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Fan for handheld blower

Abstract

A fan includes a hub and a plurality of blades extending radially outwardly from the hub and spaced circumferentially about the hub. The plurality of blades includes a reference blade, a first blade, and a second blade. The reference blade is disposed after the first blade in a circumferential direction about the hub. The second blade is disposed after the reference blade in the circumferential direction. The first blade is circumferentially spaced a first distance from the reference blade. The second blade is circumferentially spaced a second distance from the reference blade. The first distance is greater than the second distance.

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Background/Summary

RELATED APPLICATIONS (1) This application is a national phase filing under 35 U.S.C. § 371 of International Application No. PCT/US2022/046176, filed Oct. 10, 2022, which claims the benefit of U.S. Provisional Patent Application No. 63/254,296, filed Oct. 11, 2021, the entire contents of each of which are hereby incorporated by reference.

BACKGROUND

(1) The present disclosure relates to handheld blowers, and more particularly to fans used in handheld blowers.

SUMMARY

(2) In one independent aspect, the disclosure provides a fan including a hub and a plurality of blades extending radially outwardly from the hub and spaced circumferentially about the hub. The plurality of blades includes a reference blade, a first blade, and a second blade. The reference blade is disposed after the first blade in a circumferential direction about the hub. The second blade is disposed after the reference blade in the circumferential direction. The first blade is circumferentially spaced a first distance from the reference blade. The second blade is circumferentially spaced a second distance from the reference blade. The first distance is greater than the second distance.

(3) In another independent aspect, the disclosure provides a fan including a hub having an air guide cone and a blade connection portion, and a plurality of blades extending radially outwardly from the blade connection portion and spaced circumferentially about the hub. The blade connection portion tapers radially inwardly and tangentially meets the air guide cone.

(4) In another independent aspect, the disclosure provides a handheld blower including an air duct extending along an axis, the air duct including an air inlet and an air outlet opposite the air inlet, and a fan disposed in the air duct between the air inlet and the air outlet. The fan rotates about the axis. The fan includes a fan hub extending from an upstream end to a downstream end, the fan hub defining an outer surface with a radius that continuously increases from the upstream end to the downstream end, and a plurality of fan blades extending radially outward from the outer surface between the upstream end and the downstream end. The plurality of fan blades is separated into pairs of blades. The pairs of blades are evenly spaced circumferentially about the fan hub to each other.

(5) Other features and aspects of the disclosure will become apparent by consideration of the following detailed description and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE FIGURES

(1) FIG. **1** is a perspective view of a handheld blower, according to embodiments disclosed herein.

(2) FIG. **2** is a cross-sectional elevation view of a portion of the handheld blower of FIG. **1**.

(3) FIG. **3** is a perspective view of a fan, according to embodiments disclosed herein.

(4) FIG. **4** is a front elevation view of a portion of the fan of FIG. **3**.

(5) FIG. **5** is a cross-sectional front elevation view of the fan of FIG. **3**.

(6) FIG. **6** is a perspective view of a fan, according to embodiments disclosed herein.

(7) FIG. **7** is a perspective exploded view of the fan of FIG. **6**.

(8) FIG. **8** is a front elevation view of the fan of FIG. **6**.

(9) FIG. **9** is a cross-sectional side elevation view of the fan of FIG. **8** taken along line **9**-**9**.

(10) FIG. **10** is a cross-sectional side elevation view of the fan of FIG. **8** taken along line **10**-**10**.

