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Clark et al.

(54) **DAMPING SYSTEM FOR A HOUSEHOLD APPLIANCE**

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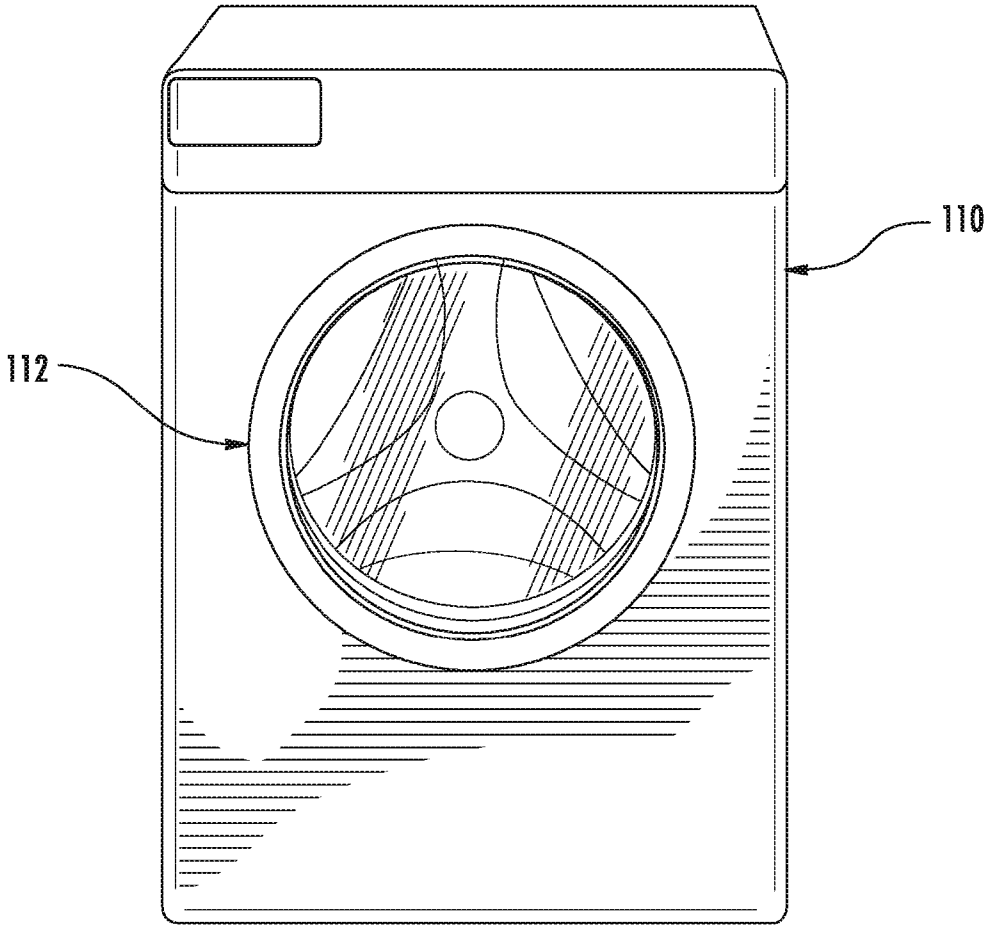
(57) **ABSTRACT**

A household appliance includes a housing having a door, a washing unit inside the housing and including a tub having a rotatable drum for receiving laundry, and a suspension system movably supporting the washing unit and including a first and second damper coupled between the tub and the housing, the first and second dampers being arranged symmetrically on opposite sides of the tub and at a substantially equal distance from a second plane extending through the center of the housing, and a third damper coupled between the tub and the housing at a mounting point that is offset a predetermined distance from at least one of a first plane, the second plane, and a third plane, and wherein an axis of the third damper is in a plane that is offset from and parallel to the second plane.



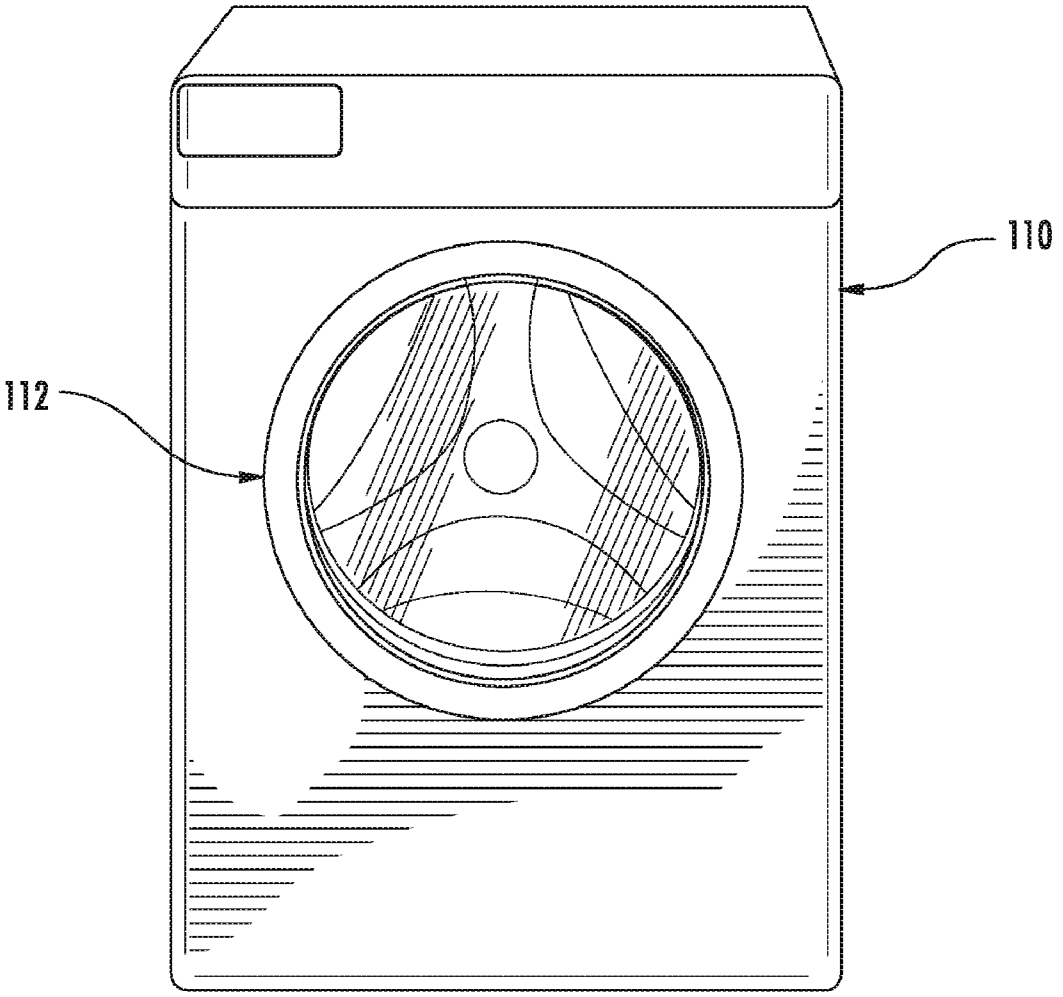
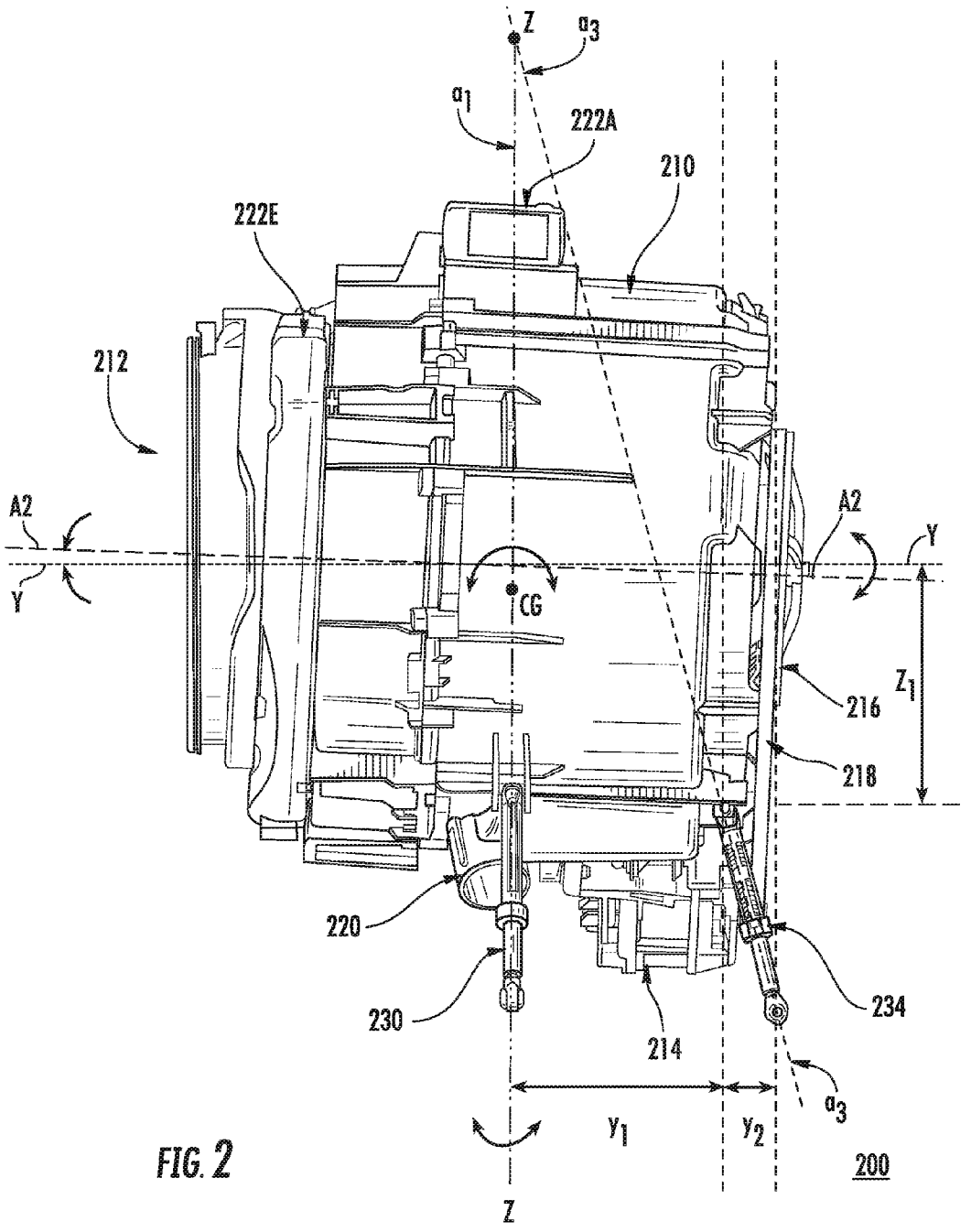


