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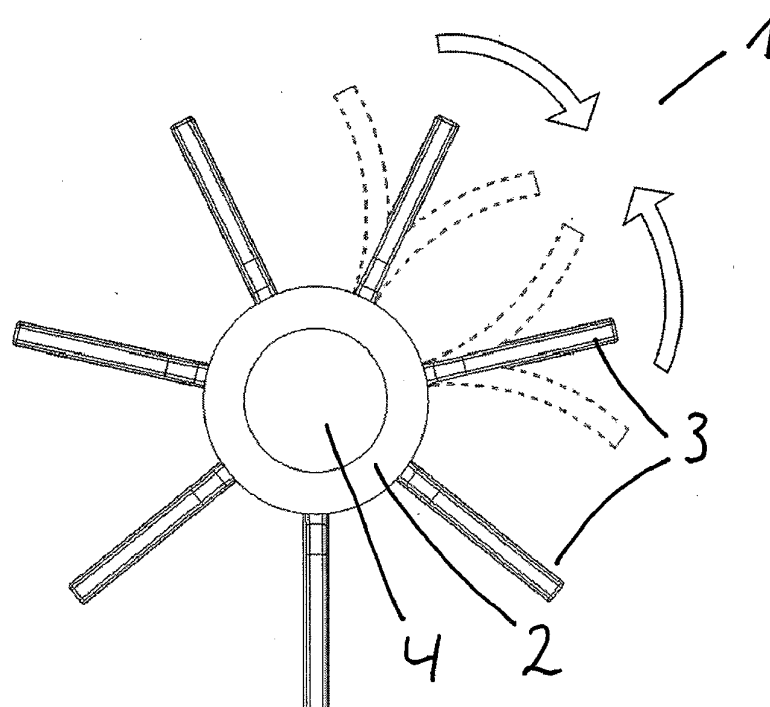
Amended claims in accordance with Rule 137(2) EPC.

(54) **HOUSEHOLD APPLIANCE WITH A CENTRIFUGAL PUMP IMPELLER HAVING FLEXIBLE BLADES AND PROCESS FOR PRODUCING IT**

(57) The invention relates to a household appliance containing a rotary centrifugal pump 1 with a centrifugal pump impeller 2 for transporting a fluid and an electric

motor for driving the pump 1, wherein the pump impeller 2 has flexible blades 3. The invention also relates to a process for producing this household appliance.

Fig. 1



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Description

[0001] The invention relates to a household appliance with a centrifugal pump impeller having flexible blades and a preferred process for producing it. In particular, the invention relates to a household appliance containing a rotary centrifugal pump with a centrifugal pump impeller for transporting a fluid and an electric motor for driving the pump and a process for producing this household appliance.

[0002] In dryers, particularly clothes dryers, laundry located in a generally rotating drum is dried by passing through the drum, and thus the laundry, a heated air stream capable of extracting moisture from the wet laundry, thereby gradually drying the laundry.

[0003] The supplied air stream ("process air stream") is heated in a supply duct (supply air duct) upstream of the drum ("laundry drum") by means of a heating device and, after passing through the laundry in the drum, is either discharged to the outside (exhaust air dryer) or supplied to a heat exchanger in which the air is cooled and the moisture precipitates as condensate. To convey the air, a blower (process air blower) is generally used, which has a rotor wheel (also called a "drum impeller" or "radial blower wheel"). The collected condensate is usually pumped out of the dryer with a pump that has an impeller with rigid blades.

[0004] EP 0 702 105 B1 describes a housing for a blower in a household appliance, in particular in a household laundry dryer, which makes it possible to reduce generated noise and to attenuate generated noise. The housing has a radial blower wheel which is rotatably installed in a spiral housing and to which the air is axially supplied, the spiral housing being separably surrounded by a housing wall having a wall form of a casing adapted to the spiral contour and extending at a distance therefrom, and means being provided for maintaining the distance.

[0005] Rotary centrifugal pumps are also used in laundry dryers for draining of condensate water. A pump with an AC, one phase, synchronous motor with permanent magnets has a random rotation direction, i.e. left or right, after switch on. This requires the use of an impeller with straight blades (axially symmetrical) to ensure the same pump performance (flow rate, delivery height) and power consumption independent from the rotation direction. Additionally, the aforementioned AC motor type gives rise to pulsations of a torque that causes vibrations and lead to an increased noise level in comparison to pumps driven by asynchronous motors. Moreover, a pump with an impeller with straight, radial blades consumes more power with increasing flowrate than a pump with an impeller with backward curved blades.

