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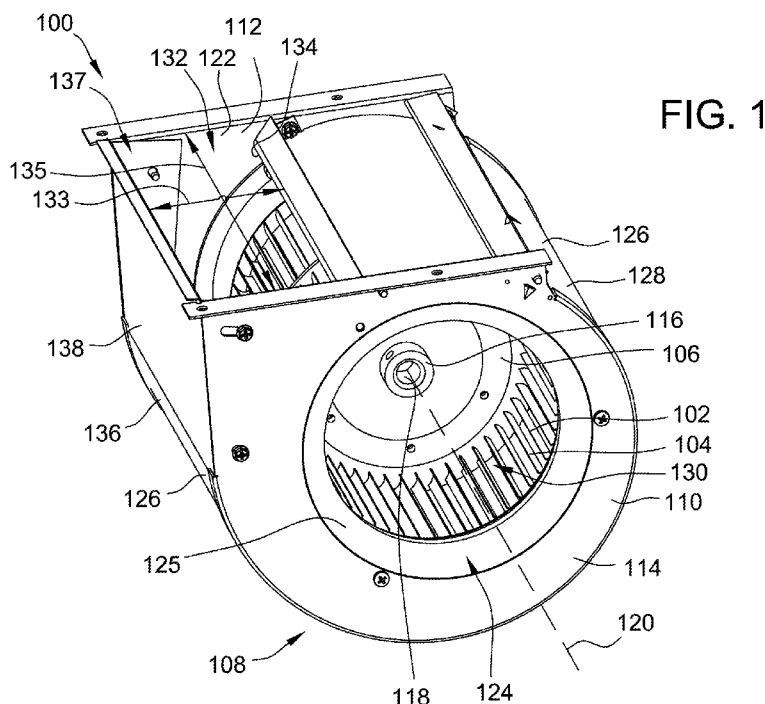
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(57) Abstract: A centrifugal blower assembly includes a scroll wall and at least one sidewall coupled to the scroll wall such that the scroll wall and the at least one sidewall define a blower chamber and a blower outlet, wherein the at least one sidewall includes an opening defined therethrough. The centrifugal blower assembly also includes an inlet ring coupled to the at least one sidewall proximate the opening. The inlet ring includes a first portion coupled to the at least one sidewall, a second portion extending from the first portion through the opening into the blower chamber, and an inner surface that defines a blower inlet and extends along the first portion and the second portion, wherein the inner surface on the second portion is obliquely oriented with respect to the axis of rotation.



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CENTRIFUGAL BLOWER ASSEMBLY

BACKGROUND

[0001] The field of the disclosure relates generally to centrifugal blower assemblies, and more specifically, to housings with an adjustable centrifugal blower discharge and impellers with high efficiency forward curved impeller blades.

[0002] Centrifugal fans or blowers are commonly used in the automotive, air handling and ventilation industries for directing large volumes of forced air, over a wide range of pressures, through a variety of air conditioning components. In a known centrifugal blower, air is drawn into a housing through one or more inlet openings by a rotating wheel. This air is then forced around the housing and out an outlet end. At least some known centrifugal blowers include a fixed discharge outlet that occupies a set volume which cannot be changed or made more compact. Fixed discharge outlets on centrifugal blowers can occupy too much volume to allow the centrifugal blower to fit within the tight spaces. Additionally, fixed discharge outlets cannot adjust to change the trajectory of the outlet flow of air. Furthermore, at least some known centrifugal blowers include an inlet ring to guide the airflow towards the impeller blades. At least some known inlet rings are oriented parallel with the axis of rotation, which may cause recirculation of the air at the inlet to the impeller.

BRIEF DESCRIPTION

[0003] In one aspect, a centrifugal blower assembly is provided. The centrifugal blower assembly includes a scroll wall and at least one sidewall coupled to the scroll wall such that the scroll wall and the at least one sidewall define a blower chamber and a blower outlet, wherein the at least one sidewall includes an opening defined therethrough. The centrifugal blower assembly also includes an inlet ring coupled to the at least one sidewall proximate the opening. The inlet ring includes a first portion coupled to the at least one sidewall, a second portion extending from the first portion through the opening into the blower chamber, and an inner surface that defines a blower inlet and extends along the first portion and the second portion, wherein the inner surface on the second portion is obliquely oriented with respect to the axis of rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a perspective view of an exemplary blower assembly.

[0005] FIG. 2 is a perspective view of an impeller wheel for use with the blower assembly shown in FIG. 1.

[0006] FIG. 3 is a cross-sectional view of the blower assembly shown in FIG. 1.

[0007] FIG. 4 is an enlarged view of a portion of the blower assembly shown in FIG. 3.

[0008] FIG. 5 is another cross-sectional view of the blower assembly shown in FIG. 1 in a compact configuration with an exemplary adjustable outlet plate in a first position.

[0009] FIG. 6 is a side view of a portion of the blower assembly shown in FIG. 1 in an open configuration with the adjustable outlet plate in a second position.

[0010] FIG. 7 is an enlarged view of a portion of the blower assembly shown in FIG. 5.

DETAILED DESCRIPTION

[0011] The exemplary embodiments of a centrifugal blower assembly described herein include many features to improve overall efficiency of the assembly. Specifically, a portion of the inlet ring is oriented obliquely with respect to the axis of rotation to more directly channel the airflow entering the blower chamber through the inlet toward the blades of the impeller wheel. Directing the airflow towards the blades reduces recirculation of the air at the inlet of the impeller wheel, which increases the efficiency and reduces noise.

[0012] Additionally, the blower assembly described herein includes an adjustable outlet plate that facilitates adjusting the shape and size of the centrifugal blower assembly outlet such that the overall volume of the blower housing is smaller

allows the centrifugal blower assembly to fit into smaller volumes. Furthermore, adjusting the centrifugal blower assembly discharge allows the discharge airflow to be directed in different directions to best match the inlet angle of equipment immediately downstream of blower assembly, which increases the efficiency of blower assembly.

[0013] Moreover, the blower assembly described herein includes a housing specifically design with a specific cutoff angle and a specific angle at cutoff. In the exemplary embodiment, the cutoff angle is designed to define the throat of the blower assembly, the area of which controls the velocity of the airflow within the blower chamber upstream of the outlet. Similarly, the angle at cutoff determines the size of the blower outlet and, therefore, controls the velocity of the airflow through the outlet.

[0014] Additionally, the blower assembly described herein includes an impeller wheel having a plurality of blades that each define a leading edge blade and a trailing edge blade angle. The leading edge blade angle is designed to substantially match the angle of the airflow at the leading edge, and the trailing blade angle is designed to balance the amount of pressure generated by the impeller wheel and the amount of torque required to rotate the impeller wheel. Similarly, a stagger angle of the blades is designed to balance the amount of pressure generated by the impeller wheel and the amount of torque required to rotate the impeller wheel.

[0015] FIG. 1 illustrates an exemplary embodiment of a centrifugal blower assembly 100 including an impeller 102 having a plurality of fan blades 104. FIG. 2 is a schematic perspective view of impeller 102 including fan blades 104. FIG. 3 is a cross-sectional view of blower assembly 100. Blower assembly 100 includes at least one wheel 102 that includes a plurality of fan blades 104 positioned circumferentially about wheel 102. Wheel 102 is further coupled to a wheel hub 106. Blower 100 further includes a housing 108 comprising a rear portion 110 and a front portion 112. Rear portion 110 includes a sidewall 114 through which a motor 116 is inserted. Motor 116 includes a shaft 118 that engages hub 106 to facilitate rotation of wheel 102 about an axis 120. In one embodiment, motor 116 is an axial flux motor. In another embodiment, Front portion 112 of housing 108 also includes a sidewall 122. Sidewalls 114 and 122 include an inlet 124 through which a volume of air is drawn by wheel 102 to provide air

to blower assembly 100. More specifically, an inlet ring 125 is coupled to each of sidewall 114 and 122 and defines inlet 124. In one embodiment, inlet rings 125 are separate from sidewalls 114 and 122 and coupled thereto. In another embodiment, inlet rings 125 are integrally formed with sidewalls 114 and 122. Inlet rings 125 guide the airflow into wheel 102, as described in further detail herein. Moreover, blower 100 includes a scroll wall 126 defining a blower circumference 128 and is positioned between sidewall 114 and sidewall 122. Scroll wall 126 extends circumferentially from a cut-off point 134 about a blower chamber 130 to a scroll wall end point 136 and covers a portion of blower circumference 128.

