



(11)

EP 2 319 971 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
11.05.2011 Bulletin 2011/19

(51) Int Cl.:
D06F 33/02 (2006.01) D06F 23/06 (2006.01)

(21) Application number: **09809568.0**

(86) International application number:
PCT/JP2009/004153

(22) Date of filing: **27.08.2009**

(87) International publication number:
WO 2010/023912 (04.03.2010 Gazette 2010/09)

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL
PT RO SE SI SK SM TR**
Designated Extension States:
AL BA RS

- **YABUUCHI, Hidetaka**
Chuo-ku, Osaka-shi
Osaka 540-6207 (JP)
- **GAMO, Ken**
Chuo-ku, Osaka-shi
Osaka 540-6207 (JP)
- **HAGIWARA, Hisashi**
Chuo-ku, Osaka-shi
Osaka 540-6207 (JP)

(30) Priority: **01.09.2008 JP 2008223125**
17.06.2009 JP 2009143860

(71) Applicant: **Panasonic Corporation**
Kadoma-shi
Osaka 571-8501 (JP)

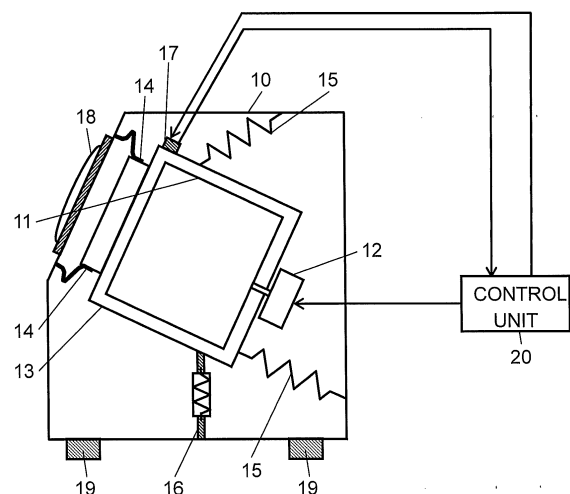
(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte
Stuntzstraße 16
81677 München (DE)

(72) Inventors:
• **OZEKI, Yuji**
Chuo-ku, Osaka-shi
Osaka 540-6207 (JP)

(54) **WASHING MACHINE**

(57) Provided is a washing machine including: a drum (11); a water tank (13) for having the drum installed therein and is filled with washing water; a motor (12) for rotationally driving the drum; a cabinet (10) for accommodating the water tank; a vibration detecting device (17) for being configured as an acceleration sensor provided in the water tank (13) and capable of switching plural acceleration detecting ranges having different minimum acceleration resolutions; and a control unit (20) for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device (17), wherein the vibration is more accurately detected by switching the acceleration detecting ranges in accordance with the detected acceleration or the rotation speed of the drum.

FIG. 1



EP 2 319 971 A1

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a washing machine equipped with a vibration detecting device that detects a vibration of a water tank.

BACKGROUND ART

10 **[0002]** In order to operate a washing machine while its vibration and noise are reduced, the vibration of the washing machine needs to be accurately detected. For this reason, various vibration detecting methods have been suggested for some time.

[0003] Among these methods, there is known a vibration detecting device that is equipped with an acceleration sensor in order to improve the accuracy of vibration detection.

15 **[0004]** For example, Patent Document 1 discloses a method of detecting a vibration of a washing machine. This method is proposed so as to effectively detect a vibration in a spinning device that exhibits different vibration modes in accordance with the rotation speed, and has a configuration in which an amplification rate of an output of an acceleration sensor in response to a vibration in a direction perpendicular to the rotation axis of a spin tub when a spin rotation speed decreases to become a predetermined value or less is set to be larger than an amplification rate of an output in response to a vibration in a direction of the rotation axis of the spin tub when the spin rotation speed increases to become a predetermined value or more.

20 **[0005]** However, in the existing configuration, a device (signal processing device) that amplifies an output of a vibration detecting mechanism is necessary for separate amplification process, and the vibration detecting mechanism becomes complex. Further, when the output of the vibration detecting mechanism is amplified, noise included in the output component is also amplified, and a countermeasure for the noise needs to be provided.

Background Art Document

Patent Document

30

[0006] Patent Document 1: Japanese Patent Unexamined Publication No. 2005-274443

DISCLOSURE OF THE INVENTION

35 **[0007]** The invention is made to solve the above-described problems of the related art, and provides a highly precise vibration detecting device at a low cost by accurately switching acceleration detecting ranges having different sensitivities in accordance with a detected acceleration or a rotation speed of a drum.

[0008] In order to solve the above-described problems of the related art, there is provided a washing machine including: a drum for having a water passage hole formed in the outer periphery thereof; a water tank for having the drum installed therein and is filled with washing water; a motor for rotationally driving the drum; a cabinet for accommodates the water tank therein; a vibration detecting device for being configured as an acceleration sensor capable of detecting a vibration of the water tank and switching plural acceleration detecting ranges having different minimum acceleration resolutions; and a control unit for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device, wherein the control unit switches the acceleration detecting ranges in accordance with the detected acceleration. Accordingly, the accuracy of vibration detection is improved.

45 **[0009]** The washing machine of the invention may detect its vibration within the highly sensitive detecting range by switching the acceleration detecting range in accordance with the detected acceleration or the rotation speed of the drum. Further, since the accuracy of vibration detection is improved, the washing machine may be highly efficiently operated while its vibration and noise are reduced. Accordingly, the operation time may be shortened, and both reliability of the product and convenience of the user may be improved.

50

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

55

Fig. 1 is a block diagram illustrating a control device of a washing machine of a first embodiment.

Fig. 2A is a configuration diagram illustrating an attachment position of a three-axis acceleration sensor which is a vibration detecting device of the first embodiment.

Fig. 2B is a configuration diagram illustrating the attachment position of the three-axis acceleration sensor which is the vibration detecting device of the first embodiment.

Fig. 3A is a graph illustrating a variation in the acceleration during a spin cycle of a drum type washing machine.

Fig. 3B is a graph illustrating a variation in the acceleration during the spin cycle of the drum type washing machine.

Fig. 3C is a graph illustrating a variation in the acceleration during the spin cycle of the drum type washing machine.

Fig. 4 is a flowchart illustrating a series of processes of switching an acceleration detecting range of the acceleration sensor of the first embodiment.

Fig. 5 is a timing chart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor capable of detecting a vibration in plural directions during the spin cycle.

Fig. 6 is a block diagram illustrating a control device of the washing machine of a second embodiment.

Fig. 7 is a flowchart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor of the second embodiment.

Fig. 8A is a timing chart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor capable of detecting a vibration in plural directions during the spin cycle.

Fig. 8B is a timing chart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor capable of detecting a vibration in plural directions during the spin cycle.

Fig. 8C is a timing chart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor capable of detecting a vibration in plural directions during the spin cycle.

Fig. 8D is a timing chart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor capable of detecting a vibration in plural directions during the spin cycle.

Fig. 9 is a flowchart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor during the spin cycle and of determining whether the spin operation is continuously performed.

Fig. 10 is a flowchart illustrating a series of processes of switching the acceleration detecting range of the acceleration sensor during the laundry cycle of the drum type washing machine of a third embodiment.

PREFERRED EMBODIMENTS FOR CARRYING OUT THE INVENTION

(First embodiment)

[0011] Hereinafter, an embodiment of the invention will be described by referring to the accompanying drawings. The invention is not limited to the embodiment.

[0012] Fig. 1 is a block diagram illustrating a control device that detects and suppresses a vibration generated by unbalanced laundry items of a (drum type) washing machine of a first embodiment. In Fig. 1, the washing machine of the first embodiment includes: cabinet 10; drum 11 for rotating laundry items accommodated therein; and motor 12 for rotating drum 11 while controlling the speed thereof. The washing machine further includes: water tank 13 for being equipped with drum 11 and into which water is introduced; cover 18 for having a laundry input opening, seal packing 14 for connecting water tank 13 and cover 18 with a laundry input opening to each other without a gap therebetween, support spring 15 for maintaining the posture of water tank 13; and antivibration damper 16 for reducing the amount of a vibration transmitted to cabinet 10 or a floor by reducing a vibration generated when the motor rotates.

[0013] The washing machine of the first embodiment further includes vibration detecting device 17 for detecting a vibration of water tank 13. As an example of vibration detecting device 17, a digital output type acceleration sensor capable of outputting a variation in the acceleration as a digital value is used in the first embodiment, but an analog output type acceleration sensor capable of outputting a variation in the acceleration as a variation in the voltage may be used.

[0014] As the acceleration sensor of the first embodiment, a capacitive acceleration sensor converting a variation in the electrostatic capacity into a voltage is used. In addition, a piezoresistive acceleration sensor or the like may be used. This so-called micro electro mechanical system (MEMS) sensor is a minute sensor that is manufactured by using a semiconductor integrated circuit manufacturing technology. Recently, the sensor has been mass-produced at a low cost, so that it has been used as various consumer devices. The MEMS sensor has a benefit in that it is small in size and light in weight, and has a lower influence with respect to the vibration. Accordingly, it is considered that the MEMS sensor is suitable as vibration detecting device 17. Further, the acceleration sensor of the first embodiment adopts an acceleration sensor capable of detecting three axes by one chip, so that it may detect vibrations in plural directions. Therefore, a vibration mode which becomes complicated with an increase in the rotation speed during a spin cycle may be accurately understood, and various unbalanced states may be determined. However, the acceleration sensor may be of a two-axis type.

[0015] The attachment position of vibration detecting device 17 of the first embodiment is set to the upper front side of water tank 13. Since the vibration generated when drum 11 rotates at a high speed with unbalanced laundry items present at the front portion of the drum becomes larger than the vibration generated when the drum rotates with unbal-

anced laundry items present at the rear portion, there is a need that the drum may not be accelerated by high-speed rotation with large unbalancing at the front portion of the drum as much as possible. When unbalancing is present at the front portion, shaking of water tank 13 becomes more apparent at the front portion. For this reason, it is preferable that vibration detecting device 17 is attached at the front portion.

[0016] Antivibration rubber 19 is used to install cabinet 10 on the floor. Support spring 15 and antivibration damper 16 constitute a support unit. The washing machine further includes control unit 20 for controlling the rotation of motor 12 and vibration detecting device 17.

