

DESCRIPTION

WASHING MACHINE

5 TECHNICAL FIELD

The present invention relates to a washing machine that performs a series of operation steps such as washing, rinsing, and spin-drying.

BACKGROUND ART

10 A washing machine presented in the conventional art has a balancer device in an upper part of a wash and spin tub to dampen vibration during spin-drying (for example, refer to PTL 1).

A balancer device of a washing machine disclosed in PTL 1 includes an upper annular case and a lower annular case that are welded together and
15 sealed to form an annular body, and has a predetermined quantity of a sealed-liquid inside the annular body. If an imbalance of a load such as clothes in the wash and spin tub makes the tub off balance, the liquid in the annular body moves to a side opposite the out-of-balance clothes. This configuration dampens vibration in the wash and spin tub.

20 The move of the liquid inside the annular body of the balancer device lags behind a rise in rotation speed of the wash and spin tub during spin-drying. In other words, the liquid in the annular body lags 180° behind the out-of-balance load during steady rotation. As a result, the balancer device produces a great effect in vibration damping especially during steady rotation.
25 Thus, according to principles of the art described above, the balancer device produces a greater effect in vibration damping if the annular body is greater in height and radial width.

However, the balancer device is disposed in an upper part of the wash and spin tub. As a result, an outside diameter of the balancer device is limited by a size of the wash and spin tub, and an inside diameter of the balancer device is limited in size in consideration of loading and unloading laundry. A height of the balancer device is limited by a height of the product and a capacity of the wash and spin tub. Consequently, as described below with reference to FIG. 12, a conventional washing machine includes a balancer device having layers of partitioned annular chambers.

FIG. 12 is a perspective opened-up view of a main portion of a balancer device in a conventional washing machine.

As shown in FIG. 12, conventional balancer device 40 is formed of annular body 43 having upper annular case 41 and lower annular case 42.

Upper annular case 41 includes upper division walls 47, 48 disposed concentrically. Lower annular case 42 includes lower division walls 50, 51 contiguous with bottom ends of upper division walls 47, 48.

Upper division walls 47, 48 and lower division walls 50, 51 divide annular body 43 into three layers of annular chambers 44, 45, 46 in a radial direction of the balancer device. A predetermined liquid (not shown) is sealed in annular chambers 44, 45, 46.

Annular chambers 44, 45, 46 have pluralities of respective upper partition walls 49a, 49b, 49c on outer peripheral upper side walls. The partition walls are formed so as to extend radially from the outer peripheral side walls. Airflow vents 53a, 53b, 53c are formed between upper partition walls 49a, 49b, 49c and inner peripheral side walls of respective annular chambers 44, 45, 46 to allow air circulation.

Annular chambers 44, 45, 46 have respective lower partition walls 52a, 52b, 52c on outer peripheral lower side walls. Liquid flow vents 54a, 54b, 54c

are formed between lower partition walls 52a, 52b, 52c and the inner peripheral side walls of respective annular chambers 44, 45, 46 to allow circulation of the liquid sealed in annular chambers 44, 45, 46.

Balancer device 40 having the above-described configuration is
5 mounted in an upper part of a wash and spin tub (not shown) as described above. In response to occurrence of an imbalance in rotation of the wash and spin tub due to out-of-balance laundry in the tub during washing, the liquid in balancer device 40 moves through liquid flow vents 54a, 54b, 54c to a position to reduce the imbalance in rotation. Along with the move of the liquid, air
10 inside annular chambers 44, 45, 46 moves through airflow vents 53a, 53b, 53c in upper annular case 41. This configuration allows the liquid to smoothly move through liquid flow vents 54a, 54b, 54c. This in turn dampens vibration in the wash and spin tub.

Unfortunately, the wash and spin tub in the washing machine having
15 the conventional configuration substantially vibrates when a rotation rate of the wash and spin tub is particularly near a secondary resonance point of 200 r/min to 300 r/min. Simultaneously, the liquid in the balancer device greatly moves. This causes the balancer device to reduce its vibration damping effect.

Citation List

20 Patent Literature

PTL 1: Unexamined Japanese Patent Publication No. H06-79087

SUMMARY OF THE INVENTION

The present invention is intended to provide a washing machine that
25 exhibits a superior vibration damping effect especially when a rotation rate of a wash and spin tub is near a secondary resonance point of 200 r/min to 300 r/min.

