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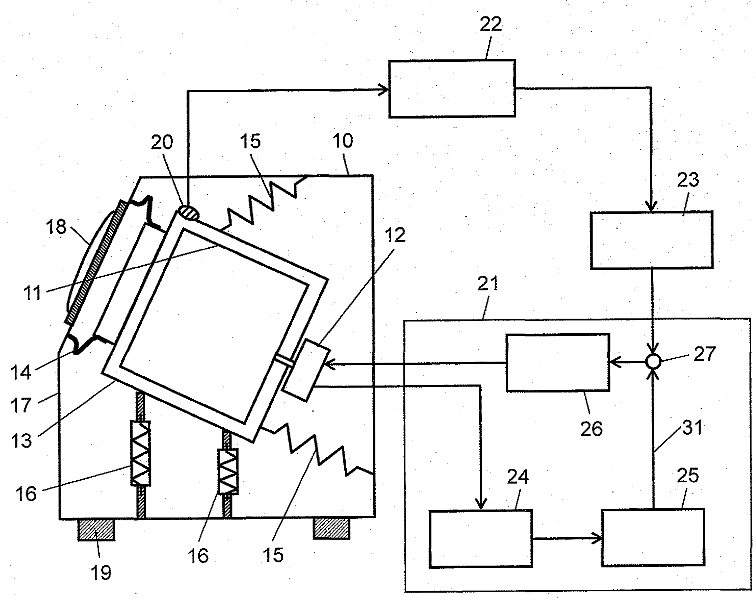
(54) WASHING MACHINE

(57) A washing machine includes a housing, a washtub for accommodating and rotating the laundry, a motor for driving the washtub, a motor controller for controlling the motor, a tubular container for accommodating the washtub and supported relative to the housing, a support device for supporting the tubular container to be in a predetermined position, an imbalance sensor for sensing imbalance caused by the laundry lying in an imbalanced manner in the washtub, and an imbalance vibration controller for adding a signal, which corrects torque fluctuation of the motor caused by the imbalance, to a motor control signal.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a washing machine equipped with a motor which generates rotary-driving force for spinning a washtub in order to implement the steps of washing, rinsing, dewatering, and drying.

Background Art

[0002] Two types of washing machines, in general, are available in the market. One is called a pulsator type machine which uses a circulating water-flow for washing the laundry. The other one is called a drum type machine which lifts and drops the laundry for washing (beat-wash).

[0003] A user loads or unloads the laundry into or from the pulsator type machine from the top face, and the machine is vertically long, so that it is also called a vertical type machine. The drum-type machine, on the other hand, is sometimes called a horizontal type machine. A dryer is generally a horizontal type.

[0004] A drum-type washing machine recently introduced in the market is equipped with a drum, i.e. washtub, laid therein slantingly based on a universal design concept. This structure allows the user to take out the laundry with ease, improves the wash performance through the beat-wash, and achieves a shorter drying time than that of the vertical type machine.

[0005] However, the drum-type washing machine tends to generate noises in the dewatering step due to the laundry lying in an imbalanced manner, so that a damper is used for reducing the noises. (Refer to e.g. Patent Literature 1.)

[0006] Another drum-type washing machine employs a vibration sensor mounted to an upper section of the washtub for sensing the vibrations of the washtub, and the rotation number of the motor is controlled by a controller over a dewatering step based on the sensed signal. (Refer to e.g. Patent Literature 2.)

[0007] Since the drum is laid slantingly in the drum-type washing machine, the laundry tends to lie in an imbalanced manner, so that the washtub generates vibrations of great magnitude.

[0008] The drum-type wasting machine disclosed in Patent Literature 2 senses the vibrations of the washtub, and then controls only the rotation number in response to the magnitude of vibration, so that the control of motor does not actively contribute to a reduction in the vibrations of the washtub. The washing machine disclosed in Patent Literature 2 is equipped with a damper at a lower section of a tubular container that accommodates the washtub, and only this damper contributes to a reduction in the vibrations. This washing machine thus cannot reduce the vibrations in a steady manner.

Related Art Literature

[0009]

Patent Literature 1: Unexamined Japanese Patent Application Publication No. 2006 - 136602
Patent Literature 2: Unexamined Japanese Patent Application Publication No. H05 - 154275

Disclosure of Invention

[0010] The washing machine of the present invention comprises the following structural elements: a housing, a washtub for accommodating and rotating the laundry therein, a motor for driving the washtub, a motor controller for controlling the motor, a tubular container for accommodating the washtub and being supported relative to the housing, a support device for supporting the tubular container to be in a predetermined position, an imbalance sensor for sensing imbalance of the laundry in the washtub, and an imbalance-vibration controller for adding a signal, which corrects torque-fluctuation caused by the imbalance of the laundry, to a motor control signal.

[0011] The washing machine discussed above allows sensing the imbalance of the laundry as well as the torque fluctuation caused by the imbalance, and then allows correcting the torque fluctuation by controlling the motor. As a result, the vibrations caused by imbalance of the washtub during the dewatering step can be reduced and noises accompanying the vibrations can be also reduced. On top of that, vibrations generated by increasing the rotation number during the dewatering step can be suppressed, and a dewatering time can be shortened.

Brief Descriptions of Drawings

[0012]

Fig. 1 is a block diagram illustrating a vibration controller of a washing machine in accordance with a first embodiment of the present invention.

Fig. 2 is a block diagram illustrating a vibration controller of a washing machine in accordance with a second embodiment of the present invention.

Fig. 3 is a block diagram illustrating a vibration controller of a washing machine in accordance with a third embodiment of the present invention.

Fig. 4 demonstrates a vibration system of the tubular container when vibrations are generated by the imbalance of the laundry in the washtub of the washing machine shown in Fig. 3.

Fig. 5A illustrates vibration loci of the washing machine shown in Fig. 3 at torque fluctuation of 2.7 Nm.

Fig. 5B illustrates vibration loci of the washing machine shown in Fig. 3 at torque fluctuation of 0 (zero) Nm.

Best Mode for Practicing then Invention

[0013] Exemplary embodiments of the present invention are demonstrated hereinafter with reference to the accompanying drawings. The embodiments do not limit the present invention.

