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(71) Applicant: **Electrolux Home Products Corporation N.V.**
1930 Zaventem (BE)

(72) Inventors:
• **Breese, Kevin**
33074 Fontanafredda (PN) (IT)

• **Patel, Vijay**
33080 Porcia (PN) (IT)
• **Bortolotti, Paolo**
33080 Porcia (PN) (IT)
• **Trani, Antonio**
33080 Porcia (PN) (IT)
• **Gandelli, Marco**
33080 Porcia (PN) (IT)
• **Zanello, Fabio**
33170 Pordenone (IT)
• **Cusinato, Adriano**
33080 Porcia (PN) (IT)

(74) Representative: **Markovina, Paolo**
Electrolux Italia S.p.A.
Corso Lino Zanussi 30
33080 Porcia (PN) (IT)

(54) **Laundry washing/drying machine**

(57) Laundry washing/drying machine (1) comprising a casing (2) and at least one revolving element (6; 21) which is fixed in axially rotating manner inside the machine casing (2) for rotating about a given rotation axis (L, R); the revolving element (6, 21) being provided with a supporting shaft (10, 22) which projects from the revolving element main body (13, 14) coaxial to the rotation axis (L, R), and is fitted in axially rotating manner into a corresponding supporting hub (11, 23) present in the machine casing (2); the supporting hub (11, 23) having a central hole and the supporting shaft (10, 21) engaging the central hole of the supporting hub (11, 23) so as to form, inside the latter, a cylindrical interspace (14) which is filled with a magnetic-field-responsive fluid having lubricant properties; the supporting hub (11, 23) also having a magnetic-field source (16, 26) capable of generating a magnetic field which restrains the magnetic-field-responsive fluid inside the cylindrical interspace (14).

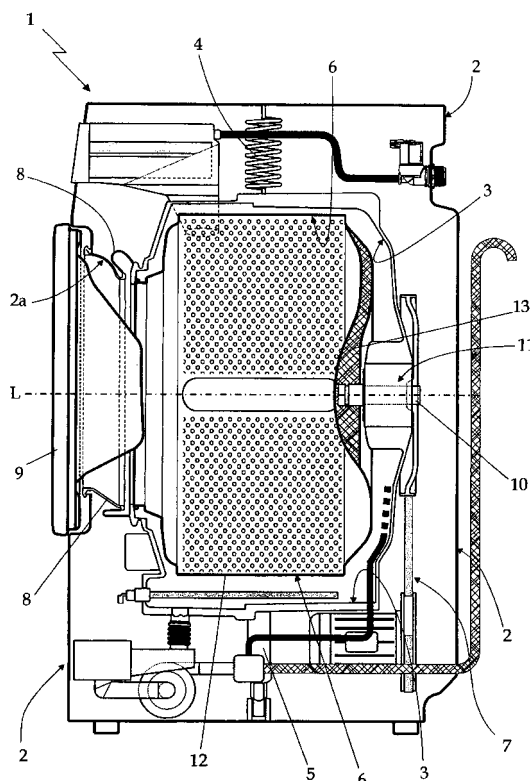


Fig. 1

Description

[0001] The present invention relates to a laundry washing/drying machine.

[0002] More specifically, the present invention relates to a front-loading home laundry washing machine, to which the following description refers purely by way of example.

[0003] As is known, front-loading home laundry washing machines generally comprise a substantially parallelepiped-shaped outer box casing resting on the floor; a substantially bell-shaped washing tub which is suspended in floating manner inside the casing by means of a number of coil springs and shock-absorber, directly facing a laundry loading and unloading opening formed in the front face of the casing; a door hinged to the front face of the casing to rotate to and from a rest position in which the door closes the opening in the front face of the casing to seal the washing tub; a revolving drum for housing the laundry to be washed, and which is housed inside the washing tub to rotate about its longitudinal axis; and an electric motor for rotating the revolving drum about its longitudinal axis inside the washing tub.

[0004] More specifically, the revolving drum is connected to the washing tub via a supporting shaft or pin which projects from the bottom of the revolving drum coaxial to the rotation axis of the drum, and is fitted in axially rotating manner into a corresponding supporting hub present on the bottom wall of the washing tub. A number of annular gaskets and ball-bearings are also interposed between the hub or bush and the supporting shaft to avoid water leakage and to reduce the starting torque to be supplied by the electric motor.

[0005] It is the aim of the present invention to further reduce the starting torque to be supplied by the electric motor, thus allowing a downsizing of the electric motor and a reduction of electricity consumption of the laundry washing machine.

[0006] According to the present invention, there is provided a home laundry washing/drying machine as claimed in Claim 1 and preferably, though not necessarily, in any one of the dependent Claims.

[0007] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

- Figure 1 shows a side view, with parts in section and parts removed for clarity, of a front-loading laundry washing/drying machine in accordance with the teachings of the present invention;
- Figure 2 shows a section view of a portion of the Figure 1 laundry washing machine;
- Figure 3 shows a section view of a different embodiment of the Figure 2 portion of the laundry washing machine;
- Figure 4 shows a side view, with parts in section and parts removed for clarity, of a second embodiment of the front-loading laundry washing/drying machine

in accordance with the teachings of the present invention.

