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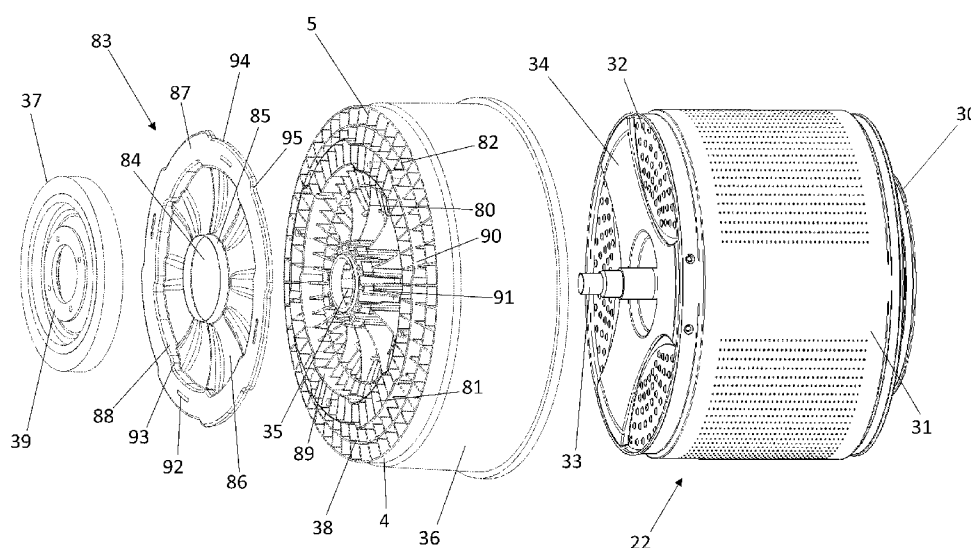


FIGURE 3

(57) Abstract: A reinforcing plate for stiffening an end wall of the water tub of a laundry washing machine. The plate is fastened to a central, recessed region of the end wall about a drive shaft and includes engagement features for contacting and engaging with complementary features formed on/in the end wall. A motor may be recess-mounted to the wall to reduce axial length of the motor and tub assembly. Once effectively engaged, the plate stiffens the thinned end wall, enabling effective transfer of out-of-balance forces from the shaft to the radially outer region of the end wall. The shape of the plate and/or the shape/arrangement of the engagement features enables rotational engagement of the plate to the end wall despite variations in plate and end wall dimensions from inherent manufacturing tolerances of those parts. A direct-drive motor assembly in which such a reinforcing plate forms a bearing housing is also described.



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APPLIANCE DIRECT-DRIVE MOTOR MOUNTING ARRANGEMENT

The present invention relates to an electric motor mounting arrangement for enabling the non-rotating part (or stator) of an electric motor to be attached to a home appliance. In particular, though not solely, the invention relates to a strengthening or reinforcing arrangement for a wall or base of a flexible (such as a plastics) component to which the non-rotating part of a direct-drive electric motor is to be attached, such as the rear/base wall of the water tub (or “outer bowl”) of a front-loading (“horizontal-axis”)/top-loading (“vertical-axis”) laundry washing machine, particularly wherein the wall or base has been weakened/thinned to accommodate or recess part of the motor for volumetric efficiency.

Early “automatic” laundry washing machines had motors which were mounted to the frame of the machine with their shaft coupled to drive a shaft of a rotatable drum (and/or agitator in top-loading machines) by a belt. More recently, it has become common to mount the non-rotating (stator) part of the motor directly to the rear wall (in the case of a front-loading machine) or base wall (in the case of a top-loading machine) of the laundry washing machine’s stationary water tub with the motor’s rotor directly coupled to/on the drum shaft of the machine. Such “direct-drive” motors are less noisy, are more reliable, and more efficiently transfer power to the rotating parts of the machine. A direct-drive electric motor may comprise a BLDC (brushless DC) motor and may have an internal rotor or may be “inside-out” with a magnet-carrying ring of the rotor spaced radially outwardly from the tips of radially outwardly-projecting stator poles.

In a laundry washing machine water tub the stiffness of the base/rear wall is critical to providing structural support to the (inner) rotatable drum via the hub of the water tub and drum shaft. Although the rear or base wall is usually a structure including integrally-formed reinforcing ribs it will be referred to simply as an “end wall” herein. When spinning at high speed with out-of-balance loads present in the drum, large rotating, radially-directed forces and moments are transmitted from the drum, via the shaft and the hub (or a bearing housing) in the end wall surrounding shaft bearings, to the mounting points of the suspension system onto the tub. If the water tub structure (particularly the end wall) is not sufficiently stiff then large cyclical deflections can occur in the water tub’s structure whereby the shaft/drum/motor is able to move radially relative to the water tub. These vibrations of the water tub can result in audible noise being generated, and are not absorbed efficiently by the suspension system. There is also a risk of the vibrations causing parts to physically clash and become damaged.

When the water tub is formed from a plastics material and its end wall has been thinned to accommodate a motor, the end wall is usually not sufficiently rigid to resist deformation resulting from the above-mentioned out-of-balance forces, particularly with the tendency towards greater laundry load-handling and increased spin speeds in modern laundry washing machines. In order to improve the stiffness of the water tub end wall, it is known to fasten a stamped sheet-metal stator support plate to the outer surface of the tub end wall, to which the stator of a direct-drive motor is then connected (see the “motor mounting bracket” and “stator supporter” disclosed respectively in US7114355B and US8220295B, for example). However, the transmission of radially directed forces and moments by such stamped sheet-metal support plates to a radially outer part of the end wall is via only a small number of fasteners such as screws which provide only localised areas of support and have the potential to loosen their engagement with the plastics end wall after repeated cyclical loading. In some cases the end wall of the water tub and the support plate may have similar profiles and the inner or outer extents of the support plate designed to contact adjacent features on the end wall. However, due to dimensional differences resulting from standard manufacturing tolerances in both components it is not possible to guarantee that a sufficiently close fit will be repeatably achievable between the engaging surfaces of the water tub end wall and support plate at a large diameter.

It is also known to locate a stator support plate within the end wall of the water tub by over-moulding the plate during injection moulding of the water tub (see US20040163428A and US8336341B, for example). Such an over-moulded support plate is often cast from Aluminium alloy and may even be a radially-extending flange of an over-moulded drum shaft bearing support tube or may be independent of the bearing support tube. Unfortunately such over-moulded castings add considerable cost to the appliance and complicate the water tub’s manufacture.

Still further, kitchen or laundry appliances are manufactured to substantially standard height, width and depth dimensions, particularly in the case of front-loading laundry machines which must fit beneath a standard-height bench or counter. In order to cater to the current tendency towards greater laundry-load handling with the benefits of a direct-drive motor, while maximising the load space within the drum, one option is therefore to reduce the thickness of the tub end wall. This of course reduces the water tub’s stiffness and so compromises the end wall’s ability to resist deformation thus worsening the abovementioned cyclical deflections and

vibrations. To compensate for this loss of stiffness a large cast aluminium hub component may be over-moulded into a region of the water tub's end wall that has been hollowed out to accommodate part of the motor. An example of this solution is shown in US6681602B but again, manufacturing is complicated and the cost of such a casting is prohibitive.

- 5 It would therefore be beneficial to provide a cost-effective, strong and rigid strengthening, mounting or reinforcing arrangement for structurally connecting the radially inner and radially outer parts of the end wall of the water tub, such as connecting the outer part of a central bearing housing to the radially outer part of the water tub end wall, in such a way that space can be provided for mounting a direct drive motor without compromising the tub stiffness, while
10 requiring a minimal number of fasteners and being able to accommodate for manufacturing size tolerances between the components.

It is therefore an object of the present invention to provide a strengthening, mounting or reinforcing plate for use with a flexible laundry machine water tub, which goes at least some way towards meeting the above desiderata or which will at least provide the public or industry
15 with a useful choice.

In a first aspect, the invention consists in a reinforcing plate suitable for stiffening an end wall of the water tub of a laundry washing machine, comprising:

- an inner rim portion surrounding an axis of a central opening,
- a body portion extending radially outward of the inner rim portion to a radially outer
20 edge of the reinforcing plate, a radial extent of the body portion forming an annular recessed region that is axially displaced relative to a radially outer extent of the body portion, and
- at least one engagement feature provided on the body region adapted to interact with at least one complementary feature of the end wall of the water tub for securing the reinforcing plate thereto, the engagement feature or features extending in a circumferential direction
25 about the axis, following a path in which the radial distance from the axis to a particular engagement feature increases with the circumferential distance from a first end of the particular engagement feature toward a second end of the particular engagement feature.

In a second aspect, the invention consists in a direct-drive electric motor assembly, the assembly comprising:

- 30 a pair of spaced apart co-axially-aligned bearings, each bearing including annular inner and outer races,

first and second bearing supports, in each of which an outer race of one of the bearings is positioned, the first and second bearing supports connected together,

a rotor including a rotor hub having an opening therethrough, the opening in the rotor hub co-axially aligned with, and located axially between, the pair of bearings, and

5 a stator non-rotationally fixed to one of the bearing supports,

wherein at least one of the bearing supports comprises a reinforcing plate according to the first aspect.

In a third aspect, the invention consists in a laundry washing machine comprising:

a cabinet,

10 a water tub attached to the cabinet via a suspension system, the water tub having an end wall with an opening formed therein about an axis, an axially outer side of the end wall of the water tub having an annular recessed region formed therein about the opening,

a rotatable drum mounted within the water tub to rotate about the axis,

a drive shaft connected to the drum on the axis, the drive shaft passing through the
15 opening in the end wall of the water tub,

wherein a direct-drive electric motor according to the second embodiment is engaged, by a reinforcing plate bearing support, to the outer side of the water tub's end wall, over the drive shaft, positioned at least partially axially within the annular recessed region.

In a fourth aspect, the invention consists in a laundry washing machine comprising:

20 a cabinet,

a water tub attached to the cabinet via a suspension system, the water tub having an end wall with an opening formed therein about an axis, an axially outer side of the end wall of the water tub having an annular recessed region formed therein about the opening , and

a rotatable drum mounted within the water tub to rotate about the axis,

25 a drive shaft connected to the drum on the axis, the drive shaft passing through the opening in the end wall of the water tub,

a reinforcing plate according to the first aspect attached to an outer side of the end wall with the annular recessed region of the reinforcing plate located in the annular recessed region in the end wall of the water tub, the at least one engagement feature of the reinforcing plate
30 contacting and engaging with a complementary engagement feature of the end wall of the water tub, and

an electric motor having a rotor mounted to the drive shaft.