[0006] The use of flexible impellers, i.e. of impellers with flexible blades, is however in principle known. In this regard, the impeller with flexible blades is mounted in a circular housing which has a flattened area at one side. This provides an eccentric path for the impeller, thereby squeezing the flexible blades on this side. Compression

and decompression of the blades creates pressure on an outlet side and suction on an inlet side. Namely, the impeller rotation and the straightening of the blades upon leaving the cam creates a vacuum on the suction side drawing the fluid into the pump chamber. The rotating impeller transfers the liquid from the inlet to the outlet port of the pump. On the pressure side, the impeller blades are compressed and the fluid is discharged constantly from the pump.

[0007] In view of this situation it is an object of the present invention to provide an improved household appliance with a centrifugal pump that allows a reduction of the noise level of the pump and also a reduction of the energy consumption.

[0008] This object is achieved according to the present invention with a household appliance according to the independent claim. Preferred embodiments of the household appliance are defined in the dependent claims.

[0009] The invention is thus directed to a household appliance containing a rotary centrifugal pump with a centrifugal pump impeller for transporting a fluid and an electric motor for driving the pump, wherein the pump impeller has flexible blades.

[0010] In a preferred embodiment, the household appliance is a water-bearing household appliance. In this regard, the water-bearing household appliance is preferably a dryer.

[0011] In the household appliance of the present invention, a dryer contains in general a drum for accepting damp laundry to be dried. Preferably, the dryer is adapted to dry damp laundry by means of warm process air, and comprises in addition a heating device for heating the process air in a process air duct upstream of the drum and a fan which contains a fan impeller with a blading, wherein the fan impeller has fan blades which are straight and/or curved backwards in the direction of travel relative to the drum.

[0012] In the household appliance, the electric motor of the pump is preferably a one phase, synchronous motor with permanent magnets that allows a random rotation direction of the pump impeller.

[0013] In the household appliance of the present invention, the pump impeller preferably contains or consists of an organic polymer. More preferably, the pump impeller consists of one or more organic polymers.

[0014] A suitable physical variable for the flexibility of the flexible blades is the Shore A scale. Blade flexibility depends on the hardness of the used material, defined by the Shore A scale, the blade cross section shape, and the blade thickness along its length. Optimal material hardness, cross section shape and thickness can thus vary.

[0015] The materials used for the rigid part, i.e. the shaft, and the flexible blades are in general organic polymers. Preferably, the rigid part contains or more preferably consists of polypropylene (PP) or polyamide (PA). Preferably, the flexible blades contain or consist of TPE, TPV, or EPDM.

[0016] The alternative solution is to make the impeller completely from flexible material and achieve stiffness of the central part by a proper geometry.

[0017] It is noted that it might be useful that the thickness of the blades in the direction away from the rigid shaft decreases. In general, it might be beneficial to control the curvature of the blade by changing thickness of the blade along its length.

[0018] With the impeller consisting of a rigid central part connected to flexible blades vibrations of the rigid impeller shaft will be partially damped while transferring momentum through flexible blades to the liquid.

[0019] To use blades made of different materials and/or thicknesses makes sense for example to have different degrees of flexibility. It makes especially sense in the case of using this type of design in different pumps where different blade curvature would be optimal.

[0020] In a preferred embodiment of the household appliance, the pump impeller has a rigid center part to which the flexible blades are attached. It is then preferred that the rigid center part comprises a central rigid impeller shaft that contains or is made of polypropylene (PP) or polyamide (PA).

[0021] In the household appliance of the present invention it is moreover preferred that the flexible blades are made of a thermoplastic polyurethane (TPU). A suitable thermoplastic polyurethane (TPU) is TPU 80ShA.