[0008] With reference to Figure 1, number 1 indicates as a whole a laundry washing/drying machine comprising a preferably, though not necessarily, parallelepiped-shaped outer box casing 2 resting on the floor; a substantially bell-shaped washing tub 3 suspended in floating manner inside casing 2 via a suspension system comprising a number of coil springs 4 (only one shown in Figure 1) preferably, though not necessarily, combined with one or more vibration dampers 5 (only one shown in Figure 1); a substantially bell-shaped revolving drum 6 for housing the laundry to be washed and/or dried, and which is fixed in axially rotating manner inside washing tub 3 for rotating about its longitudinal axis L; and an electric motor assembly 7 for rotating, on command, revolving drum 6 about its longitudinal axis L inside washing tub 3.

[0009] In particular, in the example shown, laundry washing/drying machine 1 is a front-loading home washing machine 1, and washing tub 3 is suspended in floating manner inside casing 2, with the front opening of washing tub 3 directly faced to a laundry loading and unloading opening 2a formed in the front face of casing 2.

[0010] Revolving drum 6, in turn, is housed into washing tub 3 so as that its longitudinal axis L is oriented substantially horizontally, and coincides with the longitudinal axis of washing tub 3.

[0011] More specifically, the front opening of washing tub 3 is connected to opening 2a on the front face of casing 2 via a cylindrical elastic-deformable bellows 8, and washing machine 1 is also provided with a door 9 which is hinged to the front face of casing 2 to rotate to and from a rest position in which door 4 closes opening 2a of casing 2 to seal washing tub 3.

[0012] With reference to Figures 1 and 2, revolving drum 6 is provided with a supporting shaft or pin 10 which projects from the bottom wall of drum 6 coaxial to the drum longitudinal axis L, and is fitted in axially rotating manner into a corresponding supporting hub 11 which is located on the bottom wall of washing tub 3, coaxial to longitudinal axis L of revolving drum 6.

[0013] More specifically, in the example shown, supporting hub 11 is integral to the bottom wall of washing tub 3, and is provided with a central through hole extending coaxial to the longitudinal axis L of revolving drum 6. Whereas revolving drum 6 comprises a cylindrical bell-shaped rigid container 12 having at least its cylindrical lateral wall perforated, or at any rate permeable to water, to permit water entry into drum 6; a three-arm cross spider 13 rigidly fixed to the bottom wall of container 12 coaxially to axis L; and shaft or pin 10 which is rigidly fixed to, and projects from, the centre of cross spider 13 towards the bottom wall of washing tub 3, coaxially to longitudinal axis L.

[0014] In particular, with reference to Figures 1 and 2, shaft 10 extends through the central through hole of sup-

porting hub 11 so as to project outside of washing tub 3, and the distal end of shaft 10 is mechanically coupled to a corresponding pulley of electric motor assembly 7.

[0015] Differently from known laundry washing/drying machines, shaft 10 engages the central through hole of supporting hub 11 so as to form, inside hub 11, a substantially cylindrical interspace 14 which extends coaxial to longitudinal axis L, surrounding shaft 10, and is completely filled with a magnetic-field-responsive fluid having lubricant properties.

[0016] In the present patent application, the expression "magnetic-field-responsive fluid" indicates a fluid which contains particles which shows a particular behaviour when submitted to a magnetic field (for example particles containing iron); in particular, as will be better illustrated in the following, a magnetic-field-responsive fluid can be restrained in a confined region by a suitable magnetic field.

[0017] In a first embodiment the magnetic-field-responsive fluid is advantageously a so called "ferrofluid"; ferrofluids are colloidal mixtures composed preferably of nanoscale particles (with diameter usually 10 nanometers or less) of magnetite or some other compounds containing iron, suspended in a carrier fluid, usually an organic solvent or water.

[0018] The particles are suspended by Brownian motion and generally will not settle under normal conditions; the particles are coated with a surfactant to prevent their agglomeration, so as to ensure that these particles do not form aggregates that become too heavy to be held in suspension by Brownian motion.

[0019] The small dimension of the nanoscale particles is enough for thermal agitation to disperse them evenly within the carrier fluid, and for them to contribute to the overall magnetic response of the fluid.

[0020] Ferrofluids do not display ferromagnetism, since they do not retain magnetization in the absence of an externally applied field; on the contrary ferrofluids show a bulk-scale paramagnetism, and are often referred as being "superparamagnetic" due to their large magnetic susceptibility.

[0021] Ferrofluids have friction-reducing capabilities when submitted to a suitable magnetic field; for example, if a ferrofluid is applied to the surface of a strong enough magnet, such as one made of neodymium, it can cause the magnet to glide across smooth surfaces with minimal resistance. This fact allows using ferrofluids as seals or lubricants.

[0022] In a further embodiment of the present invention, the magnetic-field-responsive fluid can advantageously be a magnetorheological fluid, that is a suspension of micrometer-sized magnetic particles in a carrier fluid, usually a type of oil.

[0023] The viscosity of a magnetorheological fluid can be controlled very accurately by varying the intensity of a magnetic field to which the magnetorheological fluid is submitted.