[0016] In the exemplary embodiment, an adjustable outlet plate 138 extends from scroll wall end point 136. As such, adjustable outlet plate 138, sidewall 114, and sidewall 122 together define blower chamber 130 and an outlet 132 through which an air stream is exhausted downstream of blower assembly 100. As shown in FIG. 1, outlet 132 includes an adjustable height 133 and a width 135 which define an adjustable outlet area 137. Although blower assembly 100 is illustrated as having two inlets, a single outlet, and a single wheel, blower assembly 100 may include any number of inlets, outlets, and wheels. Specifically, in one embodiment, blower assembly 100 includes only a single of each of inlet, outlet, and wheel. In another embodiment, blower assembly 100 includes a pair of housings, each with a wheel, positioned on either side of a single motor.

[0017] Scroll wall 126 is positioned progressively further from wheel 102 in the direction of rotation to accommodate the growing volume of air due to the scroll shape of chamber 130. Rotation of wheel 102 facilitates drawing air through inlet 124, passing it around blower chamber 130, and exhausting it through outlet 132. In the exemplary embodiment, blower assembly 100 includes a single wheel 102 and inlet 124; alternatively, blower assembly 100 may include more than one wheel and/or inlet.

[0018] FIG. 2 is a schematic perspective view of exemplary impeller 102 including fan blades 104. In the exemplary embodiment, fan blades 104 are coupled between a front endring 140 and a rear endring 142 such that a blade span 141 is defined therebetween. In the exemplary embodiment, impeller 102 includes a mounting plate

144 approximately midway along blade span 141 and is configured to couple to motor 116. Fan blades 104 are oriented such that impeller 102 is a forward curved fan. Alternatively, impeller 102 may be a backward curved fan or any fan type that facilitates operation as described herein. Endrings 140 and 142 are coaxial or substantially coaxial with an axis 120. Fan blades 104 are attached to rear endring 142 and/or front endring 140 such that a longitudinal axis of fan blades 104 is substantially parallel to axis 120. Fan blades 104 are configured to pull in air along axis 120 and eject the air radially outward when rotated about axis 120 together with rear endring 142 and front endring 140. Fan blades 104 may be attached to rear endring 142, front endring 140, and/or mounting plate 144 in any manner that permits impeller 102 to operate as described herein. In operation, motor 116 is configured to rotate impeller 102 about axis 120 to produce a flow of air for a forced air system, e.g., a residential or commercial HVAC system.

[0019] In the exemplary embodiment, fan blade 104 may be suitably fabricated from any number of materials, including, but not limited to, a plastic or other flexible or compliant material. For example, fan blade 104 may be formed by a molding, forming, extruding, or three-dimensional printing process used for fabricating parts from thermoplastic or thermosetting plastic materials and/or metals. Alternatively, fan blade 104 may be fabricated from a combination of materials such as attaching a flexible or compliant material to a rigid material. Fan blade 104, however, may be constructed of any suitable material, such as metal, that permits fan blade 104 to operate as described herein.

[0020] FIG. 4 is an enlarged view of a portion of blower assembly 100. More specifically, FIG. 4 illustrates a portion of inlet ring 125 and impeller wheel 102. In the exemplary embodiment, inlet ring 125 includes a first portion 146 coupled to sidewall 110 and oriented perpendicular to axis 120 and a second portion 148 extending into chamber 130. Inlet ring 125 also includes an inner curved surface 150 that guides the airflow through inlet 125 and into chamber 130 and an opposing outer curved surface 151 that defines a thickness of inlet ring 125. In the exemplary embodiment, at least a portion of inner surface 150 of second portion 148 is oriented obliquely with respect to

axis 120. More specifically, at least a portion of inner surface 150 of second portion 148 is oriented at an angle α from axis 120. In one embodiment, angle α is between approximately 1.5 degrees and approximately 4.0 degrees. In another embodiment, angle α is between approximately 2.0 degrees and approximately 3.0 degrees. Generally, second portion 148 is oriented at any angle α that facilitate operation of inlet ring 125 and impeller wheel 102 as described herein.

[0021] In the exemplary embodiment, outer curved surface 151 of second portion 148 is oriented perpendicular to axis 120 such that a portion of second portion 148 of inlet ring 125 includes a tapered thickness. In another embodiment, outer curved surface 151 of second portion 148 is oriented parallel to inner curved surface 150, and therefore oblique to axis 120, such that second portion 148 of inlet ring 125 includes a constant thickness.

[0022] Orienting a portion of second portion 148, and more specifically, a portion of outer surface 150 of second portion 148, obliquely with respect to axis 120 facilitates directing the air entering chamber 130 towards blades 104 to avoid recirculation of the air at the inlet of the impeller wheel 102. Avoiding recirculation increases the efficiency of the blower assembly 100 and will also lead to noise reduction.

[0023] FIG. 5 is another cross-sectional view of the blower assembly shown in FIG. 1 in a compact configuration with adjustable outlet plate 138 in a first position. FIG. 6 is a side view of blower assembly 100 shown in FIG. 1 in an open configuration with adjustable outlet plate 138 in a second position. Sidewalls 114 and 122 each include a scale slot 152 and a pivot hole 154 extending therethrough. Additionally, sidewalls 114 and 122 each include a plurality of scale markings 156 adjacent scale slot 152 which indicate an angle β of opening of outlet 132. In the exemplary embodiment, scale markings 156 include a numerical indicator and a line. The numerical indicator indicates the numeric value in degrees of angle β of outlet plate 138 with respect to a vertical line parallel to axis 120. The line indicates the location within scale slot 156 that corresponds to the numerical indicator 181.

[0024] Two pivot fasteners 158 extend through pivot holes 154 of sidewalls 114 and 122. Pivot fasteners 158 are configured to maintain the position of adjustable outlet plate 138 between sidewalls 114 and 122 while allowing adjustable outlet plate 138 to pivot around pivot fasteners 158. In the exemplary embodiment, pivot fasteners 158 include bolts. Alternatively, pivot fasteners 158 may include any fastener that enables blower assembly 100 to function as described herein.

[0025] Two adjustable fasteners 160 extend through scale slots 152 of sidewalls 114 and 122. Adjustable fasteners 160 are configured to maintain the position of adjustable outlet plate 138 between sidewalls 114 and 122 after an angle β of outlet plate 138 has been selected. In the exemplary embodiment, adjustable fasteners 160 include bolts. Alternatively, adjustable fasteners 160 may include any fastener that enables blower assembly 100 to function as described herein.

[0026] During operations of blower assembly 100, adjustable fasteners 160 are loosened to allow adjustable outlet plate 138 to pivot about pivot fasteners 158. Adjustable outlet plate 138 is pivoted about pivot fasteners 158 until angle β of outlet plate 138 is a predetermined desired angle. In the exemplary embodiment, adjustable outlet plate 138 is pivoted about pivot fasteners 158 by sliding adjustable fasteners 160 through scale slots 152 until angle β of outlet plate 138 is the predetermined angle. Alternatively, adjustable outlet plate 138 may be pivoted about pivot fasteners 158 by any method which enables blower assembly 100 to function as described herein. Adjustable fasteners 160 are tightened to secure adjustable outlet plate 138 between sidewalls 114 and 122 and to maintain angle β of outlet plate 138 at the predetermined angle during operation of blower assembly 100.

[0027] In the exemplary embodiment, angle β of adjustable outlet plate 138 ranges from approximately 0 degrees to approximately 8 degrees. Generally, angle β of adjustable outlet plate 138 may be any angle that enables blower assembly 100 to function as described herein. In the exemplary embodiment, the numerical indicators range from approximately 0 degrees to approximately 8 degrees. Generally, the numerical indicators may range between any angle that enables blower assembly 100 to function as described herein.