The invention consists in the foregoing and also envisages constructions of which the following gives examples only. In particular, the invention will be mainly described with reference to its incorporation within a front-loading laundry washing machine but those of ordinary skill in the art will appreciate that the invention may be more broadly applied. For example, the invention may be incorporated in other home appliances such as laundry washer/dryers which are conventionally front-loading. The invention could also be incorporated, for example, in a top-loading or “vertical axis” laundry washing machine. The invention will also be described with reference to an outer-rotor type electric motor although an internal-rotor motor could alternatively be used. In the following description the term “at least partially radially-facing” is used to describe the orientation of an engaging surface or edge, however it should be appreciated that the surface need not be entirely directed radially at or towards an axis but instead what is intended is that a normal vector to the surface (that is, the facing direction) has at least a component which is in a plane perpendicular to the axis, irrespective of whether the normal vector is directed generally toward or generally away from the axis. This terminology may also be understood to mean that the surface or edge is “at least partially axially-extending” so that it encompasses not only, for example, a cylindrical or other surface/edge having a constant cross-section in planes perpendicular to the axis (i.e., completely axially-extending), but also a conical surface/edge (i.e., only partially axially-extending).

Preferred forms of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view from below of a water tub assembly of a prior art top-loading laundry washing machine showing a conventional motor mounting arrangement,

Figure 2 is a perspective view from above of an exemplary front-loading laundry washing machine incorporating a direct-drive electric motor mounting arrangement in accordance with the present invention,

Figure 3 is an exploded perspective view of a first embodiment of a drum and tub assembly for the front-loading laundry washing machine of Figure 2 showing an embodiment of reinforcing plate according to the present invention,

Figure 4 is a perspective view from below of the drum and tub assembly of Figure 3 in an assembled orientation,

Figure 5 is a vertical cross-sectional view through the axis of the drum and tub assembly of Figure 4,

Figure 6 is a perspective view from below of a second embodiment of a drum and tub assembly with attached motor for the front-loading laundry washing machine of Figure 2 with an alternative form of reinforcing plate to that illustrated in Figure 3,

Figure 7 is a bottom view of the drum and tub assembly of Figure 6, and

Figure 8 is a partially exploded, cross-sectional view through a water tub assembly of a front-loading clothes washing machine incorporating a direct-drive electric motor assembly which includes, as a bearing housing, an embodiment of reinforcing plate according to the present invention.

With reference in particular to Figures 1 and 2, a laundry clothes washing machine 20, as is well known, includes an outer cabinet or “wrapper” 21 which contains an outer tub assembly 1 (not visible in Figure 2) including a generally cylindrical, fixed (non-rotating) water tub 2 for containing washing liquid. The outer tub assembly 1 shown in Figure 1 is a prior art example from a top-loading laundry washing machine in which a non-rotating stator part of a direct-drive electric motor 3 is connected directly to the end wall 4 of the cylindrical water tub on the water tub’s axis. Water tub 2 may be moulded from a plastics material to include a substantially flat circular inner end wall and in order to stiffen end wall 4 it is provided with a pattern of radially and circumferentially arranged, axially-extending ribs attached or integrated with the inner end wall and cylindrical side wall with the stator of motor 3 attached to the axially outer side of a central hub part or projection (not shown in Figure 1 but see 91 in Figure 3) formed about the axis and connected to the pattern of ribs. As mentioned above, the term “end wall” used herein includes the entire generally radially extending base or rear wall construction, including attached or integral stiffening arrangements.

Additionally, the end wall 4 of water tub 2 may be moulded over a stiff tubular bearing housing (not shown) formed, for example, as a metal extrusion to thereby provide a solid central outer housing for shaft bearings and for fastening of the stator thereto. A plurality of suspension system engagement locations 6 are circumferentially distributed around a lower portion of the water tub’s outer surface (note that the water tub’s outer surface may be discontinuous, as shown, being made up of the outermost edges of the axially-extending ribs of the end wall 4). Each engagement location 6 is for receiving the lower end of a suspension rod which is fixed at

its upper end to the cabinet of the machine so that the water tub is suspended from the cabinet. Within water tub 2 there is provided a generally cylindrical rotatable perforated spin tub or drum 22 (not visible in Figure 1) for holding a load of laundry such as clothing for washing.

The top-loading laundry machine's rotatable drum will usually include a central agitator or wash plate designed to move the laundry load when sufficient washing liquid has been added to the water tub. A rotor 7 of motor 3 is rotationally engaged with the lower end of the drive shaft. The drive shaft passes along the water tub's axis through a central opening in the stator, through a central hole in the end wall 4 (via a seal) and is engaged or engageable to selectively rotate either:

- the drum and agitator/wash plate (for centrifugal spin drying at high speed), or
- only the agitator/wash plate (for oscillatory, lower speed washing).

The electric motor 3 shown in Figure 1 is an outer-rotor brushless DC (BLDC) or electronically commutated motor (ECM) which has stator windings about radially-outwardly-extending poles of an annular stator core which are selectively energised by a motor controller (not shown). Rotor 7 is essentially "cup-shaped" and incorporates a permanent magnet ring at a radially outer part thereof, the magnet ring providing alternate north and south rotor poles which are spaced radially from the stator pole tips by a small air gap. An exemplary motor of the just described configuration is disclosed in further detail in our prior publication US20150207371A.

The above description of the prior art vertical-axis or top-loading water tub assembly of Figure 1 also applies in general to horizontal axis or front-loading laundry washing machines 20 (Figure 2) although the latter machine type has no need for an agitator or wash plate within drum 22. In the case of a front-loading laundry washing machine 20, the water tub 2 may be formed in two axially separate halves which are subsequently sealed or welded together (although the subsequent drawing figures omit the "front" tub half which includes an access opening in use aligned with the machine's door 23 opening). As is well-known, front-loading laundry washing machine 20 also includes a control panel 24, a removable upper or lid panel 25 and feet 26.

Figures 3 to 5 illustrate an exemplary wash tub assembly for the front-loading laundry washing machine of Figure 2. It can be seen that spin tub 22 (visible through the central window of door 23) includes a front opening 30, a substantially cylindrical perforated side wall 31 and a perforated end wall 32. A drum shaft 33 on the drum's axis extends away from a supporting structure such as casting 34 attached to the cylindrical wall adjacent end wall 32. Casting 34 may

for example be formed with three radially-extending spokes between the periphery of the drum and shaft 33. Shaft 33 is adapted to pass through a central opening 35 in a water tub rear half 36 for eventual connection to rotor 7 (not shown in Figure 3) which is mounted coaxially with and so as to rotate around stator 37 of the motor.

5 A pair (preferably a single pair) of axially-spaced bearings are located within central opening 35 for rotatably supporting shaft 33. Preferably the bearings are each rolling (or “rolling element”) bearings with annular, co-axially-aligned inner and outer races separated by rolling elements such as ball bearings or rollers, enabling independent rotation of the inner and outer races about their axis. As shown in Figure 5, the central opening 35 may be formed as part of a bearing
10 housing 50 including axially-spaced bearing-receiving features 51, 52. Bearing housing 50 may be a cast or extruded metal component about which water tub half 36 is moulded and to which the stator 37 may be fixed, such as by bolting as shown in the drawings, via mounting holes in a stator mounting flange 39. Radially-arranged reinforcing ribs 5, moulded as part of water tub end wall 4, preferably extend from a radially inner end in contact with bearing housing 50 to a
15 radially outer end at or near the radially outer extent of the water tub. As may be seen in Figures 3 and 4, circumferentially-arranged reinforcing ribs 38 are preferably also formed or moulded as part of end wall 4 to further improve rigidity of the water tub’s motor-carrying end wall.

End wall 4, including ribs 5, 38 has an outer, substantially axially-facing surface 82 (best seen in Figures 3 and 5) that in cross-sectional profile along the axis (Figure 5) through the centre of
20 opening 35 has:

- a central projection portion 54 forming a substantially cylindrical “hub” immediately surrounding opening 35 and mainly made up of the bearing housing 50 and some supporting material (preferably plastics) encasing the bearing housing,
- an annular recessed or depressed region or channel 80, which is preferably slightly
25 dished, extending axially below (towards drum 22) the axially outermost level of, and extending radially outwardly a predetermined distance from, the central projection portion, and
- an outer ring projection 81 spaced radially outwardly of the annular recessed region 80 and extending radially outwardly therefrom towards the radially outer extent of
30 the end wall 4 while extending axially above (away from drum 22) the axially outermost level of the annular recessed portion 80.

In the embodiment shown in Figures 3 to 5, preferably the radially outermost portion of the outer surface 82 of end wall 4 may also be slightly recessed below the outermost level of outer ring projection 81. Thus, the outer surface of end wall 4 includes an annular recessed region 80 from which base wall material has been removed. The recessed region 80 has a radial width which is sufficient to accommodate the radial width of both rotor (not shown) and stator 37 of motor 3 with required clearances therearound. For example, the radial width of recessed region 80 may be between about 5 cm to about 10 cm but of course depends on the motor dimensions. The axial depth of the recessed region 80 is sufficient to accommodate at least a portion of the motor's axial height so that the combined axial "length" of water tub and attached motor is reduced in comparison to simply mounting the motor to a substantially flat water tub end wall outer surface. For example, the axial depth of the annular recessed region 80 may be between about 3 cm and about 10 cm.

In order to stiffen or reinforce end wall 4, particularly at or adjacent the axially outer end of the hub (now that some of the end wall supporting that end of the hub has been removed to accommodate motor 3), a reinforcing plate 83 is provided. Reinforcing plate 83 may be formed from a strong and stiff yet relatively inexpensive material such as sheet metal. For example, reinforcing plate 83 may be pressed from sheet steel of, for example 1 mm to 3 mm thickness.

In general, reinforcing plate 83 is annular dish-shaped with a central opening 84 surrounded by a substantially cylindrical or slightly frusto-conical or tapered collar providing an inner rim portion 85 of the plate 83. Inner rim portion 85 is preferably sized to be a press (or interference) fit over the radially outer circumference of the central hub projection 91 of end wall 4 to provide a robust, zero-clearance connection to the hub that is not dependent upon fasteners for the transmission of radially-directed loads. A body portion of the reinforcing plate extends radially outwardly from the inner rim 85 and includes an annular recess or channel 86 over a radially inner extent thereof and an outer substantially radially-extending substantially planar annular flange 87 over a radially outer extent thereof. Annular recess 86 may be slightly convex or dished when viewed in an axial direction towards tub half 36 to match the profile of region 80 of the water tub's end wall surface 82.