[0024] Magnetorheological fluids differ from the above

mentioned ferrofluids because the magnetorheological fluid particles are micrometre-sized, while the ferrofluid particles are nanometer-sized.

[0025] In addition to the above, supporting hub 11 also comprises a magnetic-field source which is capable of generating a magnetic field which restrains the magnetic-field-responsive fluid inside cylindrical interspace 14.

[0026] More specifically, the magnetic-field source is capable of generating a magnetic field which restrains the magnetic-field-responsive fluid evenly distributed inside cylindrical interspace 14.

[0027] In particular, in the example shown, shaft 10 and supporting hub 11 are dimensioned to form a cylindrical interspace 14 having preferably, though not necessarily, a less than 1 millimeter thickness, whereas the magnetic-field-responsive fluid restrained in cylindrical interspace 14 is a Perfluoropolyether (PFPE) oil based ferrofluid, such as the magnetic fluid SBPS62 produced by the UK company Liquid Research, or a Hydrocarbon oil based ferrofluid, such as the Magneferfluid SGHS4-U by the UK company Liquids Research.

[0028] With reference to Figures 1 and 2, in the example shown supporting hub 11 comprises a cylindrical supporting bush 15 which is integral to the bottom wall of washing tub 3, and is coaxial to longitudinal axis L of revolving drum 6; a cylindrical-shaped magnetic-field source 16 which is housed into cylindrical bush 15, coaxial to axis L, so as to surround the central through hole of hub 11, and it is structured to generate, into cylindrical interspace 14, a radially oriented magnetic field which restrains the magnetic-field-responsive fluid within interspace 14, evenly distributed around shaft 10; and preferably, though not necessarily, a main annular retaining gasket (not shown) which is fixed to the bush axial end directly facing revolving drum 6, and fits to shaft 10 to avoid any water leakage into the central through hole of cylindrical bush 15, i.e. into the central through hole of hub 11.

[0029] In particular, with reference to Figure 2, in the example shown, magnetic-field source 16 comprises a cylindrical sleeve or jacket 17 made of plastic or composite material and which extends within cylindrical bush 15 coaxial to axis L, so as to surround shaft 10 and define the central through hole of hub 11; a number of ring-shaped permanent magnets 18 which are housed into cylindrical bush 15 and are fitted onto cylindrical jacket 17, one adjacent to the other and coaxial to axis L, so as to surround jacket 17, i.e. the central through hole of hub 11; and a number of spacer annular washers 19 made of plastic or composite material, each of which is fitted onto cylindrical jacket 17 coaxial to axis L, between two consecutive ring-shaped permanent magnets 18.

[0030] The ring-shaped permanent magnets 18 are made preferably, though not necessarily, of AlNiCo (i.e. Alloy, Nickel and Cobalt), TiCoNAL (i.e. Titanium, Cobalt, Nickel and Alloy) or NdFeB (i.e. Neodymium, Iron and Boron), and are structured to generate, into cylindrical interspace 14, a radially oriented magnetic field which

restrains the magnetic-field-responsive fluid within interspace 14, evenly distributed around shaft 10.

[0031] With reference to Figure 2, magnetic-field source 16 is preferably, though not necessarily, also provided with two annular retaining washers or gaskets 20 made of plastic or composite material, which are fixed into bush 15, coaxial to axis L and at both axial ends of cylindrical jacket 17, to keep permanent magnets 18 and annular washers 19 side by side on jacket 17.

[0032] In addition to the above, each retaining washer or gasket 20 preferably, though not necessarily, also fits to shaft 10, so as to avoid any leakage of magnetic-field-responsive fluid from cylindrical interspace 14.

[0033] In other words, in the example shown cylindrical interspace 14 is delimited by shaft 10, cylindrical jacket 17, and the two retaining washers or gaskets 20; and the magnetic-field-responsive fluid within interspace 14 avoids, like a traditional ball bearing, any radial movement of shaft 10 within the central through hole of hub 11.

[0034] With reference to Figure 3, in a different embodiment, magnetic-field source 16 of supporting hub 11 is replaced by a cylindrical-shaped magnetic-field source 26 which comprises a cylindrical sleeve or jacket 27 made of plastic or composite material and which extends within cylindrical bush 15 coaxial to axis L, so as to surround shaft 10 and define the central through hole of hub 11; one or more series (four in the example shown) of annularly-distributed electromagnets, each of which is formed by a number of radially-oriented electromagnets 28 which, alike the radially-oriented electromagnets of the stator of a standard asynchronous electric-motor, are housed into cylindrical bush 15 uniformly angularly distributed around axis L, so as to surround cylindrical jacket 27, i.e. the central through hole of hub 11; and an electric power unit (not shown) for supplying, on command, electric energy to the induction coils 28a of all electromagnets 28.

[0035] Each electromagnet 28 is radially oriented so as to generate, into cylindrical interspace 14 and when the corresponding induction coil 28a is supplied with electric current, a radially oriented magnetic field which restrains the magnetic-field-responsive fluid within interspace 14, evenly distributed around shaft 10.

[0036] Also in this second embodiment, therefore, the magnetic-field-responsive fluid within interspace 14 avoids, like a traditional ball bearing, any radial movement of shaft 10 within the central through hole of hub 11.

