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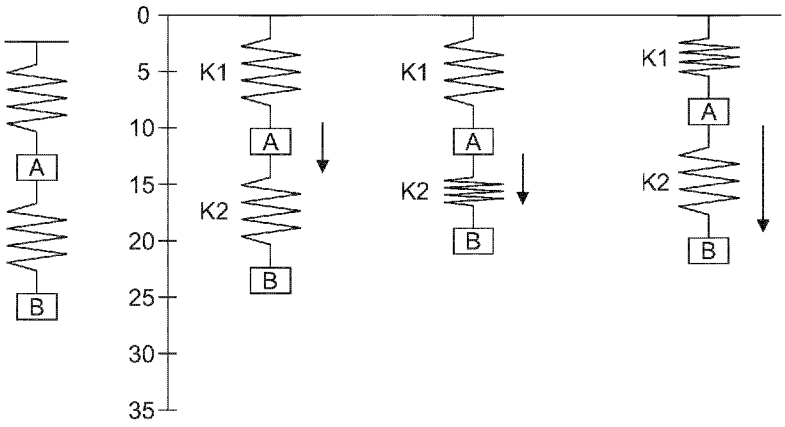
(54) **Title:** A DYNAMIC VIBRATION DAMPER AND THE HOUSEHOLD APPLIANCE USING THE SAME

Figure 1



(57) **Abstract:** The present invention relates to a dynamic vibration damper (1) suitable for use in a household appliance in which drying process is performed comprising a heat pump (7) having a compressor (6) enabling a coolant to be sucked and pumped, an evaporator (8) enabling the drying air to be dehumidified, a condenser (9) enabling the drying air to be heated, and coolant tubes (4) enabling the compressor (6), the evaporator (8) and the condenser (9) to be connected to each other in liquid communication; enabling damping the vibrations of the coolant tube (4), and the household appliance in which the dynamic vibration damper (1) is used.

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Description

A DYNAMIC VIBRATION DAMPER AND THE HOUSEHOLD APPLIANCE USING THE SAME

[0001] The present invention relates to a dynamic vibration damper enabling eliminating the noise caused by vibration in a household appliance in which drying process is performed, and the household appliance in which said dynamic vibration damper is used.

[0002] Vibrations occurring in a household appliance and its lower elements are on top of the list of circumstances which should be under control. Vibration control is simply containing undesired vibrations occurring in a structure, within appropriate limits. One of the sources of the noise problem experienced in household appliances with heat pump, is the vibration in coolant tubes. The vibration generated in a coolant tube causes the sound power level of the household appliance to increase by exciting the side panels of the household appliance. Containing such type of undesired vibrations within appropriate limits positively effects the perception of the household appliance on a customer. Dynamic vibration dampers for reducing vibrations in household appliances, particularly in washer/dryers caused by their lower elements, are present in the state of the art. Dynamic vibration dampers enable damping vibrations by having the vibrations occur on themselves instead of the main body.

[0003] Dynamic vibration dampers are secondary mechanical vibration systems utilized for reducing and thereby containing the vibration amplitudes of vibrating mechanical structures, and used by being mounted on main vibration systems. Such systems merely consist of mass, spring and/or damping element. They are very suitable to avoid the resonation of the main system. Two degree of freedom system is generated when these are coupled to a system of single degree of freedom. Single degree of freedom systems have one, and the new generated system has two natural frequencies. One of said frequencies is higher and the other is smaller than the natural frequency of the previous system before using the dynamic vibration damper.

[0004] Dynamic vibration dampers can be used for solving vibration problems of

the systems driven by a drive of a frequency proximate to its natural frequency. For example, if a drive frequency applied to a system overlaps with one of the natural frequencies of the system, the system resonates in said operating frequency and displacements of very high amplitudes are observed. When one dynamic vibration damper is introduced to the system, high amplitude vibrations are observed in the dynamic vibration damper. The primary system is thus prevented from resonating.

[0005] In Figure 1, the theoretical structure and the operation manner of dynamic vibration dampers are schematically illustrated by the vibration systems consisting of spring and mass (A, B).

