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(54) CENTRIFUGAL FAN

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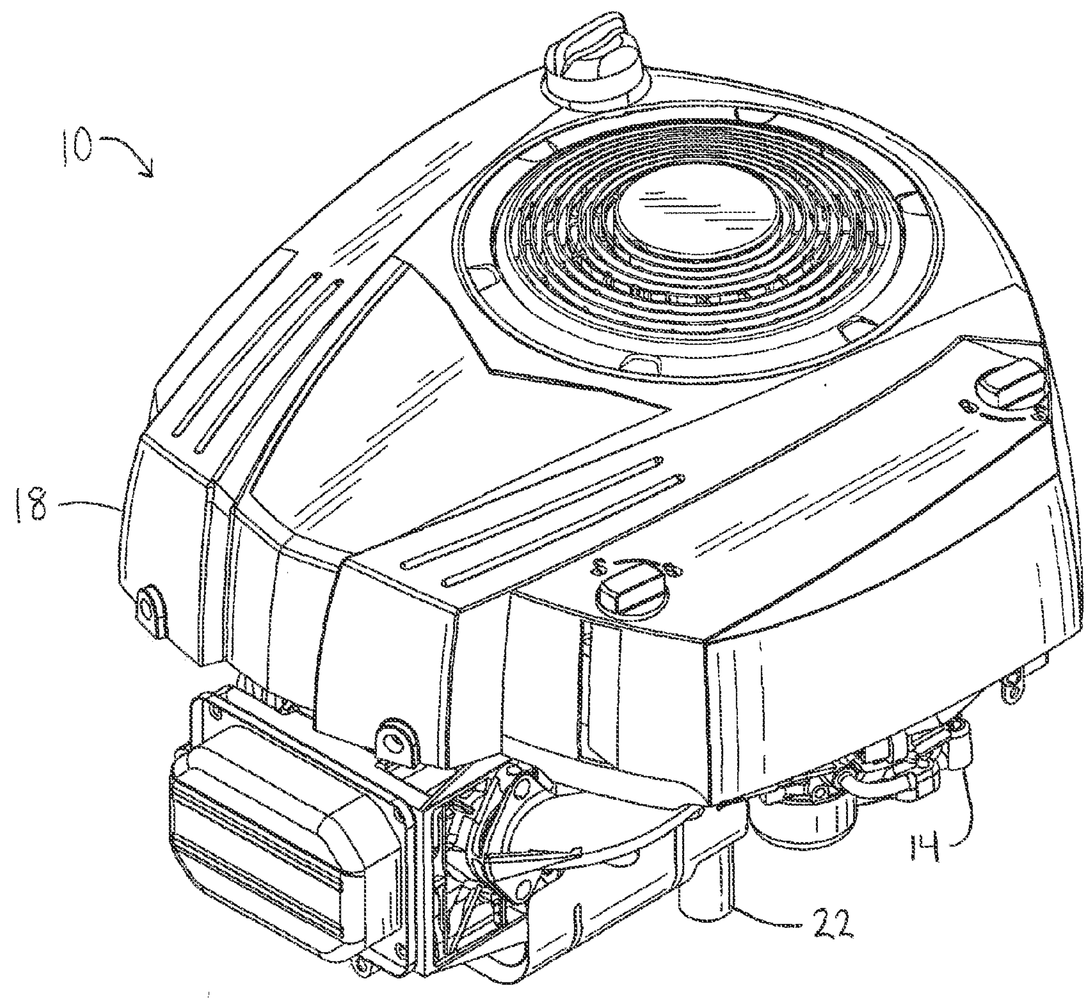
(57) **ABSTRACT**

A centrifugal fan for use with an engine includes a hub defining a rotational axis, a plurality of blades arranged about the rotational axis, and a screen coupled to the hub and blades for co-rotation therewith. The hub, the blades, and the screen are integrally formed as a single piece.