[0037] With reference to Figure 3, in the example shown, magnetic-field source 26 is preferably, though not necessarily, provided also with two additional axially-oriented and annular-shaped electromagnets 29 which are fitted onto cylindrical jacket 27, on opposite sides of the annularly-distributed and radially-oriented group of electromagnets 28. Each electromagnet 29 is coaxial with cylindrical jacket 27 and is designed to generate, into cylindrical interspace 14 and when the corresponding induction coils 29a are supplied with electric current, a magnetic field which is substantially parallel to the drum

longitudinal axis L, so as to push the magnetic-field-responsive fluid within cylindrical interspace 14, towards the centre of interspace 14 so to avoid any axial displacement of shaft 10 within the central through hole of hub 11.

[0038] In other words, in the embodiment represented in Figure 3 the magnetic-field-responsive fluid within interspace 14 avoids any axial displacement of shaft 10 within the central through hole of hub 11 and therefore it operates also like a traditional thrust bearing interposed between shaft 10 and cylindrical bush 15.

[0039] Preferably, though not necessarily, magnetic-field source 26 also comprises two annular retaining washers or gaskets 30 made of plastic or composite material, which are fixed into cylindrical bush 15, coaxial to axis L and at both axial ends of cylindrical jacket 27, to keep the annularly-distributed and radially-oriented group of electromagnets 28 and the axially-oriented electromagnets 29 side by side on jacket 27.

[0040] Each retaining washer or gasket preferably, though not necessarily, also fits to shaft 10 to avoid any leakage of magnetic-field-responsive fluid from cylindrical interspace 14.

[0041] General operation of laundry washing/drying machine 1 is clearly inferable from the above description, with no further explanation required.

[0042] The particular structure of supporting hub 11 has lots of advantages. The permanent presence of a lubricating liquid, i.e. the magnetic-field-responsive fluid having lubricant properties, between shaft 10 and cylindrical bush 15 allows a drastic reduction of the starting torque requested for starting rotation of revolving drum 6.

[0043] The reduction of starting torque value, in turn, allows the downsizing of the asynchronous motor of electric motor assembly 7 and the reduction of electricity consumption of the laundry washing/drying machine.

[0044] Clearly, changes may be made to laundry washing/drying machine 1 as described herein without, however, departing from the scope of the present invention.

[0045] For example, an auxiliary cylindrical-shaped magnetic-field source may be incorporated into shaft 10 for generating, into cylindrical interspace 14, a radially-oriented magnetic field which is opposite to that generated by magnetic-field source 16 or 26, thus shaft 10 is magnetically suspended within the central through hole of hub 11.

[0046] More specifically, a number of ring-shaped permanent magnets 18 may be fitted also on shaft 10, so that each permanent magnet 18 on jacket 17 is directly faced to a corresponding ring-shaped permanent magnet 18 on shaft 10. Thus both the magnetic-field-responsive fluid within interspace 14 and the magnetic interaction between the magnetic fields generated by the magnetic-field source 16 and the auxiliary magnetic-field source on shaft 10 avoid, like a traditional ball bearing, any radial movement of shaft 10 within the central through hole of hub 11.

[0047] In combination with any one of the embodi-

ments disclosed above, supporting hub 11 may also comprise one or more traditional annular ball bearings or thrust bearings interposed between shaft 10 and cylindrical bush 15, preferably, though not necessarily, outside of interspace 14, so to avoid any radial movement or axial displacement of shaft 10 within the central through hole of hub 11.

[0048] With reference to Figure 4, in a different embodiment laundry washing/drying machine 1 is a laundry dryer and it lacks washing tub 3 and washing-tub suspension system. In which case, the bell-shaped revolving drum 6 rests horizontally inside casing 2 with its front opening directly faced to opening 2a, on a number of horizontal supporting rollers 21 which are fitted to casing 2 to let revolving drum 6 freely rotate about its longitudinal axis L.

[0049] At least one of these supporting rollers 21 is provided with a protruding shaft or pin 22 which projects from the roller cylindrical main body coaxial to a rotation axis R substantially parallel to drum longitudinal axis L, and is fitted in axially rotating manner into a corresponding supporting hub 23 on machine casing 2.

[0050] Likewise in supporting hub 11, shaft or pin 22 engages the central through hole of supporting hub 23 so as to form, inside supporting hub 23, a cylindrical interspace which extends coaxial to rotation axis R, surrounding shaft or pin 22, and is completely filled with a magnetic-field-responsive fluid having lubricant properties, i.e. an oil or grease having magnetic particles in suspension. Supporting hub 23, in turn, is provided with a magnetic-field source which is capable of generating a magnetic field which restrains the magnetic-field-responsive fluid inside the cylindrical interspace realized into hub 23, preferably, though not necessarily, evenly distributed inside the latter.

[0051] Structure of supporting hub 23 is almost identical to structure of supporting hub 11.