[0006] In Figure 1, the dynamic vibration damper (K2) consisting of the mass (B)-spring system, is shown as mounted to the main mass (A)-spring system (K1) whose vibration amplitudes are desired to be contained. In a vibration control system formed as such, if the resonance frequency of the dynamic vibration damper (K2) is overlapped with the resonance frequency of the main mass-spring system (K1) before joining the dynamic vibration damper (K2), then the vibration amplitudes of the main mass-spring system (K1) in the determined resonance frequency would be offset. This physical condition implies that the vibration energy of the main mass-spring system (K1) in the determined resonance frequency is damped by the dynamic vibration damper (K2). The degree of freedom of the final vibration system obtained by mounting a secondary vibration system to the main vibration system, is “1” more than the degree of freedom of the main mass-spring system (K1).

[0007] In systems using dynamic vibration dampers, two resonance frequencies are formed which did not previously exist, in frequencies below and above the frequency value bearing the problematic vibration amplitudes in the main vibration system. This is illustrated in Figure 2. The curve represented by the dashed line in the figure illustrates the resonance frequency of the main vibration system, and the curve represented by the straight line illustrates the resonance frequencies of the system obtained by using dynamic vibration damper. As shown in the figure, the natural frequency number of the new system formed by implementing dynamic

vibration damper is one more than the previous system's natural frequency number, but a natural frequency does not exist anymore in the critical frequency region of the system.

[0008] It is possible to design a dynamic vibration damper adapted for a desired system, but two amplitudes should be taken into account when making the design. These are called the “frequency ratio” and the “mass ratio,” and can be expressed as follows:

1. $f = \frac{\omega_{DTA}}{\omega_{SYSTEM}}$

[0009]

$$\mu = \frac{m_{DTA}}{m_{SYSTEM}}$$

2.

[0010] When selecting the frequency ratio f, the strain frequency of the system forming due to unstable load should be taken into account rather than its natural frequency. In other words, this is the overlapping of the natural frequency of the dynamic vibration damper and the critical operating frequency (the operating frequency in which the dynamic vibration damper is desired to be activated) of the system. That is to say, this is represented as follows:

[0011]

$$\omega_{DTA} = \omega_{SYSTEM}$$

3.

[0012] Because in order to minimize the amplitude of the main mass, the natural frequency of the dynamic vibration damper to be introduced should be equal to the strain frequency (ω_{ς}) of the system.

[0013] In Equation 2, μ represents the mass ratio (there are different values suggested in the literature for μ), m_{DTA} represents the mass of the dynamic vibration damper, and ω_{SYSTEM} represents the mass of the main system. When it is desired to calculate an appropriate spring rigidity (k_{DTA}) for the dynamic vibration damper in operating frequency using Equations 1 and 2, the following can be stated:

[0014]

$$\omega_{DTA} = \sqrt{\frac{k_{DTA}}{m_{DTA}}}$$

4.

[0015] In this case, if spring rigidity (k_{DTA}) is removed from Equation 4,

[0016]

$$k_{DTA} = m_{DTA}.\omega_{DTA}^2$$

5.

[0017] The mass of the dynamic vibration damper (m_{DTA}) can be expressed from Equation 2 as follows:

[0018]

$$m_{DTA} = \mu.m_{SYSTEM}$$

6.

[0019] The operating frequency ($\omega_{\dot{C}}$) should be determined as follows:

[0020]

$$\omega_{\dot{C}} = \omega_{DTA} = \omega_{SYSTEM}$$

7.

[0021] When Equations 6 and 7 are brought into Equation 5, then the spring rigidity (k_{DTA}) is identified as follows:

[0022]

$$k_{DTA} = \mu.m_{SYSTEM}.\omega_{\dot{C}}^2$$

8.

[0023] Therefore, a dynamic vibration damper adapted to the system can be designed based on a certain operating frequency ($\omega_{\dot{C}}$) and the mass of the system (m_{SYSTEM}), and by selecting a mass ratio (μ).

[0024] There is the patent document no. CA20082645978 on the subject matter. Said document discloses a washing machine comprising a housing, a tub provided in the housing, a laundry washing drum rotatably mounted to the tub, and a vibration preventing device provided in the tub. The vibration preventing device described in said document comprises a damping system comprising a spring and a weight, and is used for damping vibrations whose resonance value is between two determined limit values.

[0025] State of the art patent document no. EP2011912 discloses a dynamic vibration damper for washing machines. The vibration damper comprises a weight, elastic elements (spring) supporting said weight, and a guide for delimiting motions of the weight. In said document, vibrations in a single

axis are damped as the weight used to stabilize vibrations is capable of moving in a single direction.

