobbin 40, middle yoke 38, upper bobbin 37, upper yoke 33, and upper bearing 35. The portion within cylinder 24 located above upper yoke 33 serves as an empty space 50. The upper end of the inserted shaft 25 extends into space 50 and dislocation of shaft 25 is prevented by stop ring 51.

[0029] Between the inserted shaft 25 and the bobbins, i.e. upper and lower bobbins 37 and 40, and between the inserted shaft 25 and the yokes, i.e. upper yoke 33, middle yoke 38, and lower yoke 41, a functional fluid is filled. The functional fluid used, in this case, is magnetic viscous fluid 52 also referred to as MR fluid.

[0030] As described earlier, a functional fluid is a fluid which functionally varies its rheological properties such as viscosity through control of external physical quantities applied to it. The functional fluid includes fluids such as magnetic viscous fluid 52 and electric viscous fluid not shown. The present embodiment employs magnetic viscous fluid 52 in which viscosity varies by the strength of magnetic field as functional fluid. Alternatively, electric viscous fluid also referred to as ER fluid in which viscosity varies by the strength electric field may be employed as functional fluid.

[0031] As described earlier, magnetic viscous fluid 52 comprises, for example, a mixture of ferromagnetic particles such as iron and carbonyl iron dispersed in oil. Application of magnetic field to magnetic viscous fluid 52 causes the ferromagnetic particles to form a chain of clusters that result in an increase in viscosity. Seals 42 and seals 45 to 48 prevent the leakage of magnetic viscous fluid 52.

[0032] Damper 23 is configured as described above. On the lower portion of shaft 25 located below and outside cylinder 24, spring receiving plate 53 is attached. Between spring receiving plate 53 and the lower end of cylinder 24, coil spring 54 comprising a compression coil spring is provided which is capable of expanding and contracting. Suspension 7 being configured as described above is installed between tub 6 and bottom plate la of exterior housing 1 to elastically support tub 6 above bottom plate 1a of exterior housing 1.

[0033] Upper coil 36 and lower coil 39 of damper 23 is connected to drive circuitry provided outside damper 23 by lead wires not shown. Coils 36 and 39 are conducted by the drive circuitry.

[0034] FIG.4 is a block diagram of electrical arrangements primarily configured by control unit 5. Control unit 5 typically comprises a microcomputer and serves a controller responsible for controlling the overall operation of the drum washer as will be later described. Control unit 5 receives inputs of various control signals from control input portion 55 comprising various control switches provided on control panel 4.

Control unit 5 further receives inputs of water level detection signals from water level sensor 56 that detects the water level within tub 6, rotation detection signal from rotation sensor 57 that detects the rotation of motor 8, and oscillation detection signal also referred to as imbalance detection signal from oscillation sensors 21 and 22.

[0035] Based on the incoming rotation detection signal from the above described rotation sensor 57, control unit 5 performs a calculation of dividing the count of rotation of motor 8 and consequently drum 10 by time, i. e. the time required for detecting the count of rotation. Control unit 5 thus, also serves a rotation speed detector that detects the rotation speed of drum 10.

[0036] Based on various inputs, detections, and the pyre-installed control programs, control unit 5 gives drive control signals to drive circuit 59. Drive circuit 59 is responsible for driving supply valve 58 that supplies water into tub 6, motor 8, drain valve 15, motor 19b shown in FIG.2 that drives vane 19a shown in FIG.2 of blower 19 provided in dry unit 17, heater 20a shown in FIG. 2 of heating element 20 provided in dry unit 17, and upper coil 36 and lower coil 39 of damper 23.

[0037] Next, a description will be given on the operation and effect of the above described structure. When the operation of the washer configured as described above is started in response to the user operation of control panel 4, control unit 5 serving as a controller executes wash, dehydrate, rinse, dehydrate, and dry steps in the listed sequence as shown in FIG.5.

[0038] FIG. 1 indicates the behavior of the dehydrate step. In the dehydrate step, the rotation of drum 10 is gradually accelerated in stepped levels as indicated by reference symbol R in FIG.1 to throw off residual moisture by centrifugal force.

In the dehydrate step, the rotation of drum 10 oscillates tub 6 mostly in the up and down direction. In response to the up and down oscillation of tub 6, cylinder 24 constituting suspension 7 and being connected to tub 6, oscillates up and down around shaft 25 with extension/contraction of coil spring 54 along with upper yoke 33, upper bearing 35, upper bobbin 37, upper coil 36, intermediate yoke 38, lower bobbin 40, lower coil 39, bracket 44, lower yoke 41, seal 42, and lower shaft 43.

[0039] When cylinder 24 oscillates up and down around shaft 25 along with the above described components, magnetic viscous fluid 52 filled between shaft 25, upper bobbin 37, and lower bobbin 40 and between shaft 25, upper yoke 33, middle yoke 38, and lower yoke, located in the vicinity of the aforementioned group of components exerts damping force through frictional resistance imparted by its viscosity to reduce the degree of oscillation of water tub 6.

[0040] Control unit 5 conducts a predetermined level of electric current, for instance, 1[A] through both the upper and lower coils 36 and 39 of damper 23 in the initial phase of the dehydrate step. The initial phase is defined as the time period spanning between the start of dehydrate step and a point in time when the rotational speed of drum 10 reaches a certain speed of, for instance, 400 [rpm] .

[0041] At this instance, conduction of coils 36 and 39 further generates magnetic field which is applied to magnetic viscous fluid 52 to increase the viscosity of magnetic viscous fluid 52. More specifically, the conduction of coils 36 and 39 generates a first magnetic circuit comprising shaft 25-magnetic viscous fluid 52-upper yoke 33-cylinder 24-middle yoke 38-magnetic viscous fluid 52, and a second magnetic circuit comprising shaft 25-magnetic viscous fluid 52-middle yoke 38-cylinder 24-lower yoke 41-magnetic viscous fluid 52-shaft 25. This significantly increases the viscosity of magnetic viscous fluid 52 residing in the path of magnetic flux. The viscosity of magnetic viscous fluid 52, and consequently the frictional force is increased in particular in the area between shaft 25 and upper yoke 33, as well as between middle yoke 38 and shaft 25, and further between lower yoke 41 and shaft 25 because of relatively high magnetic flux density in those areas.

[0042] Thus, frictional resistance exerted during the up and down oscillation of cylinder 24 along with the foregoing components, especially upper and lower coils 36 and 39, upper yoke 33, middle yoke 38, and lower yoke 41 is increased. Accordingly, damping force of damper 23 is relatively increased as indicated by "DAMPING FORCE: LARGE" on the left side of FIG.1. The run-up performance of drum 10 rotation is improved by preventing sympathetic oscillation of tub 6 which is achieved by increasing the damping force of damper 23 at the start of dehydrate step, in other words, until the rotation of drum 10 reaches, for instance, 400 [rpm] in which sympathetic oscillation of tub 6 occurs.

[0043] As typically indicated in the leftmost "imbalance detection" of FIG.1, rotation imbalance of drum 10 is detected based on the oscillation detection signal of oscillation sensors 21 and 22. When the result of imbalance detection is equal to or less than a predetermined value, control unit 5 accelerates the rotational speed of drum 10 to the next level. Thus, control unit 5 gradually accelerates the rotational speed of drum 10 to higher levels while reliably detecting a state in which the rotational imbalance of drum 10 is relatively small in each level.

[0044] When detecting the rotation imbalance of drum 10, control unit 5 maintains the damping force of damper 23 at a relatively high level. In other words, control unit 5 conducts and maintains the conduction of electric current through both upper and lower coils 36 and 39 of damper 23 at 1 [A] as described above during imbalance detection.

[0045] After the rotational speed of drum 10 has reached 400 [rpm], control unit 5 stops the rotation imbalance detection of drum 10 and maintains the rotational speed of drum 10 at 400 [rpm] for a predetermined time period "T". While the rotational speed is constant, control unit 5 reduces the damping force of damper 23 as can be seen in the transition of "DAMPING FORCE VARIATION" to "DAMPING FORCE: SMALL". Further, control unit 5 reduces or varies the damping force of damper 23 at a predetermined gradient by gradually reducing the amount of conduction through coils 36 and 39 within a time period of, for instance, 15 [sec].

[0046] Immediately thereafter, control unit 5 performs imbalance detection in which the rotation imbalance of drum 10 is detected based on the oscillation signal of oscillation sensors 21 and 22 in order to further accelerate the rotational speed of drum 10 from 400 [rpm] described earlier. This is indicated by the second "imbalance detection" counted from the left side of FIG.1. When finding that the result of detection is equal to or less than the predetermined value, control unit 5 accelerates the rotational speed of drum 10 to the next level of, for instance, 950 [rpm].

[0047] Thereafter, control unit 5 performs imbalance detection in which the rotation imbalance of drum 10 is detected based on the oscillation signal of oscillation sensors 21 and 22 in order to further accelerate the rotational speed of drum 10 from 950 [rpm] described earlier. This is indicated by the third "imbalance detection" counted from the left side of FIG.1. When finding that the result of detection is equal to or less than the predetermined value, control unit 5 accelerates the rotational speed of drum 10 to the final level of, for instance, 1200 [rpm].