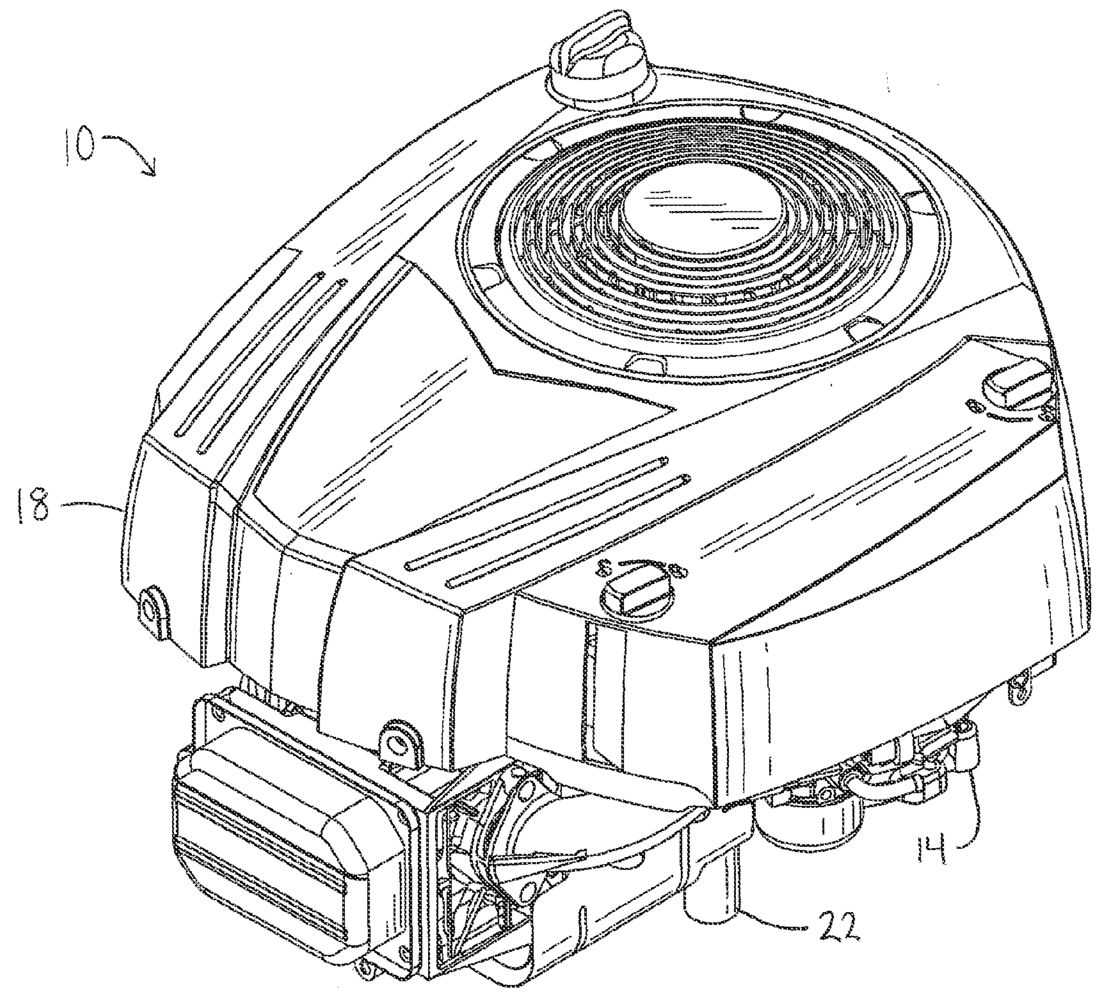


FIG. 1

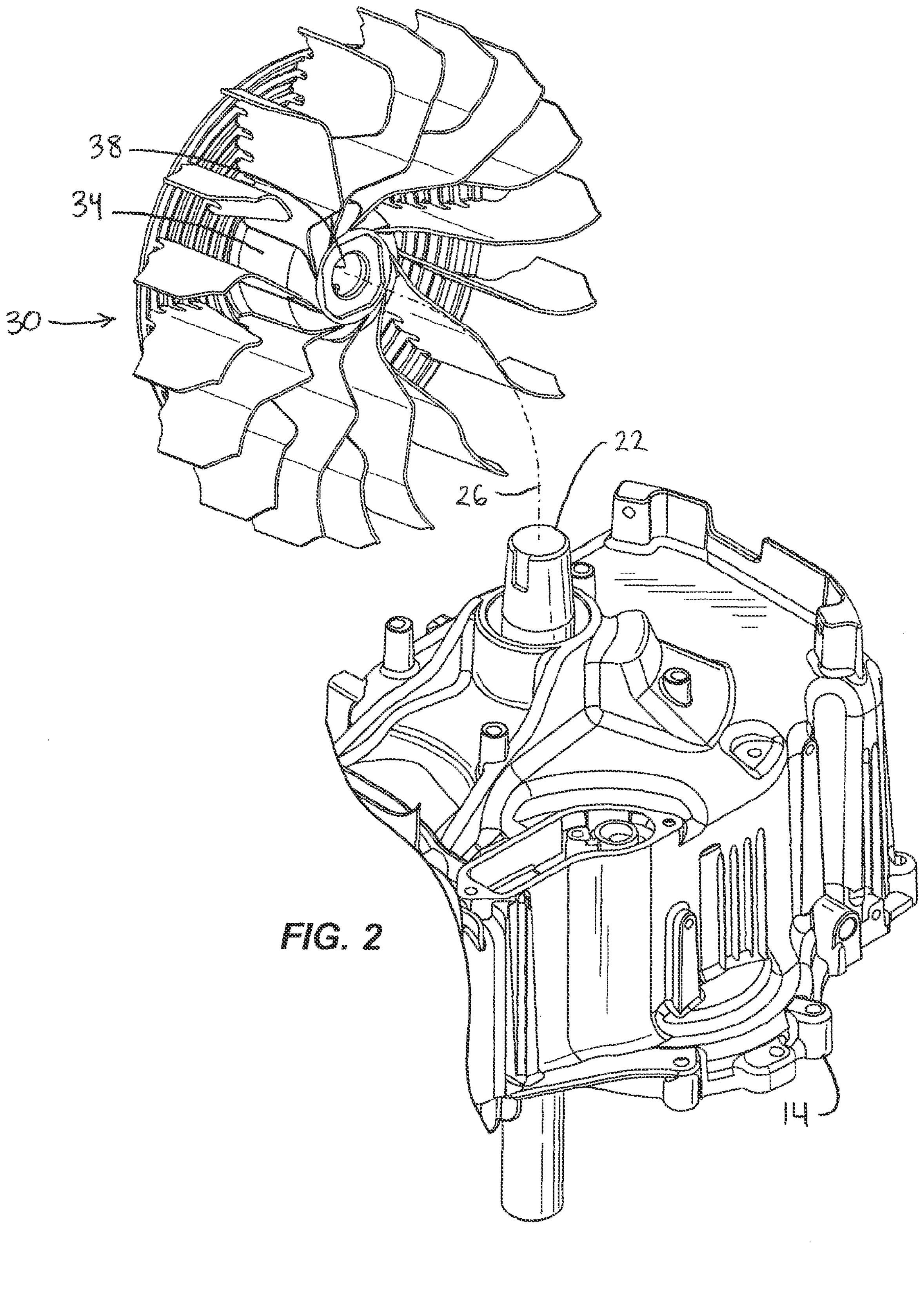


FIG. 2

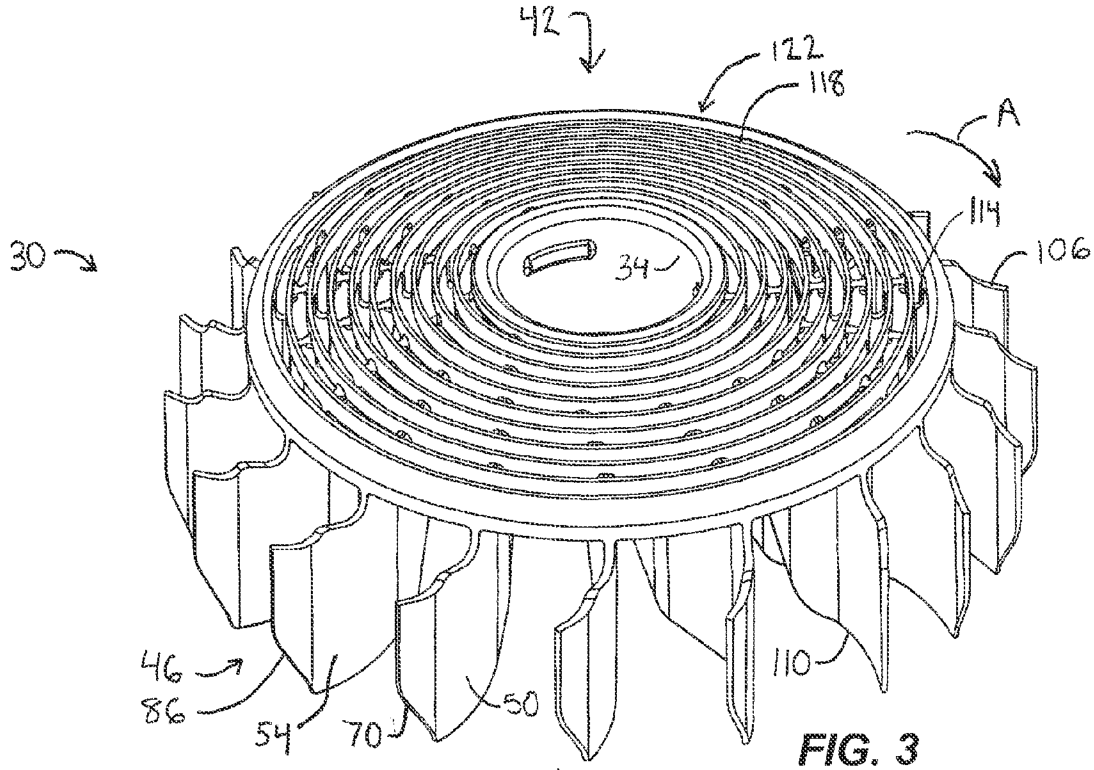

42
122
118
A
114
106
30
34
46
86
54
70
