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(54) **MOTORISED IMPELLER ASSEMBLIES**

(57) A motorised impeller assembly for delivering an air flow, the assembly comprising: a first, main air flow path having an inlet and an outlet and through which a main air flow is delivered; a second, ancillary air flow path having an inlet and an outlet and through which an ancillary air flow is delivered; an impeller which is operable to deliver the air flows through the main and ancillary air flow paths; and a motor unit which comprises a drive motor for driving the impeller, and a sensor for sensing a characteristic of the ancillary air flow as delivered through the ancillary air flow path in operation of the impeller, which characteristic is representative of a flow rate of the main air flow as delivered through the main air flow path and enables control of the delivered air flow.

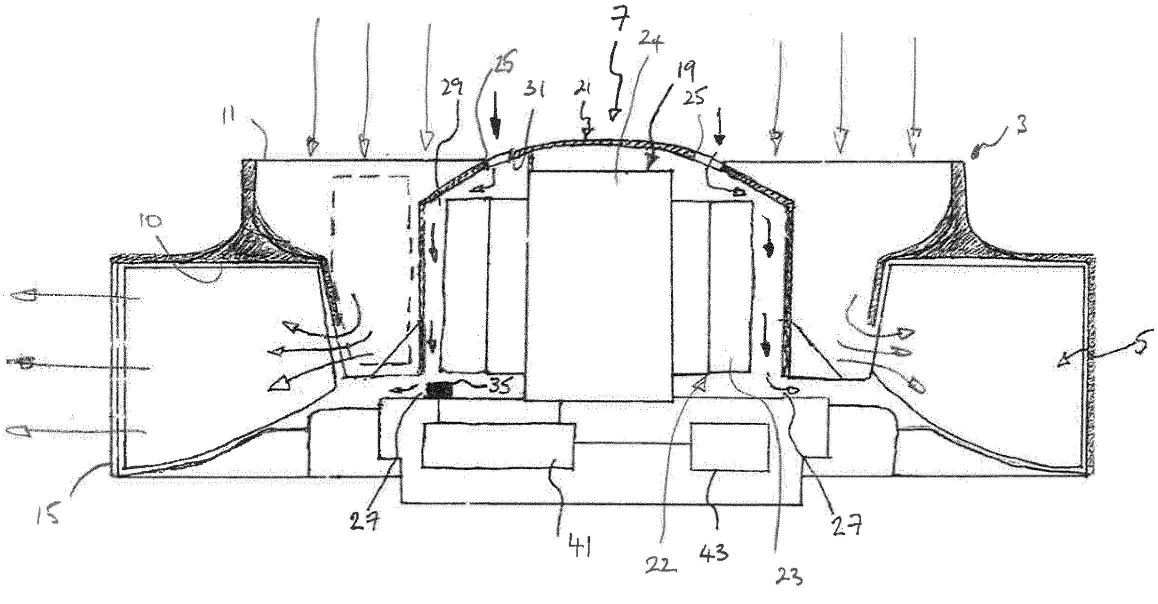

Fig. 2

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Description

[0001] The present invention relates to motorised impeller assemblies and methods for measuring, maintaining and adjusting the output air flow from the same. In particular, the present invention relates to an air-moving system, for example, a fan system, which comprises a motorised impeller assembly and methods for measuring and controlling the output air flow from the same.

[0002] Impellers are used to increase the pressure and flow of a fluid. For example, impellers are used in building ventilation systems to increase air flow through a building. It is desirable to be able to control the output air flow from an impeller, for example, so that the air flow through a building ventilation system can be maintained and/or altered to a desired level.

[0003] The impeller used in an air-moving system may be a centrifugal impeller, such as a forward curved, radial or backward curved impeller, an axial impeller or a mixed-flow impeller. Different designs of impeller exhibit different power/flow relationships due to the system pressures created by the different impellers.

[0004] Forward curved impellers have a predictable power/flow relationship as compared to radial, backward curved, axial or mixed-flow impellers. For this reason, the output air flow from forward curved impellers can be predicted from the torque and speed of the drive motor. Therefore, conventionally, control of the output air flow from forward curved impellers is provided by simply monitoring and adjusting the motor speed.

[0005] The output air flow from other impeller designs, for example, backward curved or axial impellers, cannot simply be determined from the speed of the drive motor, and, in order to obtain a desired output air flow, use of an air flow sensor is required to determine the output air flow, and this determination of the air flow is then used to adjust the speed of the impeller to achieve the desired output air flow. It is particularly difficult to predict the flow output from a backward curved impeller due to the particular power/flow relationship characteristic of this type of impeller design.

[0006] Conventionally, the output air flow produced by impellers other than forward curved impellers is measured using an air flow sensor which is located in the air flow path downstream or upstream of the impeller. Where pressure sensors are used, at least two pressure sensors are provided, with one pressure sensor being located in the air flow path upstream of the impeller and another pressure sensor being located in the air flow path downstream of the impeller. A problem with using pressure sensors in this way is that the sensors must then be either connected to the drive motor or wired separately to the drive motor, and both of these arrangements require a relatively-complicated wiring system.

[0007] Furthermore, in systems having forward curved impellers, if a filter in such a system becomes partially clogged, as disclosed in GB-A-2457534, the output air flow can no longer be determined directly from the speed of the drive motor. For this reason, systems having forward curved impellers also often employ a flow sensor in order more accurately to determine the output air flow.

[0008] Therefore, when an impeller is required as a component in an air-moving system, for example, a fan system, fabrication of the system involves not only providing the impeller within the system, but also providing at least one sensor which must be first located and then wired to the drive motor. This arrangement makes installation and repair of the drive motor and impeller difficult.

[0009] An aim of the present invention is to provide a motorised impeller assembly, particularly a motorised backward curved impeller, which provides a constant and/or controllable flow. Providing a motorised backward curved impeller with these features would be particularly advantageous owing to the high efficiency of backward curved impellers compared to other designs of impeller.

[0010] At its most general the present invention relates to a motorised impeller assembly in which the drive motor is positioned within the impeller and a sensor provides for measurement of fluid flow through the drive motor, from which the output fluid flow from the impeller is determined.

[0011] The present inventors have recognized that, in a motorised impeller assembly, an air flow through the drive motor can provide for measurement of the output air flow from the impeller, and that measuring the air flow through the drive motor allows the sensor to be disposed within the drive motor, as opposed to being required to be wired externally or separately, upstream and/or downstream of the drive motor.