(11) Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

(12) FIGS. **1** and **2** generally illustrate a handheld blower **10** including a housing **14**. The housing

14 includes a handle **18** and a battery receiving area **22** for receiving one or more battery packs **26**. A blower tube **30** connects to the housing **14** and includes an outlet **34**. With reference to FIG. **2**, the housing **14** defines an air duct **38** extending along a duct axis **42** between a duct inlet **46** and a duct outlet **50**, opposite and downstream of the duct inlet **46**. The blower tube **30** is positioned adjacent the duct outlet **50** to create an air flow path **54** extending between the duct inlet **46** and the outlet **34**. A grate **58** is positioned adjacent the duct inlet **46**. A motor assembly **62** is positioned in the air duct **38** and includes a motor **66** and a fan **74**. The motor **66** and the fan **74** are positioned in the air duct **38** for rotation about a rotation axis **78**. In the illustrated embodiment, the rotation axis **78** is coaxial with the duct axis **42**. In the illustrated embodiment, the motor assembly **62** is assembled such that the fan **74** is upstream from the motor **66**. In other embodiments, however, the motor assembly **62** may be assembled in other configurations.

(13) FIGS. **3-5** illustrate a fan **100** for use with, for example, the handheld blower **10** of FIGS. **1-2**. The fan **100** includes a fan hub **104** defining an outer surface **108**. A plurality of blades **112** extends radially outwardly from the outer surface **108** of the fan hub **104**. The fan hub **104** may include a body **116** and a hub cap or air guiding cone (not shown but discussed with regard to other embodiments below). In some embodiments, the hub cap is formed as a separate piece and is removed from the body **116**. However, in other embodiments, the hub cap may be formed integrally with the body **116**. The fan **100** may include a passage **120** extending through the fan hub **104** that defines a central rotational axis **124** or rotation axis **124** of the fan **100**. The fan **100** may be supported in a handheld blower or other air moving machine for rotation about the central rotational axis **124** in a rotation direction **128**.

(14) Each blade **112** extends between a blade base **132** and a blade tip **136**, with the blade tip **136** located at a cantilevered end **140** of the blade **112**. The blade **112** defines a leading edge **144** and a trailing edge **148** extending between the blade base **132** and the blade tip **136**. In the illustrated embodiment, the leading edge **144** may be generally straight while the trailing edge **148** may be curved. However, in other embodiments, other shapes of the fan blade may be used. In the illustrated embodiment, each of the plurality of blades **112** is identical to the others such that a pitch, shape, width, and length of the blades are the same.

(15) With specific reference to FIGS. **4** and **5**, the plurality of blades **112** may be unevenly spaced about the fan hub **104**. For purposes of discussion, one of the plurality of blades **112** has been identified as a reference blade **152**. While a specific blade has been identified, and the relationships between the blades are discussed with this respect to the reference blade **152**, the relationships apply equally no matter which blade **112** is selected as the reference blade **152**, except where otherwise noted.

(16) As shown in FIG. **4**, the reference blade **152** has a reference tip **156** and a reference leading edge **160**. The reference tip **156** and reference leading edge **160** meet at a reference corner **164**. A first neighbor blade **168** (or first blade **168**) is located next in order from the reference blade **152** in a direction opposite a circumferential direction **170** (or first direction). In other words, the reference blade **152** is disposed after the first blade **168** in the circumferential direction **170**. In the illustrated embodiment, the circumferential direction **170** is the same as the rotation direction **128** of the fan **100**, however, in other embodiments, the circumferential direction **170** may be opposite the rotation direction **128**. A second neighbor blade **172** (or second blade **172**) is located next in order from the reference blade **152** in the circumferential direction **170** (or second direction). The first neighbor blade **168** includes a first tip **180** and a first leading edge **184** which intersect in a first corner **188**. The second neighbor blade **172** includes a second tip **192** and a second leading edge **196** which intersect in a second corner **200**.

(17) The reference blade **152** is circumferentially spaced a first distance from the first blade **168**, and the reference blade **152** is circumferentially spaced a second distance from the second blade **172**. Specifically, the first distance may be measured as a first angle α**1** measured about the rotation axis **124** between the first corner **188** and the reference corner **164**. The second distance may

similarly be measured as a second angle α**2** measured about the rotation axis **124** between the reference corner **164** and the second corner **200**. The first angle α**1** and the second angle α**2** are different. In the case of the exemplary reference blade **152**, the first angle α**1** is larger than the second angle α**2**. This relationship may be inverted if another blade is selected as the reference blade. While the first distance and second distance may be described using angles, it is also possible to use the linear distances or arcuate distances between the blades. The relationships between the spacings would remain the same such that a first length would be larger than a second length.