50
110

FIG. 3

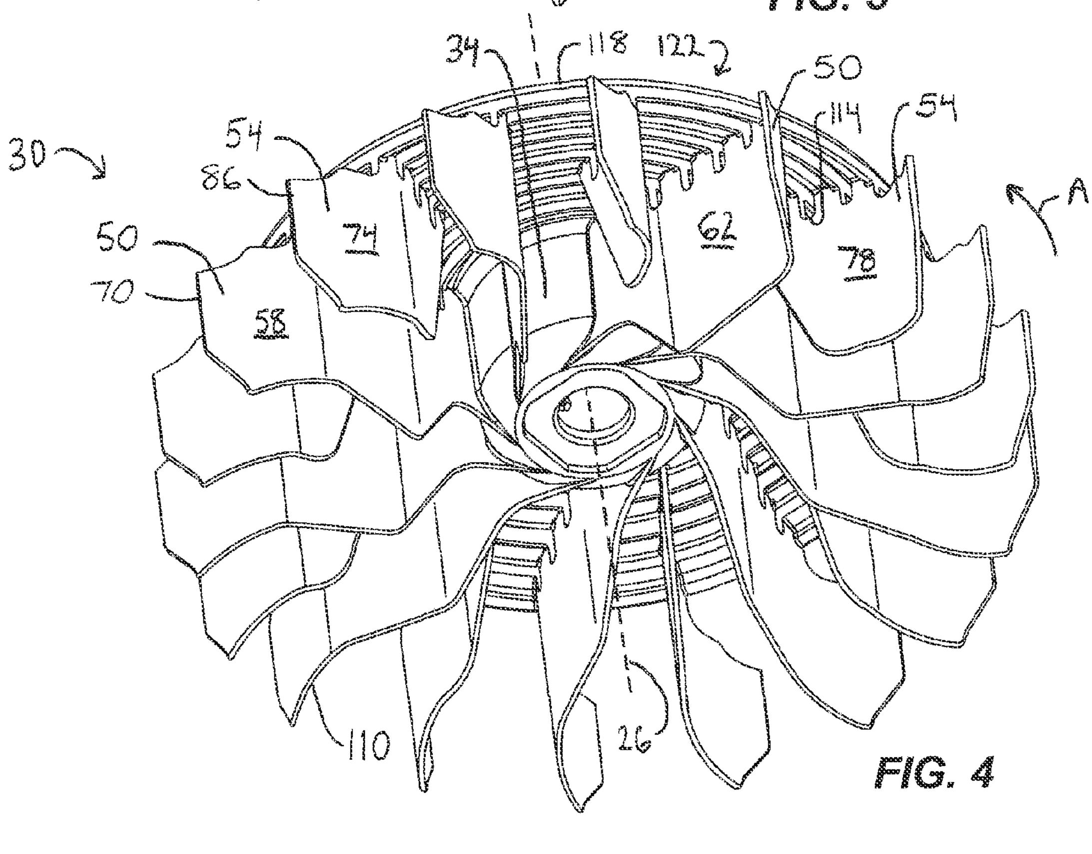

34
118
122
50
114
54
30
54
86
74
62
78
A
50
70
58
110
26

FIG. 4

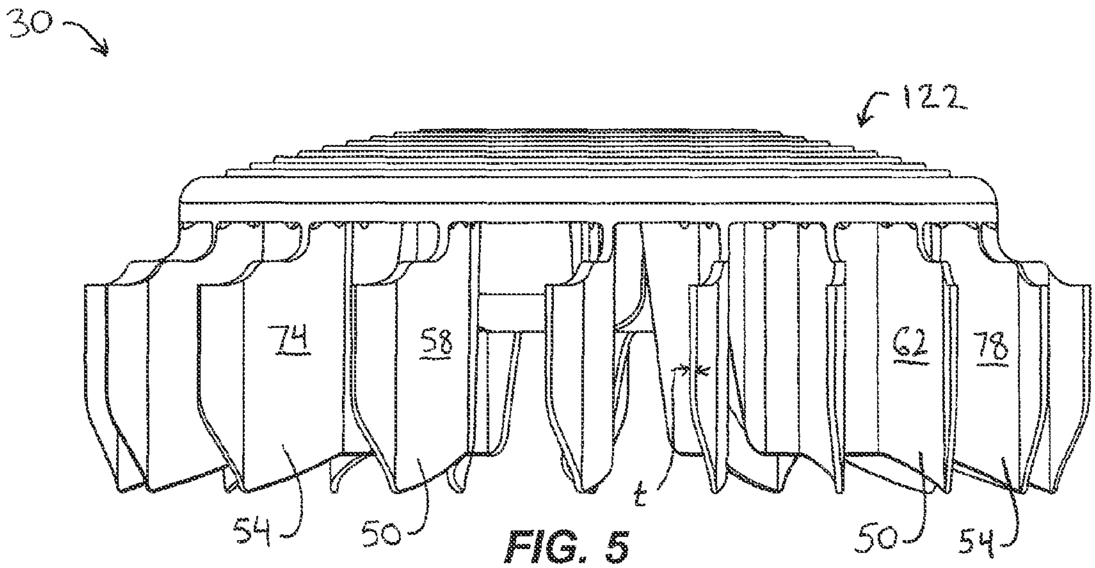

30
122
74
58