[0026] State of the art patent document no. WO2008056953 discloses reducing body vibrations of a washing machine by a dynamic vibration damper connected to the attachment point of the suspension spring of the washing machine. Said dynamic vibration damper consists of a rod and a weight joined to the end portion of the rod, and is joined to the suspension spring attachment point and damps the vibrations at said point.

[0027] State of the art patent document no. US2006117812 discloses reducing body vibrations of a washing machine by a dynamic vibration damper connected to the spring and the upper panels of the washing machine. The vibrations reaching on the body are damped by a weight connected to the middle or the end portion of an elastic element (spring, rubber, composite panel, etc.).

[0028] The present invention relates to a dynamic vibration damper suitable for use in a household appliance in order to eliminate the above-mentioned disadvantages and to bring new advantages to the related technical field, and its implementation.

[0029] The aim of the present invention is to obtain a dynamic vibration damper allowing effectively reducing the vibration forming in the coolant tubes of household appliances with heat pump having drying function.

[0030] In order to realize all aims which will appear from the detailed disclosure below, the present invention relates to a dynamic vibration damper with adjustable operating frequency provided on a coolant tube, enabling eliminating the noise caused by vibration in a household appliance, implementation of said dynamic vibration damper, and the household appliance comprising said dynamic vibration damper. Said dynamic vibration damper comprises a flat and elongated metal rod with a rectangular cross-section, enabling damping high amplitude vibrations forming on the coolant tube, and a clamp enabling mounting the metal rod on the coolant tube.

[0031] In a preferred embodiment, dynamic vibration damper comprises a clamp surrounding the circumference of the coolant tube and shaped so as to

enable the metal rod to rest in parallel to the central plane of the coolant tube, and a flat and elongated metal rod with a rectangular cross-section enabling damping the vibrations generated by the heat pump elements to which the clamp is joined by means of bolts and washers.

[0032] The dynamic vibration damper realized to achieve the aims of the present invention is illustrated in the accompanying drawings, wherein:

[0033] Figure 1 is a schematic view of the vibration systems consisting of spring and mass, illustrating the theoretical structure and the operation manner of the dynamic vibration dampers implemented in the invention.

[0034] Figure 2 is the displacement-frequency curve obtained by the dynamic vibration damper of the invention.

[0035] Figure 3 is a partial view of the household appliance.

[0036] Figure 4 is a view of the dynamic vibration damper of an embodiment of the invention, on the coolant tube.

[0037] Figure 5 is a view of the dynamic vibration damper of another embodiment of the invention.

[0038] The elements in the figures are numbered individually and the correspondence of these numbers are given hereinafter.

1. Dynamic vibration damper
2. Metal rod
3. Clamp
4. Coolant tube
5. Weight
6. Compressor
7. Heat pump
8. Evaporator
9. Condenser

[0039] In this detailed disclosure, the novelty of the invention is disclosed by way of non-limitative example only to provide a better understanding of the subject matter. Dynamic vibration damper (1) in a coolant tube and the elements it comprises are disclosed.

[0040] The dynamic vibration damper (1) is suitable for use in a household appliance in which drying process is performed, comprising a heat pump

(7) having a compressor (6) enabling a coolant to be sucked and pumped, an evaporator (8) enabling the drying air to be dehumidified, a condenser (9) enabling the drying air to be heated, and coolant tubes (4) enabling the compressor (6), the evaporator (8) and the condenser (9) to be connected to each other in liquid communication; and enables damping the vibrations of a coolant tube (4).

[0041] The dynamic vibration damper (1) of the invention comprises at least one metal rod (2) of elongated shape, fixed on the coolant tube (4) at its middle portion so as to enable damping the vibrations formed on the coolant tube (4). The dynamic vibration damper (1) on the coolant tube (4) is disclosed with reference to Figure 3. The dynamic vibration damper (1) enables damping high amplitude vibrations caused by the elements of the heat pump (7) and transmitted to the coolant tube (4). To achieve this, the natural frequency of the metal rod (2) joined to the coolant tube (4), is utilized. The natural frequency of the metal rod (2) is a property that varies according to its elasticity and mass. The elasticity (spring rigidity (k_{DTA})) and mass (m_{DTA}) on the equation given theoretically in the prior art, are brought to a desired value by way of modifying parameters such as the thickness, sectional properties, and the length and of said rod (2).