FIG. 1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222E
212
A2
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Z_1
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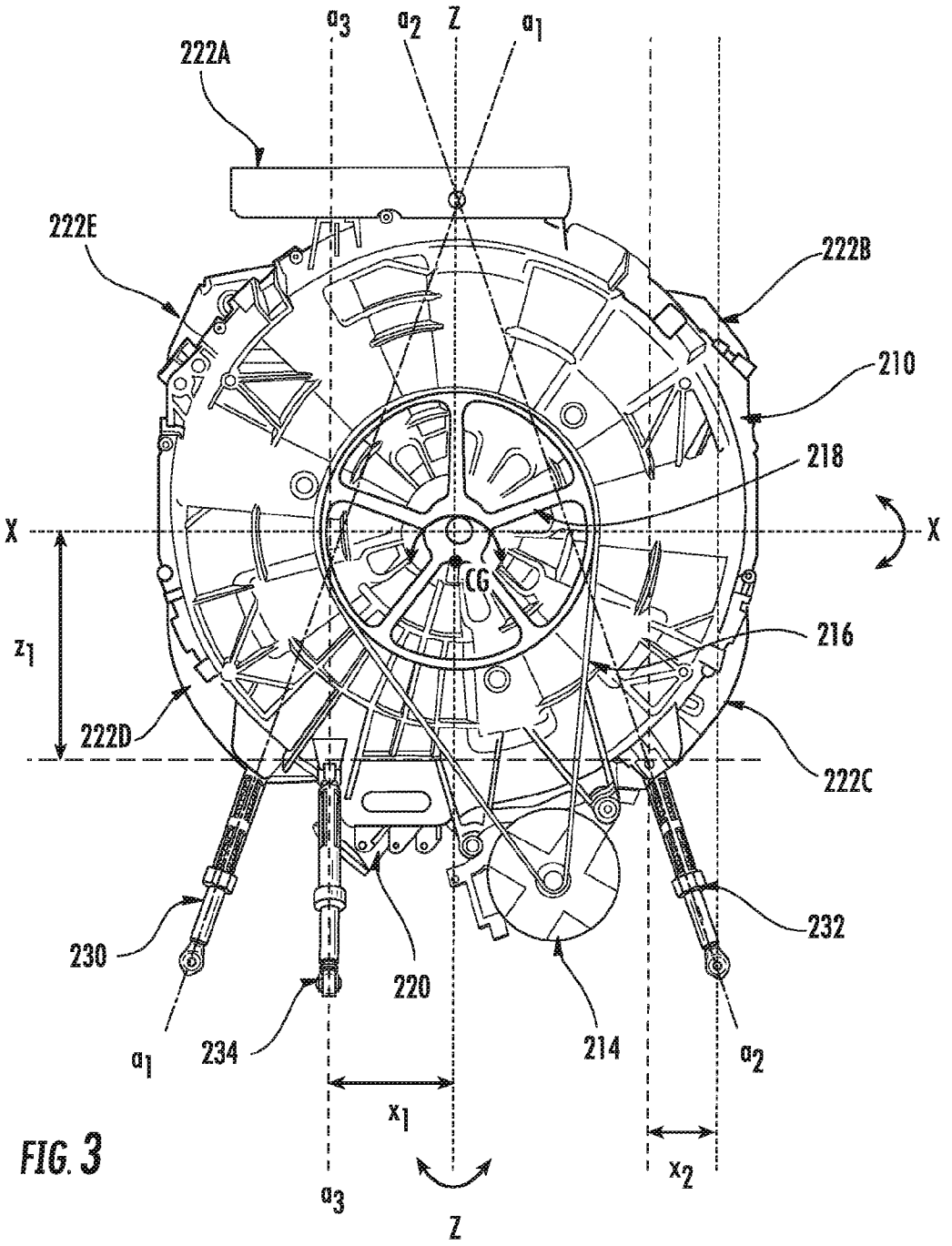
y_1
y_2
200
Z

FIG. 2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X
X
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222D
222C
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234
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a2
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a3
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FIG. 3