[0048] Control unit 5 maintains the rotation of drum 10 at the final speed level for a predetermined time. During the period spanning from the acceleration of drum 10 from 400 [rpm] to the lapse of the predetermined time of rotation at the final level, control unit 5 maintains the damping force of damper 23 at the relatively small level. This is because, though small, the oscillation of tub 6 is still observed during this period. Thus, in order to prevent the oscillation from being transmitted to exterior housing 1 and further to the floor of the room in which the washer is installed, control unit 5 maintains the damping force of damper 23, though at a relatively small level, to prevent the transmission of oscillation by the elasticity of coil spring 54 of suspension 7.

[0049] After the lapse of the predetermined time period, control unit 5 stops the rotary drive of drum 10 to reduce the rotational speed to 0. During the process of reducing the rotational speed of drum 10 to 0, drum 10 passes a speed range in which sympathetic oscillation of tub 6 is encountered. Thus, control unit 5, again, conducts electric current of 1[A] through the upper and lower coils 36 and 39. As a result, control unit 5 prevents sympathetic oscillation of tub 6 by increasing the damping force of damper 23 as indicated by the subsequent "DAMPING FORCE: LARGE" of FIG. 1, in other words, "DAMPING FORCE: LARGE" indicated in the right side of FIG. 1.

[0050] Then, control unit 5 reduces the damping force of damper 23 which was increased at the final phase of the dehydrate step by reducing the conduction of both upper and lower coils 36 and 39 and eventually cutting off the conduction after the rotational speed of drum 10 has passed the above described range of speed in which sympathetic oscillation of tub 6 occurs.

[0051] As described above, the washer of the present embodiment is provided with suspension 7 that elastically supports tub 6, containing drum 10 configured to be driven in rotation, within exterior housing 1. Suspension 7 is provided with damper 23 that reduces the oscillation of tub 6. Damper 23 is capable of varying its damping force. Control unit 5 keeps the damping force of damper 23 constant during the imbalance detection performed by the imbalance detector as identified by the left most "IMBALANCE DETECTION" indicated in FIG.1.

[0052] The imbalance detection by the imbalance detector is performed while drum 10 is in rotation. When the damping force of damper 23 is varied during the rotation of drum 10, the capacity of tub 6 to restrain oscillation is also varied to render tub 6 oscillation prone. This prevents accurate imbalance detection. In the washer of the present embodiment, control unit 5 maintains the damping force of damper 23 constant when imbalance detection is ongoing. Thus, the capacity of tub 6 to restrain the oscillation does not vary, thereby suppressing the oscillation of tub 6. This allows accurate imbalance detection which in turn allows accurate execution of controls that rely on the result of imbalance detection.

[0053] To summarize, the washer of the present embodiment is capable of controlling the variable damping force of damper 23 in a preferable way so as not to negatively affect the imbalance detection performed while the drum 10 is in rotation.

[0054] Further, the washer of the present embodiment executes a control to vary the damping force of damper 23 as identified as "DAMPING FORCE VARIATION" in FIG.1 when the rotational speed of drum 10 is constant. This is immediately followed by imbalance detection performed by the imbalance detector which is identified as the middle "IMBALANCE DETECTION" among the 3 "IMBALANCE DETECTION" indicated in FIG.1.

[0055] If the damping force of damper 23 is varied when the rotational speed of drum 10 is not constant, the instability of drum 10 rotation and the variation in the capacity of tub 6 to restrain oscillation renders tub 6 oscillation prone. This prevents accurate imbalance detection following immediately thereafter. The washer of the present embodiment executes the control to vary the damping force of damper 23 when the rotational speed of drum 10 is constant. In other words, the damping force of damper 23 is varied when the rotational speed of drum 10 does not vary. This suppresses the oscillation of tub 6. Thus, the imbalance detection immediately following the damping force variation of damper 23 can be performed accurately, which in turn allows controls relying on the result of imbalance detection to be performed accurately.

[0056] Thus, this also allows the variable damping force of damper 23 to be controlled in a preferable way so as not to negatively affect the imbalance detection performed while the drum 10 is in rotation.

[0057] Still further, the washer of the present embodiment executes the control to vary the damping force of damper 23 identified as "DAMPING FORCE VARIATION" in FIG.1 in a predetermined gradient. Damping force of damper 23, when subjected to sudden variation, produces a shock which renders tub 6 susceptible to produce abnormal oscillations. In the washer according to the present embodiment, the control to vary the damping force of damper 23 is executed with a predetermined gradient and avoids sudden variation. Thus, tub 6 is free of abnormal oscillations and consequently free of being affected by the impact of abnormal oscillation, thereby allowing accurate execution of imbalance detection following immediately thereafter. This in turn allows accurate execution of controls relying on the imbalance detection.

[0058] Yet further, damper 23 of suspension 7 is provided with a cylinder 24 containing various components. Among the components, upper bearing 35 is located at the uppermost end of cylinder interior and lower bearing 43 is located at the lowermost end of cylinder interior. The remaining components such as upper yoke 33, upper coil 36, upper bobbin 37, middle yoke 38, lower coil 39, lower bobbin 40, lower yoke 41, and seal 42 are located between upper bearing 35 and lower bearing 43. Shaft 25 is supported by upper bearing 35 and lower bearing 43 located at the upper and lower ends of cylinder 24 interior. Thus, shaft 25 does not easily wobble during the axial relative reciprocation of shaft 25, thereby suppressing the variation in the spacing between shaft 25 and coils 36 and 39. As a result, the magnetic field produced by coils 36 and 39 act evenly on magnetic viscous fluid 52 to allow the damping force of damper 23 to vary even more accurately.

[0059] FIG. 5 illustrates a second embodiment; FIGS. 6 to 9, a third embodiment; FIG.10, a fourth embodiment; and FIG.11, a fifth embodiment. In each of the embodiments, elements that are identical to those of the first embodiment are identified with identical reference symbols and are not redescribed. Description is given only on differences from the first embodiment.

[SECOND EMBODIMENT]

[0060] FIG.5 indicates the control executed in the second embodiment. When the operation of the washer configured as described above is started in response to the user operation of control panel 4, control unit 5 serving as a controller executes wash, dehydrate, rinse, dehydrate, and dry steps in the listed sequence as shown in FIG.5.

Control unit 5 begins the wash step by executing a weight detection operation also referred to as laundry weight detection that detects the weight of laundry stored inside drum 10. It is to be appreciated that the laundry load being detected is by weight and not by volume. In this case, the laundry being stored inside drum 10 is dry laundry which is yet to be washed. Thus, the weight detection in this case refers to a dry laundry weight detection. The washer of the present embodiment is provided with such dry laundry weight detection feature.

[0061] The dry laundry detection detects the laundry weight by the rotational load of motor 8. For instance, the time expended on accelerating the rotation of drum 10 to a predetermined rotational speed and the time expended on decelerating the rotation of drum 10 to a predetermined rotational speed after the drive of drum 10 is stopped and left idle may be employed in obtaining the rotational load of motor 8. Thus, in the dry laundry weight detection, rotation sensor 57 and control unit 5 serve as laundry weight detector.

[0062] During the dry laundry detection, control unit 5 conducts and maintains the conduction of electric current of 1 [A] through upper and lower coils 36 and 39 of damper 23. Control unit 5 thus, keeps the damping force of damper 23 constant and maximized.

[0063] Then, control unit 5 executes a water supply operation and opens supply valve 58 and supplies water into tub 6 up to a water level corresponding to the detected laundry weight. At this instance, detergent is also supplied from a detergent dispenser not shown.

[0064] After water supply, control unit 5 executes a wash operation in which the laundry is mostly "beat washed" by rotating drum 10 alternately in the forward and reverse directions in low speed for a duration corresponding to the amount of laundry, in this case, the dry laundry weight detected. Tub 6 oscillates mostly in the up and down direction by the rotation of drum 10 in the wash operation as well. Thus, the components of suspension 7 exert movements or functions similar to those of the dehydrate step. The rotation of drum 10 for the wash operation, however, is low speed. Accordingly, the movements of the components are smaller as compared to the corresponding movements in the dehydrate step.

[0065] Thus, control unit 5 conducts electric current of, for instance, 0.5[A] through both upper and lower coils 36 and 39 of damper 23 which is less than the electric current of 1[A] conducted in the dehydrate step. Control unit 5 thus, increases the viscosity of magnetic viscous fluid 52 to an appropriate level to increase the damping force of damper 23 to an appropriate level and suppress the oscillation of tub 6.

[0066] After completing the wash step, control unit 5 executes a drain operation in which drain valve 15 is opened to drain tub 6. Control unit 5 stops or cuts off the conduction of both upper and lower coils 36 and 39 of damper 23. Thus, the viscosity of magnetic viscous fluid 52 will not be increased by magnetic force during this period and the damping force of damper 23 is reduced to the level of inherent viscosity of magnetic viscous fluid 52.

[0067] The subsequent dehydrate operation is as described in the first embodiment. The dehydrate operation, however, is carried out for a duration corresponding to the detected laundry weight, in this case, the detected dry laundry weight.

