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(54) **Household appliance**

(57) Household appliance (1) having a casing (2) subjected to vibrations, and a vibration damper (9) fixed to the casing (2) to reduce vibrations transmitted to latter; the vibration damper (9) comprising a supporting frame (10) rigidly fixed to the appliance casing (2), at least a first magnet (11, 11') rigidly fitted to the supporting frame (10), and at least a second magnet (12, 18, 12') fitted in sliding manner to the supporting frame (10), so as to have one of its magnetic poles faced to one of the magnetic poles of the first magnet (11) for allowing the magnetic field of the second magnet (12, 18, 12') to interact with the magnetic field of the first magnet (11, 11'); the first magnet (11, 11') or the second magnet (12, 18, 12') being an electromagnet (12, 12', 18), and the vibration damper (9) also comprising an electric power unit (13) capable to power the induction coil (17, 20) of the electromagnet (12, 12', 18) with an alternate current so as to cause reciprocating movement of the second magnet (12, 18, 12') along the supporting frame (10), and a central control unit (15) which controls the electric power unit (13) and is capable to determine, instant by instant, the frequency of the alternate current to be supplied to the induction coil (17, 20) of said electromagnet (12, 12', 18) for producing mechanical vibrations almost in phase-opposition with respect to the mechanical vibrations of the appliance casing (2), so as to reduce the amplitude of the mechanical vibrations of said casing (2).

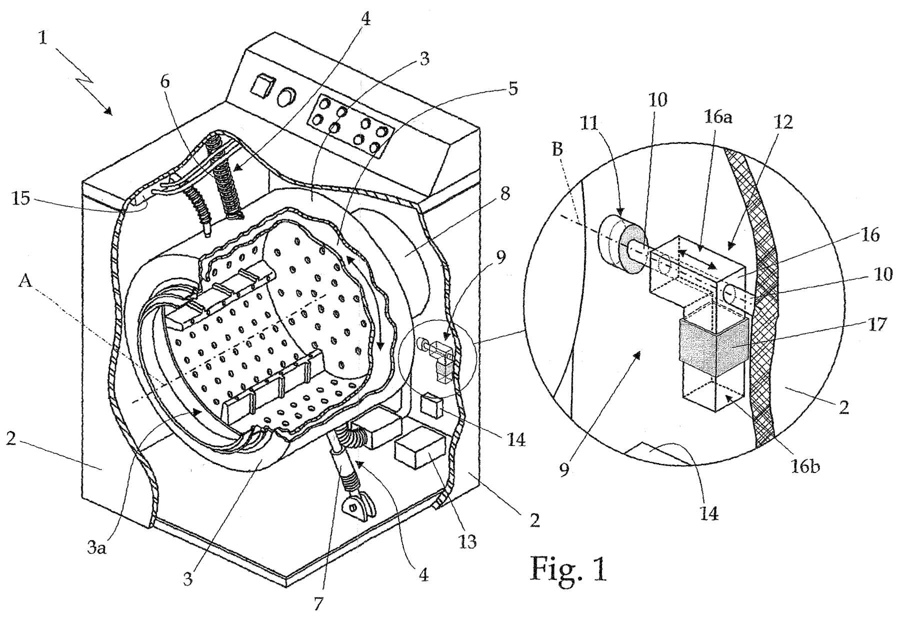

Fig. 1

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Description

[0001] The present invention relates to a household appliance.

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

[0003] As is known, high-speed rotation of the revolving drum of the washing machine produces severe machine vibrations which are transferred to the casing of the washing machine, and which normally become much more problematic as the speed of the revolving drums increases.

[0004] To reduce machine vibrations, in today's laundry washing machines the entire washing assembly (i.e. the washing tub and the revolving drum mounted in axially rotating manner inside the washing tub) is normally suspended in floating manner into the machine casing via a system of springs and dampers designed to absorb the vibrations before they reach the casing.

[0005] In particular installation conditions, however, the floating suspension system fails to sufficiently reduce machine vibrations reaching the casing, so that the washing machine becomes noisy. For example, when a washing machine rests on a flexible floor, such as a wooden floor, a soft floor, or a floor resting on a thin slab, the vibrations generated by the revolving drum during the spin cycle may be resonance-amplified to an unacceptable noise level, and may damage not only the washing machine but also the floor.