[0012] This arrangement provides a constant and/or controllable flow motorised impeller assembly which can be fitted into an air-moving system, such as a fan system.

[0013] This arrangement has also been found to provide for a more accurate determination of the output air flow from a forward curved impeller than possible using predictive methods.

[0014] The present inventors have also recognized that heat energy produced by the drive motor of a motorised impeller assembly can be used to heat air flowing through or adjacent the drive motor, and that the output air flow of the impeller assembly can be determined by measuring the difference in temperature between air entering and leaving the drive motor.

[0015] In a first aspect the present invention provides a motorised impeller assembly for delivering an air flow, the assembly comprising: a first, main air flow path having an inlet and an outlet and through which a main air flow is delivered; a second, ancillary air flow path having an inlet and an outlet and through which an ancillary air flow is delivered; an impeller which is operable to deliver the air flows through the main and ancillary air flow paths; and a motor unit which comprises a drive motor for driving the impeller, and a sensor for sensing a characteristic of the ancillary air flow as delivered through the ancillary air flow path in operation of the impeller, which characteristic is representative of a flow rate of the main air flow as delivered through the main air flow path and enables control of the delivered air flow.

[0016] Preferred embodiments of the present invention will now be described hereinbelow by way of example only with reference to the accompanying drawings, in which:

Figure 1 illustrates a perspective view of an impeller assembly in accordance with a first embodiment of the invention;

Figure 2 illustrates a vertical cross-sectional view through the impeller assembly of Figure 1;

Figure 3 illustrates a plan view of the body member of the motor unit of the impeller assembly of Figure 1;

Figure 4 illustrates a vertical cross-sectional view through an impeller assembly in accordance with a second embodiment of the invention;

Figure 5 illustrates a plot of the flow rate of the delivered air flow as a function of the temperature differential between temperatures as measured by first and second sensor elements of the sensor of the impeller assembly of Figure 4;

Figure 6 illustrates a vertical cross-sectional view through an impeller assembly in accordance with a third embodiment of the invention;

Figure 7 illustrates a vertical cross-sectional view through an impeller assembly in accordance with a fourth embodiment of the invention; and

Figure 8 illustrates a vertical cross-sectional view through an impeller assembly in accordance with a fifth embodiment of the invention.

[0017] Figures 1 to 3 illustrate an impeller assembly in accordance with a first embodiment of the present invention.

[0018] The impeller assembly comprises a housing 3, an impeller 5 which is disposed within the housing 3 and operable to deliver an air flow through the housing 3, and a motor unit 7 which is disposed within the housing 3 and operable to drive the impeller 5 to deliver the air flow through the housing 3.

[0019] The housing 3 defines a main air flow path 10, which has an inlet 11 through which an air flow is drawn and an outlet 15 through which air is expelled.

[0020] In this embodiment the impeller 5 is a radial flow impeller, and the air flow at the inlet 11 of the housing 3 is orthogonal to the air flow at the outlet 15 of the housing 3.

[0021] In an alternative embodiment the impeller 5 could be an axial flow impeller, and the air flow at the inlet 11 of the housing 3 is aligned with, or parallel to, the air flow at the outlet 15 of the housing 3.

[0022] In this embodiment the impeller 5 comprises a backward curved impeller.

[0023] In alternative embodiments the impeller 5 could be any other centrifugal impeller, such as a forward curved or radial impeller, an axial impeller or a mixed-flow impeller.

[0024] The motor unit 7 comprises an electrical drive motor 19 which is attached to the impeller 5 to drive the same, and a body member 21 which encloses the drive motor 19.

[0025] In this embodiment the drive motor 19 includes an outer stator 22 which has a plurality of windings 23, and an inner rotor 24, which is attached to the impeller 5 and drives the same.

[0026] In this embodiment the body member 21 is separate to the housing 3, but could form part of the housing 3 in an alternative embodiment.

[0027] The body member 21 includes at least one inlet 25 and at least one outlet 27 which is in fluid communication with the outlet 15 of the housing 3, and together with the drive motor 19 defines an ancillary flow path 29 through which an ancillary air flow is drawn on operation of the impeller 5.

[0028] In this embodiment the body member 21 includes a plurality of air inlets 25, which are arranged circumferentially around and in spaced relation from the rotational axis of the impeller 5.

[0029] In this embodiment the open area of the at least one inlet 25 of the body member 21 is less than 1 % of the open area of the inlet 11 of the housing 3.

[0030] In other embodiments the open area of the at least one inlet 25 of the body member 21 could be less than 0.5 %, optionally less than 0.2 % and optionally less than 0.1 % of the open area of the inlet 11 of the housing 3.

[0031] With this configuration, in which the open area of the at least one air inlet 25 is small as compared to the open area of the inlet 11 of the housing 3, the flow rate of the air flowing through the impeller assembly is not substantially reduced.

[0032] In this embodiment the body member 21 includes a flow channel 31 which defines in part the ancillary flow path 29, with one of the inlets 25 of the body member 21 defining the inlet of the ancillary flow path 29 and one of the outlets 27 of the body member 21 defining the outlet of the ancillary flow path 29.

[0033] In this embodiment the ancillary flow path 29 is defined in part by the windings 23 of the drive motor 19, whereby the ancillary air flow draws heat from the windings 23, cooling the windings 23 and causing heating of the ancillary air flow.

[0034] In an alternative embodiment the flow channel 31 could be configured such that the ancillary flow path 29 is fluidly isolated from the drive motor 19 or at least the windings 23 of the drive motor 19.

[0035] In this embodiment the motor unit 7 further comprises a sensor 35, here a flow rate sensor, which is disposed at the ancillary air flow path 29 and measures the flow rate of the ancillary air flow flowing through the ancillary air flow path 29.

[0036] In this embodiment the sensor 35 is located at the outlet 27 of the flow channel 31.

[0037] In this embodiment the sensor 35 is located in opposed relation to the outlet 27 of the flow channel 31, but in an alternative embodiment could be located within the flow channel 31.

[0038] In this embodiment the sensor 35 is a MEMS-based sensor, here a D6F-V03A1 or D6F-W MEMS flow rate sensor (as supplied by Omron Electronic Components Europe BV, Stevenage, UK), but could be any device that can be used to indicate or measure air flow.