[0028] Increasing angle β of adjustable outlet plate 138 increases adjustable height 133 (shown in FIG. 1) of outlet 132 and also enlarges outlet area 137 (shown in FIG. 1). In the exemplary embodiment, increasing angle β of adjustable outlet plate 138 from approximately 0 degrees to approximately 8 degrees enlarges outlet area 137 by approximately 13% as compared to the outlet area 137 in the second position at the 0 degree angle, as shown in FIG. 6.

[0029] The adjustability of adjustable outlet plate 138 allows blower assembly 100 to change from a compact configuration to an open configuration. Blower assembly 100 is in a compact configuration when angle β of adjustable outlet plate 138 is set to 3 degrees as shown in FIGS. 1 and 5. Alternatively, blower assembly 100 is in an open configuration when angle β of adjustable outlet plate 138 is set to 9 degrees as shown in FIG. 6. Blower assembly 100 occupies less volume when in the compact configuration as compared to the open configuration because adjustable outlet plate 138 does not extend from housing 108 in the compact configuration. As such, pivoting adjustable outlet plate 138 allows blower assembly 100 to become more compact and to fit into tight spaces and tight HVAC appliances. In application with smaller discharge duct sizes, additional efficiency gains are obtained using the compact blower.

[0030] Adjusting angle β of adjustable outlet plate 138 also allows the discharge air to be directed in different directions. The compact configuration directs discharge air in direction 162 as shown in FIG. 5. The open configuration directs a portion of discharge air in direction 164 as shown in FIG. 6. Direction 164 is at an angle relative to direction 162 and, as such, the flow of discharge air from the open configuration is more spread out than the flow of discharge air from the compact configuration.

[0031] Additionally, as previously discussed, adjusting angle β of adjustable outlet plate 138 changes the exhaust angle of the airflow leaving outlet 132. The angle of the airflow is desired to be changed to best match the inlet angle of equipment immediately downstream of blower assembly 100, which increases the efficiency of blower assembly 100. Furthermore, adjusting angle β of adjustable outlet plate 138 also increases outlet area 137, which adjusts the outlet velocity of discharge air

from blower assembly 100. The compact configuration, which has the smallest outlet area 137, has the highest outlet velocity of discharge air from blower assembly 100. Alternatively, the open configuration, which has the largest outlet area 137, has the slowest outlet velocity of discharge air from blower assembly 100. Adjusting the outlet velocity of discharge air tunes the heat transfer and pressure drops in downstream equipment. As such, adjusting an angle β of adjustable outlet plate 138 tunes the outlet velocity of discharge air from blower assembly 100, which tunes the heat transfer rates and pressure drop in downstream heat exchanging equipment, such as HVAC equipment. To avoid sudden expansion and its corresponding pressure losses, blower assembly 100 provides the flexibility to tune outlet area 137 to different discharge duct sizes while maintaining the optimal performance of blower assembly 100.

[0032] Adjustable outlet plate 138 is pivotably coupled to the pair of sidewalls 114 and 122. Adjustable outlet plate 138 is moveable between a first position or compact configuration (when angle β of adjustable outlet plate 138 is set to 3 degrees) to define a first blower outlet area 137 (the smallest outlet area 137) and a second position or open configuration (when angle β of adjustable outlet plate 138 is set to 8 degrees) to define a second blower outlet area (the largest outlet area 137). During a first operational mode, adjustable outlet plate 138 is pivotably positioned with blower outlet 132 such that blower outlet area 137 has a first area. During a second operational mode, adjustable outlet plate 138 is pivotably positioned with blower outlet 132 such that the blower outlet area 137 has a second area greater than the first area. In the exemplary embodiment, during the first operational mode, adjustable outlet plate 138 is pivotably positioned with blower outlet 132 such that angle β of adjustable outlet plate 138 is set to 3 degrees to define a first blower outlet area 137 (the smallest outlet area 137). Additionally, during the second operational mode, adjustable outlet plate 138 is pivotably positioned with blower outlet 132 such that angle β of adjustable outlet plate 138 is set to 8 degrees to define a second blower outlet area (the largest outlet area 137). Second blower outlet area 137 is greater than first blower outlet area 137.

[0033] Referring again to FIG. 5, scroll wall includes a second end 166 proximate a cutoff point 168 of blower housing 108. Housing 108 includes a curved

portion 170 that partially defines cutoff point 168 extending from scroll second end 166. Further, a flange 172 extends from curved portion 170 and at least partially defines cutoff point 168 and outlet 132. In the exemplary embodiment, an angle γ is defined between flange 172 and second end 166 of scroll wall 126. This angle γ is referred to herein as the angle at cutoff. In the exemplary embodiment, angle γ is within a range of between approximately 10 degrees to approximately 30 degrees. More specification, angle γ is within a range of between approximately 15 degrees to approximately 25 degrees. Similar to adjustable outlet plate 138, angle γ , although not adjustable, partially defines outlet 132, and more specifically, outlet area 137. When angle γ is smaller, outlet 132 and outlet area 137 are both larger. This larger outlet area 137 allows the airflow to expand and slow down once it passes the cutoff point 168. When angle γ is larger, the outlet area 137 is smaller such that the airflow retains more speed, comparatively.

[0034] Still referring to FIG. 5, a cutoff angle θ is defined between cutoff point 168 and a vertical plane 174 that is parallel to the plane of outlet 132 and perpendicular to axis 120. In the exemplary embodiment, angle θ is within a range of between approximately 55 degrees to approximately 75 degrees. More specification, angle θ is within a range of between approximately 60 degrees to approximately 70 degrees. In the exemplary embodiment, cutoff angle θ defines a minimum throat distance 176 between cutoff point 168 and adjustable outlet plate 138. A smaller cutoff angle θ reduced the throat distance 176, which reduces the area through which the air can pass at cutoff point 168, thus increasing the velocity of the air. A larger cutoff angle θ increases the throat distance 176, which relatively increases the area through which the air can pass at cutoff point 168, thus reducing the velocity of air compared to a smaller cutoff angle θ . In some embodiment, a smaller cutoff angle θ results in a longer length of scroll wall 126. Alternatively, a larger cutoff angle θ results in a shorter length of scroll wall 126.

[0035] FIG. 7 is an enlarged view of a portion of blower assembly 100. More specifically, FIG. 7 illustrates a portion of inlet ring 125 and end ring 142 with a plurality of blades 104. As shown in FIGs 5 and 7, in the exemplary embodiment, each

fan blade 104 includes a leading edge 178 that defines an inner diameter ID of impeller wheel 102 and a trailing edge 180 that defines an outer diameter OD of impeller wheel 102. In the exemplary embodiment, inner diameter ID is within a range of between approximately 4.5 inches and approximately 5.5 inches. More specifically, inner diameter ID is approximately 5.0 inches. Generally, inner diameter ID may be any diameter that facilitates operation of blower assembly 100 as described herein.

[0036] As best shown in FIGs. 4 and 5, in the exemplary embodiment, leading edge 178 is radially aligned with an inner diameter 181 of inlet ring 125. Because inner surface 150 of second portion 148 is angled away from axis 120, leading edge 178 of blades 104 is positioned slightly radially inward of inner surface 150 at a distal end 149 of second portion 148. In another embodiment, leading edge 178 is radially offset from inner diameter 181 of inlet ring 125. More specifically, leading edge 178 is radially offset from inner diameter 181 by 25% of the inner diameter 181. Generally, leading edge 178 is located at any position that facilitates operation of blower assembly 100 as described herein.

[0037] Referring again to FIG. 7, each blade 104 includes a chord line 182 defined as the linear distance between leading edge 178 and trailing edge 180. In the exemplary embodiment, each blade includes a stagger angle δ defined as the angle between chord line 182 and a line 184 intersecting axis 120 and leading edge 178. Stagger angle δ determines to what extent blades 104 are leaned forward. The larger the stagger angle δ , the more pressure created, which is desirable. However, the larger the stagger angle δ , the more torque will be required to rotate impeller wheel 102, which is undesirable. Accordingly, an optimal stagger angle δ is desirable to increase the pressure at the minimal torque. In the exemplary embodiment, stagger angle δ is within a range of between approximately 5 degrees and approximately 35 degrees. More specifically, stagger angle δ is within a range of between approximately 10 degrees and approximately 30 degrees. Even more specifically, stagger angle δ is within a range of between approximately 15 degrees and approximately 25 degrees. Generally, stagger angle δ is any angle that facilitates operation of impeller wheel 102 as described herein.

