

(19)



(11)

EP 2 559 804 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

20.02.2013 Bulletin 2013/08

(51) Int Cl.:

D06F 58/20 (2006.01)

(21) Application number: **11382281.1**

(22) Date of filing: **18.08.2011**

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

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(54) Household appliance comprising a driving unit for a heat pump

(57) The invention relates to a household appliance 100, in particular dryer or washer-dryer, comprising a driving unit 101 for a heat pump circuit, in which the driving unit 101 is connected by a mechanical fastening device 103 to another component of the household appliance 100, in which the mechanical fastening device 103 comprises a first fixing member 105 fixed to the driving unit 101, a second fixing member 106 fixed to the other component of the household appliance 100, and an elas-

tic grommet 104 connecting the fixing members 105, 106 to each other. In addition, the invention relates to a method for operating a driving unit 101 in such a household appliance 100, wherein a driving speed, in particular a compressor rotating speed, is restricted to be below a predetermined vibration threshold value. Also, the invention relates to a method for operating a driving unit 101 in such a household appliance 100, wherein at least one speed band of the driving speed, in particular of a compressor speed, is excluded.

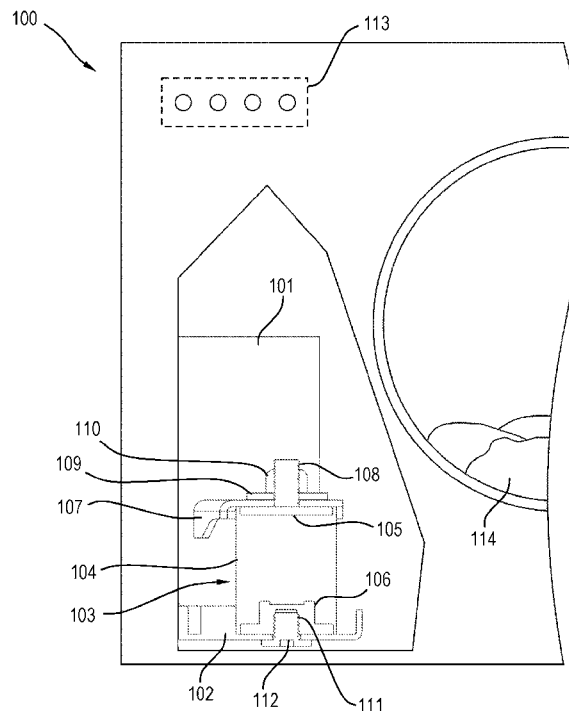


Fig.1

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Description

[0001] The invention relates to a household appliance comprising a driving unit for a heat pump, in which the driving unit is fastened by a mechanical fastening device. The invention also relates to methods for controlling such driving unit.

[0002] US 7,866,057 B2 discloses a domestic appliance for the care of washed articles. The appliance disclosed includes a heat pump having a compressor and a supplementary heat exchanger. Using a spring element the supplementary heat exchanger is pressed onto cooling elements to guarantee effective thermal coupling.

[0003] During operation of a piston-operated compressor that constitutes a driving unit for a heat pump in a domestic appliance, vibrations may occur at a rotating frequency or driving speed that is close or within a natural frequency of the appliance or a part thereof. A natural frequency is defined to be a frequency of vibration of the appliance or a part thereof where a vibrational resonance occurs. Such natural frequency may also depend on the fixation or connection of the compressor. This fixation is commonly achieved by using a continuous metal bolt that rigidly fastens the compressor to another component of the household appliance, for example to a bottom group made of molded plastic or sheet metal. The compressor may also exert a variable gas compression torque with low piston inertia. Both effects cause noise and vibration. To improve the noise and vibration caused by the occurrence of natural frequencies one may conduct a structural redesign of the compressor by using different geometry, weight and/or weight re-distribution, thereby directly influencing its moments of inertia. To improve the noise and vibration caused by the torque, the use of a (costly) twin piston rotary compressor or a variable torque input to the compressor from an inverter controller for compensation of the torque may be considered.

[0004] It is the **object** of present invention to overcome at least some of the disadvantages of the state of the art and to, in particular, provide a household appliance, in particular clothes drying device, having lower energy consumption and better rigidity achieved by reducing vibrational energy in a cost effective manner.

