

Housing For A Centrifugal Fan, Pump Or Turbine

Field of the invention

The present invention relates to a housing or chamber for a fan for moving air, pump for inducing fluid flow or torque generator which is responsive to fluid flow
5 such as a turbine. In particular it is directed to providing an improved housing for such apparatus to improve the efficiency of such devices.

Background Art

Centrifugal fans, blowers, pumps turbines and the like represent approximately half of the world's fan, pump and turbine production each year. As fans or pumps, they
10 are used to produce higher pressure and less flow than axial impellers and fans. They are used extensively where these parameters must be satisfied. They have also been used advantageously where installation limitations might not permit an axial fan to be used. For example, applications such as domestic exhaust fans require greater flow with a relatively low pressure difference. Such an application
15 would normally be satisfied by an axial type of fan. However, in many cases, a centrifugal fan is used to turn the flow path at right angles so that it can fit into a roof or wall cavity. An axial fan will not fit into the cavity and maintain efficiency. In another example, the exhaust ducting in many buildings is only 3 or 4 inches in diameter. It is impractical to fit an effective high-output axial fan to such a small
20 duct.

While centrifugal fans have been used for a long time, little attention has been given to the design of the housing in which the rotor is retained. Where issues of efficiency and noise are investigated, the designer's attention is given primarily to the impeller. Historically, such housings have not been optimised for:

- 25 1. fluid flow drag reduction;
2. noise reduction;
3. adjustment of the pressure/flow relationship,

Additionally, the housings of typical centrifugal fans, blowers, pumps turbines and the like cause the incoming fluid to turn sharply before leaving the housing.

Such shape are detrimental to efficient performance of the device overall, often introducing significant turbulence.

In the previous disclosure of the applicant for a Fluid Flow Controller as published in WO03056228, the applicant has noted the benefits that can be obtained by
5 allowing fluid to flow in the manner followed in Nature.

Disclosure of the Invention

Accordingly the invention resides in a blower, fan or pump or turbine housing, the housing adapted to receive a rotor and support the rotor for rotation about a central axis, said rotor comprising a set of radial blades supported from a central hub which
10 is to be rotatably supported from the housing, the housing having opposed end walls, the rotor to be rotatably received between the side walls, at least one side having an opening concentric with the central axis, said opening comprising the inlet, the housing having a side wall extending between the end walls and configured to provide a space surrounding the rotation path of the outer periphery of the rotor,
15 the space having an outlet which is substantially tangential to the rotation path, wherein rotation of the rotor will cause a flow of fluid through the housing from the inlet to the outlet, the internal face of the housing defining the space having a curvature generally corresponding to that of a logarithmic spiral which conforms with the Golden Section to promote vortical flow of the fluid delivered to the
20 outlet.

According to a preferred feature of the invention the cross sections area of the space between the rotation path and the internal face of the housing is of an increasing cross-sectional area about the rotation path and is of a maximum cross-sectional area at the outlet, wherein the variation in cross sectional area
25 generally conforms with the Golden Ratio.

According to a preferred feature of the invention the opening is located adjacent the respective side face of the rotor.

According to a preferred feature of the invention the internal face of the housing

defined by the end walls and the side wall define a continuous surface which has a curvature generally corresponding to that of a logarithmic spiral which conforms with the Golden Section.

5 According to a preferred feature of the invention the curvature is in a plane which is transverse to the central axis.

According to a preferred feature of the invention the curvature is also in a plane which is parallel to the central axis.

10 According to a preferred feature of the invention the degree of curvature which is in a plane which is transverse to the central axis is different from the degree of curvature which is parallel to the central axis.

According to a preferred feature of the invention the internal face defines a space of a generally helical formation wherein helix has a curvature corresponding to that of a logarithmic spiral which generally conforms with the Golden Section.

15 According to a preferred feature of the invention the internal face of the housing generally conforms in shape to the shape of a shell of the genus Trochus.

According to a preferred feature of the invention the rotor is to comprise a centrifugal rotor.

According to a preferred feature of the invention the rotor is to comprise an axial rotor.