[0038] Between leading edge 178 and trailing edge 180 of blade 104, blade 104 curves along a non-linear, arcuate path. The shape of blade 104 has a constantly changing rate of curvature such that a blade profile is not defined by a constant radius or by a combination of two or more unrelated radii. As such, blade 104 defines a blade profile having a continuously changing curvature from leading edge 178 to trailing edge 180. In the exemplary embodiment, blade 104 includes a pressure face 186 and a suction face 188 that each extend between leading and trailing edges 178 and 180. A mean camber line 190 is defined as a curve within blade 104 halfway between pressure face 186 and suction face 188.

[0039] In the exemplary embodiment, blade 104 includes a blade angle that decreases between the leading edge 178 and the trailing edge 180 of blade 104. As shown in FIG. 7, blade 104 includes a leading edge blade angle σ defined as the angle between a first line 192 tangent to mean camber line 190 at leading edge 178 and a second line 194 perpendicular to a third line 196 that intersects both leading edge 178 and axis 120. In one embodiment, leading edge angle σ is substantially similar to the angle of the airflow entering blades 104, also known as the incidence angle. In another embodiment, leading edge angle σ is offset by approximately 5 degrees from the incidence angle. In the exemplary embodiment, leading edge blade angle σ is within a range of between approximately 47.85 degrees and approximately 77.85 degrees. More specifically, leading edge blade angle σ is within a range of between approximately 57.85 degrees and approximately 67.85 degrees. Even more specifically, leading edge blade angle σ is approximately 62.85 degrees. Generally, leading edge blade angle σ can be any angle that facilitates operation of impeller wheel 102 as described herein.

[0040] Similarly, blade 104 includes a trailing edge blade angle λ defined as the angle between a first line 198 tangent to mean camber line 190 at trailing edge 180 and a second line 200 perpendicular to a third line 202 that intersects both trailing edge 180 and axis 120. Trailing blade angle λ determines how much pressure impeller wheel 102 can generate. The smaller the trailing edge blade angle λ , the more pressure impeller wheel 102 can generate, which is desirable. However, as trailing edge blade angle λ decreases, the more torque will be required to rotate wheel 102, which is

undesirable. Accordingly, an optimal trailing edge blade angle λ is desired that increases the pressure at the minimal torque.

[0041] In the exemplary embodiment, trailing edge blade angle λ is within a range of between approximately 20 degrees and approximately 50 degrees. More specifically, trailing edge blade angle λ is within a range of between approximately 30 degrees and approximately 40 degrees. Even more specifically, trailing edge blade angle λ is approximately 35 degrees. Generally, trailing edge blade angle λ can be any angle that facilitates operation of impeller wheel 102 as described herein.

[0042] The exemplary embodiments of a centrifugal blower assembly described herein include many features to improve overall efficiency of the assembly. Specifically, a portion of the inlet ring is oriented obliquely with respect to the axis of rotation to more directly channel the airflow entering the blower chamber through the inlet toward the blades of the impeller wheel. Directing the airflow towards the blades reduces recirculation of the air at the inlet of the impeller wheel, which increases the efficiency reduces noise. Additionally, the blower assembly described herein includes an adjustable outlet plate that facilitates adjusting the shape and size of the centrifugal blower assembly outlet such that the overall volume of the blower housing is smaller allows the centrifugal blower assembly to fit into smaller volumes. Furthermore, adjusting the centrifugal blower assembly discharge allows the discharge airflow to be directed in different directions to best match the inlet angle of equipment immediately downstream of the blower assembly, which increases the efficiency of blower assembly. Moreover, the blower assembly described herein includes a housing specifically design with a specific cutoff angle and a specific angle at cutoff. In the exemplary embodiment, the cutoff angle is designed to define the throat of the blower assembly, the area of which controls the velocity of the airflow within the blower chamber upstream of the outlet. Similarly, the angle at cutoff determines the size of the blower outlet and, therefore, controls the velocity of the airflow through the outlet. Additionally, the blower assembly described herein includes an impeller wheel having a plurality of blades that each define a leading edge blade and a trailing edge blade angle. The leading edge blade angle is designed to substantially match the angle of the airflow at the leading edge, and the

trailing blade angle is designed to balance the amount of pressure generated by the impeller wheel and the amount of torque required to rotate the impeller wheel. Similarly, a stagger angle of the blades is designed to balance the amount of pressure generated by the impeller wheel and the amount of torque required to rotate the impeller wheel.

[0043] Exemplary embodiments of a centrifugal blower assembly and a method for assembling the same are described above in detail. The methods and assembly are not limited to the specific embodiments described herein, but rather, components of the assembly and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein. For example, the methods may also be used in combination with other air stream distribution systems and methods, and are not limited to practice with only the assembly and methods as described herein. Rather, the exemplary embodiment can be implemented and utilized in connection with many other air stream distribution applications.

[0044] Although specific features of various embodiments of the invention may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the invention, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

[0045] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

WHAT IS CLAIMED IS:

1. A centrifugal blower assembly having an axis of rotation and comprising:
 - a scroll wall;
 - at least one sidewall coupled to said scroll wall such that said scroll wall and said at least one sidewall define a blower chamber and a blower outlet, said at least one sidewall comprising an opening defined therethrough; and
 - an inlet ring coupled to said at least one sidewall proximate said opening, said inlet ring comprising:
 - a first portion coupled to said at least one sidewall;
 - a second portion extending from said first portion through said opening into said blower chamber; and
 - an inner surface that defines a blower inlet and extends along said first portion and said second portion, wherein said inner surface on said second portion is obliquely oriented with respect to the axis of rotation.
2. The centrifugal blower assembly in accordance with Claim 1, wherein said inlet ring is integrally formed with said at least one sidewall.
3. The centrifugal blower assembly in accordance with Claim 1, wherein said inlet ring first portion is oriented perpendicular to the axis of rotation.
4. The centrifugal blower assembly in accordance with Claim 1, wherein said inner surface on said second portion is oriented at an angle within a range of between 1.5 degrees and 4.0 degrees with respect to the axis of rotation.
5. The centrifugal blower assembly in accordance with Claim 4, wherein said inner surface on said second portion is oriented at an angle within a range of between 2.0 degrees and 3.0 degrees with respect to the axis of rotation.

6. The centrifugal blower assembly in accordance with Claim 1, wherein said inlet ring comprises an opposing outer surface extending along said first portion and said second portion, wherein said inner surface and said outer surface define an inlet ring thickness therebetween.

7. The centrifugal blower assembly in accordance with Claim 6, wherein said outer surface on said second portion is obliquely oriented with respect to the axis of rotation such that said second portion comprises a constant thickness.

8. The centrifugal blower assembly in accordance with Claim 6, wherein said outer surface on said second portion is parallel to the axis of rotation such that said second portion comprises a tapered thickness.

9. The centrifugal blower assembly in accordance with Claim 1, further comprising a cutoff point positioned at an end of said scroll wall, wherein a cutoff angle is defined between a first line extending between said cutoff point and the axis of rotation and a plane parallel to said blower outlet and extending through the axis of rotation.

10. The centrifugal blower assembly in accordance with Claim 9, wherein said cutoff angle is within a range of between approximately 55 degrees and approximately 75 degrees.

11. The centrifugal blower assembly in accordance with Claim 1, further comprising a cutoff point positioned at an end of said scroll wall, wherein said cutoff point is at least partially defined by a curved portion coupled to said scroll wall end and a planar flange extending from said curved portion, wherein an angle at cutoff is defined between said flange and scroll wall end.

12. The centrifugal blower assembly in accordance with Claim 11, wherein said angle at cutoff is within a range of between approximately 10 degrees and approximately 30 degrees.

13. The centrifugal blower assembly in accordance with Claim 1, further comprising an impeller wheel comprising a plurality of blades, said impeller wheel configured to rotate about the axis of rotation to channel air from said blower chamber to said blower outlet, wherein each blade of said plurality of blades comprises a leading edge and a trailing edge.