Exemplary Embodiment 1

[0014] Fig. 1 is a block diagram illustrating a vibration controller of a washing machine in accordance with the first embodiment of the present invention. The washing machine shown in Fig. 1 includes washing mechanism 10, rotary drum 11 and motor 12. Rotary drum 11 is a washtub for accommodating the laundry. Motor 12 employs a brushless motor and drives drum 11 while motor 12 controls the rotation number of drum 11.

[0015] The washing machine also includes tubular container 13, seal-packing 14, support spring 15, damper mechanism 16, housing 17, laundry inlet 18, vibration proof rubber 19, and three-axis acceleration sensor 20. Tubular container 13 accommodates washtub 11 and is supported relative to housing 17. Support spring 15 supports washtub 11 to be in a predetermined position, and housing 17 has inlet 18 through which the laundry is loaded. Seal packing 14 eliminates space between tubular container 13 and housing 17, thereby coupling them together. Damper mechanism 16 is formed of a spring element and a damper element, and both the elements reduce the vibration generated during the wash (i.e. when the motor rotates), thereby weakening the vibrations travelling to housing 17 and the floor.

[0016] Support spring 15 and damper mechanism 16 act as a support device for supporting tubular container 13 in a predetermined position. Three-axis acceleration sensor 20 acts as a vibration sensor and is placed on the upper front of tubular container 13 at the lateral face for sensing vibrations of tubular container 13. Vibration proof rubber 19 is placed between the washing machine and the floor.

[0017] The washing machine shown in Fig. 1 is equipped with motor controller 21, velocity-sensor 24 made of Hall IC, microprocessor controlling quantity calculator 25, and inverter circuit driver 26. Velocity sensor 24 senses a rotation number of motor 12, and calculator 25 calculates an error between a target rotation number and the actual rotation number of motor 12 sensed by velocity sensor 24, thereby calculating a controlled quantity before outputting motor control signal 31. Inverter circuit driver 26 applies a driving current to motor 12.

[0018] The washing machine shown in Fig. 1 further includes imbalance sensor 22, imbalance vibration controller 23, and adder 27. Imbalance sensor 22 calculates a quantity of vibrations (displacement) based on an output from three-axis acceleration sensor 20 and the imbalance caused by the laundry lying in an imbalanced manner in washtub 11.

[0019] Imbalance vibration controller 23 estimates torque fluctuation based on an output from imbalance sensor 22, and outputs a signal for correcting the torque fluctuation of motor 12 caused by the imbalance vibrations. Microprocessor controlling quantity calculator 25 outputs motor control signal 31. Adder 27 adds the output from calculator 25 and the output from controller 23 together, and then outputs this result to inverter circuit driver 26.

[0020] The way of controlling motor 12 is demonstrated hereinafter. Motor controller 21 receives a signal of a washing mode from a washing machine controller (not shown), and then senses the washing mode, a dewatering mode, and a drying mode for setting the target rotation number respectively in response to those three operation-modes. Motor 12 employs a DC brushless motor including a Hall element, eight poles, and twelve slots. Velocity sensor 24 made of Hall IC senses a rotation number of motor 12 based on a signal supplied from the Hall IC. Microprocessor controlling quantity calculator 25 calculates a difference (an error) between the target rotation number and an actual rotation number of motor 12 sensed by sensor 24, and calculates a controlling quantity so that the error becomes zero.

[0021] The vibration control system makes imbalance sensor 22 sense the vibrations of tubular container 13 based on an acceleration signal supplied from three-axis acceleration sensor 20 as well as estimate the imbalance of the laundry. In other words, using the vibration sensor, imbalance sensor 22 senses the vibration of tubular container 13 as the imbalance of the laundry. Sensing the vibration of tubular container 13 accurately at a smaller cost with a smaller device allows reducing the vibration of tubular container 13 inexpensively during the dewatering operation as well as reducing the noises caused by the vibrations.

[0022] Imbalance vibration controller 23 senses torque fluctuation caused by imbalance vibrations, and calculates a controlling quantity which cancels the torque fluctuation, thereby controlling the imbalance vibration. In this first embodiment, adder 27 adds the controlling quantity for correcting the torque fluctuation to the controlling quantity generated by the motor rotation number control system, whereby motor 12 is driven and controlled.

[0023] In other words, the quantity of vibration, i.e. "quantity of state" in the motor vibration system, is handled as torque fluctuation, which is then added to the rotation number control quantity of motor 12, thereby lowering the vibrations which cause the torque fluctuation. Motor 12 is thus driven and controlled.

[0024] As discussed above, the washing machine in accordance with the first embodiment is equipped with three-axis acceleration sensor 20 for sensing the vibrations of tubular container 13 so that the torque fluctuation caused by the vibrations can be controlled as well as the rotation number of motor 12 can be controlled. As a result, the foregoing structure allows controlling the vibrations, caused by motor 12, of tubular container 13. Resonant vibrations of the support mechanism at the start of each step, i.e. steps of washing, dewatering, and drying, can be lowered, and the vibrations of the support mechanism caused by the resonant vibrations of tubular container 13 during the regular rotating state of the washing machine can be also lowered or prevented. On top of that, the noises generated by the vibrations of the support mechanism can be lowered. During the dewatering step, since the imbalance of the laundry and the vibration caused by the torque fluctuation of motor 12 can be reduced, the occasions, where the dewatering step is halted by greater vibrations caused by increasing the dewatering rotation number, can be also reduced. The dewatering rotation number thus can be increased at an early stage, thereby shortening the dewatering time.

Exemplary Embodiment 2

[0025] Fig. 2 is a block diagram illustrating a vibration controller of a washing machine in accordance with the second embodiment of the present invention. The structure of the vibration control device is basically similar to that of the first embodiment, so that the description thereof is omitted here. Structural elements similar to those used in the first embodiment have the same reference signs.

[0026] Fig. 2 differs from Fig. 1 in the presence of torque-fluctuation corrector 28 which belongs to imbalance vibration controller 23. Imbalance vibration controller 23, which senses torque fluctuation of motor 12, estimates fluctuation in the torque of motor 12 based on the output from imbalance sensor 22 and the output from inverter circuit driver 26 for correcting the torque fluctuation. For this purpose, torque-fluctuation corrector 28 generates a signal having the same amplitude as and an opposite phase to the torque fluctuation of motor 12 so that the torque fluctuation becomes 0 (zero), and outputs this signal to motor controller 21. As a result, the torque fluctuation caused by the imbalance of the laundry can be accurately corrected. Imbalance vibrations during the dewatering step can be thus reduced, and the noise generated by the imbalance vibrations also can be reduced.