[0039] In this embodiment the sensor 35 measures the velocity of the ancillary air flow and produces a corresponding output voltage signal, allowing the flow rate of the main air flow to be calculated by correlation with this output voltage signal.

[0040] In an alternative embodiment the sensor 35 could be a mass flow sensor which comprises a heater, such as resistor, and a temperature-measuring device, such as a thermocouple, which measures the change in temperature of the heater, which is representative of the mass flow and hence flow rate.

[0041] The motor unit 7 further comprises a controller 41 which determines the flow rate of the delivered air flow from the velocity of the ancillary air flow as measured by the sensor 35, with the velocity of the air flow through the ancillary air flow path 29 being proportional to the air flow at the outlet 15 of the housing 3, and, by feedback control, controls the speed of the drive motor 19 in order to maintain the delivered air flow at the outlet 15 of the housing 3 at a desired, predetermined level.

[0042] In one embodiment the motor unit 7 comprises an output flow selector 43, which allows for adjustment by the user of the desired level of delivered air flow, and the output flow selector 43 provides an input to the controller 41.

[0043] Figure 4 illustrates an impeller assembly in accordance with a second embodiment of the present invention.

[0044] The impeller assembly of this embodiment is very similar to the impeller assembly of the first described embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by the like reference signs.

[0045] The impeller assembly of this embodiment differs in that the sensor 35 comprises first and second sensor elements 45a, b, here temperature sensor elements, which are disposed at first and second spaced locations in relation to the ancillary flow path 29, and provide for measurement of a temperature differential along the ancillary flow path 29. As noted above, the windings 23 of the drive motor 19 act to input heat air flowing through the ancillary air flow path 29, and the differential in the temperatures measured at first and second locations is representative of the flow rate, thus allowing for a determination of flow rate from this temperature measurement. Depending upon the configuration of the drive motor 19, the temperature of the ancillary air flow could be increased or decreased along the ancillary flow path 29.

[0046] In one embodiment the first sensor element 45a is positioned at or near the inlet 25 of the ancillary flow path 29 and the second sensor element 45b is positioned at or near the outlet 27 of the ancillary flow path 29, thus measuring the difference in temperature of the air entering the ancillary air flow path 29 and the temperature of the air leaving the ancillary air flow path 29.

[0047] Figure 5 illustrates a plot showing the flow rate of the delivered air flow as a function of the temperature differential between the temperatures as measured by the first and second sensor elements 45a, b.

[0048] As will be seen, the delivered flow correlates, being substantially proportional, to the temperature differential, thus enabling the flow rate to be calculated from the temperature differential.

[0049] In an alternative embodiment the first and second sensor elements 45a, b could comprise pressure sensors, which provide for measurement of a pressure differential along the ancillary flow path 29, which is representative of the flow rate, thus allowing for a determination of flow rate from this pressure measurement.

[0050] Figure 6 illustrates an impeller assembly in accordance with a third embodiment of the present invention.

[0051] The impeller assembly of this embodiment is quite similar to the impeller assembly of the first-described embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail with like parts being designated by like reference signs.

[0052] This embodiment differs from the first-described embodiment in that the windings 23 of the drive motor 19 include a flow passage 51, having an inlet 55 and an outlet 57, which defines the ancillary flow path 29, through which the ancillary air flow is drawn on operation of the impeller 5, with the sensor 35 being located at the flow passage 51, here at the outlet 57 of the flow passage 51. Similarly to the first-described embodiment, measurement of the flow rate at the ancillary flow path 29 allows for a determination of the delivered air flow.

[0053] In an alternative embodiment the body member 21 could omit air inlets 25 of restricted, predetermined size, with the inlet 55 of the flow passage 51 defining the inlet of the ancillary flow path 29.

[0054] In another embodiment the ancillary flow path 29 could be defined by another component part of the drive motor 19 other than the windings 23 thereof.

[0055] In another embodiment the sensor 35 could be located within the flow passage 51.

[0056] Figure 7 illustrates an impeller assembly in accordance with a fourth embodiment of the present invention.

[0057] The impeller assembly of this embodiment is quite similar to the impeller assembly of the first-described embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by like reference signs.

[0058] This embodiment differs from the first-described embodiment in that the ancillary flow path 29 includes a centrifuge chamber 61 in which the sensor 35 is housed, which prevents any contaminants in the ancillary air flow from coming into contact with the sensor 35. In this embodiment, some, or all, of the ancillary air flow flows into the chamber 61.

[0059] In this embodiment the chamber 61 forces the air flowing thereinto to take a deviating path, here a circular path, from the sensor 35, which prevents contaminants in the ancillary air flow from coming into contact with the sensor 35. In this embodiment the sensor 35 is positioned in the centre of the chamber 61, and the chamber 61 forces contaminant particles to the outside of the chamber 61.

[0060] In another embodiment, alternatively or additionally, a software algorithm could be employed to compensate for contamination. For example, the software could be configured to adjust the output of the sensor 35, which is used to determine the delivered flow rate, by a predetermined amount to compensate for a predetermined level of contamination over a predetermined period of time.

[0061] Figure 8 illustrates an impeller assembly in accordance with a fifth embodiment of the present invention.

[0062] The impeller assembly of this embodiment is quite similar to the impeller assembly of the first-described embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by like reference signs.

[0063] This embodiment differs from the first-described embodiment in that the motor unit 7 includes first and second ancillary flow paths 29a, b, each defined at least in part by first and second flow channels 31a, b, and in comprising first and second sensors 35a b, whereby two characteristics of the ancillary air flow can be measured in the determination of the delivered air flow. These characteristics can be of the same kind, or different, such as humidity or gas concentration, for example, CO_2 concentration, in addition to temperature.

[0064] Finally, it will be understood that the present invention has been described in its preferred embodiments and can be modified in many different ways without departing from the scope of the invention as defined by the appended claims.

[0065] For example, the sensor 35 could instead be any kind of sensor, such as to measure humidity, a gas concentration or any characteristic of the ancillary air flow, for example, CO_2 concentration. As discussed above, by virtue of the incorporation of the sensor 35 within the motor unit 7, the need for additional wiring to various parts of the impeller assembly is avoided.

Claims

1. A motorised impeller assembly for delivering an air flow, the assembly comprising:

   a first, main air flow path having an inlet and an outlet and through which a main air flow is delivered;
   a second, ancillary air flow path having an inlet and an outlet and through which an ancillary air flow is delivered;
   an impeller which is operable to deliver the air flows through the main and ancillary air flow paths; and
   a motor unit which comprises a drive motor for driving the impeller, and a sensor for sensing a characteristic of the ancillary air flow as delivered through the ancillary air flow path in operation of the impeller, which characteristic is representative of a flow rate of the main air flow as delivered through the main air flow path and enables control of the delivered air flow.

