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(54) **VORTEX FINDER FOR A CYCLONIC SEPARATOR**

(57) A vortex finder (F) for a cyclonic separator, the vortex finder comprising a plurality of stationary vanes (V) having a round convex front end around which incoming air (A) is guided into the vortex finder (F), a cross-section of the vanes (V) having only one sharp edge (E) where air separates from the vane (V) inside of the vortex finder (F). Preferably, a mean line (M) of the cross-section of the vanes (V) does not cross a chord line (C) in an upstream half of the cross-section. A vacuum cleaner comprising a cyclonic separator preferably has such a vortex finder (F).

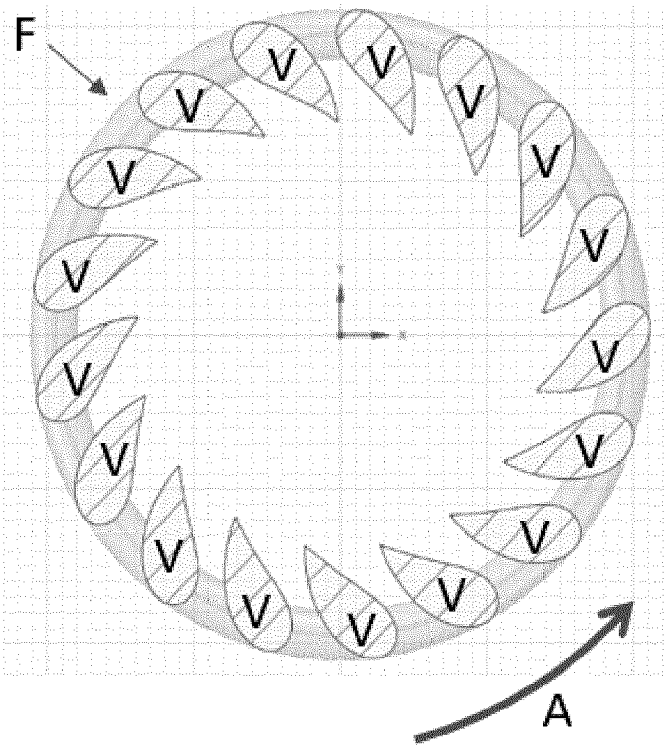

Fig. 1

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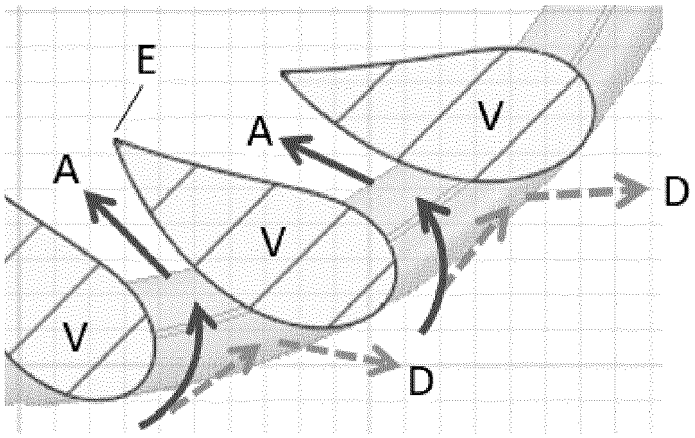

Fig. 2

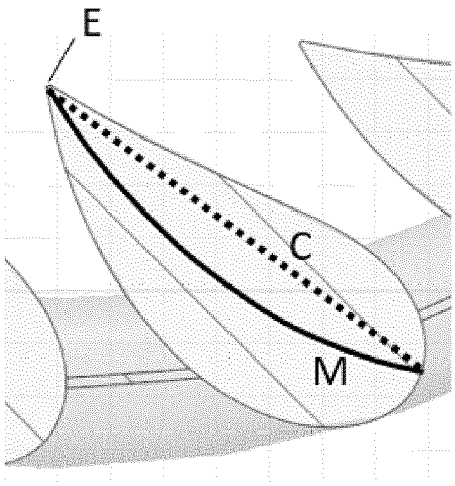

Fig. 3

Description

FIELD OF THE INVENTION

[0001] The invention relates to a vortex finder for a cyclonic separator, and to a vacuum cleaner comprising such a vortex finder.

