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Axial fan for air cooled electrical aircraft motor

Abstract

Described is a fan assembly for an electrical aircraft motor having an axial fan with an inner hub of a first diameter and an outer hub of a second diameter. The outer hub may be concentrically aligned with the inner hub. A plurality of blades may extend between the inner hub and the outer hub. The fan assembly may also have a mounting plate connected to the inner hub. The mounting plate may attach to a component of the electrical aircraft motor.

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Background/Summary

FIELD OF THE INVENTION
(1) The field of the invention relates to cooling aircraft motors. In particular, cooling electrical aircraft motors.
BACKGROUND
(2) Air cooled aircraft motors may rely on the circulation of air over cooling fins affixed to the motor or circulation of air directly over portions of the motor itself. The circulation of air may be satisfied by ram air from in-flight motion or by propeller wash.
SUMMARY
(3) The terms “invention,” “the invention,” “this invention” and “the present invention” used in this patent are intended to refer broadly to all the subject matter of this patent and the patent claims below. Statements containing these terms should be understood not to limit the subject matter described herein or to limit the meaning or scope of the patent claims below. Embodiments of the invention covered by this patent are defined by the claims below, not this summary. This summary is a high-level overview of various aspects of the invention and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this patent, any or all drawings and each claim.
(4) According to certain embodiments of the present disclosure, a fan assembly for an electrical aircraft motor is described. The fan assembly may include an axial fan. The axial fan may be defined by an inner hub having a first diameter and an outer hub having a second diameter. The outer hub may be concentrically aligned with the inner hub. A plurality of blades may extend between the inner hub and the outer hub. A mounting plate may be connected to the inner hub. The mounting plate may be connected to the inner hub and arranged for mounting the fan assembly to a component of the electrical aircraft motor. The first diameter may correspond to a third diameter of the electrical aircraft motor and the second diameter may correspond to a fourth diameter of the electrical aircraft motor.
(5) According to certain embodiments of the present disclosure, a system including an electrical aircraft motor with an annular body and a set of cooling fins extending from the annular body is described. The system may also include an axial fan connected to the electrical aircraft motor. The axial fan may be defined by an inner hub having a first diameter that may correspond to the annular body. The axial fan may also be defined by an outer hub having a second diameter that may be concentrically aligned with the inner hub. The second diameter may correspond to the set of cooling fins. The axial fan may also include a plurality of blades extending between the inner hub and the outer hub.
(6) According to certain embodiments of the present disclosure, a system including an electrical aircraft motor is described. The electrical aircraft motor may have a first annular housing that may include an electrical motor, a second housing that may include electronics, and a motor shaft that may be connected to the electrical motor. The system may also include an axial fan connected to the motor shaft. The axial fan may have an inner hub defined by a first diameter that may correspond to the first annular housing. The axial fan may also have an outer hub defined by a second diameter. The outer hub of the axial fan may be concentrically aligned with the inner hub, wherein the second diameter may be greater than the first diameter. The axial fan may have a plurality of blades extending between the inner hub and the outer hub.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is an isometric view of a fan-cooled motor system for cooling an electrical aircraft motor, according to at least one example.

(2) FIG. **2** is a sectional view of a fan-cooled motor system for cooling an electrical aircraft motor, according to at least one example.

(3) FIG. **3** is a sectional view of a fan-cooled motor system for cooling an electrical aircraft motor, according to at least one example.

(4) FIG. **4** is an isometric view of an axial fan and a mounting plate, according to at least one example.

(5) FIG. **5** is an isometric view of an electrical aircraft motor and a set of cooling fins, according to at least one example.

(6) FIG. **6** is a top view of a blade of an axial fan, according to at least one example.

DETAILED DESCRIPTION

(7) The subject matter of embodiments of the present disclosure is described here with specificity to meet statutory requirements, but this description is not necessarily intended to limit the scope of the claims. The claimed subject matter may be embodied in other ways, may include different elements or steps, and may be used in conjunction with other existing or future technologies. This description should not be interpreted as implying any particular order or arrangement among or between various steps or elements except when the order of individual steps or arrangement of elements is explicitly described.