2. The assembly of claim 1, wherein the impeller is a backward curved impeller.

3. The assembly of claim 1 or 2, wherein the motor unit further comprises a body member which defines at least in part the ancillary air flow path, optionally the ancillary air flow path is defined (a) at least in part by the drive motor, (b) at least in part by at least one winding of the drive motor, or (c) separately of the drive motor, optionally the body member provides an air flow channel which includes at least one inlet opening which defines the inlet of the ancillary air flow path, optionally the air flow channel includes at least one outlet opening which defines the outlet of the ancillary air flow path.

4. The assembly of claim 1 or 2, wherein the ancillary air flow path extends through the drive motor, optionally the ancillary air flow path is defined at least in part by at least one winding of the drive motor.

5. The assembly of any of claims 1 to 4, wherein the open area of the inlet of the ancillary flow path is less than 1 % of the open area of the inlet of the main flow path, optionally the open area of the inlet of the ancillary flow path is less than 0.5 % of the open area of the inlet of the main flow path, optionally the open area of the inlet of the ancillary flow path is less than 0.2 % of the open area of the inlet of the main flow path, optionally the open area of the inlet of the ancillary flow path is less than 0.1 % of the open area of the inlet of the main flow path.

6. The assembly of any of claims 1 to 5, wherein the impeller is (a) a radial impeller and the inlet and the

outlet of the main air flow path are arranged such that the air flow at the inlet of the main air flow path is substantially orthogonal to the air flow at the outlet of the main flow path, or (b) an axial impeller and the inlet and the outlet of the main air flow path are arranged such that the air flow at the inlet of the main air flow path is substantially parallel to the air flow at the outlet of the main flow path.

7. The assembly of any of claims 1 to 6, wherein the sensor is (a) a flow rate sensor for measuring flow rate of the ancillary air flow as delivered through the ancillary air flow path, optionally the flow rate sensor comprises a mass flow sensor, optionally comprising a thermocouple and a heater, (b) a temperature sensor for measuring temperature of the ancillary air flow as delivered through the ancillary air flow path, which temperature is representative of flow rate, optionally the temperature sensor comprises first and second temperature sensor elements which measure temperature of the ancillary air flow as delivered through the ancillary air flow path at first and second spaced locations, (c) a pressure sensor for measuring pressure of the ancillary air flow as delivered through the ancillary air flow path, which pressure is representative of flow rate, optionally the pressure sensor comprises first and second pressure sensor elements which measure pressure of the ancillary air flow as delivered through the ancillary air flow path at first and second spaced locations, or (d) an environmental sensor for measuring an environmental factor of the ancillary air flow as delivered through the ancillary air flow path, which environmental factor is representative of flow rate, optionally the environmental sensor comprises first and second environmental sensor elements which measure an environmental factor of the ancillary air flow as delivered through the ancillary air flow path at first and second spaced locations, optionally the environmental factor is humidity or a gas, optionally carbon dioxide.

8. The assembly of any of claims 1 to 7, wherein the sensor is a MEMS based sensor.

9. The assembly of any of claims 1 to 8, further comprising:

a housing which includes the inlet and the outlet of the main air flow path.

10. The assembly of any of claims 1 to 9, wherein the sensor is located on a printed circuit board of the drive motor.

11. The assembly of any of claims 1 to 10, wherein the ancillary air flow path includes a separation chamber by which particulates are separated from within the ancillary air flow, thereby reducing contamination of the sensor, optionally the separation chamber is a centrifuge chamber, in which the ancillary air flow flows radially outwardly about the sensor.

12. The assembly of any of claims 1 to 11, further comprising:

a control unit for controlling the drive motor so that the impeller assembly delivers a predetermined air flow.

13. An air-moving system comprising the assembly of any of claims 1 to 12, optionally the air-moving system is a fan system.