[0068] In the subsequent rinse step, control unit 5 opens supply valve 58 and supplies water into tub 6 up to a water level corresponding to the detected laundry weight, in this case, the dry laundry weight. Then, control unit 5 executes a rinse operation in which the laundry is mostly "beat rinsed" by rotating drum 10 alternately in the forward and reverse directions in low speed for a duration corresponding to the amount of laundry, in this case, the dry laundry weight detected. Control unit 5 conducts both upper and lower coils 36 and 39 of damper 23 as done in the wash step.

[0069] The subsequent dehydrate operation is as described in the first embodiment. The dehydrate operation, however, is carried out for a duration corresponding to the detected laundry weight, in this case, the detected dry laundry weight.

[0070] Next, control unit 5 performs a dry step. Control unit 5 begins the dry step by executing a weight detection operation also referred to as laundry weight detection that detects the weight of laundry stored inside drum 10. In this case, the laundry being stored inside drum 10 is wet laundry which has been subjected to the wash step, the rinse step, and the dehydrate step. Thus, the weight detection in this case refers to a wet laundry weight detection. The washer of the present embodiment is provided with such wet laundry weight detection feature.

[0071] The wet laundry weight detection is similar in operation to the dry laundry weight detection. Thus, during the wet laundry detection, control unit 5 conducts and maintains the conduction of electric current of 1 [A] through upper and lower coils 36 and 39 of damper 23. Control unit 5 thus, keeps the damping force of damper 23 constant and maximized.

[0072] Then, control unit 5 executes the dry operation through the operation of dry unit 17 by rotating drum 10 for a duration corresponding to the amount of laundry, in this case, the wet laundry weight detected. At this instance, control unit 5 conducts both upper and lower coils 36 and 39 as done in the wash and rinse operations in the wash and rinse steps.

[0073] In the present embodiment, the washer is provided with a dry laundry weight detecting feature which detects the weight of dry laundry stored in drum 10. When the laundry weight detection by the dry laundry weight detecting feature is ongoing, the damping force of damper 23 is kept constant. Thus, the capacity of damper 23 to restrain the oscillation does not vary during the dry laundry weight detection, thereby suppressing the oscillation of tub 6. This allows steady rotation of drum 10 and thereby accurate dry laundry weight detection which in turn allows accurate execution of controls that rely on the result of laundry weight detection.

[0074] To summarize, the washer of the present embodiment is capable of controlling the variable damping force of damper 23 in a preferable way so as not to negatively affect the dry laundry weight detection.

[0075] Further, in the present embodiment, the washer is provided with a wet laundry weight detecting feature which detects the weight of wet laundry stored in drum 10. When the laundry weight detection by the wet laundry weight detecting feature is ongoing, the damping force of damper 23 is kept constant. Thus, the capacity of damper 23 to restrain the oscillation does not vary during the wet laundry weight detection, thereby suppressing the oscillation of tub 6. This allows steady rotation of drum 10 and thereby accurate wet laundry weight detection which in turn allows accurate execution of controls that rely on the result of laundry weight detection.

[0076] To summarize, the washer of the present embodiment is capable of controlling the variable damping force of damper 23 in a preferable way so as not to negatively affect the wet laundry weight detection.

[0077] Still further in the present embodiment, the 2 types of laundry weight detection, namely the dry laundry weight detection and the wet laundry weight detection, are carried out with the damping force of damper 23 kept constant and maximized.

[0078] The subject of dry laundry weight detection may not only be dry laundry but may be a mixture of dry laundry and wet laundry such as a drenched bath towel. Similarly, the subject of wet laundry weight detection may not only be dehydrated dry laundry but may be a mixture of undehydrated wet laundry containing relatively high moisture and dehydrated dry laundry containing relatively low moisture. Drum 10, when rotated in such state is prone to be unbalanced.

[0079] In the present embodiment, the damping force of damper 23 is kept constant and maximized in both of the 2 types of laundry weight detections, namely the dry laundry weight detection and the wet laundry weight detection. Thus, oscillation of tub 6 originating from the aforementioned imbalance can be suppressed effectively during the respective laundry weight detections. This allows steady rotation of drum 10 and thereby accurate laundry weight detection which in turn allows accurate execution of controls that rely on the result of laundry weight detection.

[THIRD EMBODIMENT]

[0080] FIG.6 indicates the control executed in the third embodiment. When the operation of the washer configured as described above is started in response to the user operation of control panel 4, control unit 5 serving as a controller executes wash, dehydrate, rinse, dehydrate, and dry steps in the listed sequence.
As describe earlier, control unit 5 begins the wash step by executing the weight detection and more specifically the dry laundry weight detection.
During the dry laundry weight detection, tub 6 oscillates mostly in the up and down direction by the rotation of drum 10.

[0081] During the dry laundry weight detection, control unit 5 conducts and maintains the conduction of electric current through both upper and lower coils 36 and 39 of damper 23 at a predetermined level, one example of which may be 1 [A] . Thus, the viscosity of magnetic viscous fluid 52, and consequently the frictional force is increased in particular in the area between shaft 25 and upper yoke 33, as well as between middle yoke 38 and shaft 25, and further between lower yoke 41 and shaft 25 because of relatively high magnetic flux density in those areas.

[0082] When cylinder 24 oscillates up and down around shaft 25 along with the above described components, especially upper and lower coils 36 and 39, upper yoke 33, middle yoke 38, and lower yoke 41, the frictional resistance is increased, thereby increasing the damping force. Thus, the capacity of damper 23 to restrain the oscillation does not vary, thereby suppressing the oscillation of tub 6 and allows accurate laundry weight detection by the dry laundry weight detection feature.

[0083] Then, control unit 5 supplies water and thereafter proceeds to wash operation. In the wash operation, tub 6 oscillates mostly in the up and down direction by the rotation of drum 10 in the wash operation. Thus, the components of suspension 7 exert movements or functions similar to those of dry laundry weight detection. Thus, control unit 5 conducts both upper and lower coils 36 and 39 of damper 23 to increase the viscosity of magnetic viscous fluid 52 and increase the damping force of damper 23 to an appropriate level, to thereby suppress the oscillation of tub 6.

[0084] FIG.7 represents the level of electric current conducted through both upper and lower coils 36 and 39 during the wash operation, the subsequent rinse operation and the dry operation. The level of electric current conducted corresponds to the detected laundry weight. For instance, in case the level of detected laundry amount is "LARGE", control unit 5 conducts electric current of 0.3 [A] through both upper and lower coils 36 and 39. In case the level of detected laundry amount is "MEDIUM", control unit 5 conducts electric current of 0. 4 [A] through both upper and lower coils 36 and 39. In case the level of detected laundry amount is "SMALL", control unit 5 conducts electric current of 0.5 [A] through both upper and lower coils 36 and 39. To summarize, control unit 5 increases the level of electric current conducted through both upper and lower coils 36 and 39 as the detected laundry weight becomes smaller. The damping force of damper 23 is proportional to the level of electric current conducted through both upper and lower coils 36 and 39. Thus, stated differently, control unit 5 increases the damping force of damper 23 as the detected laundry weight becomes smaller

[0085] FIG. 8 describes the relation between the detected laundry weight and the damping force of damper 23 during the wash operation, the subsequent rinse operation and dry operation. Control unit 5 varies the damping force of damper 23 depending upon the size of the detected laundry weight. In operation, the damping force is varied linearly as shown in FIG. 8. This improves the accuracy of responsiveness of damping force variation.

[0086] After completing the wash step, control unit 5 executes the drain operation. In the drain operation, control unit 5 stops or cuts off the conduction of both upper and lower coils 36 and 39 of damper 23. Thus, the viscosity of magnetic viscous fluid 52 will not be increased by magnetic force during this period and the damping force of damper 23 is reduced to the level of inherent viscosity magnetic viscous fluid 52.

[0087] The subsequent dehydrate step, which, in this case, is an intermediate dehydrate step, is carried out as described in FIG. 1. The dehydrate operation in the dehydrate step is carried out for a duration corresponding to the detected laundry weight.

[0088] During the dehydrate operation, tub 6 oscillates mostly in the up and down direction by the rotation of drum 10. Because the rotational speed in this case is greater than in the wash operation, the components of suspension 7 exert movements or functions larger than those of the wash operation. Thus, control unit 5 conducts electric current through both upper and lower coils 36 and 39 of damper 23 which is greater in level as compared to the wash operation. Control unit 5 thus, increases the viscosity of magnetic viscous fluid 52 to increase the damping force of damper 23 and suppress the oscillation of tub 6.

[0089] FIG.9 represents the level of electric current conducted through both upper and lower coils 36 and 39 during the dehydrate operation. The level of electric current conducted corresponds to the detected laundry weight. For instance, in case the level of detected laundry amount is "LARGE", control unit 5 conducts electric current of 0.5[A] through both upper and lower coils 36 and 39. In case the level of detected laundry amount is "MEDIUM", control unit 5 conducts electric current of 0. 8 [A] through both upper and lower coils 36 and 39. In case the level of detected laundry amount is "SMALL", control unit 5 conducts electric current of 1. 0 [A] through both upper and lower coils 36 and 39. To summarize, control unit 5 increases the level of electric current conducted through both upper and lower coils 36 and 39 as the detected laundry weight becomes smaller and the damping force of damper 23 is increased as the detected laundry weight becomes smaller.