[0005] This object is achieved according to the invention by the features of the independent claims attached. Advantageous embodiments can be derived in particular from the dependent claims, as well as the subsequent description.

[0006] This object is achieved by a household appliance, comprising a driving unit for a heat pump, in which the driving unit is connected by a mechanical fastening connection or device to another component of the household appliance, and in which the mechanical fastening device comprises a first fixing member fixed to the driving unit, a second fixing member fixed to the other component of the household appliance, and an elastic grommet connecting the fixing members to each other.

[0007] Thus, a load from the driving unit to the other

component of the household appliance is in at least one section only transmitted by the elastic grommet. There is no continuous load transmission from the driving unit to the other component via a rigid or inelastic body (like a metal bolt). In other words, the driving unit is fixed to the household appliance free of rigid or inelastic fixing elements directly connecting the driving unit and the household appliance. Thereby a considerable degree of vibrational decoupling of the driving unit from other parts of the appliance is achieved.

[0008] This enables vastly reduced vibrations of the driving units and other parts of the appliance under at least some practically useful operating conditions. The reduced vibrations, in turn, yield lower energy consumption. In particular, a FRF (frequency response function) characteristic of the driving unit and its fixation can be altered by moving the occurrence of the natural frequencies to higher frequency. To a large extent, a vibration acceleration and displacement of driving unit and its transmission to other parts of the household appliance is reduced. Furthermore, the mechanical fastening device, in particular its grommet, is able to absorb and dissipate much of the vibrational energy.

[0009] Mechanical characteristics of the grommet, like its stiffness, that influence its response to dynamic loads like vibrations can easily be varied, e.g. by varying a form, a width, or a length, or a material composition.

[0010] Generally, the household appliance may be any household appliance. It is particularly advantageous that the household appliance is a cooling appliance, an air conditioner or a clothes conditioning appliance. In particular, the clothes conditioning device may be a clothes drying appliance, in particular a dryer or a washer-dryer. The clothes drying appliance may be a tumble dryer.

[0011] The household appliance in particular comprises a heat pump.

[0012] The "other part" of the household appliance may, e.g., be a frame, a mount, a bottom group, or an intermediate structural part of the household appliance (like a stiffening plate).

[0013] Generally, a "heat pump" may be any suitable heat recovery unit that utilises a driving unit for its operation.

[0014] It is a preferred embodiment that the elastic grommet is integrally formed with at least one of the fixing members. This provides a firm connection and allows an easy assembly. For example, the at least one of the fixing member and the grommet could be pressed into each other, could be connected by adhesive bonding, or by inserting one into a cavity or recess of the other. However, other connecting steps like inserting or screwing the fixing members into the grommet can provide a viable connection of the grommet and the fixing members, too.

[0015] According to a particularly preferred embodiment, the material of the elastic grommet is cast or moulded to at least one of the fixing members. This provides a particularly simple and reliable connection between the grommet and the at least one of the fixing members. The

casting or moulding may in particular be achieved by over-injection.

[0016] To provide good and steady fastening, the fixing members are preferably made from metal. Furthermore, metal can be fixed to the grommet in an easy, non-destructive manner.

[0017] It is another preferred embodiment that the elastic grommet is made from or comprises plastic, in particular from synthetic rubber but possibly also including natural rubber. For casting or moulding but also for resisting relatively high temperatures during an operation of the driving unit, the plastic may in particular be a thermostable plastic. The plastic may comprise one plastic (component) or several plastic components, in particular a plastic compound.

[0018] It is even another preferred embodiment that the elastic grommet is made with, and in particular from, heat resistant material, in particular thermoplastic material. In particular, the material should resist temperatures up to 90 °C or 100 °C. Thermoplastic material is particularly useful for casting or moulding.

[0019] It is yet another preferred embodiment that at least one of the fixing members comprises a threaded pin and/or at least one of the fixing members comprises a threaded hole. This allows for an easy and secure assembly and disassembly. It is one particularly preferred embodiment that one of the fixing members comprises a threaded pin and the other one of the fixing members comprises a threaded hole. This enables an anti-skewing protection of the mechanical fastening device. In particular, the first fixing member may comprise the threaded pin while the second fixing member comprises the threaded hole. This allows for the fixing members to act as feet of the drive unit without being damaged.