Connecting annular recess 86 to outer flange 87 is an at least partially radially-facing annular surface or wall 88 which may have an axial height of, for example, between about 10 mm and about 20 mm. Preferably, wall 88 extends in a substantially axial direction and so is completely

radially-facing. Wall 88 of reinforcing plate 83 is generally circumferential although not circular in profile (when viewed in an axial direction). The profile or shape (as explained in more detail below) and locus of wall 88 when viewed axially is arranged so that when the reinforcing plate is fitted to end wall 4 of water tub half 36, wall 88 is in contact with a corresponding radially-inwardly facing tub surface or wall 89 over at least a portion or portions of its circumferential extent. Wall 89 of end wall 4 may be the inner side surface of a circumferential rib, for example, at the interface between annular recessed region 80 and outer ring projection 81.

As best seen in Figure 3, the circumferential shape, when viewed axially, of walls 88 and 89 may include at least one section extending over at least a portion of the 360° circumference where the radial distance from the axis to the wall changes with angular position and so is non-circular. That is, starting from a first end of one of (or the one) circumferential section and moving towards a second, opposite end of the circumferential section involves a radial displacement. Ideally that radial displacement is gradual rather than abrupt/stepped and increases with the circumferential distance from the first end to the second end. For example, as shown, walls or surfaces 88 and 89 may include arc sections that are on a spiral or involute surface wherein the first end is radially inward of the second end. The circumferential section or sections could alternatively be tangential lines extending outwardly from a circle about the axis or could be circular or elliptical arcs starting on a circle about the axis. Each circumferential section may comprise an engagement feature or element for engaging the reinforcing plate with complementary engagement features or elements of the end wall of the water tub.

The circumferential extent of the walls 88, 89 could each consist of a single spiral or curved line steadily increasing in radial distance with circumferential angle/distance about the axis. However, the embodiment shown in the drawing figures includes plural circumferential sections, such as eight circumferential sections each preferably covering a corresponding or equivalent angular extent about the axis (to simplify assembly) whereby both wall 88 and wall 89 have a corresponding or matching shape. Walls 88, 89 when viewed axially may be described as generally or substantially saw-tooth shaped in a fashion similar to superimposing a saw-tooth wave shape onto the circumference of a circle. The starting (radially innermost) point of a first circumferential section may be connected to the ending (radially outermost) point of the preceding circumferential section by a short joining segment 93 that may be radially directed or slightly curved. Preferably the adjacent starting and ending points are not overlapped circumferentially and a circumferential gap is provided therebetween so that an obtuse angle is

formed between the radially outermost end of a circumferential section and its joining segment 93.

The diameter of the radially outer side of wall 88 of the reinforcing plate should be slightly smaller than the diameter of the radially inner side of wall 89 in end wall 4. In this way, and with walls 88, 89 having matching shapes (including the same number of circumferential sections), assembly of reinforcing plate 83 to the outer side of end wall 4 of the water tub is easily achieved. That is, by simply rotating the reinforcing plate (or water tub) about the axis a small amount until the reinforcing plate is able to be pushed axially onto the end wall with collar 85 a press fit over the outer surface of tub central hub projection 91, annular recessed or dished portion 86 adjacent or against surface 80 of tub end wall 4 and the underside of outer flange 87 against the surface of end wall outer ring projection 81. After the plate is secured to the end wall, stator 37 may then be attached to hub projection 91 or to bearing housing 50, for example by bolts 53. The stator fastenings may also pass through openings provided in a central, radial flange (not shown) of the reinforcing plate to assist in securing the plate to the tub. Once spin tub 22 and bearings have been added to the assembly the rotor of motor 3 may be attached to shaft 33 with the result being that the motor is at least partially housed or recessed within the thickness of tub end wall 4.

Ideally, pushing the reinforcing plate 83 onto the tub end wall 4 will result in a press fit between walls 88 and 89 so that radially-directed forces, such as those mentioned above as a result of an out-of-balance spinning laundry load, at the axially outer end of the bearing housing 50 or hub projection 91 can be transmitted, by the stiff reinforcing plate 83, to the outer part of end wall 4 which is much thicker and stiffer than the central end wall region where annular recessed region 80 is located. However, manufacturing tolerances for both the water tub base half 36 and reinforcing plate 83 mean that there will be situations where the average diameter of wall 88 is slightly smaller or slightly larger than the average diameter of wall 89 so the reinforcing plate cannot be a press fit onto end wall 4.

This situation can be easily accounted for by the present invention by ensuring that the average outer diameter of reinforcing plate wall 88 is smaller than the average diameter of tub wall 89, pushing the reinforcing plate collar 85 over hub projection 91 with the reinforcing plate rotated to a position that will allow its circumferential sections to nest within their corresponding circumferential sections of tub wall 89, then rotating the reinforcing plate in a rotational

direction that will press wall 88 sections into contact with wall 89 sections. Once in a desirable rotational position, fasteners 40 (Figure 4) such as screws may be passed through an opening or openings 92 in flange 87 and tightened into correspondingly-positioned holes formed in the outer surface of end wall 4 to fix, and rotationally lock, the reinforcing plate to the end wall.

- 5 Openings 92 are preferably slots having sufficient length to allow for the amount of relative rotational adjustment, between the end wall 4 and the reinforcing plate, that is required to compensate for the likely range of relative part diameter variation. Preferably the slots have a planar spiral or involute type trajectory to accommodate manufacturing tolerances in the slot locations and the positions of the holes in end wall 4. Preferably plural slots are each formed on
- 10 the same pitch circle about the plate's axis and have the same or a similar curvature to the circumferential wall section(s) given that the dimensional variations being accommodated by the slots, and the wall sections in any particular moulded water tub end wall, will closely correspond.

- The thus created interfacing lines or arcs of contact between circumferential wall 88 sections
- 15 compressed against circumferential wall 89 sections ensure a stiff path for transmission of radially directed forces or moments from shaft 33, through reinforcing plate 83 to the outer region of end wall 4 without requiring a large number of fasteners. It will be appreciated that the fasteners merely avoid plate rotation relative to the tub end wall, rather than transmit/transfer radial loads. Preferably, the curvature or shape of the circumferential sections
- 20 of walls 88 and 89 are substantially the same to maximise the circumferential length/area of the contact region when they are rotated into a nested position adjacent one another.

- As mentioned above, the radially outer region 82 of the outer surface of end wall 4 of the water tub half 36 may be slightly recessed below the level of outer ring projection 81 (see Figures 3 and 5). In this case, the radially outer extent of outer ring projection 81 has a circumferential
- 25 side wall 90 connecting the outer ring projection to the radially outermost portion 82 of the outer surface of end wall 4. For example, the axial height of wall 90 may be between about 5 mm and about 15 mm. When wall 90 is formed in water tub half 36, the outer periphery of outer flange 87 of reinforcing plate 83 can be provided with an axially extending lip or wall 94. Lip 94 extends away from the same side of flange 87 that wall 88 extends from. Lip 94 has an at least
- 30 partially radially-facing surface, which is preferably substantially or entirely radially-facing (that is, substantially or entirely axially-directed) and substantially parallel to or congruent with wall 88. When viewed axially, the shape of wall 90 of end wall 4 may substantially mimic or duplicate

the shape of wall 89. That is, wall 90 may be formed by adding a fixed radial offset to wall 89 with the same number of circumferential sections, each adjacent pair separated by bridging portions 95. However, outer wall 90 need not mirror precisely the shape of inner wall 89. For example, outer wall 90 may be shaped to include the same number of circumferential sections as plate wall 89 but the individual circumferential sections could have a tighter radius of curvature so that the radial width of each circumferential section of outer ring projection 81 gradually increases from a starting end to a finishing end so that each section of the outer ring projection 81 is wedge shaped.

Lip 94 of the reinforcing plate 83 is preferably shaped in a complementary fashion to the shape of wall 90. Thus, when the circumferential sections of outer ring projection 81 have a substantially constant radial width, so does outer flange 87 such that lip 94 has essentially the same shape as plate inner wall 88, although having a larger average diameter so that the circumferential length of each circumferential section of plate lip 94 is slightly greater than the circumferential length of each corresponding section of plate inner wall 88. It will be appreciated that the shape of plate lip 94, at least over the arcs making up the interfacing/contact surfaces of the circumferential sections, should substantially correspond to the shape of tub base outer wall 90, although with a slightly larger average diameter to enable lip 94 to slide over wall 90 when reinforcing plate 83 is fitted to tub end wall 4.

During the aforementioned rotational tightening of reinforcing plate 83 to end wall 4, as the radially outwardly-facing surface of plate inner wall 88 presses outwardly against tub base inner wall 89, the inwardly-facing surface of lip 94 presses inwardly against the radially outwardly-facing surface of tub base outer wall 90. Thus, outer ring projection 81 is radially squeezed between walls 88 and 94 of the reinforcing plate so that both compressive and tensile radially-directed forces may be more effectively transferred from shaft 33 or central hub projection 91 to the outer region of end wall 4 via reinforcing plate 83.

To allow for relative rotation between the water tub end wall and reinforcing plate 83 during assembly/tightening, the arc lengths of the circumferential segments of the axially directed walls of the reinforcing plate should be slightly longer than the arc lengths of the corresponding interfacing walls on the water tub. As a consequence, engagement with the side walls of the outer ring projection 81 is not achievable around the entire circumferential extent of the reinforcing plate however the length and area of engagement is still sufficient to provide a large

contact area to spread the radially-directed shaft loads and ensure that stresses and deflections in the reinforcing plate and end wall 4 are minimal. Reinforcing plate 83 may have forms pressed into it, in particular as shown in Figure 3 within annular recessed region 86, to increase its radial stiffness and resistance to deformation.

- 5 It will also be appreciated that the reinforcing plate and water tub half 36 end wall outer surface may be arranged so that the adjacent radially inner walls 88, 89 are non-engaging and only radially outer adjacent walls 90, 94 are engaged upon rotation of the reinforcing plate. For example, the radially inner walls may be cylindrical with a clearance therebetween so that once rotationally locked, the reinforcing plate is effectively radially pre-tensioned to add stiffness to
10 the end wall.