[0090] Control unit 5 varies the damping force of damper 23 depending upon the size of the detected laundry weight. In operation, the damping force is varied linearly as shown in FIG. 8. This improves the accuracy of responsiveness of damping force variation.

[0091] Thus, in the initial phase of dehydration step which spans from the start of dehydrate step and a point in time when the rotational speed of drum 10 reaches a certain speed of, for instance, 400 [rpm], electric current corresponding to the detected laundry weight is conducted through the upper and lower coils 36 and 39. FIG.1 shows an example in which an electric current of 1 [A] is conducted based on the detected laundry weight. Accordingly, the run-up performance of drum 10 rotation is improved by preventing sympathetic oscillation of tub 6 which is achieved by increasing the damping force of damper 23 at the start of dehydrate step, in other words, until the rotation of drum 10 reaches, for instance, 400 [rpm] in which sympathetic oscillation of tub 6 occurs.

[0092] Thus, control unit 5 gradually accelerates the rotational speed of drum 10 to higher levels while reliably detecting a state in which the rotational imbalance of drum 10 is relatively small in each level.

[0093] When detecting the rotation imbalance of drum 10, control unit 5 conducts and maintains the conduction of electric current through both upper and lower coils 36 and 39 of damper 23 at a constant level of, for instance, 1 [A) which corresponds to the detected laundry weight. Thus, control unit 5 maintains the damping force of damper 23 at a relatively high level.

[0094] Thereafter, when control unit 5 stops the rotary drive of drum 10 to reduce the rotational speed to 0, in other words, when the rotational speed of drum 10 passes a speed range in which sympathetic oscillation of tub 6 is encountered, control unit 5, re-conducts the upper and lower coils 36 and 39 with an electric current of, for instance, 1 [A]. As a result, control unit 5 prevents sympathetic oscillation of tub 6 by increasing the damping force of damper 23 as indicated by "DAMPING FORCE: LARGE" in FIG.1, to prevent sympathetic oscillation of tub 6.

[0095] Then, control unit 5 executes the rinse step. The rinse step also begins with the weight detection that detects the weight of laundry stored inside drum 10. In this case, the laundry being stored inside drum 10 is wet laundry which has been subjected to the wash step and the dehydrate step. Thus, the weight detection in this case refers to wet laundry weight detection.

[0096] The wet laundry weight detection is similar in operation to the dry laundry weight detection. Thus, during the wet laundry detection, control unit 5 maintains the conduction of electric current of, for instance, 1[A] through upper and lower coils 36 and 39 of damper 23 which is identical to the electric current level conducted in the dry laundry weight detection.

[0097] Then, control unit 5 opens supply valve 58 and supplies water into tub 6 up to a water level corresponding to the detected laundry weight, in this case, the wet laundry weight. Then, control unit 5 executes a rinse operation in which the laundry is mostly "beat rinsed" by rotating drum 10 alternately in the forward and reverse directions in low speed for a duration corresponding to the amount of laundry, in this case, the wet laundry weight detected. Control unit 5 conducts both upper and lower coils 36 and 39 of damper 23 as done in the wash step. The conduction of both upper and lower coils 36 and 39 is, however, carried out as indicated in FIGS.7 and 1 at the electric current level corresponding to the result of wet laundry weight detection. Thereafter, control unit 5 executes a drain operation and opens drain valve 15 to drain tub 6. Control unit 5 stops or cuts off the conduction of both upper and lower coils 36 and 39 of damper 23 in the drain operation.

[0098] The subsequent final dehydrate operation is similar to the intermediate dehydration described above. The conduction of both upper and lower coils 36 and 39 is, however, carried out as indicated in FIGS.9 and 1 at the electric current level corresponding to the result of wet laundry weight detection.

[0099] Then, control unit 5 executes a dry operation. Control unit 5 begins the dry operation by executing the weight detection and more specifically the wet laundry weight detection. Control unit 5 conducts and maintains the conduction of electric current of, for instance, 1[A] through upper and lower coils 36 and 39 of damper 23 which is identical to the electric current level conducted in the dry laundry weight detection.

[0100] Then, control unit 5 executes the dry operation through the operation of dry unit 17 by rotating drum 10 for a duration corresponding to the detected laundry weight, in this case, the detected wet laundry weight. At this instance, control unit 5 conducts both upper and lower coils 36 and 39 carried out as indicated in FIGS.7 and 1 at the electric current level corresponding to the result of wet laundry weight detection.

[0101] As described above, the washer of the present embodiment is provided with suspension 7 that elastically supports tub 6, containing drum 10 configured to be driven in rotation, within exterior housing 1. Suspension 7 is provided with damper 23 that that reduces the oscillation of tub 6. Damper 23 is capable of varying its damping force. Based on the detection of the laundry weight detector that detects the weight of laundry inside drum 10, the damping force of damper 23 is configured to increase as the detected laundry weight becomes smaller.

[0102] When the weight of laundry inside drum 10 is relatively large, it becomes easy for the laundry to be distributed evenly on the inner periphery of the rotating drum 10 by centrifugal force. As a result, there is less possibility of uneven distribution of laundry and consequently rotation imbalance, which in turn reduces the possibility of oscillation with relatively large amplitude.

[0103] The washer of the present embodiment is configured to increase the damping force of damper 23 as the detected laundry weight becomes smaller. The transmission of oscillation from drum 10 to tub 6 can be suppressed effectively by increasing the damping force of damper 23. Accordingly, the subsequent wash operation, dehydrate operation, rinse operation, dehydrate operation, and dry operation can each progress while reducing oscillation based on the detected laundry weight. This allows unstressful use of the washer on the part of the user.

[0104] Further, in the washer of the present embodiment, control unit 5 is configured to execute the laundry weight detection by the laundry weight detector when the laundry inside drum 10 is a dry laundry. A dry laundry is an indication that the laundry has not been washed. In other words, the washer of the present embodiment is capable of detecting the weight of laundry in the initial stage of before the laundry is washed. This means that control of the damping force of damper 23 based on the laundry weight detection can be executed from the start of the washing operation. Thus, the above described operation and effect can be obtained in the early stages of the washing cycle.

[0105] Further in the washer of the present embodiment, control unit 5 is configured to execute the laundry weight detection by the laundry weight detector when the laundry inside drum 10 is a wet laundry. Moisture absorbability of laundry varies depending upon the type of fabric of the laundry. Thus, when wetted, laundry with relatively higher absorbability is heavier in weight than laundry with relatively lower absorbability. Hence, high absorbability laundry is prone to become an imbalance load when drum 10 is rotated. In the washer of the present embodiment, control unit 5 is configured to execute the laundry weight detection when the laundry inside drum 10 is a wet laundry as well. Thus, the weight of laundry having different moisture absorbability depending upon fabric can be detected accurately. Thus, after the laundry weight detection, the control of damping force of damper 23 after the laundry weight detection can be executed with accuracy to reliably obtain the above described operation and effect.

[0106] The laundry weight detection when the laundry inside drum 10 is a wet laundry, that is, the wet laundry weight detection may be executed only at the beginning of the rinse step. In other words, the wet laundry weight detection may be eliminated at the beginning of the dry step.

[0107] FIG.10 pertains to a fourth embodiment and indicates the relation between detected laundry weight and the damping force of damper 23. In this case, the variation of damping force of damper 23 dependent on the size of detected laundry weight is not a linear variation as indicated in FIG.8. In the present embodiment, the variation of the damping force of damper 23 dependent on the size of detected laundry weight is a stepped variation as shown in FIG. 10 in which the damping force of damper 23 is varied in steps to each of small, medium, and large levels depending on the large, medium, and small levels of the detected laundry weight. The present embodiment allows the data stored by control unit 5 to be simplified and thereby allows cost reduction.

[FIFTH EMBODIMENT]

[0108] FIG.11 illustrates suspension 61 of a fifth embodiment.

In suspension 61, damper 62 is provided with a single set of coil 63 which is not divided into upper and lower coils and is wound on a single set of bobbin 64. Damper 62 holds bobbin 64 wound with coil 63 between upper yoke 33 and lower yoke 41 or bracket 44 within cylinder 24. Thus, suspension 61, or more specifically, damper 62 is not provided with intermediate yoke 38 described earlier.

The above described configuration also allows the damping force of damper 62 to be varied or kept constant by controlling the conduction of coil 63 through control unit 5.

[OTHER EMBODIMENTS]

[0109] The washer described above is not limited to the foregoing embodiments but may be modified without deviation. One of such modifications may be replacing oscillation sensors 21 and 22 serving as the imbalance detector with a configuration in which the imbalance is detected by arranging control unit 5 to calculate the q-axis current from the currents flowing in motor 8.