Claims

1. Laundry washing/drying machine (1) comprising a casing (2) and at least one revolving element (6; 21) which is fixed in axially rotating manner inside the machine casing (2) for rotating about a given rotation axis (L, R); the revolving element (6, 21) being provided with a supporting shaft (10, 22) which projects from the revolving element main body (12, 13) coaxial to said rotation axis (L, R), and is fitted in axially rotating manner into a corresponding supporting hub (11, 23) present in the machine casing (2); the laundry washing/drying machine (1) being **characterized in that** the supporting shaft (10, 22) engages the central hole of said supporting hub (11, 23) so as to form, inside the latter, an interspace (14) which is filled with a magnetic-field-responsive fluid having lubricant properties; the supporting hub (11, 23) also comprising a magnetic-field source (16, 26) capable

of generating a magnetic field which restrains the magnetic-field-responsive fluid inside said interspace (14).

2. Laundry washing/drying machine as claimed in Claim 1, wherein said magnetic-field source (16, 26) is capable of generating a magnetic field which restrains the magnetic-field-responsive fluid evenly distributed inside said interspace (14).
3. Laundry washing/drying machine as claimed in Claim 2, wherein said supporting hub (11, 23) comprises a supporting bush (15) and the magnetic-field source (16, 26) is a substantially cylindrical-shaped magnetic-field source (16, 26) which is housed into said supporting bush (15) coaxial to said rotation axis (L, R).
4. Laundry washing/drying machine as claimed in Claim 3, wherein said supporting hub (11, 23) comprises a cylindrical jacket (17, 27) extending within the supporting bush (15), coaxial to said rotation axis (L, R), so as to surround the shaft (10, 22) and delimit the central hole of said supporting hub (11, 23); said interspace (14) being delimited by the shaft (10, 22) and said cylindrical jacket (17, 27).
5. Laundry washing/drying machine as claimed in Claim 4, wherein said supporting hub (11, 23) also comprises two annular retaining gaskets (20, 30) which are fitted to the shaft (10), on both axial ends of the cylindrical jacket (17, 27), to avoid any leakage of magnetic-field-responsive fluid from the interspace (14).
6. Laundry washing/drying machine as claimed in Claim 3, 4 or 5, wherein said magnetic-field source (16) comprises at least one substantially annular-shaped permanent magnet (18) which is housed into the supporting bush (15) so as to surround the central hole of said supporting hub (11, 23), and which is structured to generate, into the interspace (14), a radially oriented magnetic field which restrains the magnetic-field-responsive fluid within said interspace (14).
7. Laundry washing/drying machine as claimed in Claims 4 and 6, wherein said magnetic-field source (16) comprises a number of ring-shaped permanent magnets (18) fitted onto the cylindrical jacket (17) one adjacent to the other, so as to surround said jacket (17); and a number of spacer annular washers (19) each of which is fitted on the cylindrical jacket (17) between two consecutive ring-shaped permanent magnets (18).
8. Laundry washing/drying machine as claimed in Claim 3, 4 or 5, wherein said magnetic-field source

(26) comprises at least one group of radially-oriented electromagnets (19) which are housed into the supporting bush (12, 23) angularly distributed around the central hole of said supporting hub (11, 23), and which are structured to generate, into the interspace (14), a radially-oriented magnetic field which restrains the magnetic-field-responsive fluid within said interspace (14); the magnetic-field source (26) being also provided with an electric power unit for supplying, on command, electric energy to said electromagnets (19).

9. Laundry washing/drying machine as claimed in Claim 8, wherein said magnetic-field source (26) also comprises two additional annular-shaped electromagnets (29) which are placed coaxial to the rotation axis (L, R) of said shaft (10), on opposite sides of said group of annularly-distributed and radially-oriented electromagnets (28), and each of which is structured to generate, into the interspace (14), a magnetic field which is substantially parallel to said rotation axis (L, R).
10. Laundry washing/drying machine as claimed in any one of the foregoing Claims, wherein it comprises a substantially bell-shaped washing tub (3) housed into the machine casing (2); said revolving element (6; 21) consisting in a substantially bell-shaped drum (6) for housing the laundry to be washed and/or dried, and which is fixed in axially rotating manner inside the washing tub (3) for rotating about its longitudinal axis (L); the supporting shaft (10) projecting from the bottom wall of said bell-shaped drum (6) coaxial to the drum longitudinal axis (L), and said supporting hub (11) being realized into said washing tub (3).
11. Laundry washing/drying machine as claimed in Claim 10, wherein said supporting hub (11) also comprises a main annular retaining gasket, which is fixed to the bush axial end facing said bell-shaped drum (6), and fits to said supporting shaft (10) to avoid any water leakage into the central hole of said supporting hub (11, 23).
12. Laundry washing/drying machine as claimed in any one of Claims 1 to 10, wherein it comprises a substantially bell-shaped drum (6) for housing the laundry to be washed and/or dried, and which rests horizontally inside the machine casing (2) on a number of horizontal supporting rollers (21) which are fitted to the machine casing (2) to let said bell-shaped drum (6) freely rotate about its longitudinal axis (L); said revolving element (6; 21) consisting in at least one of said supporting rollers (21).
13. Laundry washing/drying machine as claimed in any one of Claims 1 to 12, **characterized in that** said magnetic-field-responsive fluid is a ferrofluid.

14. Laundry washing/drying machine as claimed in any one of Claims 1 to 12, **characterized in that** said magnetic-field-responsive fluid is a magnetorheological fluid.