(8) The described embodiments of the disclosure provide an axial fan for an electrical aircraft motor. While the axial fan for the electrical aircraft motor is discussed for use with electrical aircraft motors, they are by no means so limited. Rather, embodiments of the axial fan may be used in any other suitable application for directing airflow, exhaust, and the like.

(9) An electrical aircraft motor may be adequately cooled in certain scenarios but may require additional cooling in other scenarios. For example, an electrical aircraft motor may be adequately cooled by ram air when the aircraft is in flight or when propeller wash provides adequate airflow. Even so, the electrical aircraft motor may lack adequate cooling during ground operating condition such as taxiing. A lack of adequate cooling may be especially problematic when taxiing precedes takeoff, where the demands on the aircraft motor's power output may be the highest. A lack of adequate cooling of the power supply electronics may also negatively impact avionics equipment.

(10) The lack of adequate cooling may be compounded by certain design decisions, such as housing power supply electronics close to the aircraft motor. Phase-change heat exchanges, such as water-cooling systems, may add undesirable weight, cost, or complexity to a design. An axial fan may compensate for the lack of airflow in some such scenarios.

(11) In a particular example, the axial fan described herein may be driven by a motor shaft common to the propeller and aircraft motor. In an alternative example, a gearbox between the propeller and the motor shaft may drive the axial fan. In such an example, the gearbox may allow the propeller, motor shaft, or axial fan to operate at different rotational speeds. The axial fan may be directed at cooling fins that may be affixed to the aircraft motor and a housing including power supply electronics. The cooling fins may be positioned within an annulus flow region of an assembly containing the aircraft motor, the housing including the power supply electronics, and the motor shaft. The axial fan may be fashioned to increase weight minimally and may not draw consequential power from the motor shaft. The axial fan may be fashioned and positioned so that it does not negatively impact in-flight operating conditions like take-off, cruising, and landing. The axial fan may avoid such negative impacts by cooling fins on the housing of the aircraft motor rather than cooling the motor cavity of the aircraft motor directly.

(12) Turning now to the figures, FIG. **1** is an isometric view of a fan-cooled motor system **100** for cooling an electrical aircraft motor **103**, according to at least one example. The fan-cooled motor

system **100** includes a fan assembly **101** and the electrical aircraft motor **103**. The fan assembly **101** includes a spinner cone **102** and an axial fan **104** with blades **106**. An inner hub of the axial fan **104** may have a first diameter **112** and an outer hub of the axial fan **104** may have a second diameter **114**. In some examples, the axial fan **104** may have between seven and thirty blades **106**. In some examples, the axial fan **104** may have less than seven blades **106** or more than thirty blades **106**. As should be appreciated, the number of blades **106** may depend on certain design considerations such as flow required for cooling, fan weight, power required to spin the axial fan **104**, and other similar considerations. The axial fan **104** may be adapted to any suitable alternate geometry of the spinner cone **102**. In some examples, the axial fan **104** may be integral to the spinner cone **102**. The axial fan **104** may be formed of materials including but not limited to aluminum, stainless steel, fiberglass, graphite fiber, nickel-aluminum-bronze alloy, manganese bronze alloy, other metallic materials, composite materials, or other suitable similar materials.

(13) The electrical aircraft motor **103** includes an aircraft motor **108** enclosed within a motor housing and power supply electronics **110** enclosed within an electronics housing. Airflow provided by the axial fan **104** may provide cooling via flow over the fins of the electrical aircraft motor **103**. In particular, electrical aircraft motor **103** may include cooling fins **111**, disposed radially about the housings of the aircraft motor **108** and the power supply electronics **110**.

(14) FIG. **2** is a sectional view of the fan-cooled motor system **100** for cooling the electrical aircraft motor **103**, according to at least one example. As illustrated, the spinner cone **102** is aligned with a rotational axis **202** that extends through a center of the fan-cooled motor system **100**. The spinner cone **102** may be integrally formed with the axial fan **104**. The blades **106** of the axial fan **104** may direct airflow **214** through an annulus **206** of the spinner cone **102**. An inner hub **226** of the axial fan **104** may have a first diameter **222** and an outer hub **228** of the axial fan **104** may have a second diameter **224**. In some examples, the first diameter **222** may correspond to a smallest diameter of the inner hub **226** (e.g., a surface that faces towards the inner portion of the fan-cooled motor system **100**) or may correspond to a largest diameter of the inner hub **226** (e.g., a surface that faces away from the inner portion of the fan-cooled motor system **100**). In some examples, the second diameter **224** may correspond to a smallest diameter of the outer hub **228** (e.g., a surface that faces towards the inner portion of the fan-cooled motor system **100**) or may correspond to a largest diameter of the outer hub **228**). Thus, in some examples, the annulus **206**, which may be defined by the difference between the second diameter **224** as measured as the smallest diameter of the outer hub **228** and the first diameter **222** as measured as the largest diameter of the inner hub **226**, may be between 5 mm and 50 mm wide. The blades **106** can be axially or radially adjusted based on the width of the annulus **206**. The number of blades **106** may vary between seven and thirty, depending on the size of the annulus **206**.