A washing machine according to the present invention includes a washing machine body and a water tub supported inside the washing machine body. The water tub is designed for vibration isolation. The washing machine further includes a rotatable wash and spin tub incorporated in the water tub, a
5 motor to rotate the wash and spin tub, a controller to control the motor and sequentially control a series of operation steps made up of washing, rinsing, and spin-drying, and a balancer device disposed in an upper peripheral part of the wash and spin tub. The balancer device has an annular chamber containing a liquid sealed inside of the annular chamber. The annular
10 chamber internally has a plurality of partition walls. Each of the partition walls includes at least an inclined part that extends downward from an outer peripheral side of the annular chamber to an inner peripheral side of the annular chamber. An angle at which the inclined part is inclined relative to a horizontal plane is set to be substantially equal to an angle of the liquid
15 inclined relative to the horizontal plane toward a surface of an outer peripheral side wall of the annular chamber by centrifugal force that is generated at a rotation rate of the wash and spin tub near a secondary resonance point.

This configuration enables the washing machine to exhibit a superior
20 vibration damping effect especially when the rotation rate of the wash and spin tub is, for example, near a secondary resonance point of 200 r/min to 300 r/min.

BRIEF DESCRIPTION OF DRAWINGS

25 FIG. 1 is a longitudinal sectional view of a washing machine according to an exemplary embodiment.

FIG. 2 is a perspective opened-up view of a main portion of a balancer

device in the washing machine.

FIG. 3 is a cross-sectional view of the balancer device in the washing machine taken along a partition wall position.

FIG. 4 is a cross-sectional view of the balancer device in the washing machine in a non-operating state taken along the partition wall position.

FIG. 5 is a cross-sectional view of the balancer device in the washing machine in no-load steady rotation taken along the partition wall position.

FIG. 6 is a cross-sectional view of the balancer device in the washing machine in a secondary resonance state taken along the partition wall position.

FIG. 7 is a characteristic graph showing changes in vibration system amplitude during spin-drying performed by the washing machine.

FIG. 8 is a cross-sectional view of a balancer device in a conventional washing machine of Comparative Example 1 taken along a partition wall position.

FIG. 9 is a characteristic graph showing changes in vibration system amplitude during spin-drying performed by the conventional washing machine of Comparative Example 1.

FIG. 10 is a cross-sectional view of a balancer device in a conventional washing machine of Comparative Example 2 taken along a partition wall position.

FIG. 11 is a characteristic graph showing changes in vibration system amplitude during spin-drying performed by the conventional washing machine of Comparative Example 2.

FIG. 12 is a perspective opened-up view of a main portion of a balancer device in a conventional washing machine.

DESCRIPTION OF EMBODIMENT

Hereinafter, an exemplary embodiment will be described in detail with reference to the drawings as appropriate. However, descriptions in more detail than necessary may be omitted. For example, the detailed description of already well-known matters and the overlap description of substantially identical configurations may be omitted. This is intended to prevent the following description from becoming unnecessarily redundant and to facilitate understanding by those skilled in the art.

Note that the attached drawings and the following description are provided for those skilled in the art to fully understand the present disclosure, and are not intended to limit the subject matter as described in the appended claims.

(Exemplary embodiment)

With reference to FIGS. 1 to 11, a washing machine according to an exemplary embodiment will now be described by structural element.

[1-1. Configuration of washing machine]

With reference to FIG. 1, a configuration of a washing machine according to the exemplary embodiment will be described.

FIG. 1 is a longitudinal sectional view of a washing machine according to the exemplary embodiment.

With reference to FIG. 1, the washing machine according to the exemplary embodiment includes washing machine body 1, upper frame 12, and water tub unit 19 incorporated in washing machine body 1.

Water tub unit 19 includes water tub 3, wash and spin tub 4, balancer device 7, motor 8, and transmission mechanism part 9, and forms a vibration system of the washing machine.

Water tub 3 is suspended and supported by suspension 2 for vibration isolation inside washing machine body 1. Water tub 3 has openable drain

valve 17 at its inner bottom. Drain valve 17 is designed to open during drainage and drain water inside water tub 3 to the outside of the washing machine through drain hose 18.

Rotatable wash and spin tub 4 having a bottomed cylindrical shape is disposed inside water tub 3. Wash and spin tub 4 has many spin-drying holes (not shown) in its side wall. Wash and spin tub 4 has balancer device 7 inside its upper peripheral part to reduce vibration. An inner bottom of wash and spin tub 4 is provided with rotatable agitator 11 for agitating clothes. Agitator 11 agitates clothes inside wash and spin tub 4 by rotation.

An outer bottom of water tub 3 is provided with transmission mechanism part 9. Transmission mechanism part 9 has built-in parts such as a gear (not shown) to reduce speed during washing, a clutch (not shown) to change connection of wash/spin shaft 5, and a brake (not shown) to stop wash and spin tub 4 during spin-drying.