[0022] A household appliance is moreover preferred, wherein the fluid is an aqueous liquid. The moving of the aqueous liquid is achieved by centrifugal force created by rotating blades instead of compression/decompression of blades as usually done. In known designs the main purpose is to create a constant, non pulsating flow of fluid while the present invention allows to provide vibrations damping leading to noise reduction and a change of power curve. The power curve shape depends on the geometry of the blades. Backward curved blades require less power than straight blades for the same operating point of a pump. With the present invention, the flexible blades provide backward curvature independent from rotation direction of the impeller. The rotation direction is in general random at pump start because an asynchronous motor is used.

[0023] A household appliance is in general preferred, wherein the flexible blades have axial symmetry and are not in contact with surrounding walls.

[0024] The present invention is moreover directed to a process for manufacturing a household appliance containing a rotary centrifugal pump with a centrifugal pump impeller for transporting a fluid and an electric motor for driving the pump, wherein the pump impeller has flexible blades, comprising process steps of 2K injection moulding. The 2K injection moulding is preferably performed by injecting in a first step the central rigid impeller shaft with a rigid organic polymer and overmoulding it then in a second step with a flexible polymer material, preferably a flexible thermoplastic elastomer (TPE). The rigid organic polymer is preferably polypropylene (PP) or poly-

amide (PA) and the flexible thermoplastic elastomer (TPE) is preferably a thermoplastic polyurethane (TPU).

[0025] The invention may be used in numerous home appliances containing a centrifugal pump impeller. The home appliance is preferably embodied as a laundry dryer for pieces of laundry, and a washer-dryer which combines the function of washing laundry with the function of drying. In a laundry dryer or a washer-dryer the drying chamber is in general a rotatable drum.

[0026] The invention has several advantages. It allows the dampening of vibrations of the electric motor of the pump and the decrease of a noise level of the pump. It is moreover possible to decrease the power consumption at a higher delivery head. A "higher delivery head" means a greater height to which pump delivers liquid.

[0027] Further details of the invention will appear from the subsequent description of specific embodiments with references to the following five Figures, wherein

Figure 1 shows a top view in a cut rotary impeller of a rotary pump, wherein the two possible rotation directions are shown and the corresponding bending of the flexible blades;

Figure 2 shows a perspective view of a rotary impeller with a rigid central part and seven flexible blades that are here in a straight configuration;

Figure 3 shows a top view in a cut rotary impeller of a rotary pump, wherein the flexible blades are in a curved configuration;

Figure 4 shows the sound power level FFT in dependence of the frequency in the case of an impeller with flexible blades;

Figure 5 shows the sound power level FFT in dependence of the frequency in the case of an impeller with straight blades.

[0028] In the Examples blades made of the thermoplastic polyurethane TPU 80ShA with constant thickness and rectangular cross section were used.

[0029] Figure 1 shows a top view in a cut centrifugal pump impeller 2 of a rotary centrifugal pump 1, wherein the two possible rotation directions (thick arrows in opposite directions) are shown and the corresponding bending of the flexible blades 3. 4 refers to the rigid center part. The flexible blades 3 are here in a straight configuration, since the pump is not running. The dotted lines show the bending of the blades during the rotation (clockwise/counterclockwise).

[0030] Figure 2 shows a perspective view of a rotary centrifugal impeller 2 with a rigid central part 4 comprising a rigid impeller shaft 5 and seven flexible blades 3 that are here also in a straight configuration.

[0031] Figure 3 shows a top view in a cut rotary centrifugal impeller 2 of a rotary centrifugal pump 1, wherein

the flexible blades 3 are in a curved configuration. A rigid central part 4 comprises a rigid impeller shaft 5. In the present invention, the shape of the flexible blades, as seen in a top view, may vary. The blade shape is generally defined by a spline curve, an inlet blade angle β_1 and an outlet blade angle β_2 . β_1 is defined as an angle between a line tangent to a circle D1 and the beginning of spline. β_2 is defined as an angle between a line tangent to circle D2 and an end of spline. Blade shape could be also a part of a circle or an ellipse whose shapes can be approximated by a spline function. There is no general best curvature as it is dependent on geometry of other hydraulic parts of the pump.

[0032] Figure 4 shows the sound power level FFT in dependence of the frequency in the case of an impeller with flexible blades, wherein FFT means Fast Fourier Transformation, which is an algorithm for calculating the frequency spectrum of a signal, in this case of sound. The pump operation is effected without water, the pump is mounted in a tumble dryer. For the noise measurements pumps were thus installed in a tumble dryer and operated separately, without running the dryer.