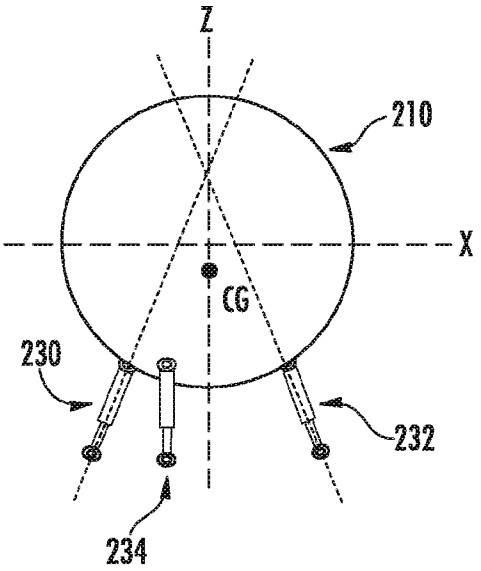

FIG. 4A

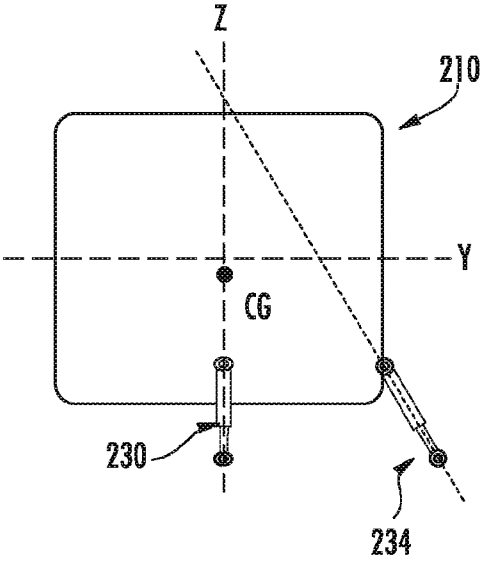

FIG. 4B

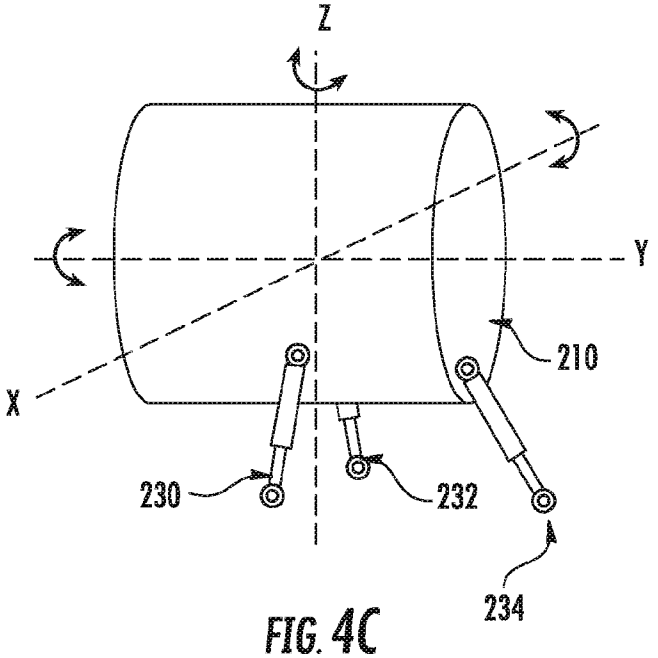

FIG. 4C

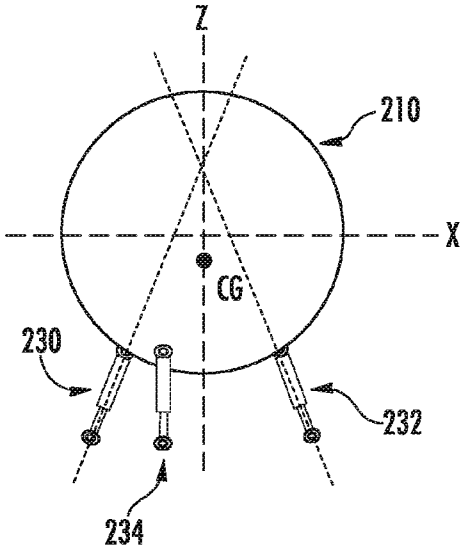

FIG. 5A

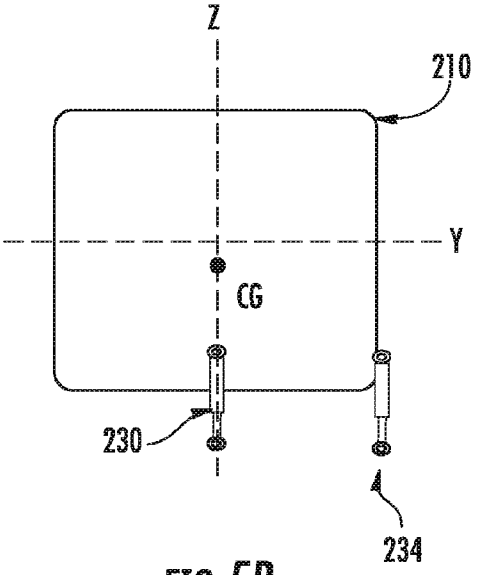

FIG. 5B

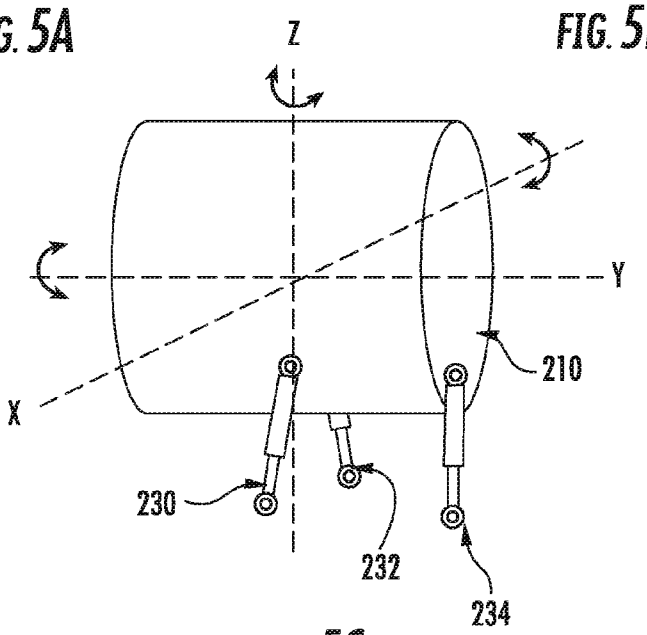

FIG. 5C

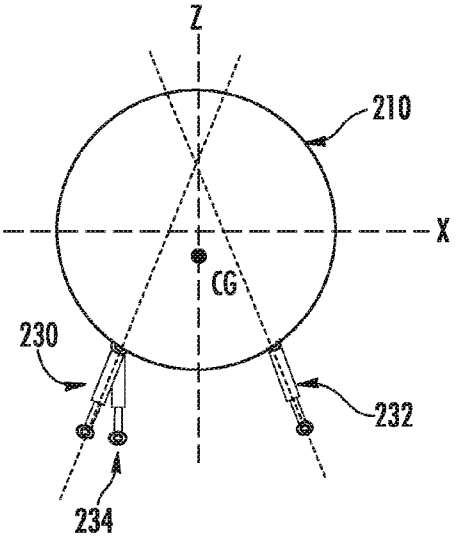

FIG. 6A

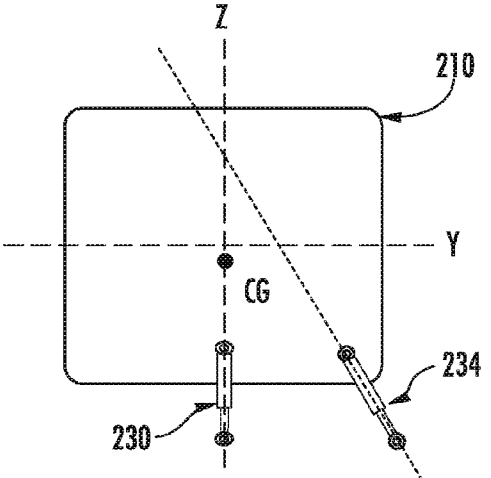

FIG. 6B

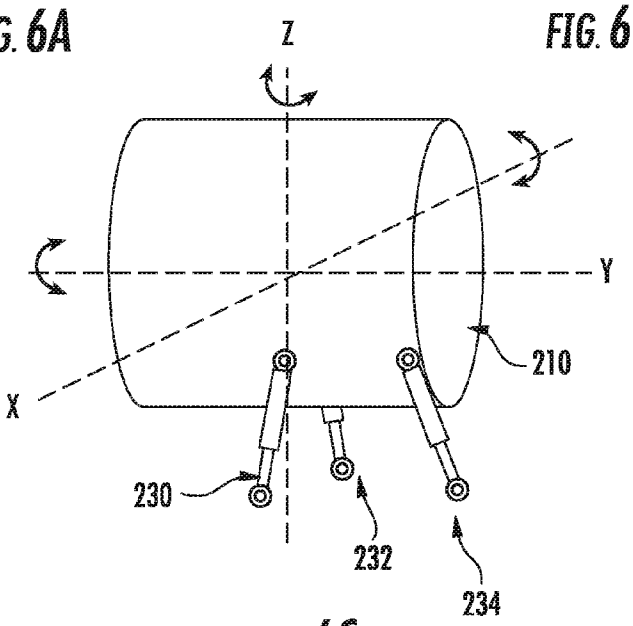

FIG. 6C

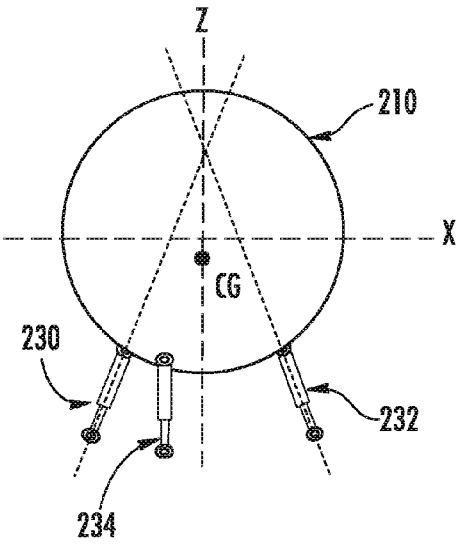

FIG. 7A

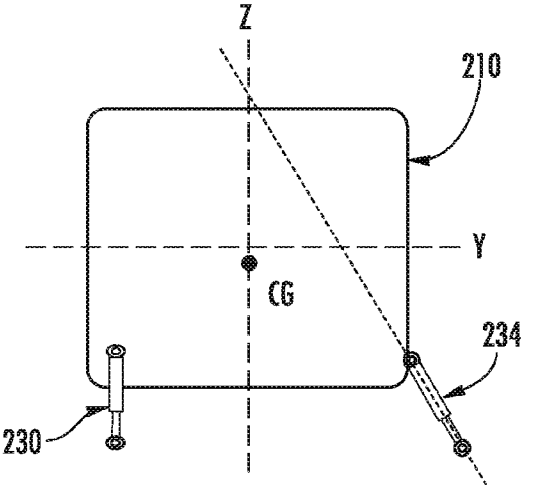

FIG. 7B

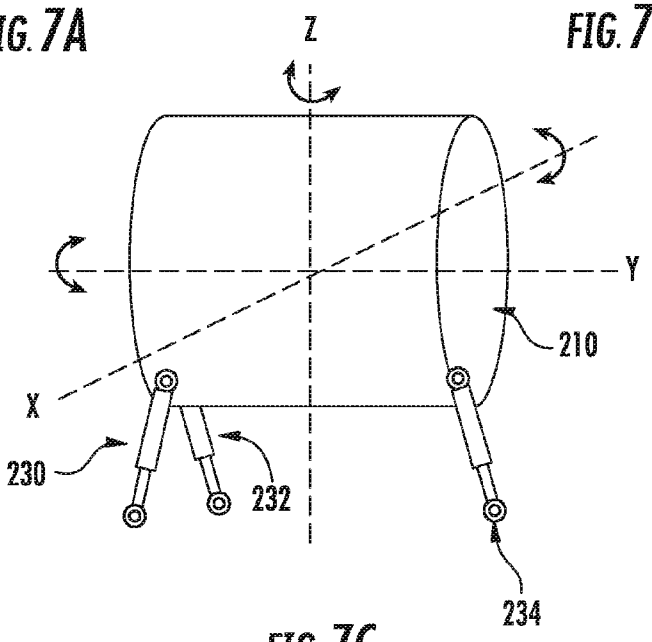

FIG. 7C

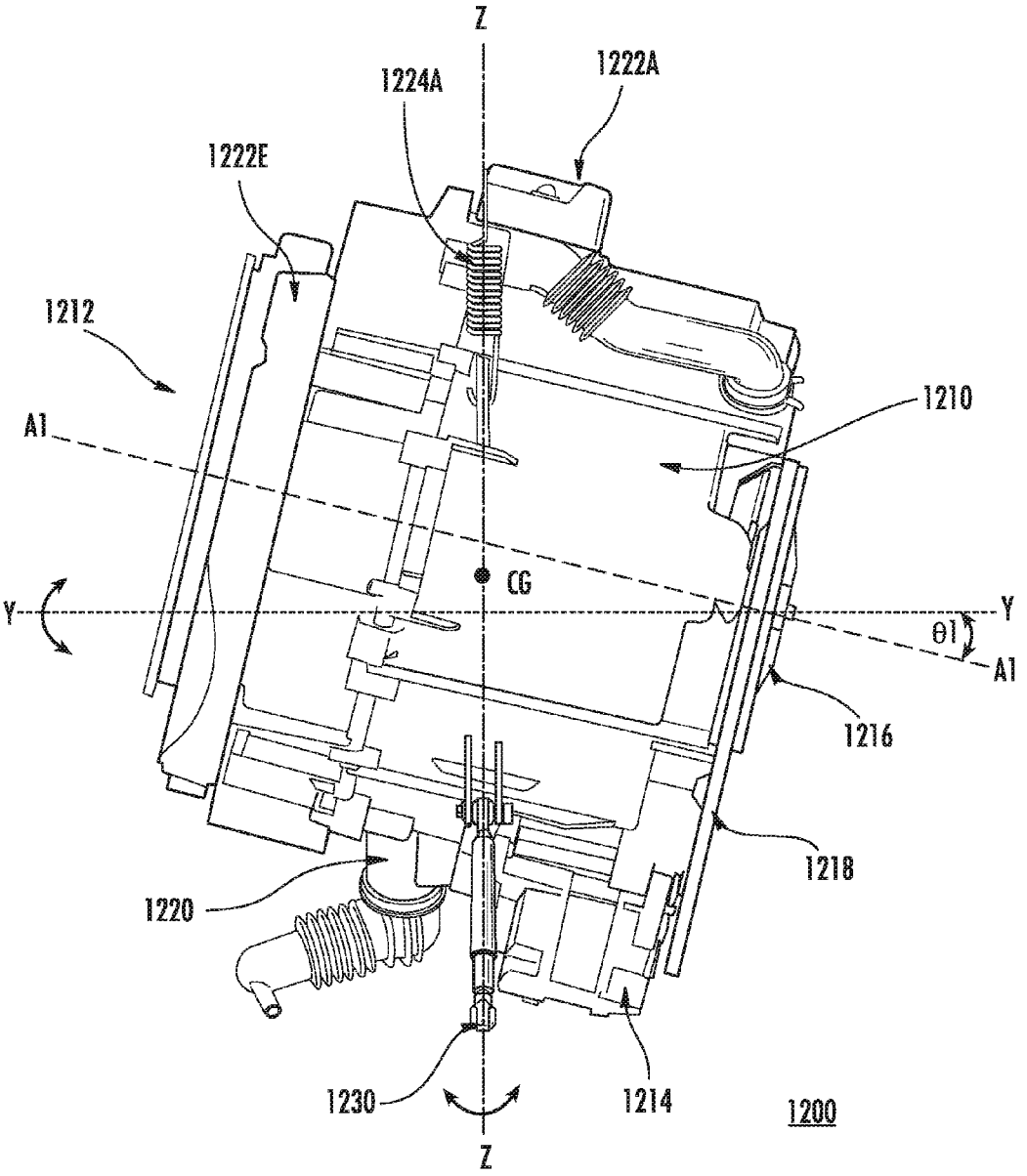

FIG. 8
CONVENTIONAL ART

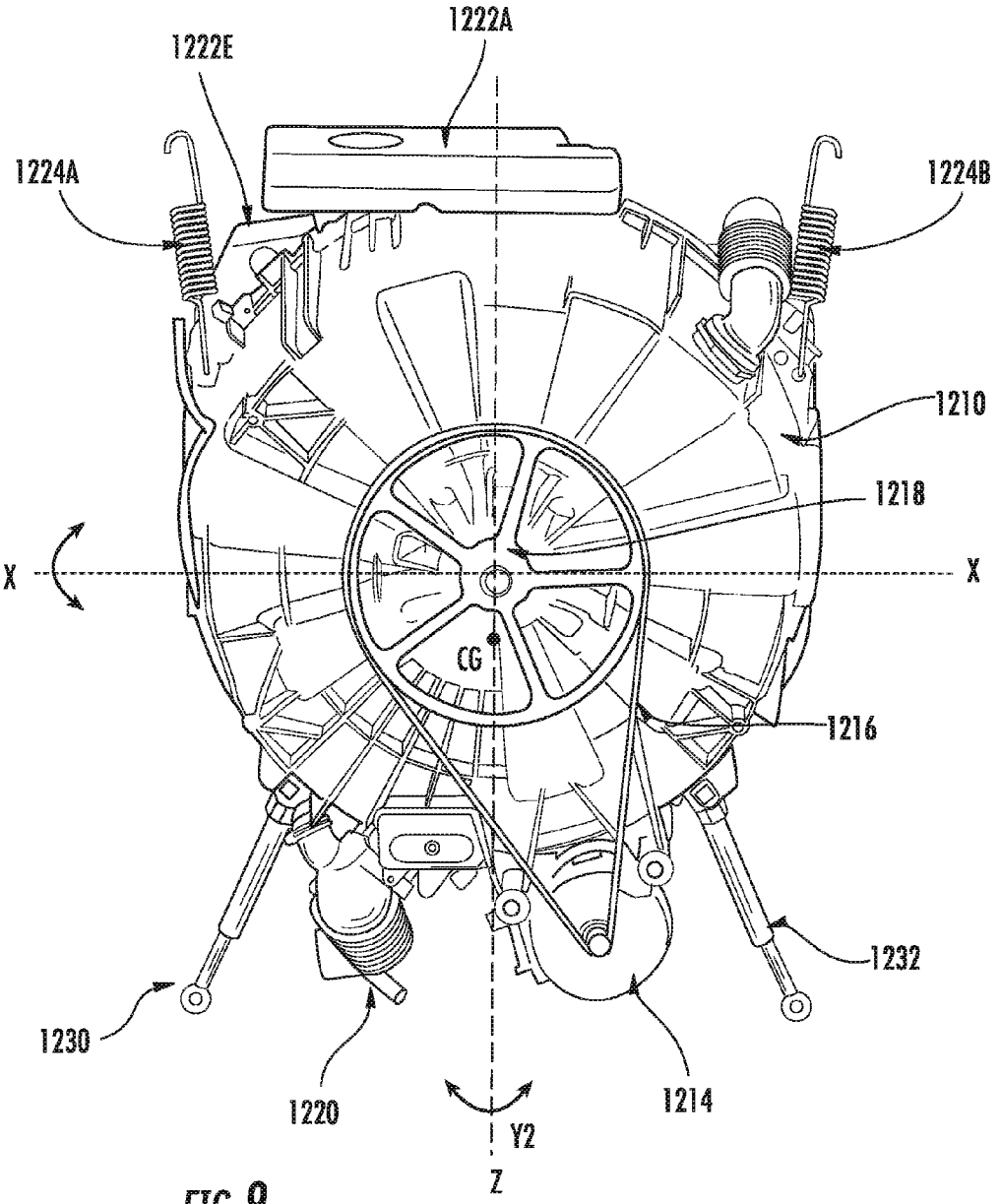

FIG. 9
CONVENTIONAL ART

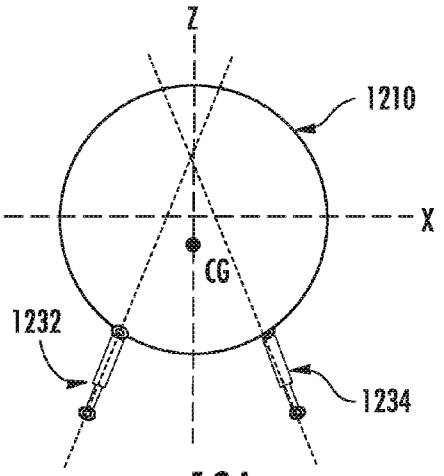

FIG. 10A
CONVENTIONAL ART

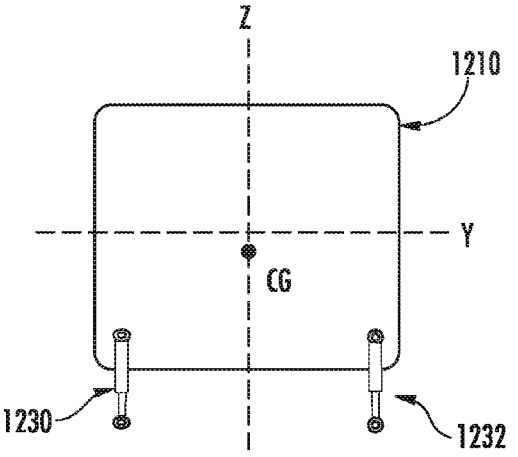

FIG. 10B
CONVENTIONAL ART

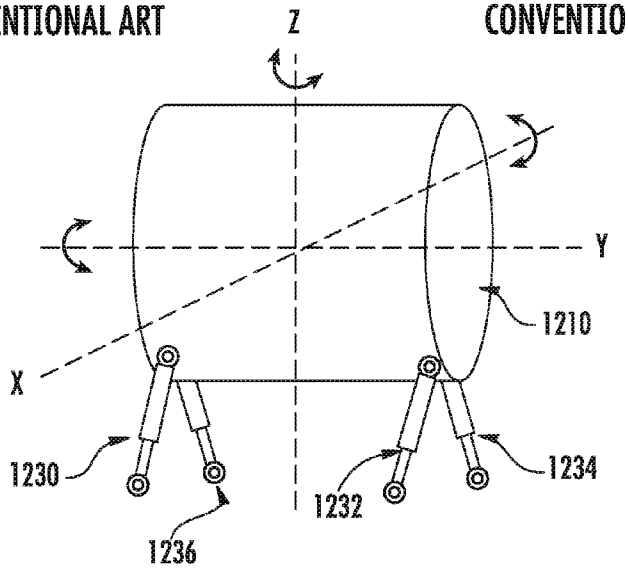

FIG. 10C
CONVENTIONAL ART

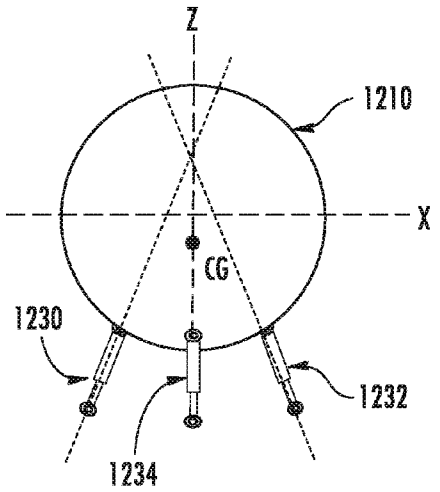

FIG. 11A
CONVENTIONAL ART

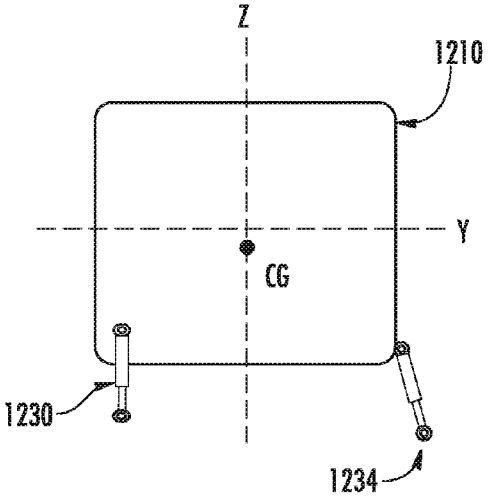

FIG. 11B
CONVENTIONAL ART

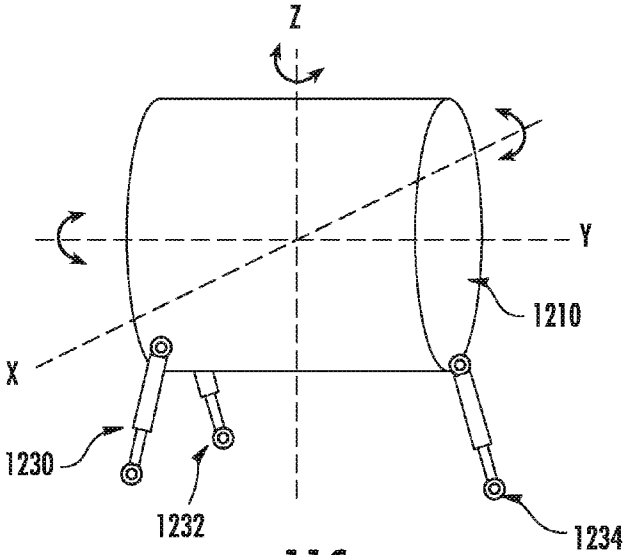

FIG. 11C
CONVENTIONAL ART

DAMPING SYSTEM FOR A HOUSEHOLD APPLIANCE

FIELD OF THE INVENTION

[0001] The present invention is directed to a household appliance, and more particularly, to a household appliance including a damping and suspension system, and more particularly, to a household appliance including a damping and suspension system having an offset damper.

BACKGROUND OF THE INVENTION

[0002] A household appliance, such as a front-loading clothes washer, includes a housing supported by a structure, such as a floor. A door provides access to a washing unit in the interior of the appliance housing. The washing unit includes a tub having a cylindrical washing drum rotatably mounted inside the tub. In operation, clothes or laundry are inserted into the washer through the door and placed in the rotating washing drum inside the tub. The household appliance wets the laundry to be washed with washing liquid and mechanically moves the laundry to release contaminants from the laundry. A drive system rotates the washing drum inside the tub about an axis of the drum. The dynamic forces associated with the rotation of the drum and movement of the washing liquid and laundry within the washing unit during operation of the washer can cause movement of the washing unit and vibration of the washing unit within the housing. The movement can include translational movement along one or more axes, as well as rotation movement about one or more axes. Such movement or vibration can be transferred to the housing and/or the floor supporting the housing, thereby resulting in movement and vibration that may be noticeable to the user. Additionally, the movement or vibration can cause excessive noise during operation. The movement, vibration, and/or noise can be exaggerated or worsened during a spinning cycle in which the drum is accelerated up to the desired spinning speed such that a centrifugal force is sufficient to remove a substantial portion of the cleaning liquid from the clothes or laundry being washed.