Motor 8 is attached to the outer bottom of water tub 3 and configured to transmit driving force to wash/spin shaft 5. This allows motor 8 to rotate agitator 11 and simultaneously rotate agitator 11 and wash and spin tub 4.

Washing machine body 1 has a control device (not shown) inside. The control device controls motor 8 and other components and sequentially controls a series of operation steps made up of washing, rinsing, and spin-drying.

Upper frame 12 is disposed on an upper part of washing machine body 1. A front part of upper frame 12 is provided with operation display unit 16. Operation display unit 16 displays various settings input by a user and set details.

Upper frame 12 has laundry load unload port 13 in a substantially middle section (including a middle section). Wash and spin tub 4 communicates with the outside of the washing machine via laundry load

unload port 13. Laundry load unload port 13 is covered with openable lid 6.

Lid 6 includes a handle (not shown) and a hinge mechanism (not shown). The user grasps the handle to open or close lid 6. The hinge mechanism enables lid 6 to be bent at a middle part.

5 [1-2. Configuration of balancer device]

Balancer device 7 is disposed inside the upper peripheral part of wash and spin tub 4. Balancer device 7, as described above, corrects an imbalance due to out-of-balance laundry in the tub during washing.

10 With reference to FIG. 2, a configuration of balancer device 7 in a washing machine according to the exemplary embodiment will now be described.

FIG. 2 is a perspective opened-up view of a main portion of balancer device 7 in the washing machine according to the exemplary embodiment.

15 As shown in FIG. 2, balancer device 7 includes upper annular case 31 and lower annular case 32 that are integrated into annular body 30.

Integrated annular body 30 includes annular division wall 35 internally, and annular inner peripheral wall 20 and outer peripheral wall 23 externally. Annular division wall 35 divides annular body 30 into two layers of annular chambers 33, 34 in a radial direction of the balancer device. Annular
20 chambers 33, 34 internally have respective partition walls 36, 37. Partition walls 36, 37 are formed along the radial direction, which extends radially from a center of annular body 30, and are disposed at 24 locations at 15° intervals, for example.

Liquid 38 is sealed in annular chambers 33, 34. Preferably, liquid 38 is
25 an aqueous solution of sodium chloride or calcium chloride in consideration of antifreezing and correction effects. This provides a decrease in price and solidification point, and hence enables the use of the washing machine in cold

climate areas. At the same time, this provides an increased specific gravity (around 1.3). As a result, the balancer device provides an improved capacity for imbalance rectification.

Preferably, a quantity of sealed-in liquid 38 falls within a range of 30% to 70% of an internal capacity of annular chambers 33, 34. This enables the balancer device to more properly maintain the capacity for imbalance rectification. In the present exemplary embodiment, the quantity of sealed-in liquid 38 is set to approximately 55% of the internal capacity of annular chambers 33, 34.

With wash and spin tub 4 rotated, liquid 38 moves inside annular chambers 33, 34 in a direction that reduces an imbalance owing to laundry.

Spaces 21, 22 are formed between partition walls 36, 37 and inner peripheral side walls of respective annular chambers 33, 34 to have annularly communicating paths inside annular chambers 33, 34.

With reference to FIGS. 3 to 5, a configuration of the partition wall inside the annular chamber of the balancer device in the washing machine will now be described.

FIG. 3 is a cross-sectional view of the balancer device in the washing machine taken along a partition wall position. FIG. 4 is a cross-sectional view of the balancer device in the washing machine in a non-operating state taken along the partition wall position. FIG. 5 is a cross-sectional view of the balancer device in the washing machine in no-load steady rotation taken along the partition wall position.

With reference to FIGS. 3, 4, and 5, partition walls 36, 37 include transverse parts 36a, 37a, vertical parts 36b, 37b, inclined parts 36c, 37c, and transverse parts 36d, 37d, respectively.

Transverse parts 36a, 37a are formed in upper parts of annular

chambers 33, 34 so as to extend from outer peripheral-side internal walls to inner peripheral-side internal walls inside annular chambers 33, 34. Transverse parts 36a, 37a provide improved mechanical strength resistant to centrifugal force that is applied to annular chambers 33, 34 in the radial direction. This prevents balancer device 7 from being deformed during rotation of wash and spin tub 4 for spin-drying. This in turn enables stable operation of balancer device 7.