[0006] To overcame this drawback today's high-end washing machines are also provided with a vibration damper fixed to the casing to reduce vibrations of the washing machine at resonance speeds, and which comprises an oscillating mass and a number of coil springs connecting the oscillating mass to the washing machine casing. The oscillating mass and the coil spring system are properly dimensioned to vibrate, during rotation of the drum, in phase-opposition with respect to vibrations transmitted to the casing by the floating suspension system, thus reducing the amplitude of the casing vibrations.

[0007] Unfortunately the above cited vibration dampers - traditionally known as "Frahm dampers" - only provide for optimum dumping performance over a limited range of the possible drum rotation speeds, i.e. over a limited range of the possible vibration frequencies.

[0008] Moreover, the drum rotation speeds at which resonance phenomena take place also depend on the unevenly distribution of the laundry on the lateral wall of the revolving drum, and on the installation conditions (for example on the type of floor upon which the washing machine rests). Thus resonance phenomena vary from one washing machine to another and from one installation place to another, and it is therefore practically impossible to precisely determine, at manufacturing stage, the frequencies at which to tune up the "Frahm damper".

[0009] Accordingly, in known washing machines with tuned vibration dampers, performance of the dampers is not always entirely satisfactory and is invariably below expectations.

[0010] It is an object of the present invention to provide a vibration damper offering optimum performance over the full range of the possible drum rotation speeds, regardless of laundry distribution into the drum and of the installation place.

[0011] According to the present invention, there is provided a household appliance as claimed in the accompanying Claims.

[0012] 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 perspective view, with parts in section and parts removed for clarity, of a laundry washing machine with a vibration damper in accordance with the teachings of the present invention;
- Figure 2 shows a schematic front view of a second embodiment of the vibration damper of Figure 1 washing machine; and
- Figure 3 shows a schematic front view of a third embodiment of the vibration damper of Figure 1 washing machine.

[0013] With reference to Figure 1, Number 1 indicates as a whole a household appliance comprising a casing 2 which is liable to severe machine vibrations during functioning.

[0014] In particular, in the example shown household appliance 1 is a laundry washing machine 1 comprising a parallelepiped-shaped outer box casing 2 resting on the floor; a cylindrical washing tub 3 which is connected in floating manner to casing 2 by a suspension system 4; and a revolving drum 5 for housing the laundry to be washed, and which is fitted in rotary manner inside washing tub 3.

[0015] More specifically, in the example shown washing tub 3 is provided with a front opening 3a faced to a corresponding laundry loading and unloading opening (not shown) which is formed in the front face of casing 2 and is selectively closable by a door (not shown) hinged to casing 2; whereas revolving drum 5 is mounted in axially rotating manner inside washing tub 3 about a horizontal rotation axis A.

[0016] As regards suspension system 4, in the example shown it consists of a number of coil springs 6 (only one shown in Figure 1) connecting the washing tub 3 to the upper portion of casing 2, combined with one or more dampers 7.

[0017] With reference to Figure 1, washing machine 1 also comprises an electric motor 8 which is mechanically connected to drum 5 so as to rotate, on command, drum 5 about its longitudinal rotation axis A inside washing tub 3.

[0018] Washing tub 3, revolving drum 5, and the other washing machine component parts suspended from casing 2 via suspension system 4 form the washing assembly of the washing machine.

[0019] With reference to Figure 1, household appliance 1, i.e. washing machine 1 also comprises a vibration damper 9 which is fixed to casing 2 to reduce vibrations transmitted to casing 2 by suspension system 4 as revolving drum 5 rotates.

[0020] More specifically, vibration damper 9 is fixed inside casing 2 and comprises a supporting bar 10 rigidly fixed to casing 2 and extending parallel to a horizontal reference axis B which is preferably, though not necessarily, perpendicular to rotation axis A of drum 5; a first permanent-, or electro- magnet 11 which generates a constant magnetic field and is rigidly fitted to supporting bar 10 with its magnetic poles aligned with reference axis B; and a second electromagnet 12 fitted in sliding manner to supporting bar 10 so as that one of its two magnetic poles is directly faced to one of the magnetic poles of magnet 11, thus allowing the magnetic field of electromagnet 12 to interact with the magnetic field of magnet 11.