- In an alternative to the embodiment shown in Figures 3 to 5, outer ring projection 81 in end wall 4 may be replaced by a ring-shaped depression, recessed below (towards drum 22) the outer surface of end wall 4. The depression could have radially separated, at least partially radially-facing, side walls of shapes corresponding, when viewed axially, to those shown in Figures 3 and
15 4. In this embodiment, a reinforcing plate could be similarly shaped to reinforcing plate 83 with a similar collar and annular recess 86 radially extending therefrom but flange 87 would be axially displaced below (towards drum 22) the rear side of the plate (when viewed in the direction of Figure 3 or Figure 4).

- Alternatively, the reinforcing plate may be similar to plate 83 but with an additional “U”-shaped
20 (in cross-section) annular extension at the plate’s outer periphery. The U-shaped extension would have radially-spaced non-circular side walls corresponding to walls 88 and 94 of plate 83 and the outer surface of the water tub end wall 4 would have a correspondingly shaped and located recessed channel near its periphery which could axially receive the U-shaped channel therein and allow tightening of the reinforcing plate to the end wall by a subsequent relative
25 rotation. In this version, the axially extending wall connecting the reinforcing plate’s outer flange to the annular recessed portion, and wall 89 of end wall 4, may be circular and designed as a simple press-fit interface.

- A second preferred embodiment of the invention will now be described with reference to Figures 6 and 7. Water tub half 60 in Figures 6 and 7 is similar to water tub half 36 and includes
30 a base or end wall 61. As in the previous preferred embodiment, end wall 61 includes a thin diaphragm forming the inner end wall of the water tub and a predetermined thickness of axially-

extending reinforcing ribs 62 to increase the water tub's end wall rigidity. As with water tub half 36, a central opening (not shown) is formed to allow the spin tub shaft to pass through for engagement to the rotor 63 of a motor (note that the inner stator is hidden by the outer rotor). As with water tub half 36, a central hub part or projection is formed about the central opening on the axis, connected to the pattern of ribs. The central hub projection may comprise an over-moulded bearing tube providing annular recesses adapted to receive the outer races of axially-separated roller bearings. Surrounding the central hub projection is an annular recess (not shown) which may have a base surface similar to that of annular recess 80 but its axially-extending, radially-separated inner and outer side walls are substantially circular. In Figures 6 and 7 the annular channel or recess formed in the outer surface of end wall 4 is not visible but it can be seen that the annular recessed reinforcing plate 64 has a circular axially-extending outer side wall 65. A corresponding circular axially-directed inner side wall is also provided on the reinforcing plate, radially inward of wall 65 but this is hidden behind rotor 63. The inner (not shown) and outer 65 radially-separated side walls and a base wall 66 together make up the annular recessed region or channel 66 in the reinforcing plate which surrounds a substantially cylindrical or slightly frusto-conical or tapered collar providing an inner rim portion similar to inner rim portion 85 of the first preferred embodiment.

As in the first preferred embodiment, during assembly reinforcing plate 64 is pressed on to the outer surface of end wall 61 with its inner rim portion a substantially zero-clearance fit over the outer radial surface of the water tub end wall's central hub projection. At the same time, the annular recess in the reinforcing plate is pressed into contact with the side and base walls of the annular recess in the end wall of the water tub base. At least the side walls, but preferably also the base wall, of the annular recess 66 may be in sliding contact or engagement with the adjacent walls of the water tub base recessed region although at least some radial clearance is intended, particularly with regard to the respective outer side walls of the recesses to allow for tub diameter manufacturing variation.

Reinforcing plate 64 includes an outer flange 67 comprising a substantially flat circular ring extending radially outwardly from the outer axial end of wall 65. Flange 67 is adapted to sit, in use, against the substantially planar outer surface 69 of water tub end wall 61 surrounding the annular recessed region in the end wall. Flange 67 includes at least one, and preferably plural, slots 68 formed or punched therethrough. In Figures 6 and 7 flange 67 includes 10 slots 68 and it is preferred that at least some of slots 68 do not follow a circular path about the reinforcing

plate's axis. For example, the slots may follow a spiral path about the axis so that moving along their length from a radially inner end toward the opposite, radially outer end, also involves a radially outward displacement from the axis. Alternatively, a slot or slots 68 could be formed along a tangent line to a circle about the axis of the water tub/reinforcing plate or even an arc of a circle (with its centre not on the axis) or an ellipse, for example. Each slot (in particular its lateral or longer side walls/edges) may comprise an engagement feature or element for engagement with a complementary engagement feature provided on the end wall of the water tub.

Slots 68 formed in flange 67 have a longitudinal (straight or curved) length that is substantially greater than their lateral width between slot side walls. The radially outer substantially planar surface 69 of tub end wall 61 is provided with axially-extending protrusions or protuberances 70 (for example, pins or pegs) located axially and radially about the axis so as to pass through slots 68 when reinforcing plate 64 is pressed onto the end wall of the water tub half 60. Axially extending protrusions 70 may have an axial height of, for example, between about 5 mm and about 15 mm above the surrounding surface of the end wall (as mentioned above, the end wall's "surface" may comprise the axially outermost ends of the network of ribs 62). Each axially extending protrusion 70 may have a shape, when viewed axially or cross-sectionally in a plane perpendicular to the axis, which is substantially rectangular including longer side walls substantially aligned with the longitudinal direction of the slot 68. The longer side walls may be straight and parallel or may themselves be on parallel or congruent arcs or spirals, preferably having the same shape to the side walls/edges of their slot.

In this second preferred embodiment, variations in diameter between the adjacent walls of the recessed region 66 in reinforcing plate 64 and the annular recess in tub end wall 61 may again be tolerated. The reinforcing plate design of this embodiment is much simpler than the previous embodiment but still tolerates manufacturing tolerance-related diametrical dimensional differences in the reinforcing plate and the water tub base's recessed region. In this embodiment, side wall 65 of the recessed region of plate 64 does not need to contact the adjacent side, radially outward wall of the annular recess in the water tub's end wall as out-of-balance shaft loads are carried, via the reinforcing plate to the thicker/stronger radially outer region of the tub's end wall via the engagement between protrusions 70/73 and slots 68/72.

Subsequent to press-fitting of reinforcing plate 64 to the water tub half (and insertion of

protrusions 70 into slots 68), relative rotation between the water tub half 60 and the reinforcing plate 64 places some radial pre-load on the protrusions to ensure that it will be able to reliably transfer shaft out-of-balance loads. As relative rotation ensues, a side wall/edge or walls/edges of a slot 68 and a side wall or walls of its axially extending protrusion 70 are pressed into contact.

- 5 Preferably each slot 68 has a lateral width (between its longer walls/edges) is substantially the same as or slightly greater than the distance between the longer side walls of protrusions 70.

Once a sufficient engagement between the slot side wall(s) and protrusion side wall(s) is obtained, the rotational position of the reinforcing plate may be locked relative to the water tub by tightening a fastener or fasteners 71 into a hole or holes in tub end wall 61 through other
10 slots formed in the reinforcing plate 64. These other slots could have the same shape and orientation as slots 68 or they may follow a circle about the axis. To accommodate water tub manufacturing diameter variations, if these other slots are circular about the axis, rather than spiralled, then their radial width should be sufficient to overlap with the expected range of tub end wall hole positions while the fastener's head diameter would of course need to be larger
15 than the slot width. It may also be seen in Figure 7 that additional slots 72 may be formed or punched through the reinforcing plate 64 in the base part of annular recessed region 66 while additional axially extending projections 73 may be formed in the outer surface of end wall 61, within the annular recessed region. These additional slots and axially extending projections may be the same or similar in size, shape and orientation as slots 68 and protrusions 70, but located
20 radially inward thereof and provide additional coupling locations to further distribute any radially-directed forces or moments.

As in the first preferred embodiment, once the reinforcing plate has been locked in a rotational position in which the reinforcing plate forms a rigid connection between the central hub projection and the axially extending protrusions 70, radially directed compressive or tensile
25 forces may be transferred from the shaft to the thicker, radially-outer part of end wall 61 while minimising the overall axial length of the combined water tub and motor assembly.

In a still further modification to any of the above embodiments, instead of the reinforcing plate providing support to a separate cast or extruded bearing housing part or hub-forming part 50, the reinforcing plate itself could have a bearing housing or "bearing tube" formed into it. That
30 is, the reinforcing plate and bearing housing could be integrally formed. Such an integrally-formed component could be fitted to the water tub half, subsequent to its moulding, by an axial

insertion step followed by a rotational locking step (as discussed above).

In all of the embodiments described herein, it will be appreciated that respective inherent manufacturing tolerances in a plastics injection moulded water tub and in a pressed steel reinforcing plate may make it difficult to guarantee an effective tight or interference or push-fit of the reinforcing plate's inner rim or collar 85 about the central hub projection of the water tub's end wall. Accordingly, the collar may instead be designed as a clearance fit about the hub projection, provided that alternative fastening is provided to secure the radially inner part of the plate to the radially inner part of the tub end wall. For example, plural screws or other fasteners may be used to secure the radially inner region of the reinforcing plate to the water tub end wall hub.

The systems described above for ensuring a rigid radial contact connection between the reinforcing plate and adjacent surfaces of the water tub end wall, both components having dimensional tolerance variations, could also be applied to other situations where adjacent mechanical parts having dimensional tolerance variations require a rigid connection without, or with minimal, fasteners. For example, in a laundry washing machine of the type described in US5809809A or our co-pending PCT patent application No. PCT/NZ2017/050076. These documents disclose a direct-drive motor that is effectively axially located between a pair of shaft bearings in a motor housing assembly manufactured separately from and for fitting to a plastics water tub end wall. The present technique could be used in the disclosed arrangements by, for either or both of the axially inner and axially outer roller bearings, providing a reinforcing plate as herein described which also provides a housing or supports a housing for the bearing(s). That is, the present support or reinforcing plate forms part of a direct-drive electric motor assembly. Such an embodiment will now be described with reference to Figure 8.

In Figure 8 (in which features already described use common reference numerals) the rear half 36 of the water tub is shown between drum 22 and a pre-assembled motor arrangement or assembly 100. The drum 22 includes a supporting structure such as casting 34 from which drum shaft 33 fixedly protrudes, adapted to pass through central opening 35 in tub half 36 for engagement with a rotor 106 of the motor assembly 100. Assembly of the laundry appliance at the appliance manufacturer's plant could include the step of inserting drum 22 into the tub half 36, followed by mounting of the motor assembly 100 upon shaft 33 on the outer side of the tub's end wall or base 4 with at least some of the motor assembly's axial height/length

accommodated within recessed region 80 of the end wall of the water tub.