Vertical parts 36b, 37b connect with transverse parts 36a, 37a and are formed so as to extend longitudinally to an extent of respective predetermined heights along an internal wall of outer peripheral wall 23 for annular chambers 33, 34. Inclined parts 36c, 37c are formed so as to extend slantly from lower ends 36b1, 37b1 of vertical parts 36b, 37b to inner peripheral lower positions of predetermined heights H3, H4 above inner bottoms 33a, 34a of annular chambers 33, 34.

An angle at which inclined parts 36c, 37c are inclined relative to a horizontal plane is set to be substantially equal (including equal) to an angle of liquid 38 inclined by centrifugal force that is generated by the rotation of water tub unit 19 at a rate of a secondary resonance point of 200 r/min to 300 r/min. In the present exemplary embodiment, inclined parts 36c, 37c of partition walls 36, 37 are inclined at an angle of substantially 80° (including 80°), for example, relative to the horizontal plane.

Transverse part 36d, a component of partition wall 36, is disposed so as to extend from the internal wall of outer peripheral wall 23 to division wall 35 at a span of predetermined height H3 above inner bottom 33a of annular chamber 33. Similarly, transverse part 37d, a component of partition wall 37, is disposed so as to extend from division wall 35 to an internal wall of inner peripheral wall 20 at a span of predetermined height H4 above inner bottom

34a of annular chamber 34. Transverse parts 36d, 37d, as with transverse parts 36a, 37a, provide improved strength for annular chambers 33, 34.

With reference to FIG. 5, a size relationship between the partition wall and the liquid inside the annular chamber will now be described.

5 As shown in FIG. 5, vertical part 37b of partition wall 37 has width W1 in the radial direction of the balancer device. Liquid 38 sealed in annular chamber 34 has width W2 in the radial direction during no-load steady rotation of wash and spin tub 4 for spin-drying. Specifically, liquid 38 has width W2 while liquid 38 in a substantially perpendicular form (including a
10 perpendicular form) is clinging to an internal surface of division wall 35 by centrifugal force.

In the present exemplary embodiment, width W1 of vertical part 37b of partition wall 37 is specified such that $W1 = (W2)/2$. This enables vertical part 37b to act as a resistance against rotating movement of liquid 38 inside
15 annular chamber 34. In other words, vertical part 37b serves to hinder the movement of liquid 38 so as to retain the liquid between radially disposed partition walls 37 and keep liquid 38 stable while no imbalance exists in the tub. This configuration averts the creation of instability of water tub unit 19 resulting from moving liquid 38. A size relationship between vertical part 36b
20 of partition wall 36 and the liquid inside annular chamber 33 is similar to the relationship described above, and hence no description of that is given.

In the present exemplary embodiment, as shown in FIG. 4, height H2 of annular chambers 33, 34 inside balancer device 7 is set to 70 mm. An inside diameter of balancer device 7 (a distance from a rotation center of balancer
25 device 7 to an external surface of inner peripheral wall 20 of annular body 30) is set to 404 mm. An outside diameter of the balancer device (a distance from the rotation center of balancer device 7 to an external surface of outer

peripheral wall 23 of annular body 30) is set to 470 mm. In other words, a radial width of annular body 30 (a distance from the external surface of inner peripheral wall 20 to the external surface of outer peripheral wall 23) is set to 33 mm.

5 With reference to FIGS. 4 and 5, an identical quantity of liquid 38 is sealed in each of annular chambers 33, 34. In other words, height H1 of a level of liquid 38 above height H3 of transverse part 36d of partition wall 36 in annular chamber 33 is set to 20 mm. Similarly, height H1 of a level of liquid 38 above height H4 of transverse part 37d of partition wall 37 in annular
10 chamber 34 is set to 20 mm. This configuration prevents liquid 38 from flowing through spaces 21, 22 in a direction toward a location of an imbalance when wash and spin tub 4 is in a secondary resonance state. This averts generation of a strong vibration from water tub unit 19.

[1-3. Operation and effects]

15 With reference to FIGS. 6 and 7, the operation and effects of a front-loading type washing machine having the configuration described above will now be described.

In response to spin-drying rotation of wash and spin tub 4 equipped with balancer device 7, liquid 38 flows through spaces 21, 22 in annular
20 chambers 33, 34. Liquid 38 moves to a position (a position opposed to the location of an imbalance) to reduce an imbalance owing to laundry in water tub unit 19. This helps the vibration system to restore balance and lets the balancer device reduce out-of-balance vibration.

FIG. 6 is a cross-sectional view of the balancer device in the washing
25 machine in a secondary resonance state taken along a partition wall position. FIG. 7 is a characteristic graph showing changes in vibration system amplitude during spin-drying performed by the washing machine.