[0027] Torque-fluctuation corrector 28 compares the vibration of tubular container 13 with the torque fluctuation indicated by motor control signal 31 with the aid of three-axis acceleration sensor 20. Out of the torque fluctuation, the frequency component, which has the same frequency as that of the vibrations of tubular container 13 and is synchronized with the rotation number, is extracted. Corrector 28 then generates a signal having the same amplitude as that of the foregoing frequency component and an opposite phase to that of the torque fluctuation, and outputs the signal to motor controller 21, where adder 27 adds this signal to controller 21, thereby controlling motor 12.

[0028] As discussed above, the washing machine in accordance with the second embodiment includes three-axis acceleration sensor 20 for sensing the vibrations of tubular container 13 so that the torque fluctuation caused by the vibrations can be controlled as well as the rotation number of motor 12 can be controlled. As a result, the foregoing structure allows controlling the vibrations, caused by motor 12, of tubular container 13. Resonant vibrations of the support mechanism at the start of each step, i.e. the steps of washing, dewatering, and drying, can be lowered, and the vibrations of the support mechanism caused by the resonant vibrations of tubular container 13 during the regular rotating state of the washing machine can be also lowered or prevented. On top of that, the noises generated by the vibrations of the support mechanism can be lowered.

Exemplary Embodiment 3

[0029] Fig. 3 is a block diagram illustrating a vibration controller of a washing machine in accordance with the third embodiment of the present invention. The structure of the vibration control device is basically similar to that of the first embodiment, so that the description thereof is omitted here. Structural elements similar to those used in the first embodiment have the same reference signs.

[0030] Fig. 3 differs from Fig. 1 in the presence of vibration-locus sensor 30 which belongs to imbalance sensor 22 and the presence of signal-phase adjuster 29 which belongs to imbalance vibration controller 23. Vibration-locus sensor 30 senses the loci of the whirling of tubular container 13. Imbalance vibration controlled 23 controls motor 12 so that the whirling of tubular container 13 can be minimized, and as a result, the vibrations of container 13 during the dewatering step can be reduced. On top of that, the noises generated by the vibrations also can be reduced. Signal-phase adjuster 29 adjusts a phase of the signal having the same amplitude as that of the torque fluctuation of motor 12 and supplied from inverter circuit driver 26, whereby the output from vibration-locus sensor 30 can be changed from drawing ovals to drawing near circles. As a result, the vibrations of tubular container 13 during the dewatering step can be reduced, and the noises generated by the vibrations also can be reduced.

[0031] Three-axis acceleration sensor 20 senses vibrations occurring along three directions orthogonal to each other, thereby sensing a whirling locus of tubular container 13. Imbalance vibration controller 23 thus controls motor 12 so that the whirling of container 13 can be minimized. As a result, the vibrations of tubular container 13 during the dewatering step can be reduced, and the noises generated by the vibrations also can be reduced.

[0032] Imbalance sensor 22 senses the vibrations of tubular container 13 as the imbalance of the laundry with the aid of three-axis acceleration sensor 20 that can sense the vibrations occurring along the directions orthogonal to each other. Using at least two signals out of three signals supplied from three-axis acceleration sensor 20, vibration locus sensor 30 then senses the locus of the whirling of container 13.

[0033] Fig. 4 demonstrates a vibration system of tubular container 13 when the laundry invites imbalance in the washtub of the washing machine in accordance with the third embodiment. The factors of the vibrations are these:

Centrifugal force "F" expressed by equation (1):

$$F = mr\omega^2 \qquad (1)$$

Torque fluctuation "T pul (t) expressed by equation (2):

$$T_{pul}(t) \qquad (2)$$

[0034] The torque fluctuation expressed as following equation (3) is formed of a component generated by gravity of imbalanced laundry and another component generated by fluctuation in bearing abrasion caused by the vibrations.

$$T_{pul}(t) = mg * r_x(t) + T_{loss}(t) \qquad (3)$$

where "m" is the mass of the laundry generating the imbalance,
"rx (t)" is x-axis component of the distance to the laundry generating the vibrations,
"ro" is a radius of the tubular container,
"g" is a gravity,
"ω" is angular velocity of the drum, and
"T_{loss} (t)" is torque fluctuation generated by the variation in the bearing abrasion caused by the vibrations.

[0035] Assume that the rotary motion of the washtub is an equiangular velocity motion as expressed by following equation (4):

$$\omega = Const. \qquad (4)$$

[0036] In tubular container 13 supported by support spring 15 and damper mechanism 16, a vibration system of rotation of the washtub encountering laundry-imbalance due to the rotation of motor 12 is studied hereinafter. This vibration system is expressed by equation (5) in a general coordinate system. Equation (5) is expressed by expression (6) in six-degree of freedom orthogonal coordinate system,

$$M\ddot{q}(t) + C\dot{q}(t) + Kq(t) = F(t) \qquad (5)$$

$$\begin{bmatrix} M & 0 & 0 & 0 & 0 & 0 \\ 0 & M & 0 & 0 & 0 & 0 \\ 0 & 0 & M & 0 & 0 & 0 \\ 0 & 0 & 0 & J_x & 0 & 0 \\ 0 & 0 & 0 & 0 & J_y & 0 \\ 0 & 0 & 0 & 0 & 0 & J_z \end{bmatrix} \begin{bmatrix} \ddot{x}(t) \\ \ddot{y}(t) \\ \ddot{z}(t) \\ \ddot{\theta}_x(t) \\ \ddot{\theta}_y(t) \\ \ddot{\theta}_z(t) \end{bmatrix} + \begin{bmatrix} C11 & C12 & C13 & C14 & C15 & C16 \\ C21 & C22 & C23 & C24 & C25 & C26 \\ C31 & C32 & C33 & C34 & C35 & C36 \\ C41 & C42 & C43 & C44 & C45 & C46 \\ C51 & C52 & C53 & C54 & C55 & C56 \\ C61 & C62 & C63 & C64 & C65 & C66 \end{bmatrix} \begin{bmatrix} \dot{x}(t) \\ \dot{y}(t) \\ \dot{z}(t) \\ \dot{\theta}_x(t) \\ \dot{\theta}_y(t) \\ \dot{\theta}_z(t) \end{bmatrix} + \begin{bmatrix} k11 & k12 & k13 & k14 & k15 & k16 \\ k21 & k22 & k23 & k24 & k25 & k26 \\ k31 & k32 & k33 & k34 & k35 & k36 \\ k41 & k42 & k43 & k44 & k45 & k46 \\ k51 & k52 & k53 & k54 & k55 & k56 \\ k61 & k62 & k63 & k64 & k65 & k66 \end{bmatrix} \begin{bmatrix} x(t) \\ y(t) \\ z(t) \\ \theta_x(t) \\ \theta_y(t) \\ \theta_z(t) \end{bmatrix} = \begin{bmatrix} F_x(t) \\ F_y(t) \\ F_z(t) \\ T_x(t) \\ T_y(t) \\ T_z(t) \end{bmatrix} \quad (6)$$