[0021] With reference to figure 1, vibration damper 9 also comprises an electric power unit 13 which is capable to power the induction coil of electromagnet 12 with a variable-frequency alternate current, so that electromagnet 12 generates a variable magnetic field which, interacting with the magnetic field generated by magnet 11, causes a reciprocating movement of electromagnet 12 along supporting bar 10. Magnetic poles having the same magnetic polarity, in fact, tend to push away one from the other, whereas magnetic poles having opposite magnetic polarity tend to attract one to the other.

[0022] Obviously the reciprocating movement of electromagnet 12 along supporting bar 10 causes mechanical vibration which are transmitted to casing 2. The frequency of said mechanical vibrations depends on the frequency of the alternate current supplied to the induction coil of electromagnet 12.

[0023] With reference to figure 1, vibration damper 9 finally comprises an accelerometer 14 or similar sensor capable of determine, instant by instant, the amplitude and frequency spectrum of casing 2 vibrations; and an electronic central control unit 15 which receives the signals from sensor 14 and is capable to determine, instant by instant, the appropriate frequency of the alternate current to be supplied to electromagnet 12 for producing mechanical vibrations in phase-opposition with respect to the mechanical vibrations transmitted to casing 2 via suspension system 4, so as to reduce casing 2 vibrations amplitude in the whole range of the possible rotation speeds of revolving drum 5.

[0024] More specifically, electronic central control unit 15 of vibration damper 9 controls electric power unit 13 for tuning up, instant by instant, the maximum value and frequency of the alternate current supplied to electromagnet 12 according to the actual amplitude and frequency spectrum of casing 2 vibration, for performing a selective damping of casing 2 vibrations while revolving drum 5 is rotating at any speed causing dangerous resonance phenomena and/or causing excessive noise.

[0025] With reference to Figure 1, in the example shown magnet 11 consists of cylindrical-shaped permanent magnet extending coaxial to reference axis B of supporting bar 10, and having its magnetic north pole directly faced to electromagnet 12, whereas electromagnet 12 consists of an upside down L-shaped metallic body 16 having preferably, though not necessarily, ferromagnetic characteristics, and which has its horizontal upper portion 16a fitted in sliding manner to supporting bar 10; and of an induction coil 17 of electrically conducting material, which is rigidly fitted to the vertical lower portion 16b of metallic body 16 so as to generate, when supplied with electric current, a magnetic field which creates on metallic body 16 a magnetic north pole and a magnetic south poles.

[0026] Electric power unit 13 of vibration damper 9 powers induction coil 17 of electromagnet 12 with a variable-frequency alternate current, so that the magnetic north and south poles on metallic body 16 shift their position in synchrony with the alternate current.

[0027] Operation of laundry washing machine 1 and vibration damper 9 can be deduced from the foregoing description with no further explanation required, except to state that vibration damper 9 is able to reduce vibrations amplitude over the whole range of the possible rotation speeds of revolving drum 5. Moreover, being able to tune up the mechanical vibrations of electromagnet 12 with respect to any possible resonant frequency of the washing machine structure, vibration damper 9 eliminates all resonance phenomena.

[0028] The use of vibration damper 9, as described above, has therefore numerous advantages: stability and silenceness of the landry washing machine 1 is strongly increased at any possible rotation speed of revolving drum 5. In fact, contrary to conventional currently used Frahm dampers (i.e. comprising a small oscillating mass and a number of coil springs) which work fine in a limited frequency range of casing 2 vibrations, operativeness of vibration damper 9 extends to all possible frequencies of casing 2 vibrations.

[0029] Clearly, changes may be made to vibration damper 9 as described herein without, however, departing from the scope of the present invention.

[0030] For example, with reference to Figure 2, according to an alternative embodiment vibration damper 9 may comprise a further electromagnet 18 which is fitted in sliding manner to supporting bar 10, on the opposite side of electromagnet 12 with respect to magnet 11, so as to be faced to the second magnetic pole of magnet 11. In other words, electromagnets 12 and 18 are located on opposite sides of magnet 11.

