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(71) Applicant: **FISHER & PAYKEL APPLIANCES LIMITED** [NZ/NZ]; 78 Springs Road, East Tamaki, Auckland 2013 (NZ).

(72) Inventor: **JACKSON, Russell Joseph**; 137 Maraetai Drive, Maraetai, Auckland 2018 (NZ).

(74) Agent: **AJ PARK**; Level 22, State Insurance Tower, 1 Willis Street, Wellington 6011 (NZ).

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(57) Abstract: An electric motor suitable for use in a laundry machine comprises an improved stator and/or rotor design.

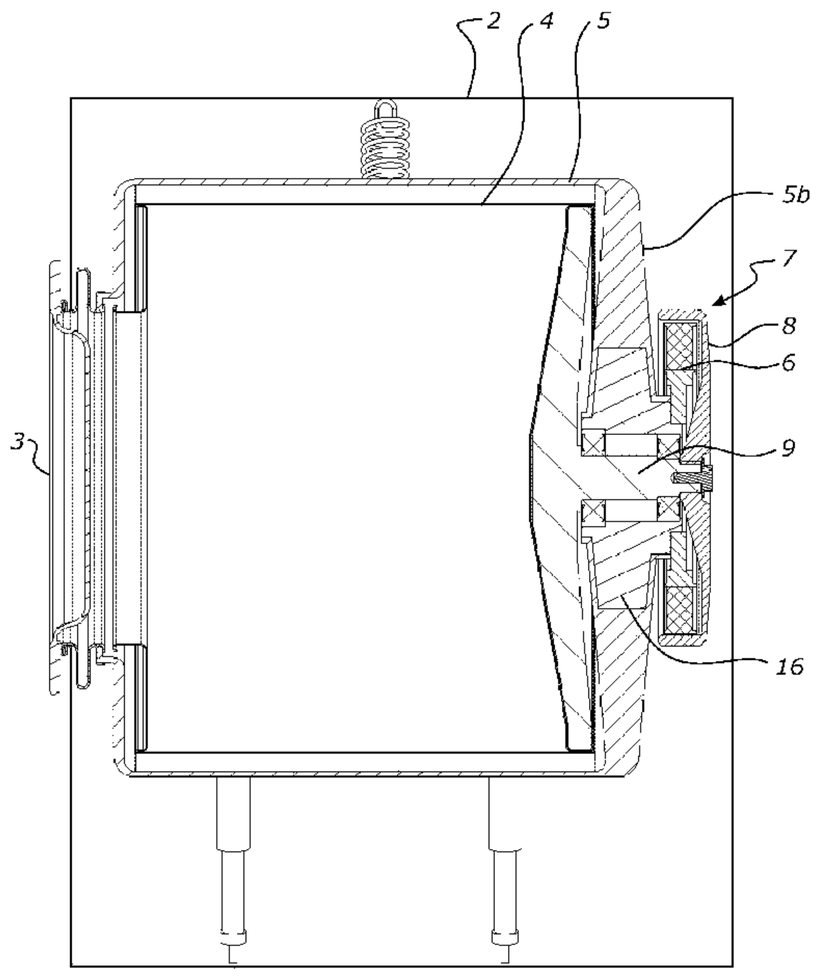


FIGURE 1B

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ELECTRIC MOTOR

TECHNICAL FIELD

The invention relates to compact electric motor suitable for use in for example a laundry washing machine or dryer or washer-dryer.

BACKGROUND

Direct-drive electric motors are commonly used in laundry washing machines. The motor directly drives a drum shaft without a belt or other form of motion transmission device between the rotor and shaft.

One of the requirements for a direct drive electric motor in a washing machine is that the motor be of a minimum thickness so the motor does not take space from the washing machine tub (therefore the washing machine can accommodate a larger amount of clothes for a given footprint - washer capacity).

Another requirement is that the motor or machine powered by the motor operates with as little vibration and as silently as possible. Vibration in operation of an electric motor is undesirable and can lead to noise, and low vibration and noise is an important requirement for electric motors in most applications.

It is an object of the invention to provide an improved or at least alternative form of direct-drive electric motor suitable for use in a laundry washing machine.

SUMMARY OF INVENTION

Stator

In broad terms in one aspect the invention comprises a stator for an electric motor for a washing machine or dryer or washer-dryer, comprising:

a core of magnetically permeable material including an annular core ring and stator poles spaced around and extending radially outward from the core ring,

a polymeric insulating structure surrounding the stator poles and comprising:

a side at least partially covering an axially upper surface of the core ring,

a cylindrical wall at least partially covering a radially inner surface of the core ring,

and further comprising two or more fastener supports for receiving fasteners at a fastener receiving portion, to fasten the stator to a non-rotating bearing hub or tub or drum or bearing housing, of said washing machine or dryer or washer-dryer.

In at least some embodiments each of said fastener supports comprise a pair of axially directed walls and at least one axially directed intermediate wall located intermediate of the

pair of walls, which project radially inward from the cylindrical wall to connect with the fastener receiving portion.

In at least some embodiments each of said axially directed walls and axially directed intermediate walls have a substantially uniform thickness in the tangential direction, and a radial length of at least twice the thickness in the tangential direction.

In at least some embodiments each of said axially directed walls and axially directed intermediate walls have a substantially uniform thickness in the tangential direction, and a radial length and axial height of at least twice the thickness in the tangential direction.

In at least some embodiments the fastener supports comprises a plurality of axially directed intermediate walls located intermediate of said pair of axially directed walls.

In at least some embodiments the stator comprises one or more shelves located between adjacent fastener supports, wherein said shelves extend radially inwards from the cylindrical wall, and are spaced apart from the fastener supports to define gaps between the shelves and fastener supports around the cylindrical wall.

In at least some embodiments the fastener supports comprise surfaces for interfacing with and aligning the fastener support structure to one or more corresponding surfaces on the hub or tub or drum or bearing housing, said corresponding surfaces being concentric with the bearing axis.

In at least some embodiments the shelves comprise upper surfaces which are offset below said side of the insulating structure.

In at least some embodiments the one or more of the shelves carry one or more terminal mounts such that the terminal mount is located partially below said side of the core ring.

In at least some embodiments the fastener supports and shelves are integrally formed with the insulating structure.

Rotor

In broad terms in another aspect the invention comprises a rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising a hub for connecting the rotor to a shaft, a perimeter portion at where the rotor interacts with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a rotor frame comprising a leg portion and an annular portion which together provide a structural connection between the hub and the perimeter portion, wherein

the leg portion comprises a plurality of legs extending from the hub radially outwards towards the annular portion, each leg having an inner end at the hub, the inner ends of a first plurality of legs being axially spaced from the inner ends of a second plurality of legs, and

wherein the annular portion comprises a plurality of substantially planar first wall segments, each defining an upper face of the rotor frame, and a plurality of substantially planar second wall segments axially offset below the first wall segments, said first wall segments and second wall segments being arranged adjacent one another in an alternating fashion about a central axis of the rotor frame.

In at least some embodiments the substantially planar first wall segments and substantially planar second wall segments extend at different angles relative to the rotational axis through the hub.

In at least some embodiments the rotor frame further comprises one or more ribs extending between adjacent first and second wall segments of the annular portion.

In at least some embodiments the substantially planar first wall segments and/or substantially planar second wall segments or part(s) thereof extend at a non-zero angle to adjacent leg portions to which the segments connect.

In at least some embodiments outer ends of the first plurality of legs are less axially spaced from outer ends of the second plurality of legs than the inner ends, or the outer ends of the first plurality of legs are not axially spaced from the outer ends of the second plurality of legs , and/or wherein said legs, at a radially outward region, converge to a common axial position substantially coincident with that of the annular portion.

In at least some embodiments one or more axially directed walls connect an edge of each first wall segment with an edge of a second wall segment.

In at least some embodiments the radial dimension of the annular portion is between 0.5 and 1.5 times the radial dimension of the leg portion and/or the radial length of the poles and coils on an associated stator.

In broad terms in a further aspect the invention comprises a rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising a hub for mounting the rotor to a shaft, a perimeter portion for interacting with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a frame between the hub and the perimeter portion, wherein

the frame is formed from a polymeric material and includes a mount for a separate component (such as a magnet) which interacts with a sensor on the stator to indicate an

absolute angular position of the rotor relative to the stator at least once per revolution, and

the mount comprises a flexible hook to enable insertion of the component, and surfaces and abutments to support the component against forces and accelerations experienced in operation without support or assistance from any additional components, and

the mount is moulded entirely as one part with the frame.

In broad terms in another aspect the invention comprises a rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising a hub for connecting the rotor to a shaft, a perimeter portion for interacting with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a frame between the hub and the perimeter portion, wherein

the frame is formed from a polymeric material and includes a feature or mount for a component on the frame which interacts with a sensor on a stator to indicate an absolute angular position of the rotor relative to the stator at least once per revolution, and

the hub comprises an axially extending opening for engagement with the shaft, and a specific protrusion or recess for interacting with a specific corresponding recess or protrusion on the shaft to ensure that the hub can only be mounted to the shaft in a single absolute angular position.

In broad terms in another aspect the invention comprises an electric motor for a washing machine, comprising a stator as herein described and a concentric rotor.

In broad terms in another aspect the invention comprises an electric motor for a washing machine, comprising a rotor as herein described and a stator.

In broad terms in another aspect the invention comprises an electric motor for a washing machine, comprising a stator and a rotor, both as herein described.

In broad terms in another aspect the invention comprises a laundry washing machine or dryer or washer-dryer comprising an electric motor as herein described.

Motor and machine

The invention also includes an electric motor comprising the stator or rotor and a laundry machine or dryer or washer-dryer including an electric motor comprising the stator and/or rotor.

Definition

In this specification:

- "drum" and "tub" are used interchangeably and include a "basket" being a perforated drum or tub, where appropriate to the context; and
- "comprising" means "consisting at least in part of", and when interpreting a statement in this specification and claims that includes "comprising", features other than that or those prefaced by the term may also be present. Related terms such as "comprise" and "comprises" are to be interpreted similarly.

BRIEF DESCRIPTION OF DRAWINGS

Embodiments of the invention are described with reference to the accompanying drawings, in which:

Figure 1A is a partly vertical cross-sectioned view of a front-loading, horizontal axis laundry washing machine,

Figure 1B is a fully vertical cross-sectioned view of a front loading, horizontal axis laundry washing machine,

Figure 2 is a part cutaway view of a top-loading, vertical axis laundry washing machine,

Figure 3 is a perspective view of the stator of a direct-drive electric motor suitable for use in a laundry washing machine, according to an embodiment of the invention,

Figure 4 is a peripheral edge view of the stator of Figure 3,

Figure 5 is a cross-sectional view of the stator of Figures 3 and 4 along line I-I of Figure 3,

Figure 5a is a perspective view of the stator of a direct-drive electric motor suitable for use in a laundry washing machine, as an alternative embodiment of the stator shown in Figures 3, 4 and 5,

Figure 6 is a perspective view from one side of the rotor of a direct-drive electric motor suitable for use in a laundry washing machine, according to an embodiment of the invention,

Figure 7 is a perspective view from the opposite side, of the rotor of Figure 6,

Figure 8 is a cross-sectional view of the rotor of Figures 6 and 7 along line II-II of Figure 6,

Figure 9 is a cross-sectional view of the rotor of Figures 6 and 7 along line III-III of Figure 6,

Figure 10 is a view of a part of the rotor of Figures 6 to 9 showing a sensor magnet mount,

Figure 11 is a perspective view from one side of a hub component of the rotor of Figures 6

to 9,

Figure 12 is a perspective view from the other side of a hub component of the rotor of Figures 6 to 9,

Figure 13 is an enlarged view of the end of a matching rotor shaft,

Figure 14 is a perspective view from one side of an alternative hub component to that shown in Figures 11 and 12, which may be used in the rotor of Figures 6 to 9, and

Figure 15 is a perspective view from the other side of an alternative hub component to that shown in Figures 11 and 12, which may be used in the rotor of Figures 6 to 9.

