REGENERATIVE BLOWER

FIELD OF THE INVENTION

The present description relates to regenerative blowers and various configurations. Such regenerative blowers can be used in respiratory apparatus, and other end-use applications.

BACKGROUND

A regenerative blower comprises a housing with an airflow channel for flow of air from an inlet to an outlet. An impeller driven by a motor rotate is in a channel that is pneumatically connected to the airflow channel. The impeller rotates to provide a flow of air within the airflow channel from the inlet to the outlet. The airflow channel has an interrupter positioned between the inlet and outlet to prevent airflow going directly from the outlet to the inlet.

SUMMARY OF INVENTION

It is an object of the present invention to provide an improved regenerative blower.

In accordance with one aspect the present invention may comprise a regenerative blower comprising: a housing, a first port and second port in the housing, an airflow channel extending between the first and second ports for airflow between the ports, an impeller rotatable in an impeller channel to promote airflow in the airflow channel from the first port to the second port, a motor to drive the impeller, and an interrupter between the first and second ports to limit airflow from the second port to the first port, wherein the housing comprises a central aperture that provides a third port, and wherein the central aperture is an outlet from the impeller channel and/or the airflow channel under relatively low flow conditions, and an inlet under relatively high flow conditions.

Optionally the first port is an inlet port and the second port is an outlet port and the impeller rotates in a direction to promote airflow in the airflow channel from the inlet port to the outlet port.

Optionally the airflow channel comprises an arcuate channel connecting the first and second ports, the first port is in fluid communication with a first end of the arcuate channel, the second port is in fluid communication with a second end of the arcuate channel, and the interrupter comprises a wall formed between the first and second ends of the arcuate channel.

Optionally the wall has a leading face facing towards the second end of the arcuate channel.

Optionally the partial turn spans 36° - 144° of a complete revolution, or 10-40% of the complete revolution.

Optionally the motor comprises a rotor and the housing comprises an aperture with a diameter that is shaped to enable, during manufacture, an assembly of the rotor coupled to the impeller by a shaft to be placed in the housing through the aperture.

Optionally the housing comprises a top housing and a bottom housing with a bottom plate, and the aperture is in the bottom plate of the bottom housing.

Optionally the aperture provides a third port.

Optionally the bottom housing comprises an impeller housing and a bottom housing cap.

Optionally the bottom housing cap includes at least one bottom housing cap aperture.

Optionally the housing comprises a top housing and a bottom housing, the impeller is disposed in the top housing, the motor is disposed at least partially in the bottom housing and the top housing is open to the bottom housing such that there is no plate or other barrier of the housing separating the impeller and the motor.

Optionally the airflow channel comprises an upper channel and a lower channel.

Optionally the impeller channel separates the upper channel and the lower channel.

Optionally lateral ends of the impeller rotate adjacent an interior lateral face of the housing.

Optionally the clearance between the lateral ends of the impeller and the interior lateral face of the housing is about 0.5 mm to 1 mm.

In accordance with another aspect the present invention may comprise an impeller for a regenerative blower comprising: a hub, a first set of blades supported from and arranged around the hub, and a second set of blade supported from and arranged around the hub.

the second port to the first port, wherein the housing comprises a central aperture that provides a third port.

Optionally the housing comprises a top housing and a bottom housing and the aperture comprises one or more openings in the top housing.

Optionally the housing comprises a top housing and a bottom housing and the aperture comprises one or more openings in the bottom housing.

Optionally the aperture is an additional inlet port or an outlet port.

Optionally the airflow channel comprises an outer airflow channel extending between the first and second ports, and an inner airflow channel.

Optionally the inner airflow channel is formed from an arcuate wall between the inner airflow channel and outer airflow channel, wherein the wall has an airflow opening allow airflow between the inner airflow channel and outer airflow channel.

Optionally the impeller channel comprises an outer impeller channel and an inner impeller channel, wherein the inner airflow channel is the inner impeller channel.

Optionally, the regenerative blower comprises a common channel that includes the airflow channel and the impeller channel.

Optionally, the impeller comprises an axial axis about which the impeller is rotatable, and wherein the first set of blades are axially displaced with respect to the second set of blades, and the first set of blades is rotationally offset around the axial axis from the second set of blades.

Optionally, the web is an annular impeller support plate.

The term "comprising" as used in this specification means "consisting at least in part of". When interpreting each statement in this specification that includes the term "comprising", features other than that or those prefaced by the term may also be present. Related terms such as "comprise" and "comprises" are to be interpreted in the same manner.

This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth.

Figure 75 shows a top perspective view of an impeller suitable for use with the fourth embodiment of the regenerative blower.