[0031] Likewise electromagnet 12, electromagnet 18 has one of its two magnetic poles directly faced to one of the magnetic poles of magnet 11 for allowing its magnetic field to interact with the magnetic field of magnet 11; and electric power unit 13 powers the induction coil of electromagnet 18 with a variable-frequency alternate current so that also electromagnet 18 generates a variable magnetic field which, interacting with the magnetic field generated by magnet 11, causes a reciprocating movement of electromagnet 18 along supporting bar 10.

[0032] In which embodiment, electronic central control unit 15 of vibration damper 9 may control electric power unit 13 for tuning up, instant by instant, the alternate current supplied to electromagnet 12 and the alternate current supplied to electromagnet 18 independently one from the other.

[0033] If the alternate current supplied to electromagnet 12 is equal to the alternate current supplied to electromagnet 18, electromagnet 18 moves in synchrony with electromagnet 12 thus the seismic mass is doubled and the amplitude of the mechanical vibrations generated by vibration damper 9 is doubled.

[0034] If the alternate current supplied to electromagnet 12 differs from the alternate current supplied to electromagnet 18, vibration damper 9 generates two mechanical vibrations having two different frequencies, thus allowing a much more accurate dumping of the vibrations transmitted to casing 2 via suspension system 4.

[0035] With reference to Figure 3, in a still further embodiment vibration damper 9 may comprise two supporting bars 10 and 10' which are rigidly fixed to casing 2 one parallel to the other, and each of which extends parallel to a respective horizontal reference axis B, B' which is preferably, though not necessarily, perpendicular to rotation axis A of drum 5; two permanent-, or electro- magnets 11 and 11', each of which generates a constant magnetic field and is rigidly fitted to a respective supporting bar 10 or 10' with its two magnetic poles aligned with reference axis B, B' of the bar; and two electromagnets 12 and 12' fitted in sliding manner to supporting bars 10 and 10' on opposite sides of both magnets 11 and 11', so as that each electromagnet 12, 12' has its two magnetic poles directly faced each to a respective magnetic pole of a different magnet 11, 11', thus allowing the magnetic field of both electromagnets 12 and 12' to interact with the magnetic field of both magnets 11 and 11'.

[0036] More specifically, in the example shown supporting bars 10 and 10' lie, one above the other, on a common vertical plane which is perpendicular to rotation axis A of drum 5, whereas the two permanent-, or electromagnets 11 and 11' are rigidly fixed to supporting bars 10 and 10' vertically aligned one above the other with a specular orientation of the magnetic poles.

[0037] As regards the two electromagnets 12 and 12', each of them consists of a preferably, though not necessarily, ferromagnetic C-shaped metallic body 19 having each of its two end-portions 19a fitted in sliding manner to a respective supporting bar 10, 10', so as to be directly faced to a corresponding permanent-, or electro- magnet 11 or 11'; and of an induction coil 20 of electrically conducting material, which is rigidly fitted to the central portion 19b of metallic body 16 so as to generate, when supplied with electric current, a magnetic field which creates on metallic body 16 a magnetic north pole and a magnetic south pole.

[0038] Also in this embodiment, electric power unit 13 powers the induction coil 20 of each electromagnet 12, 12' with a specific variable-frequency alternate current, so that each electromagnet 12, 12' generates a corresponding variable magnetic field which, interacting with the magnetic fields generated by both magnets 11 and 11', causes a reciprocating movement of the electromagnet 12, 12' along both supporting bars 10 and 10'; whereas electronic central control unit 15 controls electric power unit 13 for tuning up, instant by instant, the alternate current supplied to each of the two electromagnets 12 and 12'.

[0039] If powered with the same alternate current, the two electromagnets 12 and 12' move in synchrony along supporting bars 10 and 10', doubling the seismic mass and, thus, the amplitude of the mechanical vibrations generated by vibration damper.

[0040] If powered with different alternate currents, the two electromagnets 12 and 12' reciprocate along supporting bars 10 and 10' at different frequencies, thus allowing vibration damper 9 to generate two different mechanical vibrations.