(15) The first diameter **222** may correspond to a third diameter of the aircraft motor **108** and the second diameter **224** may correspond to a fourth diameter of the aircraft motor **108**. The annulus **206** may also be defined by the difference between the fourth diameter and the third diameter of the aircraft motor **108**. The cooling fins **111** of the aircraft motor **108** may fit within the space between the fourth diameter and the third diameter. In some examples, the height of the cooling fins **111**.

(16) The airflow **214** may fluidly communicate with cooling fins **111** of the aircraft motor **108** and power supply electronics **110**. The height of the cooling fins **111** may correspond to the size of the annulus **206**. Swirling airflow may be caused by the axial fan **104**. In some examples, the height of the cooling fins **111** may be about the same as the width of the annulus **206**. In some examples, the width of the annulus **206** may be greater than height of the cooling fins **111** or smaller than the height of the cooling fins **111**. In alternative examples, a flow-straightening component, such as an air straightener screen **230** may be introduced between the axial fan **104** and the aircraft motor **108** to mitigate swirling airflow within the annulus **206**. The air straightener screen **230** may include a pattern of hexagonal channels. In some examples, other form factors of flow-straightening components may be used.

(17) The power supply electronics **110** may supply electrical power to the aircraft motor **108**. The aircraft motor **108** may turn a motor shaft **204**. A mounting plate **220** may connect an inner hub **226** of the axial fan **104** to the motor shaft **204** via suitable fasteners, which include but are not limited to screws, bolts, rivets, or other mechanical or chemical fasteners. Motion of the motor shaft **204** may cause the axial fan **104** to produce the airflow **214** through the annulus **206**. In some examples, the inner hub **226** of the axial fan **104** may be integrally formed with the spinner cone **102**. While not shown, the motor shaft **204** may also be used to turn a propeller of the fan-cooled motor system **100**.
(18) FIG. **3** is a sectional view of a fan-cooled motor system **300** for cooling an electrical aircraft motor, according at least one example. The fan-cooled motor system **300** is an alternative example of the fan-cooled motor system **100** described herein. The axial fan **307** is an alternative example of the axial fan **104** described herein. The motor shaft **304** is an alternative example of the motor shaft **204** described herein. The present example may differ from the example illustrated in FIG. **2** because the axial fan **307** is not integrally formed with a propeller spinner. As a result, the axial fan **307** may be directly installed on the motor shaft **304**, which may alter the position of the axial fan **307** relative to the motor shaft **304** and may alter the distance between the axial fan **307** and the aircraft motor **108**. An inner hub **328** of the axial fan **307** may have a first diameter **322** and an outer hub **330** of the axial fan **307** may have a second diameter **324**. The values of the diameters described with respect to FIG. **2** may be equally applicable to the diameters shown in FIG. **3**.
(19) Blades **308** of the axial fan **307** may direct airflow **312** through an annulus **306** of the fan-cooled motor system **300**. The annulus **306** is an alternative example of the annulus **206** described herein. The airflow **312** may fluidly communicate with cooling fins **111** of the aircraft motor **108** and the power supply electronics **110**. The airflow **312** is an alternative example of the airflow **214** described herein. The axial fan **307** may be formed of materials including but not limited to aluminum, stainless steel, fiberglass, graphite fiber, nickel-aluminum-bronze alloy, manganese bronze alloy, other metallic materials, composite materials, or other similar materials. The sizes of the inner hub, the outer hub, the annulus **306**, and the fin shown in FIG. **3** may be similar configured those elements shown in FIG. **2**.
(20) A mounting plate **326** may connect to an inner hub **328** of the axial fan **307** to the motor shaft **304** via suitable fasteners, which include but are not limited to screws, bolts, rivets, or other mechanical or chemical fasteners. The mounting plate **326** may also connect a narrow region of a propeller spinner cone to the motor shaft **304**. Motion of the motor shaft **304** may cause the axial fan **307** to produce the airflow **312** through the annulus **306**.
(21) FIG. **4** is an isometric view of an axial fan **104** and a mounting plate **220** according to at least one example. The axial fan **104** is depicted with a spinner cone **102**, integral to the axial fan **104**, in FIG. **1** and FIG. **2**. An inner hub **226** of the axial fan **104** may have a first diameter **222** and an outer hub **228** may have a second diameter **224**. The outer hub **228** may be concentrically aligned with the inner hub **226**. The blades **106** of the axial fan **104** may extend between the inner hub **226** and the outer hub **228**. The outer hub **228** may reduce tip losses and may contribute to the structural integrity of the axial fan **104**. The mounting plate **220** may be integrally formed with the inner hub **226** and may extend radially from the center of the axial fan **104** to the first diameter **222** of the inner hub **226**. The outer hub **228** of the axial fan **104** may comprise a ring of uniform thickness characterized by the second diameter **224** as an inner ring and a fifth diameter of some thickness as an outer ring. The inner hub **226** of the axial fan **104** may be connected to the outer hub **228** of the axial fan **104** by the plurality of blades **106** between the inner hub **226** and the outer hub **228**. The root of each of the blades **106** may be connected to the inner hub **226** and the tip of each blade may be connected to the outer hub **228**.
(22) The mounting plate **220** may be connected to a motor shaft, such as the motor shaft **204** of FIG. **2**. The mounting plate **220** may be connected by suitable fasteners, which include but are not limited to screws, bolts, rivets, or other mechanical or chemical fasteners. A motor shaft may