Figure 76 shows a top view of the impeller of Figure 75.

Figure 77 shows a bottom view of the impeller of Figure 75.

Figure 78 shows a bottom perspective view of the impeller of Figure 75

Figure 79 shows a top perspective view of a regenerative blower according to a fifth embodiment.

Figure 80 shows a cross-sectional view of the fifth embodiment of the regenerative blower.

Figures 81-84 show elevation views of the fifth embodiment of the regenerative blower.

Figure 85 shows a cross-sectional view of the fifth embodiment of the regenerative blower.

Figure 86 shows a top view of the fifth embodiment of the regenerative blower.

Figure 87 shows a bottom view of the fifth embodiment of the regenerative blower.

Figures 88 to 105 show graphs of experimental data indicating performance of the various embodiments.

Figure 106 is a diagram of a respiratory apparatus, such as a continuous positive airway pressure (CPAP), high flow therapy, non-invasive ventilation or other respiratory apparatus that utilises a regenerative blower such as described herein.

DETAILED DESCRIPTION

1. Gas flow apparatus using regenerative blower

The regenerative blower described herein in various embodiments can be used in any suitable gas flow apparatus application. The regenerative blower described can be particularly useful for respiration apparatus, but is not restricted to use solely in that application. Other applications where a regenerative blower as described could be used could be envisaged by those skilled in the art. Also, the regenerative blower could be reconfigured to act as a vacuum and be used in any suitable gas flow apparatus where a vacuum is required. For example, the regenerative blower described herein can be configured as a suction generating device. Such a suction generating device could be used as part of a suction system, or a system configured to provide suction. The regenerative blower will be arranged to generate suction or a

As the behaviour of the bottom housing aperture 148 is variable, (acting as an inlet when running at high flow, and an outlet when running at high pressure) it can be beneficial to use a one-way valve to control the behaviour of the bottom housing aperture. A plurality of apertures in a bottom housing cap 141 feed the bottom housing aperture 148. The one-way valve would be placed over/blocking the bottom housing cap plurality of apertures, which would in turn act as a one way valve on the bottom housing aperture 148. Examples of a one way valves that can be used include mechanical valves, or fixed-geometry passive valves such as a Tesla Valve. Incorporating the one-way valve improves the performance of the blower in both low flow (high pressure) conditions, as leak through the port is no longer able to occur, and high flow (low pressure) conditions, as the port is able to be used as an inlet to draw in additional air. Similar one-way valve arrangements can also be added to the bottom housing apertures of the other embodiments described herein to improve performance as described.

Figure 10 shows an alternative variation the bottom housing 103, in which the bottom housing aperture 148' is smaller than that of the variation of Figures 7 and 8. The smaller bottom housing aperture 148' reduces the flow of air that leaks from the aperture 148' when the blower 100 is operated. This can improve the pressure and flow performance of the blower 100 as the amount of air leaking from the bottom housing aperture 148' is minimised.

Referring to Figures 8, 9, the bottom housing 103 comprises an annular wall 150. The housing 101 further comprises the bottom housing cap 141. The bottom housing cap 141 includes a plurality of bottom housing cap apertures 152. The annular wall 150 comprises a plurality of lugs 153 extending therefrom for removably coupling the bottom housing cap 141 to the bottom housing 103, via screws, bolts or other fasteners. Alternatively, other coupling means could be used instead of lugs/screw arrangements, for example welding, gluing or use of adhesive bonding techniques. The annular wall 150, when coupled to the bottom housing cap 141, forms an interior region 155 (internal cavity) for housing the motor assembly 110. The bottom housing cap 141 can be removed from the bottom housing 103 to allow access to the internal cavity 155 and/or components such as the motor assembly, which is contained within the internal cavity 155. The bottom housing cap apertures 152 also allow airflow to and from the blower 100 via the bottom housing aperture 148. In combination with the bottom housing aperture 148, the bottom housing cap apertures 152 provides an additional airflow path (port) into the blower 100. In addition, the bottom housing cap apertures 152 allow for improved motor cooling as a result of the additional and/or alternate air flow paths. It can also allow for