where in equation (6), "M" is the total mass of tubular container 13, the drum of washtub, and the laundry,
"J" is the moment of inertia on respective axes of tubular container 13,
"c" is viscosity coefficient,
"k" is spring constant,
"Fx(t), Fy(t), Fz(t)" are components of centrifugal force along respective axes,
"Tx(t), Ty(t), Tz(t)" are components of torque fluctuation along respective axes,
"x(t)" is vibration along x-axis at origin,
"y(t)" is vibration along y-axis at origin,
"z(t)" is vibration along z-axis at origin,
"θx(t)" is rotation vibration on x-axis,
"θy(t)" is rotation vibration on y-axis, and
"θz(t)" is rotation vibration on z-axis.

[0037] Now, let us study, as a decoupling system, only the rotating coordinates on x-axis, y-axis, z-axis to which external force works respectively, and assume that the external forces vibrate harmonically. Then the equation of motion is expressed by following equation (7), where constant "k" and coefficient "c" take values as indicated by following equation (8), then the vibration measured on the outer wall of tubular container 13 at angle ϕ and point (x, y) can be expressed by following equation (9).

$$\begin{bmatrix} M & 0 & 0 \\ 0 & M & 0 \\ 0 & 0 & J_z \end{bmatrix} \begin{bmatrix} \ddot{x}(t) \\ \ddot{y}(t) \\ \ddot{\theta}_z(t) \end{bmatrix} + \begin{bmatrix} k_x & 0 & 0 \\ 0 & ky & 0 \\ 0 & 0 & k\theta \end{bmatrix} \begin{bmatrix} \dot{x}(t) \\ \dot{y}(t) \\ \dot{\theta}_z(t) \end{bmatrix} + \begin{bmatrix} c_x & 0 & 0 \\ 0 & c_y & 0 \\ 0 & 0 & c_0 \end{bmatrix} \begin{bmatrix} x(t) \\ y(t) \\ \theta_z(t) \end{bmatrix} = \begin{bmatrix} F_x(t) \\ F_y(t) \\ T_z(t) \end{bmatrix} = \begin{bmatrix} mr\omega^2 * \cos(\omega t) \\ mr\omega^2 * \sin(\omega t) \\ T_{pul} * \sin(\omega t + \delta) \end{bmatrix} \quad (7)$$

$$k_x = k_{11} \quad k_y = k_{22} \quad k_\theta = k_{66} \quad c_x = c_{11} \quad c_y = c_{22} \quad c_\theta = c_{66} \quad (8)$$

$$\begin{bmatrix} x_\varphi(t) \\ y_\varphi(t) \end{bmatrix} = \begin{bmatrix} 1 & 0 & r_0 * \sin(\varphi) \\ 0 & 1 & r_0 * \cos(\varphi) \end{bmatrix} \begin{bmatrix} x(t) \\ y(t) \\ \theta_z(t) \end{bmatrix} \quad (9)$$

[0038] Next, Fig. 5A illustrates vibration loci of the washing machine shown in Fig. 3 at torque fluctuation of 2.7 Nm, and Fig. 5B illustrates vibration loci of the washing machine shown in Fig. 3 at torque fluctuation of 0 (zero) Nm.

[0039] In equations (7) and (9), assume that imbalance of 700 g is generated by the laundry, and the torque fluctuates at 2.7 Nm, then tubular container 13 whirls like ovals as shown in Fig. 5A. However, the control allows the torque fluctuation to approach 0 (zero), and then tubular container 13 whirls like circles as shown in Fig. 5B, so that the whirling can be minimized. Vibration locus sensor 30 senses the locus of this whirling, and imbalance vibration controller 23 reduces the torque fluctuation with the aid of signal phase adjuster 29. This mechanism allows the whirling of tubular container 13 to decrease from what is shown in Fig. 5A to what is shown in Fig. 5B.

[0040] As discussed above, the washing machine in accordance with this third embodiment is equipped with three-axis acceleration sensor 20 for sensing the vibrations of tubular container 13 so that the torque fluctuation caused by the vibrations can be controlled as well as the rotation number of motor 12 can be controlled. As a result, the foregoing structure allows controlling the vibrations, caused by motor 12, of tubular container 13. Resonant vibrations of the support mechanism at the start of each step, i.e. steps of washing, dewatering, and drying, can be lowered or prevented, and the vibrations of the support mechanism caused by the resonant vibrations of tubular container 13 during the regular rotating state of the washing machine can be also lowered or prevented. On top of that, the noises generated by the vibrations of the support mechanism can be lowered or prevented.

[0041] In the first embodiment, the vibration sensor is placed on the upper section of lateral face of tubular container 13; however, it can be placed on a top face, a lateral face, on a foot of the bottom face of housing 17, or on the bottom face of container 13 with an advantage similar to what is discussed previously maintained.

[0042] In the embodiments 1 - 3, the signal supplied from three-axis acceleration sensor 20 is fed back as it is for controlling the vibrations; however, an observer can be formed of the signal supplied from sensor 20 and a motor current, and the quantity of state of the observer can be fed back for the vibration control.

[0043] In the embodiments 1 - 3, three-axis acceleration sensor 20 is used; however, a gyro-sensor, i.e. an angular-velocity sensor, can be used with an advantage similar to what is discussed previously maintained.