14. The centrifugal blower assembly in accordance with Claim 13, wherein each blade of said plurality of blades comprises a leading edge blade angle within a range of approximately 57.85 degrees and approximately 67.85 degrees.

15. The centrifugal blower assembly in accordance with Claim 13, wherein each blade of said plurality of blades comprises a trailing edge blade angle within a range of approximately 20 degrees and approximately 50 degrees.

16. The centrifugal blower assembly in accordance with Claim 13, wherein each blade of said plurality of blades comprises a stagger angle within a range of approximately 5 degrees and approximately 35 degrees.

17. The centrifugal blower assembly in accordance with Claim 1, further comprising an adjustable outlet plate pivotably coupled to said at least one sidewall, wherein said adjustable outlet plate is moveable between a first position to define a first blower outlet area and a second position to define a second blower outlet area.

18. The centrifugal blower assembly in accordance with Claim 17, wherein said adjustable outlet plate is oriented at an angle within a range of between approximately 0 degrees in the first position and approximately 8 degrees in the second position.

19. The centrifugal blower assembly in accordance with Claim 1, further comprising a cutoff point positioned at an end of said scroll wall and at least partially defined by a curved portion coupled to said scroll wall end and a planar flange extending from said curved portion;

wherein a cutoff angle is defined between a first line extending between said cutoff point and the axis of rotation and a plane parallel to said blower outlet and extending through the axis of rotation, wherein said cutoff angle is within a range of between approximately 55 degrees and approximately 75 degrees; and

wherein an angle at cutoff is defined between said flange and scroll wall end and is within a range of between approximately 10 degrees and approximately 30 degrees.

20. The centrifugal blower assembly in accordance with Claim 19, further comprising an adjustable outlet plate pivotably coupled to said at least one sidewall, wherein said adjustable outlet plate is moveable between a first position to define a first blower outlet area and a second position to define a second blower outlet area, wherein said adjustable outlet plate is oriented at an angle within a range of between approximately 0 degrees in the first position and approximately 8 degrees in the second position.

21. The centrifugal blower assembly in accordance with Claim 1, further comprising an impeller wheel comprising a plurality of blades, said impeller wheel configured to rotate about the axis of rotation to channel air from said blower chamber to said blower outlet, wherein each blade of said plurality of blades comprises a leading edge and a trailing edge;

wherein each blade of said plurality of blades comprises a leading edge blade angle within a range of approximately 57.85 degrees and approximately 67.85 degrees;

wherein each blade of said plurality of blades comprises a trailing edge blade angle within a range of approximately 20 degrees and approximately 50 degrees; and

wherein each blade of said plurality of blades comprises a stagger angle within a range of approximately 5 degrees and approximately 35 degrees.

22. The centrifugal blower assembly in accordance with Claim 21, further comprising an adjustable outlet plate pivotably coupled to said at least one sidewall, wherein said adjustable outlet plate is moveable between a first position to define a first blower outlet area and a second position to define a second blower outlet area, wherein said adjustable outlet plate is oriented at an angle within a range of between approximately 0 degrees in the first position and approximately 8 degrees in the second position.

23. The centrifugal blower assembly in accordance with Claim 21, further comprising a cutoff point positioned at an end of said scroll wall and at least partially defined by a curved portion coupled to said scroll wall end and a planar flange extending from said curved portion;

wherein a cutoff angle is defined between a first line extending between said cutoff point and the axis of rotation and a plane parallel to said blower outlet and extending through the axis of rotation, wherein said cutoff angle is within a range of between approximately 55 degrees and approximately 75 degrees; and

wherein an angle at cutoff is defined between said flange and scroll wall end and is within a range of between approximately 10 degrees and approximately 30 degrees.

24. The centrifugal blower assembly in accordance with Claim 23, further comprising an adjustable outlet plate pivotably coupled to said at least one sidewall, wherein said adjustable outlet plate is moveable between a first position to define a first blower outlet area and a second position to define a second blower outlet area, wherein said adjustable outlet plate is oriented at an angle within a range of between approximately 0 degrees in the first position and approximately 8 degrees in the second position.