[0017] Figs. 2A and 2B are configuration diagrams illustrating the attachment position of the three-axis acceleration sensor which is vibration detecting device 17. The detecting axes of the three-axis acceleration sensor are attached such that the X axis is aligned with the left/right horizontal direction when seen from the front side of the body, the Y axis is aligned with the substantially front/rear (rotation axis) direction, and the Z axis is aligned with the substantially up/down direction, whereby the motion of water tank 13 may be three-dimensionally monitored.

[0018] Vibration detecting device 17 is attached to the front upper portion of the body which is the farthest position from antivibration damper 16. Accordingly, the vibration may be detected with high sensitivity even when the water tank is shaken with large displacement particularly at low-speed spinning.

Table 1 shows the main specification of the acceleration sensor of the first embodiment.

[Table 1]

OUTPUT TYPE	DETECTING AXIS	ACCELERATION DETECTING RANGE	SENSITIVITY
SPI	X, Y, AND Z	± 2 g	1024 LSb/g
		± 6 g	340 LSb/g
SPI: SERIAL PERIPHERAL INTERFACE			

[0019] This is a multi-axis detecting sensor of which the output type is a digital serial peripheral interface (digital SPI) and which may detect acceleration in three axes (X, Y, and Z) perpendicular to each other. As the acceleration detecting range, two types such as a first detecting range (-2 g to $+2$ g) and a second detecting range (-6 g to $+6$ g) may be set, and the detecting range may be switched in accordance with a setting of an internal resistor of the sensor. Further, regarding the sensitivity of each detecting range, the first detecting range is about 1024 [LSb/g], and the second detecting range is about 340 [LSb/g], so that the sensitivity of the first detecting range is higher than that of the second detecting range, and the acceleration detecting range is narrower than the other.

[0020] That is, when the first detecting range is set, unbalancing of drum 11 may be accurately measured by setting the narrow sensitivity of the acceleration detecting range to be large. Accordingly, precise control may be performed. On the contrary, when the second detecting range is set, acceleration in a wide range may be detected by lowering the sensitivity and widening the acceleration detecting range. This second detecting range may appropriately handle the event of an abnormal vibration or the like.

[0021] An acceleration sensor may be used in which three or more acceleration detecting ranges (for example, ± 2 g, ± 6 g, and ± 8 g) are switched. It is preferable that the optimal sensor is selected depending on the specification such as an allowable vibration range of the washing machine or a maximum rotation speed of the drum in the spin cycle thereof.

[0022] Since the output of the acceleration sensor is a digital type, the output may be more easily and directly input to a microcontroller than the analog type. Also, the digital type is stronger with respect to noise generated from an inverter circuit or the like driving motor 12, and a noise removing device is not required, which may suppress a factor causing an increase in the cost.

[0023] Figs. 3A, 3B, and 3C are graphs illustrating detected acceleration as an example of the output of the acceleration sensor during the spin cycle of the drum type washing machine together with the rotation speed of the drum.

[0024] It is understood that acceleration increases with an increase in the rotation speed of the drum, and the level of the amplitude for each detecting axis is different when the spinning operation is started. Further, it is understood that the detecting ranges of the X and Y axes almost exceeds ± 2 g of the first detecting range around 900 rpm, and the detecting range of the Z axis already exceeds the detecting range around at a low speed of 600 rpm. This is because the acceleration sensor of the first embodiment is of a type that may detect dynamic acceleration and acceleration of gravity, and the margin until $+2$ g is smaller than those of the other two axes due to the acceleration of gravity ($\approx +1$ g) normally applied in the Z axis. The level of the amplitude (Peak-to-Peak value) is equal to the levels of the other two axes, but the detecting range needs to be widened at a fast timing.

[0025] In this way, when the detecting range is switched, the detecting range needs to be appropriately switched while observing a variation in the acceleration which is different for each axis.

[0026] Fig. 4 is a flowchart illustrating a process of switching the acceleration detecting range during the spin cycle of

the first embodiment, where the acceleration detecting range is switched in accordance with the detected acceleration. Hereinafter, each Step will be described in its order.

[0027] First, the acceleration detecting range is set as the first acceleration detecting range (± 2 g) by control unit 20 (for example, a microcontroller) after the spin cycle is started (Step 1). Since there is slight shaking of water tank 13 at a low speed immediately after starting the spin cycle, it is preferable that the acceleration is detected at the setting having high sensitivity.

[0028] Subsequently, the rotation of drum 11 is started (Step 2). Subsequently, the acceleration is continuously monitored, and it is determined whether the detected acceleration exceeds the first acceleration detecting range (Step 3). In Step 3, when the detected acceleration is within the first acceleration detecting range, the rotation is continued without switching the detecting range, and it is determined whether the spin setting time is elapsed (Step 4). In Step 3, when it is determined that the detected acceleration exceeds the first acceleration detecting range, the current acceleration detecting range is switched to the second acceleration detecting range (± 6 g), and the rotation of the drum is continued (Step 5). Subsequently, it is determined whether the spin setting time is elapsed (Step 6). In Step 6, when it is determined that the spin setting time is not elapsed, the rotation of the drum is continued, and the current step returns to Step 6. In Step 6, when it is determined that the spin setting time is elapsed, the rotation of drum 11 is terminated (Step 7). Further, in Step 4, when it is determined that the spin setting time is not elapsed, the current step returns to Step 3. In Step 4, when it is determined that the spin setting time is elapsed, the rotation of drum 11 is terminated (Step 7).

[0029] Fig. 5 is a timing chart illustrating a process of switching the acceleration detecting range during the spin cycle when the washing machine is equipped with an acceleration sensor capable of detecting vibrations in plural directions. Fig. 5 illustrates an example of a process individually switching the acceleration detecting range for each axis, but the acceleration detecting ranges for all axes may be simultaneously switched.

[0030] As understood from the graph of the acceleration, the amplitudes of the accelerations of the X axis and the Z axis are substantially equal to each other, and the vibration of the Y axis is comparatively smaller than the other two axes. Since the Z axis has the acceleration of gravity in the up/down direction, 1 g of output is already generated at the spin start Step, and the timing reaching 2 g is faster than that of the X axis. On the other hand, the acceleration of the Y axis is within ± 2 g of acceleration during the spin cycle, and may be detected by the first acceleration detecting range which is the initially set acceleration detecting range. Further, the vibration having different amplitude for each detecting direction randomly changes during an operation due to the biasing of laundry items adhered to the inside of drum 11, and the vibration may have a different waveform of acceleration compared with the vibration of Fig. 5. However, when the acceleration detecting range is switched for each direction in accordance with a variation in the acceleration as shown in the first embodiment, the vibration of the drum may be detected by the setting having satisfactory sensitivity at all times.

(Second embodiment)

[0031] Hereinafter, a second embodiment will be described by referring to the drawings. The invention is not limited to the embodiment.

[0032] Fig. 6 is a block diagram illustrating a control device that detects and suppresses a vibration generated by unbalanced laundry items of the (drum type) washing machine of the second embodiment. In the configuration of Fig. 6, the washing machine includes rotation speed detecting device 21 for detecting a rotation speed of drum 11, and the acceleration detecting range may be switched in accordance with the detected rotation speed.

[0033] Fig. 7 is a flowchart illustrating a process of switching the acceleration detecting range during the spin cycle of the second embodiment, where the acceleration detecting range is switched in accordance with the rotation speed of drum 11. Hereinafter, each Step will be described in its order.

[0034] The acceleration detecting range is set as the first acceleration detecting range (± 2 g) by control unit 20 after starting the spin cycle (Step 1).

[0035] Subsequently, the rotation of drum 11 is started (Step 2). Subsequently, the rotation speed is increased, and it is determined whether the rotation speed reaches the acceleration detecting range switching rotation speed (330 rpm in the second embodiment) (Step 3). Even at this time, the acceleration is continuously monitored, and the rotation of the drum is stopped when detecting a predetermined acceleration or more causing abnormal vibration. In Step 3, when it is determined that the rotation speed of drum 11 does not reach a predetermined rotation speed, the rotation speed is continuously increased, and the current step returns to Step 3. In Step 3, when it is determined that the rotation speed of drum 11 reaches a predetermined rotation speed, the acceleration detecting range is switched to the second acceleration detecting range while the rotation of drum 11 is constantly maintained. When the switching to the second acceleration detecting range is completed, the rotation of drum 11 is accelerated again (Step 4). Subsequently, it is determined whether the spin setting time is elapsed (Step 5). In Step 5, when it is determined that the spin setting time is not elapsed, the rotation of the drum is continued, and the current step returns to Step 5. In Step 5, when it is determined that the spin setting time is elapsed, the rotation of drum 11 is terminated (Step 6).

[0036] Further, the acceleration detecting range switching rotation speed may be a rotation speed at which a variation in the acceleration is not included in an active resonance range (120 to 300 rpm). The acceleration detecting range is switched while drum 11 is rotated at a constant speed. Accordingly, a problem may be prevented in which the current detecting range exceeds the set detecting range due to an abrupt increase in the acceleration in the resonance range, so that the acceleration is not detected.

[0037] Figs. 8A, 8B, 8C, and 8D are timing charts illustrating a process of switching the acceleration detecting range during the spin cycle when the washing machine is equipped with an acceleration sensor capable of detecting vibrations in plural directions. In this process, the acceleration detecting ranges for all axes are simultaneously switched, but may be individually switched.

[0038] The first acceleration detecting range is set when the spin cycle is started, the rotation speed of the drum is increased, and is maintained at a constant speed of 330 rpm after the resonance range. Then, when a predetermined time is elapsed, the current acceleration detecting range is switched to the second acceleration detecting range. Since the amplitude of the resonance range in the second embodiment has a margin with respect to the first acceleration detecting range (± 2 g), the acceleration detecting range may be switched even after the resonance range.

[0039] Fig. 9 is a flowchart illustrating a process of switching the acceleration detecting range during the spin cycle, where the acceleration detecting range is switched in accordance with the rotation speed of drum 11, and it is determined whether the spinning operation is continued. Hereinafter, each Step will be described in its order.

[0040] The acceleration detecting range is set as the first acceleration detecting range (± 2 g) in which the detecting resolution is the most sensitive by control unit 20 after the spin cycle is started (Step a).