Industrial Applicability

[0044] The washing machine of the present invention senses imbalance of the laundry and torque fluctuation caused by the imbalance, whereby the torque fluctuation can be corrected by controlling the motor. As a result, the imbalance vibrations during the dewatering step can be reduced, and the noises generated by the imbalance vibrations also can be reduced. On top of that, vibrations generated by increasing the rotation number during the dewatering step can be suppressed, and a dewatering time can be shortened. The present invention is thus useful for the drum-type washing machine among others.

Description of Reference Sings

[0045]

11	rotary drum (washtub)
12	motor
13	tubular container
14	seal packing
15	support spring (support device)
16	damper mechanism (support device)
17	housing
18	laundry inlet
20	three-axis acceleration sensor (vibration sensor)
21	motor controller
22	imbalance sensor
23	imbalance vibration controller
24	velocity sensor made of Hall IC
25	microprocessor controlling quantity calculator
26	inverter circuit driver
27	adder
28	torque-fluctuation corrector
29	signal phase adjuster
30	vibration-locus sensor
31	motor control signal

Claims

1. A washing machine comprising:

   a housing;
   a washtub for accommodating and rotating laundry;
   a motor for driving the washtub;
   a motor controller for controlling the motor;
   a tubular container for accommodating the washtub and supported relative to the housing;
   a support device for supporting the tubular container to be in a predetermined position;
   an imbalance sensor for sensing imbalance caused by the laundry lying in an imbalanced manner in the washtub; and
   an imbalance vibration controller for adding a signal, which corrects torque fluctuation of the motor caused by the imbalance, to a motor control signal.

2. The washing machine of claim 1, wherein the imbalance vibration controller senses torque fluctuation of the motor.

3. The washing machine of claim 2, wherein the imbalance vibration controller includes a torque-fluctuation corrector which generates a signal having an opposite phase to and an equal amplitude to those of the torque fluctuation of the motor for making the torque fluctuation zero.

4. The washing machine as defined in one of claim 2 or claim 3, wherein the imbalance sensor includes a vibration-locus sensor which senses a locus of whirling of the tubular container:

5. The washing machine of claim 4, wherein the imbalance vibration controller includes a signal-phase adjuster which adjusts a phase of a signal having an equal amplitude to that of the torque fluctuation of the motor so that an output, shaped like an oval, from the vibration locus sensor can approach a circular shape.

6. The washing machine of claim 1, wherein the imbalance sensor senses vibrations of the tubular container as imbalance of the laundry with a vibration sensor.

7. The washing machine of claim 6, wherein the vibration sensor senses vibrations at a front side of the tubular container.

8. The washing machine of claim 6, wherein the vibration sensor senses vibrations at a bottom side of the tubular container.

9. The washing machine as defined in one of claims 6 - 8, wherein the vibration sensor senses vibrations occurring along three directions orthogonal to each other.

10. The washing machine as defined in one of claim 4 or claim 5, wherein the imbalance sensor senses vibrations of the tubular container as imbalance of the laundry with a vibration sensor that can sense vibrations occurring along three directions orthogonal to each other, and the vibration locus sensor senses a locus of whirling of the tubular container by using at least two signals from out of three signals supplied from the vibration sensor.