20 According to a further aspect the invention resides in a blower, fan or pump or turbine comprising a housing and a rotor, the housing adapted to receive the rotor and support the rotor for rotation about a central axis, said rotor comprising a set of radial blades supported from a central hub which is rotatably supported from the housing, the housing having opposed end walls, the rotor
25 rotatably received between the side walls, at least one side having an opening concentric with the central axis, said opening comprising the inlet, the housing

having a side wall extending between the end walls and configured to provide a space surrounding the rotation path of the outer periphery of the rotor the space having an outlet which is substantially tangential to the rotation path, wherein rotation of the rotor will cause a flow of fluid through the housing from the inlet to the outlet, the internal face of the housing defining the space having a curvature corresponding to that of a logarithmic spiral which generally conforms with the Golden Section to promote vortical flow of the fluid delivered to the outlet and wherein the active surfaces of the radial blades have a curvature generally corresponding to that of a logarithmic spiral which conforms with the Golden Section.

The invention will be more fully understood in the light of the following description of several specific embodiments.

Brief Description of the Drawings

The description is made with reference to the accompanying drawings of which:

15 Figure 1 is an isometric diagrammatic representation of a conventional centrifugal fan of the prior art.

Figure 2 illustrates graphically the form of the Golden Section;

Figure 3 is an isometric view of a fan according to the first embodiment;

Figure 4 is a plan view of the fan of Figure 3;

20 Figure 5 is a diagrammatic cut-away of the fan of Figure 3;

Figure 6 is an exploded view of a fan according to a second embodiment;

Figure 7 is an isometric view of the fan of Figure 6, showing the location of the rotor within the housing in dotted lines;

Figure 8 is a diagrammatic cut-away of a fan according to a third embodiment;

25 Figure 9 is an isometric exploded view of a fan according to a fourth embodiment;

Figure 10 is an isometric view of a fan according to a fifth embodiment;

Figure 11 is a plan view of the fan shown in Figure 10;

Figure 12 is an isometric view of a fan according to a sixth embodiment;

Figure 13 is a side view of the fan shown in Figure 12.

Detailed Description of Preferred Embodiments

Each of the embodiments is directed to a housing for a fan, blower, pump or turbine or the like which provides an efficient fluid pathway. Hereinafter in this description the term "fan" will be used generically to refer to any fan, blower, pump, turbine or the like. Where a reference is made to a fan driving or promoting fluid flow, it is to be appreciated that the reference is intended to encompass the situation where the fluid flow drives a rotor of a turbine or the like.

In order to appreciate the differences from the prior art, it is helpful to describe the key features of housings conventionally used for centrifugal fans. An example is illustrated diagrammatically in Figure 1 which illustrates the key features of a typical arrangement of a housing 1 for a centrifugal fan. Conventionally, such a housing 1 is configured in shape to follow the form of a spiralling arc in two dimensions. It generally comprises a pair of flat-sided panels 3 and 4 disposed apart, parallel to each other and sealed around the perimeter by an edge panel 5 formed from a planar sheet. This creates angled corners 6 at the junction between the top panel 3 and edge panel 5 and similarly between the bottom panel 4 and edge panel 5. Such angled corners induce unwanted turbulence in the fluid passing within the housing.

The shape of a spiralling arc means that a space is provided between the inner surface of the edge panel and the imaginary surface swept by the outer edges of the vanes of the rotor. It will be appreciated that the depth of this space increases progressively from a minimum to a maximum through an angle of 360 degrees. In the vicinity of the maximum depth an outlet is provided to exhaust the fluid.

Each of the embodiments is directed to a housing for a fan which provides an efficient fluid pathway for fluid passing through the housing. Such fans comprise a rotor which is normally provided with a plurality of vanes or blades although a rotor having a single blade is possible. The vanes are generally configured to provide an outward or radial component of acceleration to the fluid being driven,

or in the case of a turbine, the fluid is deflected to provide a radial component to the force applied to the vane and thereby a deflection to the fluid including a radial component.