62
78
t
54
50
50
54

FIG. 5

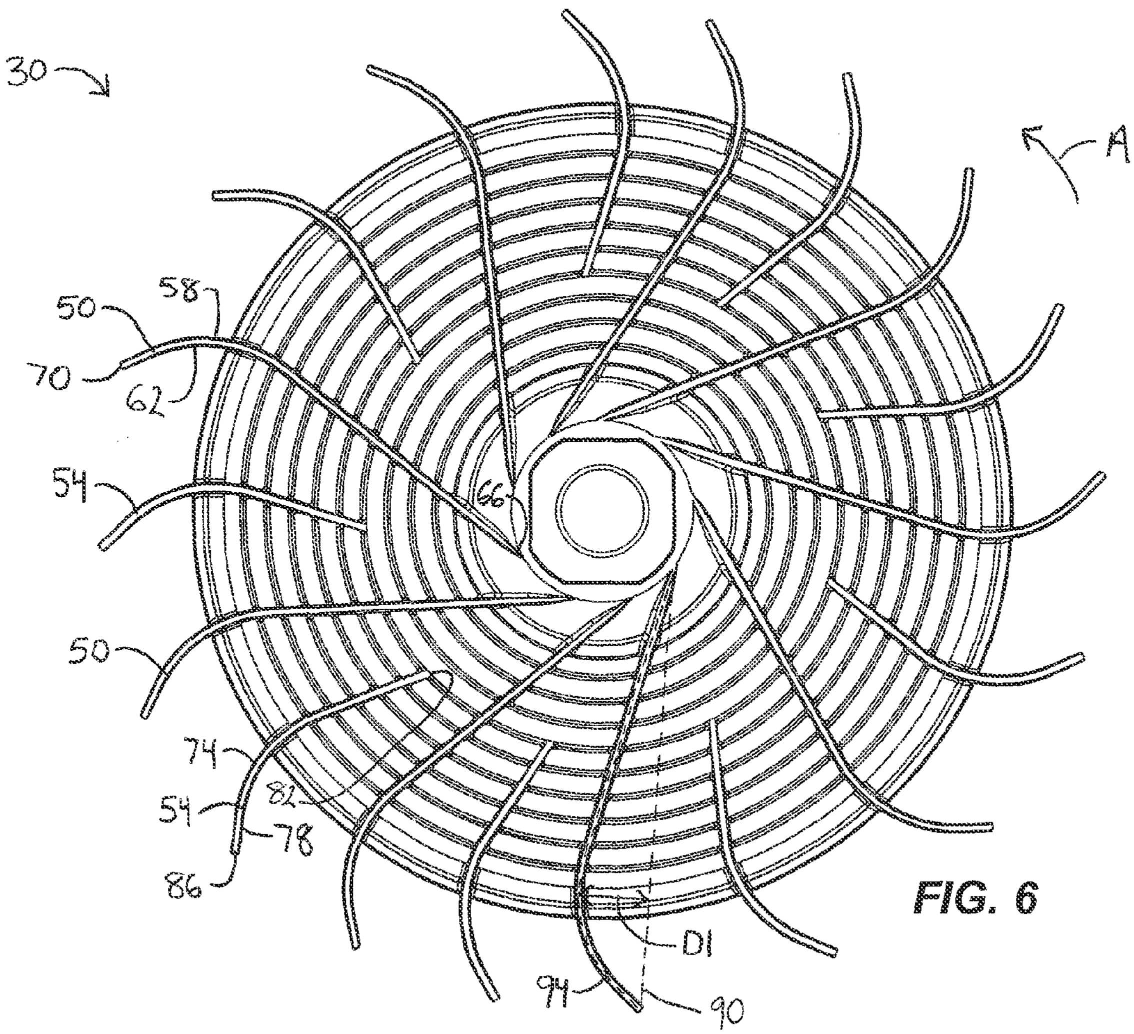

30
A
50
58
70
62
54
66
50
74
82
54
78
86
D1
94
90

FIG. 6

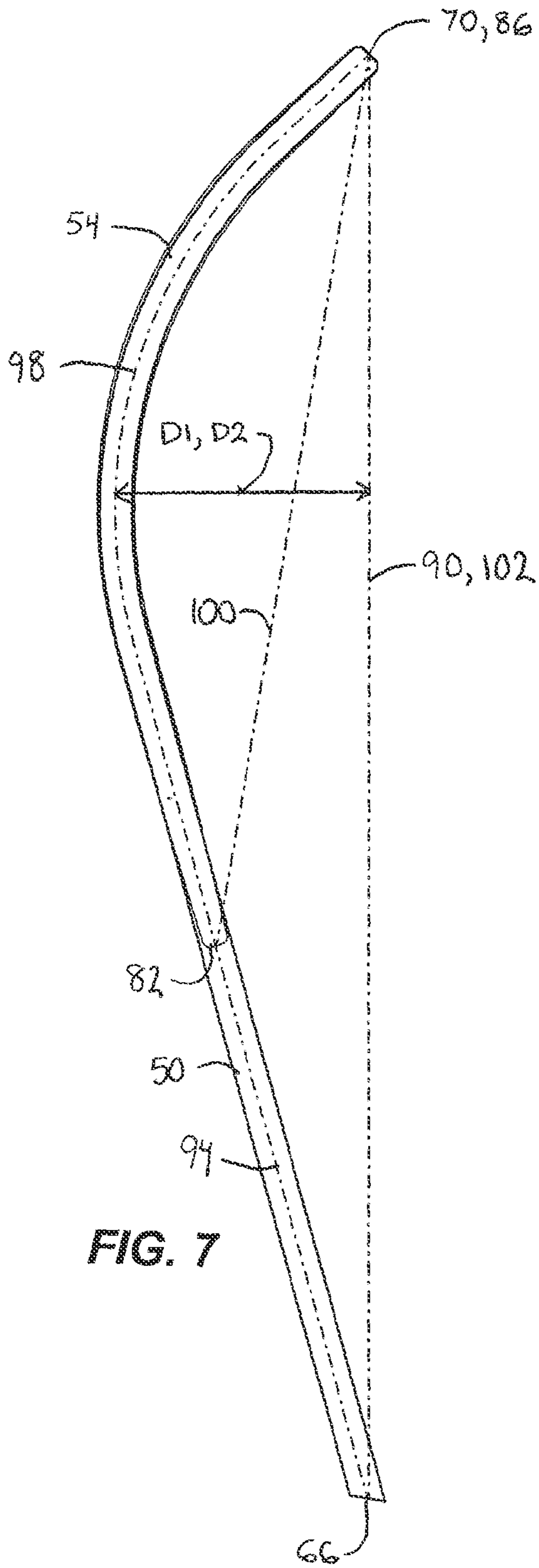


FIG. 7

CENTRIFUGAL FAN

FIELD OF THE INVENTION

[0001] The present invention relates to centrifugal fans, and more particularly to centrifugal fans for use with internal combustion engines.