As shown in FIG. 7, rotation speed at which wash and spin tub 4 operates spin-drying increases from a stop state at the start of operation. Along with a rise in rotation speed, water tub unit 19, the vibration system of the washing machine, increases in both longitudinal amplitude and transverse amplitude.

In the present exemplary embodiment, as shown in FIG. 3, partition wall 36 in annular chamber 33 has an inclined part that extends downward at an angle of substantially 80° (including 80°) from the internal wall of outer peripheral wall 23 to division wall 35 of annular body 30. Similarly, partition wall 37 in annular chamber 34 has an inclined part that extends downward at an angle of substantially 80° (including 80°) from division wall 35 to an internal surface of inner peripheral wall 20 of annular body 30. This provides spaces 21, 22 formed even for lower portions of partition walls 36, 37 (corresponding to inclined parts 36c, 37c). Thus, while wash and spin tub 4 is switching from a stop state to the start of rotation, liquid 38 flows through spaces 21, 22. As a result, liquid 38 efficiently moves to a position opposed to the location of an imbalance.

The speed of rotation of wash and spin tub 4 increases and then reaches a rotation speed of 200 r/min to 300 r/min, which is a secondary resonance point for water tub unit 19. Generally, in a neighborhood of the secondary resonance point, liquid 38 moves inside balancer device 7 substantially 90° (including 90°) behind an imbalance. However, water tub unit 19 greatly vibrates in the neighborhood of the secondary resonance point. Consequently, liquid 38 moves inside each of annular chambers 33, 34 in a direction toward the location of the imbalance. This reduces the vibration damping effect of balancer device 7.

To resolve this problem, partition walls 36, 37 in balancer device 7

according to the present exemplary embodiment are formed, as shown in FIG. 6, such that inclined parts 36c, 37c are inclined at an angle comparable to an inclination of liquid 38 that is produced by centrifugal force in the neighborhood of the secondary resonance point toward the outer peripheral side. When wash and spin tub 4 is in a secondary resonance state, the configuration described above prevents liquid 38 from flowing through spaces 21, 22 in a direction toward the location of an imbalance. This averts generation of a strong vibration from water tub unit 19.

The speed of rotation of wash and spin tub 4 further increases from that in the secondary resonance state and then reaches a state in which wash and spin tub 4 rotates steadily. In the description herein, this state is referred to as a "steady state" for convenience sake.

In a steady state, liquid 38, as shown in FIG. 5, is in a substantially perpendicular shape (including a perpendicular shape) and clings both to the internal surface of outer peripheral wall 23 for annular chamber 33 and to the internal surface of division wall 35 for annular chamber 34. In this state, according to the present exemplary embodiment, widths W1 of vertical parts 36b, 37b of partition walls 36, 37 are approximately a half of respective widths W2 of clinging liquid 38 in annular chambers 33, 34.

In other words, if an imbalance exists in water tub unit 19 in a steady state, liquid 38 in annular chambers 33, 34 moves to a side opposite the imbalance in water tub unit 19. This corrects the imbalance in water tub unit 19 and thereby dampens out-of-balance vibration.

Meanwhile, if no huge imbalance exists in water tub unit 19 in a steady state, transverse parts 36a, 37a, vertical parts 36b, 37b, inclined parts 36c, 37c, and transverse parts 36d, 37d serve as a resistance against the rotating movement of liquid 38 in a circumferential direction. This reduces

vibration in water tub unit 19 associated with the movement of liquid 38.

In other words, vertical parts 36b, 37b having widths as described above enable the movement of liquid 38 if an imbalance exists in a steady state. At the same time, vertical parts 36b, 37b limit the movement of liquid 38 if no
5 huge imbalance exists.

As described above, balancer device 7 in the washing machine according to the present exemplary embodiment provides an improved vibration damping effect as shown in FIG. 7 irrespective of the rotation speed of wash and spin tub 4.

10 [1-4. Comparison with conventional configuration]

With reference to Comparative Example 1 and Comparative Example 2 shown in FIGS. 8 to 11, differences in action and effect between balancer device 7 of the present exemplary embodiment and a balancer device of a conventional configuration will now be described.

15 FIGS. 8 to 11 are drawings illustrating workability for laundry loading and unloading and vibration reduction effect provided by a washing machine of the present exemplary embodiment in comparison with a conventional washing machine.

[1-4-1. Comparison with balancer device of Comparative Example 1]

20 First, with reference to FIGS. 8 and 9, differences in action and effect between balancer device 7 of the present exemplary embodiment and a conventional balancer device shown in Comparative Example 1 will be described.