[0110] For instance, motor 8 for rotating drum 10 may be a brushless DC motor. The brushless DC motor comprises rotor 8a provided with a permanent magnet and stator 8b provided with a coil as shown in FIG. 2. The current flowing in motor 8 is divided into a d-axis current and a q-axis current by a generally known vector control. The d-axis current is oriented in a parallel direction or in a direction of rotation with respect to the magnetic flux being produced by the S pole and the N pole of the stator coil, whereas the q-axis current is oriented in a perpendicular direction with respect to the magnetic flux. The level of q-axis current depends on the load applied to motor 8. Thus, oscillation, in other words, imbalance can be detected based on the q-axis current.

[0111] More specifically, oscillation can be detected by calculating the variation, one example of which may be difference between the maximum value and the minimum value, of q-axis current during 1 revolution of motor 8. Accordingly, control unit 5 may replace oscillation sensors 21 and 22 with a control to calculate variation in q-axis current level during 1 revolution of motor 8 to serve as the imbalance detector.

[0112] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Claims

1. A washing machine comprising:

an exterior housing;
a tub disposed inside the exterior housing;
a rotary tub driven in rotation within the tub;
a suspension elastically supporting the tub inside the exterior housing and being provided with a damper that is capable of exerting variable damping force and that reduces oscillation of the tub; and
a controller that executes a control to keep the damping force of the damper constant while a predetermined detecting operation is ongoing.

2. The washing machine according to claim 1, further comprising an imbalance detector that detects imbalance during the rotation of the rotary tub, wherein the controller execute a control to keep the damping force of the damper constant while the imbalance detection by the imbalance detector is ongoing.

3. The washing machine according to claim 1, further comprising an imbalance detector that detects imbalance during the rotation of the rotary tub,
wherein the controller executes a control to vary the damping force of the damper while the rotary tub is rotating at a constant speed which is immediately followed by a control to detect imbalance by the imbalance detector.

4. The washing machine according to claim 3, wherein the controller executes the control to vary the damping force of the damper with a predetermined gradient.

5. The washing machine according to claim 1, further comprising a laundry weight detector that detects weight of laundry inside the rotary tub,
wherein the controller executes a control to keep the damping force of the damper constant while the weight detection by the laundry weight detector is ongoing.

6. The washing machine according to claim 5, wherein the laundry weight detector comprises a dry laundry weight detector that detects weight of dry laundry inside the rotary tub, and
wherein the controller executes a control to keep the damping force of the damper constant while the weight detection by the dry laundry weight detector is ongoing.

7. The washing machine according to claim 5, wherein the laundry weight detector comprises a wet laundry weight detector that detects weight of wet laundry inside the rotary tub, and
wherein the controller executes a control to keep the damping force of the damper constant while the weight detection by the wet laundry weight detector is ongoing.

8. The washing machine according to claim 5, wherein the controller executes a control to keep the damping force of the damper maximized while the weight detection by the laundry weight detector is ongoing.

9. A washing machine comprising:

an exterior housing;
a tub disposed inside the exterior housing;
a rotary tub driven in rotation within the tub;
a laundry weight detector that detects weight of laundry inside the rotary tub;
a suspension elastically supporting the tub inside the exterior housing and being provided with a damper that is capable of exerting variable damping force and that reduces oscillation of the tub; and
a controller that controls the damping force of the damper based on a result of detection of the laundry weight detector such that the damping force of the damper becomes greater as the detected laundry weight becomes smaller.

10. The washing machine according to claim 1, further comprising a dry unit that dries laundry inside the rotary tub.

11. The washing machine according to claim 9, further comprising a dry unit that dries laundry inside the rotary tub.

12. The washing machine according to claim 1 or 9, wherein the damper includes a magnetic viscous fluid that varies viscous properties based on strength of externally applied magnetic field and a coil that applies magnetic field to the magnetic viscous fluid, and thereby allowing variation of the damping force.

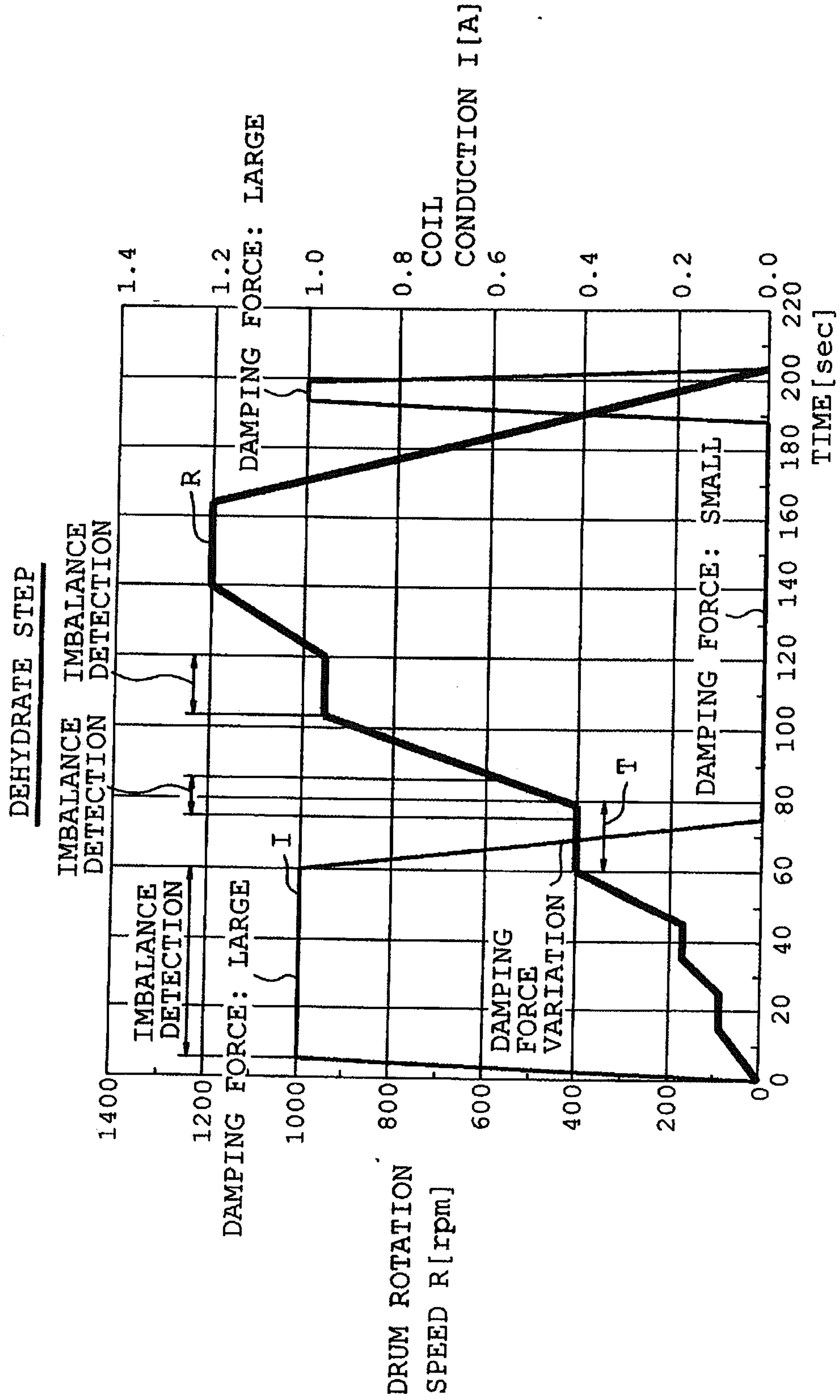
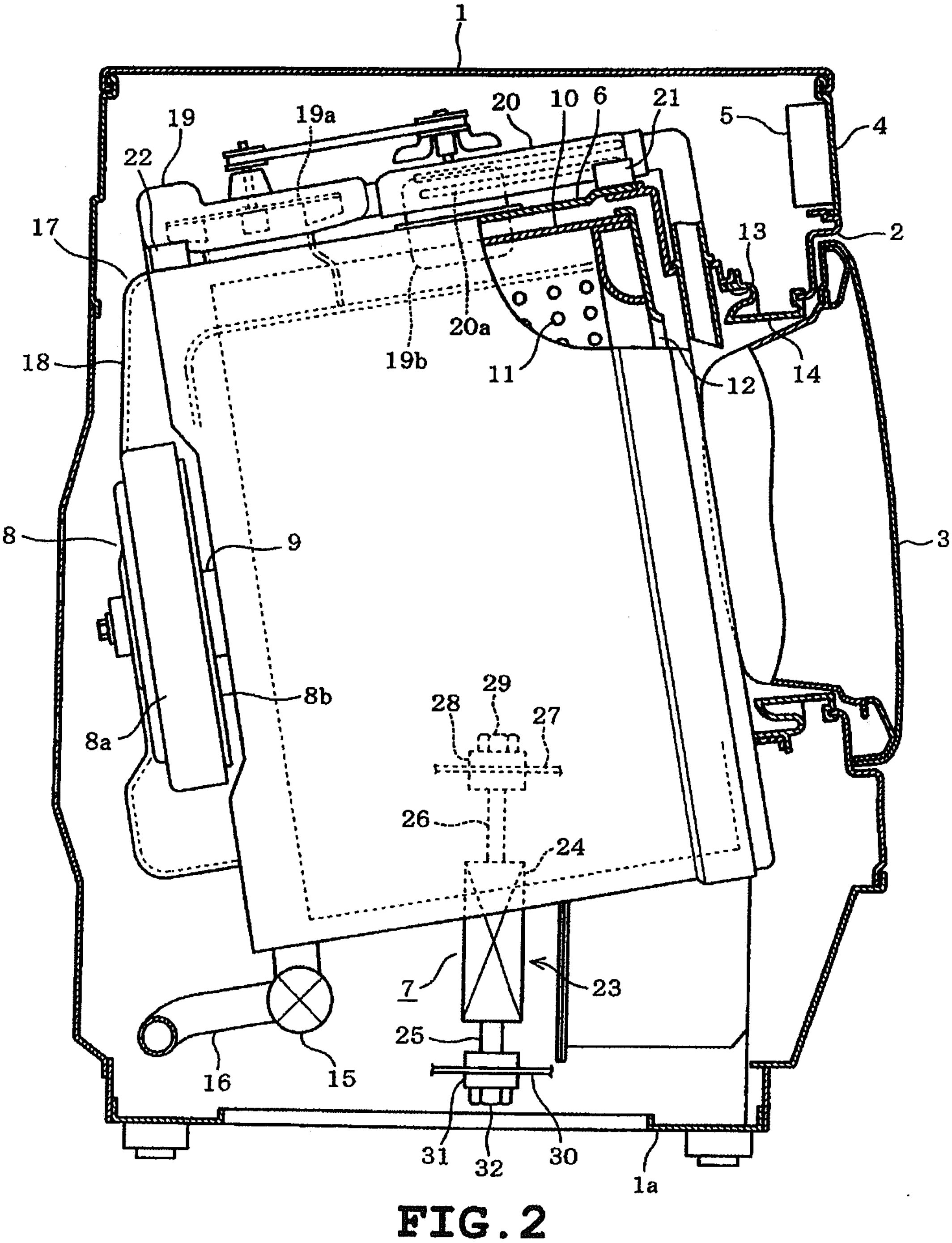