Alternatively, the assembly process could include mounting the motor assembly 100 to end wall 4 and then inserting drum 22 into tub half 36 so that shaft 33 extends through hole 35 and into motor assembly 100. The motor assembly 100 may be fixed to the shaft by a bolt (not shown) passing axially into a hole in the end of the shaft and having a head diameter sufficient to engage with a housing outer surface, or the inner race of an outer bearing (described below) of the motor assembly. In an alternative embodiment, shaft 33 could be provided as part of motor assembly 100 and subsequently connected to casting 34 of drum 22 when the shaft is inserted through tub half 36. Irrespective of the particular assembly arrangement/procedure employed, with the outer housing 103/104 of the motor assembly non-rotationally secured to the tub end wall, energisation of the motor will rotationally drive drum 22 via shaft 33. Although this embodiment is illustrated in relation to a front-loading laundry washing machine, it is equally applicable to a front-loading laundry drying or washing/drying machine or to a top-loading laundry washing machine. In the case of a top-loading laundry washing machine, motor energisation may also selectively rotationally drive a wash plate or agitator within drum 22 utilising known clutch mechanisms to selectively rotationally couple the drum and wash plate/agitator.

A pair of (preferably a single pair of; that is two) axially-spaced bearings 101, 102 are provided within motor assembly 100 to rotatably support shaft 33. Preferably the bearings are each rolling (or “rolling element”) bearings with annular, co-axially-aligned inner and outer races separated by rolling elements such as ball bearings or rollers enabling independent rotation of the inner and outer races about their common axis. An outer or first bearing 101 is provided at or near the axially outer end of shaft 33 while an inner or second bearing 102 is also provided within the assembly 100. Bearings 101, 102 are located in the motor assembly 100 by respective first 103 and second 104 bearing housings or supports. A seal 105 mounts to second bearing housing 104 and extends radially inwardly therefrom to shaft 33 to provide a rotational seal thereto and additionally provides a static seal to the tub end wall 4 about opening 35. The bearing housings 103, 104 may be formed from pressed sheet metal, such as pressed sheet steel. To increase the stiffness of the motor assembly 100, one or both of the bearing housings could be formed from a stronger material such as a cast metal (e.g., cast steel or aluminium) or could be formed by injection-moulding a sufficiently strong engineering plastics material.

It will be appreciated from Figure 8 that the first 103 and second 104 bearing housings are each generally oppositely dished circular or plate-like structures including bearing-outer-race-seating features for locating and holding in place one of bearings 101, 102. Bearing housings 103, 104 extend radially outwardly from their respective bearings and, when connected at their peripheral flanges 115/116, enclose a volume in which the motor components (including outer rotor 106 and inner stator 107) are contained. In the embodiment illustrated the first bearing housing 103 and the second bearing housing 104 are fixed together (in such a manner as to substantially fix the relative axial and radial positions of the respective bearing seating features) radially outwardly of the rotor's outer diameter and fasteners (not shown) may lock the first and second bearing housings together about their peripheries to thereby form a unitary, monolithic motor assembly 100.

At least inner bearing housing 104 is formed as a reinforcing plate generally as described above in any of the various embodiments while end wall 4 of the water tub is provided with complementary engaging features to those provided in the bearing housing(s). As a result, the bearing housing(s) not only locate and support the bearing(s) within motor assembly 100, but also effectively transfer radially-directed out-of-balance loads from drum shaft 33 to the outer region of the (thinned and therefore weakened) tub end wall. In addition, it will be appreciated that such an arrangement of motor assembly and tub end wall beneficially minimises the axially height (or length) of the combined water tub and motor.

In this embodiment, as the reinforcing plate also acts as a bearing housing, the previously-described inner rim portion of the reinforcing plate (for engaging the outer cylindrical surface of a central hub projection in the tub's end wall, the hub projection containing a bearing housing) is not required. The reinforcing plate(s), in this embodiment, therefore include(s) a central opening for passage of the shaft, surrounded by an annular, generally concave (109) or convex (110) region bounded radially outwardly by an at least partially radially-facing surface or wall 111/112 which may incorporate the aforementioned rotational locking circumferential surface(s) for ensuring effective transfer of lateral shaft loads. In Figure 8, the outer at least partially radially-facing wall 112 of bearing housing 104 may therefore have a non-circular profile (when viewed axially) such as that shown in Figure 3 in relation to reinforcing plate 83 (e.g., the aforementioned circular saw-tooth or spiral circumferential section(s), for example). Similarly, wall 89 of the recessed region 80 of the end wall of tub 36 in Figure 8 may be formed with a profile similar to that shown in Figure 3 for the corresponding surface.

The region of each bearing housing surrounding its central opening includes a bearing-outer-race-seating feature 113/114 which are preferably annular structures for receiving and retaining the outer race of a respective bearing. The previously-mentioned peripheral flanges 115/116 may be provided around the outer peripheries of the at least partially radially-facing walls 111/112 to facilitate connecting the bearing housings together. As shown in Figure 8, openings, such as slots 117, may be formed through and about the flanges of the bearing housings to enable fasteners such as screws to be passed therethrough and into the end wall 4 of the tub to secure the motor assembly 100 to the tub and to lock its rotational position relative to the tub end wall. Bearing housings 103/104 may be fastened together via the same fasteners passing through flange slots 117 and into end wall 4 but preferably the flanges will already have been fastened together, prior to incorporation of the motor assembly with the water tub.

Instead of the radially-facing (axially-extending) bearing housing wall 112 and engaging wall 89 in the water tub base having a non-circular profile, as just described, the engaging arrangement shown and described with reference to Figures 6 and 7 could be incorporated into the bearing housing(s) of the Figure 8 embodiment. That is, the at least partially radially-facing wall 89 in tub end wall 4 could be substantially cylindrical (or circular in a cross-section perpendicular to the axis). Similarly, the at least partially radially-facing wall 112 of bearing housing 104 could have a similar shape and be dimensioned to be a clearance (non-contact) fit with wall 89 of the tub end wall recessed region 80.

In this embodiment, effective transmission of out-of-balance forces from the shaft to the outer region of the tub end wall 4 may be achieved using the arrangement previously described with reference to reinforcing plate 64 in Figures 6 and 7. Accordingly, plural axially extending protuberances or protrusions 118 may be formed in end wall 4 with a similar shape and function as protrusions 70 shown in Figures 6 and 7. Bearing housing 104 may be formed to include plural slots 119, each shaped and located to enable it to receive a protrusion 118 therethrough. The shape and arrangement of slots 119 may be similar to that of slots 68 and 72 in Figures 6 and 7.

Protrusions 118 may be provided in only the base of recessed region 80 to engage with slots only provided in region 110 of bearing housing 104, or protrusions 118 may be provided only outside the recessed region, about its periphery so that only slots 117 in flange(s) 115/116 of the bearing housings engage with protrusions of the water tub. Preferably however, protrusions are provided both within and outside the recessed region 80 for engagement with slots in region

110 of bearing housing 104 as well as slots in flange(s) 115/116. Accordingly, outer bearing housing 103 may also be considered a reinforcing plate in accordance with an embodiment of the present invention, although it is not adapted to fit within a central recessed region of the tub end wall.

5 Assembly and fastening of this embodiment of motor assembly 100 to water tub 36 is analogous to the fitting of reinforcing plate 64 to water tub 60, as already explained with reference to Figures 6 and 7. That is, motor assembly 100 is positioned within recessed region 80 of end wall 4 with bearing housing 104 adjacent the base of recess 80 and motor assembly rotated so that axial protrusions 118 may pass through their respective slots 119 in bearing housing 104 and
10 slots 117 in the peripheral flanges of both bearing housings. Relative rotation between the water tub 36 and the motor assembly then ensues to place some radial pre-load on the protrusions, thus ensuring that the motor assembly is securely integrated with the water tub end wall and that the contact between the protrusions and bearing housing(s) are reliable so will be able to effectively transfer shaft out-of-balance loads from the bearing housing(s) to outer regions of
15 the water tub end wall. As relative rotation progresses, a side wall or walls of a slot 117/119 and a side wall or walls of its axially extending protrusion 118 are pressed into contact. Once a sufficient engagement between the slot side wall(s) and protrusion side wall(s) is obtained, the rotational position of motor assembly 100 may be locked relative to the water tub by tightening a fastener or fasteners 71 into a hole or holes in the axially outer face of tub end wall 4 through
20 slots 117, or other holes/slots (not shown), formed in peripheral flanges 115/116.

The stator 107 of the motor assembly is fastened to one of the bearing housings, for example the stator may be mounted to the second bearing housing 104. As is well-known, the stator may be formed as a stack of thin, generally circular steel laminations (or a single helically-wound lamination), the lamination(s) having pole cores extending radially (radially outwardly for an
25 outer rotor-type motor) from an annular base section, and stator windings wound upon the stacked pole cores. The stator core may be over-moulded by a plastics frame having an inwardly-projecting substantially flat-, curved- or frusto-conical disc-shaped mounting section radially inside the stack having a central opening through which the shaft may pass (see our publication WO2012087156A for examples of exemplary plastics stator frames).

30 Rotor 106 is rotationally fixed to the drum shaft 33 by its hub at a position axially between the first bearing 101 and the second bearing 102. Complementary, engaging tooth, key or spline

features may be provided on both the drum shaft 33 and the internal surface of the rotor hub to transmit driving torque from the rotor to drum shaft 33 and drum 22. Means may be provided to maintain position and alignment of the rotor within the motor assembly, prior to fitting to the spin tub and shaft. For example, as shown in Figure 8, the inner races of bearings 101/102
5 may be provided with axially-extending projections (or annuli) for engaging with complementary axial projections or annuli on the rotor hub.

It will be appreciated that the direct-drive motor assembly 100 includes at least the motor rotor 106, motor stator 107, pair of bearings 101/102 and bearing housings 103/104. Although the preferred embodiment illustrated includes an electronically-commutated or brushless DC
10 external rotor motor, other types of motor, including internal-rotor motors, could alternatively be incorporated in the motor assembly.

CLAIMS

1. A reinforcing plate suitable for stiffening an end wall of the water tub of a laundry washing machine, comprising:

5 an inner rim portion surrounding an axis of a central opening,
a body portion extending radially outward of the inner rim portion to a radially outer edge of the reinforcing plate, a radial extent of the body portion forming an annular recessed region that is axially displaced relative to a radially outer extent of the body portion, and

at least one engagement feature provided on the body region adapted to interact with
10 at least one complementary feature of the end wall of the water tub for securing the reinforcing plate thereto, the engagement feature or features extending in a circumferential direction about the axis, following a path in which the radial distance from the axis to a particular engagement feature increases with the circumferential distance from a first end of the particular engagement feature toward a second end of the particular engagement feature.