5 Nature provides excellent models of optimised streamlining, drag reduction, and noise reduction. Any biological surface grown or eroded to optimise streamlining has no angled corners and does not make fluid turn at right angles but generally follows the shape of an eddy constructed in accordance with a three-dimensional equiangular or Golden Ratio spiral. The underlying geometry of this spiral is also found in the design of a bird's egg, a snail, and a sea shell.

10 These spirals or vortices generally comply with a mathematical progression known as the Golden Ratio or a Fibonacci like Progression.

Each of the embodiments, in the greater part, serves to enable fluids to move in their naturally preferred way, thereby reducing inefficiencies created through turbulence and friction which are normally found in housings for centrifugal fans.

15 Previously developed technologies have generally been less compliant with natural fluid flow tendencies.

It has been found that it is a characteristic of fluid flow that, when it is caused to flow in a vortical motion through a pathway that the fluid flow is substantially non-turbulent and as a result has a decreased tendency to separate or cavitate. It is a
20 general characteristic of the embodiments that the housings described are directed to promote vortical flow in the fluid passing through the housing. It has also been found that vortical flow is encouraged where the configuration of the housing conforms to a two-dimensional or three-dimensional spiral. It has further been found that such a configuration tends to be optimised where the curvature
25 of that spiral conforms substantially or in greater part to that of the Golden Section or Ratio. It is a characteristic of each of the embodiments that the greater proportion of the internal surfaces which form the housing have a curvature which takes a two dimensional or three dimensional shape approaching the lines of vorticity or streak lines found in a naturally occurring vortex. The

general form of such a shape is a logarithmic spiral. It has further been found that the performance of the embodiments will be optimised where the curvature of the surfaces of the housing substantially or in the greater part conform to the characteristics of the Golden Section or Ratio. It has further been found that the performance is optimised if any variation in cross-sectional area of the fluid pathway also substantially or in greater part conforms to the characteristics of the Golden Section or Ratio.

It has also been found fluid flow is more efficient if the surfaces over which the fluid flows have a curvature substantially or in greater part correspond to that of the Golden Section. As a result of the reduced degree of turbulence which is induced in the fluid in its passageway through such a fan, the housing according to the various embodiments can be used for conducting fluid with less noise and wear and with a greater efficiency than has previously been possible with conventional housing of equivalent dimensional characteristics.

The greater percentage of the internal surfaces of the housings of each of the embodiments described herein are generally designed in accordance with the Golden Section or Ratio and therefore it is a characteristic of each of the embodiments that the housings provides a fluid pathway which is of a spiralling configuration and which conforms at least in greater part to the characteristics of the equiangular or Golden Section or Ratio. The characteristics of the Golden Section are illustrated in Figure 2 which illustrates the unfolding of the spiral curve according to the Golden Section or Ratio. As the spiral unfolds the order of growth of the radius of the curve which is measured at equiangular radii (eg E, F, G, H, I and J) is constant. This can be illustrated from the triangular representation of each radius between each sequence which corresponds to the formula of $a:b = b:a+b$ which conforms to the ratio of 1:0.618 approximately and which is consistent through out the curve.

This invention may, alternatively, use a snail or sea shell-like shaped flow path housing which may be logarithmic but not a Golden Ratio. Although it is not

optimised if it doesn't conform to the three-dimensional Golden Ratio, it will still provide superior performance in its intended use over conventional designs.

A first embodiment of the invention is a fan assembly as shown in Figures. 3 to 5. The fan assembly 11 comprises a fan rotor 12 having a plurality of vanes 13, the rotor 12 being adapted to be rotated by an electric motor, not shown. The fan motor is supported within a housing 14 having an inlet 16 and an outlet 17.

The housing 14 has a whirl-shaped form, at least on the internal surfaces which resembles the shape of shellfish of the genus Trochus. This shape corresponds generally to the streamlines of a vortex. In the drawings it is to be appreciated that the form indicated on the external surfaces is intended to correspond with the form of the internal surface, although in a real fan the form of the external surface is not of importance to the performance of the fan as such and may be quite different from the internal surfaces. Indeed, the housing might be constructed with an internal shroud which comprises a separate component from the external surface of the housing, and it is to be appreciated that where such a design is undertaken, it is the internal surfaces of the separate shroud which must conform to the principles as described herein.