FIG. 8 is a cross-sectional view of a balancer device taken along a
25 partition wall position in a conventional washing machine shown as Comparative Example 1. FIG. 9 is a characteristic graph showing changes in vibration system amplitude during spin-drying in the Comparative Example.

As shown in FIG. 8, balancer device 107 of Comparative Example 1, in common with balancer device 7 of the present exemplary embodiment, has an inside diameter of 404 mm and an outside diameter of 470 mm, with a radial width of annular body 135 set to 33 mm and internal height H2 of annular chambers 133, 134 set to 70 mm. Meanwhile, distance H1 from liquid level 38a of liquid 38 to lower ends of upper portions 136a, 137a of partition walls 136, 137 is set to 5 mm.

In other words, an inner peripheral-side height of partition walls 136, 137 in Comparative Example 1 is formed so as to be higher than inner peripheral-side heights of partition walls 36, 37 in balancer device 7 of the present exemplary embodiment shown in FIG. 4. This results in a narrow channel for liquid 38 flowing circumferentially in annular chambers 133, 134.

Thus, as shown in FIG. 9, correction made by the balancer device to each vibration system amplitude is delayed if an imbalance is created by out-of-balance laundry after a start of spin-drying. Even if the rotation speed of wash and spin tub 4 increases and reaches a spin-drying rotation speed of 200 r/min to 300 r/min, i.e., a secondary resonance point for water tub unit 19, liquid 38 cannot smoothly move to a position opposite the imbalance (a delay of 180°). Specifically, liquid 38 can move to a position only about 120° to 150° behind the imbalance, for example. This, as shown in FIG. 9, results in increased amplitude of each component of water tub unit 19.

[1-4-2. Comparison with balancer device of Comparative Example 2]

Next, with reference to FIGS. 10 and 11, differences in action and effect between balancer device 7 of the present exemplary embodiment and a conventional balancer device shown in Comparative Example 2 will be described.

FIG. 10 is a cross-sectional view of a balancer device taken along a

partition wall position in a conventional washing machine shown as Comparative Example 2. FIG. 11 is a characteristic graph showing changes in vibration system amplitude during spin-drying in the Comparative Example.

As shown in FIG. 10, balancer device 207 of Comparative Example 2, in common with balancer device 7 of the first exemplary embodiment, has an outside diameter of 470 mm, with internal height H2 of annular chambers 233, 234 set to 70 mm. Meanwhile, balancer device 207 has an inside diameter of 381 mm, with a radial width of annular body 235 set to 44.5 mm. Distance H1 from liquid level 38a of liquid 38 to inner peripheral-side lower ends of upper portions 236a, 237a of partition walls 236, 237 is set to 5 mm.

In other words, balancer device 207 of Comparative Example 2 is similar to the balancer device of Comparative Example 1 in distance H1 from liquid level 38a to lower ends of the upper portions 236a, 237a of partition walls 236, 237. Meanwhile, the inside diameter (381 mm) of balancer device 207 is smaller than the inside diameter (404 mm) in Comparative Example 1 shown in FIG. 7, so that annular body 235 has an increased radial width of 44.5 mm. Thus, a channel for liquid 38 in Comparative Example 2 is wider than the channel for liquid 38 in Comparative Example 1. This enables liquid 38 to smoothly move in the wide channel after a start of spin-drying. This also enables liquid 38 to smoothly move to a position opposite an imbalance (a delay of 180°) when the rotation speed of wash and spin tub 4 increases and reaches a spin-drying rotation speed of 200 r/min. As a result, as shown in FIG. 11, the balancer device provides an improved vibration damping effect at a secondary resonance point.

However, balancer device 207 of Comparative Example 2, as described above, has a decreased inside diameter of 381 mm. This configuration lowers the workability for loading and unloading laundry into and from wash and

spin tub 4 because the workability is determined by the inside diameter. In particular, this configuration makes it difficult to load and unload a blanket, a sheet, or any large laundry.

In comparison with the balancer device of Comparative Example 2,
5 balancer device 7 of the present exemplary embodiment provides a large inside diameter for wash and spin tub 4 as shown in FIG. 4. This configuration contributes to improvement in the workability for loading and unloading even large laundry.

In other words, in contrast to Comparative Examples 1 and 2, balancer
10 device 7 in the washing machine of the present exemplary embodiment offers improvement both in the workability for laundry loading and unloading and vibration damping effect.