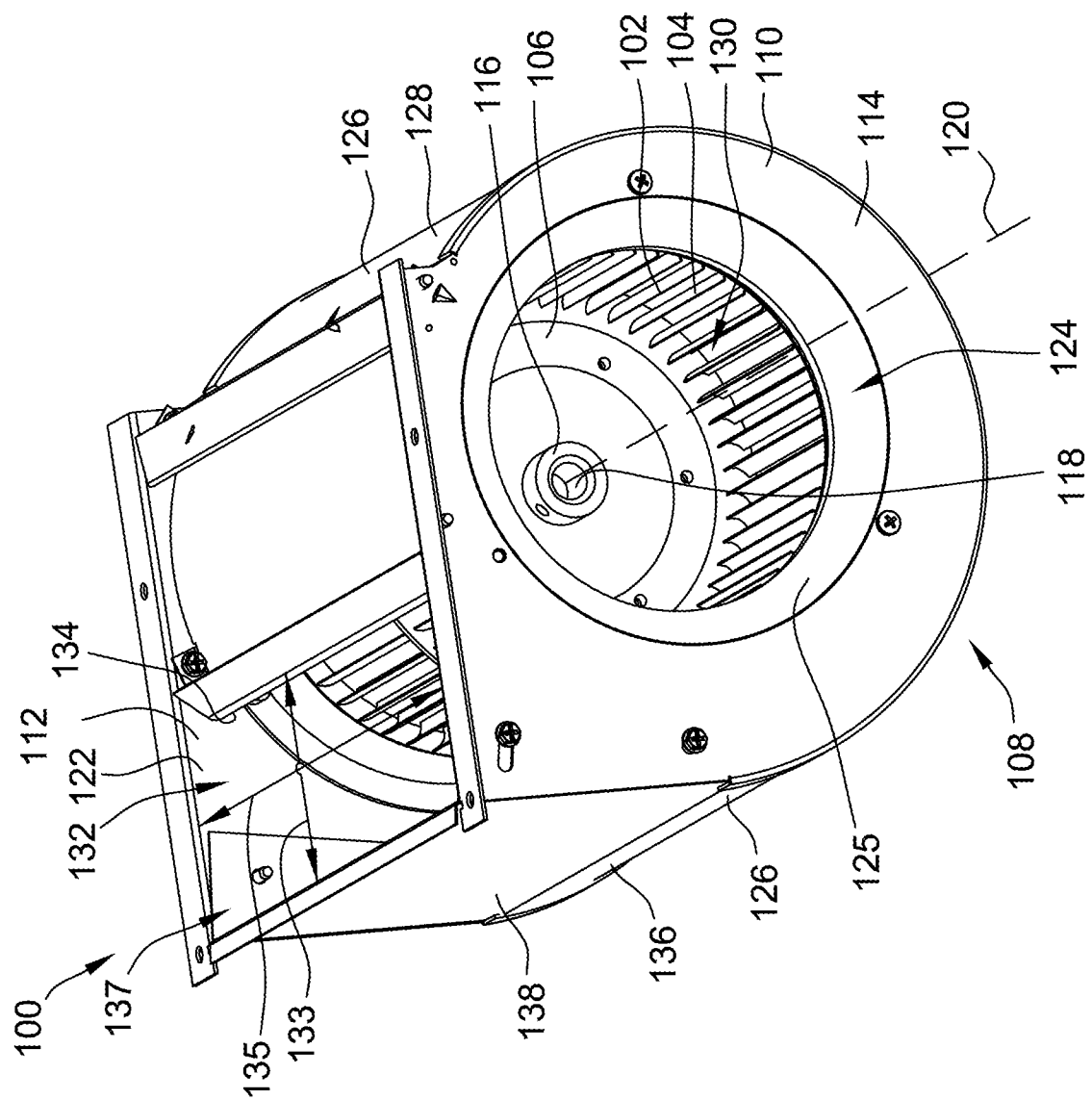


Fig. 1

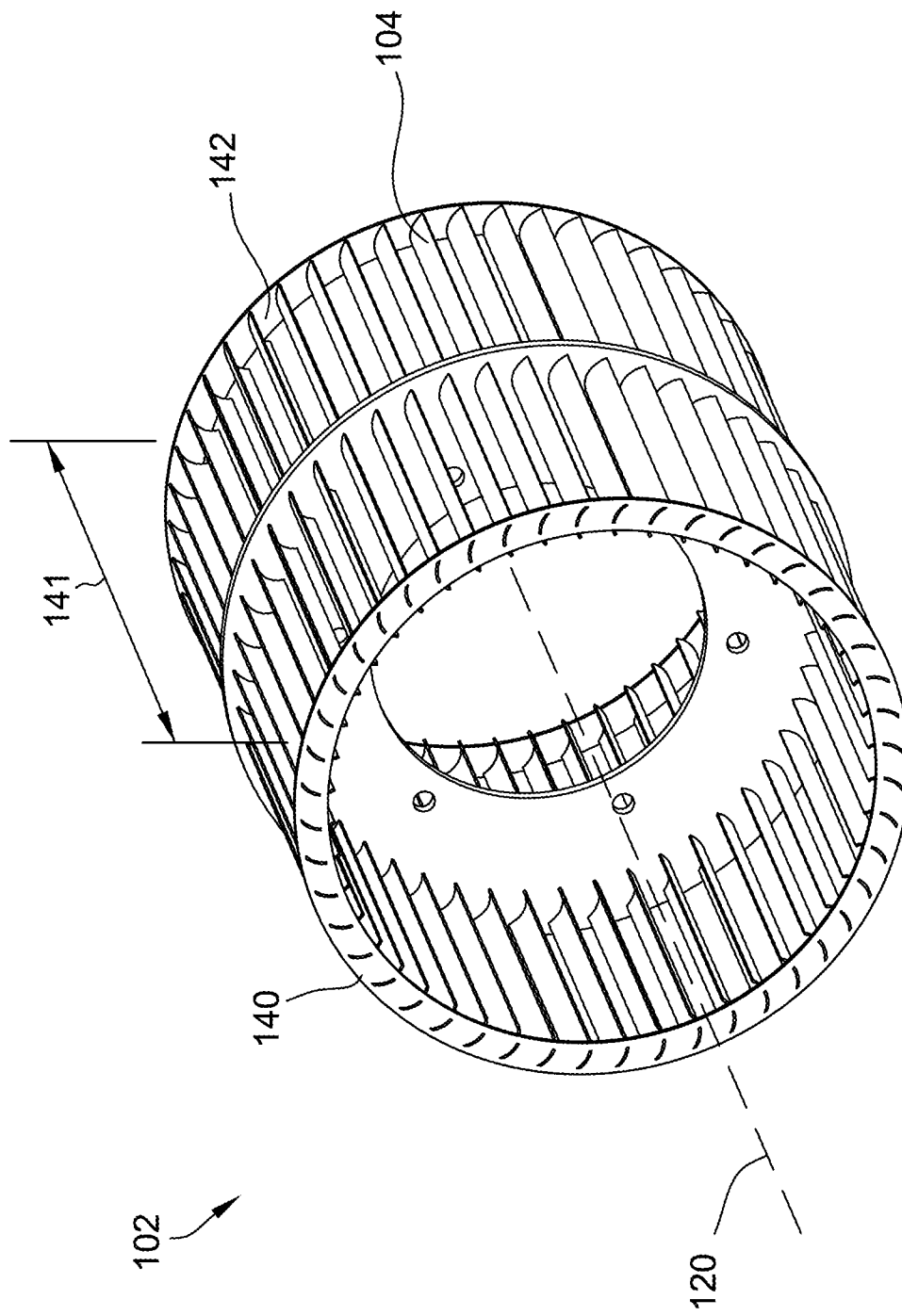


FIG. 2

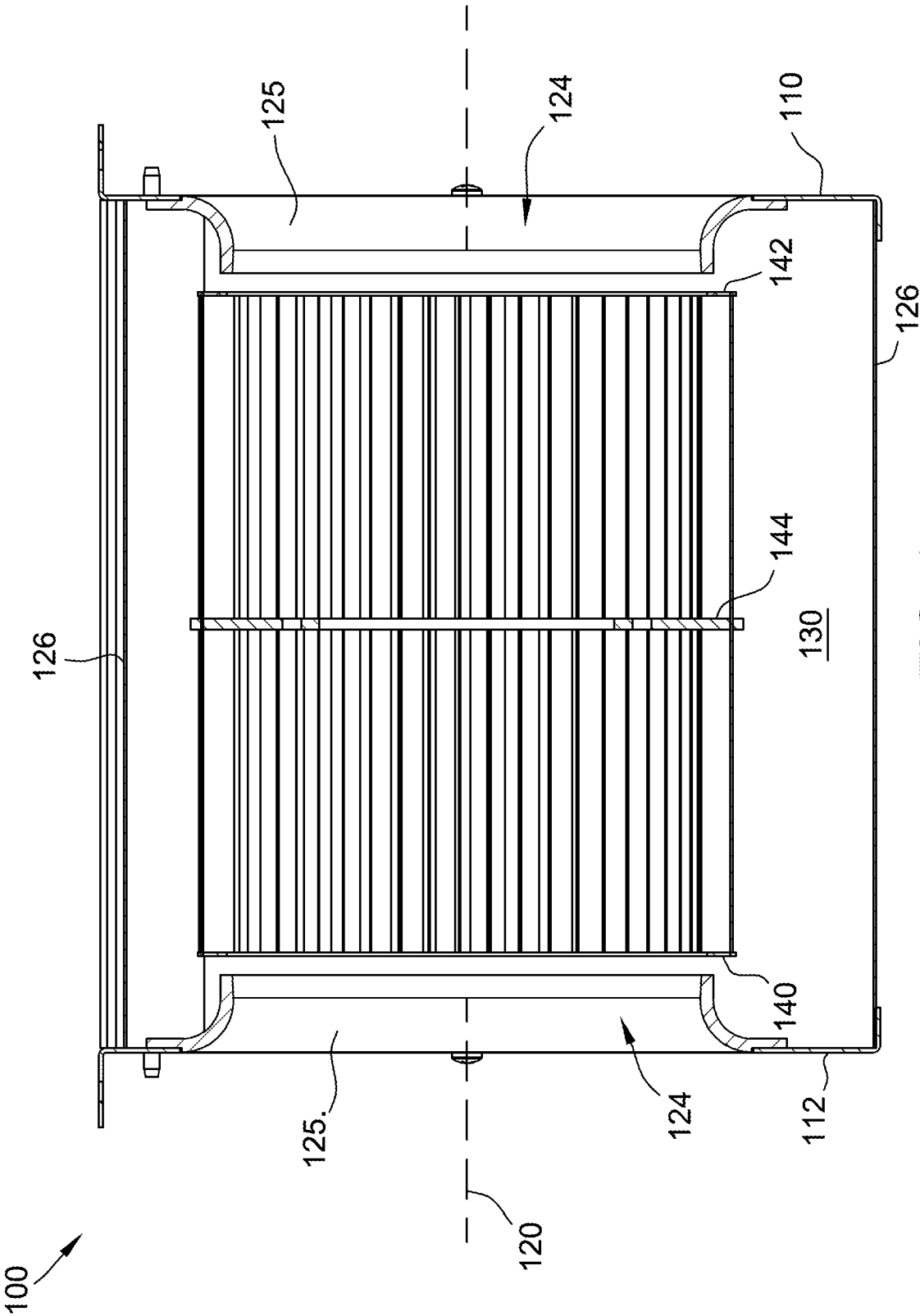


FIG. 3

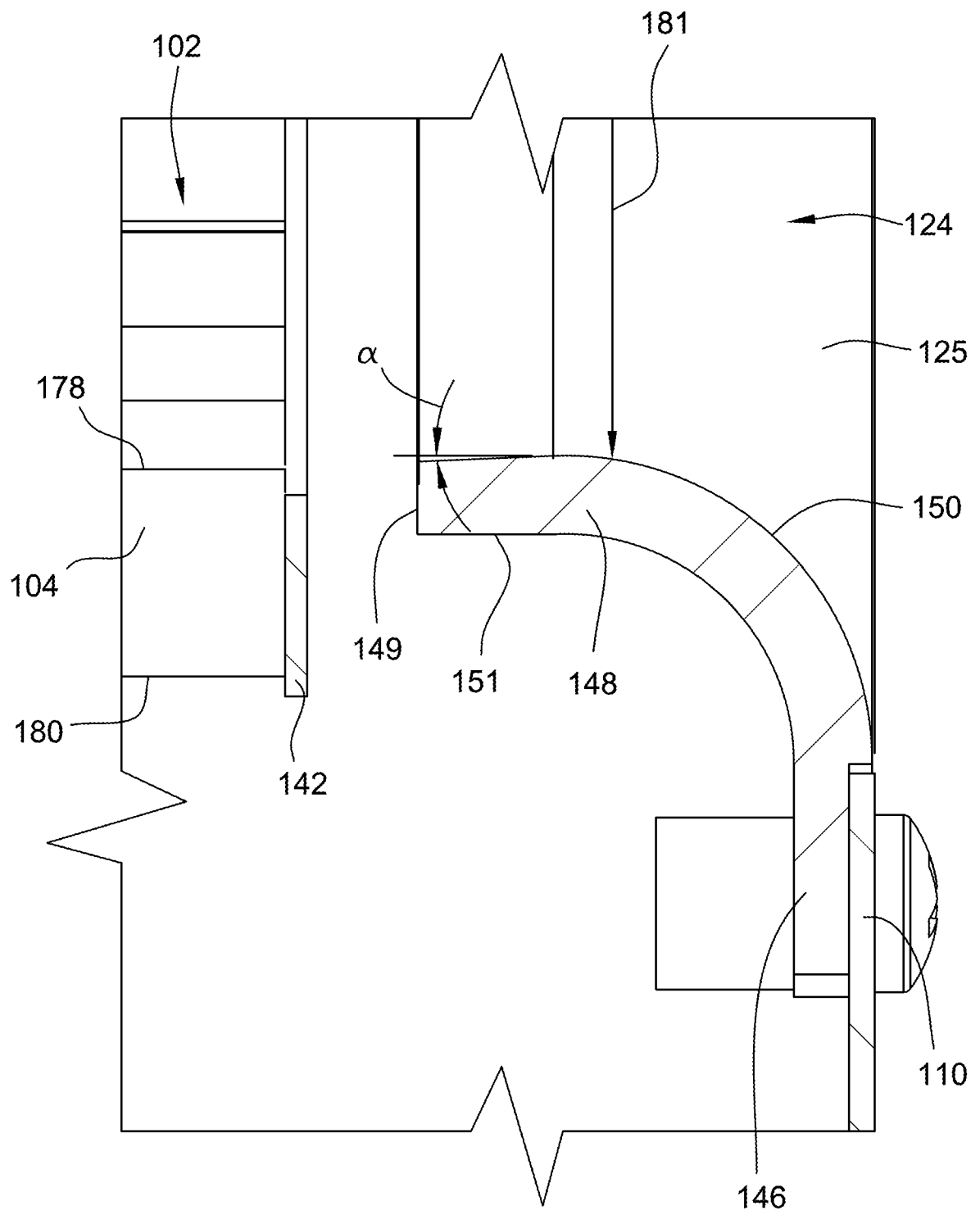


FIG. 4

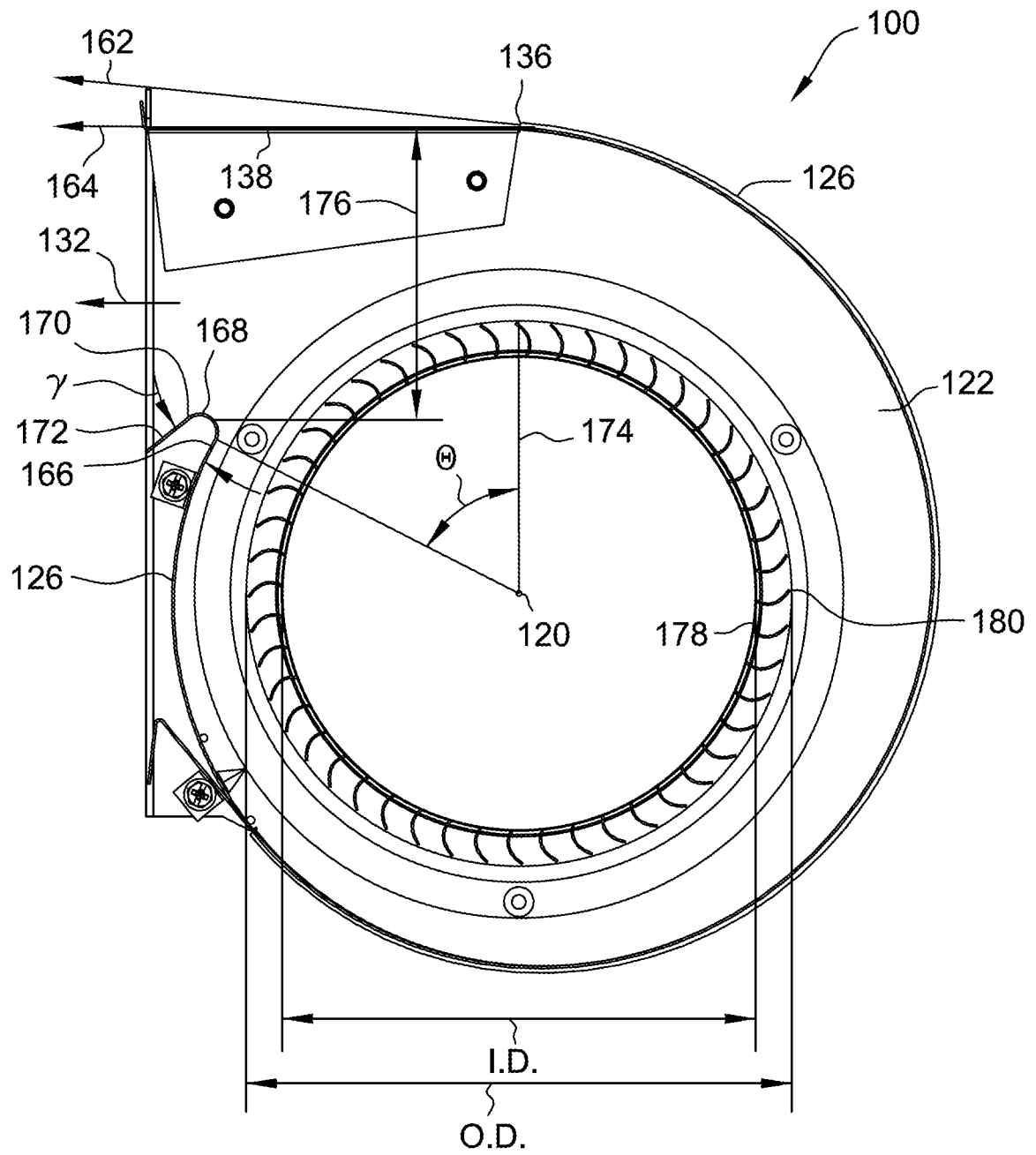


FIG. 5

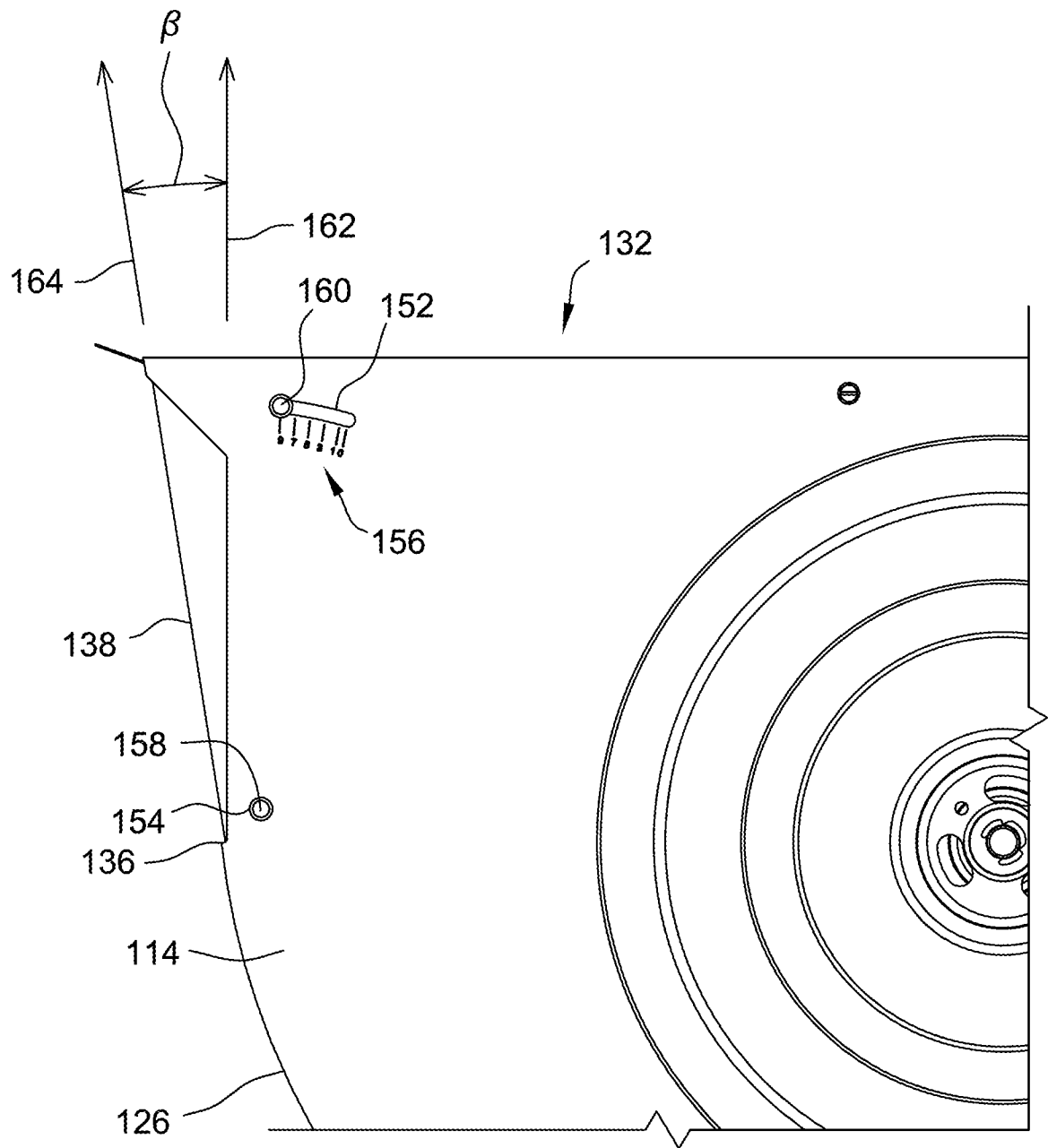


FIG. 6

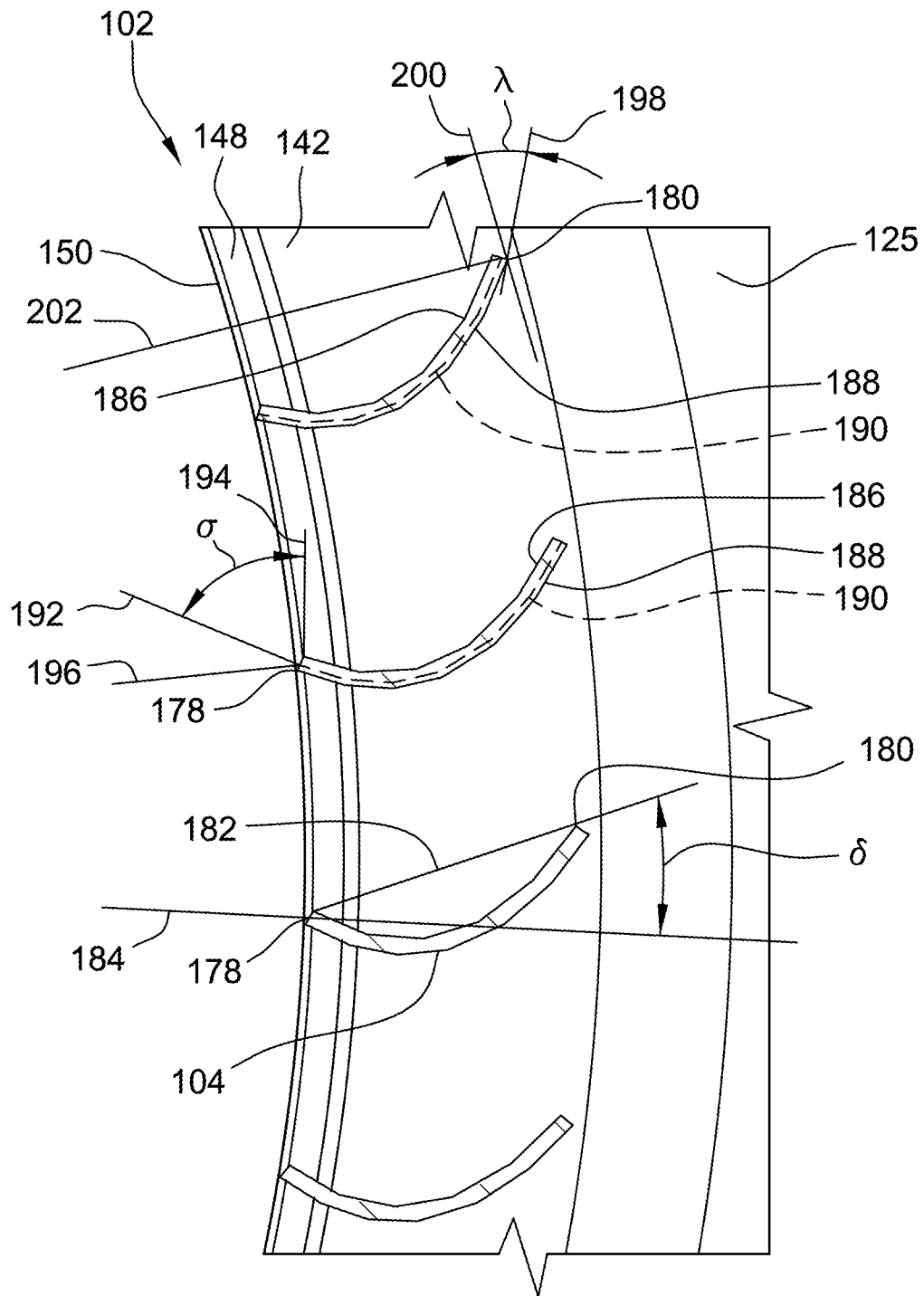


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 18/59795

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F04D 29/42, F04D 29/44, F04D 29/46, F04D 17/08, F24F 7/06 (2019.01)