[0020] However, other fastening solutions like a bayonet nut connector or fixing by soldering, brazing, or welding are also possible.

[0021] In particular, the fixing members may comprise a disc-like base. From the disc-like base the threaded pin may protrude or the disc-like base may comprise the threaded hole. The disc-like base (that may have a circular, three-sided, four-sided etc. basic shape) may be easily formed by casting.

[0022] The grommet may in particular be formed cylindrical or cuboidal; it may be formed as a solid body or may have recesses, hollows or other cavities. It is a preferred embodiment that the grommet comprises recesses in different faces, in particular in opposite faces, for receiving a respective fixing member, in particular for receiving a disc-like base of a respective fixing member.

[0023] It is yet another preferred embodiment that the driving unit is fixed to the household appliance via two or more, in particular three, such elastic grommets. This allows for a safe and precise seat of the driving unit.

[0024] At least two of the elastic grommets may be integrally formed with an intermediate structural part. Such intermediate structural part forms one first or second fixing member instead of a plurality of either first or

second fixing members reducing the number of parts and reducing the effort when mounting the driving unit to the household appliance.

[0025] It is another advantageous and preferred embodiment that the driving unit is a compressor of the heat pump. The use of a compressor allows the use of widely available, effective heat pumps. The use of a BLDC (BrushLess Direct Current) or PMR (Permanent Magnet Rotor) compressor is particularly advantageous. Alternatively, the driving unit may be a driving unit of a Vuilleumier-style heat pump or Vuilleumier circuit. In another alternative, the driving unit may be a driving unit of a Stirling-style heat pump or Stirling circuit.

[0026] It is even another preferred embodiment that a control circuit is arranged to limit a driving speed of the driving unit to a value below a maximum value that corresponds to a predetermined vibration threshold value. This makes use of the fact that now, with these mechanical fastening devices, significant vibrational amplitudes may occur at higher frequencies or driving speeds. Such a limitation of the driving speed avoids these significant vibrational amplitudes without a practical disadvantage since lower driving speeds are preferred for lowering energy consumption. It is a particularly preferred and advantageous embodiment that the maximum value that corresponds to a predetermined vibration threshold value lays within a range from 23 Hz to 35 Hz.

[0027] The object is also achieved by a method for operating a driving unit in a household appliance as described above, wherein a driving speed, in particular a compressor rotating speed, is restricted to be below a predetermined vibration threshold value, in particular to a maximum value that corresponds to a predetermined vibration threshold value within a range from 23 Hz to 35 Hz. This method achieves the same advantages as the household appliance described above and may be arranged in an analogous fashion. This is particularly easy to implement using a variable speed driving unit like e.g. a variable speed compressor (e.g. a BLDC or PMR compressor) which may be controlled or loop-controlled.

[0028] The object is further achieved by a method for operating a driving unit in a household appliance as described above, wherein at least one speed band of the driving speed, in particular of the compressor speed, is excluded.

[0029] The vibration threshold value and the at least one speed band may depend, e.g., on the grommet stiffness. This is based, inter alia, on the effect that a frequency response function characteristic and natural frequencies are moved to higher values with increasing grommet stiffness.

[0030] The following figures show a preferred embodiment that describes the invention in a schematic fashion.

Fig. 1 shows side view of a household appliance comprising a driving unit for a heat pump circuit, in which the driving unit is connected by a mechanical fastening device to another component of

the household appliance,

Fig.2 shows in perspective view an intermediate structural part forming such other component of the household appliance, carrying three mechanical fastening devices,

Fig.3 shows a side view of Fig. 2 in partly cut view, and

Fig.4 shows components of Fig. 2 and such driving unit mounted thereon.

[0031] Fig.1 shows a partially cut-out household appliance 100 in form of a front loaded tumble dryer or washer-dryer designed for at least drying clothes 114. The household appliance 100 internally comprises a driving unit 101, in particular a compressor, for a heat pump or heat pump circuit.

[0032] At its outside, the driving unit 101 comprises fastening members 107 to be connected, via a mechanical fastening device 103, to another component of the household appliance 100 like e.g. a frame or body component of the household appliance 100. According to the shown preferred embodiment, this other component of the household appliance 100 is a stiffening plate 102.