[0041] Finally, according to an alternative structure of vibration damper 9, electromagnet/s 12, 12' and 18 may be rigidly fixed to supporting bar/s 10, 10', while permanent-, or electro- magnet/s 11 and 11' may be fitted in sliding manner to supporting bar/s 10 and 10'.

Claims

1. Household appliance (1) comprising a casing (2) subjected to vibrations, and a vibration damper (9) fixed to said casing (2) to reduce casing vibrations; the household appliance(1) being **characterized in that** said vibration damper (9) comprises:

    - a supporting frame (10) rigidly fixed to the appliance casing (2);
    - at least a first magnet (11, 11'; 12, 18, 12') rigidly fitted to the supporting frame (10), and
    - at least a second magnet (12, 18, 12'; 11, 11') fitted in sliding manner to said supporting frame (10) so as to have one of its magnetic poles faced to one of the magnetic poles of the first magnet (11) for allowing the magnetic field of said second magnet (12, 18, 12'; 11, 11') to interact with the magnetic field of said first magnet (11, 11'; 12, 18, 12'); the first magnet (11, 11'; 12, 18, 12') or the second magnet (12, 18, 12'; 11, 11') being an electromagnet (12, 12', 18), and the vibration damper (9) also comprising:
    - electric power means (13) capable to power the induction coil (17, 20) of said electromagnet (12, 12', 18) with an alternate current so as to cause reciprocating movement of the second magnet (12, 18, 12'; 11, 11') along said support-

ing frame (10), and
- a central control unit (15) which controls the electric power means (13) and is capable to determine, instant by instant, the frequency of the alternate current to be supplied to the induction coil (17, 20) of said electromagnet (12, 12', 18) for producing mechanical vibrations almost in phase-opposition with respect to the mechanical vibrations of the appliance casing (2).

2. Household appliance as claimed in Claim 1, **characterized by** also comprising detecting means (14) capable to determine, instant by instant, the amplitude and frequency spectrum of the mechanical vibrations of the appliance casing (2); the central control unit (15) being connected to said detecting means (14), and being able to determine the frequency of the alternate current to be supplied to the induction coil (17, 20) of said electromagnet (12, 12', 18) on the basis of the amplitude and frequency spectrum of said mechanical vibrations.

3. Household appliance as claimed in any of the foregoing Claims, **characterized in that** the first magnet (11, 11'; 12, 18, 12') or the second magnet (12, 18, 12'; 11, 11') not being an electromagnet (12, 12', 18) is a permanent-magnet (11, 11').

4. Household appliance as claimed in any one of the foregoing Claims, **characterized in that** said second magnet (12, 18, 12'; 11, 11') is able to reciprocate on said supporting frame (10) along an substantially horizontal reference axis (B).

5. Household appliance as claimed in any one of the foregoing Claims, **characterized in that** said vibration damper (9) comprises a couple of second magnets (12, 18, 12'; 11, 11') fitted in sliding manner to said supporting frame (10) on opposite sides of said first magnet (11, 11'; 12, 18, 12').

6. Household appliance as claimed in Claim 5, **characterized in that** said vibration damper (9) comprises a couple of first magnets (11, 11'; 12, 18, 12') located between said second magnets (12, 18, 12'; 11, 11'); each of said first magnets (11, 11'; 12, 18, 12') being faced to one of the two magnetic poles of each second magnet (12, 18, 12'; 11, 11').

7. Household appliance as claimed in any one of Claims 1 to 4, **characterized in that** said vibration damper (9) comprises a couple of first magnets (11, 11'; 12, 18, 12') fixed to said supporting frame (10) on opposite sides of said second magnet (12, 18, 12'; 11, 11').

8. Household appliance as claimed in any one of the foregoing Claims, **characterized in that** said vibration damper (9) is fixed inside of said casing (2).

9. Household applianceas claimed in any one of the foregoing Claims, **characterized in that** it is a laundry washing machine (1).

10. Household appliance as claimed in Claims 9 and 4, **characterized in that** said washing machine (1) comprises a revolving drum (5) for housing the laundry to be washed, and which is fitted in rotary manner inside the casing (2) about a given rotation axis (A); the reference axis (B) along which the second magnet (12, 18, 12'; 11, 11') reciprocates, being substantially perpendicular to said rotation axis (A).