CPC - F04D 29/4226, F04D 29/4206, F04D 29/424, F04D 17/105, F04D 29/30, F04D 29/462

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y --- A	US 2,727,680 A (Madison et al.) 20 December 1955 (20.12.1955) Entire document especially Fig. 1-2, 4; col 2, ln 17-68	1, 3-7, 9-10, 13-16, 21 ----- 17-18, 20, 22, 24 ----- 8
X --- A	US 2015/0330394 A1 (Regal Beloit America, Inc) 19 November 2015 (19.11.2015) Entire document especially Fig. 1, 7; para [0017]-[0020], [0034]-[0035]	1-2, 11-12, 19, 21, 23 ----- 8
Y	US 2,834,535 A (Autry et al.) 13 May 1958 (13.05.1958) Entire document especially Fig. 1; col 2, ln 35-56; col 2, ln 66 - col 3, ln 24	17-18, 20, 22, 24
A	US 2018/0142702 A1 (Ziehl-Abegg SE) 24 May 2018 (24.05.2018) Entire document	1-20
A	US 2018/0094641 A1 (ebm-papst Mulfingen GmbH & Co.) 5 April 2018 (05.04.2018) Entire document	1-20
A	DE 102012021372 A1 (Ziehl Abegg AG) 30 April 2014 (30.04.2014) Entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

9 April 2019

Date of mailing of the international search report

10-MAY 2019

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