connect to the mounting plate **220** at a shaft opening **402**. Inserts **404** for connecting the mounting plate **220** to the axial fan **104** may be threaded or smooth, depending on the mode of attachment. In an alternative example, a mounting plate similar to the mounting plate **326** of FIG. **3** may connect an axial fan **307**, without an integrally attached propeller spinner, to a motor shaft. The mounting plate **220** may be further defined by weight relief features **406**, which may reduce rotational inertia, thus reducing power loss.

(23) The first diameter **222** may correspond to a third diameter of the aircraft motor **108** and the second diameter **224** may correspond to a fourth diameter of the aircraft motor **108**. The radial distance between the first diameter **222** and the second diameter **224** may be about equal to the radial distance between the third diameter of the aircraft motor **108** and the fourth diameter of the aircraft motor **108**.

(24) FIG. **5** is an isometric view of an electrical aircraft motor **103** and a set of cooling fins **504** according to at least on example. The set of cooling fins **504** is an example of the cooling fins **111**. The electrical aircraft motor **103** may be encompassed by the cooling fins **504**. Power supply electronics, such as the power supply electronics **110** of FIG. **1** and FIG. **2**, may include similar cooling fins, such as cooling fins **111**. The cooling fins **504** may be encompassed by a cowl **502**. A third diameter **522**, which in some examples may be roughly equal to the first diameter **222**, may correspond to the body of the electrical aircraft motor **103**. A fourth diameter **524**, which in some examples may be roughly equal to the second diameter **224**, may correspond to the diameter of the cowl **502**. The radial distance between the third diameter **522** and the fourth diameter **524** may be of roughly equal height as the cooling fins **504** that extend from the body of the electrical aircraft motor **103** toward the cowl **502**. Airflow may pass through an annulus **506**, defined by the difference between the fourth diameter **524** and the third diameter **522**.