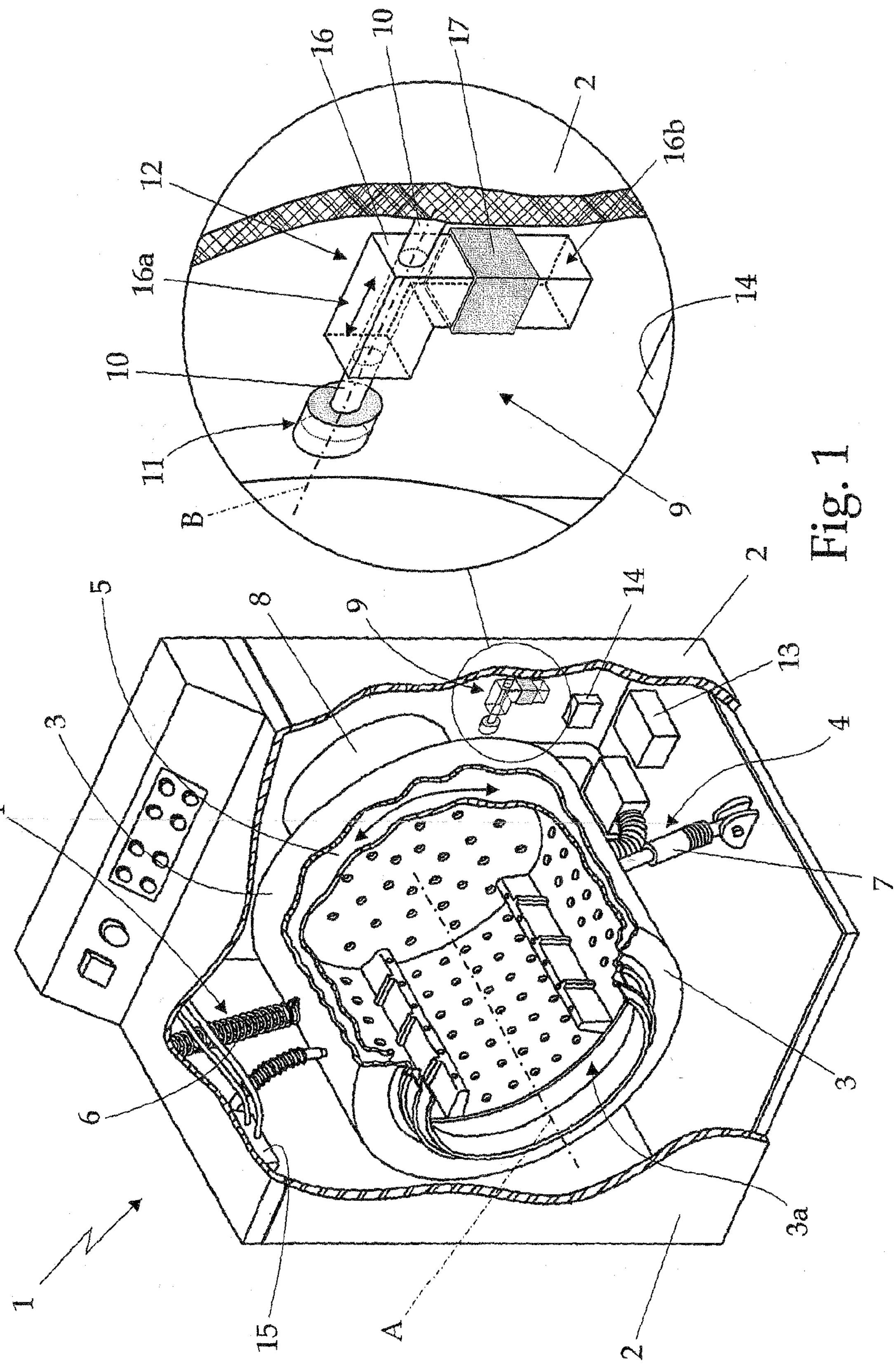

Fig. 1

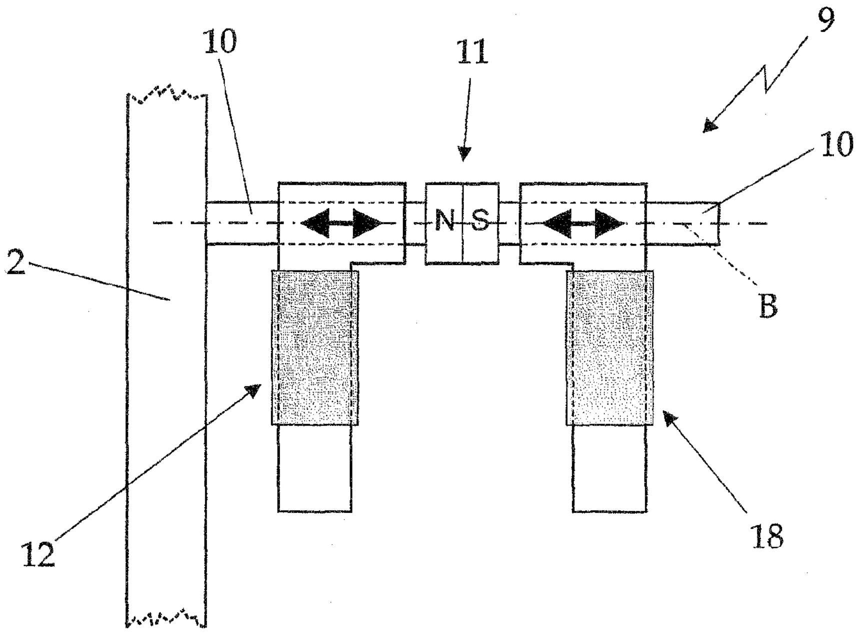
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Fig. 2

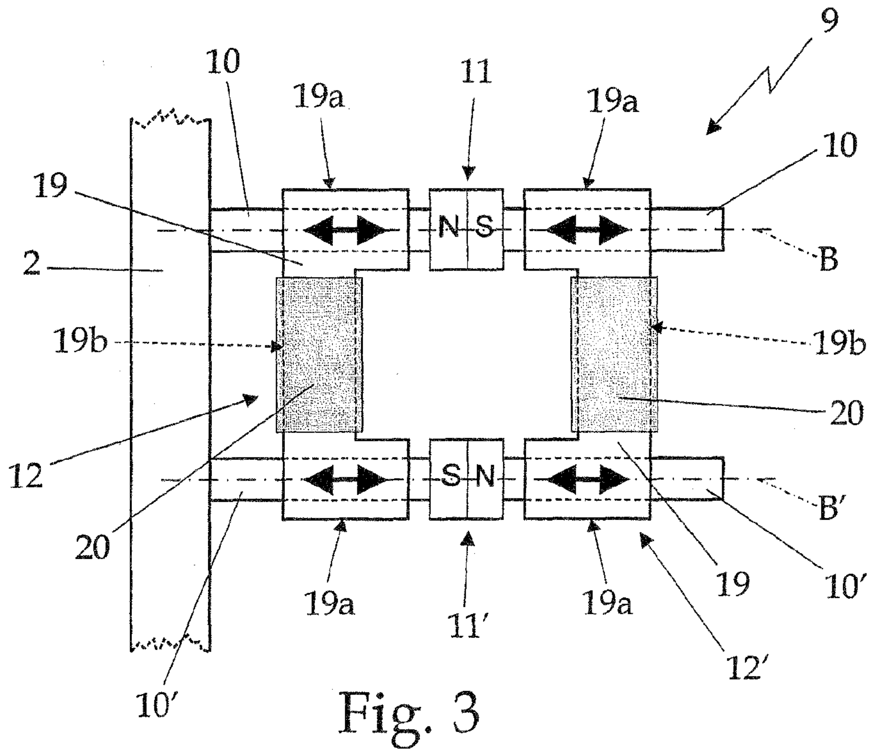
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Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 07 12 1046

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 2002/050671 A1 (FUJITA ETSUNORI [JP] ET AL) 2 May 2002 (2002-05-02) * paragraph [0010] - paragraph [0024]; figure 1 * -----	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 April 2008	Fachin, Fabiano

CATEGORY OF CITED DOCUMENTS

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