[0003] Additionally, the movement or vibration of the washing unit can result in an increase in forces applied to other components of the appliance, thereby increasing the likelihood of failure of these components and decreasing the durability of the appliance, which can increase the operating costs of the appliance to the consumer.

[0004] Many conventional washers include one or more systems for reducing or absorbing movement or vibration of the washing unit during operation. Common solutions include mounting one or more masses on the washing unit and suspending or supporting the washing unit from the housing using one or more springs and/or dampers.

[0005] These conventional suspension systems are intended to reduce movement and vibration of the washing unit during operation. However, these systems also may increase the manufacturing costs and complexity of the appliance. Additionally, the durability of the appliance may be reduced as a result of a failure of one or more components of the suspension systems. A failure of one or more components of these systems commonly renders the appliance inoperable until the repair is completed, thereby increasing the out-of-service time for the appliance to be repaired.

SUMMARY OF THE INVENTION

[0006] The exemplary embodiments of the present invention recognize that further reductions in the movement and vibration of the washer can provide important advantages such as further reducing or limiting noise and vibration of the washer during operation, as well as reducing stress on components of the washer, thereby extending the life of components of the washer. The exemplary embodiments recognize that it is desirable to balance such further reductions in movement and vibration with other factors, such as cost, size, and complexity of the washing unit. Accordingly, exemplary embodiments of the invention can provide a suspension system that can reduce or minimize movement and vibration of the washing unit, while at the same time, minimizing the costs associated with these features and the complexity of these features.

[0007] As explained above, the dynamic forces associated with the rotation of the drum and movement of the washing liquid and laundry within the washing unit during operation of the washer can cause shifting or movement of the center of gravity of the washing unit with respect to a fixation axis (e.g., neutral or stability axis) of the housing and vibration of the washing unit within the housing. The movement of the center of gravity of the washing unit can include translational movement along one or more fixation axes of the housing, as well as rotation movement about one or more fixation axes of the housing.