[0041] Subsequently, the rotation of drum 11 is started (Step b). Subsequently, a disentangling cycle is performed so as to solve fabric entangling or biasing (Step c). Subsequently, the acceleration of the rotation of drum 11 is started (Step d).

[0042] Subsequently, it is determined whether the detected acceleration exceeds threshold value 1 during the acceleration (Step e). Here, the threshold value is obtained from the relationship between the acceleration and the vibration, where the vibration is converted into acceleration when the vibration of water tank 13 becomes a specific vibration value or more, and threshold value 1 is a value used as a reference detecting an abnormal vibration within the first detecting range.

[0043] In Step e, when it is determined that the detected acceleration does not exceed threshold value 1, it is determined whether the rotation speed reaches the acceleration detecting range switching rotation speed (Step i). In Step i, when it is determined that the rotation speed does not reach the acceleration detecting range switching rotation speed, the current step returns to Step e. In Step i, when it is determined that the rotation speed reaches the acceleration detecting range switching rotation speed, the acceleration detecting range is set to the second detecting range (± 6 g) having a detecting range wider (a detecting resolution is lower) than that of the first acceleration detecting range (Step j). Subsequently, it is determined whether the detected acceleration exceeds threshold value 2 (Step k). Here, threshold value 2 is a value that is used as a reference detecting abnormal vibration within the second detecting range. In Step k, when it is determined that the detected acceleration does not exceed threshold value 2, it is determined whether the spin setting time is elapsed (Step 1). In Step 1, when it is determined that the spin setting time is not elapsed, the current step returns to Step k. In Step 1, when it is determined that the spin setting time is elapsed, the rotation of drum 11 is terminated so that the spin cycle is terminated, and the subsequent cycle is performed (Step m). When it is determined that the detected acceleration exceeds threshold value 1 in Step e and when it is determined that the detected acceleration exceeds threshold value 2 in Step k, it is determined that an abnormal vibration occurs, and the rotation of drum 11 is decelerated and stopped (Step f). Subsequently, when the drum stops due to the detected acceleration exceeding the threshold value, it is determined whether the number of rotation stops reaches a predetermined number of times (Step g). In Step g, when it is determined that the number of rotation stops of drum 11 due to a high level of vibration does not reach a predetermined number of times, the current step returns to Step a, and the spin cycle is started again. When it is determined that the number of rotation stops of drum 11 due to a high level of vibration reaches a predetermined number of times, it is determined that the unbalanced state is not solved even when the spin cycle is started again, and an error is informed to a user (Step h).

[0044] In this way, the vibration may be highly accurately detected even at the minute level of the vibration by making the detecting resolution of the acceleration sensor more sensitive in the low-speed rotation range in the spin cycle, and the acceleration detecting range is set to be narrow when drum 11 reaches a predetermined rotation speed or less. Further, the acceleration detecting range is set to be wide at a predetermined rotation speed or more compared with the case of a predetermined rotation speed or less, thereby handling the level of the acceleration increasing with an increase in the rotation speed of drum 11. With such a configuration, an abnormal vibration may be efficiently prevented by handling the level of the vibration that greatly changes with an increase in the rotation speed of the drum.

[0045] The rotation of the drum may be decelerated at the timing when the rotation speed of drum 11 is the resonance range (120 to 300 rpm) or less and the acceleration detected by vibration detecting device 17 exceeds a predetermined acceleration. Alternatively, the rotation of drum 11 may be decelerated or stopped when the acceleration of water tank 13 is detected in a range where the acceleration is very small such as to reach the resonance range or less and the

level of the vibration is large. Accordingly, an abnormal vibration may be prevented in advance, the operation efficiency of the spin cycle may be improved, and the spin cycle may be performed at a low level of vibration.

(Third embodiment)

[0046] Hereinafter, a third embodiment will be described by referring to the drawings. The invention is not limited to the embodiment.

[0047] The invention may be applied to a laundry cycle of the drum type washing machine.

[0048] Fig. 10 is a flowchart illustrating a process of switching the acceleration detecting range during the laundry cycle of the drum type washing machine. The laundry cycle of the drum type washing machine is performed in a tumbling manner such that laundry items are lifted upward by baffles attached to the inner surface of drum 11, and the lifted laundry items are dropped so as to remove dirt therefrom. Accordingly, since there is a tendency that the cleaning degree becomes higher as the dropping impact (acceleration) becomes larger, the rotation speed of motor 12 may be controlled in accordance with the acceleration, and the cleaning degree may be improved. However, the acceleration of water tank 13 due to the dropping impact of the fabric during the laundry cycle is extremely smaller than the acceleration during the spin cycle (particularly at a high-speed rotation). Accordingly, when the laundry cycle is controlled in accordance with the acceleration, the sensitivity needs to be increased.

[0049] The laundry cycle of the drum type washing machine is mainly performed by a sequence of repeatedly normally or reversely rotating drum 11 with a predetermined on-off time limit for a predetermined time. When drum 11 continuously rotates in the same direction, fabrics are entangled, so that the cleaning operation becomes irregular or the cleaning force becomes degraded. However, when the rotation direction of drum is periodically reversed, fabrics may be prevented from being entangled. Accordingly, the entangled state of the fabrics is solved by each reversed rotation, and the dropping impact (that is, the vibration of water tank 13) also changes. It is preferable that the vibration is detected in the acceleration setting having the highest sensitivity for the changed vibration (acceleration). Hereinafter, each Step will be described in its order.

[0050] The acceleration detecting range is set as the first acceleration detecting range (± 2 g) after the laundry cycle is started by control unit 20 (Step 1). Subsequently, the rotation of drum 11 is started (Step 2). Subsequently, the tumbling of the fabrics is performed while continuously monitoring the acceleration.

[0051] During the tumbling of the fabrics, it is continuously determined whether the detected acceleration exceeds the first detecting range (Step 3). In Step 3, when it is determined that the detected acceleration exceeds the first detecting range, the acceleration detecting range is switched to the second acceleration detecting range, and then the rotation of drum is continued (Step 5). Subsequently, it is determined whether the rotation on-time is elapsed by a predetermined time (Step 6). In Step 6, when it is determined that the rotation on-time is not elapsed by a predetermined time, the current step returns to Step 3. In Step 6, when the rotation on-time is elapsed by a predetermined time, the rotation of drum 11 is stopped (Step 7). Subsequently, it is determined whether the laundry setting time is elapsed (Step 8). In Step 8, when it is determined that the laundry setting time is elapsed, the rotation of the drum is terminated, and the subsequent cycle is performed. In Step 8, when it is determined that the laundry setting time is not elapsed, it is determined whether a predetermined rotation off-time is elapsed (Step 9). In Step 9, when it is determined that a predetermined rotation off-time is not elapsed, the current step returns to Step 3. In Step 9, when it is determined that a predetermined rotation off-time is elapsed, the drum rotates in the reverse direction (Step 10). Then, the current step returns to Step 1. Further, in Step 3, when it is determined that the detected acceleration does not exceed the first detecting range, the rotation of the drum is continued without switching the detecting range, and it is determined whether a predetermined rotation on-time is elapsed (Step 4). In Step 4, when it is determined that a predetermined rotation on-time is not elapsed, the current step returns to Step 3. When it is determined that a predetermined rotation on-time is elapsed, the rotation of drum 11 is stopped (Step 7).

[0052] As described above, since the detected acceleration changes in a wide range in accordance with the operation cycles (the laundry cycle, the spin cycle, and the like) of the washing machine, the rotation speed of the drum, or the configuration of the machine body (the characteristic or the layout of antivibration damper 16 or support spring 15, the size or the inclination angle of drum 11, the installation place of vibration detecting device 17, and the like), it is important to switch the current acceleration detecting range to the optimal acceleration detecting range. Accordingly, since the acceleration detecting range is switched in accordance with the detected acceleration or the rotation speed of the drum, the vibration may be detected with high accuracy.

[0053] Further, not only when the acceleration detected by vibration detecting device 17 increases in accordance with an increase in the rotation speed of drum 11 as in the first embodiment, but also when the acceleration detected by vibration detecting device 17 decreases in accordance with a decrease in the rotation speed of drum 11 due to a reason such as generation of unbalancing depending on the state of laundry items, the vibration may be detected with high accuracy by narrowing the acceleration detecting range in a direction in which acceleration is settled at the time point when the acceleration in a certain direction is settled within the predetermined acceleration detecting range.

[0054] Furthermore, the accuracy of vibration detection may be improved, and the acceleration detecting range may be simply switched by narrowing the acceleration detecting range in all directions at the time point when the acceleration in all directions is settled in the predetermined acceleration detecting range.

[0055] Moreover, when the rotation speed of drum 11 is controlled so that the detected acceleration of vibration detecting device 17 does not exceed the maximum acceleration detecting range (± 6 g in the third embodiment) while monitoring the detected acceleration of vibration detecting device in accordance with an increase in the rotation speed of drum 11, an abnormal vibration may be prevented, the drum may rotate at a high speed as much as possible, and the spinning performance may be improved while reducing the vibration.

[0056] As described above, a washing machine includes: a drum for having a water passage hole formed in the outer periphery thereof; a water tank for having the drum installed therein and is filled with washing water; a motor for rotationally driving the drum; a cabinet for accommodating the water tank therein; a rotation speed detecting device for detecting a rotation speed of the drum; a vibration detecting device for being configured as an acceleration sensor capable of detecting a vibration of the water tank and switching plural acceleration detecting ranges having different minimum acceleration resolutions; and a control unit for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device, wherein the control unit switches the acceleration detecting ranges in accordance with the rotation speed of the drum. Accordingly, since the acceleration detecting range is appropriately set in accordance with the level of the changing vibration (acceleration) of the water tank depending on the rotation speed, the detecting range having the highest sensitivity may be used, and the accuracy of vibration detection may be improved.

[0057] Further, a washing machine includes: a drum for having a water passage hole formed in the outer periphery thereof; a water tank for having the drum installed therein and is filled with washing water; a motor for rotationally driving the drum; a cabinet for accommodating the water tank therein; a vibration detecting device for being configured as an acceleration sensor capable of detecting a vibration of the water tank and switching plural acceleration detecting ranges having different minimum acceleration resolutions; and a control unit for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device, wherein the control unit switches the acceleration detecting ranges in accordance with the detected acceleration. Accordingly, the detecting range having the highest sensitivity may be used, and the accuracy of vibration detection may be improved.