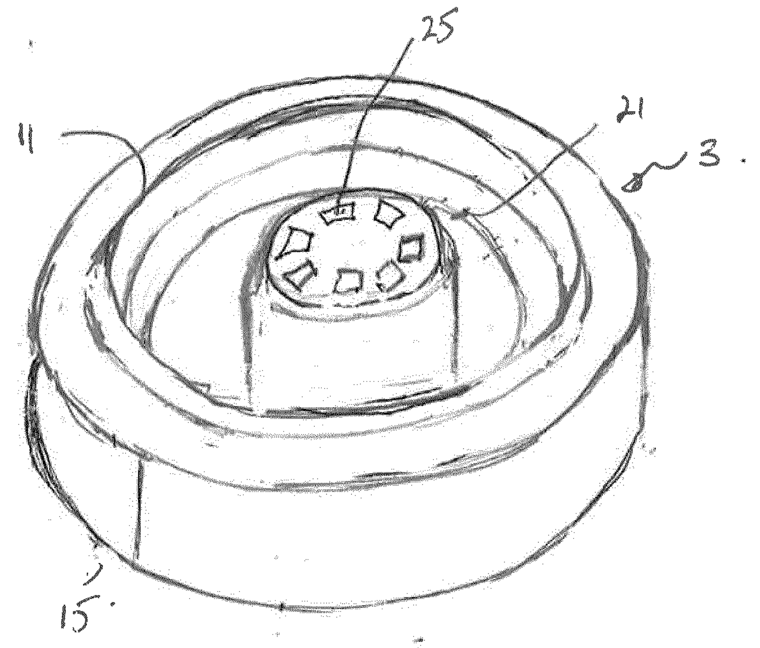

Fig. 1

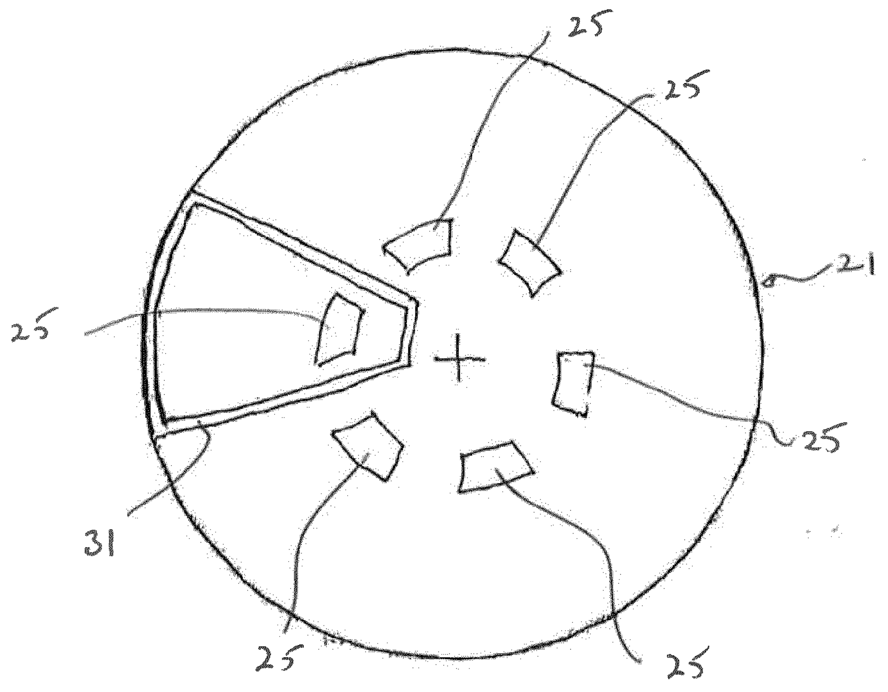

Fig. 3

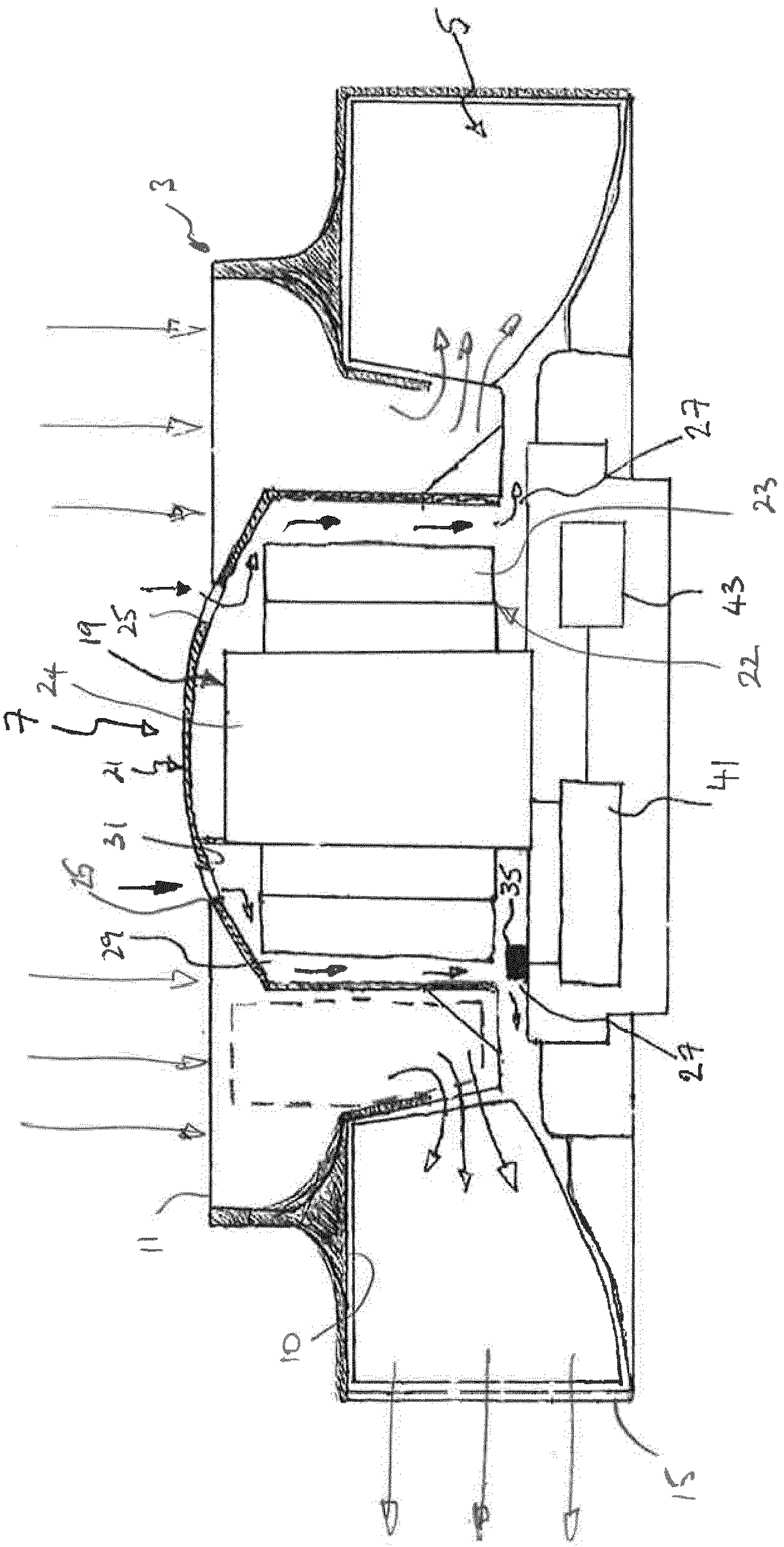