(18) In the illustrated embodiment, the plurality of blades **112** includes twelve blades **112** separated into pairs of blades **204** evenly spaced around the fan hub **104**. Therefore, each blade **112** has a corresponding diametrically opposed blade **112**. Additionally, a third neighbor blade **208** (or third blade **208**) is located next in order from the first neighbor blade **168** in the first direction. Or in other words, the third blade **208** is positioned before the first blade **168** in the circumferential direction **170**. A fourth neighbor blade **212** is located next in order from the second neighbor blade **172** in the second direction. In other words, the fourth blade **212** is positioned after the second blade **172** in the circumferential direction **170**. The third neighbor blade **208** includes a third leading edge **216** and a third tip **220** intersecting in a third corner **224**, and the fourth neighbor blade **212** includes a fourth leading edge **228** and a fourth tip **232** intersecting in a fourth corner **236**. The third blade **208** is circumferentially spaced by a third distance from the reference blade **152**. The third distance may be measured as a third angle α**3** measured about the rotation axis **124** between the third corner **224** and the reference corner **164**. The fourth blade **212** is circumferentially spaced by a fourth distance from the reference blade **152**. The fourth distance may be represented as a fourth angle α**4** measured about the rotation axis **124** between the fourth corner **236** and the reference corner **164**. The third angle α**3** is the equal to the fourth angle α**4**. Again, linear distances may be used instead of angles with the same result, such that a third length would be equal to a fourth length.

(19) The fan **100** is rotationally symmetrical about the rotation axis **124**. In other words, the spacing between each of the plurality of blades **112** alternates between the first distance (e.g. the first angle α**1**) and the second distance (e.g. the second angle α**2**) in the circumferential direction **170**. The rotational symmetry means that the plurality of blades **112** are rotationally balanced about the fan hub **104**.

(20) With reference to FIG. **5**, while the distances were described as angles measured between respective corners, the relationships between the blades remain the same if like points on each blade are used. For example, FIG. **5** illustrates alternate angles (ß**1**-ß**4**) measured between center points on each blade. The first angle ß**1** is still different from, and larger than, the second angle ß**2**. The third angle ß**3** is still equal to the fourth angle ß**4**.

(21) In operation, the uneven spacing allows air to flow through the fan **100** at a high speed while reducing frequencies that are typically perceived by users as being unpleasant compared to fans with evenly spaced blades. For example, embodiments of the fan **100** may primarily generate an output frequency of approximately 1500 Hertz. For comparison, a fan with evenly spaced blades may primarily generate an output frequency of approximately 3200 Hertz.

(22) FIGS. **6-10** illustrate another embodiment of a fan **300** for use with, for example, the handheld blower **10** of FIGS. **1** and **2**. The fan **300** includes a fan hub **304** and a plurality of blades **308** extending radially outwardly from the fan hub **304**. The plurality of blades **308** are shown as evenly spaced around the hub **304**, however, the plurality of blades **308** may be unevenly spaced as described with respect to FIGS. **3-5** in some embodiments. The fan hub **304** includes a body **312** and an air guiding cone **316**. As shown in FIG. **7**, the air guiding cone **316** may be removably coupled to the body **312**. However, in some embodiments, the air guiding cone **316** may be integrally formed with the body **312**. The fan **300** includes a passageway **320** extending through the body **312**. The passageway **320** defines a central rotational axis **324** (or rotation axis **324**). The

passageway **320** may receive a shaft or other support to rotatably support the fan **300** in the handheld blower **10**. In the illustrated embodiment of FIG. **6**, the forward direction may be generally upstream while a rearward direction may be generally downstream. While the terms forward, front, upstream, rearward, rear, and downstream may be used to describe the fan, these directions do not necessarily correspond to the directions of the motor assembly, the handheld blower, or the environment. The directional language is used for description purposes only and is not meant to limit the embodiment to a certain orientation.