DEHYDRATE STEP
IMBALANCE DETECTION
IMBALANCE DETECTION
IMBALANCE DETECTION
DAMPING FORCE: LARGE
DAMPING FORCE: LARGE
DAMPING FORCE: SMALL
DAMPING FORCE VARIATION
DAMPING FORCE: LARGE
I
T
R
DRUM ROTATION SPEED R[rpm]
COIL CONDUCTION I[A]
TIME[sec]
1400
1200
1000
800
600
400
200
0
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
140
160
180
200
220

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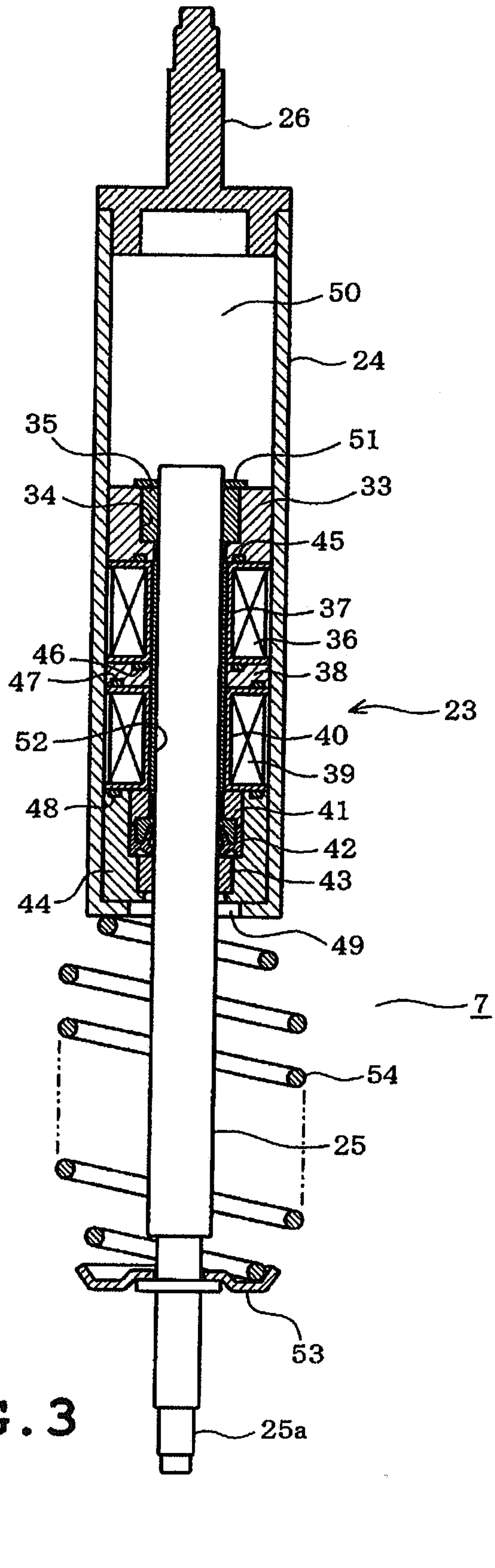
10
6
21
5
4
19
19a
22
2
13
17
14
20a
12
18
19b
11
8
9
3
29
28
27
8b
8a
26
24
23
7
25
15
16
31
32
30
1a

FIG.2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37
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49
7
54
25
53
25a

FIG.3

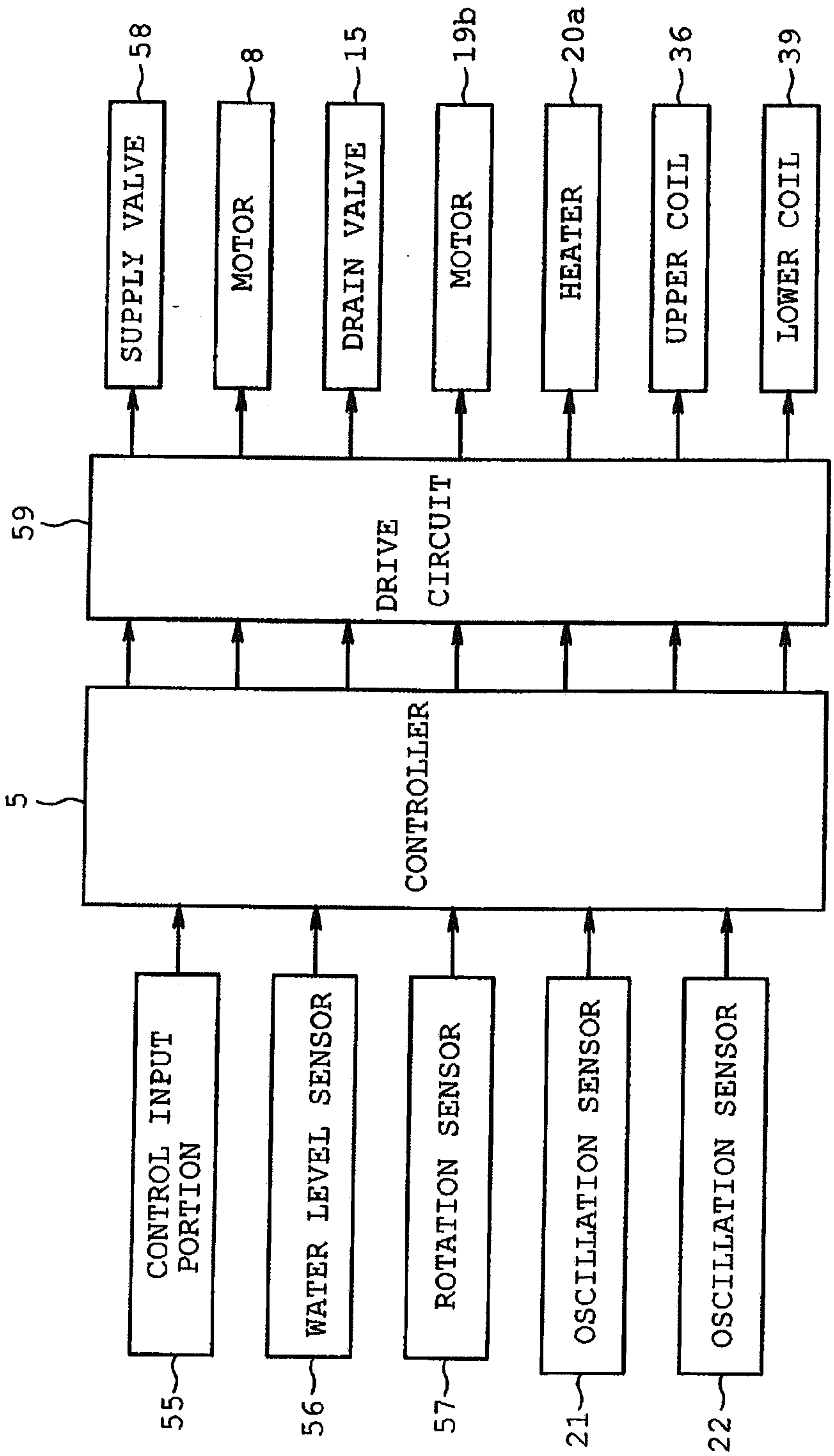
CONTROL INPUT PORTION
55
WATER LEVEL SENSOR
56
ROTATION SENSOR
57
OSCILLATION SENSOR
21
OSCILLATION SENSOR
22
CONTROLLER
5
DRIVE CIRCUIT
59
SUPPLY VALVE
58
MOTOR
8
DRAIN VALVE
15
MOTOR
19b
HEATER
20a
UPPER COIL
36
LOWER COIL
39