[0033] The mechanical fastening device 103 comprises a first fixing member 105 fixed to the fastening members 107 of the driving unit 101, a second fixing member 106 fixed to the stiffening plate 102, and an elastic grommet 104 connecting the fixing members 105, 106 to each other and holding them together. In particular, the mechanical fastening devices 103 may act as feet of the driving unit 101.

[0034] The first fixing member 105 comprises a threaded pin 108 centrally extending from a disc-shaped base element in an upside direction. The threaded pin 108 extends through a through hole of the fastening member 107 protruding from the driving unit 101 and through a washer 109. A nut 110 is screwed to the threaded pin 108 protruding out of the washer 109 to fasten the first fixing member 105 to the driving unit 101.

[0035] The second fixing member 106 comprises a screw hole 111 that opens to its bottom. A screw 112 extends through a through hole of the intermediate structural part 102 and is screwed into the threaded hole 111 of the second fixing member 106 to fasten the second fixing member 106 to the intermediate structural part 102. Thus, the driving unit 101 is fixed to the household appliance 100 free of rigid or inelastic fixing elements directly connecting the driving unit 101 and the household appliance 100.

[0036] The elastic grommet 104 is integrally formed with the fixing members 105, 106 to connect and hold one fixing member 105 to the other fixing member 106 and to connect the driving unit 101 to the intermediate structural part 102 of the household appliance 100. In particular, the material of the elastic grommet 104 is cast or moulded to the fixing members 105, 106 by over-in-

jection of a thermo-stable compound made from synthetic material, in particular rubber.

[0037] Such household appliance 100 usually comprises a control circuit 113, which is arranged to control a driving speed of the driving unit 101 among other functions. According to a method for operating the driving unit 101, a control unit 113 limits a maximum driving speed of the driving unit 101 to a value below a maximum value that corresponds to a predetermined vibration threshold value. This method or another method for operating the driving unit 101 may set at least one speed band exclusion of the driving speed.

[0038] Fig.2 shows that the driving unit 101 is fixed to the stiffening plate 102 via three such mechanical fastening devices 103 thus reducing the number of components to be handled during insertion of the driving unit 101 into the household appliance 100. Optionally, the elastic grommets 104 could be integrally formed at the intermediate structural part 102. The stiffening plate 102 has a basically triangular shape wherein a respective fastening device 103 is fastened in each corner. This arrangement allows a high stability and offers excellent vibration reduction.

[0039] Fig.3 shows a side view of Fig. 2 with the fastening device 103 displayed to the left shown in a sectional view.

[0040] Fig.4 shows a perspective view of a section view of the household appliance 100 showing two fastening devices 103.

[0041] The present invention is not restricted to the embodiment shown. Modifications of components and functions can be done without leaving scope of protection, e.g. under consideration of the specification in total and the claims.

[0042] The mechanical fastening device described can be used for all kinds of driving units, in particular compressors. Regarding compressors, the mechanical fastening device can be used for all types of compressors and is not restricted to rotary compressors of piston-type compressors.

List of Reference Numerals

[0043]

100	household appliance
101	driving unit
102	stiffening plate
103	mechanical fastening device
104	elastic grommet
105	first fixing member
106	second fixing member

- 107 fastening member protruding from driving unit
- 108 threaded pin
- 109 washer
- 110 nut
- 111 threaded hole
- 112 screw
- 113 control unit
- 114 clothes

preceding claims, wherein the driving unit (101) is fixed to the household appliance (100) via two or more, in particular three, fastening devices (103).

- 5 8. Household appliance (100) according to any of the preceding claims, wherein at least two of the elastic grommets (104) are integrally formed to an intermediate structural part (102).
- 10 9. Household appliance (100) according to any of the preceding claims, wherein the driving unit (101) is a compressor.
- 15 10. Household appliance (100) according to any of the preceding claims, wherein a control circuit (113) is arranged to limit a driving speed of the driving unit (101) below a maximum value that corresponds to a predetermined vibration threshold value.