[0008] For purposes of this disclosure, rotational movement about the X axis (e.g., X fixation axis) of the housing will be referred to as pitch, rotational movement about the Y axis (e.g., Y fixation axis) of the housing will be referred to as roll, and rotational movement about the Z axis (e.g., Z fixation axis) of the housing will be referred to as yaw.

[0009] Many conventional washers include one or more systems for reducing or absorbing movement or vibration of the washing unit during operation. Common solutions include mounting one or more masses on the washing unit, and suspending/supporting the washing unit from the housing using one or more springs and/or dampers.

[0010] These systems are intended to reduce movement and vibration of the washing unit during operation. However, as a result of these systems, the manufacturing costs and complexity of the appliance can be increased. Also, the durability of the appliance may be reduced as a result of a failure of one or more components of these systems. The out-of-service time for the appliance to be repaired also may be increased since a failure of one or more components of these systems commonly renders the appliance inoperable until the repair is completed.

[0011] Examples of conventional solutions for reducing movement and vibration of the washing unit will now be described with reference to FIGS. **8**-**11**C.

[0012] FIGS. **8** and **9** illustrate a washing unit **1200** of a conventional washer. The washing unit **1200** includes a tub **1210** having a rotating washing drum (not shown) that rotates about its axis A**1** inside the tub **1210** in order to move the clothes or laundry in the washer. A drive system rotates the washing drum within the tub **1210**. The drive system commonly includes a motor **1214**, a pulley **1216**, and a drive belt **1218**. The washing unit **1200** includes a drain assembly **1220** coupled to the tub **1210**. The drain assembly **1220** can include

a discharge pump and corrugated tube for discharging the washing liquid from the tub **1210**.

[0013] With reference to FIG. **8**, in many conventional washers, the washing unit **1200** can be suspended or positioned in the housing **1210** such that the axis of rotation A**1** of the rotating washing drum can be inclined with respect to a fixation horizontal axis Y of the housing. In this manner, the opening of the conventional washer can be tilted toward the user, thereby improving visibility and access into the tub **1210** through the front-loading opening **1212**. For example, the axis A**1** commonly can be inclined 13° with respect to the horizontal axis Y, as illustrated in FIG. **8**.

[0014] When at rest, the washing unit **1200** has a center of gravity (CG) as shown in FIGS. **8** and **9**. In operation, clothes or laundry are inserted into the washer through the front load opening **1212** and placed in the rotating washing drum of the tub **1210**. During operation of the washer, a volume of washing liquid, which commonly includes a mixture of water and detergent, or a rinsing liquid is supplied to the interior of the tub **1210** and the drive system rotates the washing drum inside the tub **1210** about the rotational axis A**1** of the drum. The dynamic forces associated with the rotation of the drum and the movement of the washing liquid and laundry within the washing unit **1200** during operation of the washer may (1) change the center of gravity of the washing unit **1200** and/or (2) cause movement of the center of gravity of the washing unit **1200** away from a fixation axis (e.g., a neutral or stability axis) of the housing, such as the Z axis of the housing.

[0015] For example, during operation of the washing unit **1200** of the loaded washer, such as a regular washing or tumbling cycle, the drive system rotates the washing drum inside the tub **1210** about the rotational axis A**1** of the drum to mechanically move the clothes or laundry in the washing unit **1200**. The rotating washing drum causes the wet laundry to be lifted in a direction away from the floor and then dropped back in a direction toward the bottom of the washing unit. Depending on the amount, type, and weight of the clothes or laundry, the impact of the laundry cyclically returning to the bottom of the washing unit **1200** can result in shifting or movement of the center of gravity of the washing unit **1200** away from one or more fixation axes of the housing.

[0016] Such movement of the center of gravity of the washing unit **1200** away from one or more fixation axes of the housing can be exaggerated or worsened as compared to the regular washing or tumbling cycle, for example, during a spinning cycle in which the drum is accelerated up to the desired spinning speed such that a centrifugal force is sufficient to remove a substantial portion of the cleaning liquid from the clothes or laundry being washed. The movement of the washing liquid or rinsing liquid in the washing unit **1200** and/or the acceleration of the drum up to the desired spinning speed can cause the forces on the system to be unbalanced, thereby resulting in movement of the center of gravity of the washing unit **1200** away from a fixation axis (e.g., neutral axis or stability axis) of the housing, such as the Z axis of the housing.

[0017] The movement can include translational movement of the center of gravity of the washing unit **1200** with respect to one or more fixation axes, as well as pitching, rolling, and yawing of the washing unit **1200** with respect to one or more fixation axes. This movement can result in noise, shaking of the washer, and/or shaking of the floor that is supporting the washer during operation of the washer. This movement also can result in stress on components of the washer, such as springs **1224**A, **1224**B, bearings, corrugated pipe, gaskets, etc., which may lead to failures and reduce reliability of the washer.

[0018] Many conventional washers include one or more systems for reducing or absorbing movement of the center of gravity of the washing unit **1200** away from one or more fixation axes during operation. As shown in FIGS. **8** and **9**, the conventional washing unit **1200** can include a plurality of masses **1222**A to **1222**E to dampen the movement and/or vibration of the washing unit **1200** during operation. Additionally, the washing unit **1200** commonly can be suspended in a moveable manner within the housing by a suspension system. FIGS. **8** and **9** illustrate a conventional suspension system having springs **1224**A and **1224**B and dampers **1230** and **1232**.

[0019] In the illustrated conventional aspect, the suspension system can include, for example, an 8.3N/mm spring **1224**A, **1224**B on each side of the tub **1210**. An axis of each spring **1224**A, **1224**B can be disposed in a fixation plane X-Z that extends through the center of the housing.

[0020] The suspension system can include dampers **1230**, **1232** for supporting the washing unit **1200** within the housing. The dampers **1230**, **1232** can be coupled on one end to the housing and on the other end to the tub **1210**. As illustrated in FIG. **8**, the dampers **1230** and **1232** can be arranged in the fixation plane X-Z that extends through the housing (e.g., the center of the housing).

[0021] With reference to FIGS. **10**A to **10**C, another conventional suspension system includes four dampers **1230**, **1232**, **1234**, and **1236**. A first end of each damper can be coupled to the housing and a second end of each damper can be coupled to the tub **1210**. The dampers **1230**, **1232**, **1234**, and **1236** commonly are arranged symmetrically at or near the four corners of the tub **1210** to provide a stable and symmetric platform for the tub **1210**. However, the increased number of dampers, four (4) in this case, results in an increase in the labor and material costs associated with manufacturing the appliance, as well as an increase in the complexity of the suspension system. Also, in the event of a failure of one or more of the dampers **1230**, **1232**, **1234**, and **1236**, the suspension system may become unstable, thereby rendering the appliance inoperable until such failed damper is repaired and increasing an amount of out-of-service time for the appliance.

[0022] FIGS. **11**A to **11**C illustrate another conventional suspension system that includes three dampers **1230**, **1232**, and **1234**. A first end of each damper can be coupled to the housing and a second end of each damper can be coupled to the tub **1210**. In this arrangement, a pair of dampers **1230** and **1232** can be arranged at the same end of the tub **1210** (e.g., at the front end of the tub **1210**) and on opposite sides of the tub **1210**. A third damper **1232** can be arranged on an opposite end of the tub **1210** from the dampers **1230**, **1232** (e.g., at the rear end of the tube **1210**) and in a fixation plane Y-Z extending through the housing (e.g., the center of the housing).

[0023] In this illustrated arrangement, three (3) dampers are provided instead of four (4) dampers, which may be helpful for minimizing the labor and material costs associated with manufacturing the appliance, as well as for reducing the complexity of the suspension system. However, in this arrangement, a failure of one or more of the dampers **1230**, **1232**, and **1234** may cause the suspension system to become unstable, thereby rendering the appliance inoperable until such failed damper is repaired and increasing an amount of out-of-service time for the appliance.

[0024] Moreover, as explained above with reference to FIG. **8**, in many conventional washers, the washing unit **1200** can be suspended or positioned in the housing **1210** such that the axis of rotation A**1** of the rotating washing drum can be inclined with respect to a fixation horizontal axis Y of the housing. For example, the axis A**1** commonly can be inclined 13° with respect to the horizontal axis Y, as illustrated in FIG. **8**. Aspects of the invention recognize that providing such an inclined axis A**1** of the tub may increase the likelihood that the movement of the clothes or laundry in the tub may shift or move the center of gravity (CG) of the washing unit, thereby increasing movement and vibration of the washer.

[0025] These problems and others are addressed by the present invention, a first exemplary embodiment of which comprises a household appliance including a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing, a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation, and a suspension system movably supporting the washing unit in the housing, wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base, wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base, wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base, and wherein the suspension system includes a first damper and a second damper coupled between the tub and the housing, the first damper and the second damper being arranged symmetrically on opposite sides of the tub and at a substantially equal distance from the second plane, and a third damper coupled between the tub and the housing, wherein the third damper is coupled to the tub at a mounting point that is offset a predetermined distance from at least one of the first plane, the second plane, and the third plane, and wherein an axis of the third damper is in a plane that is offset from and parallel to the second plane.

[0026] Another exemplary embodiment of the invention comprises a household appliance including a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing, a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation, and a suspension system movably supporting the washing unit in the housing, wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base, wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base, wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base, and wherein the suspension system includes a plurality of dampers coupled between the tub and the housing, wherein an axis of each of the plurality of dampers is parallel to the third plane, and an offset damper coupled between the tub and the housing, wherein an axis of the offset damper is in a plane that is offset from and parallel to the second plane.

[0027] A further exemplary embodiment of the invention comprises a household appliance including a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing, a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation, and a suspension system movably supporting the washing unit in the housing, wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base, wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base, wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base, and wherein the suspension system includes a first damper and a second damper coupled between the tub and the housing, the first damper and the second damper arranged symmetrically on opposite sides of the tub and at a substantially equal distance from the second plane, and an offset damper coupled between the tub and the housing and arranged asymmetrically with respect to the second plane.

[0028] A further exemplary embodiment of the invention comprises a household appliance including a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing, a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation, and a suspension system movably supporting the washing unit in the housing, wherein a fixation axis of the washer extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base, and wherein the washing unit is suspended inside the housing such that an inclination of the axis of rotation of the rotatable drum from the fixation axis of the washer is substantially equal to a maximum pitching movement of the washing unit during operation of the washer.

[0029] The present invention recognizes that reductions in the movement of the center of gravity of the washing unit away from one or more fixation axis of the housing can provide an important advantage of reducing the stress on other components of the washer, thereby extending the life of these components of the washer and improving reliability and durability of the washer. The exemplary embodiments further recognize that the cost and complexity of the system are important factors in improving or eliminating behavior such as movement or vibration.