15 2. The reinforcing plate as claimed in claim 1, wherein the at least one engagement feature comprises a straight or curved surface or edge which extends at least partially axially.

3. The reinforcing plate as claimed in claim 1 or claim 2, wherein a radially outer extent of the body portion comprises an outer flange extending radially outwardly from a radially outer extent of the recessed region.

20 4. The reinforcing plate as claimed in claim 3, wherein plural engagement features are provided, located either only on the recessed region, or only on the outer flange, or on both the recessed portion and the outer flange.

5. The reinforcing plate as claimed in any one of the preceding claims, wherein plural identical engagement features are provided, regularly spaced about and at a common radial
25 distance from the axis.

6. The reinforcing plate as claimed in claim 5, wherein the plural engagement features comprise a first set of first engagement features at a first radial distance from the axis and a second set of plural identical second engagement features is also provided, spaced circumferentially about the axis, each of the second engagement features positioned at a
30 common second radial distance from the axis which is not the same as the first radial distance.

7. The reinforcing plate as claimed in any one of the preceding claims, wherein the at least one engagement feature comprises a slot extending through the body portion.

8. The reinforcing plate as claimed in any one of the preceding claims, wherein a radially outer side wall forms a radially outer extent of the recessed region of the body portion, the radially outer side wall having an at least partially axially-extending surface connecting the recessed region to the radially outer extent of the body portion.

9. The reinforcing plate as claimed in claim 8, wherein the radially outer side wall includes at least one circumferentially-extending surface portion, each surface portion providing an engagement feature preferably arranged to form a sawtooth-shape profile extending about at least a portion of the entire circumference about the axis.

10. The reinforcing plate as claimed in claim 8 or claim 9, wherein the radially outer side wall comprises a first wall and a second at least partially axially extending wall is also formed in the body portion and extends circumferentially about at least a portion of the entire circumference about the axis, the second wall spaced radially outwardly of the first wall by an annular flange region, the first and second walls extending axially from a common side of the flange region.

11. The reinforcing plate as claimed in claim 10, wherein the second wall comprises an at least partially axially-extending annular surface having at least one circumferentially-extending surface portion providing an engagement feature, wherein the radial distance from the axis to a particular surface portion increases with the circumferential distance from a first end of the particular surface portion toward a second end of the particular surface portion.

12. The reinforcing plate as claimed in any one of the preceding claims, wherein the inner rim portion comprises an inner collar extending at least partially in an axial direction away from the body portion and forming a radially inner side wall of the annular recessed region.

13. The reinforcing plate as claimed in any one of the preceding claims, formed from sheet metal.

14. A direct-drive electric motor assembly, the assembly comprising:

a pair of spaced apart co-axially-aligned bearings, each bearing including annular inner and outer races,

first and second bearing supports, in each of which an outer race of one of the bearings is positioned, the first and second bearing supports connected together,

a rotor including a rotor hub having an opening therethrough, the opening in the rotor hub co-axially aligned with, and located axially between, the pair of bearings, and

a stator non-rotationally fixed to one of the bearing supports,

wherein at least one of the bearing supports comprises a reinforcing plate according to

5 any one of the preceding claims.

15. A laundry washing machine comprising:

a cabinet,

a water tub attached to the cabinet via a suspension system, the water tub having an end wall with an opening formed therein about an axis, an axially outer side of the end wall of

10 the water tub having an annular recessed region formed therein about the opening,

a rotatable drum mounted within the water tub to rotate about the axis,

a drive shaft connected to the drum on the axis, the drive shaft passing through the opening in the end wall of the water tub,

wherein a direct-drive electric motor assembly as claimed in claim 14 is engaged, by a
15 reinforcing plate bearing support, to the outer side of the water tub's end wall, over the drive shaft, positioned at least partially axially within the annular recessed region.

16. The laundry washing machine as claimed in claim 15, wherein the end wall of the water tub is provided with at least one complementary engagement feature for engaging with the at least one engagement feature of the reinforcing plate bearing support.

20 17. The laundry washing machine as claimed in claim 16, wherein the at least one engagement feature of the reinforcing plate bearing support comprises a slot through the reinforcing plate bearing support, and the at least one complementary engagement feature comprises a protrusion from the end wall, wherein the protrusion extends axially through the slot.

25 18. The laundry washing machine as claimed in claim 16, wherein the at least one engagement feature comprises a radially outwardly-facing annular side wall forming a radially outer extent of the recessed region of the reinforcing plate body portion of the reinforcing plate bearing support, and the at least one complementary engagement feature comprises a radially-inwardly facing annular wall on the radially outer side of the annular recessed region in the
30 water tub end wall.

19. The laundry washing machine as claimed in any one of claims 15 to 18, wherein

engagement between the motor assembly and water tub end wall is effected by a relative rotation of the motor assembly and tub end wall and at least one fastener passes through the reinforcing plate bearing support and into the water tub end wall to lock the rotational position of the motor assembly relative to the water tub end wall.

5 20. A laundry washing machine comprising:

a cabinet,

a water tub attached to the cabinet via a suspension system, the water tub having an end wall with an opening formed therein about an axis, an axially outer side of the end wall of the water tub having an annular recessed region formed therein about the opening , and

10 a rotatable drum mounted within the water tub to rotate about the axis,

a drive shaft connected to the drum on the axis, the drive shaft passing through the opening in the end wall of the water tub,

a reinforcing plate as claimed in any one of claims 1 to 13 attached to an outer side of the end wall with the annular recessed region of the reinforcing plate located in the annular
15 recessed region in the end wall of the water tub, the at least one engagement feature of the reinforcing plate contacting and engaging with a complementary engagement feature of the end wall of the water tub, and

an electric motor having a rotor mounted to the drive shaft.

21. The laundry washing machine as claimed in claim 20, wherein the reinforcing plate is
20 adapted to be coupled to the water tub by an initial relative axial movement to bring the reinforcing plate into contact with the outer side of the water tub with the annular recessed region of the reinforcing plate within the annular recessed region in the end wall of the water tub, followed by a relative rotational movement about the axis which results in the at least one engagement feature of the reinforcing plate radially compressing a contacting adjacent
25 complementary engagement feature of the water tub end wall.

22. The laundry washing machine as claimed in claim 20 or claim 21, wherein the axially outer side of the end wall includes a central annular projection about the opening with the annular recess positioned radially outside the central annular projection, the inner rim portion of the reinforcing plate being in contact with a radially outer side wall of the annular central
30 projection.

23. The laundry washing machine as claimed in any one of claims 20 to 22, wherein the at

least one complementary engagement feature of the end wall of the water tub comprises an axially-extending projection from its axially outer side, either in the recessed region or radially outward of the recessed region, the reinforcing plate having at least one slot formed therethrough and comprising the at least one engagement feature, the projection passing
5 through a slot.

24. The laundry washing machine as claimed in claim 23, wherein the axially outer side of the end wall of the water tub is provided with fastener-receiving openings, each fastener-receiving opening adapted to be aligned axially with a slot formed through the reinforcing plate.

25. The laundry washing machine as claimed in any one of claims 20 to 22, wherein the
10 annular recessed region of the end wall of the water tub has a radially inwardly-facing circumferential wall that has at least one circumferentially-extending surface portion forming the at least one complementary engagement feature, each particular surface portion having a profile in which the radial distance from the axis to the particular surface portion increases with the circumferential distance from a first end of the particular surface portion toward a second
15 end of the particular surface portion.

26. The laundry washing machine as claimed in claim 25, wherein the profile, when viewed axially, of the at least one circumferentially-extending surface portion is a sawtooth-shape extending about at least a portion of the entire circumference about the axis.

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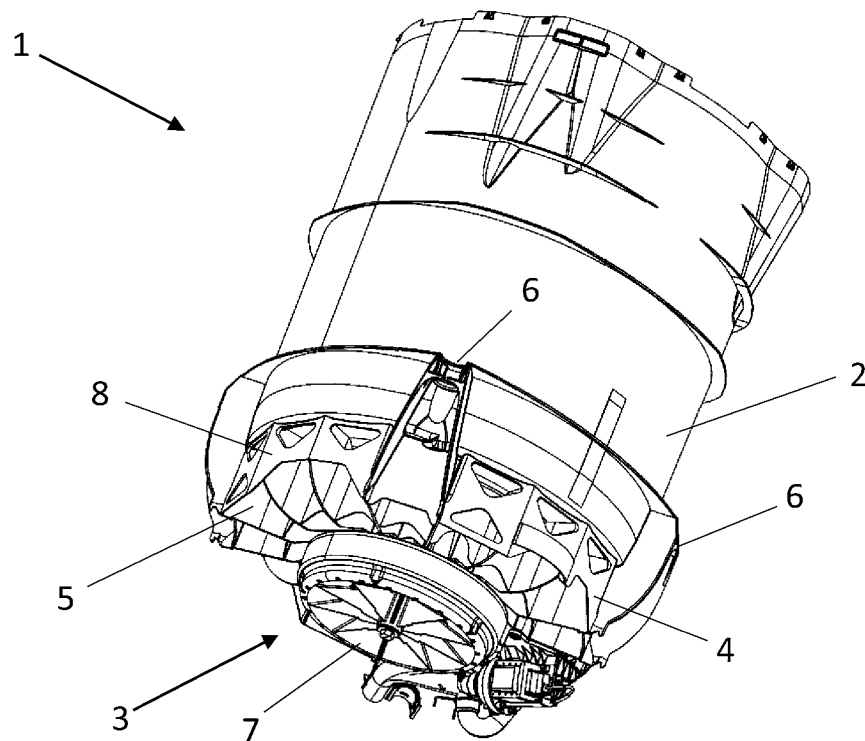


FIGURE 1 (Prior art)