BACKGROUND OF THE INVENTION

[0002] A bag-less vacuum cleaner uses a cyclone in order to separate the dirt particles from the air. A cyclone consists of a cylindrical chamber in which the air flow rotates fast. Centrifugal force generated by the circular air flow throws the dust particles towards the wall of the cyclone chamber from where they fall into a collection chamber. The cleaned air flows in an opposite direction through the center of the cyclone and is exhausted via the vortex finder to the outlet of the cyclone. The function of the vortex finder is to ensure a stable rotational flow to improve separation performance. The vortex finder usually has a plurality of vanes guiding the air towards the outlet.

[0003] US2012167336 discloses a vacuum cleaner with a separation module that comprises an exhaust grill positioned fluidly between a separator chamber and an air outlet. The exhaust grill can comprise a body having a plurality of louvers and a plurality of inlets defined between adjacent louvers. At least one of the louvers comprises an airfoil configured to deflect dirt away from at least one of the plurality of inlets. The leading end of a louver can include an airfoil tip that is configured to deflect dirt particles away from the gap. In an embodiment, the airfoil tip is formed by a curved guide surface formed on the upstream surface. The guide surface can be located at the outermost portion of the upstream surface. The guide surface can have a smaller radius of curvature toward the leading end as compared with the radius of curvature of the upstream surface toward the trailing end. The guide surface includes a transition point which defines the point at which the slope of a first tangent line on the side of the transition point closer to the leading end is less than the slope of a second tangent line on the side of the transition point closer to the trailing end, which results in a concave crescent shape on the upstream surface of the airfoil tip.

[0004] WO2015150435 discloses a vortex finder for a cyclonic separator through which air flowing in a helical path about an axis of a cyclone chamber passes to an outlet. The vortex finder comprises a plurality of stationary overlapping vanes extending in an axial direction and spaced radially around the axis, the vanes being positioned relative to each other so a helical flow of air about the axis of the cyclone chamber passes over an outer surface of the vanes with a portion of the air flow being redirected around a leading edge of each vane and through a gap between adjacent vanes to the outlet. At any point along the axis, a portion of an outer surface of each vane lies on a circle having its center coaxial with the axis, the outer surface of each vane having a portion leading towards the leading edge that extends inwardly away from the circle so that the leading edge of each vane about which air is redirected through the gap between vanes is located within a region bound by the circle to create a region of overpressure on the outer surface of the adjacent vane in the vicinity of the gap.

SUMMARY OF THE INVENTION

[0005] It is, inter alia, an object of the invention to provide an improved vortex finder. The invention is defined by the independent claims. Advantageous embodiments are defined in the dependent claims.

[0006] One aspect of the invention provides a vortex finder for a cyclonic separator, the vortex finder comprising a plurality of stationary vanes having a round convex front end around which incoming air is guided into the vortex finder, a cross-section of the vanes having only one sharp edge where air separates from the vane inside of the vortex finder. Preferably, a mean line of the cross-section of the vanes does not cross a chord line in an upstream half of the cross-section. A vacuum cleaner comprising a cyclonic separator preferably has such a vortex finder.

[0007] Prior art vanes of the vortex finder result in a relatively big turbulence in the air flow separating from the vanes. Turbulence in general is an energy consuming flow behavior. Embodiments of the invention provide a new vortex finder vane geometry that significantly reduces the flow turbulence while it still maintains easy manufacturing properties. In embodiments of the invention, the vanes of the vortex finder have the shape of a droplet or an airfoil profile. It has only one sharp edge that is located where the flow separates from the shape.

[0008] To a large extent, embodiments of the present invention are similar to those of WO2015150435, incorporated herein by reference. A major difference is formed by the shape of the vanes of the vortex finder, where embodiments of the present invention include vanes having a droplet-shaped cross-section of the vanes, i.e. with a round surface at the front, and only having a sharp edge at a trailing end of the droplet.