FIG. 1

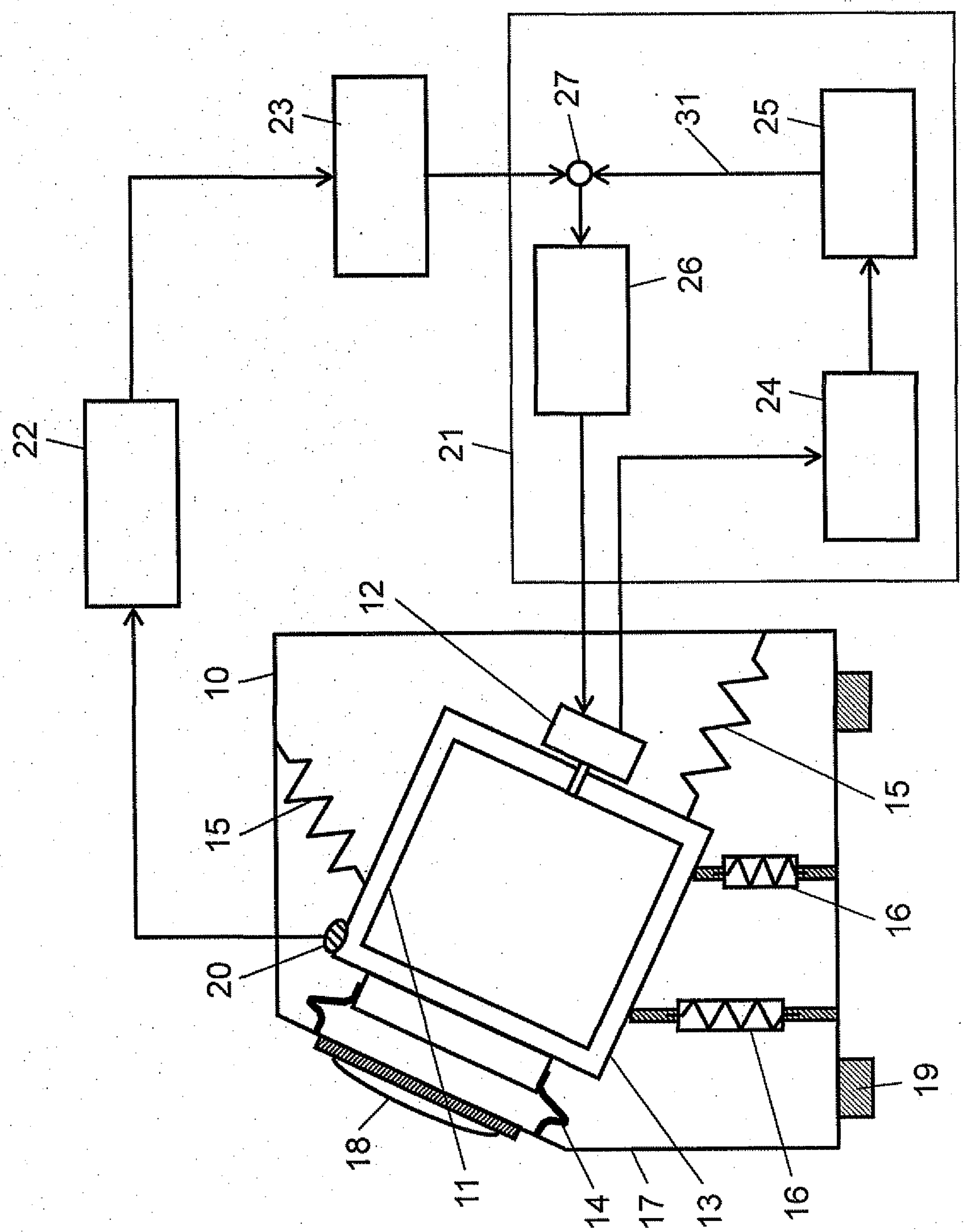


FIG. 2

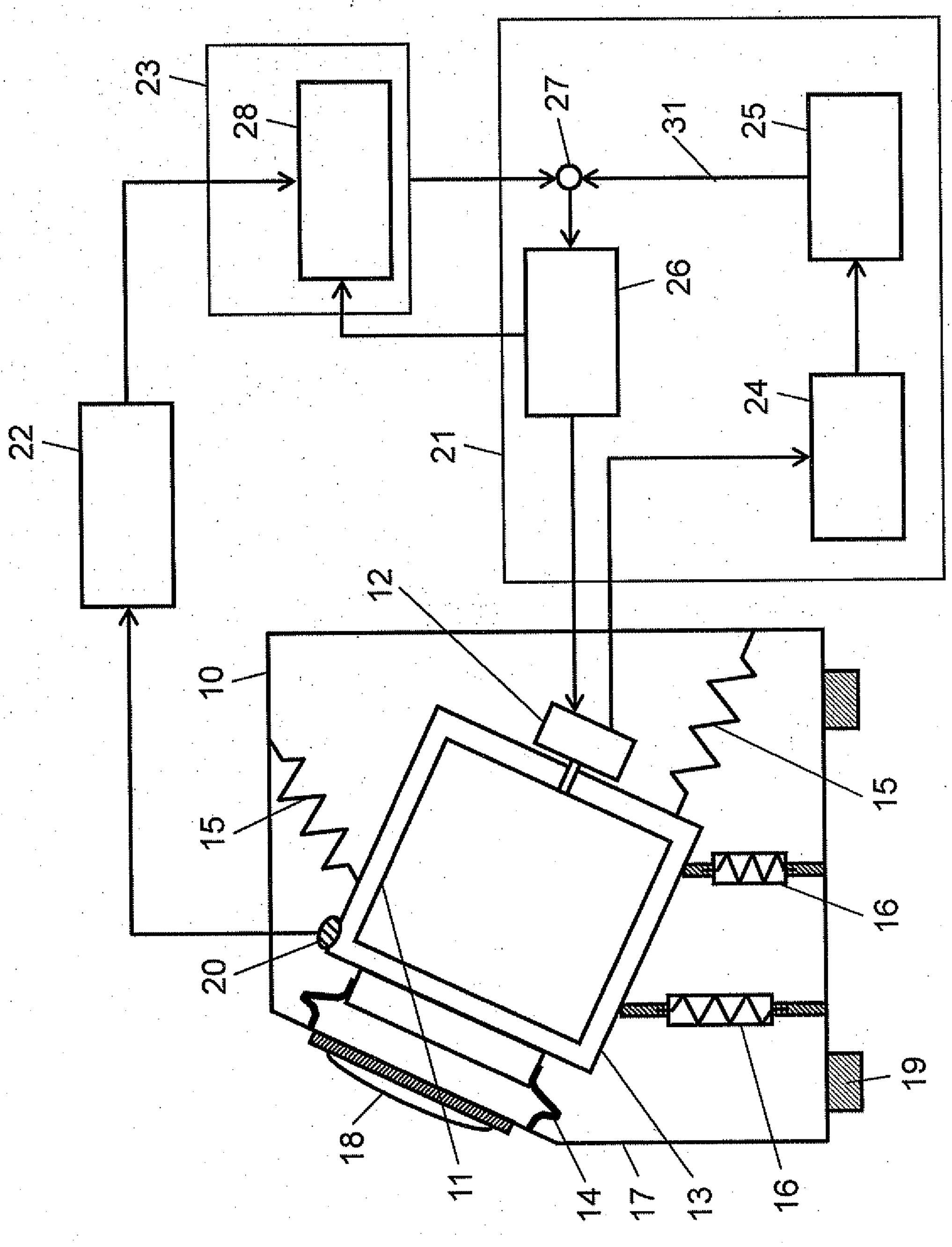