[0030] As explained above, an exemplary embodiment of the invention provides a suspension system having an offset damper on the tub, thereby reducing or minimizing movement of the center of gravity of the washing unit with respect to a fixation axis of the housing. More particularly, the offset damper can be configured to reduce or minimize movement of the center of gravity of the washing unit away from a fixation axis of the housing, as well as to reduce or minimize rotation, pitching, or yawing of the washing unit with respect to a fixation axis of the housing.

[0031] In this manner, the exemplary embodiments of the suspension system can provide the advantages of a system having a larger number of shocks/dampers with a system that has a lesser number of shocks/dampers, thereby minimizing

the costs and complexity of the system. For example, an exemplary embodiment can provide the advantages of a four-damper system using a three-damper system, thereby reducing or minimizing noise, movement, and vibration of the washing unit, as well as minimizing the costs and complexity of the system.

[0032] The disclosed exemplary embodiments also are important for reducing the stress on components of the washer, thereby extending the life of components of the washer. The exemplary embodiments can be optimized to balance such further reductions in movement and vibration with other factors, such as cost, size, and complexity of the washing unit.

[0033] In an exemplary embodiment, the system is configured such that a failure of the offset damper will not render the system inoperable. In this manner, the exemplary embodiments provide an important advantage in that the offset damper reduces movement of the center of gravity of the washing unit away from one or more fixation axes, while at the same time, preventing the washer from being rendered inoperable as a result of a failure of the offset damper. In this exemplary embodiment, the first and second dampers are configured to support the tub during operation without the offset damper.

[0034] As explained above, the exemplary embodiments of the present invention can provide a suspension system that reduces movement of the center of gravity of the washing unit away from a fixation axis of the housing during operation, while also satisfying other important design criteria, such as improving durability and minimizing or reducing noise, manufacturing costs, overall weight of the appliance, etc.

[0035] Exemplary embodiments of the invention also can provide a suspension system that can maintain the incline of the axis within a predetermined range, and more particularly, such that an inclination of the axis of rotation of the rotatable drum from the first axis of the washer is substantially equal to a maximum pitching movement of the washing unit during operation of the washer, the exemplary embodiments of the invention can provide a suspension system that reduces or minimizes movement and vibration of the washer unit, thereby reducing or minimizing movement and vibration of the washer unit.

[0036] Other features and advantages of the present invention will become apparent to those skilled in the art upon review of the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] These and other aspects and features of embodiments of the present invention will be better understood after a reading of the following detailed description, together with the attached drawings, wherein:

[0038] FIG. **1** is a front elevation view of a washer;

[0039] FIG. **2** is a side elevation view of a washing unit according to an exemplary embodiment of the invention;

[0040] FIG. **3** is a rear elevation view of the washing unit of FIG. **2**;

[0041] FIG. **4**A is a schematic front view of a washing unit according to an exemplary embodiment of the invention;

[0042] FIG. **4**B is a schematic side view of the washing unit of FIG. **4**A;

[0043] FIG. **4**C is a schematic perspective view of the washing unit of FIG. **4**A;

[0044] FIG. **5**A is a schematic front view of a washing unit according to an exemplary embodiment of the invention;

[0045] FIG. **5**B is a schematic side view of the washing unit of FIG. **5**A;

[0046] FIG. **5**C is a schematic perspective view of the washing unit of FIG. **5**A;

[0047] FIG. **6**A is a schematic front view of a washing unit according to an exemplary embodiment of the invention;

[0048] FIG. **6**B is a schematic side front view of the washing unit of FIG. **6**A;

[0049] FIG. **6**C is a schematic perspective view of the washing unit of FIG. **6**A;

[0050] FIG. **7**A is a schematic front view of a washing unit according to an exemplary embodiment of the invention;

[0051] FIG. **7**B is a schematic side view of the washing unit of FIG. **7**A;

[0052] FIG. **7**C is a schematic perspective view of the washing unit of FIG. **7**A;

[0053] FIG. **8** is a side elevation view of a conventional washing unit;

[0054] FIG. **9** is a rear elevation view of the conventional washing unit of FIG. **8**;

[0055] FIG. **10**A is a schematic front view of a conventional washing unit;

[0056] FIG. **10**B is a schematic side view of the conventional washing unit of FIG. **10**A; and

[0057] FIG. **10**C is a schematic perspective view of the conventional washing unit of FIG. **10**A.

[0058] FIG. **11**A is a schematic front view of a conventional washing unit;

[0059] FIG. **11**B is a schematic side view of the conventional washing unit of FIG. **11**A; and

[0060] FIG. **11**C is a schematic perspective view of the conventional washing unit of FIG. **11**A.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS OF THE INVENTION

[0061] The present invention now is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0062] Referring now to the drawings, FIGS. **1**-**7**C illustrate exemplary embodiments of a household appliance.

[0063] FIG. **1** illustrates a household appliance **100**, such as a front-loading clothes washer, having a housing **110** and a door **112** to provide access to the interior of the appliance housing **110**. The household appliance wets the laundry to be washed with washing liquid and mechanically moves the laundry to release contaminants from the laundry.

[0064] The housing **110** encloses a washing unit **200**, which is suspended in the housing **110** to absorb movement and vibration of the washing unit **200** during operation. Exemplary embodiments of the washing unit **200** will now be described with reference to FIGS. **2** and **3**.

[0065] An exemplary embodiment of a washing unit **200** can include a tub **210** having a rotating washing drum (not shown) that rotates about an axis A**2** to move the clothes or laundry in the tub **210**. A drive system rotates the rotating washing drum within the tub **210**. The drive system can include, for example, a motor **214**, a pulley **216**, and a drive belt **218**. The washing unit **200** can include a drain assembly

220 coupled to the tub 210. The drain assembly 220 can include, for example, a discharge pump and corrugated tube for discharging the washing liquid from the tub 210.

[0066] As shown in FIG. 2, the washing unit 200 can be supported inside the housing by the dampers 230, 232, and 234. In this exemplary embodiment, the dampers 230 and 232 alone are sufficient for supporting the washing unit within the housing. The third damper 234 is not needed for operation of the washing unit. Further, in this exemplary embodiment, a plurality of springs is not illustrated. However, in other exemplary embodiments, a plurality of springs can be provided for aiding in the suspending of the washing unit 200 in the housing.

[0067] In an exemplary embodiment, the washing unit 200 can be suspended or positioned such that the axis of rotation A2 of the rotating washing drum is not inclined with respect to a horizontal axis Y, or fixation axis Y, of the housing 110. In another exemplary embodiment, the tub 210 can be configured to have an angle of inclination with respect to the horizontal axis Y. In this way, the opening 212 can be slightly tilted toward the user to provide visibility and access into the tub 210.

[0068] The exemplary embodiments recognize, however, that when the washer is operated in a loaded condition, the shifting or movement of the clothes or laundry during operation of the washer can, in some circumstances, cause the washing unit to pitch forward about the X axis toward the front-loading opening 212, for example, by an angle of approximately +2° or −2° from the initial axis of rotation A2. In some instances, the washing unit can pitch forward about the X axis by an amount that is sufficient to cause the axis of rotation A2 to be declined (i.e., $\theta 2 < 0°$) with respect to the horizontal axis Y (i.e., front-down or nose-down), which can affect the operation or efficiency of the washer.

[0069] For example, if the tub 210 pitches about the X axis such that the axis of rotation A2 is declined (i.e., $\theta 2 < 0°$) with respect to the horizontal axis Y, the washing liquid may not drain properly or completely from the tub 210 during a spinning cycle. The forward pitching movement also may cause the clothes or laundry to shift forward in the tub 210, which may result in an increase in movement or vibration of the washer. Additionally, this pitching movement of the tub 210 can exert forces on the physical connection between the front-loading opening 212 and the washer housing 110, which may lead to premature failures of these components, thereby reducing the durability and reliability of the washer.

[0070] The exemplary embodiment of FIGS. 2 and 3 addresses these and other problems by providing a washing unit 200 that can be suspended or positioned such that the inclination of the axis of rotation A2 of the rotating washing drum with respect to a horizontal axis Y toward the front-loading opening 212 can be optimized, thereby reducing or eliminating movement and vibration associated with the angle of inclination. For example, in an exemplary embodiment, the resting angle of inclination θ2 of the axis of rotation A2 can be selected such that $\theta 2 \geqq 020$ during the maximum movement of the tub 210 during operation. That is, the resting angle of inclination θ2 can be selected to be substantially equal to a maximum anticipated movement or pitching of the tub 210 during operation. Accordingly, the exemplary embodiments can minimize or eliminate a risk that the angle of inclination θ2 goes negative (i.e., $\theta 2 < 0°$) during a maximum anticipated movement or pitching of the tub 210 during operation.

[0071] For example, in an exemplary embodiment in which the maximum anticipated movement or pitching of the tub 210 during operation is 2°, the tub 210 can be configured to have an angle of inclination θ2 that is substantially equal to 2° with respect to the horizontal axis Y. In this exemplary embodiment, the angle of inclination θ2 of the axis of rotation A2 will be equal to or greater than 0° during the maximum pitch of the tub 210.

[0072] In another exemplary embodiment, the tub 210 can be configured to have an angle of inclination θ2 that is substantially equal to 3° with respect to the horizontal axis Y, in order to provide a factor of safety. In this exemplary embodiment, the angle of inclination θ2 of the axis of rotation A2 can be equal to or greater than 1° during the maximum pitch of the tub 210.

[0073] In these exemplary embodiments, the opening 212 thereby can be slightly tilted toward the user to provide visibility and access into the tub 210 while being configured in a way that minimizes or reduces movement and vibration of the tub 210 during operation of the washer.

[0074] As explained above, during operation of the loaded washer, such as a regular washing or tumbling cycle, the drive system rotates the washing drum inside the tub 210 about the rotational axis A1 of the drum to mechanically move the clothes or laundry in the washing unit 200. The rotating washing drum causes the wet laundry to be lifted in a direction away from the floor and then dropped back in a direction toward the bottom of the washing unit 200. Depending on the amount, type, and weight of the clothes or laundry, the impact of the laundry cyclically returning to the bottom of the drum can result in shifting or movement of the center of gravity of the washing unit 200 away from one or more fixation axes of the housing 110.

[0075] Such movement of the center of gravity of the washing unit 200 away from one or more fixation axes of the housing 110 can be exaggerated or worsened as compared to the regular washing or tumbling cycle, for example, during a spinning cycle in which the drum is accelerated up to the desired spinning speed such that a centrifugal force is sufficient to remove a substantial portion of the cleaning liquid from the clothes or laundry being washed. The movement of the washing liquid or rinsing liquid in the washing unit 200 and/or the acceleration of the drum up to the desired spinning speed can cause the forces on the system to be unbalanced, thereby resulting in movement of the center of gravity of the washing unit 200 away from a fixation axis (e.g., neutral axis or stability axis) of the housing 110, such as the Z axis of the housing.

[0076] The movement can include translational movement of the tub 210 along one or more axes, as well as pitching, rolling, and yawing of the tub 210. This movement of the center of gravity of the washing unit 200 with respect to one or more fixation axes of the housing 110, thereby reducing pitching, rolling, and yawing of the washing unit 200 with respect to one or more fixation axes of the housing 110. This movement can result in noise, shaking of the washer, and/or shaking of the floor that is supporting the washer during operation of the washer. This movement can result in noise, shaking of the washer, and/or shaking of the floor that is supporting the washer during operation of the washer 100. This movement also can result in stress on other components of the washer 100, such as springs (if so equipped), bearings, corrugated pipe, gaskets, etc.