[0009] In US2012167336, the shape of the vanes is configured to deflect dirt away from at least one of the plurality of air inlets of the vortex finder. To that end, these prior art vanes have a concave crescent shape on the upstream surface of the vane tip. A clear disadvantage of that prior art shape is that not only the dirt, but also the air is deflected away from the air inlets of the vortex finder, while the air should eventually enter those inlets. So, a lot of suction energy is required to make the air turn so as to enter the air inlets of the vortex finder, and such a suction energy loss is particularly problematic in view of the increasingly strict energy consumption requirements imposed on vacuum cleaners. In embodiments of the present invention, the droplet-like shape of the vanes

that results from the round convex front end, ensures that air is not first directed into the wrong direction away from the vortex finder, but that air can directly and smoothly enter into the gaps between the vanes of the vortex finder.

[0010] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figs. 1 - 3 show a cross-section of a first embodiment of a vortex finder in accordance with the present invention.

DESCRIPTION OF EMBODIMENTS

[0012] Fig. 1 shows a cross-section of a first embodiment of a vortex finder F in accordance with the present invention. The vortex finder F has a plurality of vanes V. An incoming airflow A circulates around the vortex finder F.

[0013] Fig. 2 shows a section of the vanes of Fig. 1 in more detail. Air A enters between the vanes into the vortex finder F as a result of suction exercised by a fan (not shown). As a result of inertia, dirt particles D either do not enter the vortex finder A but follow a straight line towards an outer hull of the cyclone, or are bounced off by a subsequent vane V. In this way, dirt D is separated from the air A. The vanes have only one sharp edge E at a trailing edge of the vanes V, where air A separates from the vanes V. With an airfoil-shaped cross-section of the vanes, a sharp edge means that in a downstream half of the cross-section, upper and lower surfaces of the airfoil intersect at an angle of less than 90°. While in practice, manufacturing restrictions may result in a slight rounding, it still holds that in a downstream half of the cross-section of the vanes, straight lines approximating the upper and lower surfaces of the airfoil in that downstream half, intersect at an angle of less than 90°.

[0014] Fig. 3 shows a mean line M and a chord line C drawn in one of the vanes V. In line with the definitions used in the Wikipedia item on airfoils, the geometry of the airfoil is described with a variety of terms:

- The leading edge is the point at the front of the airfoil that has maximum curvature (minimum radius).
- The trailing edge is defined similarly as the point of maximum curvature at the rear of the airfoil.
- The chord line C is the straight line connecting leading and trailing edges. The chord length, or simply chord, is the length of the chord line.
- The mean camber line or mean line M is the locus of points midway between the upper and lower surfaces of the airfoil. Its shape depends on the thickness distribution along the chord.

[0015] In the embodiments shown, the mean line M has a C-shape that does not cross the chord line C. It at least holds that the mean line M does not cross the chord line C in the upstream half of the vane V. In contrast, in the prior art of US2012167336, the mean line has a S-shape and crosses the chord line at least once in the upstream half of the vane. As a result of the prior art concave crescent shape on the upstream surface of the airfoil tip, air is not smoothly entering the vortex finder, resulting in a high pressure loss.

[0016] As a result of the shape of the vanes in accordance with the present invention, air A is smoothly entering the vortex finder F, thereby minimizing pressure loss, so that the suction energy is most efficiently used. This positive effect also results from the feature that the vanes only have a sharp edge at their trailing ends, so that turbulences resulting from blunt trailing ends are avoided. Such turbulences also contribute to an undesired pressure loss.

[0017] Advantageously, the vortex finder is shaped in the form of a cylinder, which results in that the desired shape of the vanes can be easily manufactured by means of molding.

[0018] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. Measures recited in mutually different dependent claims may advantageously be used in combination.

Claims

1. A vortex finder (F) for a cyclonic separator, the vortex finder comprising:
   a plurality of stationary vanes (V) having a round convex front end around which incoming air (A) is guided into the vortex finder (F), a cross-section of the vanes (V) having only one sharp edge (E) where air separates from the vane (V) inside of the vortex finder (F).

2. A vortex finder (F) as claimed in claim 1, wherein a mean line (M) of the cross-section of the vanes (V) does not cross a chord line (C) in an upstream half of the cross-section.