BACKGROUND OF THE INVENTION

[0002] Centrifugal fans draw air from an axial direction and discharge a radial airflow. Centrifugal fans are often used for air-cooling internal combustion engines. Centrifugal fans are typically assembled using a number of components having differing materials. Such components are separately formed and fastened together, thereby increasing manufacturing costs and complexity.

SUMMARY OF THE INVENTION

[0003] The present invention provides in one aspect, a centrifugal fan for use with an engine including a hub defining a rotational axis, a plurality of blades arranged about the rotational axis, and a screen coupled to the hub and blades for co-rotation therewith. The hub, the blades, and the screen are integrally formed as a single piece.

[0004] The present invention provides, in another aspect, an engine including a crankcase, a cover at least partially enclosing the crankcase, and a centrifugal fan rotatable while the engine is in use for discharging a cooling airflow between the crankcase and the cover. The centrifugal fan includes a hub defining a rotational axis, a plurality of blades arranged about the rotational axis, and a screen coupled to the hub and blades for co-rotation therewith. The hub, the blades, and the screen are integrally formed as a single piece.

[0005] Other features and aspects of the invention will become apparent by consideration of the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a perspective view of an engine including a centrifugal fan of the present invention.

[0007] FIG. **2** is an exploded perspective view of the engine of FIG. **1**, illustrating the centrifugal fan.

[0008] FIG. **3** is a top perspective view of the centrifugal fan of FIG. **2**.

[0009] FIG. **4** is a bottom perspective view of the centrifugal fan of FIG. **2**.

[0010] FIG. **5** is a front plan view of the centrifugal fan of FIG. **2**.

[0011] FIG. **6** is a bottom plan view of the centrifugal fan of FIG. **2**.

[0012] FIG. **7** is a top view of a splitter blade superimposed on a main blade, illustrating the camber of the splitter blade and the main blade.

[0013] Before any embodiments of the invention are explained in detail, it is to be understood that the invention 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 invention 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

[0014] FIG. **1** illustrates an engine **10** including a crankcase **14** and a crankcase cover **18** that at least partially encloses the crankcase **14**. The engine **10** is a single-cylinder engine; however, the engine **10** may alternatively include two cylinders arranged in a V-twin configuration, or more than two cylinders in any of a number of different configurations (e.g., inline, horizontally opposed, etc.), and so forth. With reference to FIG. **2**, the engine **10** also includes a crankshaft **22** that is rotatable about an axis **26** while the engine **10** is in use. The engine further includes a centrifugal fan **30** that is coupled for co-rotation with the crankshaft **22**. Particularly, the centrifugal fan **30** includes a hub **34** having an aperture **38** through which the crankshaft **22** is inserted. The hub **34** may be coupled to the crankshaft **22** by any suitable means (e.g., fasteners, flanges, keyways, cooperating splines, etc.). Although not shown, a flywheel may optionally be included between the centrifugal fan **30** and the crankshaft **22**.

[0015] With reference to FIG. **3**, the centrifugal fan **30** includes an inlet portion **42** through which axially-directed air is drawn and an outlet portion **46** through which the cooling airflow is discharged in a radially outward direction. The cooling airflow passes through an airspace defined between the crankcase **14** and the crankcase cover **18** in order to remove waste heat from the crankcase **14**. Now referring to FIG. **6**, the centrifugal fan **30** further includes a plurality of main blades **50** arranged about the axis **26** and a plurality of splitter blades **54** arranged about the axis **26**. The main blades **50** and the splitter blades **54** are alternately spaced such that a single splitter blade **54** is positioned between adjacent main blades **50**. Alternate constructions of the centrifugal fan **30** may include more than one splitter blade **54** between adjacent main blades **50**, or may not include any splitter blades **54** at all. Each of the main blades **50** includes a suction surface **58**, a pressure surface **62** opposite the suction surface **58**, a leading edge **66**, and a trailing edge **70**, with the collection of trailing edges **70** of the main blades **50** coinciding with the outlet portion **46** of the centrifugal fan **30**. Similarly, each of the splitter blades **54** includes a suction surface **74**, a pressure surface **78** opposite the suction surface **74**, a leading edge **82**, and a trailing edge **86**, with the collection of trailing edges **86** of the splitter blades **54** coinciding with the outlet portion **46** of the centrifugal fan **30**. The leading edge **66** of each of the main blades **50** is integral with the hub **34**, and the leading edge **82** of each of the splitter blades **54** is spaced from the hub **34**. Accordingly, the main blades **50** are longer than the splitter blades **54**.