[0033] A comparison with Figure 5 wherein straight blades have been used reveals that the noise level of a pump can be decreased, for example by > 7 dB. In particular the Sound Power Level of a pump in dry operation can be decreased due to damping of N*50 Hz harmonics. The Sound Power Level was measured according standards IEC 60704-1 and IEC 60704-2-6.

[0034] The N*50 Hz harmonics are frequencies being a multiple of power supply frequency (50Hz) : 50, 100, 150Hz etc. The term "LWA_Eq [dB]" means A-weighted Equivalent Sound Power Level and is a standard parameter quantifying sound power of household appliances, given in decibels (dB).

[0035] In the present example the LWA is higher for flexible blades in the frequency range 930 to 1130 Hz. It is higher in a particular frequency range which may be due to the appearance of some kind of resonance/mechanical interaction or change in motor operation. The assembly of the pump in the dryer is not 100% fixed, also the type of motor used for the pump is characterized by a less stable operation.

[0036] Figure 5 shows the sound power level FFT in dependence of the frequency in the case of an impeller with straight blades. It can be thus used for a comparison with Figure 4.

LIST OF REFERENCE NUMERALS

[0037]

- 1 Rotary centrifugal pump
- 2 Centrifugal pump impeller
- 3 Flexible blades
- 4 Rigid center part
- 5 Rigid impeller shaft

Claims

1. A household appliance containing a rotary centrifugal pump (1) with a centrifugal pump impeller (2) for transporting a fluid and an electric motor for driving the pump (1), **characterized in that** the pump impeller (2) has flexible blades (3).
2. Household appliance according to claim 1, wherein the household appliance is a water-bearing household appliance.
3. Household appliance according to claim 2, wherein the water-bearing household appliance is a dryer.
4. Household appliance according to claim 3, wherein the dryer contains a drum for accepting damp laundry to be dried.
5. Household appliance according to claim 4, wherein the dryer is adapted to dry damp laundry by means of warm process air, and comprises in addition a heating device for heating the process air in a process air duct upstream of the drum and a fan which contains a fan impeller with a blading, wherein the fan impeller has fan blades which are straight and/or curved backwards in the direction of travel relative to the drum.
6. Household appliance according to any of claims 1 to 5, wherein the electric motor is a one phase, synchronous motor with permanent magnets that allows a random rotation direction of the pump impeller (2).
7. Household appliance according to any of claims 1 to 5, **characterized in that** the pump impeller (2) contains or consists of an organic polymer.
8. Household appliance according to one of claims 1 to 7, **characterized in that** the pump impeller (2) has a rigid center part (4) to which the flexible blades (3) are attached.
9. Household appliance according to claim 8, wherein the rigid center part (4) comprises a central rigid impeller shaft (5) that contains or is made of polypropylene (PP) or polyamide (PA).
10. Household appliance according to any of claims, wherein the flexible blades (3) are made of a thermoplastic polyurethane (TPU)
11. Household appliance according to any of claims 1 to 10, wherein the fluid is an aqueous liquid.
12. Household appliance according to any of claims 1 to 11, wherein the flexible blades (3) have axial symmetry and are not in contact with surrounding walls.

13. Process for manufacturing a household appliance containing a rotary centrifugal pump (1) with a centrifugal pump impeller (2) for transporting a fluid and an electric motor for driving the pump, wherein the pump impeller (2) has flexible blades (3), comprising process steps of 2K injection moulding.
14. Process according to claim 13, wherein the 2K injection moulding is performed by injecting in a first step the central rigid impeller shaft (5) with a rigid organic polymer and overmoulding it then in a second step with a flexible polymer material, preferably a flexible thermoplastic elastomer (TPE).
15. Process according to claim 14, wherein the rigid organic polymer is polypropylene (PP) or polyamide (PA) and the flexible thermoplastic elastomer (TPE) is a thermoplastic polyurethane (TPU).

Amended claims in accordance with Rule 137(2) EPC.