[0042] In an embodiment of the invention, the dynamic vibration damper (1) comprises at least one weight (5) provided at the end portion of the metal rod (2), allowing adjusting the vibrational frequency of the metal rod (2). Weights (5) can be joined to both ends of the metal rod (2) in order to modify the mass of the system (m_{DTA}). The operating frequency of the metal rod (2) and the masses joined thereon is thus modified. The mass of the system is selected according to the frequency (ω_c) in which the dynamic vibration damper (1) will operate.

[0043] In another embodiment of the invention, the dynamic vibration damper (1) comprises at least one clamp (3) enabling the connection of the metal rod (2) with the coolant tube (4). A clamp (3) configured to surround the coolant tube (4) is provided between the metal rod (2) and the coolant tube (4). The clamp (3) enables the metal rod (2) to rest in a position fixed to the coolant tube (4).

[0044] In another embodiment of the invention, the clamp (3) surrounds the circumference of the coolant tube (4) and enables the metal rod (2) to extend almost in parallel to the portion of the coolant tube (4) on which it is joined. The clamp (3) is fixed on the metal rod (2) by means of bolts and washers. The clamp's (3) holding position of the metal rod (2) is important in terms of damping the vibrations. The clamp (3) is passed through the middle point of the coolant tube (4) and is mechanically joined at its end point to the metal rod (2) by means of bolts and washers. The metal rod (2) is enabled to be positioned in parallel to the middle plane of the coolant tube (4).

[0045] In an embodiment of the invention, the dynamic vibration damper (1) is disposed on the coolant tube (4) joined to the compressor (6) provided on the heat pump (7). The high amplitude vibrations on the coolant tube (4) extending from the compressor (6) which is the main source of the vibrations, are thus damped. The obtained results display a significant reduction also in the noise levels caused by the compressor (6).

[0046] Within the scope of the present invention, the natural frequency of the metal rod (2) with respect to the frequency of the coolant tube (4) is determined to be 200 Hz and this was subjected to vibration measurements. Positive results were obtained as a result of the invention implemented to the coolant tube (4) in a household appliance. The metal rod (2) whose natural frequency was set to 200 Hz, reduces vibrations of high accelerations forming on the coolant tube (4) 100 times from 100 m/sec^2 to 1 m/sec^2. The improvement this result generates on the household appliance body is 10 times. The vibrations of 1 m/sec^2 acceleration coming on the household body are reduced up to 0.1 m/sec^2 in 200 Hz frequency.

[0047] The implementation method of the dynamic vibration damper (1) with adjustable operating frequency, enabling stabilizing the body of a household appliance, suitable for use on a coolant tube (4), comprises the processing steps of:

- Determining the operating frequency of the coolant tube (4) whose vibration is to be damped,

- Adjusting the cross-section, length and weight parameters of the metal rod (2) according to the determined operating frequency, and
- Mounting the metal rod (2) in the middle of the coolant tube (4) by means of the clamp (3).

[0048] The household appliance of the invention comprises the above-disclosed dynamic vibration damper (1).

[0049] In an embodiment of the invention, the household appliance is a laundry drying machine, or a washer-dryer.

[0050] With the invention, the vibrations occurring on the coolant tube (4) during operation of the heat pump (7), are damped.

Claims

1. A dynamic vibration damper (1) suitable for use in a household appliance in which drying process is performed comprising a heat pump (7) having a compressor (6) enabling a coolant to be sucked and pumped, an evaporator (8) enabling the drying air to be dehumidified, a condenser (9) enabling the drying air to be heated, and coolant tubes (4) enabling the compressor (6), the evaporator (8) and the condenser (9) to be connected to each other in liquid communication; enabling damping the vibrations of the coolant tube (4), **characterized in that**, the dynamic vibration damper (1) comprises at least one metal rod (2) of elongated shape, fixed on the coolant tube (4) at its middle portion so as to enable damping the vibrations forming on the coolant tube (4).
2. A dynamic vibration damper (1) according to claim 1, **characterized in that**, it comprises at least one clamp (3) enabling the connection of the metal rod (2) with the coolant tube (4).
3. Dynamic vibration damper (1) according to claim 2, **characterized in that**, it comprises a clamp (3) enabling the metal rod (2) to extend almost in parallel to the portion of the coolant tube (4) on which it is joined, by surrounding the circumference of the coolant tube (4).
4. A dynamic vibration damper (1) according to claim 2 or claim 3, **characterized in that,** it comprises bolts and washers enabling the clamp (3) to be fixed on the metal rod (2).
5. A dynamic vibration damper (1) according to any one of the preceding claims, **characterized in that**, it comprises at least one weight (5) provided at the end portion of the metal rod (2), allowing adjusting the vibrational frequency of the metal rod (2).
6. A dynamic vibration damper (1) according to any one of the preceding claims, **characterized in that**, it is provided on the coolant tube (4) joined to the compressor (6).
7. Method of implementation of the dynamic vibration damper (1) enabling stabilizing the body of a household appliance, suitable for use on a coolant tube (4), **characterized in that**, the method comprises the processing steps of:
   - Determining the operating frequency of the coolant tube (4) whose vibration is to be damped,