[0016] With continued reference to FIG. **6**, each of the main blades **50** is curved in the direction of rotation of the centrifugal fan **30**, indicated by arrow “A.” The extent of this curvature is known in the art as “camber,” which is measured with reference to a nose-tail line **90** and a mean line **94**. The nose-tail line **90** is a straight line that extends from the trailing edge **70** to the leading edge **66**, while the mean line **94** extends from the trailing edge **70** to the leading edge **66**, half-way between the suction surface **58** and the pressure surface **62**. Camber is a non-dimensional quantity defined as a perpendicular distance “D**1**” between the mean line **94** and the nose-tail line **90** divided by the length of the nose-tail line **90**, otherwise known as the blade “chord.” Generally, the larger the non-dimensional quantity of camber, the greater the curvature of the blade. In the illustrated construction, the camber of the main blades **50** is between about 0.1 and about 0.2. Preferably, the camber of the main blades **50** is about 0.16.

[0017] With continued reference to FIG. **6**, the splitter blades **54** are also curved in the direction of rotation of the centrifugal fan **30**, as indicated by arrow A. However, the camber of the splitter blades **54** is not measured independently of the main blades **50**, using the procedure described above. Rather, the geometry of the splitter blades **54** is defined by the geometry of the main blades **50** because the splitter blades **54** are essentially "shortened" main blades **50**. Like the main blades **50**, each of the splitter blades **54** defines a mean line **98** extending from the leading edge **82** to the trailing edge **86**, half-way between the suction surface **74** and the pressure surface **78** of the splitter blade **54**. However, a nose-tail line **100** drawn from the leading edge **82** of the splitter blade **54** to the trailing edge **86** of the splitter blade **54** is not used to calculate the curvature of the splitter blade **54** (FIG. **7**). Rather, the curvature of the splitter blades **54** is described in terms of the main blade nose-tail line **90**, drawn as if the trailing edge **86** of the splitter blade **54** was the trailing edge **70** of the main blade **50**.

[0018] With reference to FIGS. **6** and **7**, to describe the camber of the splitter blade **54** relative to the camber of the main blade **50**, the shape of the splitter blade **54** is superimposed on the shape of the main blade **50**. To do this, the splitter blade **54** mean line **98** is rotated about the axis **26** from its location shown in FIG. **6** to a location where at least a portion of the splitter blade mean line **98** near the leading edge **82** of the splitter blade **54** is superimposed on the main blade mean line **94** (FIG. **7**). The splitter blade mean line **98** has a substantially parallel curvature to that of the main blade mean line **94**, at least in the portion of the splitter blade mean line **98** near the leading edge **82**, because the splitter blade **54** shares some of its geometry with the main blade **50**.

[0019] With continued reference to FIG. **7**, the camber of the splitter blade **54** is the same as the camber of the main blade **50**. To calculate the camber of the splitter blade **54**, another nose-tail line **102** is drawn between the leading edge **66** of the main blade **50** and the trailing edge **86** of the splitter blade **54**. This nose-tail line **102** is representative of the chord of the splitter blade **54**, if the splitter blade **54** was not shortened and its leading edge geometry was identical to that of the main blade **54**. Further, a perpendicular distance "D**2**" is measured from this nose-tail line **102** to the splitter blade mean line **98**. The camber of the splitter blade **54** is then the ratio of the perpendicular distance D**2** to the length of the new nose-tail line **102**. Because the camber of the splitter blade **54** is the same as the camber of the main blade **50** in the illustrated construction, the nose-tail line **102** is collinear with the nose-tail line **90** of the main blade **50**. The perpendicular distance D**2** is therefore equal to the perpendicular distance D**1**. In the illustrated construction, the camber of the splitter blade **54** is between about 0.1 and about 0.2. Preferably, the camber of the splitter blades **54** is about 0.16, the same as the camber of the main blades **50**.

[0020] With reference to FIGS. **3** and **4**, each of the main blades **50** and the splitter blades **54** includes a top edge **106** and a bottom edge **110** spaced axially from the top edge **106**. The top edge **106** of each of the main and splitter blades **50**, **54** includes a plurality of notches **114** configured to allow fluid communication between adjacent blades **50**, **54**. This fluid communication equalizes static pressure between adjacent blades **50**, **54** to provide a more uniform flow rate of the cooling airflow discharged from the centrifugal fan **30**.

[0021] With continued reference to FIG. **3**, the centrifugal fan **30** includes a plurality of concentric rings **118** comprising a screen **122**. The screen **122** prevents an operator from accidentally contacting the blades **50**, **54** and prevents large debris from being drawn into the inlet portion **42** and damaging the centrifugal fan **30**. The concentric rings **118** are attached to the top edge **106** of each of the main and splitter blades **50**, **54** between adjacent notches **114**. The main blades **50** act as structural members to rigidly interconnect the hub **34** and the screen **122** such that the hub **34**, the main blades **50**, and the screen **122** all co-rotate with the crankshaft **22** about the axis **26**. Unlike the main blades **50**, the splitter blades **54** are not directly attached to the hub **34** and are therefore supported only by their attachment with the screen **122**.