1. A water-bearing household appliance containing a rotary centrifugal pump (1) with a centrifugal pump impeller (2) for transporting an aqueous liquid and an electric motor for driving the pump (1), wherein the pump impeller (2) has flexible blades (3) and a rigid center part (4) to which the flexible blades (3) are attached, **characterized in that** the rigid center part (4) comprises a central rigid impeller shaft (5) that contains or is made of polypropylene (PP) or polyamide (PA) and **in that** the thickness of the blades in the direction away from the rigid shaft decreases.
2. Household appliance according to claim 1, wherein the water-bearing household appliance is a dryer.
3. Household appliance according to claim 2, wherein the dryer contains a drum for accepting damp laundry to be dried.
4. Household appliance according to claim 3, wherein the dryer is adapted to dry damp laundry by means of warm process air, and comprises in addition a heating device for heating the process air in a process air duct upstream of the drum and a fan which contains a fan impeller with a blading, wherein the fan impeller has fan blades which are straight and/or curved backwards in the direction of travel relative to the drum.
5. Household appliance according to any of claims 1 to 4, wherein the electric motor is a one phase, synchronous motor with permanent magnets that allows a random rotation direction of the pump impeller (2).

6. Household appliance according to any of claims, wherein the flexible blades (3) are made of a thermoplastic polyurethane (TPU)
7. Household appliance according to any of claims 1 to 6, wherein the flexible blades (3) have axial symmetry and are not in contact with surrounding walls.
8. Process for manufacturing a water-bearing household appliance containing a rotary centrifugal pump (1) with a centrifugal pump impeller (2) for transporting an aqueous liquid and an electric motor for driving the pump, wherein the pump impeller (2) has flexible blades (3), and a rigid center part (4) to which the flexible blades (3) are attached, wherein the rigid center part (4) comprises a central rigid impeller shaft (5) that contains or is made of polypropylene (PP) or polyamide (PA) and in that the thickness of the blades in the direction away from the rigid shaft decreases, comprising process steps of 2K injection moulding the centrifugal pump impeller (2), wherein 2K injection moulding is performed by injecting in a first step the central rigid impeller shaft (5) with a rigid organic polymer and overmoulding it then in a second step with a flexible polymer material.
9. Process according to claim 8, wherein the flexible polymer material is a flexible thermoplastic elastomer (TPE).
10. Process according to claim 9, wherein the flexible thermoplastic elastomer (TPE) is a thermoplastic polyurethane (TPU).