FIG. 4

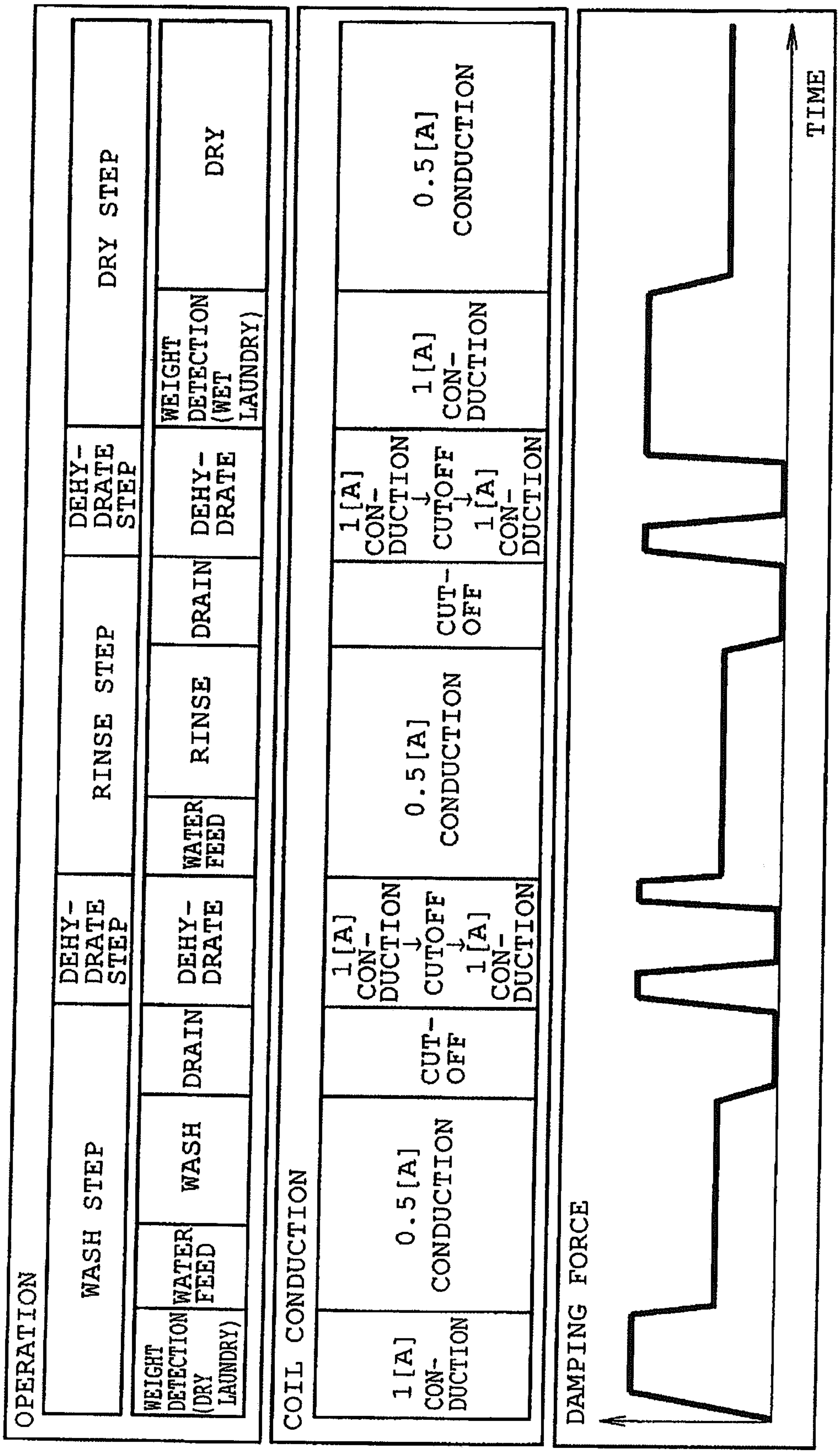
OPERATION
WASH STEP
DEHY-DRATE STEP
RINSE STEP
DEHY-DRATE STEP
DRY STEP
WEIGHT DETECTION (DRY LAUNDRY)
WATER FEED
WASH
DRAIN
DEHY-DRATE
WATER FEED
RINSE
DRAIN
DEHY-DRATE
WEIGHT DETECTION (WET LAUNDRY)
DRY
COIL CONDUCTION
1[A] CON-DUCTION
0.5[A] CONDUCTION
CUT-OFF
1[A] CON-DUCTION → CUTOFF → 1[A] CON-DUCTION
0.5[A] CONDUCTION
CUT-OFF
1[A] CON-DUCTION → CUTOFF → 1[A] CON-DUCTION
1[A] CON-DUCTION
0.5[A] CONDUCTION
DAMPING FORCE
TIME

FIG.5

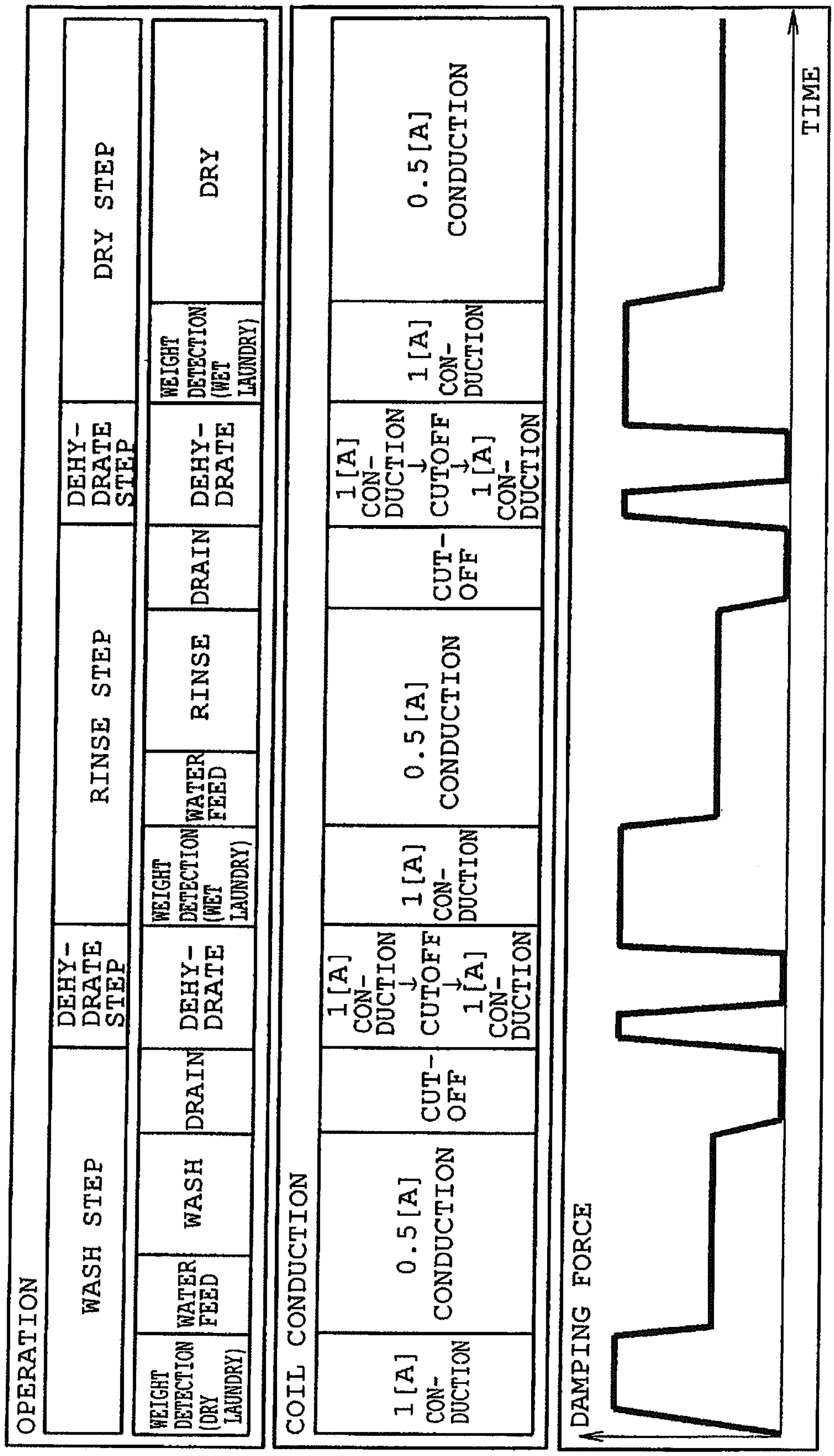
OPERATION
WASH STEP
DEHY-DRATE STEP
RINSE STEP
DEHY-DRATE STEP
DRY STEP
WEIGHT DETECTION (DRY LAUNDRY)
WATER FEED
WASH
DRAIN
DEHY-DRATE
WEIGHT DETECTION (WET LAUNDRY)
WATER FEED
RINSE
DRAIN
DEHY-DRATE
WEIGHT DETECTION (WET LAUNDRY)
DRY
COIL CONDUCTION
1[A] CON-DUCTION
0.5[A] CONDUCTION
CUT-OFF
1[A] CON-DUCTION ↓ CUTOFF ↓ 1[A] CON-DUCTION
1[A] CON-DUCTION
0.5[A] CONDUCTION
CUT-OFF
1[A] CON-DUCTION ↓ CUTOFF ↓ 1[A] CON-DUCTION
1[A] CON-DUCTION
0.5[A] CONDUCTION
DAMPING FORCE
TIME