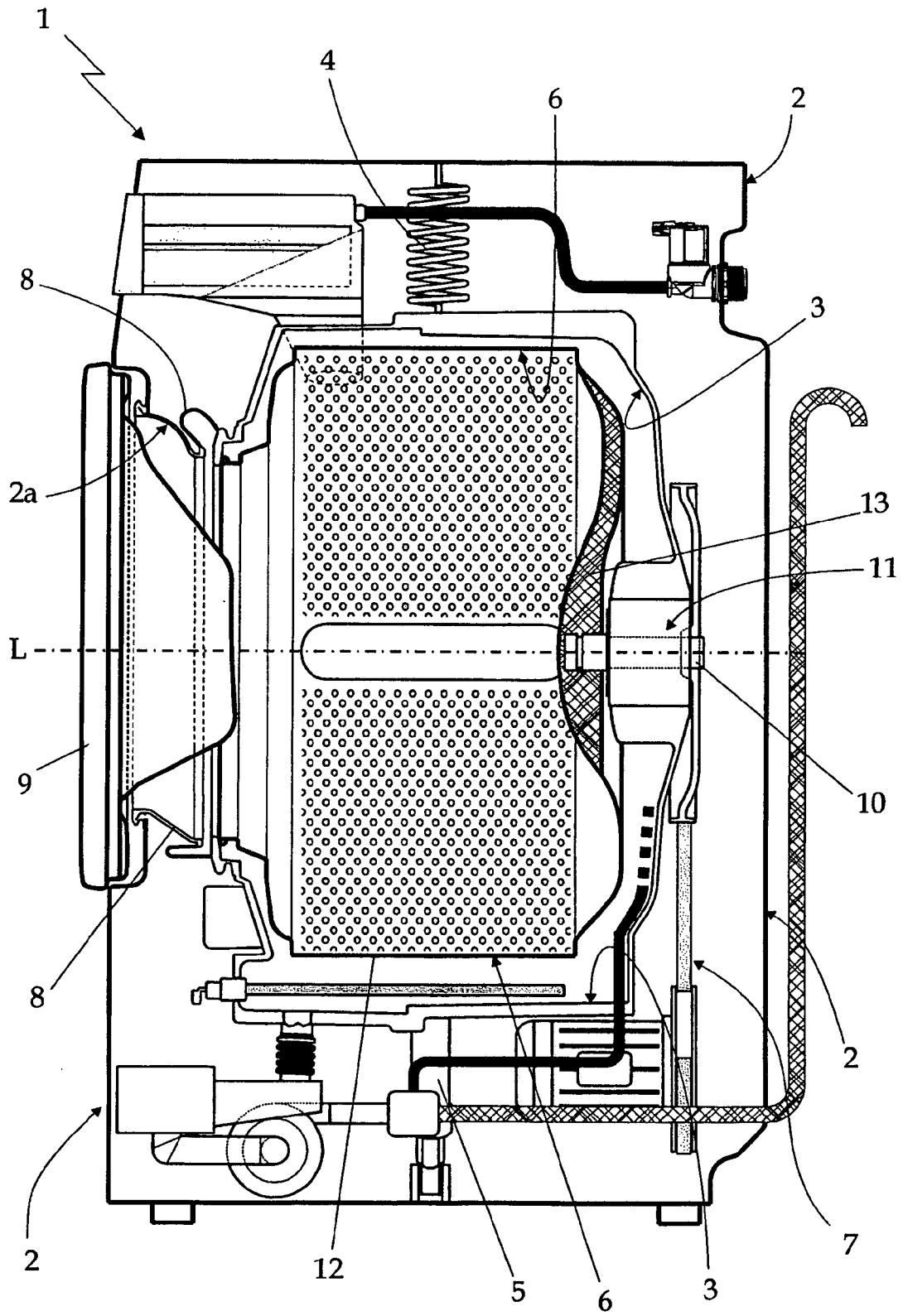


Fig. 1