[0058] Accordingly, since the vibration and noise particularly during the spin cycle may be reduced, the washing machine may be highly efficiently operated while its vibration and noise are reduced, and hence the operation time may be shortened.

[0059] The control unit widens and fixes the acceleration detecting range of the vibration detecting device when the vibration detecting device detects a predetermined magnitude or more of acceleration. Accordingly, the washing machine may be controlled by the setting having appropriately high sensitivity so that the peak value of the acceleration does not exceed the acceleration detecting range of the acceleration sensor, and the accuracy of vibration detection may be improved.

[0060] The control unit switches the acceleration detecting range of the vibration detecting device before and/or after a spin resonance range. Accordingly, the acceleration detecting range may be switched so as to avoid the resonance range where a variation in the acceleration is large during the spin cycle, and the acceleration may be reliably detected in the spin resonance range.

[0061] The control unit widens the acceleration detecting range in a direction in which acceleration exceeds the acceleration detecting range at a time point when the acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions exceeds the acceleration detecting range. Accordingly, since the acceleration detecting range may be individually switched for each vibration detecting direction, the vibration may be detected for each vibration detecting direction with the highest sensitivity.

[0062] The control unit widens the acceleration detecting range in all directions at a time point when acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions exceeds an acceleration detecting range. Accordingly, the acceleration detecting range switching process using the control unit may be simplified.

[0063] The control unit narrows the acceleration detecting range in a direction in which acceleration is settled within the acceleration detecting range at a time point when the acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions is settled within the predetermined acceleration detecting range. Accordingly, the acceleration detecting range having the high sensitivity may be selected in accordance with the level of the vibration, and the accuracy of vibration detection may be improved.

[0064] The control unit narrows the acceleration detecting range in all directions at a time point when acceleration detected in all directions by the vibration detecting device capable of detecting vibrations in plural directions is settled within the predetermined acceleration detecting range. Accordingly, the acceleration detecting range having the highest sensitivity may be selected in accordance with the level of the vibration, and the accuracy of vibration detection may be improved. Also, the acceleration detecting range switching process using the control unit may be simplified.

[0065] The control unit switches the acceleration detecting range of the vibration detecting device while the rotation

speed of the drum is constant. Accordingly, the vibration may be accurately detected in the rotation range where a variation in the acceleration is large when the rotation speed of the drum increases or decreases.

[0066] The control unit makes the acceleration detecting range of the vibration detecting device narrowest when the drum starts to rotate. Accordingly, the vibration may be detected by the setting having high sensitivity at all times when a spinning operation is started at low acceleration.

[0067] The control unit controls the rotation speed of the drum so that acceleration detected by the vibration detecting device does not exceed the maximum acceleration detecting range when the rotation speed of the drum increases. Accordingly, the spinning operation may be performed at a high speed while preventing an abnormal vibration particularly during the spin cycle, and both reduced vibration and improved spinning performance may be realized.

[0068] The acceleration sensor is capable of switching the acceleration detecting range just by changing a setting value of an internal resistor. Accordingly, since a separate switch switching the acceleration detecting range is not needed, the vibration detecting device may be simplified.

[0069] The acceleration sensor is of a digital output type. Accordingly, the acceleration sensor is difficult to be influenced particularly by noise generated from the motor or the like mounted on the washing machine, the vibration may be highly accurately detected, and the number of the wirings wired to the control unit may be decreased compared with the analog type. Therefore, the system may be easily simplified.

[0070] The control unit sets the acceleration detecting range of the vibration detecting device to be narrowed when the rotation speed of the drum is a predetermined rotation speed or less compared with the case where the rotation speed of the drum exceeds the predetermined rotation speed, and decelerates the rotation of the drum at a time point when the detected acceleration exceeds a predetermined acceleration. Accordingly, when the level of the acceleration of the water tank at a low-speed rotation is very small, the acceleration is highly accurately detected by the setting having a more sensitive resolution. Even when the level of the acceleration of the water tank at a high-speed rotation is large, the maximum vibration value may be reliably detected by the setting having the wide acceleration detecting range. When a vibration is generated so that the detected acceleration exceeds a predetermined threshold value in each setting, the rotation of the drum is decelerated or stopped, so that the vibration may be prevented in advance from becoming larger. Therefore, since the vibration and noise particularly during the spin cycle may be reduced, the washing machine may be highly efficiently operated while its vibration and noise are reduced, and hence the operation time may be shortened.

[0071] The control unit decelerates the rotation of the drum at a time point when acceleration, detected by the vibration detecting device while the rotation speed of the drum increases, exceeds a predetermined acceleration. Accordingly, when the level of the vibration is large while the water tank's acceleration changing with an increase in the rotation speed of the drum is continuously monitored, the rotation of the drum is decelerated or stopped, so that the vibration may be prevented in advance from becoming larger. Therefore, since the vibration and noise particularly during the spin cycle may be reduced, the washing machine may be highly efficiently operated while its vibration and noise are reduced, and hence the operation time may be shortened.

[0072] The control unit decelerates the rotation of the drum at a time point when the acceleration, detected by the vibration detecting device at a resonance range or less, exceeds a predetermined acceleration. Accordingly, the rotation of drum may be decelerated or stopped when the acceleration of water tank is detected in a range where the acceleration is very small such as to reach the resonance rotation speed or less and the level of the vibration is large. Therefore, an abnormal vibration may be prevented in advance, the operation efficiency of the spin cycle may be improved, and the spin cycle may be performed at a low level of vibration.

INDUSTRIAL APPLICABILITY

[0073] As described above, since the washing machine according to the invention may use the acceleration detecting range having the highest sensitivity in accordance with the detected acceleration or the rotation speed of the drum, the accuracy of vibration detection may be improved and the vibration may be accurately suppressed during the spin cycle or the laundry cycle.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0074]

10: CABINET

11: DRUM

12: MOTOR

- 13: WATER TANK
- 14: SEAL PACKING
- 5 15: SUPPORT SPRING
- 16: ANTIVIBRATION DAMPER
- 17: VIBRATION DETECTING DEVICE
- 10 18: COVER
- 19: ANTIVIBRATION RUBBER
- 15 20: CONTROL UNIT

Claims

20 **1.** A washing machine comprising:

a drum for having a water passage hole formed in the outer periphery thereof;
a water tank for having the drum installed therein and is filled with washing water;
a motor for rotationally driving the drum;
25 a cabinet for accommodating the water tank therein;
a rotation speed detecting device for detecting a rotation speed of the drum;
a vibration detecting device for being configured as an acceleration sensor capable of detecting a vibration of the water tank and switching plural acceleration detecting ranges having different minimum acceleration resolutions; and
30 a control unit for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device,
wherein the control unit switches the acceleration detecting ranges in accordance with the rotation speed of the drum.

35 **2.** A washing machine comprising:

a drum for having a water passage hole formed in the outer periphery thereof;
a water tank for having the drum installed therein and is filled with washing water;
a motor for rotationally driving the drum;
40 a cabinet for accommodating the water tank therein;
a vibration detecting device for being configured as an acceleration sensor capable of detecting a vibration of the water tank and switching plural acceleration detecting ranges having different minimum acceleration resolutions; and
a control unit for controlling the motor and the vibration detecting device on the basis of the output of the vibration detecting device,
45 wherein the control unit switches the acceleration detecting ranges in accordance with the detected acceleration.

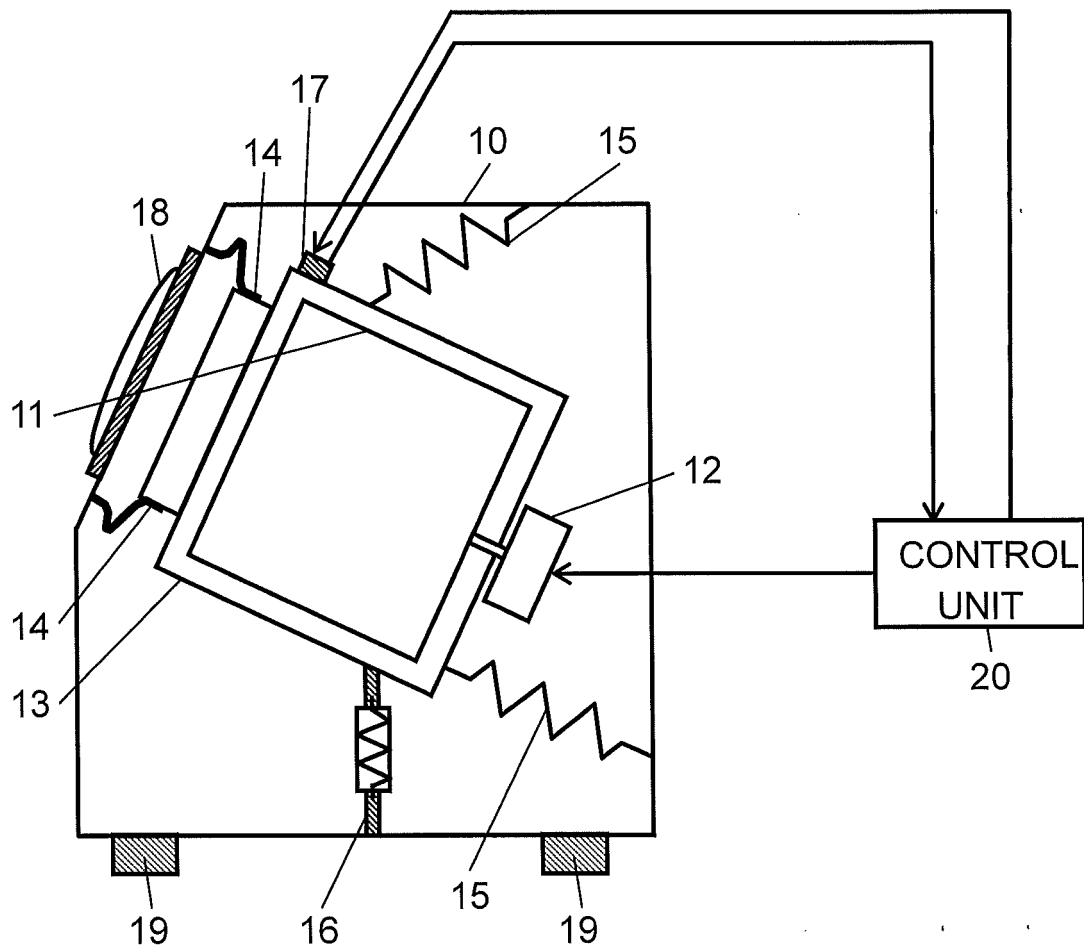
3. The washing machine of claim 1 or 2, wherein the control unit widens and fixes the acceleration detecting range of the vibration detecting device when the vibration detecting device detects a predetermined magnitude or more of acceleration.
50

4. The washing machine of claim 1 or 2, wherein the control unit switches the acceleration detecting range of the vibration detecting device before and/or after a spin resonance range.