As described above, the exemplary embodiment has been described to illustrate the technique disclosed in the present application. The technique in
15 the present disclosure, however, can be applied to any exemplary embodiment to which modification, replacement, addition, omission, or the like are made, other than the foregoing exemplary embodiment.

In the exemplary embodiment described above, partition walls 36, 37 are formed radially and are disposed at 24 locations at 15° intervals inside
20 annular chambers 33, 34, respectively, for example. However, a configuration of the annular chambers is not limited to this example. Partition walls 36, 37 may be formed at 36 locations at 10° intervals or at 12 locations at 30° intervals, for example.

In the exemplary embodiment described above, widths W1 of vertical
25 parts 36b, 37b of partition walls 36, 37 are approximately a half (including a half) of respective widths W2 of liquid 38 having a substantially perpendicular form (including a perpendicular form) and clinging to outer peripheral-side

wall surfaces of annular chambers 33, 34 by centrifugal force during no-load steady rotation of wash and spin tub 4. However, the relationship between the widths is not limited to this example. The relationship between the widths may be $W1 = (W2)/3$, or $W1 = (2 \times W2)/3$, for example.

5 In the exemplary embodiment described above, inclined parts 36c, 37c of partition walls 36, 37 are formed so as to extend from lower ends 36b1, 37b1 of vertical parts 36b, 37b to the positions of predetermined heights H3, H4 above inner bottoms 33a, 34a of annular chambers 33, 34. However, a configuration of the inclined parts is not limited to this example. In other
10 words, inclined parts 36c, 37c may be formed so as to extend to inner bottoms 33a, 34a, for example, other than to the positions of predetermined heights H3, H4 above inner bottoms 33a, 34a of annular chambers 33, 34, with proviso that inclined parts 36c, 37c are inclined at an angle comparable to an inclination of liquid 38 that is tilted by wash and spin tub 4 in a secondary resonance state.

15 In the exemplary embodiment described above, partition walls 36, 37 include transverse parts 36a, 37a, vertical parts 36b, 37b, inclined parts 36c, 37c, and transverse parts 36d, 37d, respectively. However, a configuration of the partition walls is not limited to this example. Partition walls 36, 37 may not particularly include transverse parts 36a, 37a, vertical parts 36b, 37b, and
20 transverse parts 36d, 37d, with proviso that the partition walls include inclined parts 36c, 37c, respectively. In this case, it is preferable that annular body 30 of balancer device 7 has dimensions or is made of a component or a material so as to possess satisfactory mechanical strength against centrifugal force generated by the rotation of wash and spin tub 4.

25 In the exemplary embodiment described above, balancer device 7 has two layers of annular chambers 33, 34 in the radial direction. However, a configuration of the balancer device is not limited to this example. The

balancer device may have one layer of an annular chamber, or three or more layers of annular chambers, for example. A balancer device having one layer of an annular chamber shows less vibration damping effect than that having two layers of annular chambers, but produces a vibration damping effect adequate
5 for a washing machine that provides a small space. Meanwhile, a balancer device having three layers of annular chambers provides a further improved vibration damping effect.

The above exemplary embodiment is an illustration of the technique of the present disclosure. Therefore, various changes, replacements, additions, or
10 omissions may be made to the exemplary embodiment within the scope of claims or their equivalents.

As described above, a washing machine according to the present invention includes a washing machine body and a water tub supported inside the washing machine body. The water tub is designed for vibration isolation.
15 The washing machine further includes a rotatable wash and spin tub incorporated in the water tub, a motor to rotate the wash and spin tub, a controller to control the motor and sequentially control a series of operation steps made up of washing, rinsing, and spin-drying, and an annular balancer device disposed in an upper peripheral part of the wash and spin tub. The
20 balancer device is airtight. The balancer device has an annular chamber containing a liquid sealed inside of the annular chamber. The annular chamber internally has a plurality of partition walls. Each of the partition walls includes at least an inclined part that extends downward from an outer peripheral side of the annular chamber to an inner peripheral side of the
25 annular chamber. An angle at which the inclined part is inclined relative to a horizontal plane is set to be substantially equal to an angle of the liquid inclined relative to the horizontal plane toward the outer peripheral side of the

annular chamber by centrifugal force that is generated at a rotation rate of the wash and spin tub near a secondary resonance point. This configuration enables the washing machine to exhibit a superior vibration damping effect especially when the rotation rate of the wash and spin tub is, for example, near
5 a secondary resonance point of 200 r/min to 300 r/min.

In the washing machine according to the present invention, each of the partition walls may further include a vertical part connecting with the inclined part and extending substantially longitudinally. This configuration hinders the movement of liquid in the annular chamber while no imbalance exists in
10 the washing machine. This averts the creation of instability of the wash and spin tub resulting from an unsteady continuous movement of the liquid.