comprises a leading face 161 and a trailing face 160. The leading face 161 is the face that an impeller blade 175 passes as it encounters the interrupter 125 for the first time during a given rotation. The trailing face 160 is the face that the impeller blade 175 passes as it completes its traversion of the interrupter 125. Each of the inlet port 120 and the outlet port 121 include an interrupter edge 163 and an airflow channel edge 165. The interrupter edge 163 is the edge of the inlet port 120 and/or the outlet port 121 that is adjacent to, and/or forms part of the interrupter 125. In the illustrated configuration, the interrupter edge 163 (shown in Figure 11) of the outlet port 120 is an edge of the leading face 161 of the interrupter 125. In the illustrated configuration, the interrupter edge 163 of the inlet port is an edge of the trailing face 160 of the interrupter 161. The airflow channel edge 165 of each of the inlet port 120 and the outlet port 121 is the edge of each respective port that is adjacent to, or forms part of the boundary of the airflow channel 132 of the top housing 102. In the illustrated configuration, each interrupter edge 163 and airflow channel edge 165 are rounded. The rounded edges help reduce the blade pass noise as the impeller 115 rotates past (transits) the inlet port 120 and outlet port 121. In alternatives, each interrupter edge 162 and airflow channel edge 165 can be non-rounded or square edge, or be a chamfered edge, if different behaviours are desired. For example, sharper edges result in better pressure and flow performance, and are better for power consumption, and so can be used where noise isn't a large concern.

2.2.4 Motor

The bottom housing aperture 148 is large enough that the rotor 113 can fit through it. This is beneficial in the manufacturing process of the motor. The impeller 115 and rotor 113 can be attached to the shaft 112, and then the combined impeller/shaft/rotor part can then be fit through the bottom housing aperture 148. The side of the shaft 112 with the rotor 113 is moved through the bottom housing aperture 148 so that the rotor 113 is on the bottom side of the bottom housing 103, and the impeller 115 fits within the impeller channel 145 of the bottom housing. This can reduce the cost and/or number of steps involved in manufacturing the blower 100.

2.2.5 Impeller

As described above, the impeller 115 sits in the impeller channel 145 (bottom portion of the channel 104) and rotates therein**.** Figures 14 to 18 show a possible embodiment of the impeller 115. The impeller comprises a central hub 170 with an aperture 171 for supporting the impeller 115 on the shaft 112 extending from the motor 110. A plurality of spokes 172 supported on a central support plate 173 extend from the hub 170 to the inner side of an annular impeller blade support channel 174

manufactured. An impeller with low rotational inertia can be quickly accelerated and decelerated. A lightweight impeller is therefore suited for quickly responding to fluctuating pressure requirements, such as the normal inhalation and exhalation cycle of a patient connected to the breathing assistance device in which the impeller operates.

2.2.6 Operation

The blower 100 can be used in a gas flow apparatus, such as one of those described previously, to effect the operations of the gas flow apparatus 600. In at least one form, the respiration apparatus 600 can be a breathing assistance apparatus 600. A controller is used to control operation of the blower 100, and in particular to control provision of power to the motor and operation of the motor (more generally, "energise" the motor). Referring to Figures 2, 5A, 5B, in one configuration, the regenerative blower 100 is operated by the controller to blow in a single direction. The controller provides power and control to rotate the motor, which in turn rotates the impeller 115 within the impeller channel 145, drawing air in through the inlet port 120 and blowing the air out through the outlet port 121.

In another configuration, the regenerative blower 100 can be configured to rotate the impeller 115 in both of a first direction of rotation and an opposite or second direction of rotation (i.e. to function as a dual outlet, bi-directional or reversible blower). The controller energises the motor to rotate the impeller 115 in a first direction of rotation to generate a flow of gases to exit the outlet port of the housing. Energizing the motor to rotate the impeller 115 in an opposite second direction of rotation generates a flow of gases to exit what was formerly the inlet port, and is now the outlet port of the housing, drawing air through what was formerly the outlet port, and is now the inlet port. So as opposed to strictly having an inlet port and an outlet port, the bi-directional blower can be said to have a first port and a second port, where the first port is the inlet when blowing in the first direction, and the second port is the inlet when blowing in the second direction. Figure 13 shows the blower with a reversed direction.

Cycling the direction of rotation of the impeller 115 allows rapid alternation between positive pressure and negative pressure at one of the ports of the blower 100. A rapidly reversible blower can be useful in applications including simulating lungs, or providing ventilation to patients with breathing difficulties. This effect can be performed best when a lightweight and/or low inertia impeller is used, such as that previously described (or also, build according to principles such as those described in WO2013009193, which is incorporated herein by reference in its entirety) because the moment of inertia is minimised for a lightweight impeller. A lightweight and/or

about 5 mm to 10 mm, such as equal to or about 7.5 mm. Again, as a non-limiting example, blade surface area could be between about 50 mm2 to 100 mm2, such as equal to or about 76.95 mm2. In a non-limiting example, the impeller 115 can be made from plastic such as ABS plastic, or other material resulting in a relatively lightweight impeller with a low moment of inertia. As an example, an impeller made from ABS plastic or similar to the dimensions above weighs between about 3g and 12g, such as equal to or about 6.7 g if made from ABS plastic, or 8g if made from 3D printed material (e.g. a photopolymer resin).