55 5. The washing machine of claim 1 or 2, wherein the control unit widens the acceleration detecting range in a direction in which acceleration exceeds the acceleration detecting range at a time point when the acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions exceeds the predetermined acceleration detecting range.

6. The washing machine of claim 1 or 2, wherein the control unit widens the acceleration detecting range in all directions at a time point when acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions exceeds a predetermined acceleration detecting range.
- 5 7. The washing machine of claim 1 or 2, wherein the control unit narrows the acceleration detecting range in a direction in which acceleration is settled within the acceleration detecting range at a time point when the acceleration detected in one direction by the vibration detecting device capable of detecting vibrations in plural directions is settled within the predetermined acceleration detecting range.
- 10 8. The washing machine of claim 1 or 2, wherein the control unit narrows the acceleration detecting range in all directions at a time point when acceleration detected in all directions by the vibration detecting device capable of detecting vibrations in plural directions is settled within the predetermined acceleration detecting range.
- 15 9. The washing machine of claim 1 or 2, wherein the control unit switches the acceleration detecting range of the vibration detecting device while the rotation speed of the drum is constant.
10. The washing machine of claim 1 or 2, wherein the control unit makes the acceleration detecting range of the vibration detecting device narrowest when the drum starts to rotate.
- 20 11. The washing machine of claim 1 or 2, wherein the control unit controls the rotation speed of the drum so that acceleration detected by the vibration detecting device does not exceed the maximum acceleration detecting range when the rotation speed of the drum increases.
- 25 12. The washing machine of any one of claims 1 to 11, wherein the acceleration sensor is capable of switching the acceleration detecting range just by changing a setting value of an internal resistor.
13. The washing machine of any one of claims 1 to 12, wherein the acceleration sensor is of a digital output type.
- 30 14. The washing machine of claim 1, wherein the control unit sets the acceleration detecting range of the vibration detecting device to be narrowed when the rotation speed of the drum is a predetermined rotation speed or less compared with the case where the rotation speed of the drum exceeds the predetermined rotation speed, and decelerates the rotation of the drum at a time point when the detected acceleration exceeds a predetermined acceleration.
- 35 15. The washing machine of claim 1 or 14, wherein the control unit decelerates the rotation of the drum at a time point when acceleration, detected by the vibration detecting device while the rotation speed of the drum increases, exceeds a predetermined acceleration.
- 40 16. The washing machine of claim 1, 14, or 15, wherein the control unit decelerates the rotation of the drum at a time point when the acceleration, detected by the vibration detecting device at a resonance range or less, exceeds a predetermined acceleration.
- 45
- 50
- 55

FIG. 1



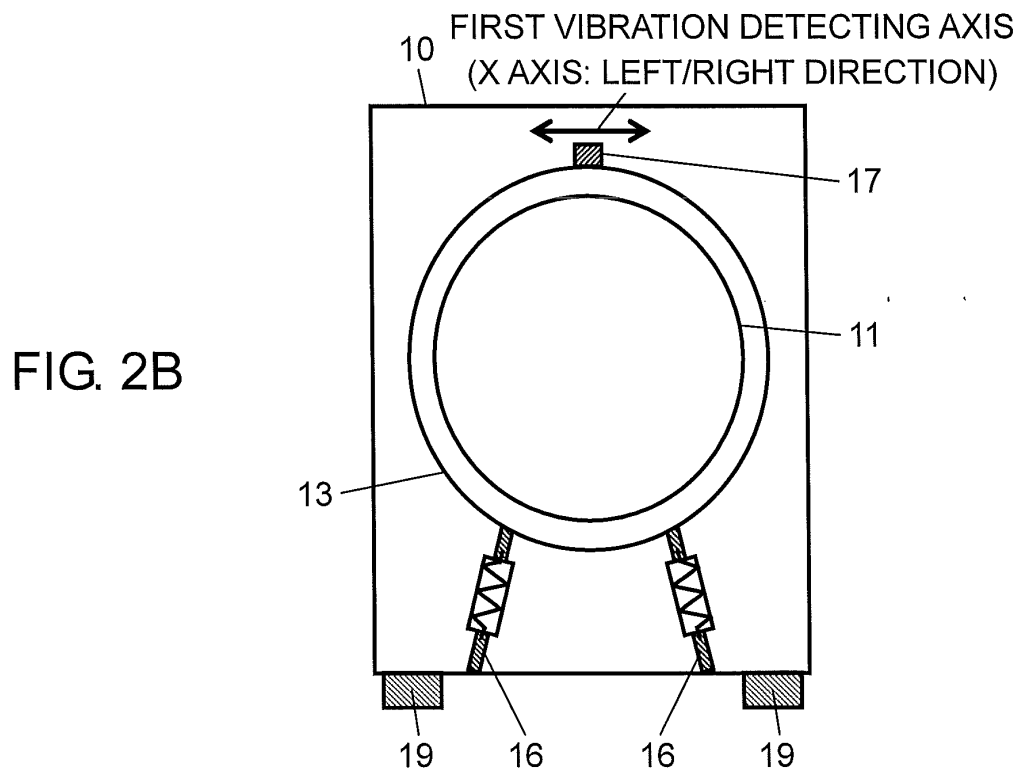
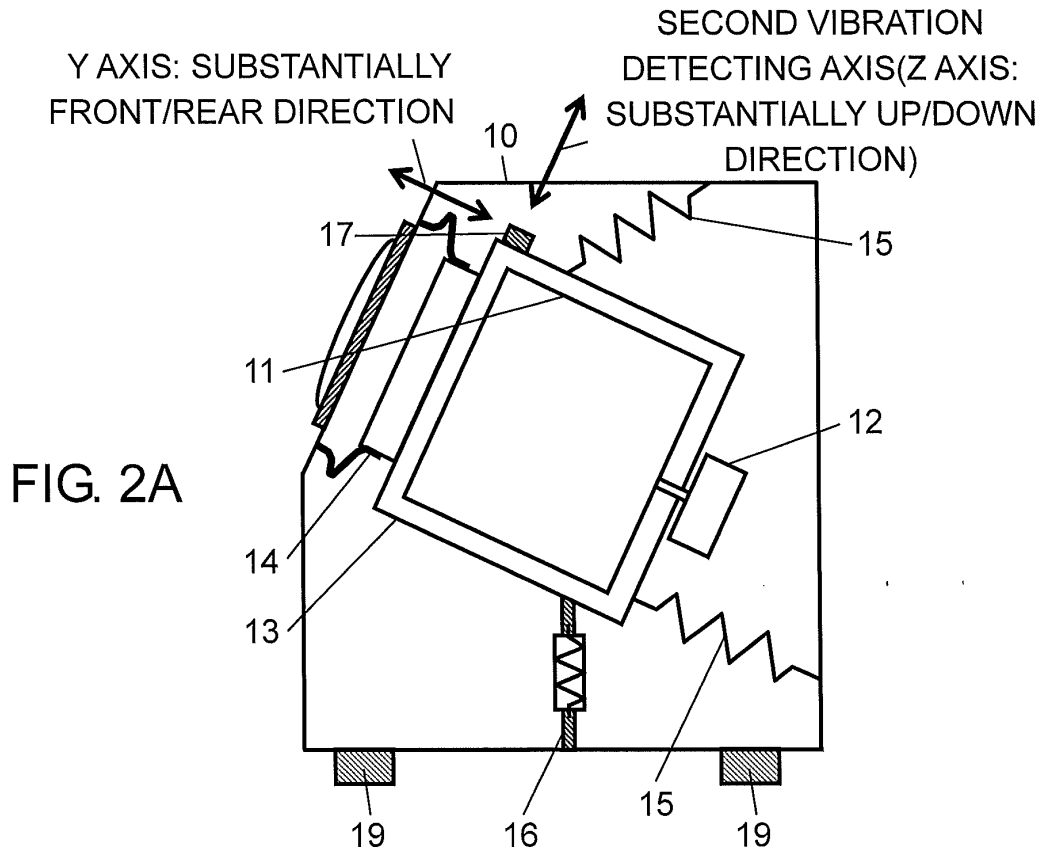