In the first embodiment, the housing is formed in two portions, 18 and 19. The first of these comprises an inlet portion 18 which includes the inlet 16 and also provides mounting means (not shown) to support the fan motor to which the fan rotor 12 is attached. The inlet portion 18 also acts as a shroud around outer extents of the vanes 13 of the rotor 12 and provides a space 22 between the inner surface 21 of the inlet portion 18 and the imaginary surface swept by the outer edges 23 of the vanes 13 during rotation of the rotor 12. It will be seen in Figure 5 that the depth of this space increases between a minimum space 25 and a maximum space in a manner akin to the corresponding space in a conventional centrifugal fan. Unlike a conventional centrifugal fan, however, this increase in the space is accompanied by displacement of the fluid path axially away from the region of rotation of the rotor in the first portion 18 towards the outlet 17.

The second portion of the housing 14 comprises an outlet shroud 19 extending the flow path in a continuous manner from the first portion. In the outlet shroud 19, the inner surface of the shroud 19 continues to expand while the fluid path is displaced axially. As a result, a generally vortically shaped fluid path is provided which urges fluid flowing through the housing 14 to adopt a vortical flow pattern, as indicated by the dotted line 27 in Figure 5. Such a flow pattern is of higher efficiency and lower noise than for a comparable conventional fan. In addition, by being spun into vortical flow, the fluid may be urged to be redirected in a generally transverse direction relative to the incoming flow without requiring an abrupt and turbulent change in flow direction. This also improves efficiency and reduces noise.

As mentioned earlier, while a housing having a generally vortical internal form can be expected to provide significant improvements in higher efficiency and reduced noise, the benefits will be optimised by configuring the housing to have a vortical form in the nature of a three dimensional equi-angular spiral or "Golden-Section" spiral. Such a shape should have the internal surfaces configured to have a curvature conforming to the Golden Section. Such a shape will conform with the natural flow tendencies of fluids, thereby further improving efficiency.

It is to be appreciated that the configuring of the housing to be in two portions is to provide ease of manufacture, assembly and maintenance, only. The two portions of such a housing may be held together by releasable clamping means such as clips (not shown), or may include cooperating flanges, bayonet fastenings, or other suitable joining means.

In a second embodiment, as shown in Figures 6 and 7, the first embodiment is adapted so that the housing 31 may be manufactured as a single piece, for example, by rota-moulding. Alternatively, the housing may comprise more than two portions.

Figure 8 depicts a third embodiment of a fan 41 comprising a rotor 42 having a single vane 43 having an expanding screw-like form. This rotor 42 is

accommodated within an extended housing 44 which nevertheless takes a vortical form. It is envisaged that such a design may be appropriate for more viscous fluids or fluid-like materials.

5 While a housing according to the first and second embodiments will provide improved performance when used with rotors having a wide range of vane configurations, it is to be appreciated that performance of the fan assembly will also depend on the configuration of the rotor. It has been found that performance may be further improved where the rotor itself is designed to provide flow in accordance with the principles of nature. Such a rotor is described in the
10 applicants co-pending application entitled "Vortical Flow Rotor". It is to be understood that such a rotor is directed to providing a vortical flow stream, and when appropriately configured in conjunction with a housing according to the first or second embodiment, an optimised performance characteristic can be achieved.

15 It can be understood in light of the above description that a housing according to the first and second embodiments will provide performance improvements where a centrifugal rotor is used. As mentioned in relation to Figure 5, it can be seen that the application of a radial component of fluid flow to the flow stream, will urge fluid outwardly as well as rotationally, thereby adopting a vortical flow. It is not so
20 obvious that use of a housing of the first embodiment with an axial fan will also provide a significant performance improvement, yet this has been found to be the case. It seems that the provision of a housing that easily accommodates vortical flow promotes such vortical flow in practice. Therefore, it is within the cope of the invention now disclosed that the housing may be used with a rotor axial
25 configuration.