2.3 Second embodiment of a regenerative blower

Figures 19 to 32 show a regenerative blower according to a second embodiment. Features of the second embodiment that are the same or similar to those of the first embodiment may not be described fully or at all, but it will be appreciated by those skilled in the art that relevant portions of the description relating the first embodiment or any other embodiments described herein apply to this embodiment, where appropriate.

2.3.1 Overview

Referring to Figure 19, the regenerative blower 200 of the second embodiment, like the first embodiment, comprises a housing 201 with a top housing 202 and a bottom housing 203. The housing 201 comprises first 220 and second 221 ports for an inlet and an outlet, a channel 204, an interrupter 225, and a motor assembly 210 including a stator 211, a rotor 213, a shaft 211, and an impeller 215 coupled to the motor 210. The impeller 215 can be that described previously in relation to the first embodiment.

Features the blower according to the second embodiment that may not have been described in relation to other embodiments will now be described in more detail.

2.3.2 Housing – configuration #1

Like the other embodiments, the blower housing 201 comprises a top housing 202, a bottom housing 203 and a bottom housing cap 241.

In a first configuration of the second embodiment (shown in Figures 19-28), the top housing 202 provides a different configuration (compared to the first embodiment) of first 220 and second 221 ports (inlet port and outlet port). The inlet port 220 comprises an aperture 220A, an inlet collar 220B and inlet conduit 220C. The inlet aperture 220A and inlet collar 220B are arranged proximate the centre of the top housing 202, with the inlet aperture 220A inclined at an angle to face away from the top housing 202. The inlet collar 220B and an inlet aperture 220A are spaced

edges thereof) are orientated and/or shaped to present at an angle to the impeller blades when they rotate.

In the first configuration of the second embodiment interrupter 225 (shown in Figures 27 and 28), the interrupter 225 comprises a blocking wall on the top housing 202 between the inlet port 220 and the outlet port 221. The blocking wall is in the form of a bridge between a hub 239 and the perimeter portion 231. The interrupter 225 comprises a leading face 261 adjacent/interfacing with the outlet conduit 221C (the leading face 261) and forms a wall of at least some of the outlet conduit 221C on the top housing 202. The leading face 261 is concave curved as per the concave surface of the outlet conduit 221C. The leading face 261 can be in the form of a swept leading face. The leading face 261 can be swept when viewed from bottom of the interrupter 225 as shown in Figure 27. The leading face 261 can comprise a leading edge. The leading face 261 extends from point C1 to point D1 across the airflow channel 232 of the top housing 202, such that the leading face 261 blocks the airflow channel 232 to limit airflow going directly from the outlet port 221 to the inlet port 220. The leading face 261 sweeps across an angle C formed between the radius line between the central aperture and C1 and the radius line between the central aperture and D1 (which is also on othe same radius line as C2). The sweep of the leading face 261 can be any suitable configuration or shape, such as straight, curved or the like. The angle C can be anything such that the leading face 261 may take any configuration from between radial to tangential, depending on the required configuration and the configuration of the outlet conduit.

The interrupter 225 also has a trailing face 260 adjacent/interfacing the inlet conduit 220C and forms a wall of at least some of the inlet conduit 220C on the top housing 202. The trailing face 260 is concave curved as per the concave surface of the inlet conduit 220C. The trailing face 260 can be swept when viewed from bottom of the interrupter 225. The trailing face 260 extends from point C2 to point D2 across the airflow channel 232 of the top housing 202, such that the interrupter 225 blocks the airflow channel 232 to limit airflow going directly from the outlet port 221 to the inlet port 220. The trailing face 260 sweeps across an angle D formed between the radius line between the central aperture and C2 and the radius line between the central aperture and D2. The sweep of trailing face 260 can be any suitable configuration or shape. The angle D can be anything such that the swept edge may take any configurations from between radial to tangential, depending on the required configuration and the configuration of the inlet conduit 220C.

In this configuration, the arc length between point C1 and point C2 is less than the arc length between point D1 and point D2. Furthermore, point D1 is displaced

impeller channel 345. The inlet port 320, formed of a generally straight inlet, comprising itself and inlet aperture 320A, inlet collar 320B and inlet conduit 320C, integrally forms with the upper airflow channel 332A at a nominal junction 370. The upper airflow channel 332A is formed in the generally circular portion 302A of the top housing. The upper airflow channel 332A extends between the inlet port 320 and the outlet port 321. The outlet port 321 comprises an outlet aperture 321A, outlet collar 321B and outlet conduit 321C which is integrally formed at a nominal juncture 371 with the other end of the upper airflow channel 332A as the inlet port 320.