(23) With reference to FIGS. **6-8**, as described above, the fan hub **304** includes the body **312** and the air guiding cone **316**. The plurality of blades **308** may extend from and be unitarily formed with the body **312**. In other embodiments, the plurality of blades **308** may be otherwise secured to the body **312**. The body **312** may also be referred to herein as the blade connection portion **312**. The body **312** may be tapered radially inward. The body **312** may include a circumferential surface **328**. The circumferential surface **328** may be the radial outermost surface of the body **312**. The plurality of blades **308** may extend from the circumferential surface **328**. The body **312** may extend between a rear end **332** and a body connection end **336** configured to couple to the air guiding cone **316**.

(24) The air guiding cone **316** may extend between a truncated tip **340** and a cone connection end **344**. The cone connection end **344** may couple to the body connection end **336** of the body **312**. The air guiding cone **316** may further include a cone surface **348**. The cone surface **348** may be the radially outermost surface of the air guiding cone **316**. The cone surface **348** may be curved with respect to the central rotational axis **324**.

(25) Turning now to FIGS. **9** and **10**, the circumferential surface **328** and the cone surface **348** may combine to form an outer hub surface **352**. The shape of the air guiding cone **316** and body **312** may be such that the circumferential surface **328** and the cone surface **348** meet tangentially at a connection point **356**. The outer hub surface **352** may taper radially inwardly continuously between the rear end **332** and the truncated tip **340**.

(26) Specifically, as shown in FIG. **9**, in a vertical cross section taken through the fan **300** parallel to the rotation axis **324**, the outer hub surface **352** may form a curved profile **360**. The curved profile **360** may include a first point **364** located at the truncated tip **340**, a second point **368** located at the rear end **332**, and an intermediate point **372** located between the first point **364** and second point **368**. In some embodiments, the intermediate point **372** is co-located with the connection point **356** between the cone surface **348** and the circumferential surface **328**. However, the intermediate point **372** may be any point on the curved profile **360** between the first point **364** and the second point **368**. The first point **364** may be radially located at a first distance R**1** with respect to the rotation axis **324**. The second point **368** may be located at a second distance R**2** with respect to the rotation axis **324**, and the intermediate point **372** may be radially located at an intermediate distance R**1** from the rotation axis **324**.

(27) As shown in FIG. **9**, a tangent is taken at each of the points **364**, **368**, **372**. A tangent line taken at the first point **364** forms a first angle **388** with respect to the rotation axis **324**. A tangent line taken at the second point **368** forms a second angle **392** with respect to the rotation axis **324**. Finally, a tangent line taken at the intermediate point **372** forms an intermediate angle **396** with respect to the rotation axis **324**. The hub **304** tapers inwardly such that a slope of the outer hub surface **352** is more aggressive at the truncated tip **340** than at the rear end **332**. In other words, the first angle **388** is larger than the second angle **392**. Additionally, the hub **304** is shaped such that the outer hub surface **352** is never parallel to the rotation axis **324**. Finally, the hub **304** is shaped such that the angle of the tangent to the curved profile **360** decreases constantly between the truncated tip **340** and the rear end **332**. Thus, the first angle **388** is larger than the intermediate angle **396**, which is larger than the second angle **392**.

(28) In operation, the shape of the air guiding cone **316** is such that the fan hub **304** has an increased draft angle as compared a standard fan hub. As shown in FIG. **10**, each blade **308** is connected to the fan hub **304** at an upstream connection point **400** and a downstream connection

point **404**. A first length L**1** is measured between the upstream connection point **400** and a tip **408** of the blade **308**. A second length L**2** is measured between the downstream connection point **404** and a tip **408** of the blade **308**. Because of the taper of the blade connection portion **312**, the first length L**1** is larger than the second length L**2**, meaning that the available blade surface of the plurality of fan blades **308** is maximized, or at least greater than is the case for standard fans, for contacting the operational medium (e.g., air). Thus, the fan **300** has an increased fan efficiency compared to a standard fan.