(25) FIG. **6** is a top view of a blade **602** of an axial fan according to at least one example. The blade **602** may be formed of materials including but not limited to aluminum, stainless steel, fiberglass, graphite fiber, nickel-aluminum-bronze alloy, manganese bronze alloy, other metallic materials, composite materials, or other suitable similar materials. The root **608** of the blade may be connected to an inner hub of the axial fan and the tip **610** of the blade may be connected to an outer hub of the axial fan. The blade **602** may taper from the root **608** of the blade to the tip **610** of the blade. The blade **602** may be one of a plurality of blades, between seven and thirty, and may be characterized by a root angle **604** between 25 and 75 degrees. The blade **602** may also be characterized by a tip angle **606** between 25 and 75 degrees. The difference between the root angle **604** and the tip angle **606** may define a twist of the blade **602**. Other configurations are also possible. The blade twist, blade thickness, and blade angle may be varied according to the rotational speed of the application in order to maintain aerodynamic flow with minimal flow separation in order to keep energy losses low. The twist may be adjusted, based on the engine for which they are paired, to maintain aerodynamic flow with minimal flow separation.

(26) In the following, further examples are described to facilitate the understanding of the disclosure:

Example A

(27) A fan assembly for an electrical aircraft motor, comprising: an axial fan comprising: an inner hub having a first diameter; an outer hub having a second diameter and being concentrically aligned with the inner hub; and a plurality of blades extending between the inner hub and the outer hub; and a mounting plate connected to the inner hub and configured for mounting the fan assembly to a component of the electrical aircraft motor, wherein the first diameter corresponds to a third diameter of the electrical aircraft motor and the second diameter corresponds a fourth diameter of the electrical aircraft motor.

Example B

(28) The fan assembly of any preceding or subsequent examples, wherein a first radial distance measured between the first diameter and the second diameter is about equal to a second radial

distance measured between the third diameter and the fourth diameter.
Example C
(29) The fan assembly of any preceding or subsequent examples, wherein the third diameter corresponds to a body of the electrical aircraft motor and the fourth diameter corresponds to a cowl of the electrical aircraft motor.
Example D
(30) The fan assembly of any preceding or subsequent examples, wherein a radial distance between the third diameter and the fourth diameter is about equal to a height of a set of cooling fins that extend radially from the body of the electrical aircraft motor toward the cowl.
Example E
(31) The fan assembly of any preceding or subsequent examples, wherein a radial distance between the third diameter and the fourth diameter is about equal to a height of a set of cooling fins that extend radially from a body of the electrical aircraft motor.
Example F
(32) The fan assembly of any preceding or subsequent examples, wherein the component comprises at least one of a motor shaft of the electrical aircraft motor or a propeller.
Example G
(33) The fan assembly of any preceding or subsequent examples, wherein the inner hub is integrally formed with a propeller spinner.
Example H
(34) The fan assembly of any preceding or subsequent examples, wherein the plurality of blades comprises a number between seven and thirty.
Example I
(35) The fan assembly of any preceding or subsequent examples, wherein a root of each blade of the plurality of blades is connected to the inner hub and a tip of each blade of the plurality of blades is connected to the outer hub.
Example J
(36) The fan assembly of any preceding or subsequent examples, wherein each blade of the plurality of blades is characterized by a root angle and a tip angle between 25 degrees and 75 degrees.
Example K
(37) The fan assembly of any preceding or subsequent examples, further comprising a cone concentrically aligned with and connected to the inner hub.
Example L
(38) The fan assembly of any preceding or subsequent examples, wherein an annulus region of the cone is between 5 mm and 50 mm wide.
Example M
(39) The fan assembly of any preceding or subsequent examples, wherein the mounting plate is integrally formed with the inner hub and extends radially from a center of the axial fan to the first diameter of the inner hub.
Example N
(40) The fan assembly of any preceding or subsequent examples, wherein the outer hub comprises a ring of uniform thickness characterized by the second diameter as an inner ring diameter and a fifth diameter as an outer ring diameter.
Example O
(41) The fan assembly of any preceding or subsequent examples, wherein the inner hub is connected to the outer hub via the plurality of blades.
Example P
(42) A system, comprising: an electrical aircraft motor comprising an annular body and a set of cooling fins extending from the annular body; and an axial fan connected to the electrical aircraft

motor, the axial fan comprising: an inner hub having a first diameter corresponding to the annular body; an outer hub having a second diameter and being concentrically aligned with the inner hub, wherein the second diameter corresponds to the set of cooling fins; and a plurality of blades extending between the inner hub and the outer hub.

Example Q

(43) The system of any preceding or subsequent examples, wherein the electrical aircraft motor further comprises an annular cowl that surrounds the set of cooling fins, wherein a first radial distance between the first diameter and the second diameter is about equal a second radial distance between the annular body and the annular cowls.