A plurality of lugs 342 are formed in a perimeter portion of the top housing to allow for coupling of the top housing 302 with the bottom housing 303, with screws, bolts or other fasteners. A perimeter wall 331 extends from the inlet port 320 around the perimeter of the top housing to the outlet port 321, and also between the space between the inlet and outlet ports ("front wall" 331A). The inner wall of the upper airflow channel 332A extends up and across into a flat shelf/plateau 380 that extends between opposite sides of the upper airflow channel 332A. An inner portion of the interior of the top housing 302 on the top shelf 380 comprises a central hub/boss 339 with an aperture or hole 338 for receiving a motor shaft 312 bearing. The hub 339 defines a wall of the impeller channel 345. The hub 339, like the interrupter 325, acts to impede the flow of air leaking from the outlet port 321 to the inlet port 320 during operation by creating a barrier preventing the flow of air from the outlet port 321 to the inlet port 320 via the central region of reduced vertical thickness of the impeller 315. The hub 339, the shelf 380 above the channel between hub and the front wall 331A, and the front wall 331A together form an interrupter 325, which will be described further below. The front wall 331A comprises an inside surface 369. The inside surface 369 of the front wall 331A is adjacent to, or at least partially defines a boundary of the impeller channel 345 in the region of the interrupter 325.

The top housing 302 also has a triangular lattice and central hub as shown in Figure 40 which provide stiffening for the structure.

It should be appreciated that Figure 41 does not show the full height of the top housing as is apparent from Figure 34 and 35. As can be seen from those Figures, the top housing 302 forms or holds the majority of the height of the airflow channel 332 (being the upper, lower and later airflow channels) which is rectangular in cross-section with filleted or rounded corners. The bottom part of the lower airflow channel 332B and inside corner of the lower airflow channel 332B is formed from a plate of the bottom housing 303, and the inside surface of the airflow channel 332 is formed from the central plateau/interrupter portion of the bottom housing. Figure 44 shows a top perspective view of the bottom housing 303 and the bottom housing cap 341.

edge 363 can be in the form of a swept edge. If the direction of rotation of the impeller 315 was the reverse of what is shown in Figure 46, the illustrated leading face 361 would become a trailing face 360, and the illustrated trailing face 360 would become a leading face 361.

Referring to Figure 46, the configuration of the interrupter 325 (that is that shape and orientation) is such that a plurality of impeller blades 375 to transit the leading face 361 and/or the leading edge 363 at any one point in time during rotation of the impeller 315. Also this configuration of the interrupter 325 result in the leading face 361 and/or the leading edge 363 presenting non-square to the impeller blades 375 such that each impeller blade 375 intersects the leading face 361 and/or leading edge 363 at an (non-zero) angle (that is, not parallel). This provides advantages as discussed the previous embodiment.

Referring to Figures 47, 48, the interrupter 325 can optionally comprise a recess 385 (e.g. a notch, groove, indent, channel or the like). The recess 385 can be disposed on front wall side portions 331B bordering the inside of the inlet port 320 and outlet port 321 respectively. The recess 385 can optionally extend beyond the edges of the front wall side portion 331B and into the wall 320C, 321C and/or collar of the conduit of the inlet/outlet port itself. This provides a swept border on the perpendicular region of the interrupter 325. In addition to swept edges on the planar portion of the interrupter, a swept border on the perpendicular/transverse interrupter region can improve the noise characteristics of the blower 300. In one, non-limiting, example, the recess is a substantially 'v'-shaped notch as shown in Figure 47. In one example, referring to Figure 47, each notch can be 9.3% of the total horizontal length of the front wall 331A. Alternatively, each notch can be between 5-15% of the horizontal length of the front wall 331A (measured along the curved surface), and for example 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15% of the horizontal length of the front wall when viewed like in Figure 47.

Referring to Figure 48, recess 385 starts at the outlet/inlet port end 385A of the front wall side portion 331B bordering the outlet/inlet port 320/321. It is formed from the front wall side portion 331B gradually curving inwards (in the vertical plane) to a centre line/axis from the outlet/inlet port end 385A to the front edge 385B of the front wall side portion 331B in combination with the front wall side portion 331B curving inwards to the centre axis/line (planar with the axis of rotation of the impeller 315) from the top 385C and bottom 385D edges towards the centre line 385E of the bordering wall 331B. This forms the V shaped cross-section recess 385 along the centre 385E of the bordering wall 331B that increases in depth along the length of the front wall side portion 331B.