[0077] With reference again to FIGS. **2** and **3**, the washing unit **200** can include a suspension system having a plurality of dampers for reducing translational movement of the washing unit **200** with respect to one or more fixation axes of the housing **110** during operation, thereby reducing pitching, rolling, and yawing of the washing unit **200** with respect to one or more fixation axes of the housing **110** during operation.

[0078] In an exemplary embodiment, a plurality of symmetric dampers, such as a first damper **230** and a second damper **232** can be provided for supporting the tub **210** inside the housing **110**. Each damper **230**, **232** can include an upper mount that can be pivotably coupled to the tub **210**, and a lower mount that can be pivotably coupled to the housing. The tub **210** and housing **110** can include mounting points, such as flanges or other suitable devices or engaging means, for receiving the upper and lower mounts of the dampers **230**, **232**.

[0079] A fastener, such as a bolt, pin, or the like, can secure each of the upper and lower mounts to each mounting point on the tub **210** and the housing **110** in a pivotable manner. The upper and lower mounts can include bushings (not shown) to reduce friction during pivoting of the dampers **230**, **232**. Depending on the stiffness of the bushings, these bushings can be selected to allow slight movement in a direction other than the pivoting direction of the damper with respect to the mounting points on the tub **210** and housing **110**.

[0080] Each damper can be, for example, a shock absorber, a spring-damper, or other damping device. For example, in the disclosed exemplary embodiment, each damper **230**, **232** can be a shock, such as a 90N or 110N free-stroke shock or the like. One of ordinary skill in the art will recognize that other suitable dampers or damping devices can be employed within the spirit and scope of the invention. In an exemplary embodiment, each of the dampers **230**, **232** can have the same characteristics. However, in other exemplary embodiments, each damper may have different characteristics from the other damper.

[0081] As shown in FIG. **2**, the first damper **230** and second damper **232** are disposed along the sides of the tub **210** and at or near the mid-point of the tub **210**. For example, the first damper **230** and second damper **232** can be configured such that an axis a_1, a_2 of each damper **230**, **232** lies in a fixation plane X-Z that extends through the housing **110**, and more particularly, the center of the housing **110**. As shown in FIG. **3**, the first damper **230** and the second damper **232** can be disposed symmetrically on opposite sides of the tub **210** and at an equal distance from a fixation plane Y-Z extending through the housing **110**, and more particularly, the center of the housing **110**.

[0082] As shown in FIG. **3**, the dampers **230**, **232** can be mounted at an angle with respect to the housing **110** and the tub **210**. For example, the mounting point on the tub **210** for receiving the upper mount of each damper **230**, **232** can be closer to the plane Y-Z than the mounting point of the housing **110** for receiving the lower mount of each damper **230**, **232** by a distance x_2. The dampers **230** and **232** can be angled such that an axis a_1, a_2 of each of the dampers **230** and **232**, respectively, intersects the plane Y-Z of the housing **110** at a location above the center of gravity (CG) of the washing unit **200**. For example, a distance x_2 between the upper mount and the lower mount of each of the dampers **230** and **232** can be selected such that the axis a_1, a_2 of each of the dampers **230** and **232** intersects the plane Y-Z of the housing **110** at a location above the center of gravity (CG) of the washing unit **200**. The exemplary embodiments are not limited, however, to the disclosed arrangements and in other exemplary embodiments the dampers **230** and **232** can be configured such that an axis of each of the dampers **230** and **232** is parallel to the plane X-Z of the housing **110**.

[0083] In the exemplary embodiment of FIGS. **2** and **3**, the first damper **230** and second damper **232** can provide a stable platform for the tub **210**, such that the first and second dampers **230**, **232** alone can be sufficient for supporting the washing unit **200** during operation.

[0084] Moreover, the disclosed arrangement of the dampers **230** and **232** can be effective for reducing or minimizing movement of the center of gravity (CG) of the washing unit **200** with respect to one or more fixation axes of the housing **110** during operation. The exemplary embodiments illustrated in FIGS. **2** and **3** can be particularly advantageous for reducing or minimizing translational movement of the center of gravity of the washing unit **200** along the X axis and the Z axis, and reducing or minimizing roll of the washing unit **200** about the Y axis of the housing **110**.

[0085] The exemplary embodiments recognize that the movement of the center of gravity of the washing unit **200** away from a fixation axis of the housing **110** during operation can be further reduced by providing a third damper **234**, or offset damper, between the housing **110** and the tub **210**. Particularly, the third damper **234** can be configured particularly to reduce or minimize translational movement of the center of gravity of the washing unit **200** along the Y axis and pitch about the X axis as well as yaw about the Z axis of the housing **110**. One of ordinary skill in the art will recognize that the third damper **234** also can affect or reduce movement and rotation about the other axes. In this manner, the exemplary embodiments can provide advantages of a four-damper system using a three-damper system, thereby reducing or minimizing movement and vibration of the washing unit while also minimizing costs and complexity of the system.

[0086] With reference again to FIGS. **2** and **3**, the third damper **234**, or offset damper, can include an upper mount that can be pivotably coupled to the tub **210** and a lower mount that can be pivotably coupled to the housing **110**. The third damper **234** can be coupled to the tub **210** and housing **110** in a similar manner as the first and second dampers **230**, **232**. The third damper **234** also can include bushings (not shown) to reduce friction during pivoting of the third damper **234**. Depending on the stiffness of the bushings, these bushings can be selected to allow for slight movement in a direction other than the pivoting direction of the damper with respect to the mounting points on the tub **210** and housing **110**. In this way, the third damper **234** may be optimized to reduce movement or vibration in a number of axes.

[0087] The third damper **234** can be, for example, a shock absorber, a spring-damper, or other damping device. For example, in the disclosed exemplary embodiment, the third damper **234** can be a shock, such as a 90N or 110N free-stroke shock or the like. One of ordinary skill in the art will recognize that other suitable dampers or damping devices can be employed within the spirit and scope of the invention. In an exemplary embodiment, the third damper **234** can have the same characteristics as the first and second dampers **230**, **232**. However, in other exemplary embodiments, the third damper **234** can be selected to have different characteristics than those of the first and second dampers **230**, **232**. For example, in some cases, a less expensive or less robust damper can be

selected for the third damper **234**. In this way, the exemplary embodiments may reduce movement and vibration while further reducing the manufacturing costs, size, and/or complexity of the system.

[0088] As shown in FIG. **3**, the third damper **234** can be configured such that an axis a_3 of the third damper **234** is parallel to a plane Y-Z of the housing **110**.

[0089] As shown in FIG. **2**, the third damper **234** can be disposed at an angle with respect to a plane X-Z of the housing. The mounting point on the tub **210** for receiving the upper mount of the third damper **234** can be closer to the plane X-Z than the mounting point of the housing **110** for receiving the lower mount of the third damper **234** by a distance y_2. The distance y_2 between the upper mount and the lower mount can be selected such that the axis a_3 of the third damper **234** intersects the plane X-Z of the housing at a location above the center of gravity (CG) of the washing unit **200**.

[0090] FIGS. **4**A to **4**C schematically illustrate the arrangement of FIGS. **2** and **3**. In this exemplary embodiment, the first and second dampers **230**, **232** can be sufficient for supporting the washing unit **210** during operation of the washer. The first and second dampers **230**, **232** can be effective for substantially reducing or minimizing the movement of the center of gravity of the washing unit **210** away from one or more fixation axes during operation. Particularly, the first and second dampers **230**, **232** can be effective for substantially reducing or minimizing the translational movement of the center of gravity of the washing unit **210** along the X and Z axes, as well as substantially reducing or minimizing rolling of the washing unit **210**. The third damper **234**, or offset damper, provides an important advantage of substantially reducing or minimizing the translational movement of the center of gravity of the washing unit **210** along the Y axis, as well as substantially reducing or minimizing pitching about the X axis and yawing about the Y axis of the housing **110**. As explained above, these features are important for providing advantages of a four-damper system using a three-damper system, thereby reducing or minimizing movement and vibration of the washing unit while also minimizing costs and complexity of the system.

[0091] With reference again to FIGS. **2** and **3**, the third damper **234** can be offset away from a plane extending through the center of the housing **110** in one or more directions. The maximum available offset for mounting the third damper **234** in any single direction commonly is dictated by the physical structure of the tub **210**. However, in other exemplary embodiments, an extension, such as a flange, mounting plate, or the like, can be mechanically coupled to the tub **210** to extend the maximum offset of the third damper **234** in one or more directions.

[0092] As illustrated in FIG. **2**, the upper mount of the third damper **234** can be offset by a distance y_1 from the X-Z plane of the housing **110**. In the illustrated embodiment, the distance y_1 can be maximized to offset the upper mount of the third damper **234** to the furthest point on the tub **210** from the X-Z plane of the housing **110**. The upper mount of the third damper **234** can be coupled to a flange or seat on the rear face of the tub **210**, or another feature on the rear face of the tub **210**, thereby maximizing the distance y_1 of the third damper **234** from the X-Z plane of the housing **110**.

[0093] As illustrated in FIG. **3**, the upper mount of the third damper **234** can be offset by a distance x_1 from the Y-Z plane of the housing **110**. Additionally or alternatively, the upper mount of the third damper **234** can be offset by a distance z_1 from the X-Y plane of the housing **110**.

[0094] In the illustrated exemplary embodiment, the third damper **234** can be offset by a maximum distance z_1 from the X-Y plane of the housing and toward the floor or support structure of the washer, thereby providing a stable platform for the tub **210**. In this exemplary embodiment, the mounting point can be selected to provide the largest distance x_1 from the Y-Z plane of the housing **110** while maximizing the distance z_1 of the offset from the X-Y plane of the housing **110**.

[0095] The arrangements are not limited to the exemplary embodiment illustrated in FIGS. **2** and **3**. For example, in another exemplary embodiment, the mounting point can be selected to provide the largest distance z_1 from the X-Y plane of the housing **110** while maximizing the distance x_1 of the offset from the Y-Z plane of the housing **110**.

[0096] In other exemplary embodiments, the mounting point for the third damper **234** can be arranged to maximize both the distance x_1 and the distance z_1. More particularly, the mounting point for the third damper **234** can be arranged to maximize each of the offset distances x_1, y_1, and z_1.

[0097] The exemplary embodiments are not limited to the arrangement disclosed in FIGS. **2**, **3**, and **4**A to **4**C. In other exemplary embodiments, the third damper **234** can be configured such that an axis of the third damper **234** is perpendicular to the plane X-Y and offset from the plane X-Z of the housing **110**, as illustrated in FIGS. **5**A to **5**C.

[0098] The exemplary embodiments also are not limited to coupling the third damper **234** to the rear face of the tub **210**. In another exemplary embodiment, as illustrated in FIGS. **6**A to **6**C, the mounting point for receiving the upper mount of the third damper **234** can be located on a side of the tub **210**.