3. A vacuum cleaner comprising a cyclonic separator having a vortex finder (F) as claimed in any of the preceding claims.

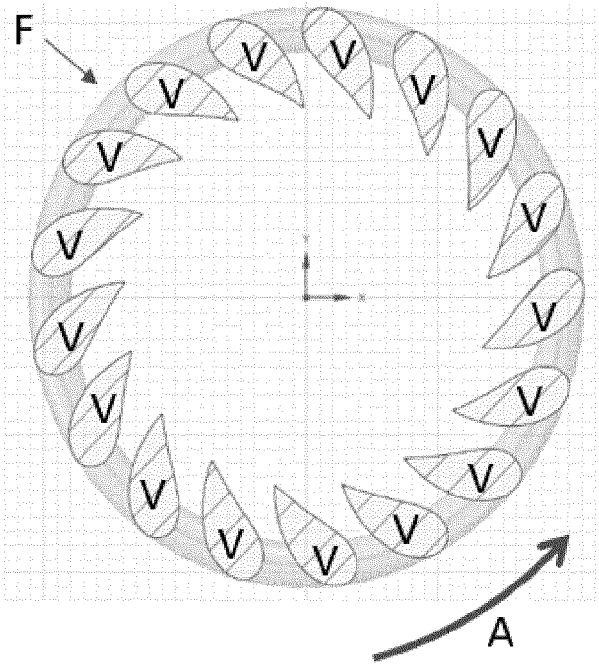

Fig. 1

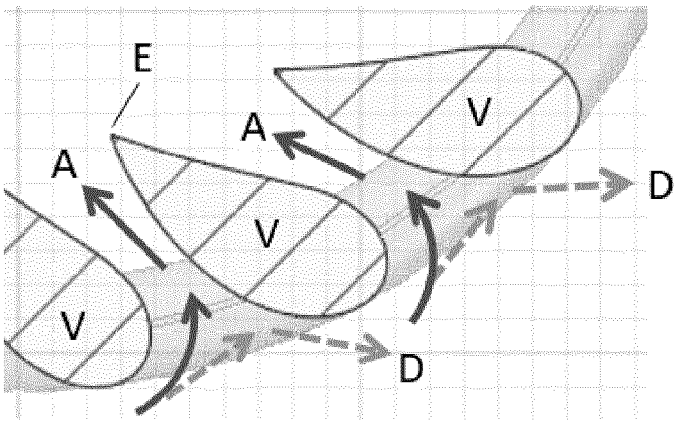

Fig. 2

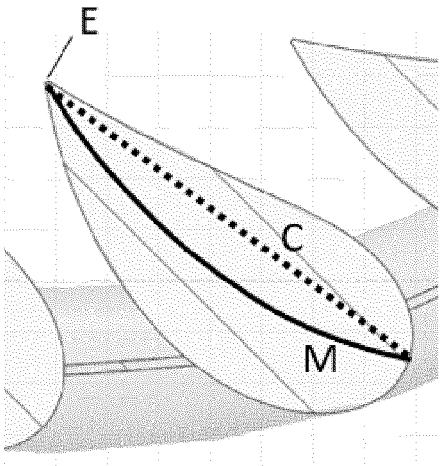

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 8400

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2015/150435 A1 (KONINKL PHILIPS NV [NL]) 8 October 2015 (2015-10-08) * abstract * * figures 6-9b *	1-3	INV. A47L9/16 B04C5/13
A	EP 2 044 996 A1 (JAPAN COOPERATION CT PETROLEUM [JP]; NIPPON OIL CORP [JP]) 8 April 2009 (2009-04-08) * abstract * * figures 1-6 *	1-3	
A	US 2006/037294 A1 (OH JANG-KEUN [KR] ET AL) 23 February 2006 (2006-02-23) * abstract * * figures 2-7 *	1-3	

TECHNICAL FIELDS SEARCHED (IPC)

A47L
B04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 July 2019	Redelsperger, C

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 15 8400

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- US 2012167336 A **[0003] [0009] [0015]**
- WO 2015150435 A **[0004] [0008]**