Fig. 2

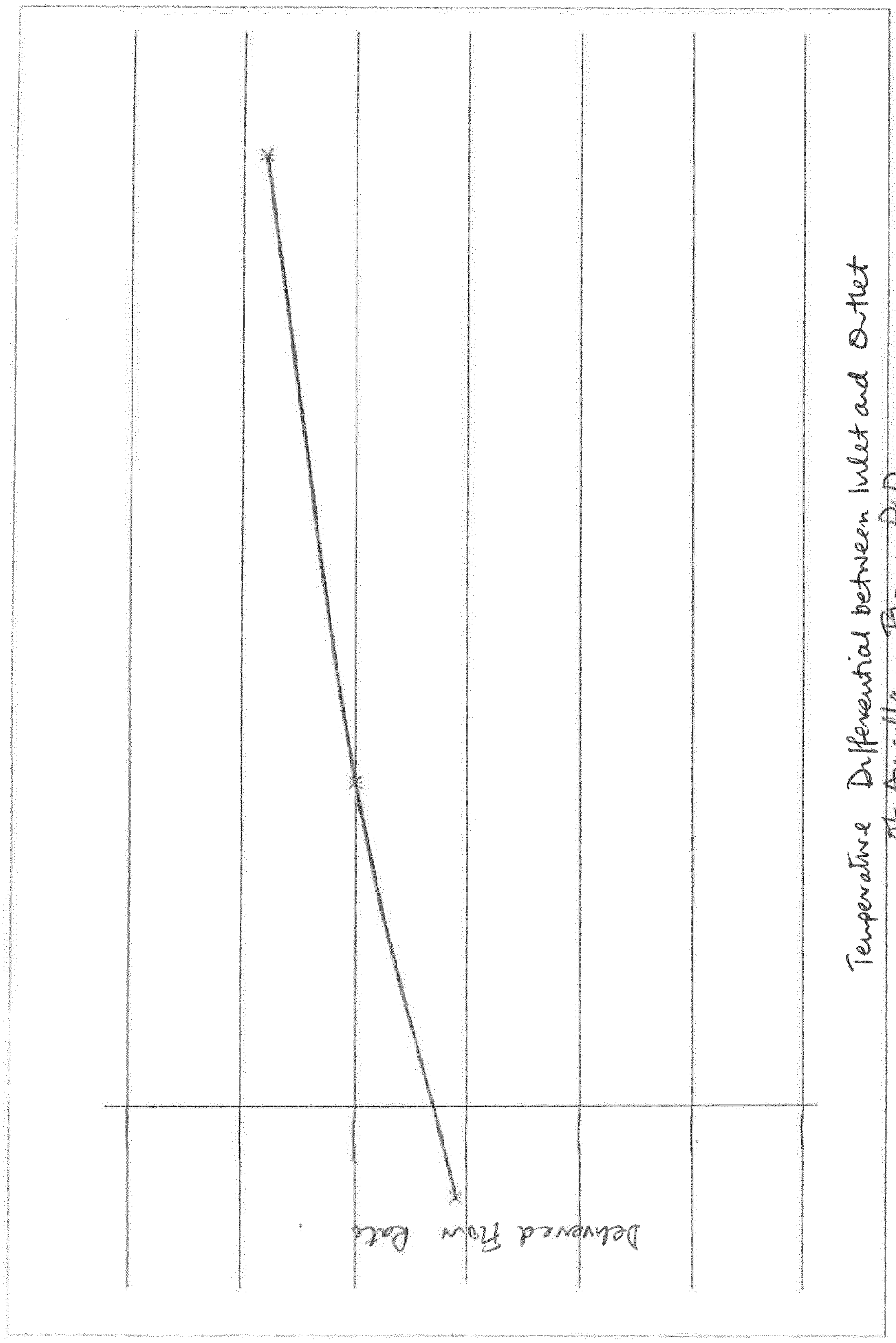
Temperature Differential between Inlet and Outlet of Ancillary Flow Path
Delivered Flow Rate