The configuration of Figures 47 and 48 can be described in another way. The front wall 331A has a first side face 331B proximate the first end of the channel 304, and the impeller blades 375 are adapted in use to rotate away from and pass the first side face 331B, wherein the first side face comprises a recess 385. The front wall 331A has a second side face 331B proximate the second end of the channel 304, the impeller blades 375 adapted in use to rotate towards and pass the second side face 331B, wherein the second side face comprises a recess 385. The recess on the first side face 331B and/or the recess on the second side face 331B: a) curves inwards from a back edge to a front edge along the centre axis, and b) curves inwards from the top and bottom edges towards a centre axis between the top and bottom edges.

Alternatively, the recess 385 can be other shapes, such as a gradient from the upper end of the vertical interrupter region 367 to the lower end, a substantially 'U'-shaped, 'W'-shaped, 'M'-shaped cross-section recesses or the like.

In an alternative configuration, instead of a recess 385 in the front wall side portions 331B, a recess or recesses 386 (e.g. groove, notch, indent, channel or the like) are provided in the inside surface 369 of the front wall 331A bordering the impeller channel 345. In at least one form, the one or more recesses 386 can be in the form of, or referred to as transverse recesses. Referring to Figures 49 and 50, there are two tapered elongated recesses 387A, 387B at each end of the inside surface 369 of the front wall 331A. Each of these recesses can be called a transverse recess 387A, 387B. The recesses 387A, 387B span across the concave front wall 331A, with each recess 387A, 387B starting with a maximum width and depth at a one edge 385B of the inside surface 369 of the front wall 331A, decreasing to a minimum width and depth towards the centre of the front wall 331A and then expanding out to a maximum width and depth at the opposite edge 385B of the front wall 331A. In at least one alternative configuration, instead of two recesses 386, the interrupter front wall 331A could have one recess, or more than two recesses. Also, the configuration of the recess could take a different shape.

In another alternative configuration a recess starts at one or both edges of the front wall 331A and each proceeds as a tapered recess across the inside surface 369 of the front wall towards the centre and terminates at an end point along the surface, such as some percentage along the length of the surface. Where there is a recess starting at both edges, they can meet at a nominal juncture, which may be half way, but also could be at another point. But, alternatively, the recesses might not meet at all and not traverse the entire inside surface 369 of the front wall 331A. As such, each recess terminates at a distance along the front wall which can be some percentage of

10.81 mm. Although curved blades are used, alternate configurations of the impeller may include straight blades, serpentine blades, convex blades, or another shape as desired. For example, straight blades may be preferred in a blower arranged to operate in two directions (a dual outlet or bi-directional blower). In a variation, a different number of blades a provided on the top to the bottom. For example, 61 blades on the top and 67 blades on the bottom.

Offsetting the upper impeller blades 375A from the lower impeller blades 375B as shown is beneficial in reducing the noise produced by the blower. Reasons for this comprise reducing the impact of the blades encountering the interrupter 325, by further splitting when the upper row and the lower row of impeller blades encounter the interrupter (in comparison to a single "full" row of blades). Furthermore, offsetting the blades can increase the frequency of the noise produced by the blower. Higher frequencies can be easier to attenuate. If pushed high enough, the frequencies can also be outside the audible range (of approximately 20 kHz). Although the blades of this embodiment of the impeller 315 are curved, splitting the blades would reduce the noise produced by impellers with straight blades, or other blade arrangements as well.

Referring to Figure 60, 61, in another configuration, there is only one row of impeller blades 375. Each impeller blade 375 is the height of the annular ring support 376, as opposed to split blades of previous impellers. Therefore each blade spans the full height of the impeller 315.

Each of the spokes 372 are optionally of a height that is less than the combined stacked height of the impeller blades 375/annular ring support 376. This reduces the mass and inertia of the impeller 315. When the impeller 315 rotates, the spokes 372 cause turbulence in the central region of the impeller 315. This turbulence acts as a fluid seal to help 'seal' the central portion of the blower, reducing leak across the central portion of the impeller 315.

The impeller can include a number of central notches, or alternatively, region/s of reduced vertical thickness in the hub and/or spokes of the impeller, between the centre of rotation of the impeller and the blades. These regions of reduced thickness allow the spokes and hub to accommodate the height of the annular ring support, while still reducing the thickness to allow the impeller's mass, and therefore moment of inertia to be reduced. As a result, the impeller requires less energy to operate, and its direction and/or speed can be changed more rapidly.