(29) Although the disclosure has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the disclosure as described.

Claims

1. A fan comprising: a hub; a plurality of blades, each blade of the plurality of blades including a blade base coupled to the hub, each blade extending radially outwardly from the hub to a cantilevered end, the plurality of blades spaced circumferentially about the hub at a common axial location of the hub, the plurality of blades including a reference blade, a first blade, and a second blade; and wherein the reference blade is disposed after the first blade in a circumferential direction about the hub and the second blade is disposed after the reference blade in the circumferential direction, the first blade is circumferentially spaced a first distance from the reference blade, the second blade is circumferentially spaced a second distance from the reference blade, and the first distance is greater than the second distance; and wherein the fan is rotationally symmetrical.

2. The fan of claim 1, wherein the plurality of blades includes twelve blades.

3. The fan of claim 1, wherein the hub includes an outer surface, and the plurality of blades extends from the outer surface.

4. The fan of claim 1, wherein the blades are grouped in pairs circumferentially about the hub.

5. The fan of claim 1, wherein the blades are identical.

6. The fan of claim 1, wherein the hub includes a passage for receiving a shaft, the passage defining a central rotational axis of the fan.

7. The fan of claim 1, wherein each blade of the plurality of blades has a corresponding diametrically opposed blade.

8. The fan of claim 1, wherein any blade of the plurality of blades can be the reference blade.

9. The fan of claim 8, wherein the circumferential spacing between respective blades alternates between the first distance and the second distance in the circumferential direction.

10. A fan comprising: a hub including an air guide cone and a blade connection portion, the blade connection portion tapering radially inwardly and tangentially meeting the air guide cone; and a plurality of blades, each blade of the plurality of blades including a blade base coupled to the hub at a common axial location of the hub, each blade extending radially outwardly from the blade connection portion to a cantilevered end, wherein at least a portion of the plurality of blades are unevenly spaced about the hub, wherein the plurality of fan blades separated into pairs of blades, the pairs of blades evenly spaced circumferentially about the hub with each other, wherein the fan is rotationally symmetrical.

11. The fan of claim 10, wherein the blade connection portion tapers radially inwardly along an entire axial length of the blade connection portion.

12. The fan of claim 10, wherein the air guide cone is removably coupled to the blade connection portion.

13. The fan of claim 10, wherein each blade is formed as a single unitary part with the blade connection portion.

14. The fan of claim 10, wherein the air guide cone and the blade connection portion form an outer surface of the hub, and the outer surface of the hub tapers inwardly along an entire axial length of

the hub.
15. The fan of claim 10, wherein each blade of the plurality of blades is longer radially through an upstream connection point than through a downstream connection point.
16. The fan of claim 10, wherein the air guide cone has a truncated tip.
17. The fan of claim 10, wherein the blade connection portion includes a passage defined therein for receiving a shaft, the passage defining a central rotational axis of the fan.
18. The fan of claim 17, wherein the blade connection portion tapers radially inwardly along the central rotational axis in an upstream direction.
19. A handheld blower comprising: an air duct extending along an axis, the air duct including an air inlet and an air outlet opposite the air inlet; and a fan disposed in the air duct between the air inlet and the air outlet, the fan configured to rotate about the axis, the fan including a fan hub extending from an upstream end to a downstream end, the fan hub defining an outer surface with a radius that continuously increases from the upstream end to the downstream end, the fan hub including an air guide cone and a blade connection portion, and a plurality of fan blades extending radially outwardly from the outer surface of the blade connection portion between the upstream end and the downstream end, each blade of the plurality of blades including a blade base coupled to the blade connection portion of the hub, each blade of the plurality of blades extending to a cantilevered end, the plurality of fan blades separated into pairs of blades, the pairs of blades evenly spaced circumferentially about the fan hub with each other, wherein at least a portion of the plurality of blades are unevenly spaced about the hub, further wherein the fan is rotationally symmetrical.