Fig. 1

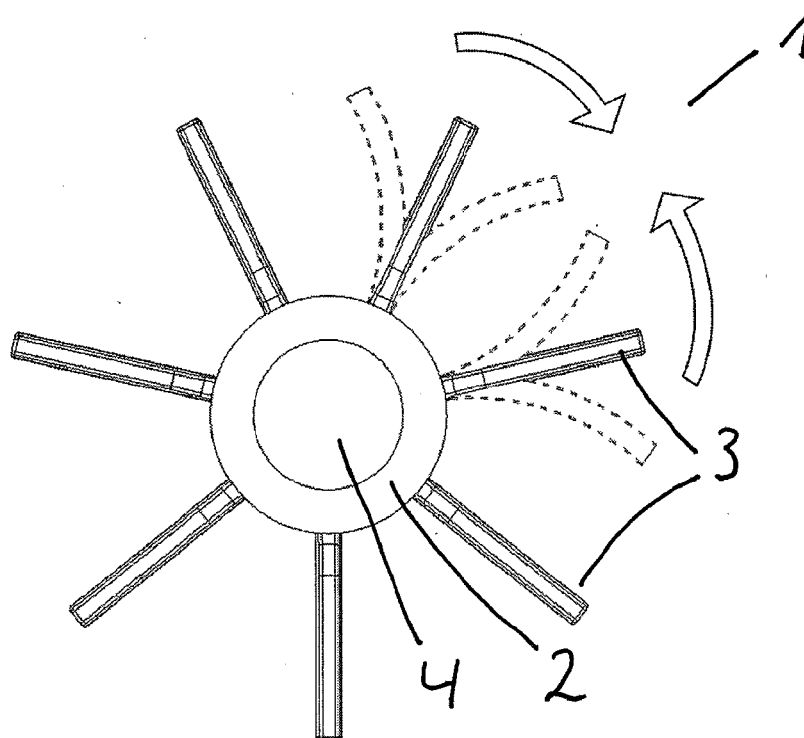


Fig. 2

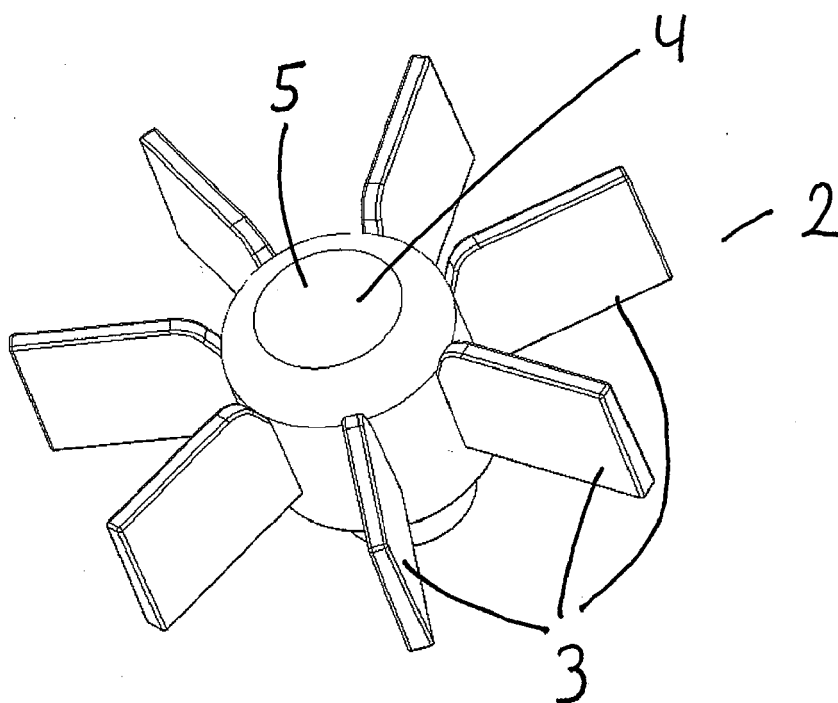


Fig. 3

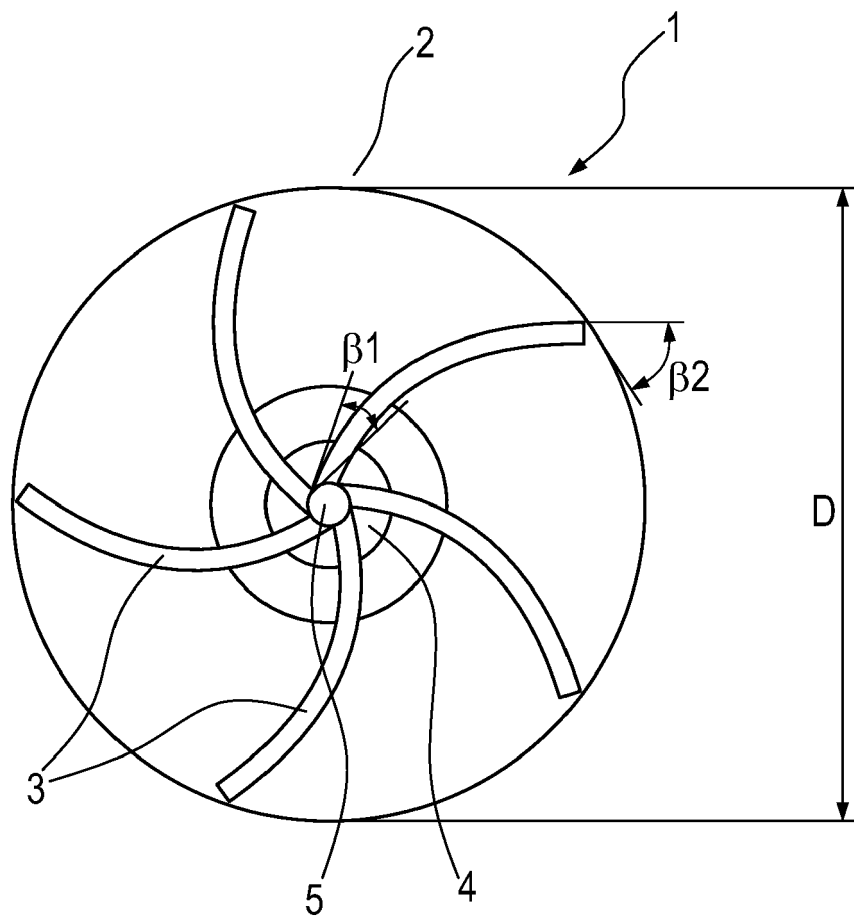


Fig. 4

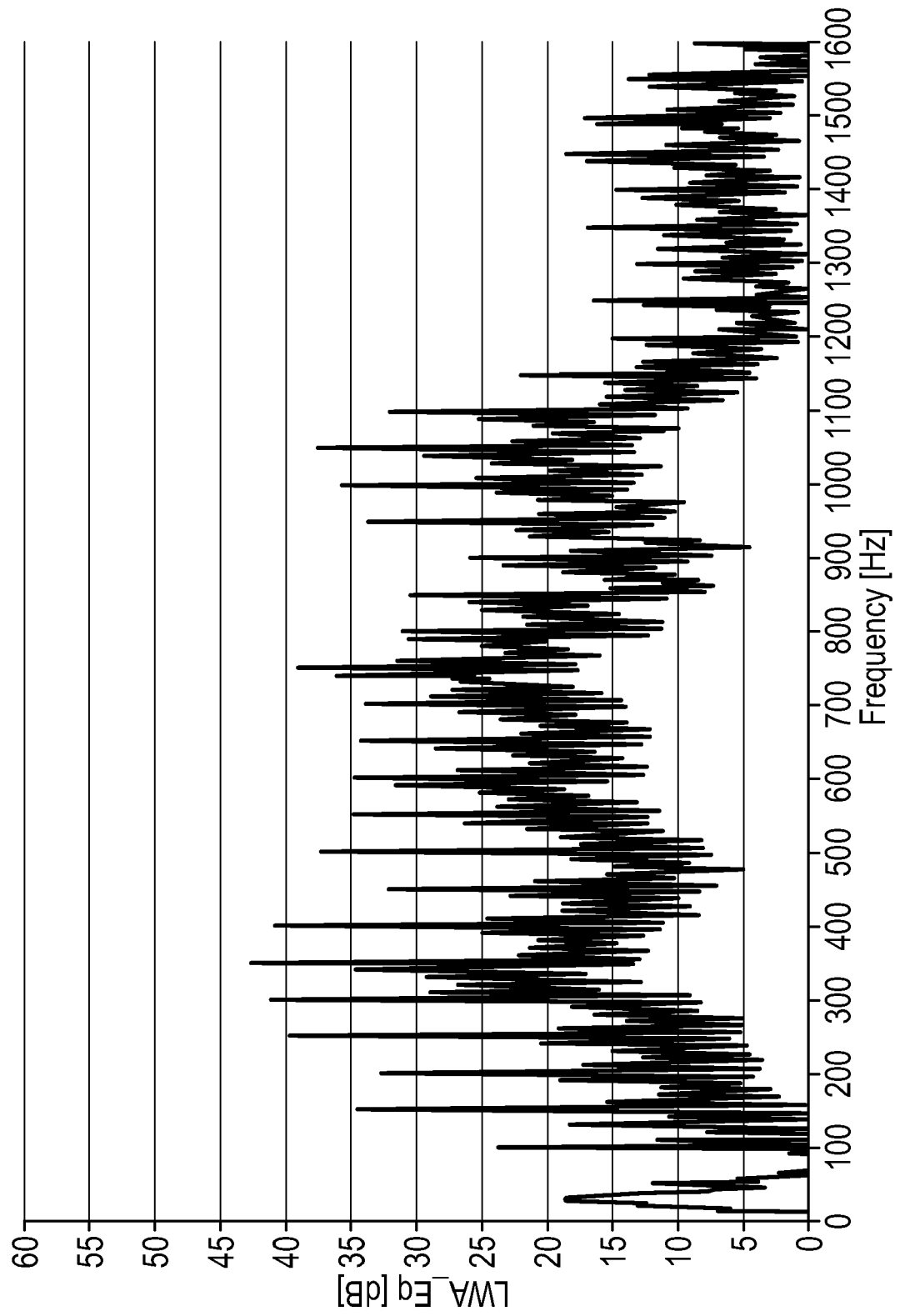