In one configuration, the impeller is made from a plastic or one or more other polymeric materials. For example, ABS, polycarbonate, Nylon or the like could be

Referring to Figures 34, 35, 42, the radial clearance between the impeller blades 375 and the airflow channel 332 outer perimeter is between about 5mm and 7mm, such as equal to or about 6.15 mm. The radial clearance is the distance between the tips of the impeller blades 375 and the inner surface of the airflow channel 332. In other words, the ratio of the radial clearance to the impeller blade length (e.g. 13.23 mm in the radial direction) is between about 1:2 to 1:3, such as equal to or about 6.15:13.23 or 1:2.15. The ratio of the radial clearance to the impeller diameter (e.g. 69.69 mm) is between about 1:10 to 1:14, such as equal to or about 6.15:69.69 or 1:11.33. The channel 304 is between about 16mm and 23mm, such as equal to or about 19 mm in width. That is, the width of the impeller channel 345 and the airflow channel 332 together can be approximately 19 mm. The radial clearance is therefore between about 20% and 43% (e.g. equal to or about 32.3%) of the width of the annular channel. The specified radial clearance can be beneficial in improving the performance of the blower.

2.4.7 Housing - configuration #2

Figures 64 to 66 show a second configuration of the third embodiment of the regenerative blower.

The second configuration of the third embodiment differs from the first configuration in that the width of the channel 104 is reduced. That is, the combined width of the impeller channel 345 and airflow channel 332 is reduced. Referring to the structure established with reference to Figure 1, the second configuration of the third embodiment can be said to lack a lateral channel. As a result, the radial clearance (distance between the tips of the impeller blades 375 and the interior surface of the airflow channel 332) is substantially reduced. The radial clearance can be reduced to a distance of the order of magnitude of the manufacturing tolerances of the blower housing 101 and/or the impeller 315. In some cases this can be between 0.5 – 1 mm. This provides for reduced blower size and reduced power consumption in relatively low flow operation – e.g. below about 60L/min

2.5 Fourth embodiment of a regenerative blower

Figures 67 to 78 show a regenerative blower according to a fourth embodiment. Features of the fourth embodiment that are the same or similar to those of the third embodiment or other embodiments may not be described fully or at all, but it will be appreciated by those skilled in the art that relevant portions of the description relating the first and second embodiment or any other embodiments described herein apply to this embodiment, where appropriate.

2.5.1 Overview

directed into the airflow channel 432 via the inner impeller channel 445B to combine with the air from the (first) inlet as previously described. Under relatively high flow conditions, the top housing port 490 acts like another inlet (a second inlet (or a third inlet if you consider the bottom housing aperture 448 an inlet)), allowing additional air to be drawn into the blower, improving the high flow performance. Under relatively low flow conditions, the top housing port 490 acts like another outlet, with an amount of air drawn into the blower being blown out through the top housing port 490.

Referring to Figure 72, which shows the interior region of the top housing 402, the top housing 402, in addition to an having an arcuate upper airflow channel 432A, lateral airflow channel 432C, part of the lower airflow channel 432C and outer impeller channel 445 as per the third embodiment, further comprises an inner annular channel, which provides an inner annular impeller channel 445B. The internal impeller channel 445B is formed by way of a channel isolator 497 formed as an arcuate wall 497 disposed on the top shelf 480 and extending concentrically around the central hub 439. The arcuate wall 497 is broken to provide an air flow opening 498 between the inner impeller channel 445B and the: a)(outer) upper/lower/lateral airflow channels, and/or b) the outer impeller channel 445. The channel isolator 497 isolates the air flow from the inner impeller channel 445B and outer airflow channels, except for the air flow path through the air flow opening 498. Referring to Figure 72, an impeller 415 is disposed in the inner 445B and outer 445 impeller channels, as will be described later. In other words, the impeller 415 occupies the inner impeller channel 445B and the outer impeller channel 445.

As the behaviour of the top housing port 490 is variable, (acting as an inlet when running at high flow, and an outlet when running at high pressure) it can be beneficial to use a one-way valve to control the behaviour of the top housing port 490. In a variation, optionally, a one-way valve ("check-valve") can be incorporated into the top housing port 490 to make port act only as an inlet. Examples of a one way valves that can be used include mechanical valves, or fixed-geometry passive valves such as a Tesla Valve. Incorporating the one-way valve improves the performance of the blower in both low flow (high pressure) conditions, as leak through the port is no longer able to occur, or is at least reduced, and high flow (low pressure) conditions, as the port is able to be used as an inlet to draw in additional air. Such a valve can also be combined with a one-way valve also covering the bottom housing apertures 448 so that they act only as an inlet as well. This improves pressure performance of the blower.

2.5.3 Impeller – configuration #1

remainder of the height is constant in the radial direction until the end of the bottom inner impeller blade 416C'.