DESCRIPTION OF EMBODIMENTS

Machine

Referring to Figure 1A a laundry washing machine 1 of the front-loading, horizontal-axis variety is shown. The washing machine includes an outer cabinet 2 with a front door 3 allowing access to a perforated rotatable inner drum/basket 4 for holding a load of laundry such as clothing for washing, and mounted within the outer cabinet to rotate about a horizontal axis. A generally cylindrical, fixed (non-rotating) liquid outer drum/tub 5 for containing washing liquid is mounted (suspended) within the cabinet 2 around the inner drum 4. Figure 1B shows the inner and outer drums 4 and 5 and motor 7 of a horizontal-axis machine fully cross-sectioned, in this case front loading, horizontal-axis machine and does not also show the external cabinet.

Figure 2 is a part cutaway view of a top-loading, vertical axis laundry washing machine 1a. The machine includes an outer cabinet 2a with a lid 3a allowing access to a perforated rotatable inner drum/basket 4a for holding a load of laundry for washing, and mounted within the outer cabinet to rotate about a vertical axis. A generally cylindrical, fixed (non-rotating) liquid outer drum/tub 5a for containing washing liquid is mounted (suspended) within the cabinet 2a around the inner drum 4a.

The stator 6 of a Brushless DC (BLDC) or Permanent Magnet (PM) electric motor 7 is fixedly attached to the end 5b (see Figures 1B and 2) of the outer drum 5/5a, directly or alternatively indirectly by the stator 6 being attached to a bearing housing component 16 fixed to the end of the outer drum 5/5a. Rotor 8 external to the outer drum 5/5a is rotationally fixed to the outer end of a rotor shaft 9 which extends through a passage in the end of the outer drum 5/5a and carries the inner drum 4/4a at its other end. The rotor shaft 9 is mounted via at least one pair of spaced apart bearings, such as roller bearings carried by the bearing housing component 16. In a horizontal axis top or tilt access machine (not shown) the drum may be supported by bearings at both horizontal ends. A machine controller and/or motor controller

(not shown) provide appropriate commutation signals to stator windings provided around the stator poles so that the rotor's rotational speed and direction may be dictated during the various cycles of a user-set wash programme of the machine.

Stator

Figures 3 to 5 and 5a show a stator 6 according to an embodiment of the invention, of a direct-drive electric motor suitable for use in a washing machine or a dryer or a washer-dryer.

The stator comprises an annular core ring 20 having a central opening 21, and which carries individual poles extending radially outward from the core ring 20 (transverse to the rotational axis of the rotor) around the core ring. The core ring and poles are formed of a magnetically permeable material. The core ring and stator poles may be formed as a stack of thin, generally circular steel laminations, or as a single helically-wound lamination. In at least some embodiments of the invention the stack of core ring and stator poles laminations is over-moulded, and encapsulated or partially encapsulated, by a polymeric material (herein also 'plastics') insulating structure. The stator coils are wound around the poles after plastics encapsulation, so that the plastics encapsulation insulates the coil windings from the steel stator poles. The poles and coils are indicated together at 22.

In at least some embodiments of the invention the insulating structure surrounding the stator poles is formed of a plastics material and comprises a planar side or wall 23 covering or at least partially covering an axially upper surface of the core ring 20, and a cylindrical wall 24 covering or at least partially covering a radially inner surface of the core ring.

Fastener supports 25 comprising a fastener receiving portion 25a defining an aperture or similar (typically each comprising a metal sleeve) for receiving fasteners to fix the stator, for example to the non-rotating drum 5 as indicated in Figures 1 and 2 and for example in particular a non-rotating bearing hub 16. In the embodiment pictured in Figures 3 to 5a, the fastener supports 25 are integrally formed with the plastics insulating structure. The fastener supports 25 extend radially inward of the cylindrical wall 24, with the fastener receiving portion 25a located at or near, or comprising, a radially innermost surface 27 of the fastener support 25. The fastener support 25 also comprises one or more (and preferably a pair of) axially directed walls 26 which project radially inward from the cylindrical wall 24, and connect with the fastener receiving portion. The axially directed walls 26 have uniform thickness (in the tangential direction), and a radial length of at least twice the tangential thickness. The radially innermost surface 27 of the fastener support 25 may be a curved shape for interfacing with, and aligning the fastener support 25 to, one or more corresponding curved surfaces of the bearing hub that are concentric with the bearing axis. The fastener supports 25 also comprise intermediate walls 28 as shown, which project

radially inward from the cylindrical wall 24 and connect with the fastener receiving portion. The intermediate walls 28 also have uniform thickness (in the tangential direction), and a radial length of at least twice the tangential thickness.

In an alternative embodiment the fastener supports 25 may be integrally formed with the core ring 20 rather than the plastics insulating structure, or the fastener supports 25 may each comprise a metallic part formed with the core ring 20, which is over-moulded by the plastics insulating structure. There may be at least two fastener supports, for example between two and eight, and in some exemplary embodiments there are five fastener supports.

In at least some embodiments of the invention the stator also comprises one or more shelves 30 located between adjacent fastener supports 25, integrally moulded as part of the over-moulded insulating structure of the stator, which extend radially inwards from the cylindrical wall 24. One or more of the shelves 30 carry electrical terminal mounts or pockets 31 for connecting to the stator coils. The shelves 30 are offset below the surface of the insulating structure such that the terminal mounts 31 are located partially or wholly below the axially upper surface of the core ring. As shown, the terminal pockets can sit partially below the surface of the lamination stacks of the stator poles. This facilitates a compact and in particular low axial thickness or slim motor. Preferably the terminal parts on the lead wires which connect to the stator, are also low profile terminals such as flag terminals crimped directly to the lead wires.

The shelves 30 may comprise a tab 32 on one or both sides, around which the lead wires pass before the terminal mounts 31, as a strain relief feature – see Figure 3.

Also, the shelves 30 are structurally separated from the fastener supports 25 by gaps as shown, extending radially inward from the cylindrical wall 24 to the stator centre opening.

To reduce noise and vibration the structural response of the stator is optimized to attenuate internal torque oscillations and external accelerations. Reduced motor noise can be achieved by reducing the torsional stiffness of the connection between the stator and the component to which it is fixed (for example, bearing hub 16) so that torsional resonance is passed through at low speed and then at higher motor speed the compliance in the axially and radially directed walls 26, 28, reduces the transmission of torque oscillations from the motor into the drum and tub structure. However reducing torsional stiffness can also reduce the lateral and axial stiffness of the connection, causing airgap variation during operation, twisting and unwanted axial or lateral responses to tub vibrations. In at least some embodiments of the invention, minimizing torsional stiffness of the stator while maximizing axial and radial stiffness is achieved by connecting each fastener support 25 to the lamination

over-mould of the insulating structure with walls, (26 and 28 in the embodiments shown) that have radial length and axial height, but are thinner in the tangential direction (relative to the radial length and axial height). Because the bending stiffness of each section of wall is a function of its tangential thickness x axial height, a series of radially projecting walls that have radial lengths and axial heights which are significantly greater than their tangential thickness, will create a stator structure that has low twisting or torsional stiffness but high axial and lateral stiffness.

In preferred embodiments the axial height of each wall 26, 28 is significantly greater (for example, at least two times greater) than its tangential thickness, and the radial length is at least twice the tangential thickness (for example, three or four times as long). In preferred embodiments each of the walls has a constant tangential thickness along its radial length, and optionally also a constant axial height. In some embodiments the radial length of the walls 26,28 may be between approximately $1/5^{th}$ and $1/15^{th}$ of the internal diameter of the core ring 20. For example, the radial length of the walls 26,28 may be approximately $1/8^{th}$ of the internal diameter of the core ring 20 as shown in Figures 3 to 5.

In alternative embodiments, the number of intermediate walls 28 of the fastener support 25 can be varied in order to adjust the overall stiffness of the connection between the stator and the component to which it is fixed (for example, bearing hub 16). Adjusting the fastener support stiffness enables tuning of the stator structure to avoid, to some extent, coincidence of resonance peaks and noise with rotational speeds/frequencies encountered during operation of the laundry washing machine or dryer or washer-dryer that are sustained for periods of time or cause particular dissatisfaction to the user (although it is possible that the machine may pass through those frequencies.as it spins up to speed and decelerates during the wash cycle). Figure 5A shows an alternative embodiment to the stator shown in Figures 3 to 5, wherein the fastener mount 25 comprises three intermediate walls 28 between the pair of walls 26, rather than a single intermediate wall 28. In preferred embodiments, the fastener mount 25 comprises between one and three intermediate walls 28, and most preferably comprises three intermediate walls 28. In preferred embodiments the tangential thickness of the intermediate walls 28 may be substantially equal to that of the walls 26.

Rotor

Figures 6 to 13 and in particular Figures 6 to 9 show a rotor according to an embodiment of the invention, of a direct-drive electric motor suitable for use in a washing machine or a dryer or a washer-dryer. The rotor of Figures 6 to 9 is designed to be used with the stator of Figures 3 to 5 and vice versa.

The rotor 8 preferably comprises a relatively light-weight yet rigid and cost-effective polymeric or plastics frame 40 formed for example by injection moulding. The rotor frame 40 comprises a central rotor hub 41 shown separately in Figures 11 and 12, 14 and 15,

having a splined aperture 42 which is fitted to splines on the end of a drive shaft (see 9 in Figures 1B and 2 for example, and Figure 13 which shows the end of the matching rotor shaft 9), and a perimeter portion 43 carrying a circumferential ring of permanent magnetic poles or multiple pole elements 44. The rotor frame 40 may be formed from a plastics material and the hub 41 of metal (for example, with the hub 41 insert-moulded into the centre of the plastic rotor frame 40, as visible in Figure 9), or alternatively the rotor frame 40 may be formed as a single component from a single material such as a polymeric material or a metal.

An alternative rotor hub 41 is shown in Figures 14 and 15.

Between the hub 41 and perimeter portion 43 the rotor comprises a leg portion 45 and an annular portion, which together provide a structural connection between the hub 41 to a perimeter portion 43 of the rotor. The leg portion 45 comprises a plurality of legs 45a and 45b extending from the hub 41 radially outwards towards annular portion 46. The alternating legs 45a and 45b are axially spaced, at least towards the hub or inner ends of the legs. That is to say, each leg has an inner end at the hub, and the inner ends of a first plurality of legs 45a are axially spaced from the inner ends of a second plurality of legs 45b, so that there are axial gaps between the first plurality of legs 45a and the second plurality of legs 45b. Thus the first plurality of legs 45a and second plurality of legs 45b extend at different angles to the rotational axis through the hub. In the embodiment shown the first plurality of legs 45a are maximally spaced at their inner ends and are less axially spaced from, or are not axially spaced from, outer ends of the second plurality of legs 45b at their outer regions where they engage the annular portion 46. By way of further example, the legs may be arranged substantially as described in US Patent 9325210, the entirety of which is incorporated herein. At a region radially outward of the hub, the legs (which are axially spaced at their inner ends) may converge to common axial position, which is substantially coincident with that of the annular portion 46.

The annular portion 46 is between the leg portion 45 and the perimeter portion 43. It comprises a plurality of substantially planar first wall segments 46a, each defining an upper face of the rotor frame 40, and a plurality of substantially planar second wall segments 46b axially offset below the first wall segments 46a. The first wall segments 46a and second wall segments 46b of the annular portion 46 are arranged adjacent one another in an alternating fashion about the central axis of the rotor frame 40, each wall segment being connected to its adjacent wall segment by an axially directed wall portion 47.. Also in the embodiment shown, annular wall parts or ribs 49 extend between adjacent wall segments 46a and 46b. In the embodiment shown the annular portion 46 comprises two radially spaced annular wall parts or ribs 49 between each pair of adjacent wall segments 46a and 46b.

In some embodiments the substantially planar first wall segments 46a and substantially planar second wall segments 46b extend at different angles relative to the rotational axis through the hub – that is, they lie upon planes that are angularly offset from one another. The wall segments 46a and 46b may be integral with or connect to the radially outer regions of the legs 45a and 45b. In this manner the planar wall segments 46a, 46b co-operate with the legs 45a and 45b to enhance the rigidity and strength of the rotor frame 40 (in comparison to a rotor frame 40 with only legs 45a, 45b, and no offset planar wall segments connecting the legs to the perimeter) without adding significantly to the mass of the rotor frame.

Typically the radial dimension of the annular portion 46 is approximately equal to the radial dimension of the leg portion 45 and/or is approximately equal to the radial length of the salient poles and coils on the stator. For example the radial dimension of the annular portion 46 may be between 0.5 and 1.5 times the radial dimension of the leg portion 45 and/or the radial length of the poles and coils on the stator.