In the washing machine according to the present invention, a radial width of the vertical part may be set to substantially a half of a radial width of the liquid clinging to the outer peripheral side of the annular chamber by
15 centrifugal force during no-load steady rotation of the wash and spin tub. This configuration enables the movement of the liquid if an imbalance exists during steady rotation of the wash and spin tub. This configuration can also limit the movement of the liquid if no huge imbalance exists.

In the washing machine according to the present invention, each of the
20 partition walls may further include a transverse part connecting with the vertical part and extending from the outer peripheral side to the inner peripheral side of the annular chamber. This configuration provides improved strength resistant to centrifugal force that is applied to an annular body of the balancer device.

25 In the washing machine according to the present invention, the balancer device may have a plurality of the annular chambers layered in a radial direction, the annular chambers each being the annular chamber. This

allows the liquid to be sealed in a plurality of the annular chambers layered. This configuration enables the washing machine to provide a further improved vibration damping effect.

5 INDUSTRIAL APPLICABILITY

In a washing machine according to the present invention, a balancer device internally has a partition wall that includes a portion inclined at an angle comparable to an inclination of internal liquid in a secondary resonance state. This technique is useful for washing machine applications such as front-loading type washing machines having balancer devices that need to suit requirements for the workability for laundry loading and unloading and vibration damping effect.

REFERENCE MARKS IN THE DRAWINGS

- 15 1: washing machine body
- 2: suspension
- 3: water tub
- 4: wash and spin tub
- 5: wash/spin shaft
- 20 6: lid
- 7, 40, 107, 207: balancer device
- 8: motor
- 9: transmission mechanism part
- 11: agitator
- 25 12: upper frame
- 13: laundry load unload port
- 16: operation display unit

	17: drain valve
	18: drain hose
	19: water tub unit
	20: inner peripheral wall
5	21,22: space
	23: outer peripheral wall
	30, 43, 135, 235: annular body
	31, 41: upper annular case
	32, 42: lower annular case
10	33, 34, 44, 45, 46, 133, 134, 233, 234: annular chamber
	33a, 34a: inner bottom
	35: division wall
	36, 37, 136, 137, 236, 237: partition wall
	36a, 37a, 36d, 37d: transverse part
15	36b, 37b: vertical part
	36b1, 37b1: lower end
	36c, 37c: inclined part
	38: liquid
	38a: liquid level
20	47, 48: upper division wall
	49a, 49b, 49c: upper partition wall
	50, 51: lower division wall
	52a, 52b, 52c: lower partition wall
	53a, 53b, 53c: airflow vent
25	54a, 54b, 54c: liquid flow vent
	136a, 137a, 236a, 237a: lower end of upper portion

CLAIMS

1. A washing machine comprising:

a washing machine body;

5 a water tub supported inside the washing machine body, the water tub being designed for vibration isolation;

a rotatable wash and spin tub incorporated in the water tub;

a motor to rotate the wash and spin tub;

10 a controller to control the motor and sequentially control a series of operation steps made up of washing, rinsing, and spin-drying; and

a balancer device disposed in an upper peripheral part of the wash and spin tub,

wherein the balancer device has an annular chamber containing a liquid sealed inside of the annular chamber,

15 the annular chamber internally has a plurality of partition walls,

each of the partition walls includes at least an inclined part that extends downward from an outer peripheral side of the annular chamber to an inner peripheral side of the annular chamber, and

20 an angle at which the inclined part is inclined relative to a horizontal plane is set to be substantially equal to an angle of the liquid inclined relative to the horizontal plane toward a surface of an outer peripheral side wall of the annular chamber by centrifugal force that is generated at a rotation rate of the wash and spin tub near a secondary resonance point.

25 2. The washing machine according to claim 1, wherein each of the partition walls further includes a vertical part connecting with the inclined part and extending substantially longitudinally.

3. The washing machine according to claim 2, wherein a radial width of the vertical part is set to substantially a half of a radial width of the liquid clinging to the outer peripheral side wall of the annular chamber by
5 centrifugal force during no-load steady rotation of the wash and spin tub.

4. The washing machine according to either claim 2 or 3, wherein each of the partition walls further includes a transverse part connecting with the vertical part and extending from the outer peripheral side wall of the annular
10 chamber to an inner peripheral side wall of the annular chamber.

5. The washing machine according to claim 1, wherein the balancer device has a plurality of the annular chambers layered in a radial direction, the annular chambers each being the annular chamber.