Fig. 4

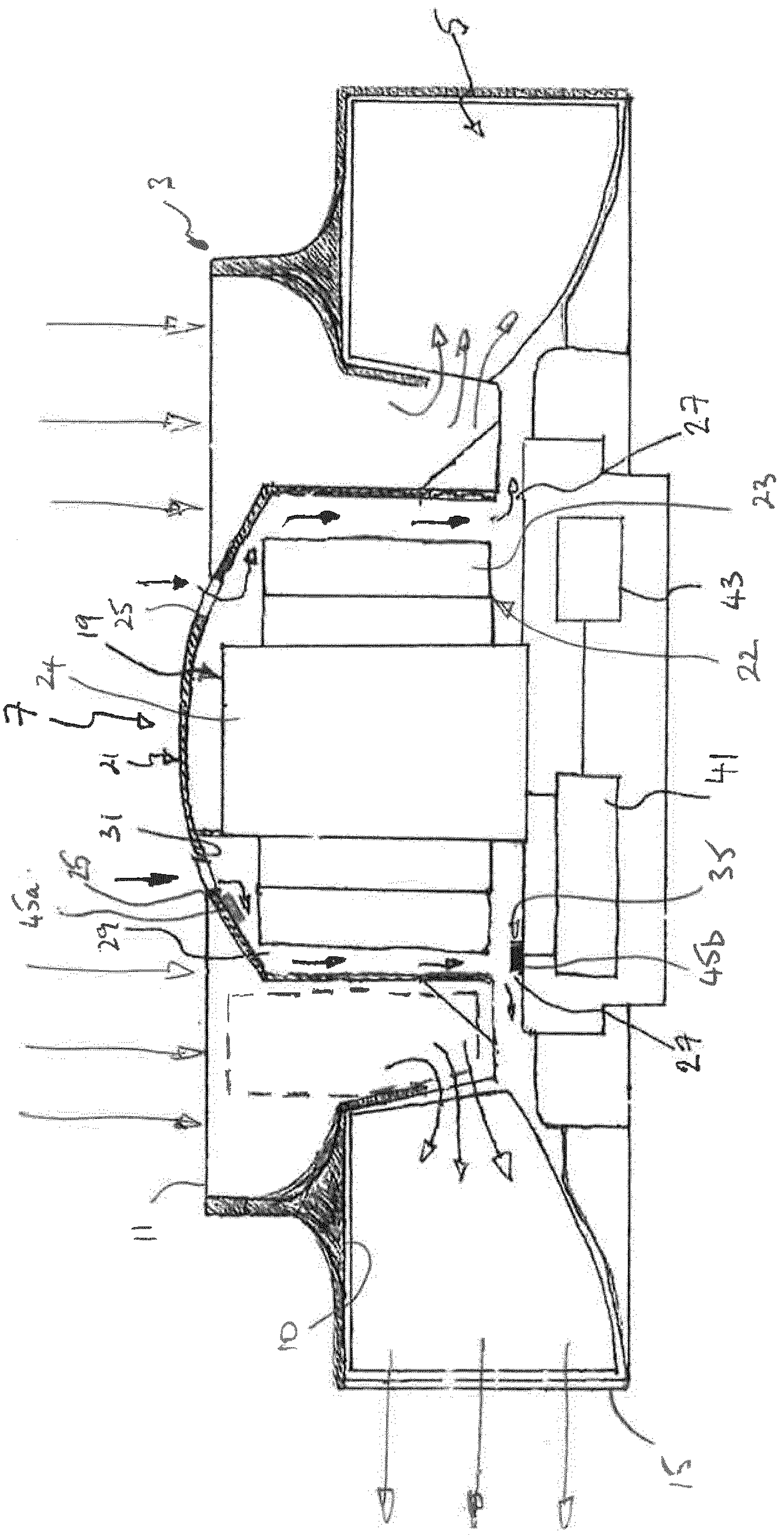

Fig. 5

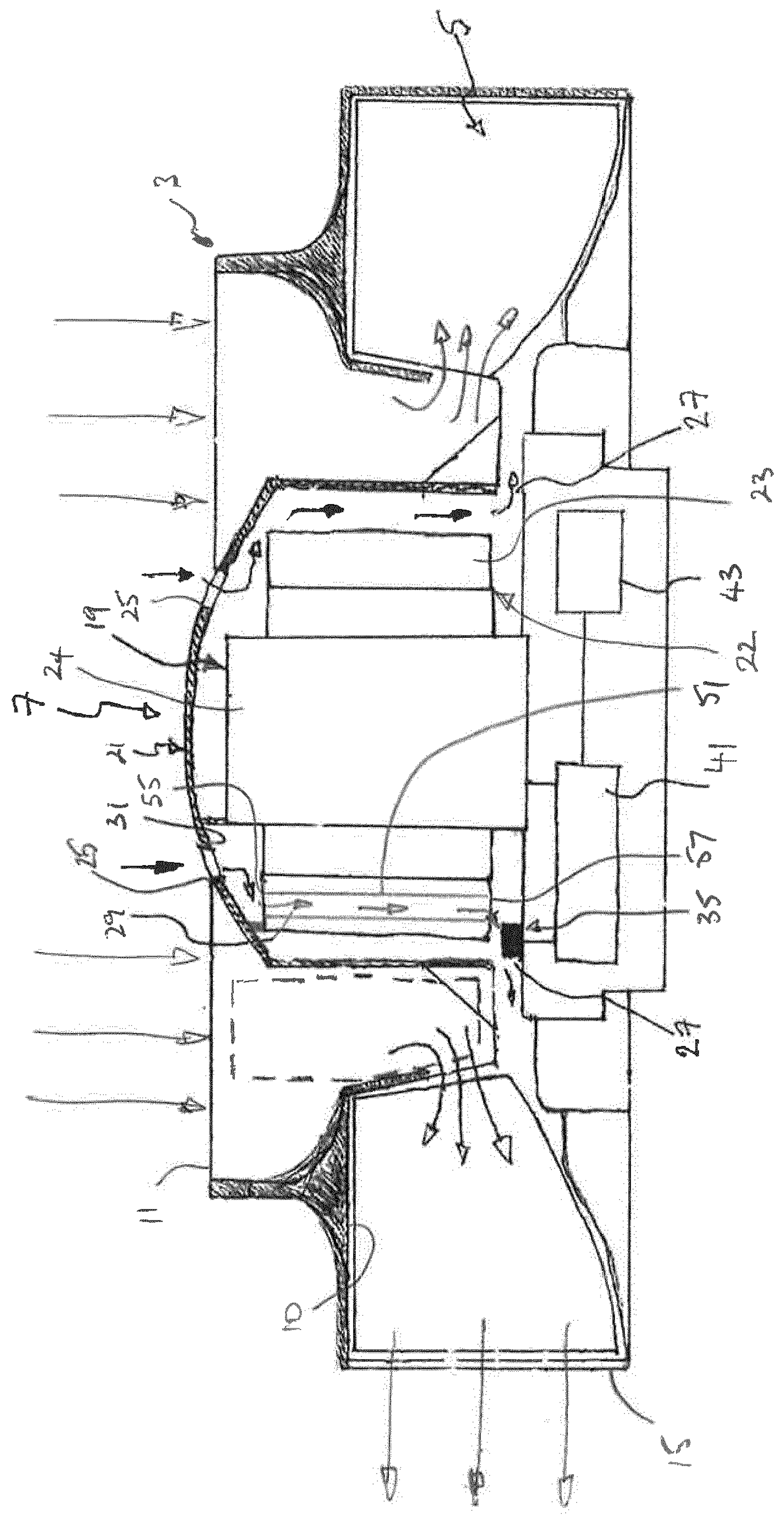

Fig. 6

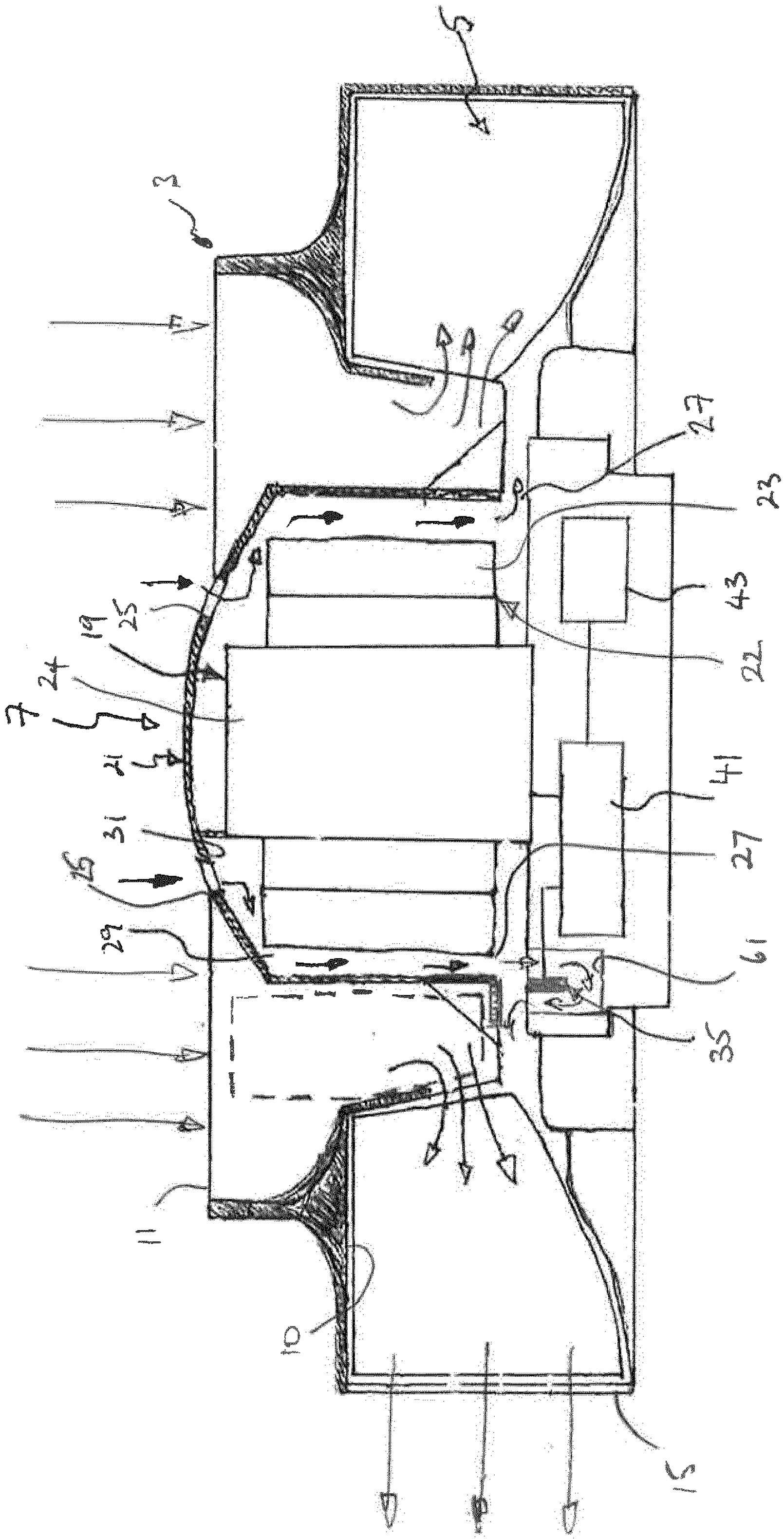

Fig. 7

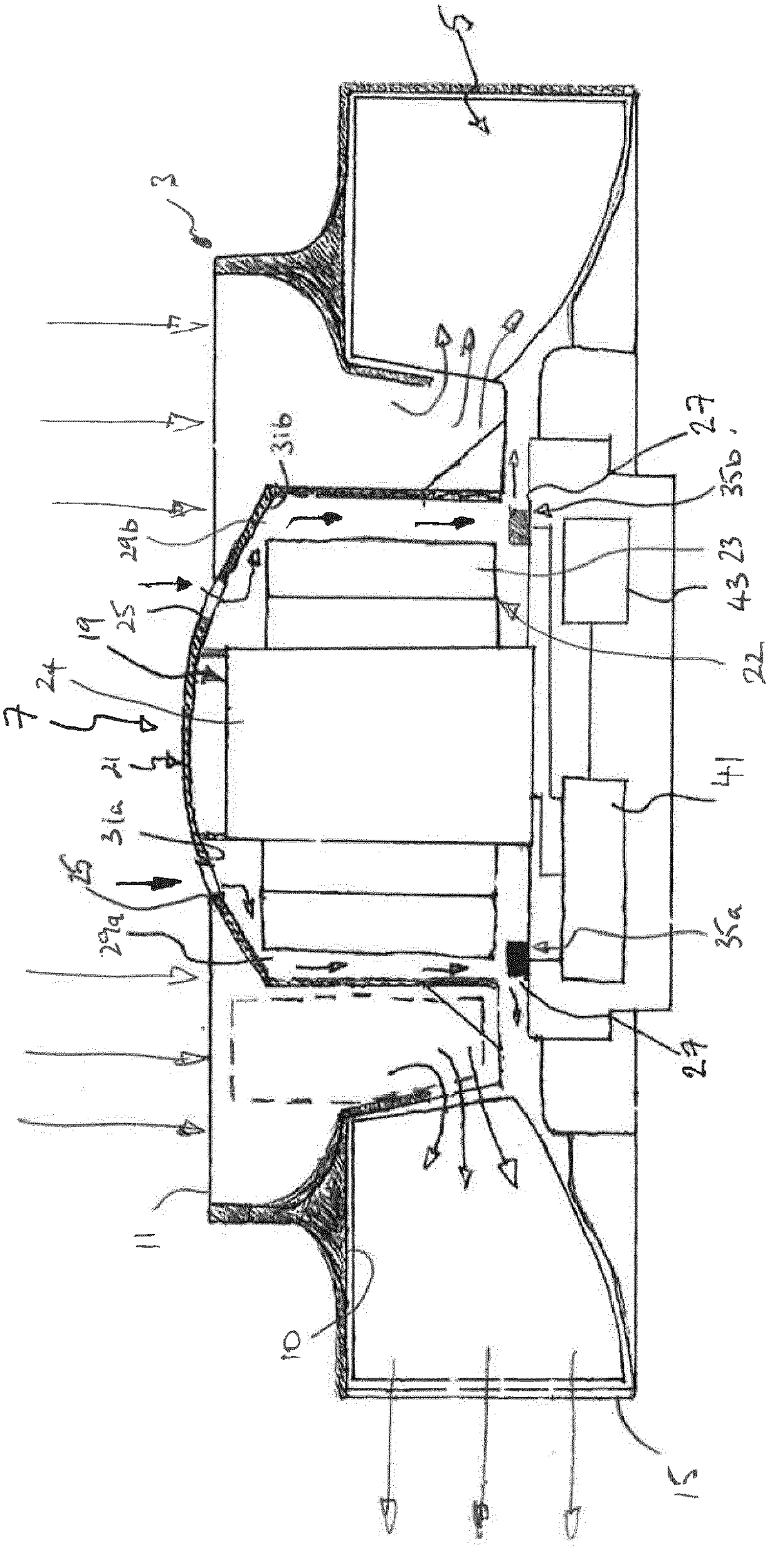

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 1980

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2010/178181 A1 (CHEN HUNG-CHI [TW] ET AL) 15 July 2010 (2010-07-15) * figures 3a, 3b * * paragraphs [0026] - [0027] * -----	1-13	INV. F04D25/08 F04D27/00
A	US 2013/209218 A1 (REUNANEN ARTTU [FI] ET AL) 15 August 2013 (2013-08-15) * claims 1,6 * * figure 1 * -----	1-13	
A	EP 0 626 519 A1 (BROD & MCCLUNG PACE CO [US]) 30 November 1994 (1994-11-30) * figure 2 * * column 3, lines 23-28 * -----	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

F04D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	9 May 2016	Ingelbrecht, Peter

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 15 1980

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

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