Referring to Figure 10, in a preferred embodiment the rotor frame 40 is formed from a polymeric material and includes a mount, integrally moulded with the frame, for a separate component such as a magnet (not shown), which interacts with a sensor on the stator to indicate an absolute angular position of the rotor relative to the stator at least once per revolution. The mount may comprise a flexible hook 50. Surrounding surfaces and abutments 51 define a recess 52 in the frame below the hook 50 which also support the component against forces and accelerations experienced in operation, without support or assistance from any additional components.

In a preferred embodiment the hub 41 comprises the axially extending opening 42 for engagement with the rotor shaft, and also a specific protrusion or recess 43 for interacting with a corresponding keying protrusion 55 on the shaft (see Figure 13) or alternatively recess, to ensure that the rotor can only be mounted to the shaft in a single absolute angular position. Essentially the hub has a missing spline tooth for angular alignment

While in the figures the rotor comprises a plastics frame 40 a rotor hub 41 formed as a separate metal component, alternatively the frame and hub may be formed of a single material for example from metal pressing or casting, or of a plastics material.

Motor type

As stated an electric motor of the invention preferably comprises both a rotor and stator as described above.

Electric motors used in direct-drive laundry machines are commonly of the radial flux – permanent magnet synchronous motor type (RF-PMSM), with an external rotor, and the rotor

and stator shown in the figures and described above are of an RF-PMSM motor. Alternatively the motor may be an axial flux permanent magnet synchronous motor (AF-PMSM) motor. An AF-PMSM motor is one in which the magnetic flux air gap is oriented axially.

The motor may be an electric motor in any form, with permanent magnets. For example the motor may be a permanent magnet synchronous motor (PMSM), either a radial flux – permanent magnet synchronous motor - the magnetic flux path is oriented radially (RF-PMSM motor) or an axial flux permanent magnet synchronous motor - the magnetic flux path is oriented axially (AF-PMSM motor). Alternatively the motor may be a DC brushed or brushless motor (DCBM) with permanent magnets. The motor may have an external or internal rotor carrying the permanent magnets. The motor may be a direct drive electric motor - namely a motor in which the motor directly drives an output drive shaft or drum or tub or basket of a machine without a belt or other form of motion transmission device between the rotor and shaft, or an indirect drive motor.

The invention has thus far been described with reference to multiple pole pair permanent magnets on the rotor of an electric motor. However the multiple pole pair permanent magnets may instead be on the stator such as on the stator of a DC brushed motor. Thus the invention includes an electric motor comprising a stator comprising the multiple pole pair permanent magnets, and all of the foregoing description of embodiments of the invention applies equally substituting stator for rotor and vice versa.

The invention includes laundry washing machines or dryers or washer-dryers incorporating an electric motor according to the invention, such as top-loading, vertical axis washing machines, front-loading or top or tilt access, horizontal axis laundry washing machines or top-loading, vertical axis laundry washing machines, and laundry dryers or washer-dryers, which are conventionally horizontal access. Typically a laundry machine comprises an outer cabinet with a top or front door, an outer drum/tub, and a rotating inner drum/basket which in use holds the laundry load. Typically the stator of the electric motor of the machine is fixed to one end of the outer drum/tub and the rotor external to the outer drum is rotationally fixed to the outer end of a rotor/basket shaft which extends through a passage in the end of the outer drum/tub and carries the inner drum/basket at its other end. A machine controller and/or motor controller (not shown) provide appropriate commutation signals to stator windings provided around the stator poles so that the rotor's rotational speed and direction may be dictated during the various cycles of a user-set wash programme of the machine.

The foregoing describes the invention including preferred forms thereof. Modifications and alterations as will be obvious to those skilled in the art may be made without departing from the scope of the invention.

CLAIMS

1. A stator for an electric motor for a washing machine or dryer or washer-dryer, comprising:

a core of magnetically permeable material including an annular core ring and stator poles spaced around and extending radially outward from the core ring,

a polymeric insulating structure surrounding the stator poles and comprising:

a side at least partially covering an axially upper surface of the core ring,

a cylindrical wall at least partially covering a radially inner surface of the core ring, and further comprising two or more fastener supports for receiving fasteners at a fastener receiving portion, to fasten the stator to a non-rotating bearing hub or tub or drum or bearing housing of said washing machine or dryer or washer-dryer; and

wherein each of said fastener supports comprises a pair of axially directed walls and at least one axially directed intermediate wall located intermediate of the pair of walls, which project radially inward from the cylindrical wall to connect with the fastener receiving portion;

each of said axially directed walls and axially directed intermediate walls having a substantially uniform thickness in the tangential direction, and a radial length and axial height of at least twice the thickness in the tangential direction.

2. A stator as claimed in claim 1, wherein said fastener supports comprises a plurality of axially directed intermediate walls located intermediate of said pair of axially directed walls.

3. A stator as claimed in either claim 1 or claim 2 wherein the fastener supports comprise surfaces for interfacing with and aligning the fastener support structure to one or more corresponding surfaces on the hub or tub or drum or bearing housing, said corresponding surfaces being concentric with the bearing axis.

4. A stator as claimed in any one of claims 1 to 3 wherein the stator comprises one or more shelves located between adjacent fastener supports, wherein said shelves extend radially inwards from the cylindrical wall and are spaced apart from the fastener supports to define gaps between the shelves and fastener supports around the cylindrical wall.

5. A stator as claimed in claim 4 wherein the shelves comprise upper surfaces which are offset below said side of the insulating structure.

6. A stator as claimed in claim 4 or claim 5 wherein one or more of the shelves carry one or more terminal mounts such that the terminal mount is located partially below said side of the core ring.

7. A stator as claimed in any one of claims 4 to 6 wherein the fastener supports and shelves are integrally formed with the insulating structure.

8. A rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising:

a hub for connecting the rotor to a shaft, a perimeter portion at where the rotor interacts with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a rotor frame comprising a leg portion and an annular portion which together provide a structural connection between the hub and the perimeter portion,

wherein the leg portion comprises a plurality of legs extending from the hub radially outwards towards the annular portion, each leg having an inner end at the hub, the inner ends of a first plurality of legs being axially spaced from the inner ends of a second plurality of legs, and

wherein the annular portion comprises a plurality of substantially planar first wall segments, each defining an upper face of the rotor frame, and a plurality of substantially planar second wall segments axially offset below the first wall segments, said first wall segments and second wall segments being arranged adjacent one another in an alternating fashion about a central axis of the rotor frame.

9. A rotor as claimed in claim 8 wherein the substantially planar first wall segments and substantially planar second wall segments extend at different angles, relative to the rotational axis through the hub.

10. A rotor as claimed in claim 8 or claim 9 wherein said rotor frame further comprises one or more ribs extending between adjacent first and second wall segments of the annular portion.

11. A rotor as claimed in any one of claims 8 to 10 wherein the substantially planar first wall segments and/or substantially planar second wall segments or part(s) thereof extend at a non-zero angle to adjacent leg portions to which the segments connect.

12. A rotor as claimed in any one of claims 8 to 11 wherein outer ends of the first plurality of legs are less axially spaced from outer ends of the second plurality of legs than the inner ends, or the outer ends of the first plurality of legs are not axially spaced from the outer ends of the second plurality of legs, and/or wherein said legs, at a radially outward region, converge to a common axial position substantially coincident with that of the annular portion.

13. A rotor as claimed in any one of claims 8 to 12, with one or more axially directed walls connecting an edge of each first wall segment with an edge of a second wall segment.

14. A rotor as claimed in any one of claims 8 to 13 wherein the radial dimension of the annular portion is between 0.5 and 1.5 times the radial dimension of the leg portion and/or the radial length of the poles and coils on an associated stator.

15. A rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising a hub for mounting the rotor to a shaft, a perimeter portion for interacting with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a frame between the hub and the perimeter portion, wherein

the frame is formed from a polymeric material and includes a mount for a separate component (such as a magnet) which interacts with a sensor on the stator to indicate an absolute angular position of the rotor relative to the stator at least once per revolution, and

the mount comprises a flexible hook to enable insertion of the component, and surfaces and abutments to support the component against forces and accelerations experienced in operation without support or assistance from any additional components, and

the mount is moulded entirely as one part with the frame.

16. A rotor for an electric motor for a washing machine or dryer or washer-dryer, comprising a hub for connecting the rotor to a shaft, a perimeter portion for interacting with a stator of the motor to cause the rotor to rotate about an axis of rotation, and a frame between the hub and the perimeter portion, wherein

the frame is formed from a polymeric material and includes a feature or mount for a component on the frame which interacts with a sensor on a stator to indicate an absolute angular position of the rotor relative to the stator at least once per revolution, and

the hub comprises an axially extending opening for engagement with the shaft, and a specific protrusion or recess for interacting with a specific corresponding recess or protrusion on the shaft to ensure that the hub can only be mounted to the shaft in a single absolute angular position.

17. An electric motor for a washing machine, comprising a stator according to any one of claims 1 to 7 and a concentric rotor.

18. An electric motor for a washing machine, comprising a rotor according to any one of claims 8 to 16 and a stator.

19. An electric motor for a washing machine, comprising a stator according to any one of claims 1 to 7 and a rotor according to any one of claims 8 to 16.

20. A laundry washing machine or dryer or washer-dryer comprising an electric motor as claimed in any one of claims 17 to 19.