Example R

(44) The system of any preceding or subsequent examples, wherein the axial fan is connected to the electrical aircraft motor via a motor shaft of the electrical aircraft motor or via a propeller that is connected to the motor shaft.

Example S

(45) A system, comprising: an electrical aircraft motor housing comprising: a first annular housing that includes an electrical motor; a second housing that includes control electronics; and a motor shaft that is rotatably connected to the electrical motor; and an axial fan connected to the motor shaft, the axial fan comprising: an inner hub having a first diameter corresponding to the first annular housing; an outer hub having a second diameter and being concentrically aligned with the inner hub, wherein the second diameter is greater than the first diameter; and a plurality of blades extending between the inner hub and the outer hub.

Example T

(46) The system of any preceding or subsequent examples, further comprising a propeller, and wherein the axial fan is connected to the motor shaft via the propeller.

(47) Different arrangements of the components depicted in the drawings or described above, as well as components and steps not shown or described are possible. Similarly, some features and sub-combinations are useful and may be employed without reference to other features and sub-combinations. Embodiments of the disclosure have been described for illustrative and not restrictive purposes, and alternative embodiments will become apparent to readers of this patent. Accordingly, the present disclosure is not limited to the embodiments described above or depicted in the drawings, and various embodiments and modifications may be made without departing from the scope of the claims below.

(48) The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense. It will, however, be evident that various modifications and changes may be made thereunto without departing from the broader spirit and scope of the disclosure as set forth in the claims.

(49) Other variations are within the spirit of the present disclosure. Thus, while the disclosed techniques are susceptible to various modifications and alternative constructions, certain illustrated examples thereof are shown in the drawings and have been described above in detail. It should be understood, however, that there is no intention to limit the disclosure to the specific form or forms disclosed, but on the contrary, the intention is to cover all modifications, alternative constructions and equivalents falling within the spirit and scope of the disclosure, as defined in the appended claims.

(50) The use of the terms “a” and “an” and “the” and similar referents in the context of describing the disclosed examples (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (e.g., meaning “including, but not limited to,”) unless otherwise noted. The term “connected” is to be construed as partly or wholly contained within, attached to, or joined together, even if there is something intervening. Recitation of ranges of values herein are merely intended to

serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate examples of the disclosure, and does not pose a limitation on the scope of the disclosure unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the disclosure.
(51) Disjunctive language such as the phrase "at least one of X, Y, or Z," unless specifically stated otherwise, is otherwise understood within the context as used in general to present that an item, term, etc., may be either X, Y, or Z, or any combination thereof (e.g., X, Y, and/or Z). Thus, such disjunctive language is not generally intended to, and should not, imply that certain examples require at least one of X, at least one of Y, or at least one of Z to each be present.
(52) Use herein of the word "or" is intended to cover inclusive and exclusive OR conditions. In other words, A or B or C includes any or all of the following alternative combinations as appropriate for a particular usage: A alone; B alone; C alone; A and B only; A and C only; B and C only; and all three of A, B, and C.
(53) Preferred examples of this disclosure are described herein, including the best mode known to the inventors for carrying out the disclosure. Variations of those preferred examples may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the disclosure to be practiced otherwise than as specifically described herein. Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.
(54) All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

Claims

1. A fan assembly for an electrical aircraft motor, comprising: an axial fan comprising: an inner hub having a first diameter; an outer hub having a second diameter and being concentrically aligned with the inner hub; and a plurality of blades extending between the inner hub and the outer hub; an air straightener screen positioned between the axial fan and the electrical aircraft motor; and a mounting plate connected to the inner hub and configured for mounting the fan assembly to a component of the electrical aircraft motor, wherein the mounting plate is integrally formed with the inner hub and extends radially outward from a center of the axial fan to the first diameter of the inner hub such that the axial fan is positioned at a first location that is offset from a second location of the electrical aircraft motor when the fan assembly is mounted to the component of the electrical aircraft motor, wherein the first diameter is the same as a third diameter of the electrical aircraft motor and the second diameter is the same as a fourth diameter of the electrical aircraft motor, wherein a gap is defined between the first location and the second location that is open to an environment, and wherein the inner hub is connected to the outer hub via the plurality of blades.
2. The fan assembly of claim 1, wherein a first radial distance measured between the first diameter and the second diameter is equal to a second radial distance measured between the third diameter and the fourth diameter.
3. The fan assembly of claim 1, wherein the third diameter corresponds to a body of the electrical