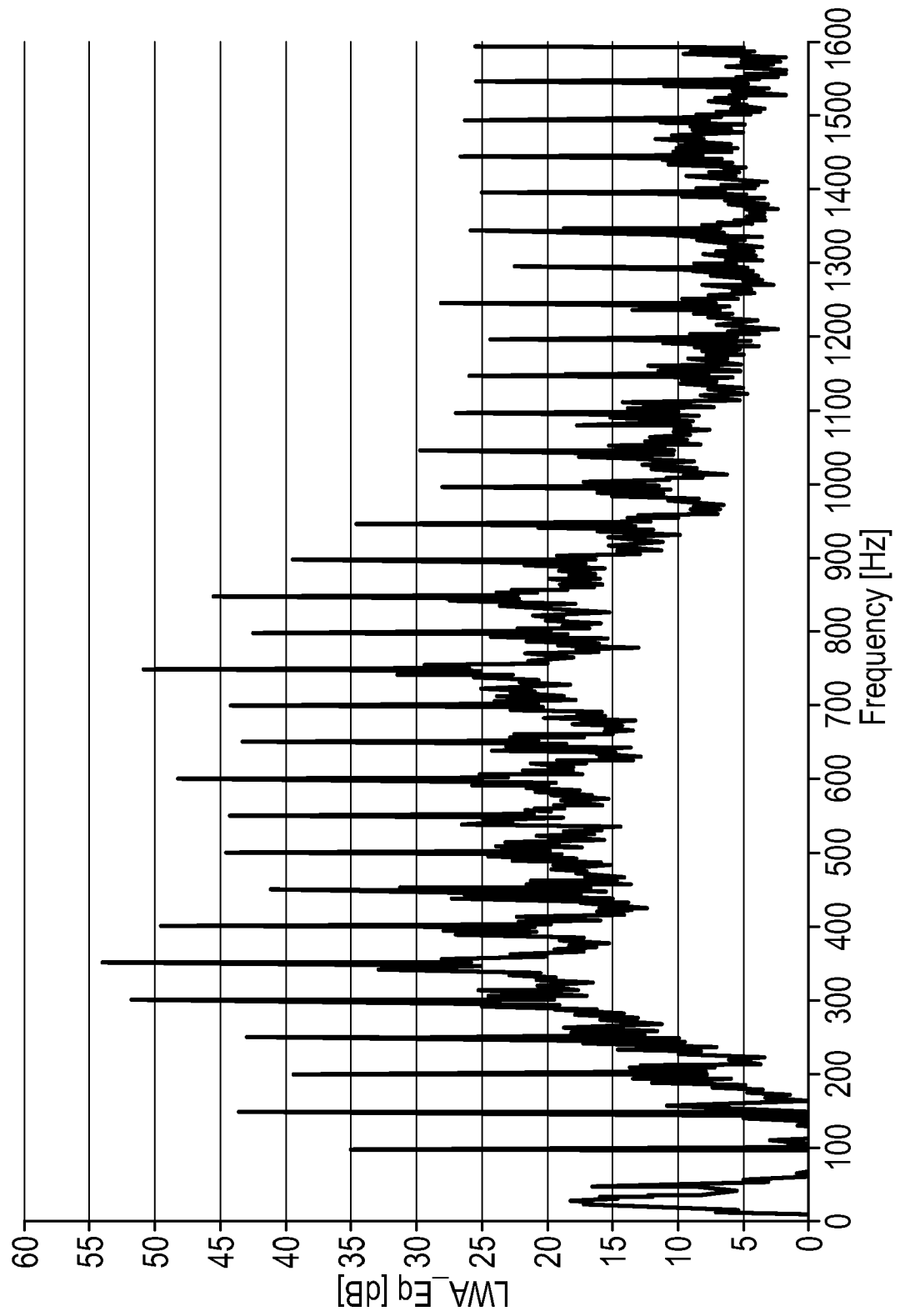


Fig. 5





EUROPEAN SEARCH REPORT

Application Number

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			TECHNICAL FIELDS SEARCHED (IPC)
			D06F F04D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 February 2022	Examiner De Tobel, David
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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