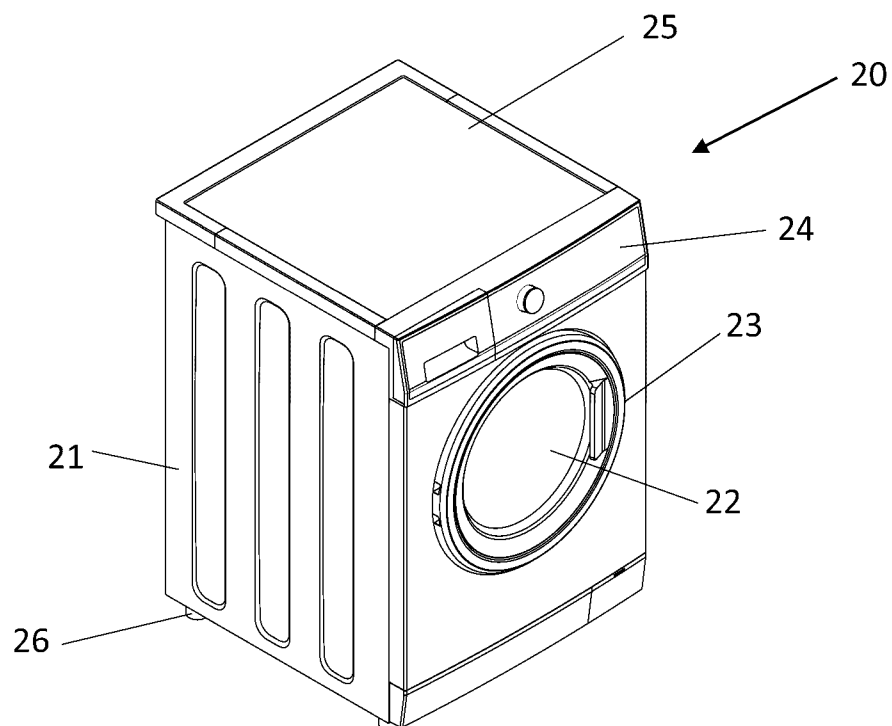


FIGURE 2

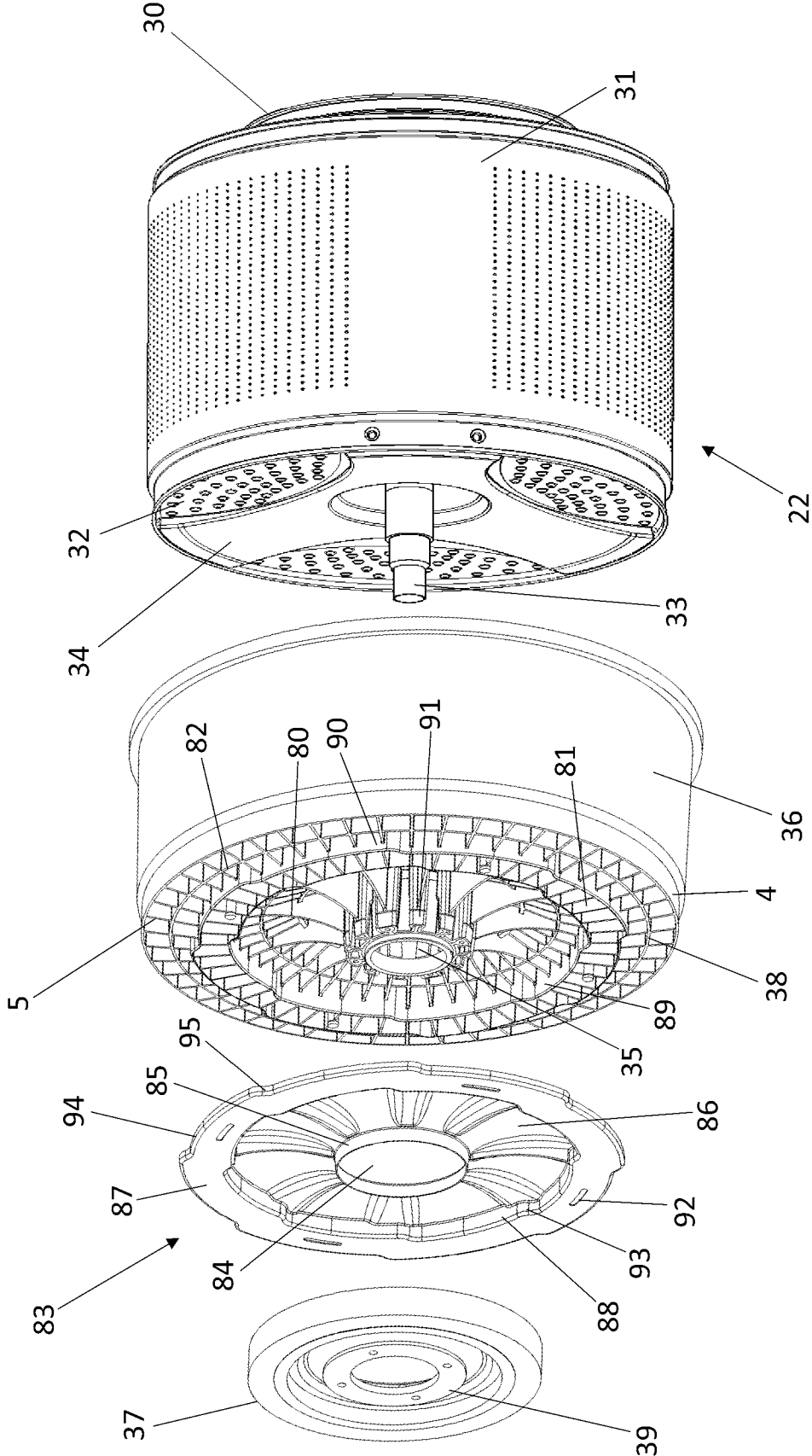


FIGURE 3

3/5

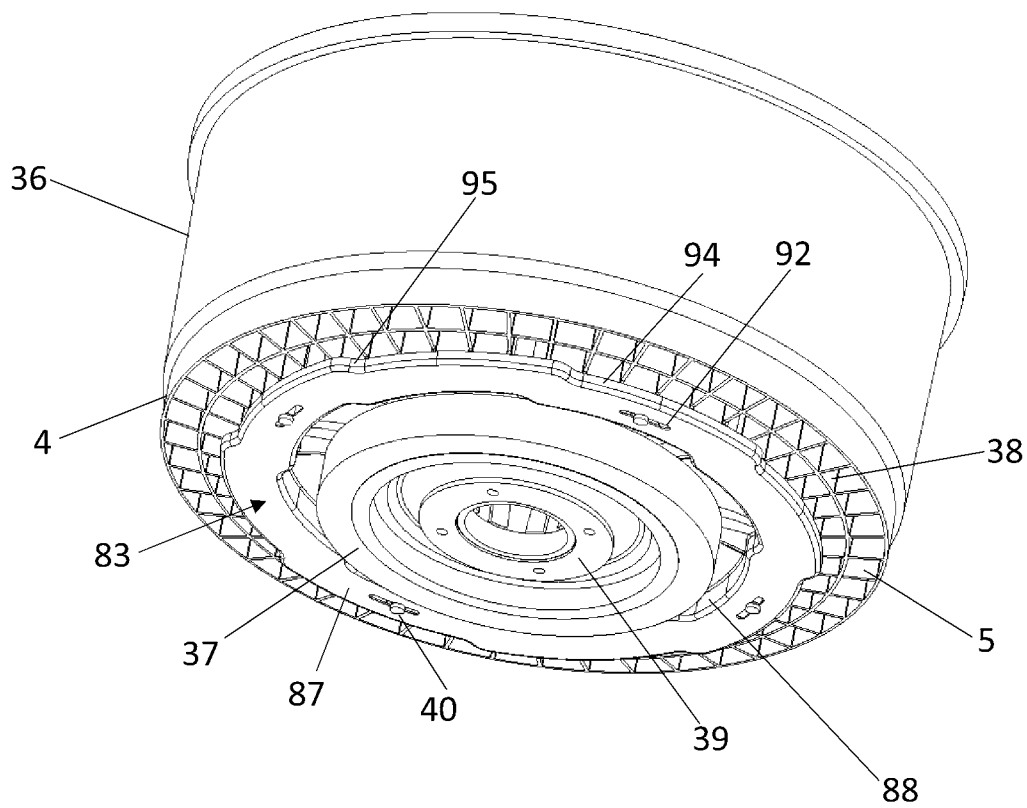


FIGURE 4

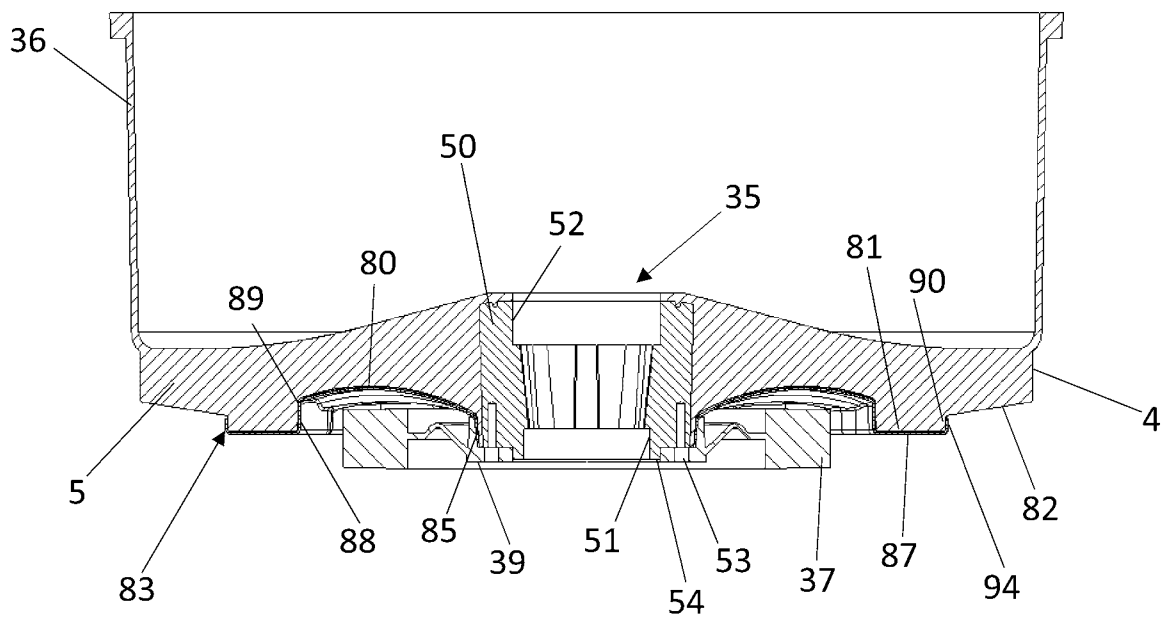


FIGURE 5

4/5

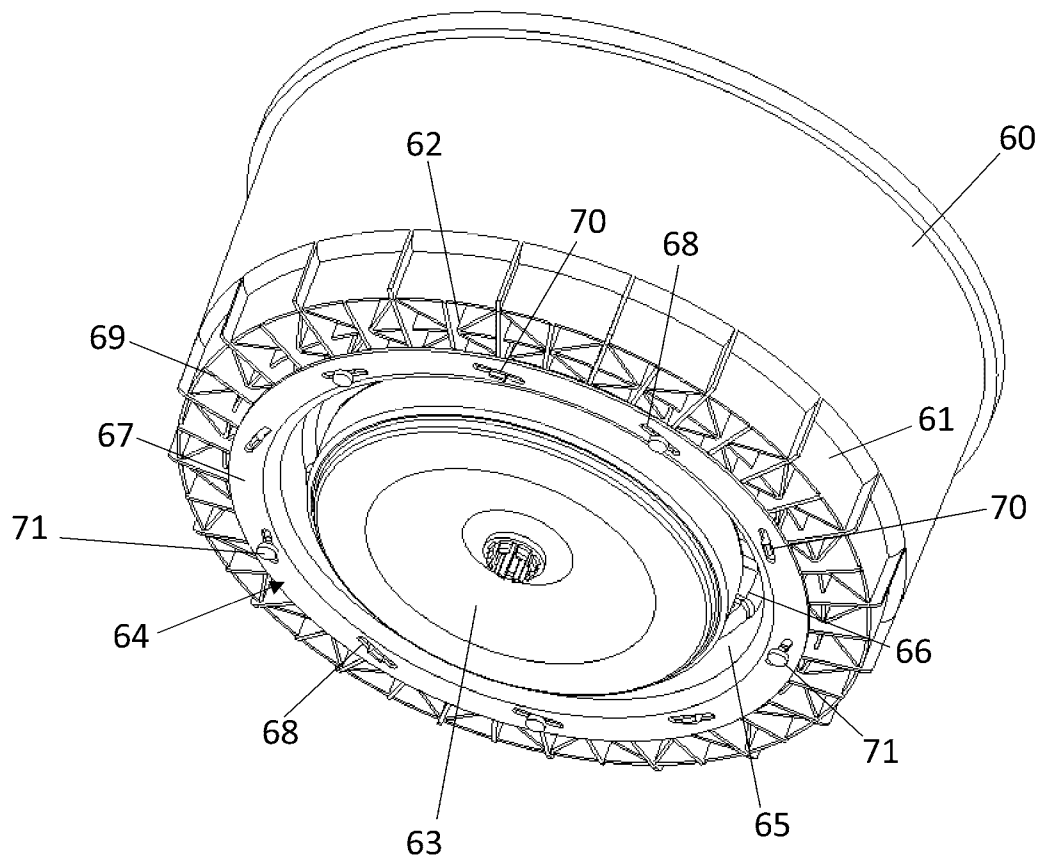


FIGURE 6

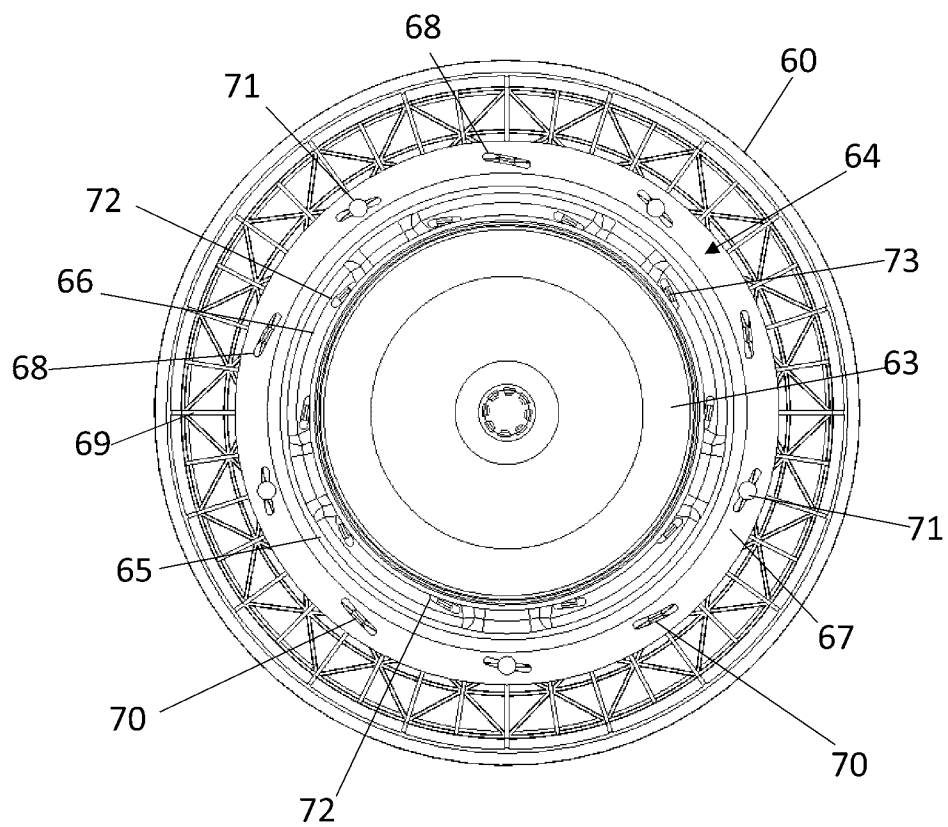


FIGURE 7

5/5

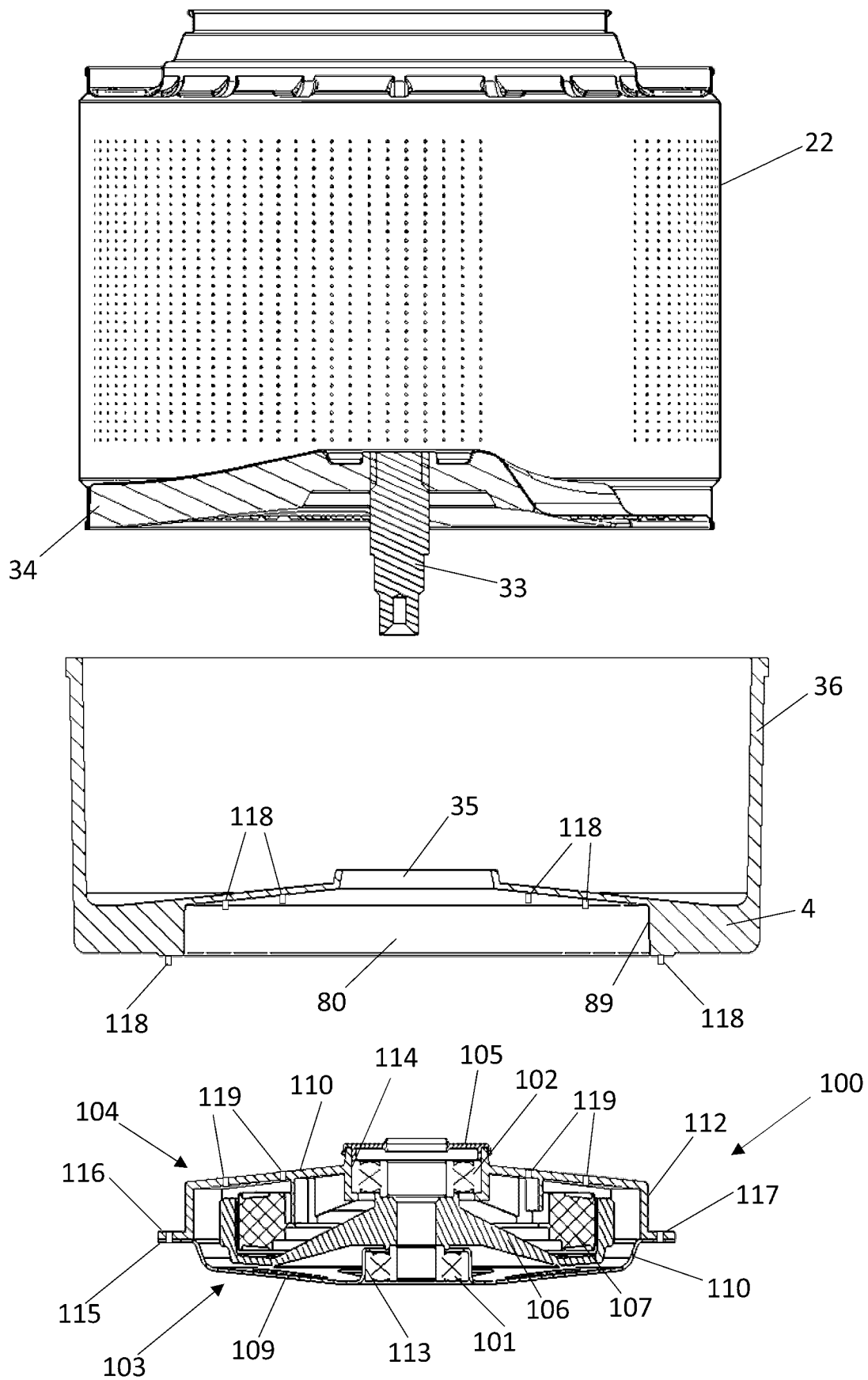


FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ2017/050116

A. CLASSIFICATION OF SUBJECT MATTER

D06F 39/12 (2006.01) D06F 37/26 (2006.01) H02K 5/15 (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

PATENW: /C/CNO D06F37/264, D06F37/206, D06F37/269, D06F37/26, D07F39/12, H02K5/15 & Keywords (tub, base, reinforce, plate, engage) and similar terms and/or combinations.

Google Patent & Keywords: (tub, base, reinforce, plate, engage) and similar terms and/or combinations.

Applicant/Inventor searched using both internal (provided by IP Australia) and external (Google Patent, Espacenet, AUSPAT) databases: Fisher & Paykel Appliances Limited; Jackson Russell Joseph and similar terms and/or combinations.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

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

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search 19 January 2018		Date of mailing of the international search report 19 January 2018	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustalia.gov.au		Authorised officer Aditya Angadi AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61399359624	

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/NZ2017/050116
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/0287995 A1 (MANCINI et al.) 18 November 2010 See whole document	1-26
A	US 2009/0100879 A1 (KIM et al.) 23 April 2009 See whole document	1-26
A	US 5329791 A (CARGNEL et al.) 19 July 1994 See whole document	1-26
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A	US 2009/0113943 A1 (LEE) 07 May 2009 See whole document	1-26
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A	EP 2671998 A1 (ELECTROLUX HOME PRODUCTS CORPORATION N.V.) 11 December 2013 See whole document	1-26
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INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/NZ2017/050116	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.			
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INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/NZ2017/050116	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
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