aircraft motor and the fourth diameter corresponds to a cowl of the electrical aircraft motor.
4. The fan assembly of claim 3, wherein a radial distance between the third diameter and the fourth diameter is equal to a height of a set of cooling fins that extend radially from the body of the electrical aircraft motor toward the cowl.
5. The fan assembly of claim 1, wherein a radial distance between the third diameter and the fourth diameter is equal to a height of a set of cooling fins that extend radially from a body of the electrical aircraft motor.
6. The fan assembly of claim 1, wherein the component comprises at least one of a motor shaft of the electrical aircraft motor or a propeller.
7. The fan assembly of claim 1, wherein the inner hub is integrally formed with a propeller spinner.
8. The fan assembly of claim 1, wherein the plurality of blades comprises a number between seven and thirty.
9. The fan assembly of claim 1, wherein a root of each blade of the plurality of blades is connected to the inner hub and a tip of each blade of the plurality of blades is connected to the outer hub.
10. The fan assembly of claim 1, wherein each blade of the plurality of blades is characterized by a root angle and a tip angle between 25 degrees and 75 degrees.
11. The fan assembly of claim 1, further comprising a cone concentrically aligned with and connected to the inner hub.
12. The fan assembly of claim 11, wherein an annulus region of the cone is between 5 mm and 50 mm wide.
13. The fan assembly of claim 1, wherein the outer hub comprises a ring of uniform thickness characterized by the second diameter as an inner ring diameter and a fifth diameter as an outer ring diameter.
14. A system, comprising: an electrical aircraft motor comprising an annular body and a set of cooling fins extending from the annular body; an axial fan connected to the electrical aircraft motor, the axial fan comprising: an inner hub having a first diameter corresponding to the annular body; an outer hub having a second diameter and being concentrically aligned with the inner hub, wherein the second diameter corresponds to the set of cooling fins; and a plurality of blades extending between the inner hub and the outer hub; an air straightener screen positioned between the axial fan and the electrical aircraft motor; and a mounting plate connected to the inner hub and configured for mounting the axial fan to the electrical aircraft motor, wherein the mounting plate is integrally formed with the inner hub and extends radially outward from a center of the axial fan to the first diameter of the inner hub such that the axial fan is positioned at a first location that is offset from a second location of the electrical aircraft motor when the axial fan is mounted to the electrical aircraft motor, wherein a gap is defined between the first location and the second location that is open to an environment, and wherein the inner hub is connected to the outer hub via the plurality of blades.
15. The system of claim 14, wherein the electrical aircraft motor further comprises an annular cowl that surrounds the set of cooling fins, wherein a first radial distance between the first diameter and the second diameter is equal to a second radial distance between the annular body and the annular cowls.
16. The system of claim 14, wherein the axial fan is connected to the electrical aircraft motor via a motor shaft of the electrical aircraft motor or via a propeller that is connected to the motor shaft.
17. A system, comprising: an electrical aircraft motor housing comprising: a first annular housing that includes an electrical motor; a second housing that includes control electronics; and a motor shaft that is rotatably connected to the electrical motor; an axial fan connected to the motor shaft via a mounting plate, the axial fan comprising: an inner hub having a first diameter corresponding to the first annular housing; an outer hub having a second diameter and being concentrically aligned with the inner hub, wherein the second diameter is greater than the first diameter; and a plurality of blades extending between the inner hub and the outer hub; an air straightener screen

positioned between the axial fan and the electrical aircraft motor; and the mounting plate that is integrally formed with the inner hub and extends radially outward from a center of the axial fan to the first diameter of the inner hub such that the axial fan is positioned at a first location that is offset from a second location of the electrical aircraft motor when the axial fan is mounted to the electrical aircraft motor, wherein a gap is defined between the first location and the second location that is open to an environment, and wherein the inner hub is connected to the outer hub via the plurality of blades.

18. The system of claim 17, further comprising a propeller, and wherein the axial fan is connected to the motor shaft via the propeller.