FIG. 3

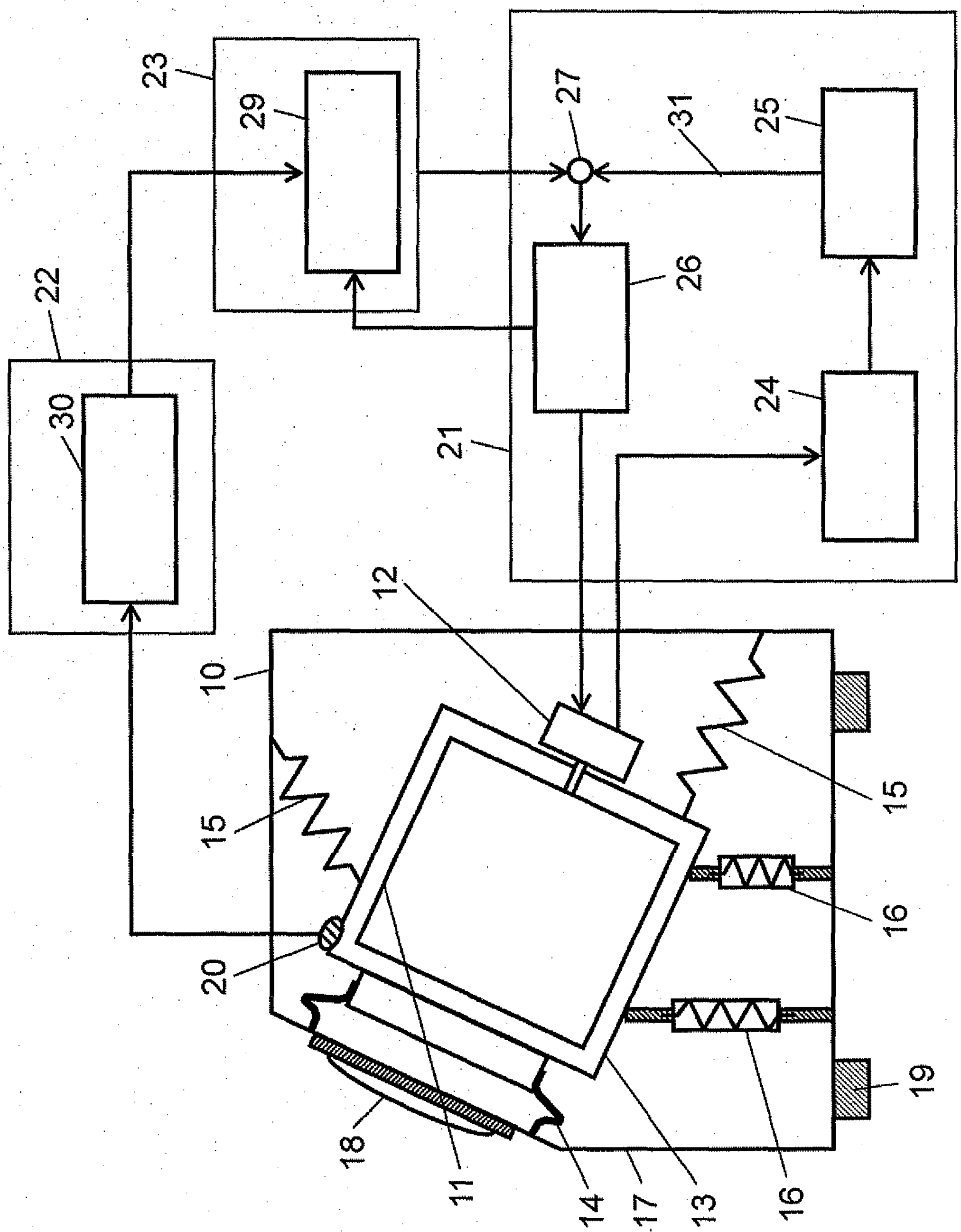
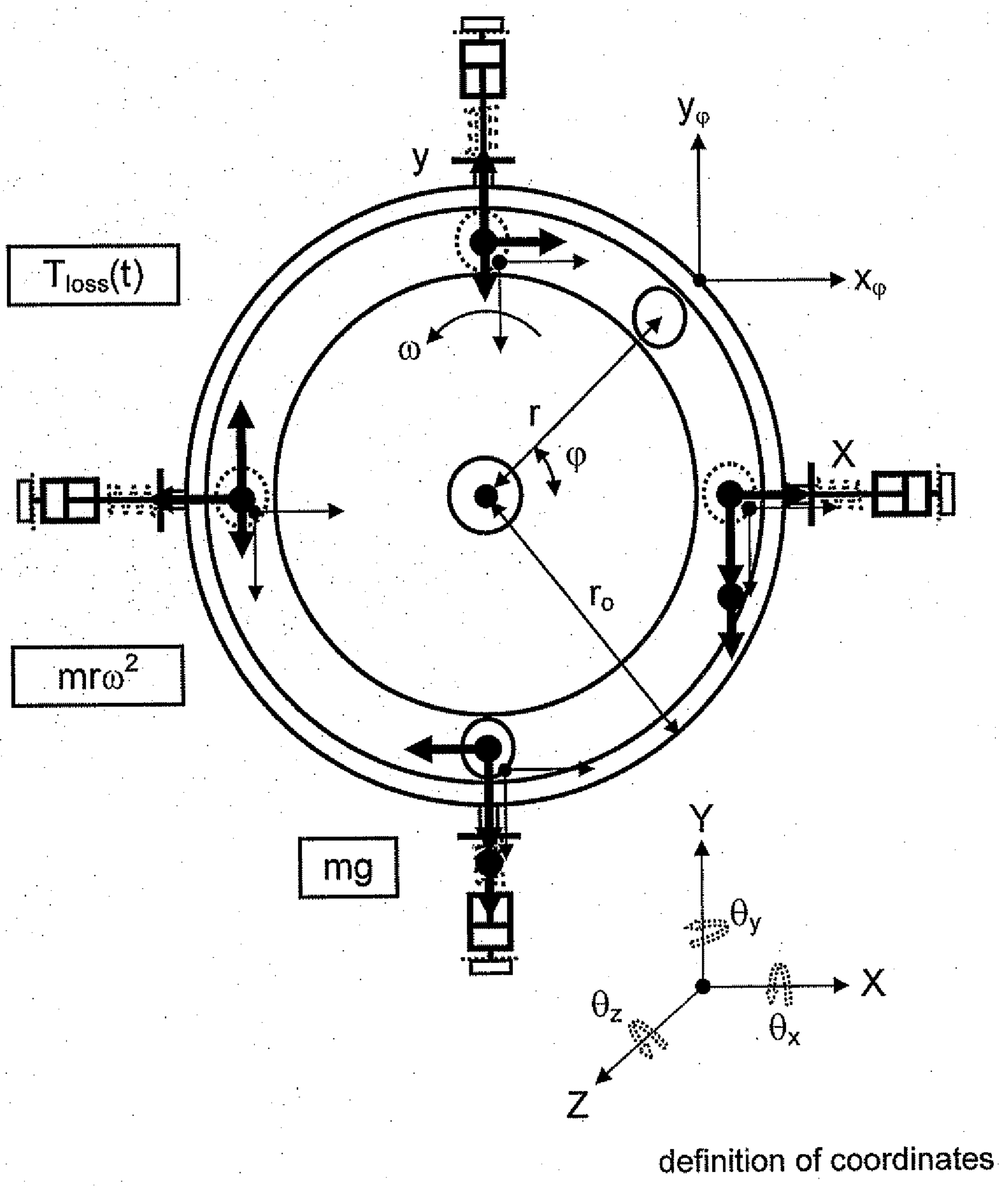