[0022] The centrifugal fan **30** of the present invention, including the combination of features described above, is formed as a single piece by a suitable molding process such as injection molding. The centrifugal fan **30** may be molded with a relatively simple mold (not shown) that is separable into first and second mold halves. The mold halves may be brought together or separated from one another along a mold axis that is coaxial with the rotational axis **26** of the centrifugal fan **30**. With reference to FIG. **5**, the main blades **50** and splitter blades **54** have a thickness "t" that varies from the top edge **106** to the bottom edge **110**. More specifically, the thickness "t" is greater at the top edge **106** than at the bottom edge **110**. This thickness variation defines a draft in the direction of mold separation that facilitates ejection of the centrifugal fan **30** from the mold.

[0023] In contrast to conventional fans (not shown), which require multiple manufacturing steps before the final product is complete, the single piece design is greatly simplified. The molding process allows for accurate and consistent formation of the various features described above without the need for separate machining and fastening operations. In addition, conventional fans often include a base portion (e.g., a flat disk) to which all other components are connected. In the single piece design according to the present invention, the hub **34**, the blades **50**, **54**, and the screen **122** are all integrally formed and do not require any additional base portion. As such, the manufacturing of the centrifugal fan **30** of the present invention is greatly simplified, and material cost and tolerance requirements are reduced.

[0024] Various features of the invention are set forth in the following claims.

We claim:

1. A centrifugal fan for use with an engine, comprising:

a hub including a rotational axis;

a plurality of blades arranged about the rotational axis and coupled to the hub for co-rotation therewith, wherein each blade includes a pressure surface, a suction surface opposite the pressure surface, a leading edge defining a boundary between the suction surface and the pressure surface, and a trailing edge opposite the leading edge; and

a screen coupled to the hub and the blades for co-rotation therewith, wherein the hub, the blades, and the screen are integrally formed as a single piece, wherein the plurality of blades comprises a plurality of main blades and a plurality of splitter blades, wherein the leading edge of each main blade is integral with the hub and wherein the leading edge of each splitter blade is spaced from the hub.

2. (canceled)

3. The centrifugal fan of claim **1**, wherein each of the blades defines a nose-tail line connecting the leading edge and the trailing edge, the nose-tail line being a straight line and defining a length; and

a mean line half-way between the pressure surface and the suction surface and intersecting the nose-tail line at the leading edge and the trailing edge.

4. (canceled)

5. The centrifugal fan of claim **3**, wherein each of the blades includes a camber between about 0.1 and about 0.2.

6. The centrifugal fan of claim **5**, wherein the plurality of blades comprises a plurality of main blades and a plurality of splitter blades, wherein the camber of the splitter blades is the same as the camber of the main blades.

7. The centrifugal fan of claim **4**, wherein the main blades and the splitter blades are alternately spaced about the rotational axis.

8. The centrifugal fan of claim **1**, wherein the screen includes a plurality of concentric rings coaxial with the rotational axis and interconnected by the blades.

9. The centrifugal fan of claim **1**, wherein each of the blades includes at least one notch in a top edge of the blade, the notch configured to allow an airflow to pass between adjacent blades.

10. An engine comprising:

a crankcase;

a cover at least partially enclosing the crankcase; and

a centrifugal fan that is rotatable while the engine is in use for discharging a cooling airflow between the crankcase and the cover, the centrifugal fan including

a hub including a rotational axis,

a plurality of blades arranged about the rotational axis and coupled to the hub for co-rotation therewith, wherein each blade includes a pressure surface, a suction surface opposite the pressure surface, a leading edge defining a boundary between the suction surface and the pressure surface, and a trailing edge opposite the leading edge, and

a screen coupled to the hub and the blades for co-rotation therewith;

wherein the hub, the blades, and the screen are integrally formed as a single piece, and wherein the plurality of blades comprises a plurality of main blades and a plurality of splitter blades, and wherein the leading edge of each main blade is integral with the hub and wherein the leading edge of each splitter blade is spaced from the hub.

11. (canceled)

12. The engine of claim **10**, wherein each of the blades defines

a nose-tail line connecting the leading edge and the trailing edge, the nose-tail line being a straight line and defining a length; and

a mean line half-way between the pressure surface and the suction surface and intersecting the nose-tail line at the leading edge and the trailing edge.

13. (canceled)

14. The engine of claim **12**, wherein each blade includes a camber between about 0.1 and about 0.2.

15. The engine of claim **14**, wherein the plurality of blades comprises a plurality of main blades and a plurality of splitter blades, wherein the camber of the splitter blades is the same as the camber of the main blades.

16. The engine of claim **10**, wherein the main blades and the splitter blades are alternately spaced about the rotational axis.

17. The engine of claim **10**, wherein the screen includes a plurality of concentric rings coaxial with the rotational axis and interconnected by the blades.

18. The engine of claim **10**, wherein each of the blades includes at least one notch in a top edge of the blade, the notch configured to allow an airflow to pass between adjacent blades.

19. The engine of claim **10**, wherein each of the blades includes a top edge attached to the screen and a bottom edge, and wherein the bottom edge of each of the blades is a free edge.

20. The engine of claim **19**, wherein the bottom edge includes a thickness less than that of the top edge.

* * * * *