Claims

- 1. Household appliance (100), in particular clothes conditioning device, comprising a driving unit (101) for a heat pump circuit, in which the driving unit (101) is connected by a mechanical fastening device (103) to another component of the household appliance (100),
wherein the mechanical fastening device (103) comprises a first fixing member (105) fixed to the driving unit (101), a second fixing member (106) fixed to the other component of the household appliance (100), and an elastic grommet (104) connecting the fixing members (105; 106) to each other. 20
- 2. Household appliance (100) according to claim 1, wherein the elastic grommet (104) is integrally formed with at least one of the fixing members (105; 106). 25
- 3. Household appliance (100) according to claim 2, wherein a material of the elastic grommet (104) is moulded to the at least one of the fixing members (105; 106). 30
- 4. Household appliance (100) according to any of the preceding claims, wherein a material of the elastic grommet (104) comprises plastic. 35
- 5. Household appliance (100) according to claim 4, wherein the material of the elastic grommet (104) comprises a heat resistant material, in particular thermoplastic material. 40
- 6. Household appliance (100) according to any of the preceding claims, wherein at least one of the fixing members (105; 106) comprises a threaded pin (108) and/or wherein at least one of the fixing members (105; 106) comprises a threaded hole (111). 45
- 7. Household appliance (100) according to any of the preceding claims, wherein the driving unit (101) is fixed to the household appliance (100) via two or more, in particular three, fastening devices (103). 50
- 8. Household appliance (100) according to any of the preceding claims, wherein at least two of the elastic grommets (104) are integrally formed to an intermediate structural part (102). 55
- 9. Household appliance (100) according to any of the preceding claims, wherein the driving unit (101) is a compressor.
- 10. Household appliance (100) according to any of the preceding claims, wherein a control circuit (113) is arranged to limit a driving speed of the driving unit (101) below a maximum value that corresponds to a predetermined vibration threshold value.
- 11. Method for operating a driving unit (101) in a household appliance (100) according to any of the preceding claims, wherein a driving speed, in particular a compressor rotating speed, is restricted to be below a predetermined vibration threshold value.
- 12. Method for operating a driving unit (101) in a household appliance (100) according to any of claims 1 to 10, or to the method according to claim 14, wherein at least one speed band of the driving speed, in particular of compressor speed, is excluded.