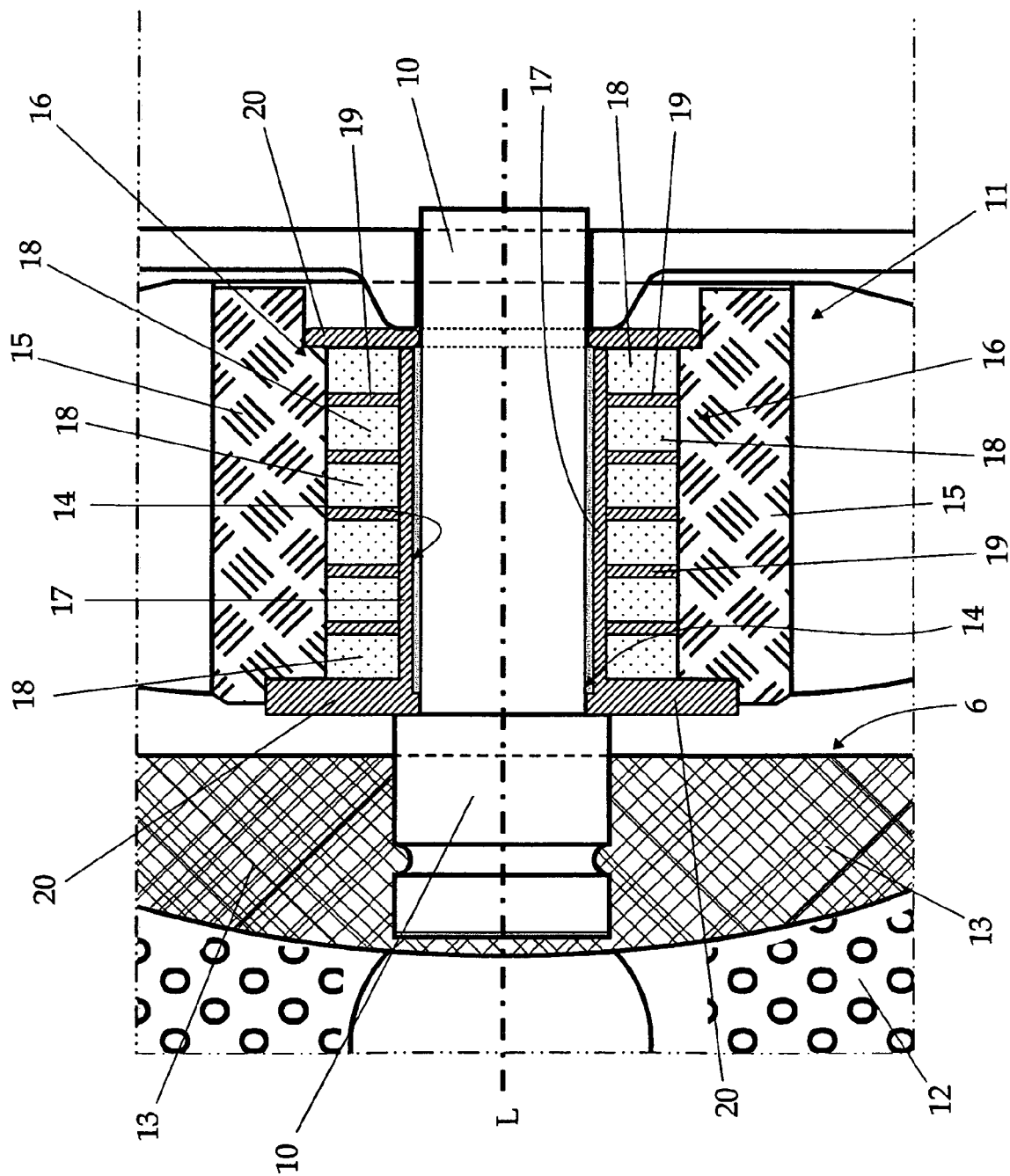


Fig. 2

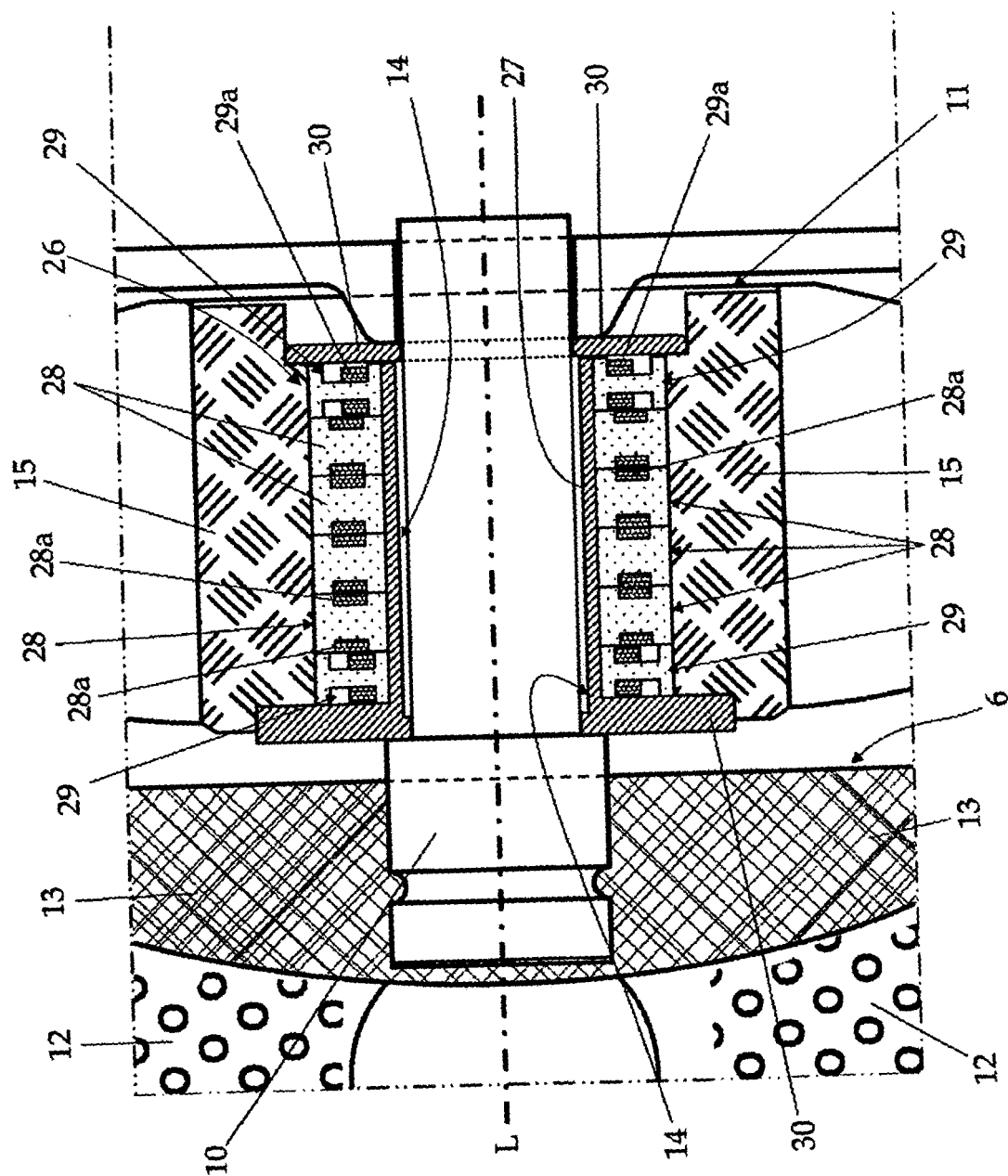