FIG.6

WASH/RINSE/DRY

LAUNDRY LOAD	DAMPER CONDUCTION[A]
LARGE	0.3
MEDIUM	0.4
SMALL	0.5

FIG.7

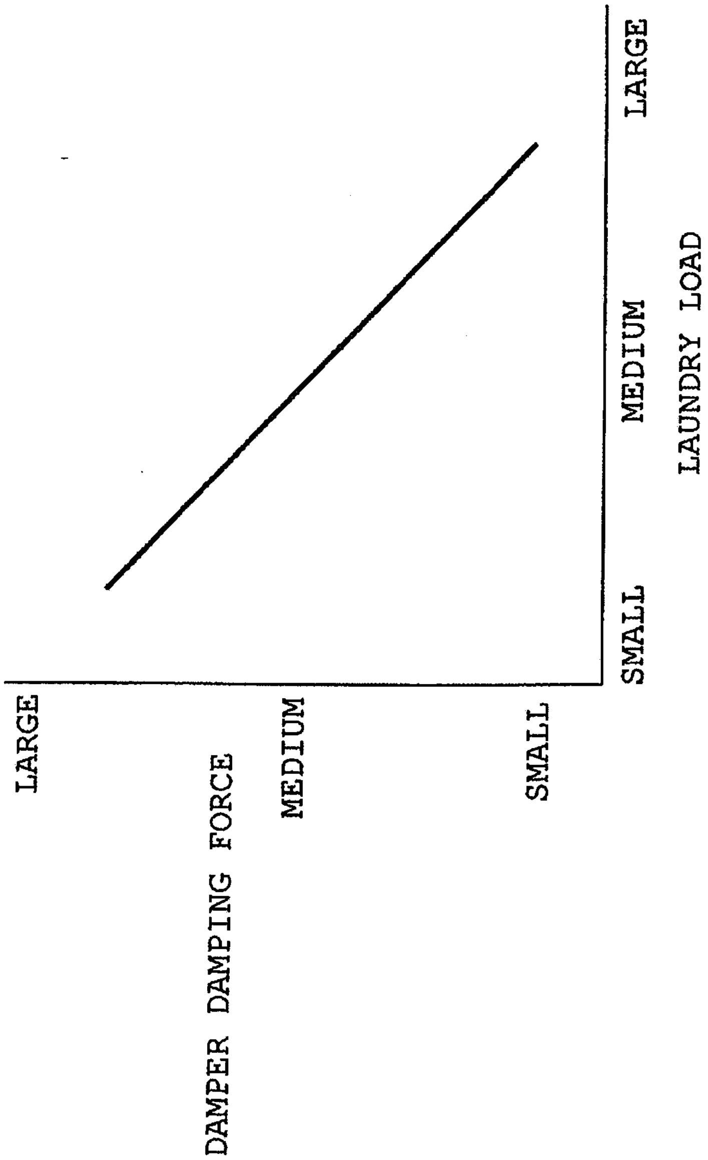
DAMPER DAMPING FORCE
LARGE
MEDIUM
SMALL
LAUNDRY LOAD
SMALL
MEDIUM
LARGE

FIG.8

DEHYDRATE

LAUNDRY LOAD	DAMPER CONDUCTION[A]
LARGE	0.5
MEDIUM	0.8
SMALL	1

FIG.9

LAUNDRY LOAD	DAMPER DAMPING FORCE
LARGE	SMALL
MEDIUM	MEDIUM
SMALL	LARGE

FIG.10

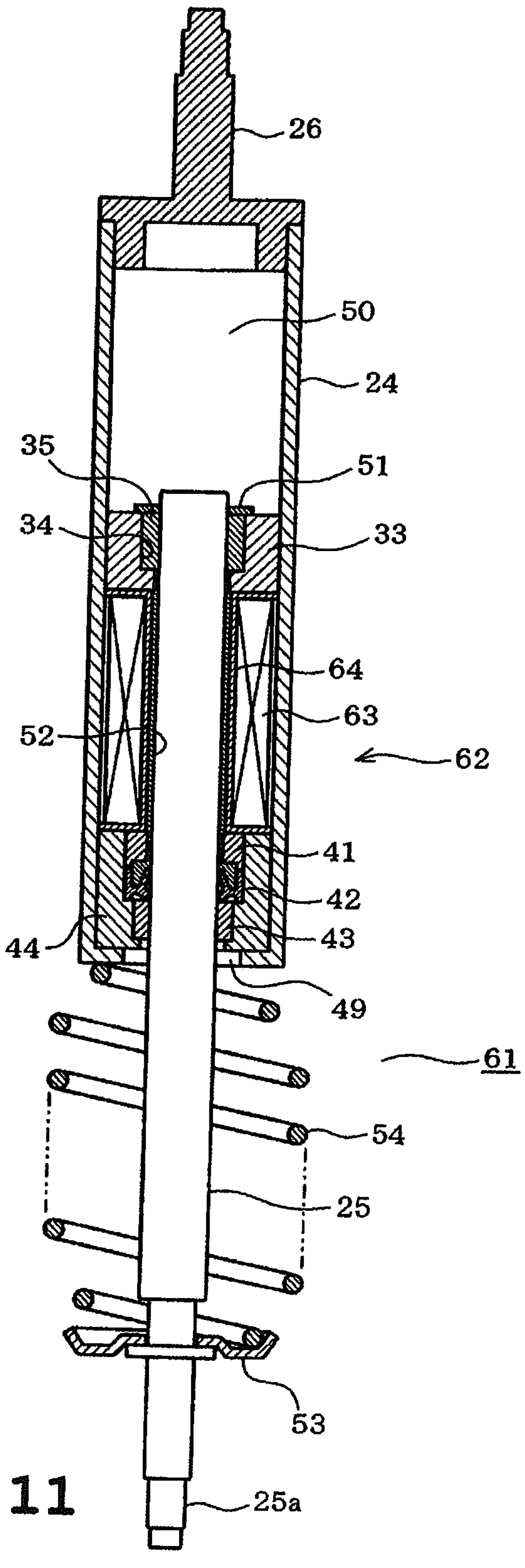

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/052701

A. CLASSIFICATION OF SUBJECT MATTER
D06F33/02(2006.01)i, *D06F37/22*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D06F33/02, D06F37/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 10-323489 A (Electrolux Zanussi S.p.A.), 08 December 1998 (08.12.1998), paragraphs [0001], [0011], [0025] to [0041] & US 5907880 A & EP 878574 A1 & DE 69806100 D & DE 69806100 T & IT 97660029 A & ES 2178795 T & IT 97660029 A0	1-4,10,12 5-9,11
Y	JP 2009-189539 A (Panasonic Corp.), 27 August 2009 (27.08.2009), paragraphs [0044] to [0048] (Family: none)	5-9,11
A	JP 8-19687 A (Hitachi, Ltd.), 23 January 1996 (23.01.1996), paragraphs [0027] to [0029] (Family: none)	1-12

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 May, 2011 (13.05.11)	24 May, 2011 (24.05.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/052701

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-502 A (Matsushita Electric Industrial Co., Ltd.), 10 January 2008 (10.01.2008), paragraphs [0083] to [0086] (Family: none)	1-12
A	JP 10-328479 A (Electrolux Zanussi S.p.A.), 15 December 1998 (15.12.1998), entire text; all drawings & EP 879913 A1 & IT 97660030 A & IT PN970030 D0	1-12

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/052701

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The search revealed that the matter common to the invention in claim 1 and the invention in claim 9 is not novel, since the matter is disclosed in JP 10-323489 A (Electrolux Zanussi S.p.A.), 8 December 1998 (08.12.1998), paragraph [0001], paragraph [0011], paragraphs [0025] - [0041].

(continued to extra sheet)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

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INTERNATIONAL SEARCH REPORT

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Continuation of Box No.III of continuation of first sheet(2)

As a result, the above-said common matter is not a special technical feature within the meaning of PCT Rule 13.2, second sentence, since said common matter does not make a contribution over the prior art.

Consequently, it is obvious that the inventions in claims 1 - 12 do not comply with the requirement of unity of invention.

In conclusion, the number of inventions of the present international application is two.

The inventions in claims 1 - 8, 10, 12
The inventions in claims 9, 11

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002502942 A **[0004]**
- JP 2005291284 A **[0004]**
- JP 2008183297 A **[0004]**
- JP 2008295906 A **[0004]**