- Adjusting the cross-section, length and weight parameters of the metal rod (2) according to the determined operating frequency, and
- Mounting the metal rod (2) in the middle of the coolant tube (4) by means of the clamp (3).

8. A household appliance, **characterized in that**, it comprises a dynamic vibration damper (1) according to any one of the preceding claims.
9. A household appliance according to claim 8, **characterized in that**, the household appliance is a laundry drying machine or a washer-dryer.

Figure 1

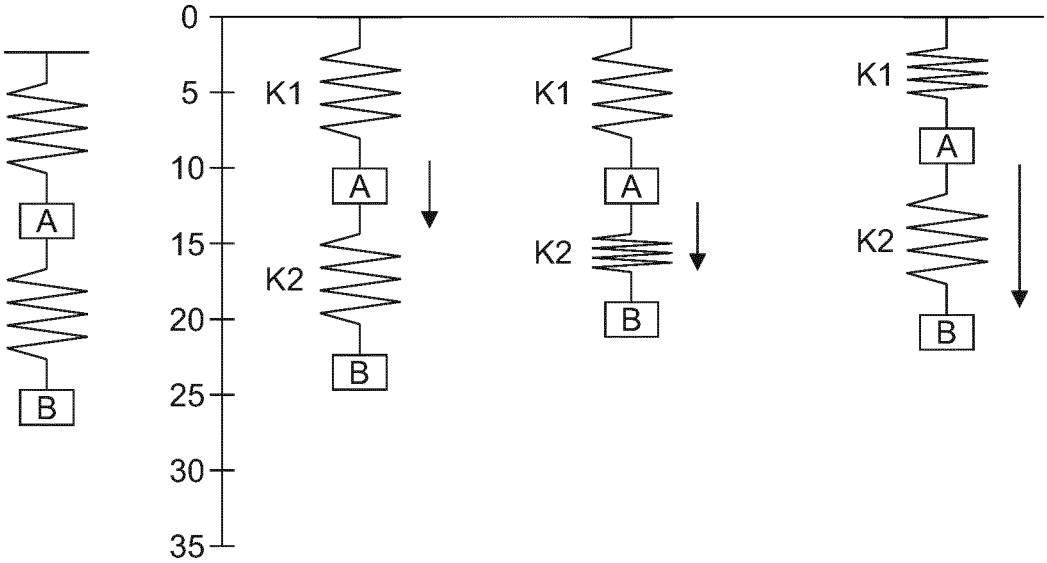


Figure 2

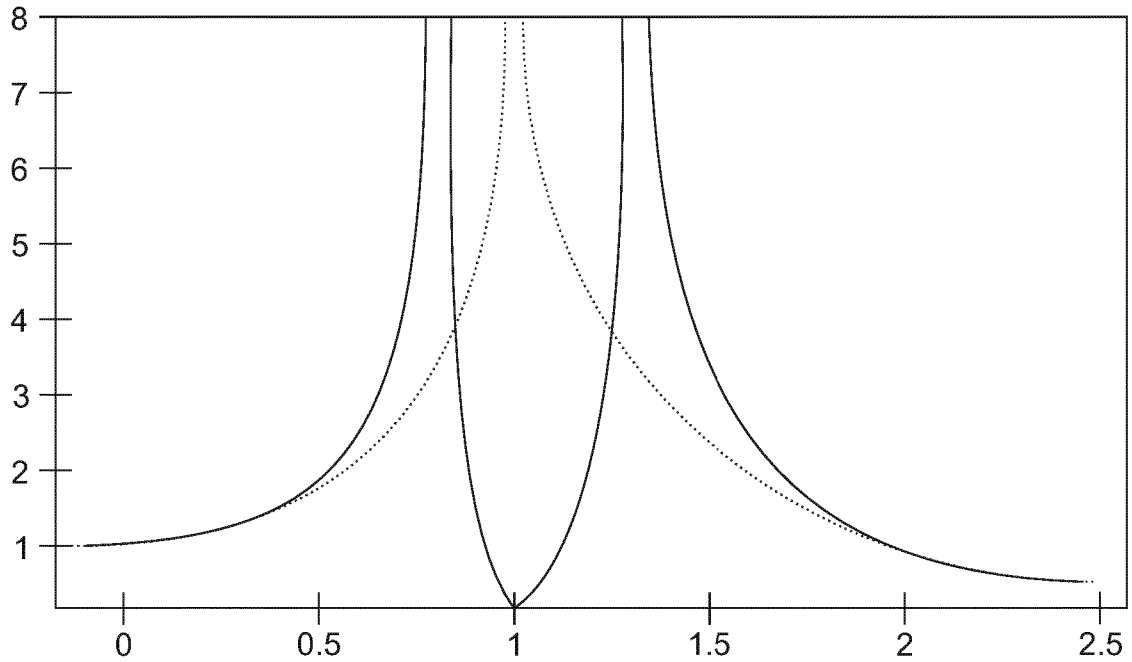


Figure 3

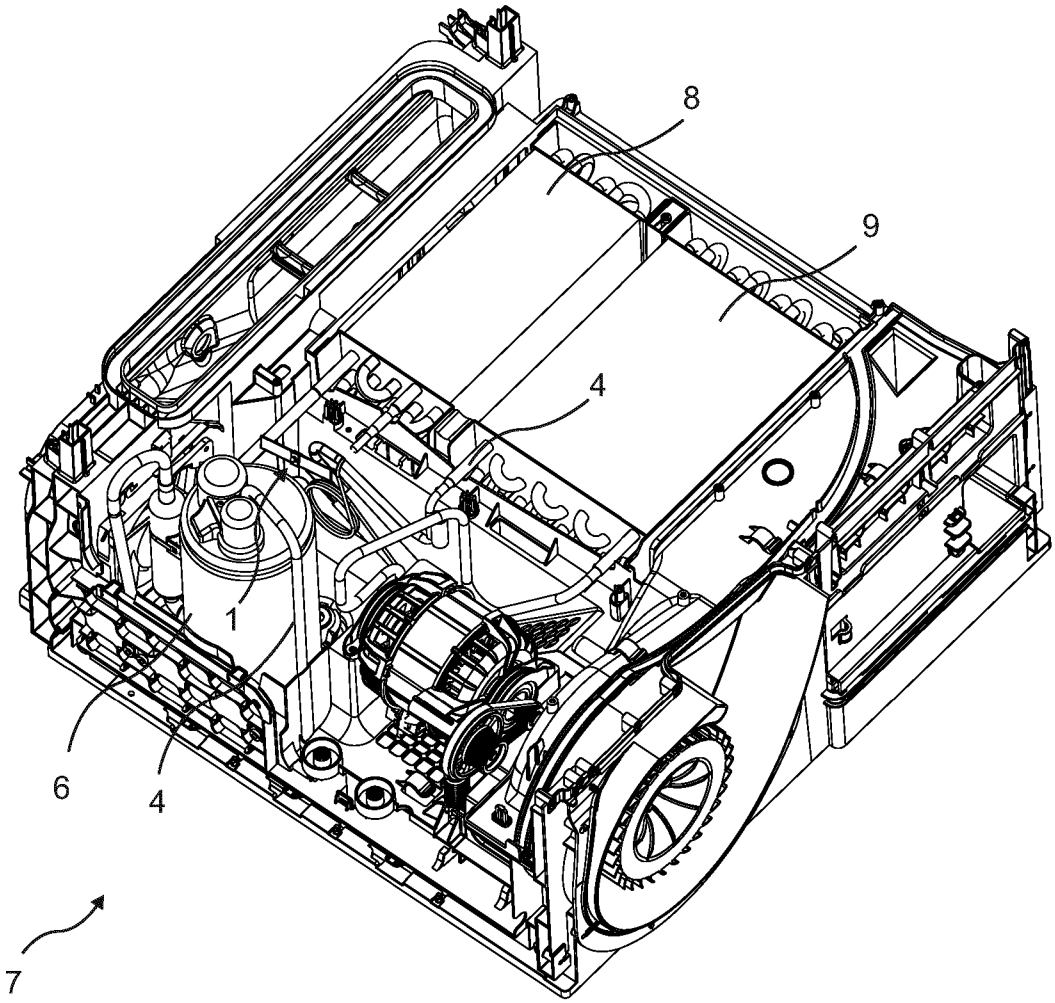


Figure 4

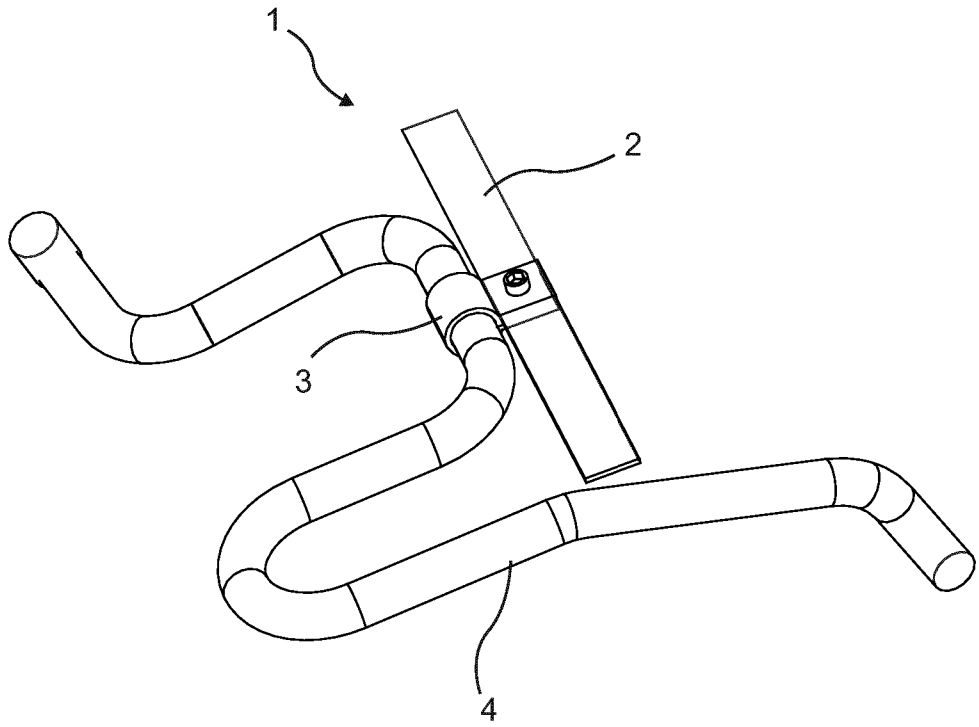
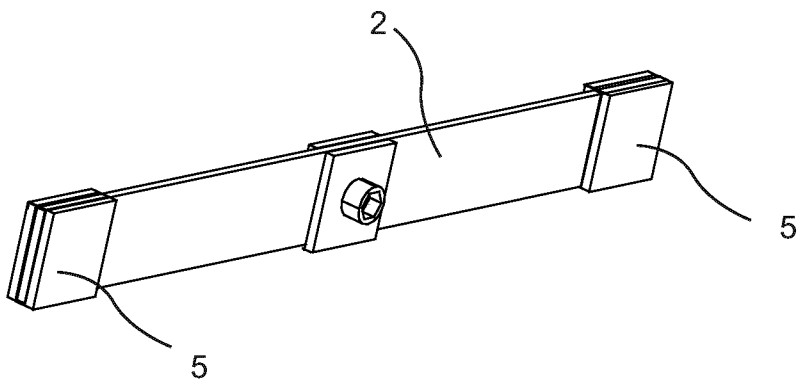


Figure 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/060968

A. CLASSIFICATION OF SUBJECT MATTER
INV. D06F58/20 D06F37/20 D06F49/06 F16F7/116
ADD.

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)
D06F F16F

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP S60 20070 A (MITSUBISHI ELECTRIC CORP) 1 February 1985 (1985-02-01) paragraph [0001]; figures 1,3-6	1,2,4,6,8 9
Y	KR 2017 0016750 A (LG ELECTRONICS INC [KR]) 14 February 2017 (2017-02-14) abstract	9
X	JP S58 69773 U (UNKOWN) 12 May 1983 (1983-05-12) paragraph [0001]; figures 9-17	1,2,4
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 June 2018	04/07/2018

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/060968

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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