Fig. 3

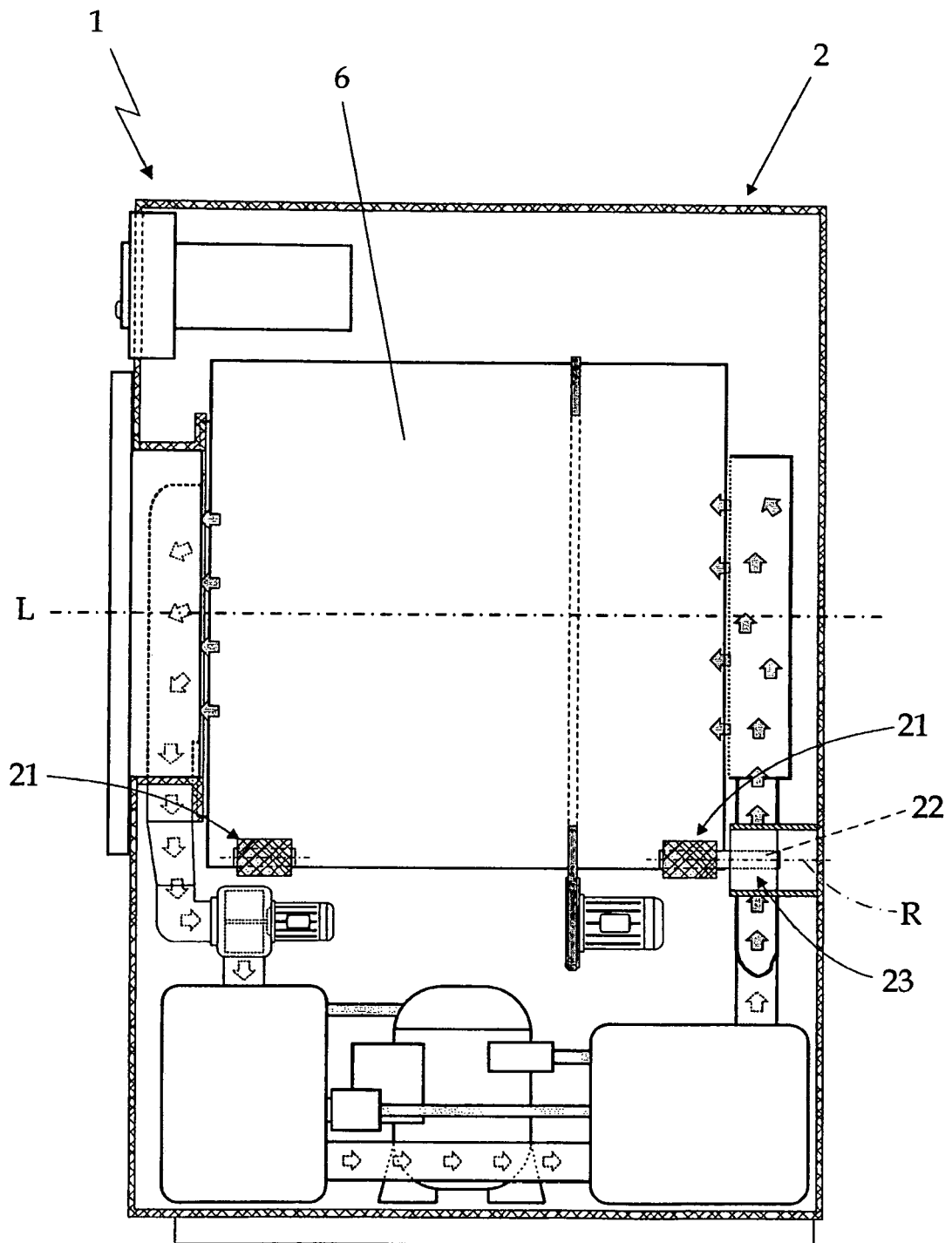


Fig. 4