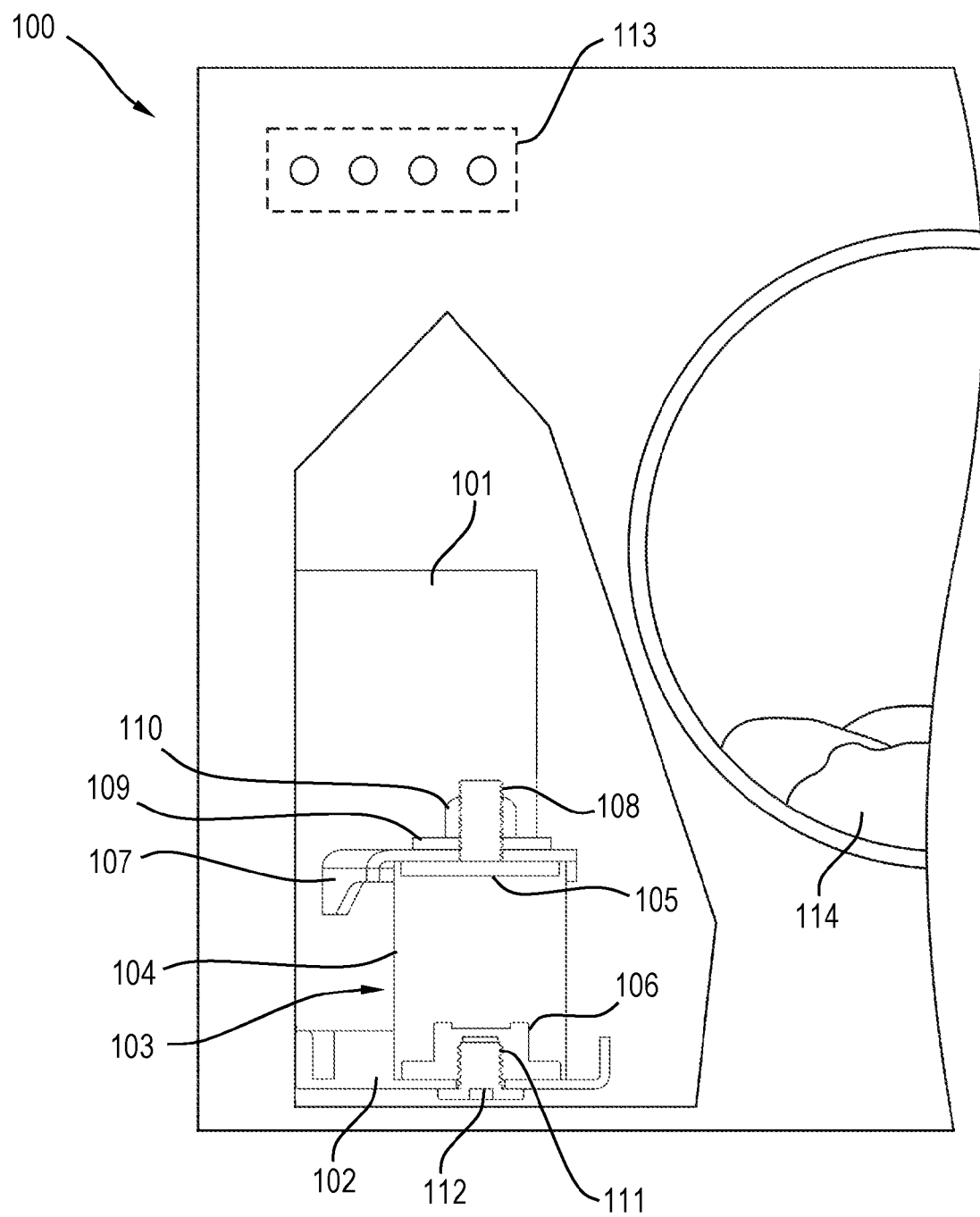


Fig.1

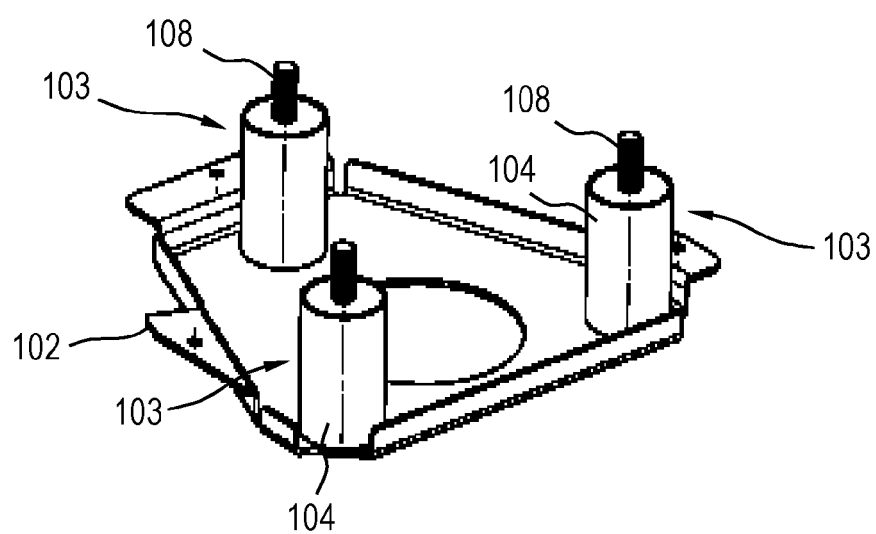


Fig.2

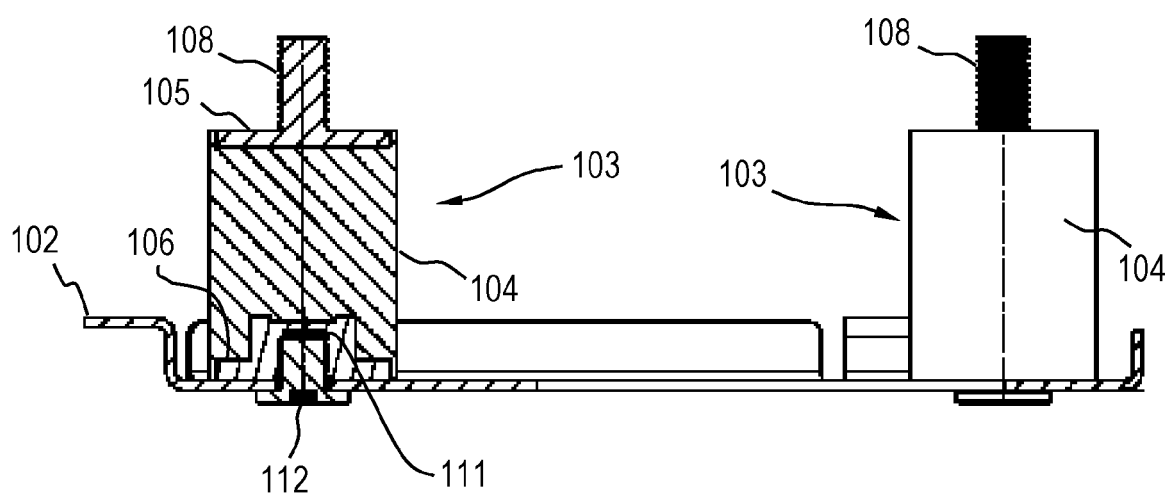


Fig.3

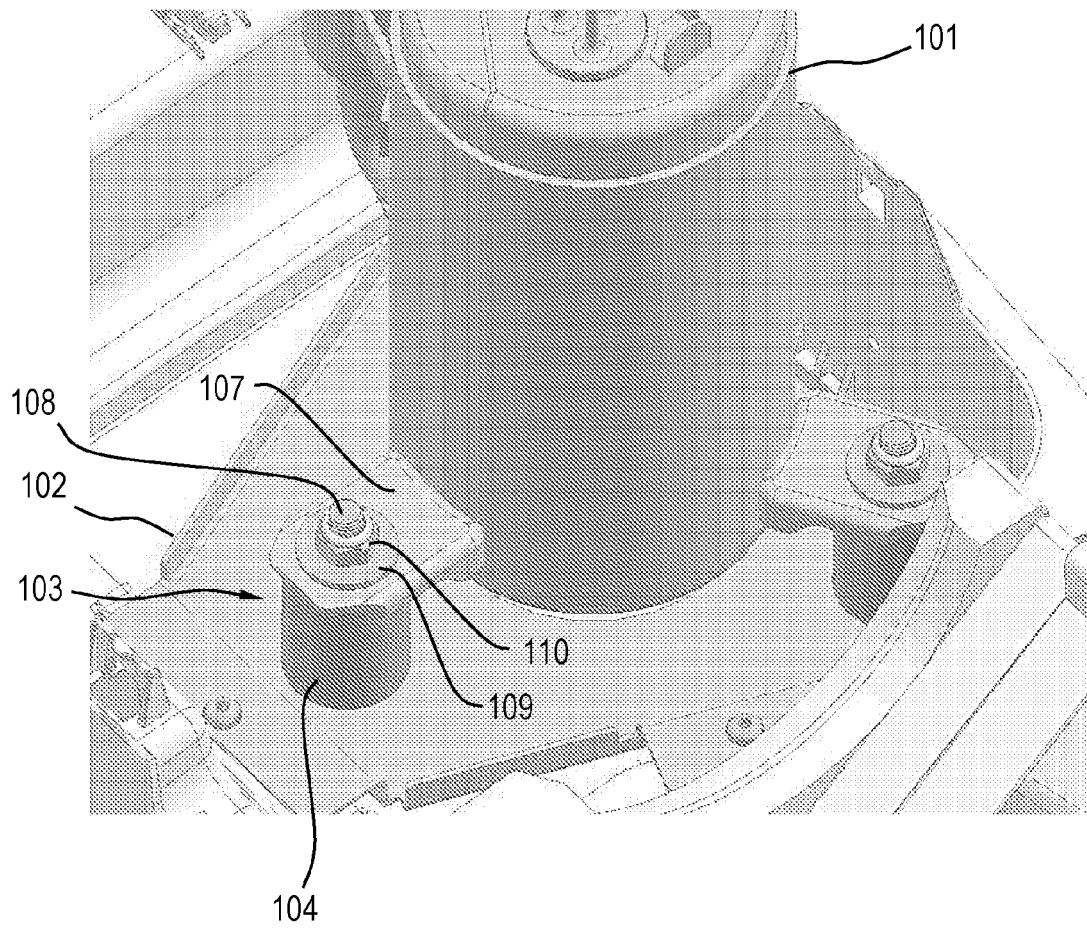


Fig.4



EUROPEAN SEARCH REPORT

Application Number
EP 11 38 2281

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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