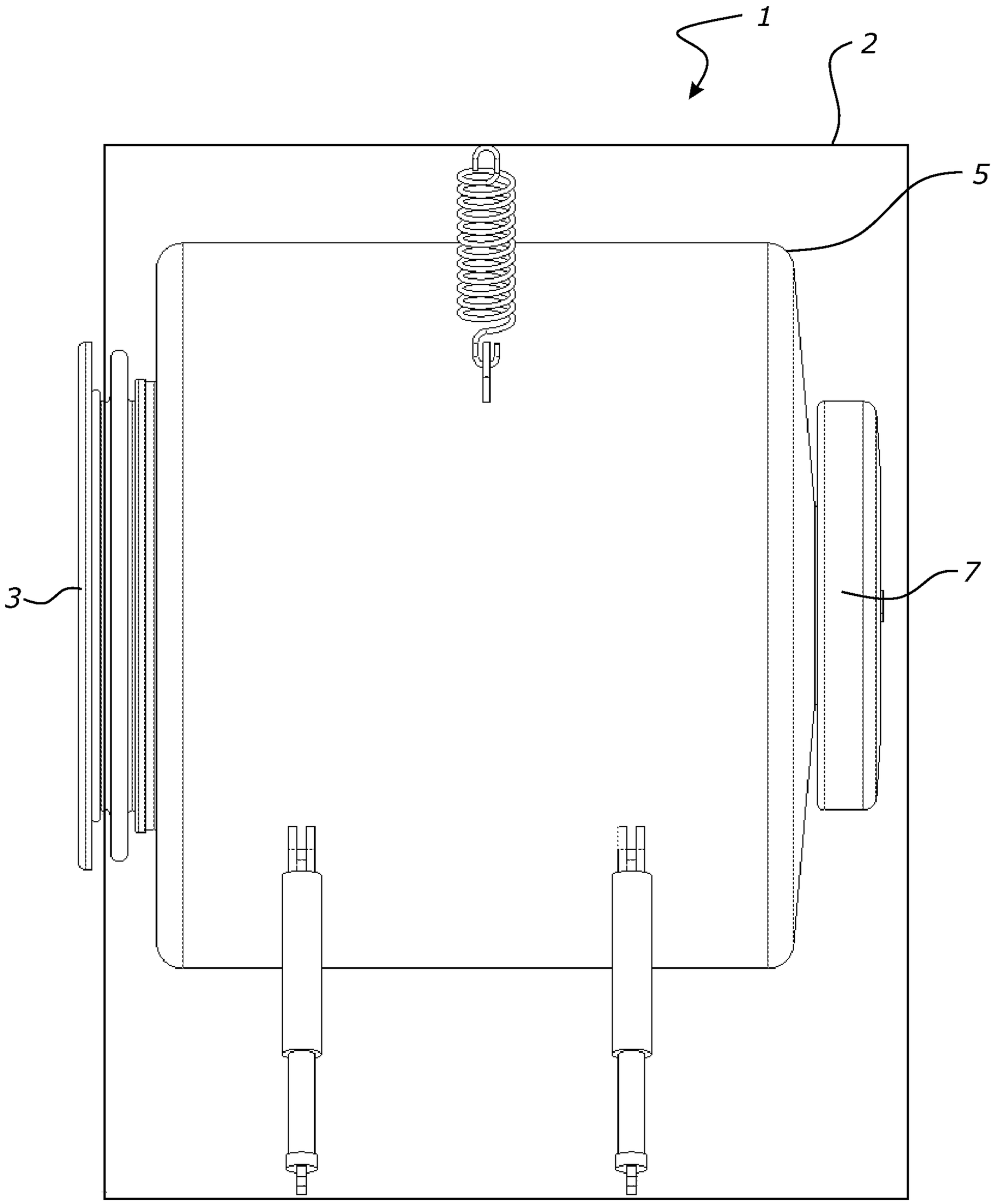


FIGURE 1A

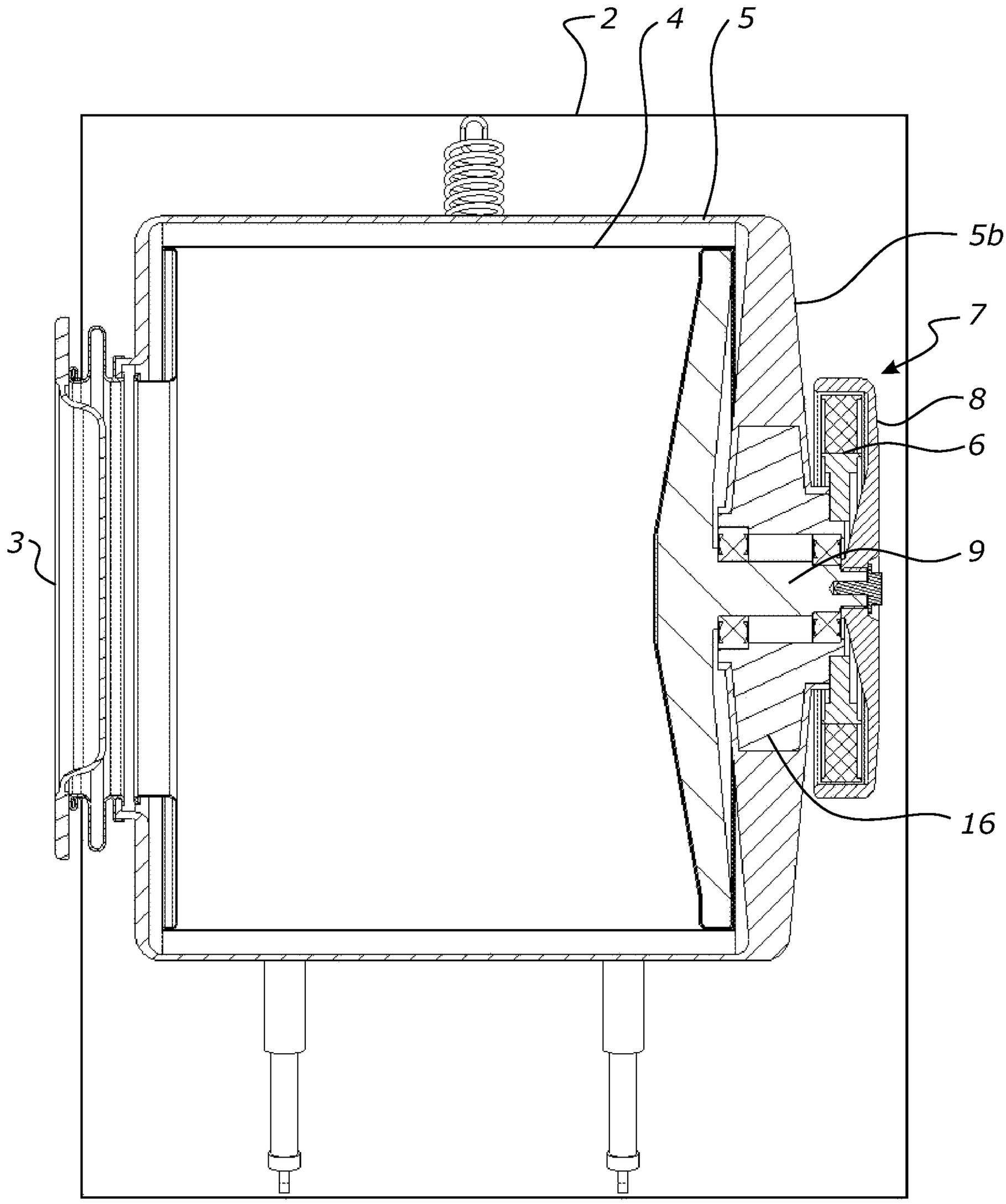


FIGURE 1B

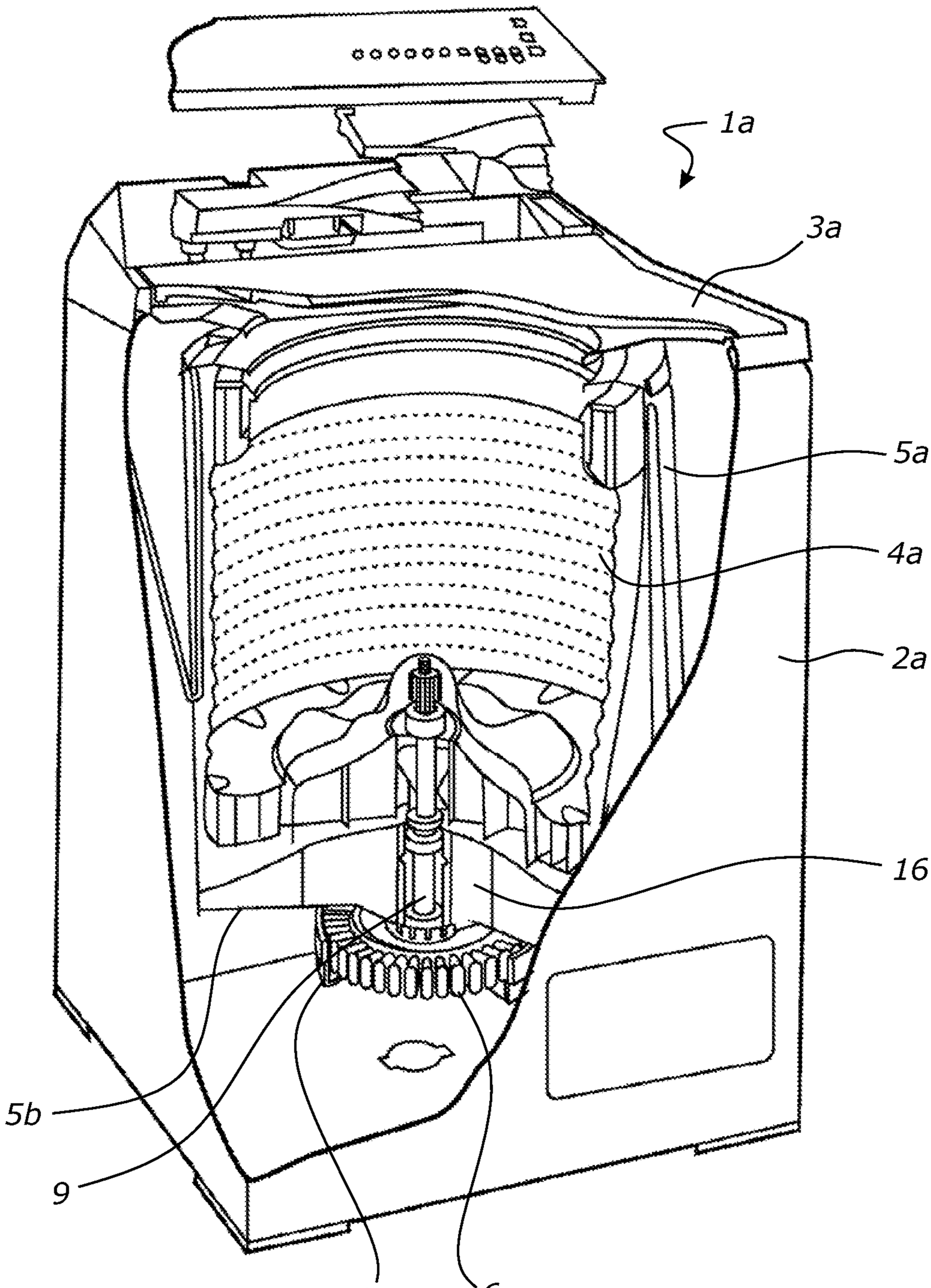


FIGURE 2

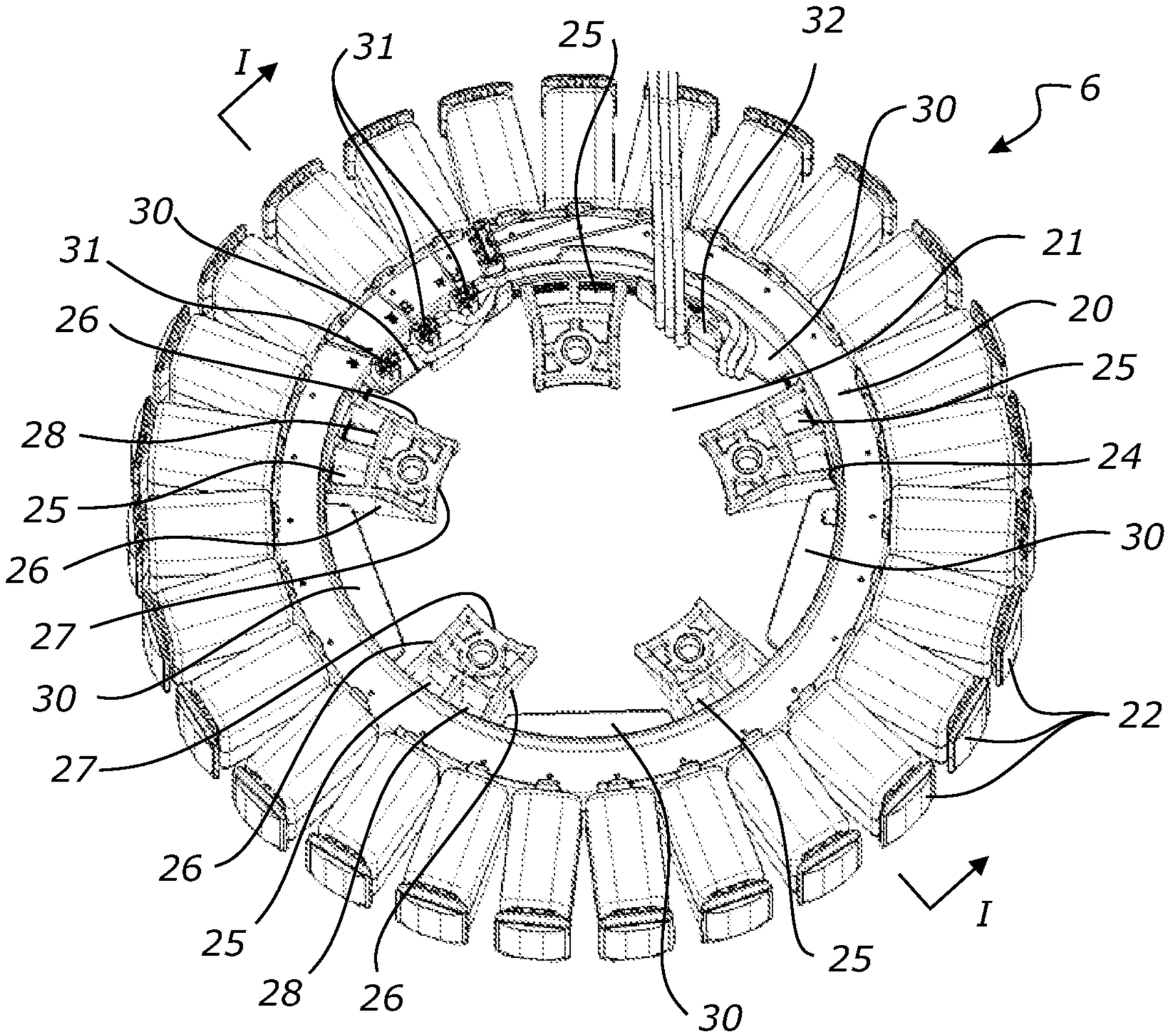


FIGURE 3

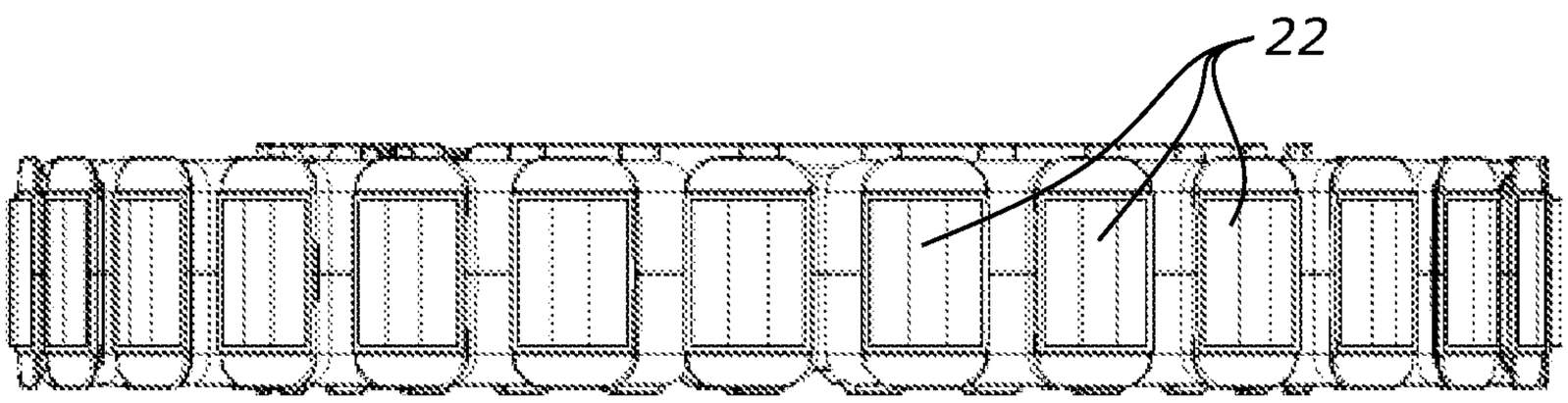


FIGURE 4

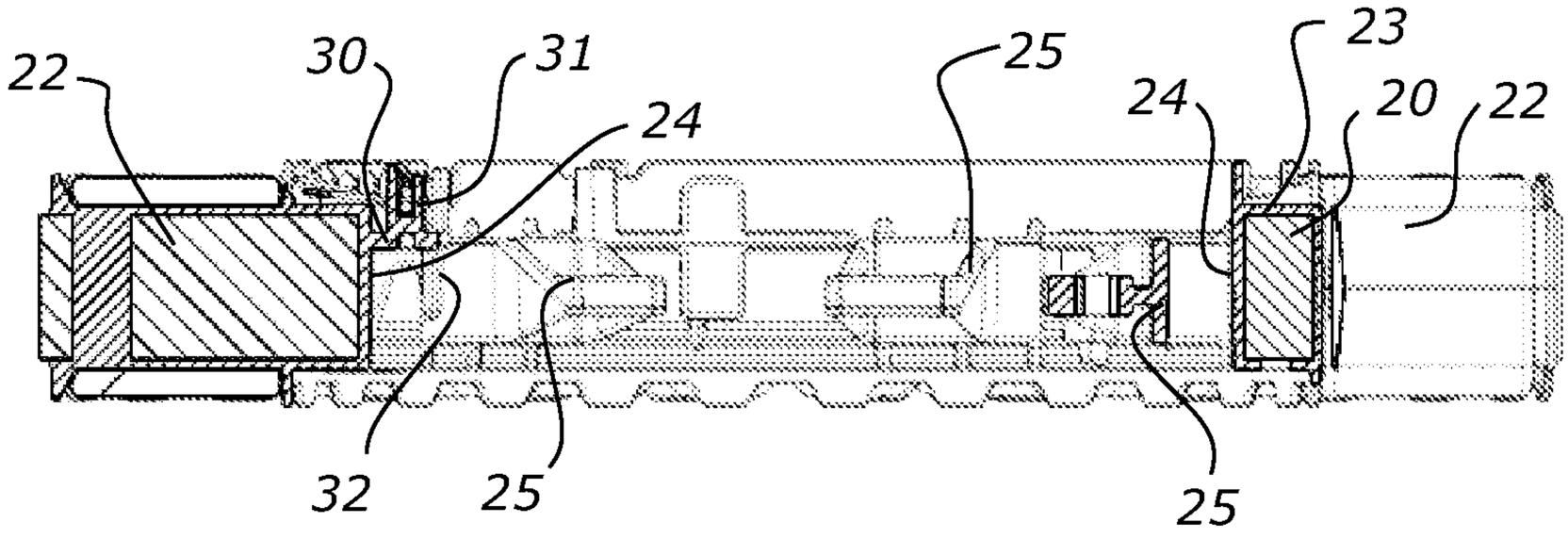


FIGURE 5

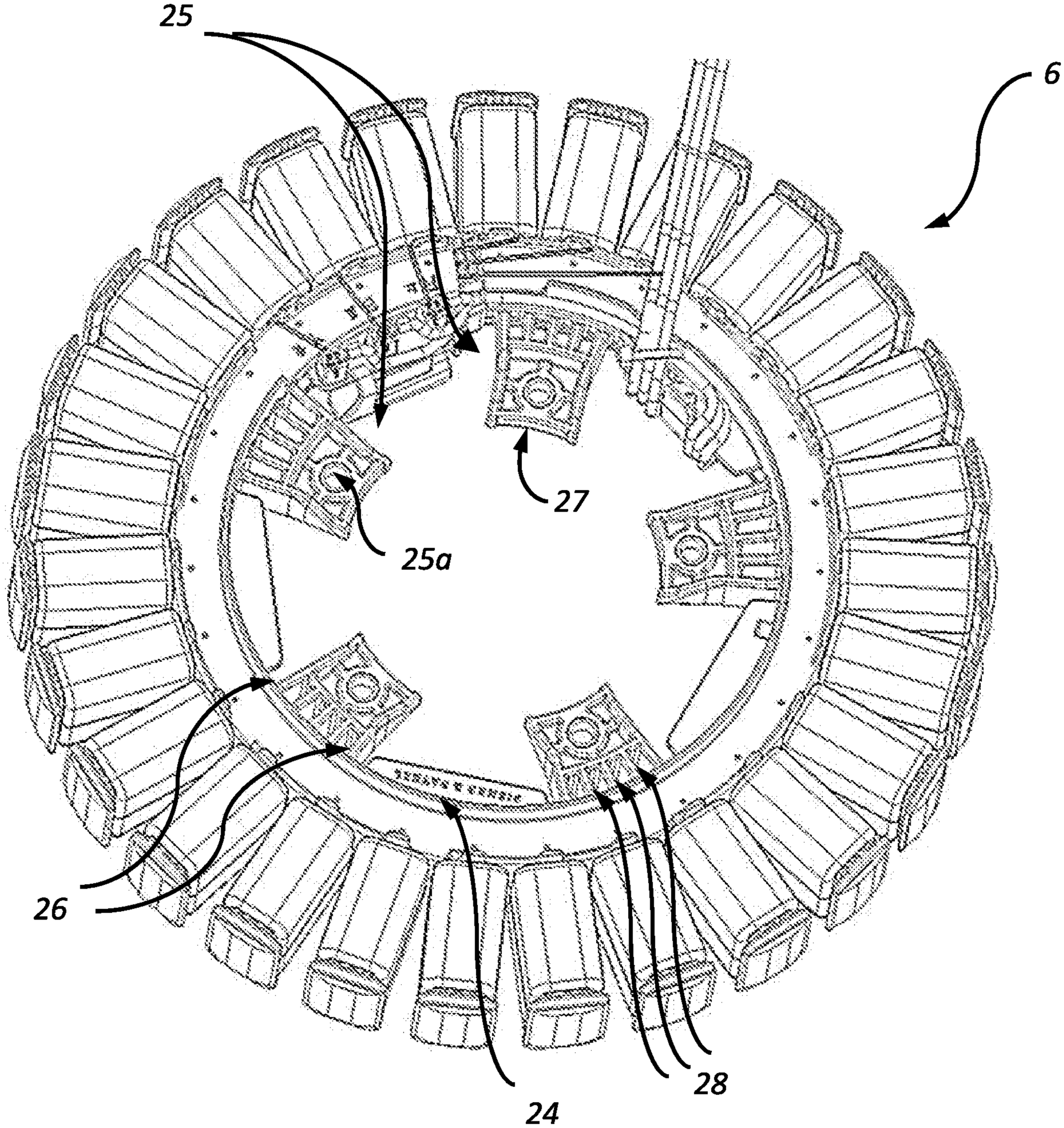


FIGURE 5A

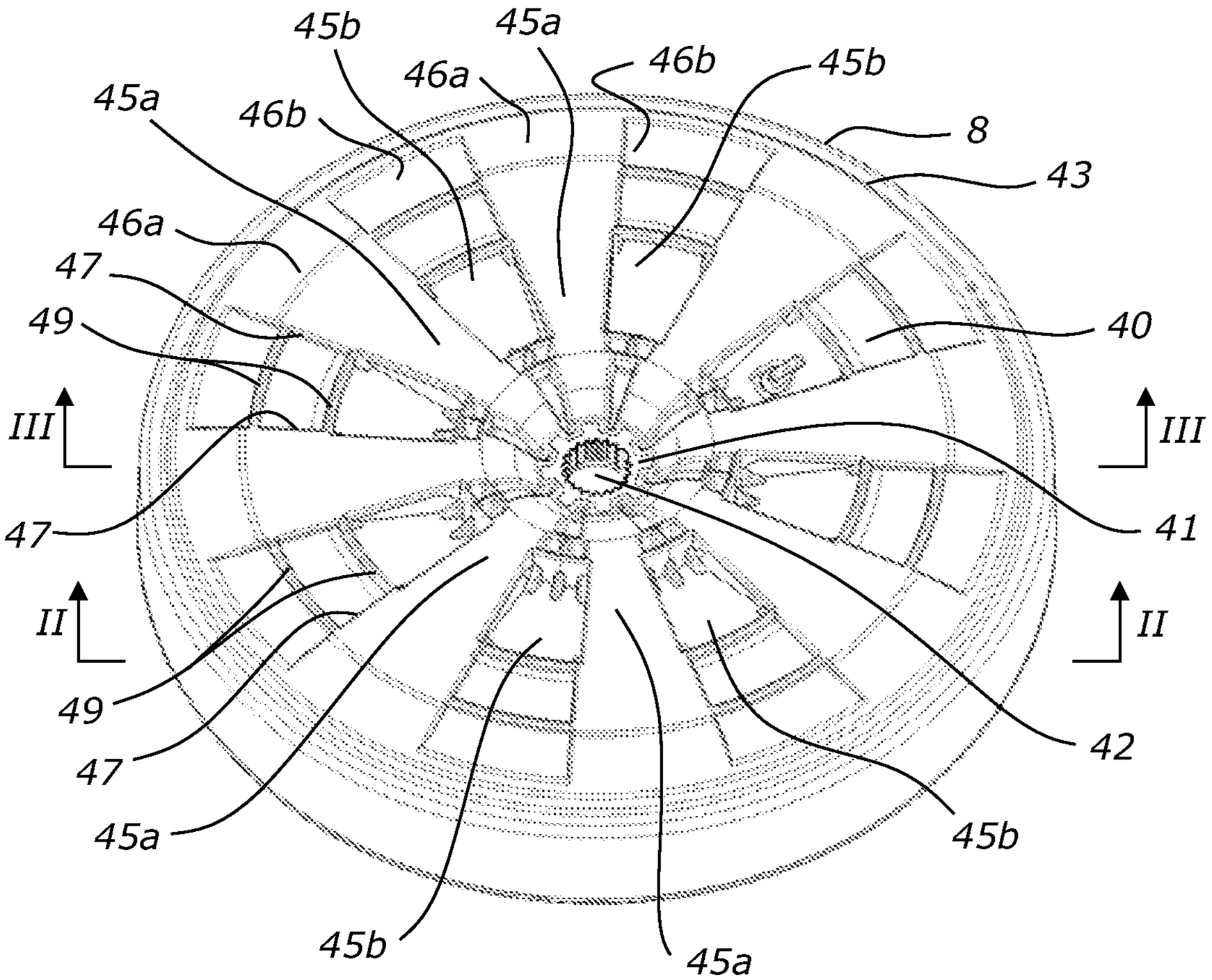


FIGURE 6

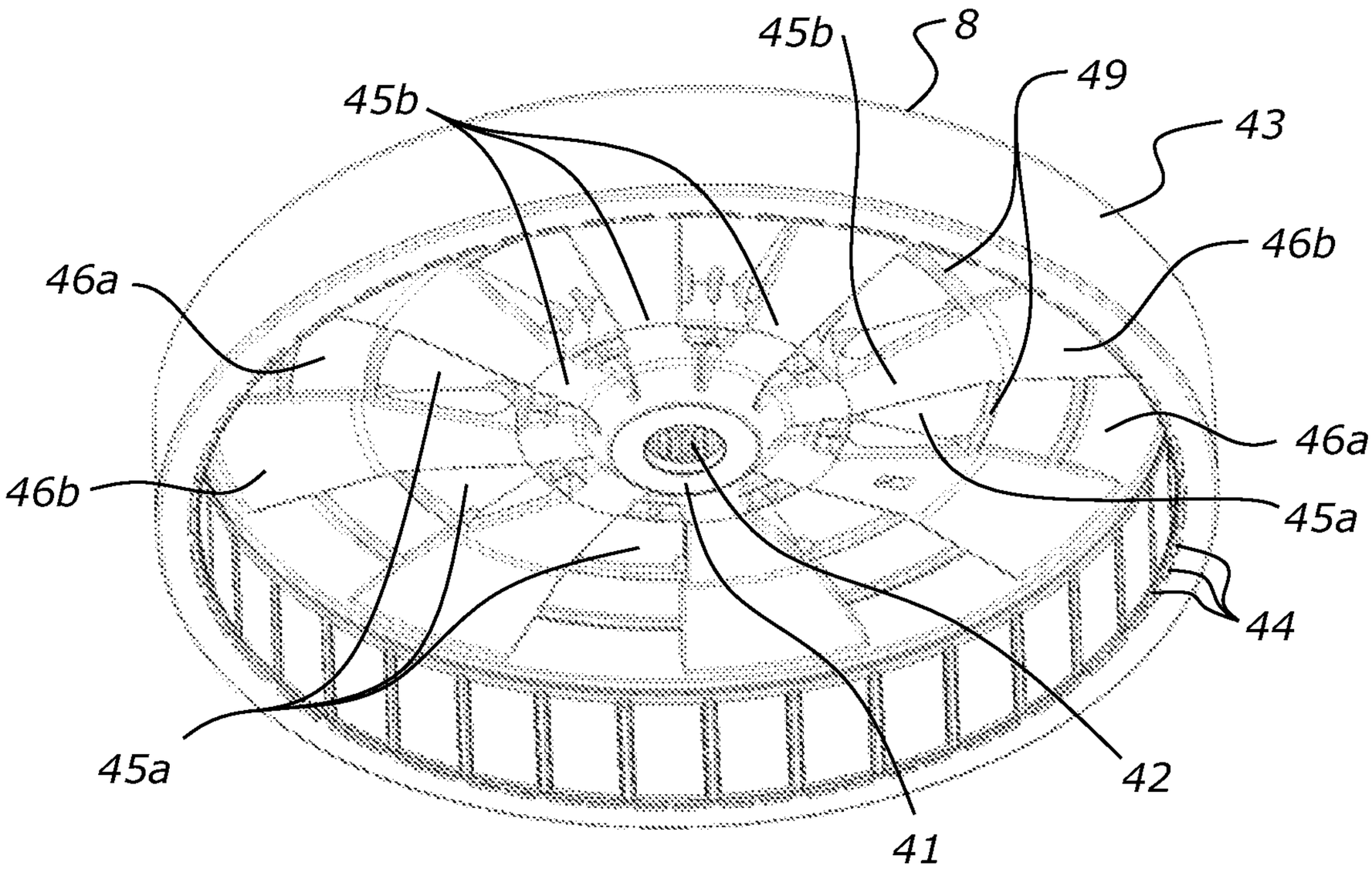


FIGURE 7

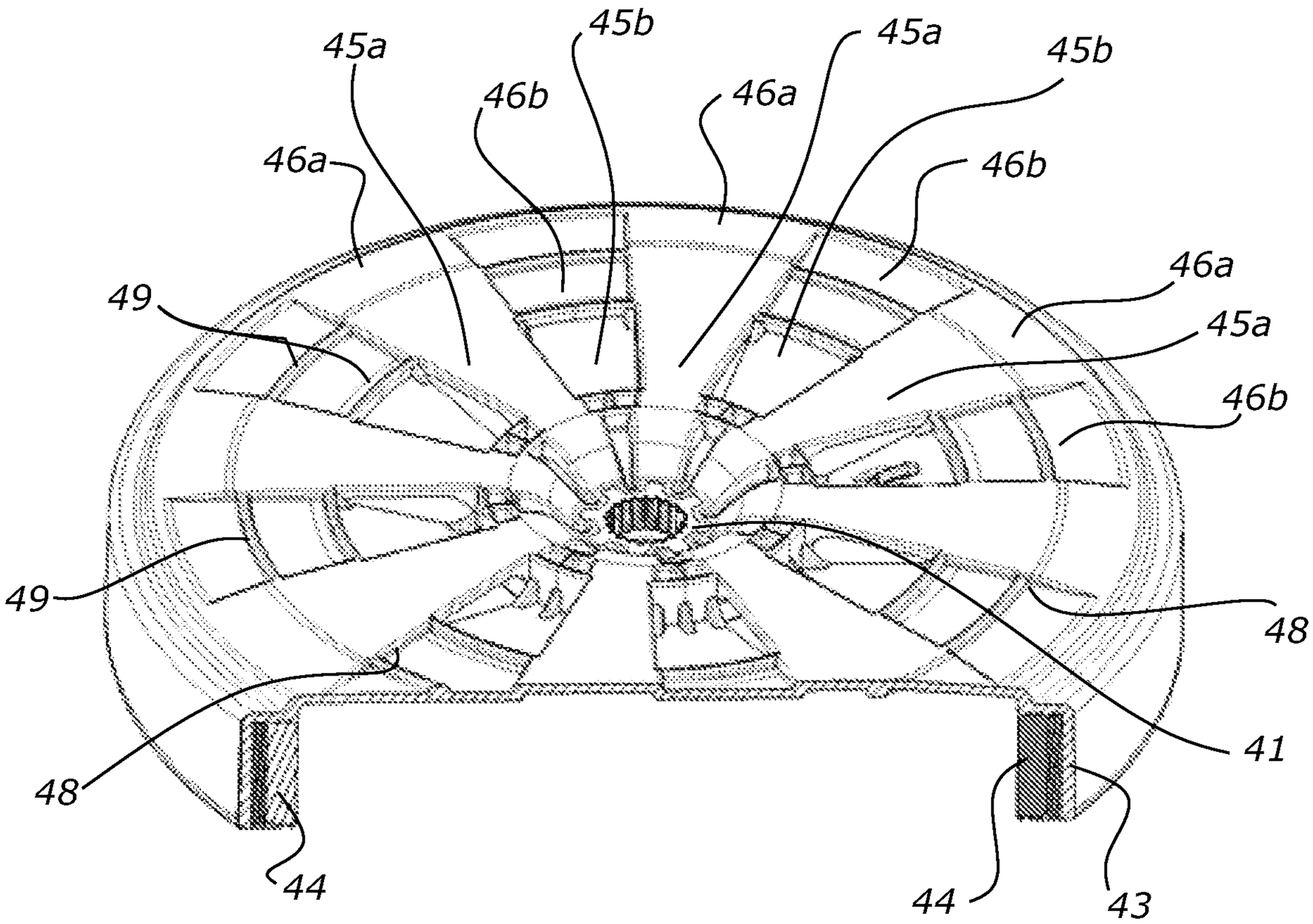


FIGURE 8

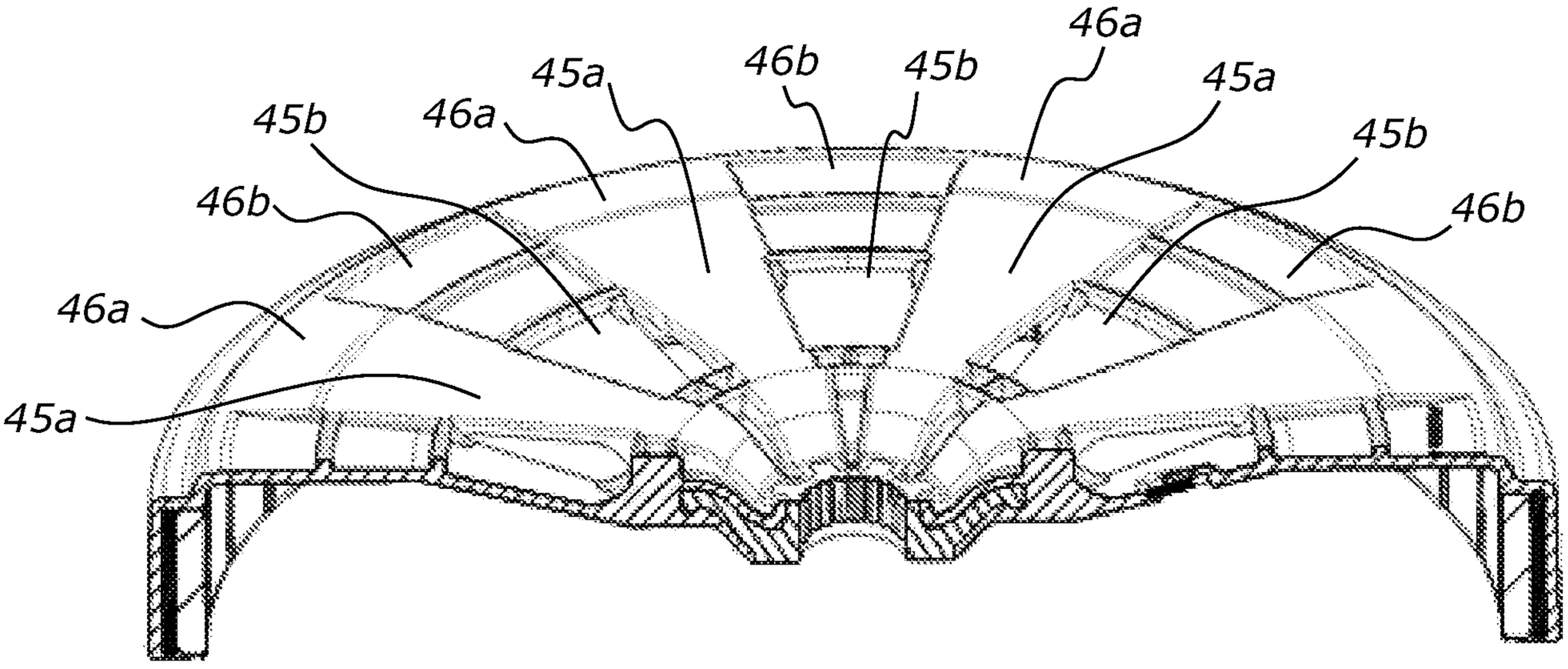


FIGURE 9

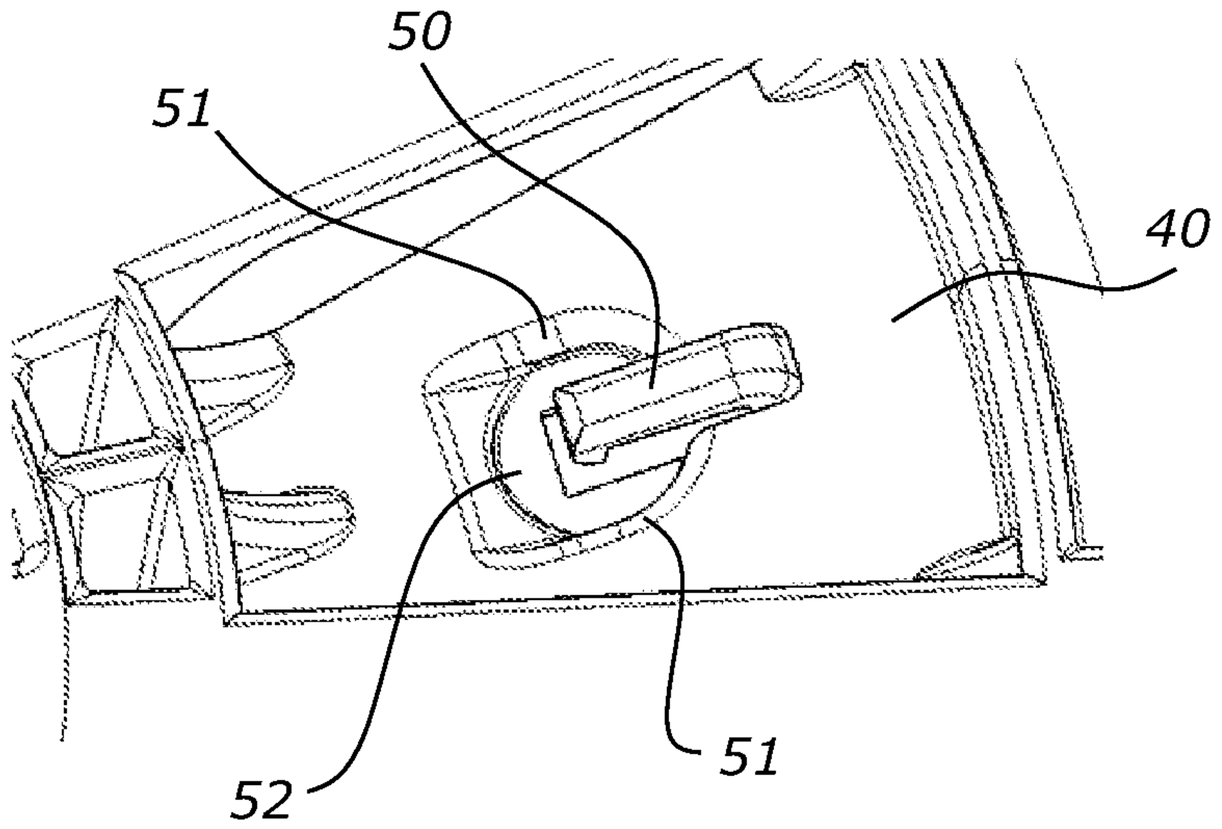


FIGURE 10

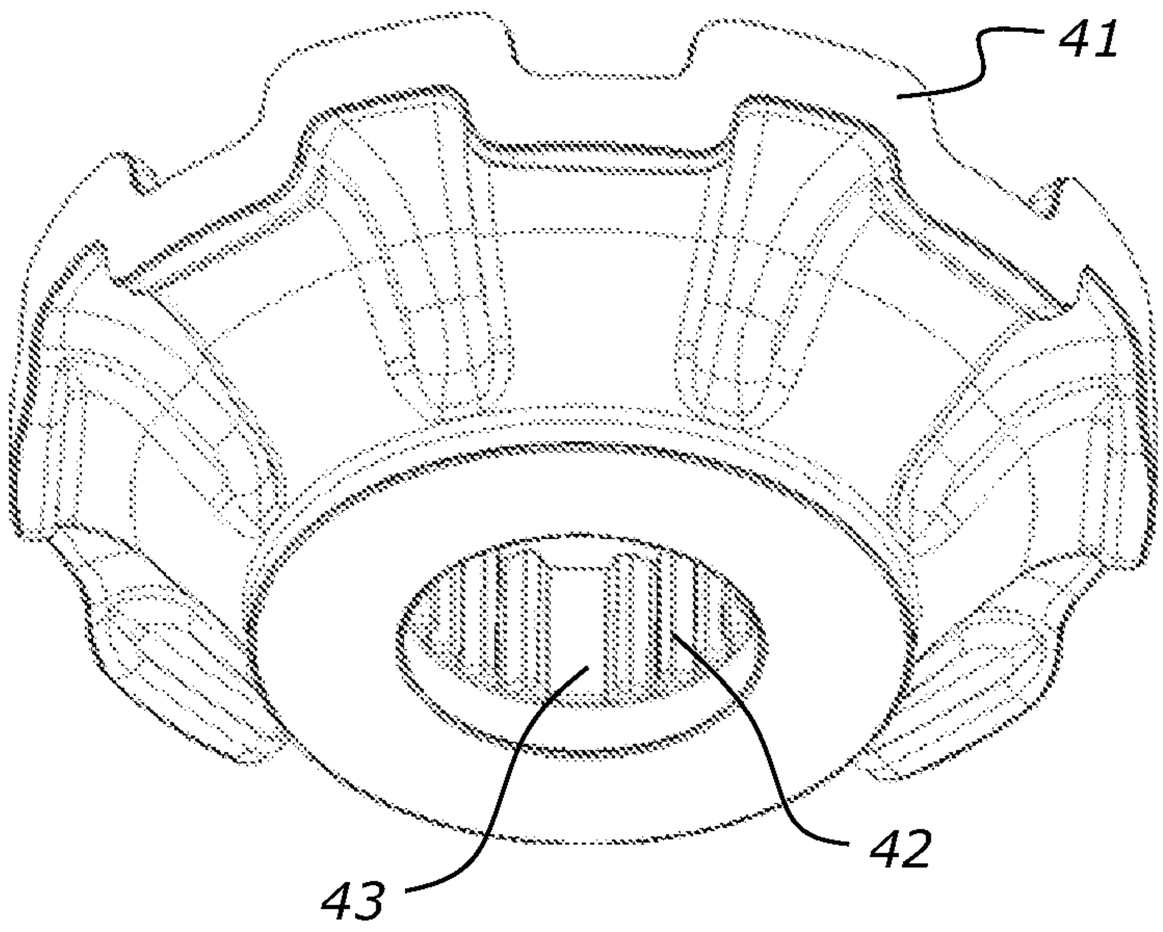


FIGURE 11

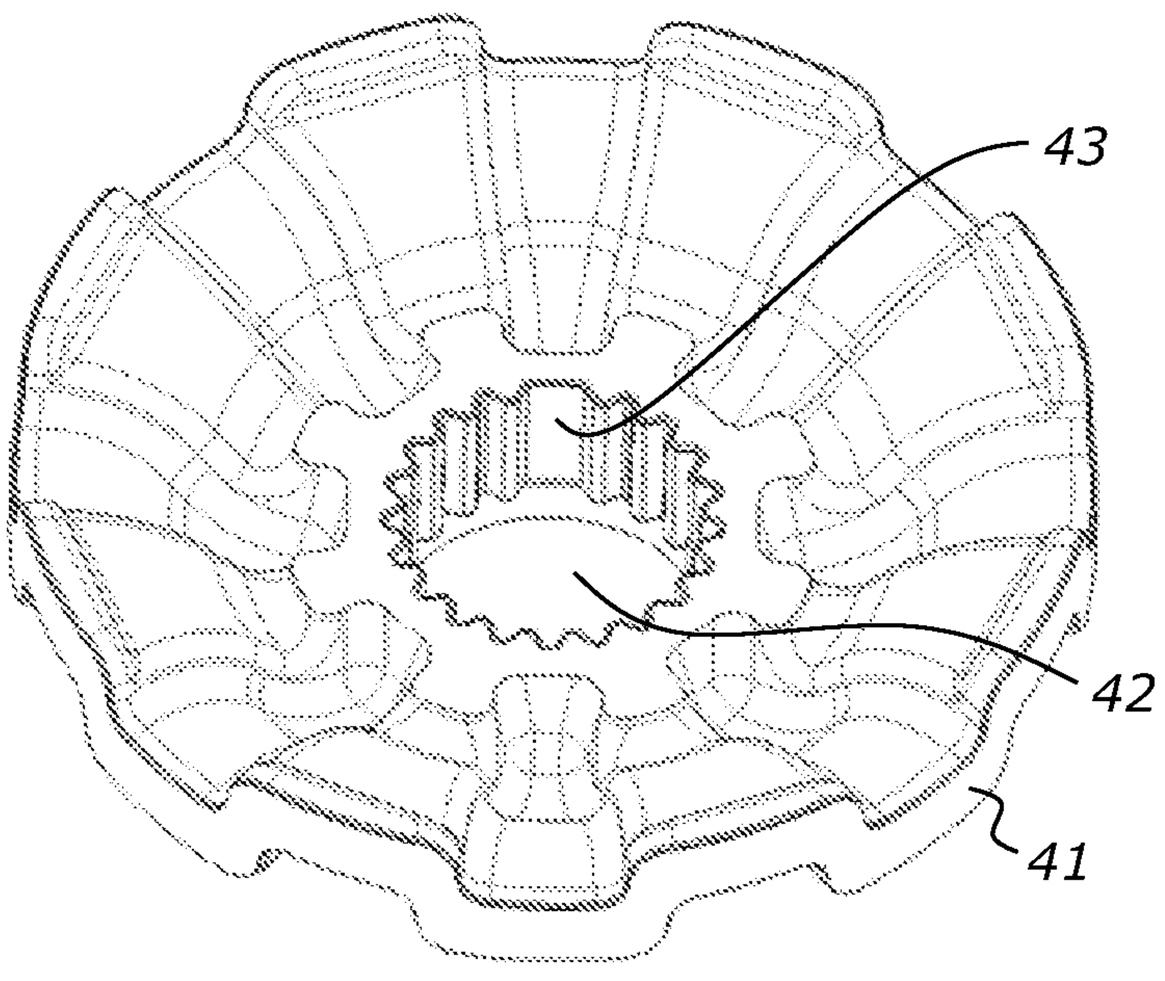


FIGURE 12

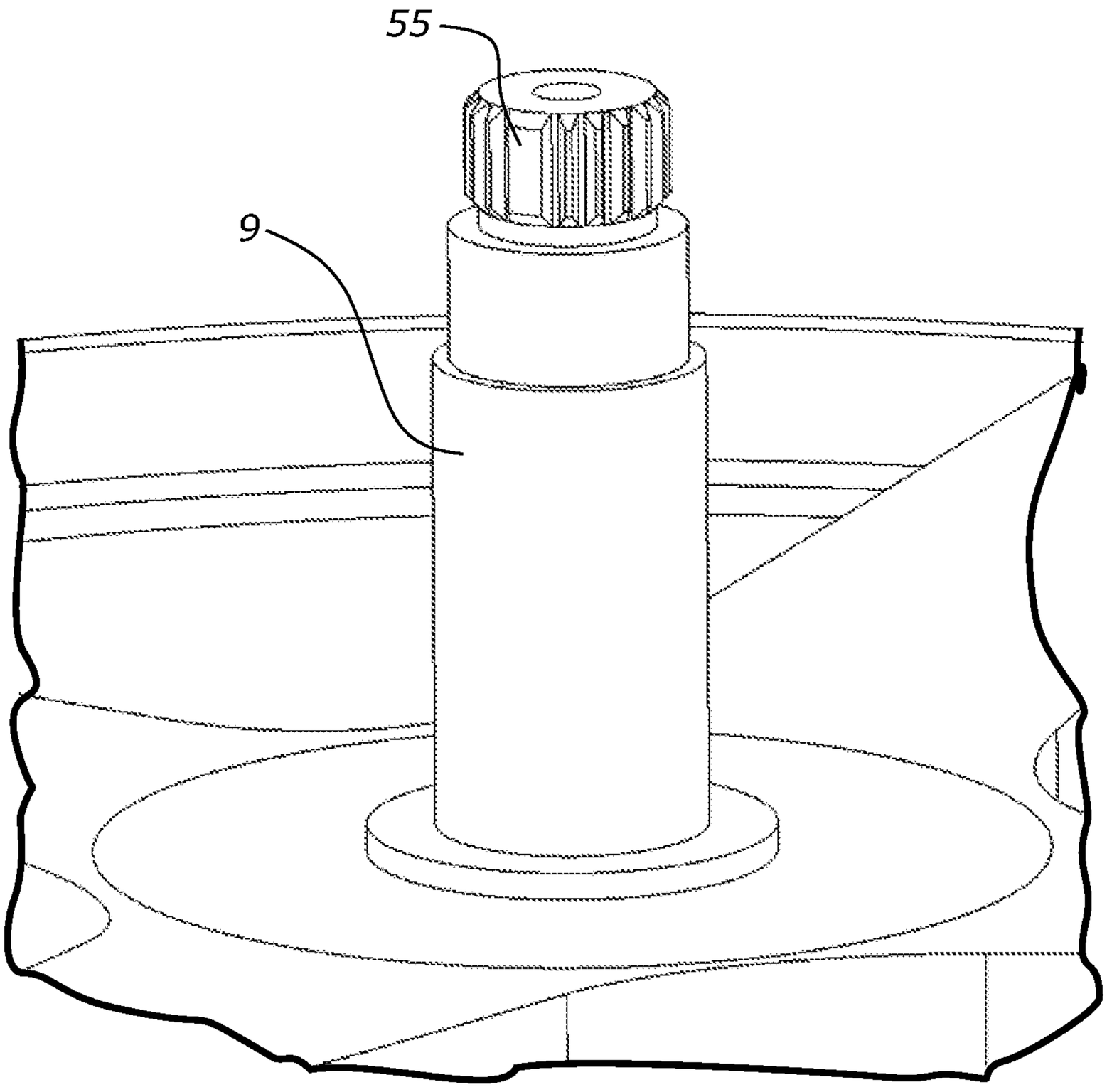


FIGURE 13

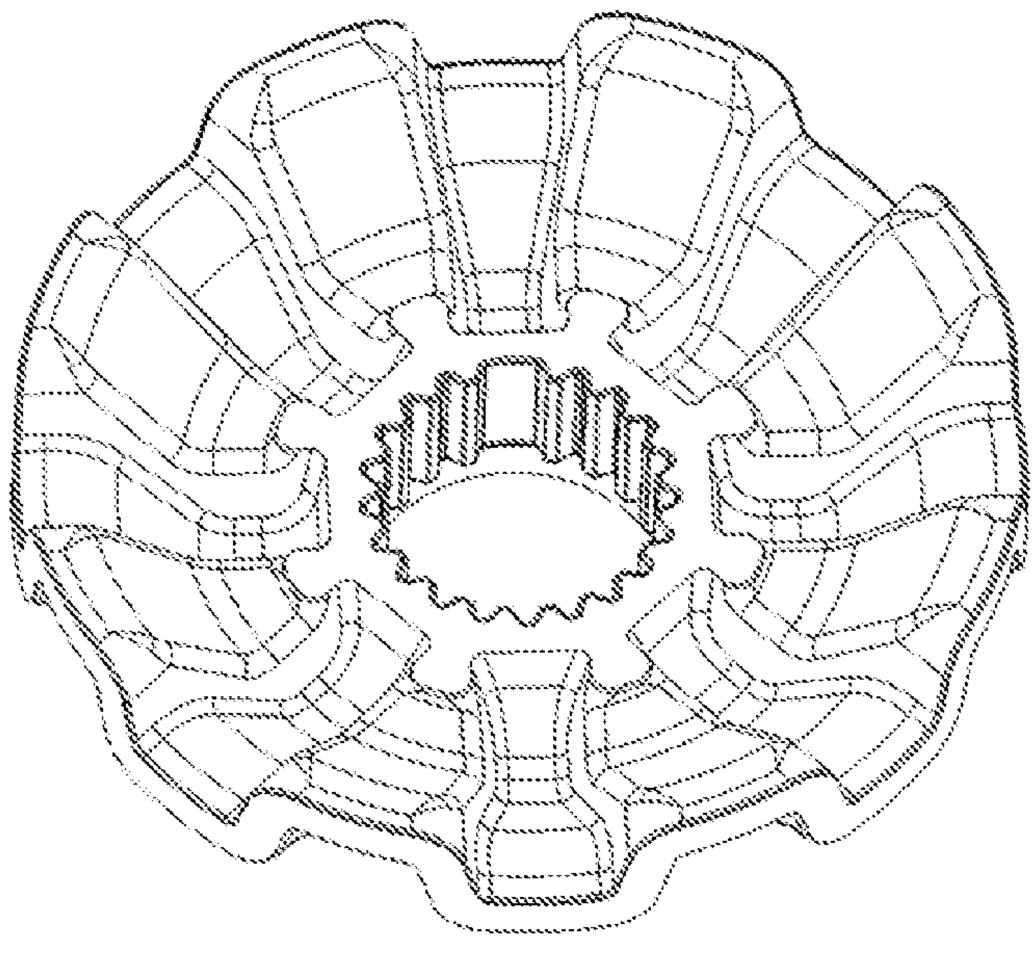


FIGURE 14

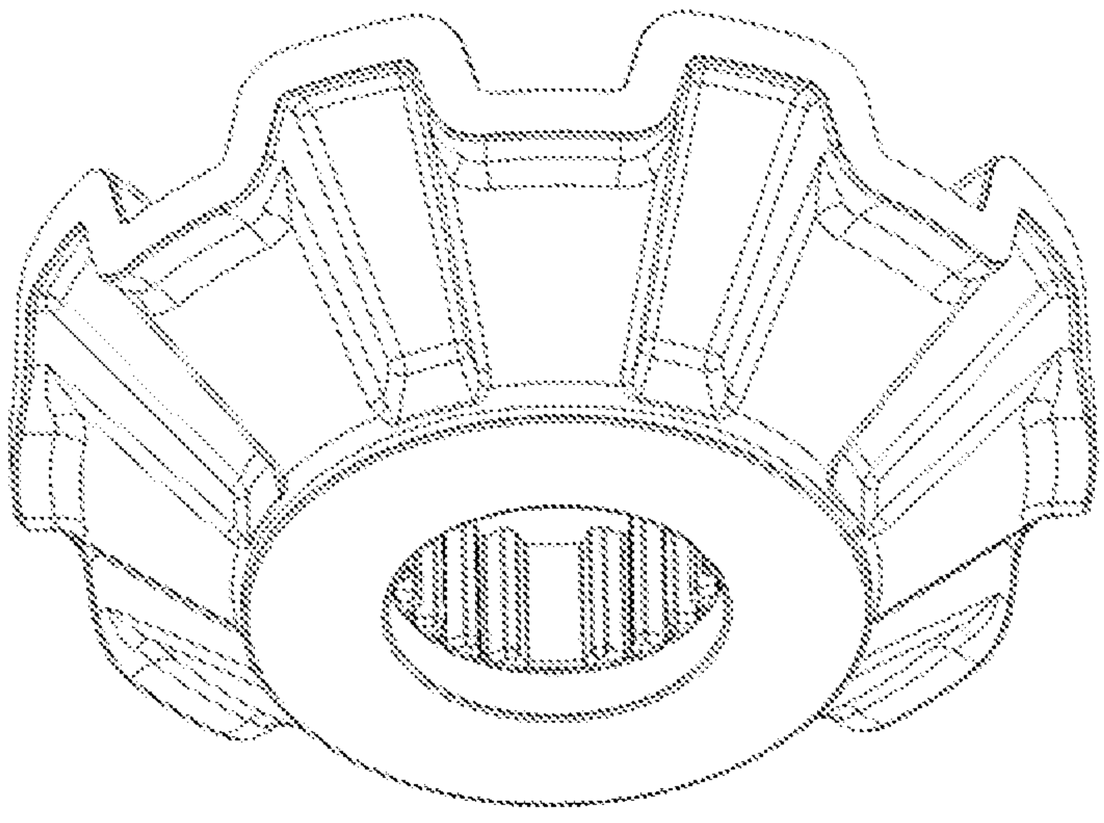


FIGURE 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2020/061198

A. CLASSIFICATION OF SUBJECT MATTER

D06F 37/30 (2020.01) H02K 1/04 (2006.01) H02K 15/14 (2006.01) H02K 5/24 (2006.01) D06F 37/22 (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)

Databases: Epoque database PATENW, WPI, EPODOC; Google Patents, Auspat, Espacenet