FIG. 3A

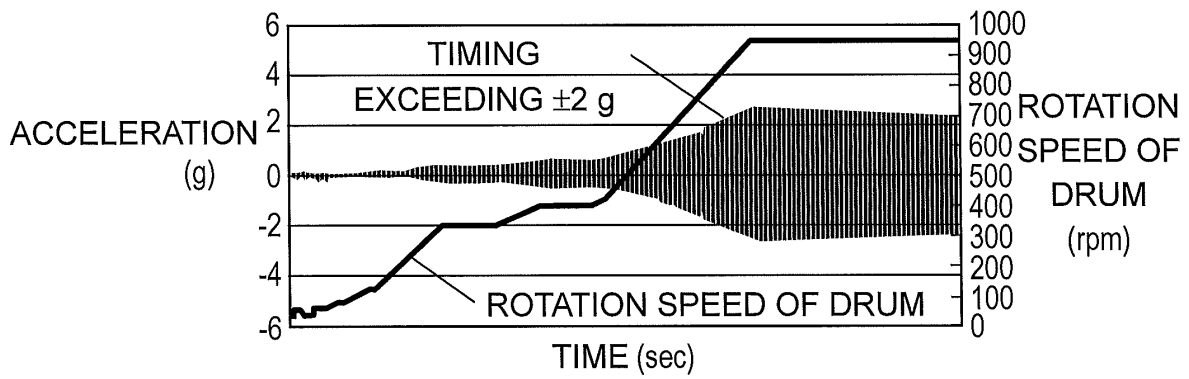


FIG. 3B

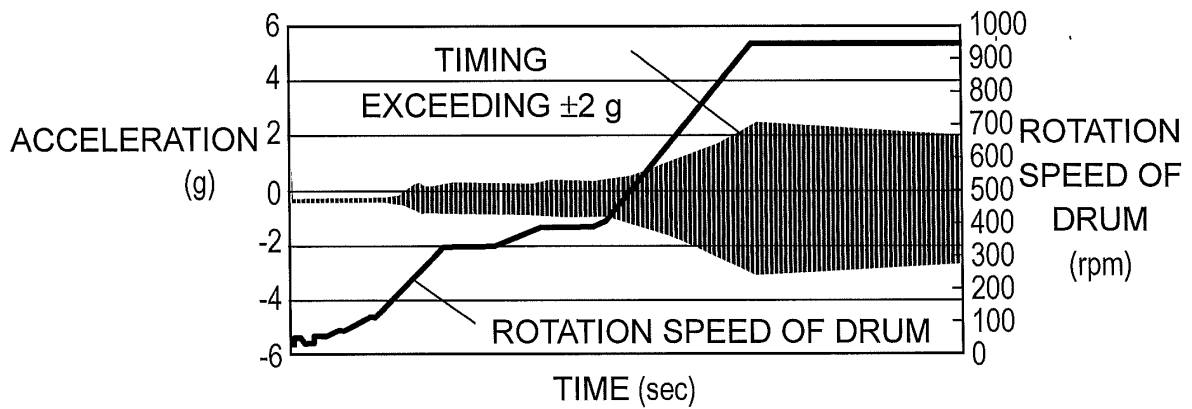


FIG. 3C

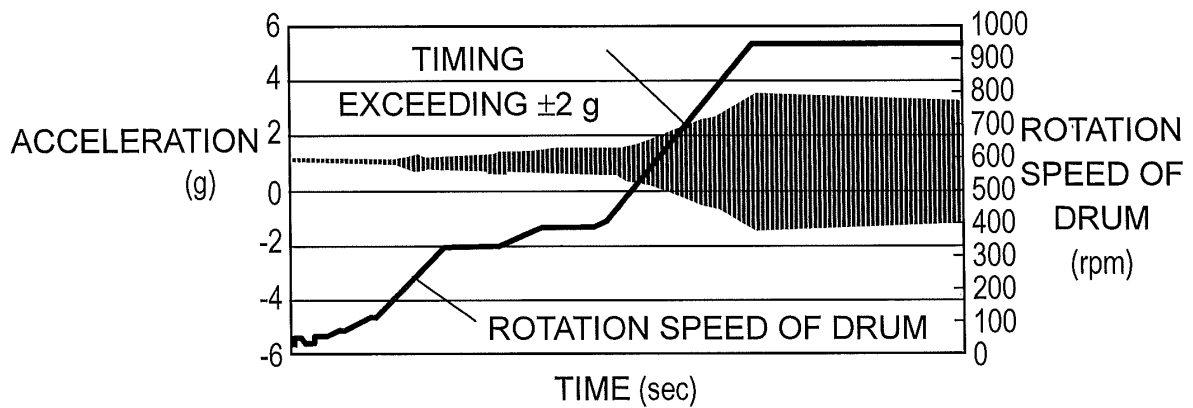


FIG. 4

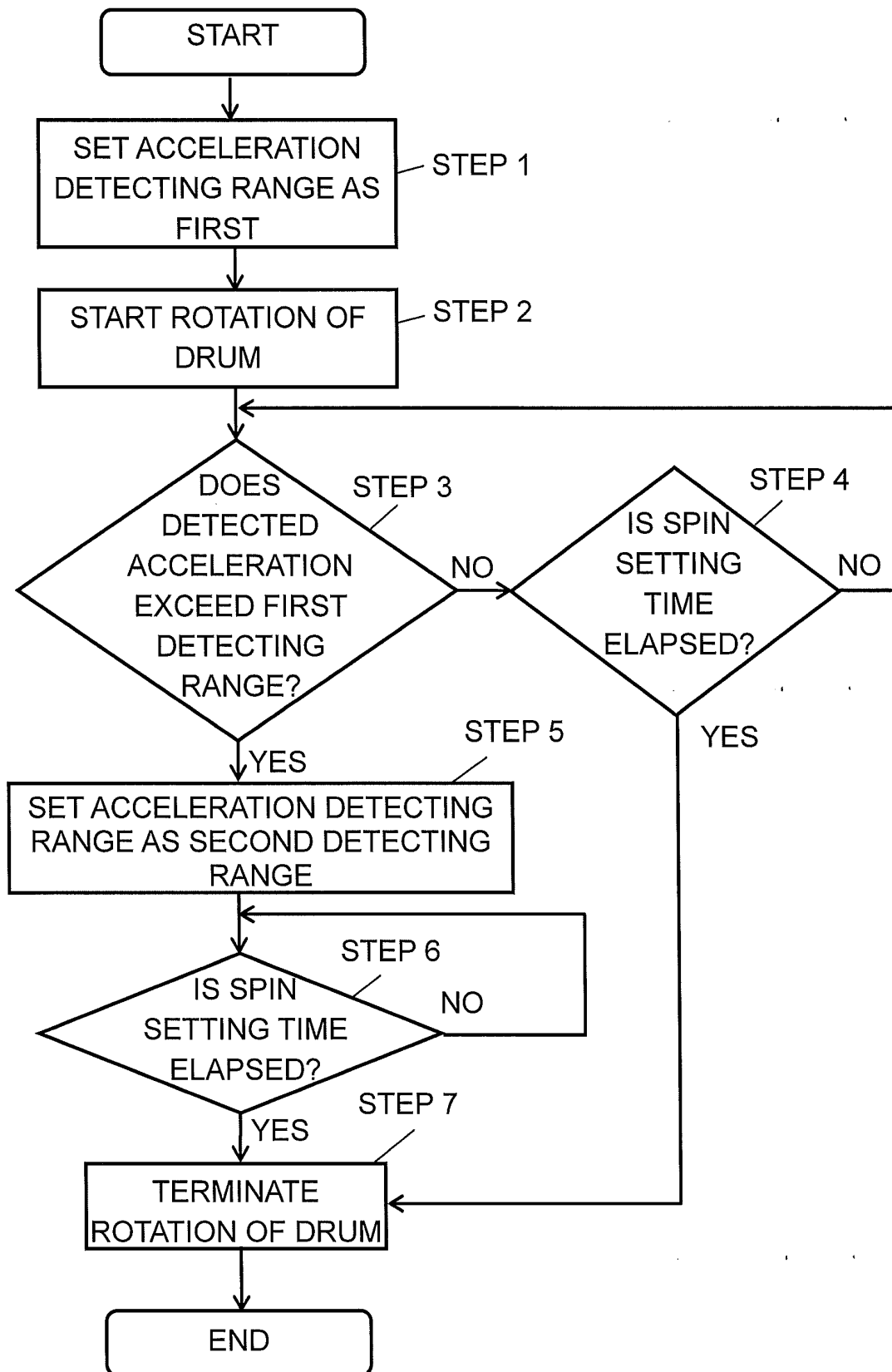


FIG. 5

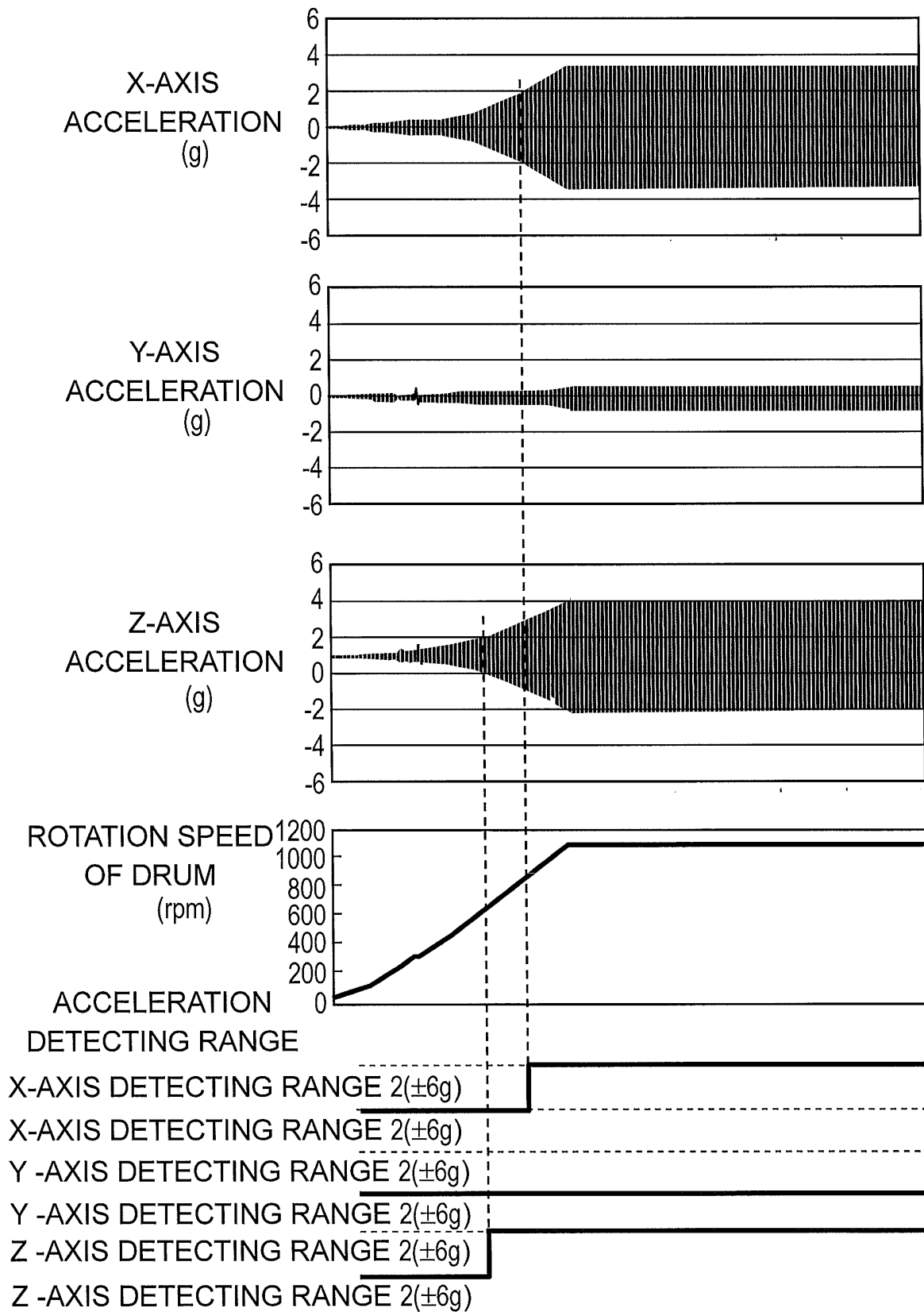


FIG. 6