2.5.4 Operation

In use, rotation of the outer impeller blades 416A, 416B (in a clockwise direction when referring to the top view of Figure 71) draws air through the tangential inlet port 420. Additionally, rotation of the inner impeller blades 416C in the inner impeller channel 445B draws in air through the top housing inlet port 490 into the inner impeller channel 445B. The inner impeller blades 416C rotate to pressurize the air drawn from the top housing port 490 prior to its entry into the outer impeller channel 445. The pre-pressurised air passes through the air flow opening 498 in the arcuate wall (channel isolator 497) to combine in the airflow channel 432 and outer impeller channel 445 with air drawn directly from the tangential inlet port 420. The air is then pressurized in the channel 404 by rotation of the outer impeller blades 416A, 416B and directed through the outlet port 421. The channel isolator 497 forms part of an interrupter 425 and acts in a similar manner to the hub 339 in the third embodiment, to interrupt flow leaking from the outlet port 421 to the inlet port 420, in addition to flow leaking from the outer airflow channel 332 to the inner impeller channel 445B.

Rotating the motor in an opposing direction can change the direction of airflow in the blower, such that it is a reversible blower, or a dual outlet blower.

Similar to the first embodiment, the fourth embodiment optionally can comprise a bottom housing aperture large enough for the rotor to fit through to simplify and/or reduce the cost of the manufacturing process. Alternatively, the bottom housing aperture of RG4 can be of reduced size as disclosed for the first embodiment.

2.6 Fifth embodiment of a regenerative blower

Figures 79 to 87 show a regenerative blower according to a fifth embodiment. This blower is of a reduced size compared to the other embodiments.

Features of the fifth embodiment that are the same or similar to those of the fourth embodiment or other embodiments may not be described fully or at all, but it will be appreciated by those skilled in the art that relevant portions of the description relating the first and second embodiment or any other embodiments described herein apply to this embodiment, where appropriate.

Like the other embodiments, the fifth embodiment blower 500 has a housing 501 with an inlet port 520, outlet port 521 and channel 504. The channel 504 comprises an upper airflow channel 532A and a lower airflow channel 532B. The channel 504

Claims

1. A regenerative blower comprising:

a housing,

a first port and second port in the housing providing an inlet and outlet,

an airflow channel extending between the first and second ports,

an impeller rotatable in an impeller channel to promote airflow in the airflow channel from the first port to the second port,

a motor to drive the impeller, and

an interrupter between the first and second ports to limit airflow from the second port to the first port,

wherein the housing comprises a central aperture that provides a third port, and

wherein the central aperture is an outlet from the impeller channel and/or the airflow channel under relatively low flow conditions, and an inlet under relatively high flow conditions.

2. A regenerative blower according to claim 1 wherein the housing comprises a top housing and a bottom housing and the central aperture comprises one or more openings in the top housing.

3. A regenerative blower according to claims 1 or 2 wherein the motor comprises a rotor and the central aperture having a diameter that is shaped to enable, during manufacture, an assembly of the rotor coupled to the impeller by a shaft to be placed in the housing through the central aperture.

4. A regenerative blower according to claims 1 or 3 wherein the housing comprises a top housing and a bottom housing with a bottom plate, and the central aperture is in the bottom plate of the bottom housing.

5. A regenerative blower according to claim 4 wherein the housing further comprises a bottom housing cap, and wherein the bottom housing cap includes at least one bottom housing cap aperture.

6. A regenerative blower according to claim 1 wherein the housing comprises a top housing and a bottom housing, the impeller is disposed between the top housing and the bottom housing, the motor is disposed at least partially in the bottom housing, and the top housing is open to the bottom housing such that there is no plate or other barrier of the housing separating the impeller and the motor.

7. A regenerative blower according to claim 6 wherein the airflow channel comprises an upper channel and a lower channel.

8. A regenerative blower according to claim 7 wherein the impeller channel separates the upper channel and the lower channel.

9. A regenerative blower according to claims 6 to 8 wherein lateral ends of the impeller rotate adjacent an interior lateral face of the housing.

10. A regenerative blower according to claim 1 further comprising a one-way valve for the third port.

11. A regenerative blower according to claim 1 further comprising an arcuate wall in the impeller channel forming an inner impeller channel and an outer impeller channel, the arcuate wall having an air flow opening between the inner impeller channel and the outer impeller channel.

12. A regenerative blower according to claim 11 wherein the impeller comprises inner impeller blades and outer impeller blades which rotate in the inner impeller channel and the outer impeller channel, respectively.

13. A regenerative blower according to claims 1 to 12 wherein the first port is an inlet and the second port is an outlet or the first port is an outlet and the second port is an inlet.