IPC/CPC: H02K5/24, D06F37/30, D06F37/20, D06F37/22

Keywords: mount, fasten, bolt, connect, stator, rib, wall, reinforce, flex, twist, elastic, tangent, angular, circumferential, and synonyms, see SIS for details.

Applicant/inventor name searched in external databases and internal databases provided by IP Australia.

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	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2021	08 February 2021
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Andrew Burgess AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262832636

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2020/061198

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-7 and 17 (and 19-20 in part)

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/IB2020/061198**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0084126 A1 (LEE et al.) 10 April 2008 Figures 2, 20-25; [0098]-[0135]	1-3, 17, 19-20
X	US 2013/0025330 A1 (BAE et al.) 31 January 2013 Figure 2; [0066]-[0071]	1-2, 17, 19-20
X	US 2005/0097928 A1 (CHOI) 12 May 2005 Figures 6A-B; [0065], [0070]	1-3, 17, 19-20
X	US 2009/0211312 A1 (AHN et al.) 27 August 2009 Figure 16-17	1-3, 17, 19-20
X	KR 20140111355 A (SAMSUNG ELECTRONICS CO LTD) 19 September 2014 Figure 2	1-2, 17, 19-20

INTERNATIONAL SEARCH REPORT	International application No. **PCT/IB2020/061198**

Supplemental Box

Continuation of: **Box III**

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

i. Claims 1-7 and 17 (and 19-20 in part) are directed to a stator. The features of a core, a polymeric insulating layer, and two or more fastener supports (paraphrased) are specific to this group of claims.

ii. Claims 8-14 (and 18-20 in part) are directed to a rotor. The feature of a rotor frame comprising a plurality of legs extending radially from the hub, the inner ends of a first plurality of legs being axially spaced from the inner ends of a second plurality of legs, and an annular portion comprising of substantially planar first wall segments defining an upper face of the rotor frame and a plurality of substantially planar second wall segments axially offset below the first wall segments, said first and second wall segments being arranged adjacent one another in a alternating fashion about a central axis of the rotor frame are specific to this group of claims.