This discovery has led to a further advance. The vanes of the rotor that can be used within the housing of the first embodiment may be configured with a profile that is intermediate between an axial and a centrifugal rotor. As mentioned earlier, axial and centrifugal rotors have quite differing performance
30 characteristics: the axial rotor promoting high flow at low pressure while the

centrifugal rotor promotes low flow at high pressure. By selecting a rotor with an intermediate characteristic, the performance of the fan can be "tailored" to more precisely match the application. The precise configuration of the housing may also be "tuned" to cooperate fully with the selected rotor to even further improve the design characteristics. Such flexibility has not been appreciated previously. A designer can now approach a project knowing that he can properly design an appropriate fan for the task, rather than adopting an inappropriate fan due to physical constraints.

Additionally, it has been found that the compound curves of the housing of the above embodiments have rigidity and structural integrity considerably beyond flat sided panels found in conventional housings and thereby can be built from lighter and thinner materials. Nevertheless, the inherent stiffness, combined with the lack of turbulence within the fluid flow also reduce noise - a major problem in conventional housings. Flat-sided housings vibrate, drum, resonate, and amplify noise. The housing of the embodiments reduces vibration, drumming, resonance, and amplification of noise.

While it is believed that a fan having superior performance will generally be achieved by designing the housing in a three-dimensional vortical form as described in relation to the first embodiment, there will be instances where it will not be practicable to adopt such a form. This is more likely to be the case where the fan is to be used in an existing installation that has previously incorporated a conventional centrifugal fan. Nevertheless, significant improvements can be obtained by incorporating into the design of a conventional centrifugal fan the principles revealed in the first embodiment.

Figure 9 shows a fourth embodiment comprising a housing 51 adapted to receive a fan rotor 52, constructed as closely as possible in accordance with the principles described above. As shown in the embodiment, the housing is somewhat similar in form to a conventional housing as shown in Figure 1, but is altered modified in design to adopt the natural flow principles. This fan is configured according to a two dimensional logarithmic spiral conforming to the

Golden Ratio. Further, the internal surfaces are curved with a curvature configured in accordance with the Golden Section. Such a configuration has been found to provide considerably improved efficiencies compared with the conventional housing of Figure 1.

5 Figures 10 and 11 show a fifth embodiment of a fan that has adopted the features of the fourth embodiment in a very practical design. As shown in Figures 10 and 11, the fan comprises a housing 61 which comprising two halves, a first half 62 and a second half 63, each of corresponding spiralling form. The first half 62 is provided with a centrally-located, circular inlet opening 63 which includes a
10 support member 64 adapted to support the shaft 65 of a fan motor 66. The second half 63 has corresponding supporting means adapted to support the motor 66. The first 62 and second 63 halves each have corresponding flanges 67 around their perimeters with apertures 68 which enable the halves to be secured together easily by bolts or similar securing means (not shown). The
15 motor 66 drives an impeller 69 having vanes 70 mounted on the motor shaft 65.

When assembled together, the first and second halves provide a fluid space between the internal surface of the housing and the imaginary surface swept by the outer edges of the vanes 13 during rotation of the impeller 69. This space increase from a minimum at a point "A" to a maximum at an adjacent point "B".
20 At the maximum point "B" the housing incorporates an outlet opening 71 transverse to the plane of rotation of the impeller which is co-planar with the axis. In use an outlet duct 72 (as shown in dotted lines) will normally be mounted to the outlet to convey the fluid from the housing.

Importantly, the walls of the two halves around the space are curved with a
25 curvature which substantially conforms with the Golden Section. This curvature is also be configured to cause the fluid to flow within the space in a spiralling, vortical motion. As a result, drag in the fluid flow through the space is reduced. This drag reduction minimizes vibration, resonance, back pressure, turbulence, drumming, noise and energy consumption and efficiency is improved in
30 comparison to a conventional fan of the type shown in Figure 1.

It has also been found to be advantageous that this space increases at a logarithmic rate conforming to the Golden Ratio.