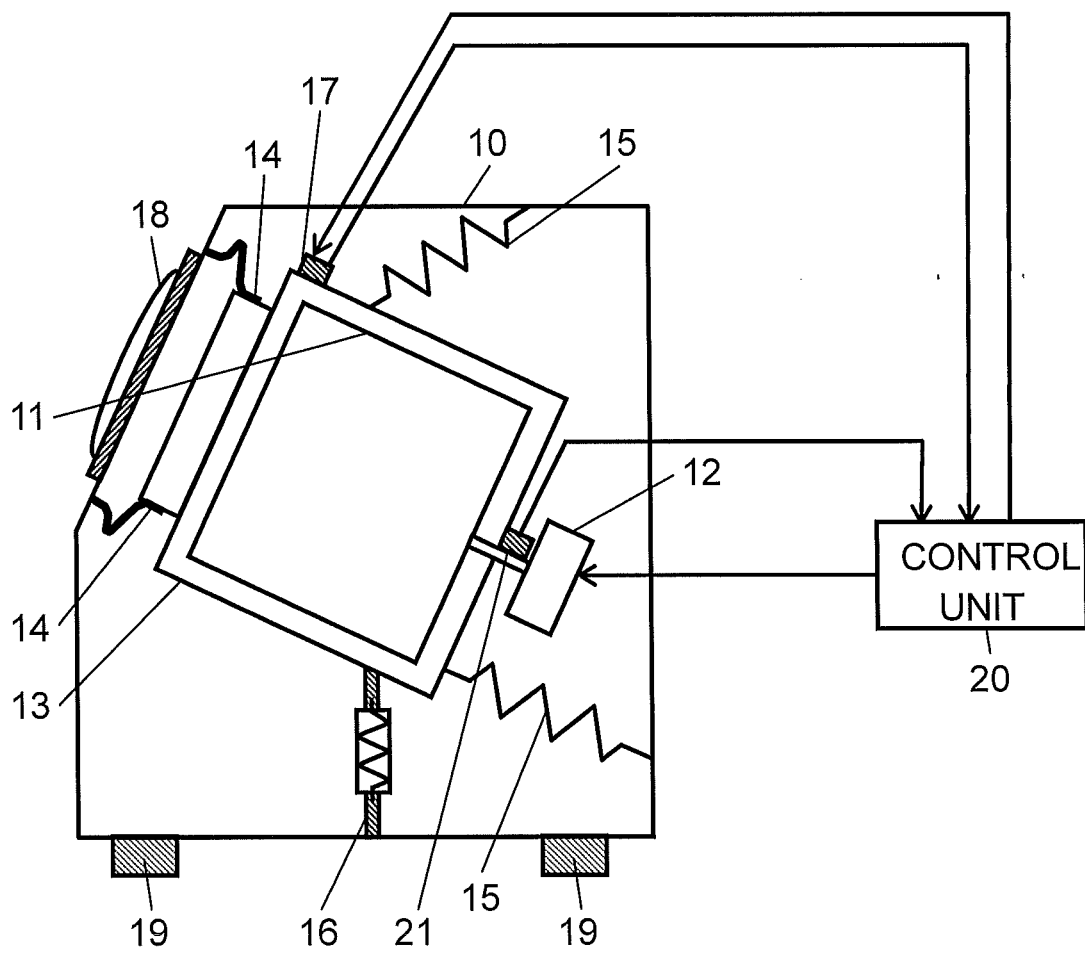


FIG. 7

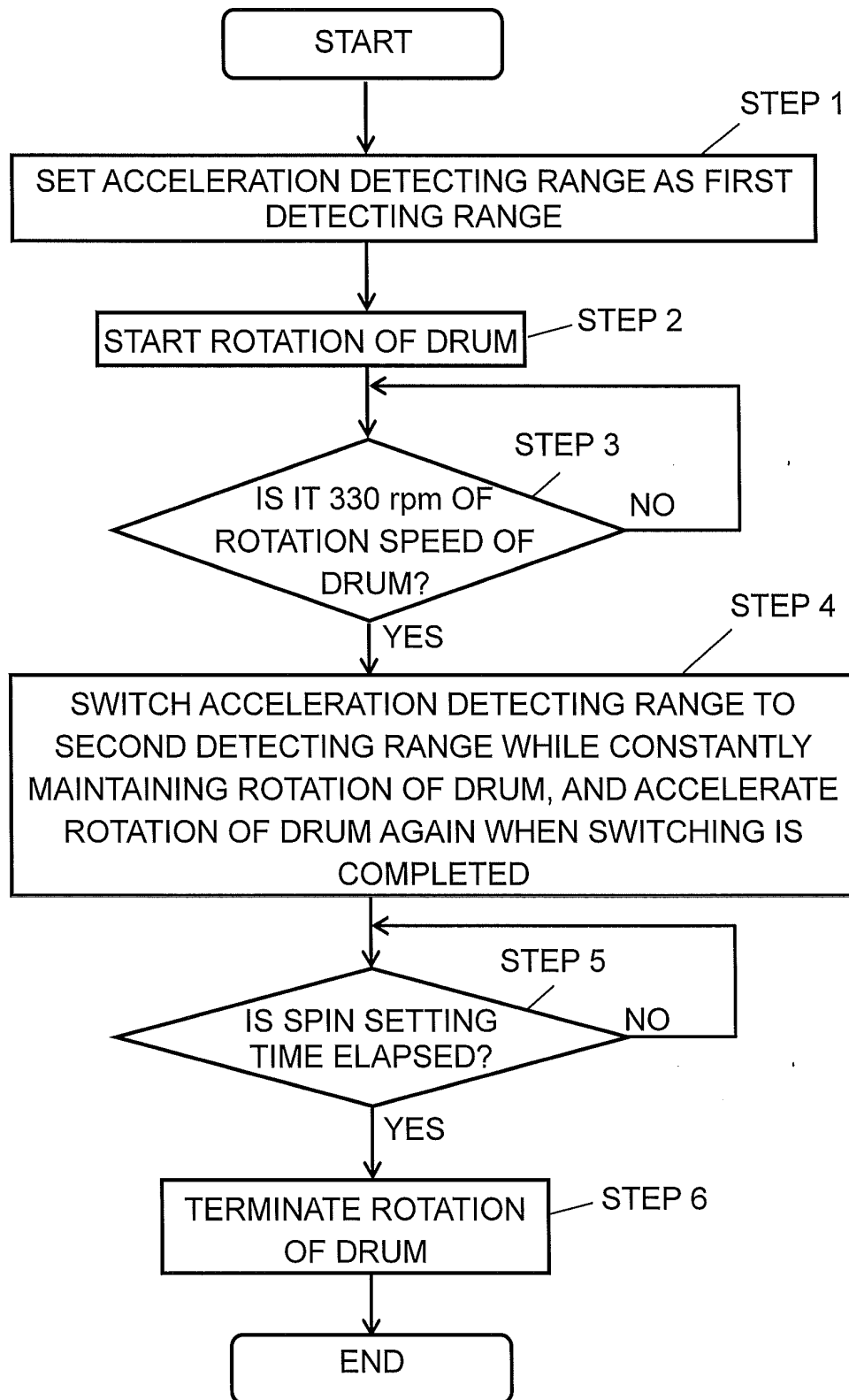


FIG. 8A

X-AXIS
ACCELERATION
(g)

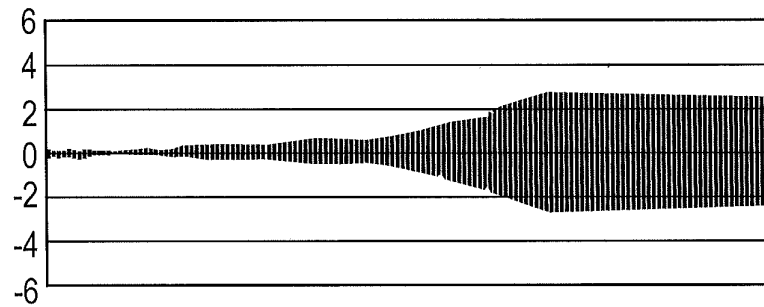


FIG. 8B

Y-AXIS
ACCELERATION
(g)

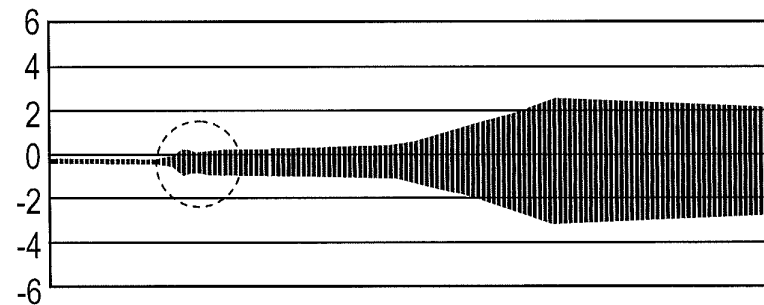


FIG. 8C

Z-AXIS
ACCELERATION
(g)