FIG. 4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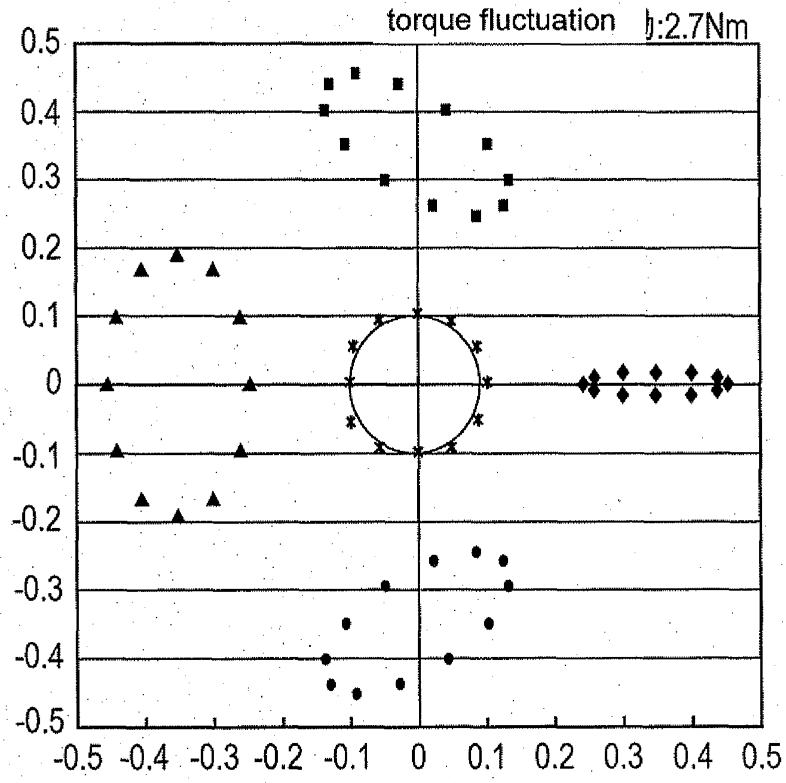
Z
definition of coordinates

FIG. 5A


torque fluctuation
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0.3
0.2
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-0.3
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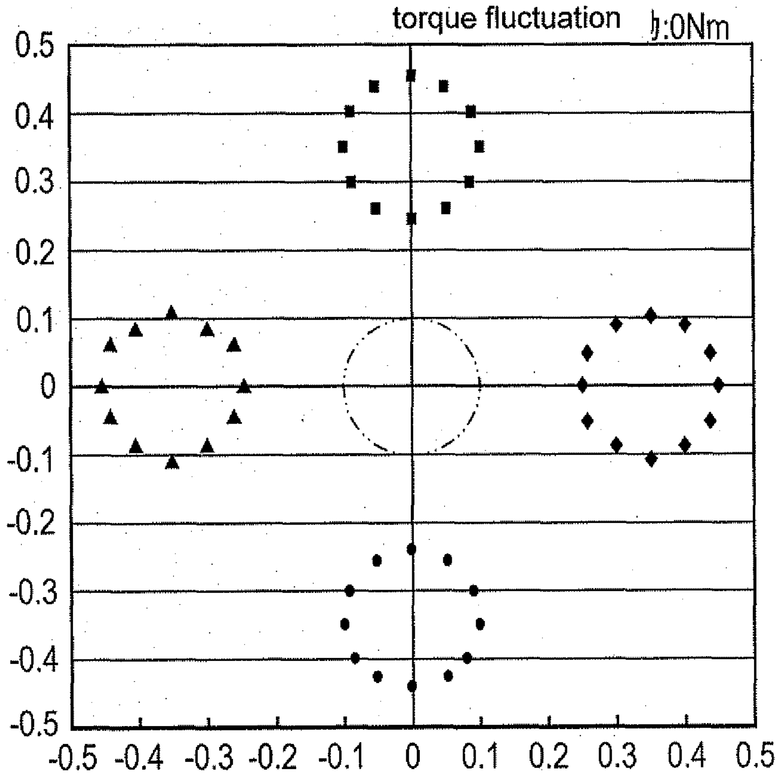
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5

FIG. 5B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-0.4
-0.5
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/005176

A. CLASSIFICATION OF SUBJECT MATTER
D06F33/02(2006.01)i, *D06F49/04*(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, D06F49/04

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	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

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 2008-142231 A (Matsushita Electric Industrial Co., Ltd.), 26 June 2008 (26.06.2008), paragraphs [0009] to [0013], [0029] to [0040], [0048]; fig. 1, 5, 7 & KR 10-2008-0053225 A & CN 101195954 A & CN 201195795 Y	1,6-9 2-5,10
Y	JP 2006-346270 A (Toshiba Corp.), 28 December 2006 (28.12.2006), claim 2; paragraphs [0032], [0035] to [0043]; fig. 1 to 9 (Family: none)	2-5,10

☒ 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
24 December, 2009 (24.12.09)	12 January, 2010 (12.01.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/005176

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 2008-183297 A (Matsushita Electric Industrial Co., Ltd.), 14 August 2008 (14.08.2008), paragraphs [0024] to [0039]; fig. 1 (Family: none)	1-10
A	JP 2008-501 A (Matsushita Electric Industrial Co., Ltd.), 10 January 2008 (10.01.2008), paragraphs [0031] to [0045]; fig. 1 (Family: none)	1-10
A	JP 10-244091 A (Hitachi, Ltd.), 14 September 1998 (14.09.1998), paragraphs [0009] to [0019]; fig. 1 to 4 (Family: none)	1-10
A	JP 2001-334096 A (Toshiba Corp.), 04 December 2001 (04.12.2001), paragraphs [0006] to [0009], [0034] to [0041]; fig. 1 to 2 (Family: none)	1-10

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

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PCT/JP2009/005176

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 invention in claim 1 is not novel, since the invention is disclosed in JP 2008-142231 A (Matsushita Electric Industrial Co., Ltd.), 26 June 2008 (26.06.2008), paragraphs [0009] - [0013], [0029] - [0040], [0048], fig. 1, 5, 7.

As a result, the invention in claim 1 does not have a special technical feature in the meaning of the second sentence of PCT Rule 13.2, since the invention does not make contribution over the prior art.

Therefore, it is obvious that the inventions in claims 1 - 10 do not satisfy the requirement of unity of invention.

(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)

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

- The invention in claims 1 and 6 - 9
- The invention in claims 2 - 5 and 10

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REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2006136602 A **[0009]**
- JP H05154275 B **[0009]**