The fifth embodiment may be adapted further. A sixth embodiment is shown in Figures 12 and 13 which incorporates a suitable mounting bracket 75. In other
5 respects, the embodiment is the identical to that of the fifth embodiment and therefore in the drawings, like numerals are used to depict like features of the fifth embodiment.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood
10 to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The Claims Defining the Invention are as Follows

1. A blower, fan or pump or turbine housing, the housing adapted to receive a rotor and support the rotor for rotation about a central axis, said rotor comprising a set of radial blades supported from a central hub which
5 is to be rotatably supported from the housing, the housing having opposed end walls, the rotor to be rotatably received between the side walls, at least one side having an opening concentric with the central axis, said opening comprising the inlet, the housing having a side wall extending between the end walls and configured to provide a space
10 surrounding the rotation path of the outer periphery of the rotor, the space having an outlet which is substantially tangential to the rotation path, wherein rotation of the rotor will cause a flow of fluid through the housing from the inlet to the outlet, the internal face of the housing defining the space having a curvature generally corresponding to that of a logarithmic
15 spiral which conforms with the Golden Section to promote vortical flow of the fluid delivered to the outlet.

2. A blower, fan or pump or turbine housing, as claimed at claim 1 wherein the cross sections area of the space between the rotation path and the internal face of the housing is of an increasing cross-sectional
20 area about the rotation path and is of a maximum cross-sectional area at the outlet, wherein the variation in cross sectional area generally conforms with the Golden Ratio

3. A blower, fan or pump or turbine housing, as claimed at claim 1 or 2 wherein the opening is located adjacent the respective side face of the
25 rotor.

4. A blower, fan or pump or turbine housing as claimed at any one of the preceding claims wherein the internal face of the housing defined by the end walls and the side wall define a continuous surface which has a

curvature generally corresponding to that of a logarithmic spiral which conforms with the Golden Section.

5. A blower, fan or pump or turbine housing, as claimed at claim 4 wherein the curvature is in a plane which is transverse to the central axis.

5 6. A blower, fan or pump or turbine housing, as claimed at claim 5 wherein the curvature is also in a plane which is parallel to the central axis.

7. A blower, fan or pump or turbine housing, as claimed at claim 6 wherein the degree of curvature which is in a plane which is transverse to
10 the central axis is different from the degree of curvature which is parallel to the central axis.

8. A blower, fan or pump or turbine housing, as claimed at any one of claims 4 to 8 wherein the internal face defines a space of a generally helical formation wherein helix has a curvature corresponding to that of a
15 logarithmic spiral which generally conforms with the Golden Section.

9. A blower, fan or pump or turbine housing as claimed at any one of the preceding claims wherein the internal face of the housing generally conforms in shape to the shape of a shell of the genus Trochus.

10. A housing as claimed at any one of the preceding claims wherein the
20 rotor is to comprise a centrifugal rotor.

11. A housing as claimed at any one of claims 1 to 4 wherein the rotor is to comprise an axial rotor.

12. A blower, fan or pump or turbine comprising a housing and a rotor, the housing adapted to receive the rotor and support the rotor for rotation
25 about a central axis, said rotor comprising a set of radial blades supported from a central hub which is rotatably supported from the housing, the

housing having opposed end walls, the rotor rotatably received between the side walls, at least one side having an opening concentric with the central axis, said opening comprising the inlet, the housing having a side wall extending between the end walls and configured to provide a space surrounding the rotation path of the outer periphery of the rotor the space having an outlet which is substantially tangential to the rotation path, wherein rotation of the rotor will cause a flow of fluid through the housing from the inlet to the outlet, the internal face of the housing defining the space having a curvature corresponding to that of a logarithmic spiral which generally conforms with the Golden Section to promote vortical flow of the fluid delivered to the outlet and wherein the active surfaces of the radial blades have a curvature generally corresponding to that of a logarithmic spiral which conforms with the Golden Section.

13.A blower, fan or pump or turbine housing, substantially as herein described with reference to the accompanying drawings.

14.A blower, fan or pump or turbine substantially as herein described with reference to the accompanying drawings.