[0099] If the tub **210** has a sufficient stiffness, the mounting point for receiving the upper mount of the third damper **234** can be located on any face or side of the tub **210**. That is, the third damper **234** can be coupled to the tub **210** on the front or rear face, along the sides of the tub **210**, or along the top or bottom of the tub **210**.

[0100] Furthermore, the arrangement of the third damper **234** is not limited to use with the arrangement of dampers **230**, **232** as shown in FIGS. **2** to **6**C.

[0101] For example, in an exemplary embodiment illustrated in FIGS. **7**A to **7**C, the first damper **230** and second damper **232** can be disposed on the front end of the tub **210** such that an axis of each damper **230**, **232** is in a plane that is parallel to and offset from a plane X-Z. As shown in FIG. **7**A, the first damper **230** and the second damper **232** can be disposed symmetrically on opposite sides of the tub **210** and offset an equal distance from a plane Y-Z extending through the center of the housing **110**.

[0102] In this exemplary embodiment, a third damper **234**, or offset damper, can be provided on the tub **210** to reduce or minimize translational movement of the center of gravity of the washing unit **200** along the Y axis and pitch about the X axis. The third damper **234** can be coupled to the tub **210** in a similar manner as described above with respect to FIGS. **2** to **6**C. In this way, this exemplary embodiment can provide important advantages of minimizing translational movement of the center of gravity of the washing unit **200** along all axes of the housing **110**, as well as reducing pitch, yaw, and roll of the washing unit **200** during operation. As explained above, the exemplary embodiments can provide advantages of a four-damper system using a three-damper system, thereby

reducing or minimizing movement and vibration of the washing unit while also minimizing costs and complexity of the system.

[0103] To summarize, the exemplary embodiments illustrated in FIGS. **2** to **7**C can provide a system for reducing the movement of the center of gravity of the washing unit away from one or more fixation axes of the housing of the washer, thereby reducing or limiting noise, movement, and vibration of the washer during operation, while also minimizing or reducing the costs associated with such reductions in noise, movement, and vibration.

[0104] The exemplary embodiments can provide an important advantage in that a failure of the third damper **234** may not render the washer inoperable, in some cases, since the dampers **230**, **232** can be capable of separately supporting the tub **210** during operation without the third damper **234**. These exemplary embodiments also can provide important advantages of reducing the stress on other components of the washer, thereby extending the durability and reliability of the washer.

[0105] The discloses exemplary embodiments can provide important advantages of minimizing translational movement of the center of gravity of the washing unit **200** along all axes of the housing **110**, as well as reducing pitch, yaw, and roll of the washing unit **200** during operation, using a minimal number of components. In this manner, the exemplary embodiments can provide advantages of a four-damper system using a three-damper system, thereby reducing or minimizing movement and vibration of the washing unit while also minimizing costs and complexity of the system.

[0106] Moreover, by maintaining the incline of the axis of the tub within a predetermined range, and more particularly, such that an inclination of the axis of rotation of the rotatable drum from the first axis of the washer is substantially equal to a maximum pitching movement of the washing unit during operation of the washer, the exemplary embodiments of the invention can provide a suspension system that reduces or minimizes movement and vibration of the washer unit.

[0107] The present invention has been described herein in terms of several preferred embodiments. However, modifications and additions to these embodiments will become apparent to those of ordinary skill in the art upon a reading of the foregoing description. It is intended that all such modifications and additions comprise a part of the present invention to the extent that they fall within the scope of the several claims appended hereto.

[0108] Like numbers refer to like elements throughout. In the figures, the thickness of certain lines, layers, components, elements or features may be exaggerated for clarity.

[0109] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0110] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, phrases such as "between X and Y" and "between about X and Y" should be interpreted to include X and Y. As used herein, phrases such as "between about X and Y" mean "between about X and about Y." As used herein, phrases such as "from about X to Y" mean "from about X to about Y."

[0111] It will be understood that when an element is referred to as being "on", "attached" to, "connected" to, "coupled" with, "contacting", etc., another element, it can be directly on, attached to, connected to, coupled with or contacting the other element or intervening elements may also be present. In contrast, when an element is referred to as being, for example, "directly on", "directly attached" to, "directly connected" to, "directly coupled" with or "directly contacting" another element, there are no intervening elements present. It will also be appreciated by those of skill in the art that references to a structure or feature that is disposed "adjacent" another feature may have portions that overlap or underlie the adjacent feature.

[0112] Spatially relative terms, such as "under", "below", "lower", "over", "upper", "lateral", "left", "right" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the descriptors of relative spatial relationships used herein interpreted accordingly.

What is claimed is:

1. A household appliance comprising:

a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing;

a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation; and

a suspension system movably supporting the washing unit in the housing,

wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base,

wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base;

wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base; and

wherein the suspension system includes:

a first damper and a second damper coupled between the tub and the housing, the first damper and the second

damper being arranged symmetrically on opposite sides of the tub and at a substantially equal distance from the second plane; and

a third damper coupled between the tub and the housing,

wherein the third damper is coupled to the tub at a mounting point that is offset a predetermined distance from at least one of the first plane, the second plane, and the third plane, and

wherein an axis of the third damper is in a plane that is offset from and parallel to the second plane.

2. The household appliance of claim **1**, wherein the axis of the third damper intersects the third plane at a predetermined angle.

3. The household appliance of claim **2**, wherein the axis of the third damper intersects the third plane above a center of gravity of the washing unit.

4. The household appliance of claim **1**, wherein the predetermined distance of the mounting point of the third damper from one of the first plane, the second plane, and the third plane is maximized such that the mounting point is offset a substantially furthest distance on the tub from the one of the first plane, the second plane, and the third plane.

5. The household appliance of claim **1**, wherein the predetermined distance of the mounting point of the third damper from at least two of the first plane, the second plane, and the third plane is maximized such that the mounting point is offset a substantially furthest distance on the tub from the at least two of the first plane, the second plane, and the third plane.

6. The household appliance of claim **1**, wherein the predetermined distance of the mounting point of the third damper from each of the first plane, the second plane, and the third plane is maximized such that the mounting point is offset a furthest distance on the tub from each of the first plane, the second plane, and the third plane.

7. The household appliance of claim **1**, wherein the predetermined distance of the mounting point of the third damper from the first plane is maximized in a direction toward the base such that the mounting point is offset a furthest distance on the tub from the first plane in the direction of the base.

8. The household appliance of claim **1**, wherein a first distance of the mounting point of the third damper from the first plane is greater than a second distance of the mounting point of the third damper from the second plane.

9. The household appliance of claim **1**, wherein the mounting point of the third damper is on a rear face of the tub.

10. The household appliance of claim **1**, wherein the mounting point of the third damper is on a side surface of the tub.

11. The household appliance of claim **1**, comprising:

an extension coupled to the tub,

wherein the mounting point of the third damper is on the extension.

12. The household appliance of claim **1**, wherein the axis of each of the first damper and the second damper is in the third plane.

13. The household appliance of claim **12**, wherein the axis of each of the first damper and the second damper intersects the second plane at a predetermined angle.

14. The household appliance of claim **1**, wherein an axis of each of the first damper and the second damper is in a plane parallel to the third plane.

15. The household appliance of claim **14**, wherein the first damper and the second damper are located closer to the front of the housing than to the third plane.

16. The household appliance of claim **14**, wherein the axis of each of the first damper and the second damper intersects the second plane at a predetermined angle.

17. The household appliance of claim **1**, wherein the axis of rotation of the rotatable drum extends substantially in a direction of the second plane.

18. The household appliance of claim **17**, wherein the axis of rotation of the rotatable drum intersects the first plane at an angle.

19. The household appliance of claim **1**, wherein an upper mount of each of the first damper, the second damper, and the third damper is pivotably coupled to the tub and a lower mount of each of the first damper, the second damper, and the third damper is pivotably coupled to the housing.

20. The household appliance of claim **1**, wherein the household appliance is a front-loading washer.

21. The household appliance of claim **1**, wherein the washing unit is suspended inside the housing such that an inclination of the axis of rotation of the rotatable drum from the first axis of the washer is substantially equal to a maximum pitching movement of the washing unit during operation of the washer.

22. The household appliance of claim **21**, wherein the washing unit is suspended inside the housing such that a difference between the inclination of the axis of rotation of the rotatable drum from the first axis of the washer and the maximum pitching movement of the washing unit during operation of the washer is one of equal to and less than **10**.

23. The household appliance of claim **21**, wherein the washing unit is suspended inside the housing such that the inclination of the axis of rotation of the rotatable drum from the first axis of the washer is one of equal to and less than 3°.

24. A household appliance comprising:

a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing;

a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation; and

a suspension system movably supporting the washing unit in the housing,

wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base,

wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base;

wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base; and

wherein the suspension system includes:

a plurality of dampers coupled between the tub and the housing, wherein an axis of each of the plurality of dampers is parallel to the third plane; and

an offset damper coupled between the tub and the housing, wherein an axis of the offset damper is in a plane that is offset from and parallel to the second plane.

25. A household appliance comprising:

a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing;

a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation; and

a suspension system movably supporting the washing unit in the housing,

wherein a first plane extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base,

wherein a second plane extending through the center of the housing is perpendicular to the plane of the front and perpendicular to the plane of the base;

wherein a third plane extending through the center of the housing is parallel to the plane of the front and perpendicular to the plane of the base; and

wherein the suspension system includes:

a first damper and a second damper coupled between the tub and the housing, the first damper and the second damper arranged symmetrically on opposite sides of the tub and at a substantially equal distance from the second plane; and

an offset damper coupled between the tub and the housing and arranged asymmetrically with respect to the second plane.

26. The household appliance of claim **25**, wherein the offset damper is arranged asymmetrically with respect to the first plane and the second plane.

27. The household appliance of claim **25**, wherein the offset damper is arranged asymmetrically with respect to the first plane, the second plane, and the third plane.

28. A household appliance comprising:

a housing having a base, a top, a front, and a rear, wherein the housing includes a door formed in the front for accessing an interior of the housing;

a washing unit inside the housing and accessible through the door, the washing unit including a tub having a rotatable drum therein for receiving laundry through the door, the rotatable drum having an axis of rotation; and

a suspension system movably supporting the washing unit in the housing,

wherein a fixation axis of the washer extending through a center of the housing is perpendicular to a plane of the front and parallel to a plane of the base, and

wherein the washing unit is suspended inside the housing such that an inclination of the axis of rotation of the rotatable drum from the fixation axis of the washer is substantially equal to a maximum pitching movement of the washing unit during operation of the washer.

29. The household appliance of claim **28**, wherein the washing unit is suspended inside the housing such that a difference between the inclination of the axis of rotation of the rotatable drum from the fixation axis of the washer and the maximum pitching movement of the washing unit during operation of the washer is one of equal to and less than 1°.

30. The household appliance of claim **28**, wherein the washing unit is suspended inside the housing such that the inclination of the axis of rotation of the rotatable drum from the fixation axis of the washer is one of equal to and less than 3°.

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