iii. Claim 15-16 (and 18-20 in part) is directed to a rotor. The feature of a mount for a separate component which interacts with a sensor on the stator is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature in common between the all the claims is that the stator and rotor are each suitable for use in an electric motor suitable for use in a washing machine or dryer or washer-dryer. Since this general concept is ubiquitous in the art it cannot be considered a special technical feature. The only feature in common between the second a third groups of claims is a rotor with a hub and perimeter portion. Since this general concept is ubiquitous in the art it cannot be considered a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/IB2020/061198**

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**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2008/0084126 A1	10 April 2008	US 2008084126 A1	10 Apr 2008
		US 7615895 B2	10 Nov 2009
		AU 2004237798 A1	30 Jun 2005
		AU 2004237798 B2	24 Jun 2010
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		EP 1541738 B1	12 Jun 2013
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		US 9260813 B2	16 Feb 2016
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		AU 2012287653 B2	17 Sep 2015
		BR 112014001990 A2	21 Feb 2017
		CA 2842915 A1	31 Jan 2013
		CN 102899847 A	30 Jan 2013
		CN 102899847 B	18 May 2016
		EP 2551398 A1	30 Jan 2013
		KR 20130013060 A	06 Feb 2013
		KR 101555897 B1	07 Oct 2015
		MX 2014000961 A	26 Aug 2014
		MX 343821 B	24 Nov 2016

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/IB2020/061198**

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**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		WO 2013015593 A1	31 Jan 2013
US 2005/0097928 A1	12 May 2005	US 2005097928 A1	12 May 2005
		US 7520148 B2	21 Apr 2009
		AU 2004226978 A1	26 May 2005
		AU 2004226978 B2	17 Jun 2010
		CN 1614123 A	11 May 2005
		EP 1529870 A1	11 May 2005
		EP 1529870 B1	19 Oct 2016
		JP 2005137911 A	02 Jun 2005
		JP 4076990 B2	16 Apr 2008
		KR 20050043558 A	11 May 2005
		KR 100595192 B1	30 Jun 2006
		US 2009178444 A1	16 Jul 2009
		US 7950258 B2	31 May 2011
		US 2009199599 A1	13 Aug 2009
		US 8393182 B2	12 Mar 2013
US 2009/0211312 A1	27 August 2009	US 2009211312 A1	27 Aug 2009
		US 8499591 B2	06 Aug 2013
		EP 2052104 A2	29 Apr 2009
		EP 2052104 B1	30 Jan 2013
		KR 100777305 B1	20 Nov 2007
		KR 100777307 B1	20 Nov 2007
		WO 2008010674 A2	24 Jan 2008
KR 20140111355 A	19 September 2014	KR 20140111355 A	19 Sep 2014

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.