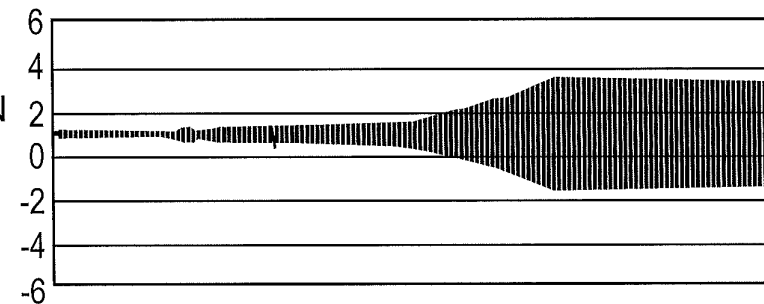


FIG. 8D

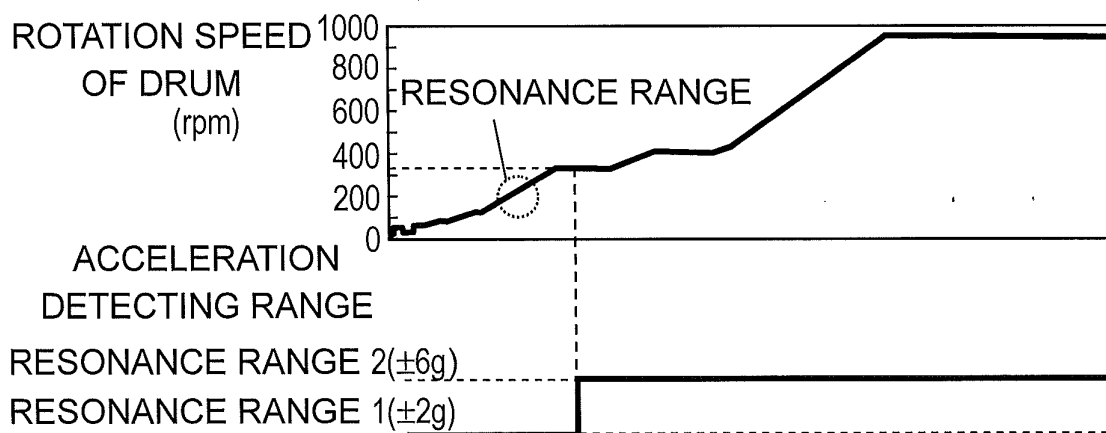


FIG. 9

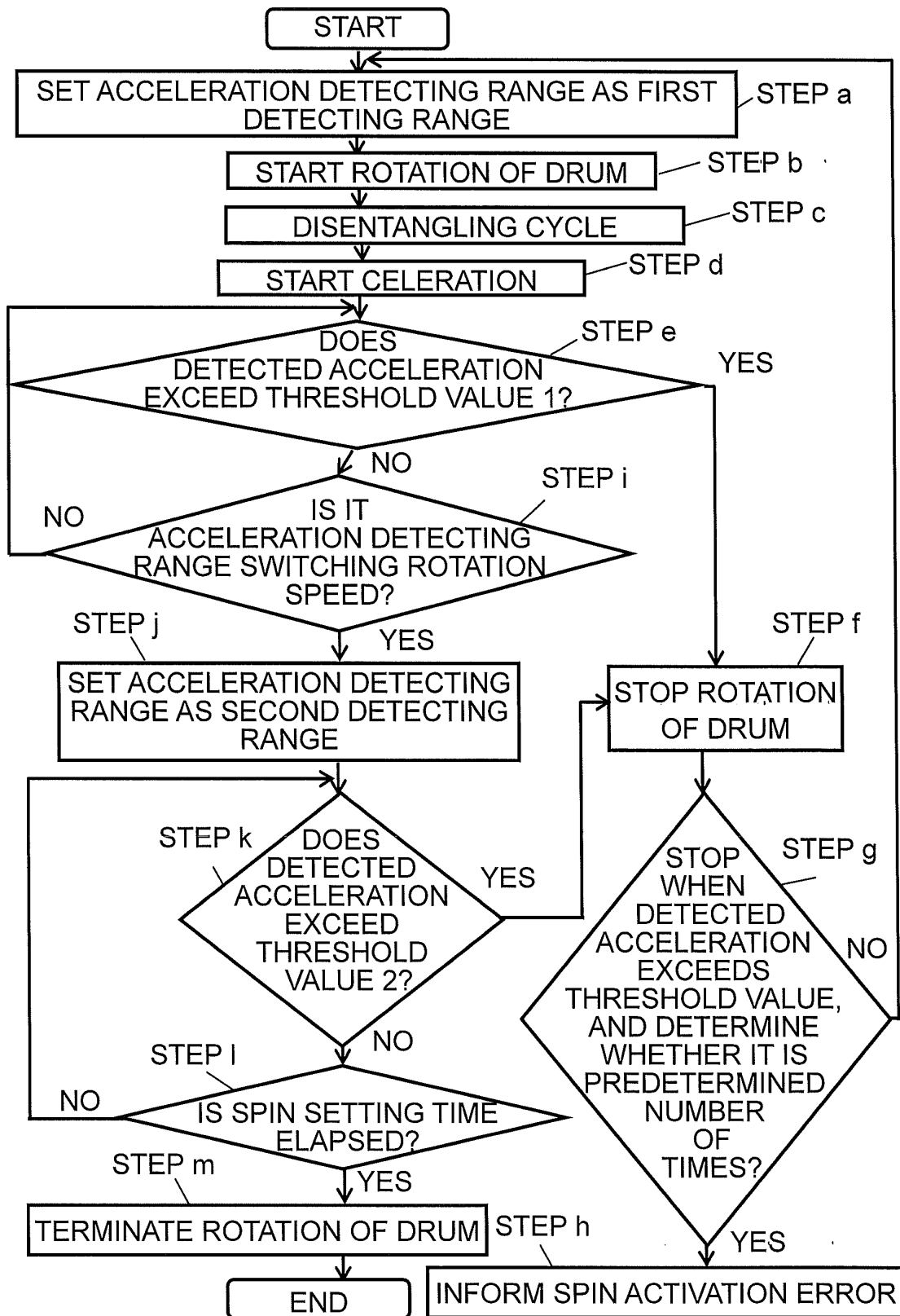
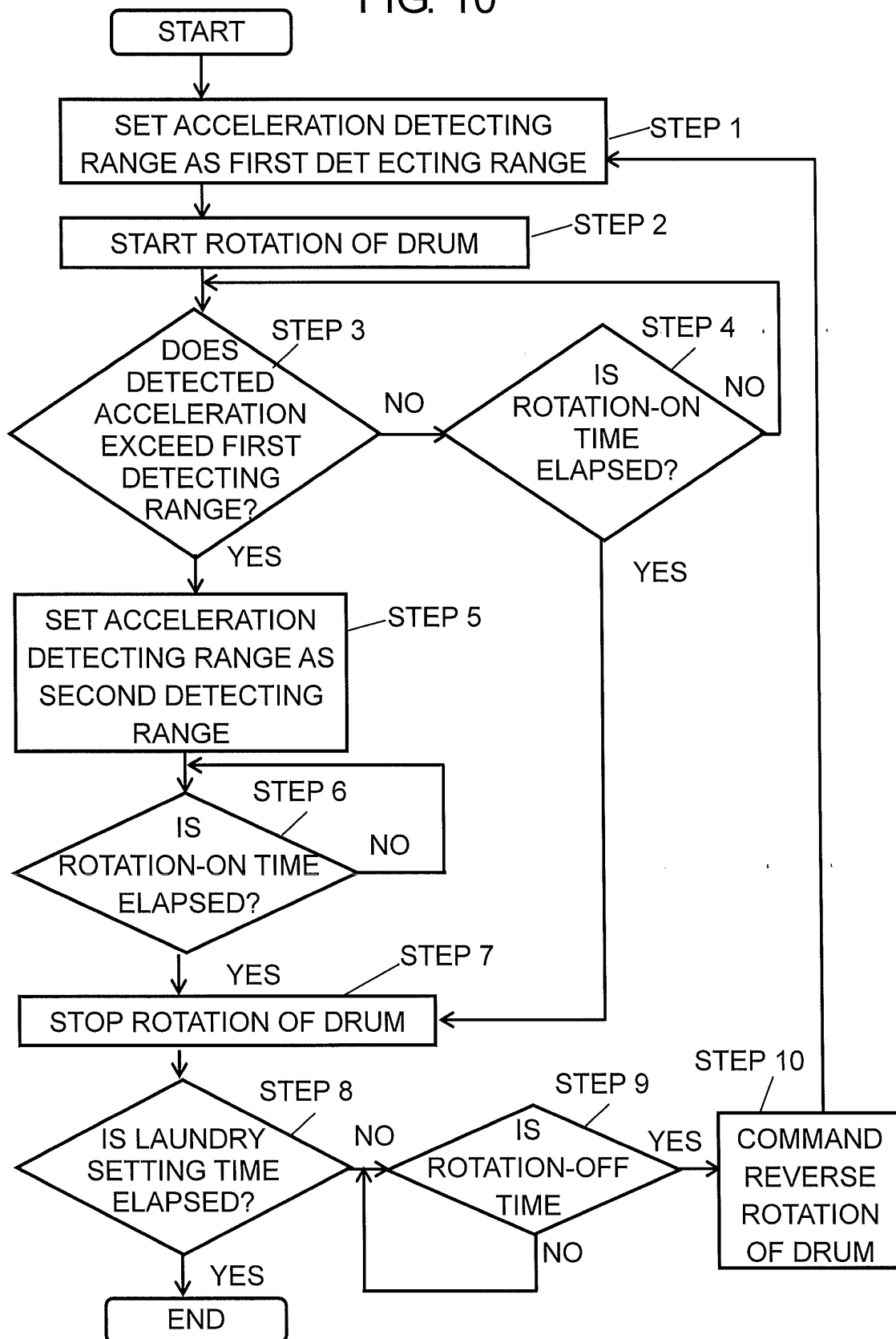


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/004153

A. CLASSIFICATION OF SUBJECT MATTER

D06F33/02 (2006.01) i, D06F23/06 (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, D06F23/06, G01P15/00

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.
Y	JP 2005-296431 A (Star Micronics Co., Ltd.), 27 October, 2005 (27.10.05), Full text; all drawings (Family: none)	1-16
Y	JP 2004-198310 A (Tamagawa Seiki Co., Ltd.), 15 July, 2004 (15.07.04), Full text; all drawings (Family: none)	1-16
Y	JP 2005-274443 A (Star Micronics Co., Ltd.), 06 October, 2005 (06.10.05), Par. No. [0033] (Family: none)	5-8

☐ 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
10 September, 2009 (10.09.09)Date of mailing of the international search report
29 September, 2009 (29.09.09)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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 2005274443 A [0006]