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(54) CEILING FAN

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(52) **U.S. Cl.**

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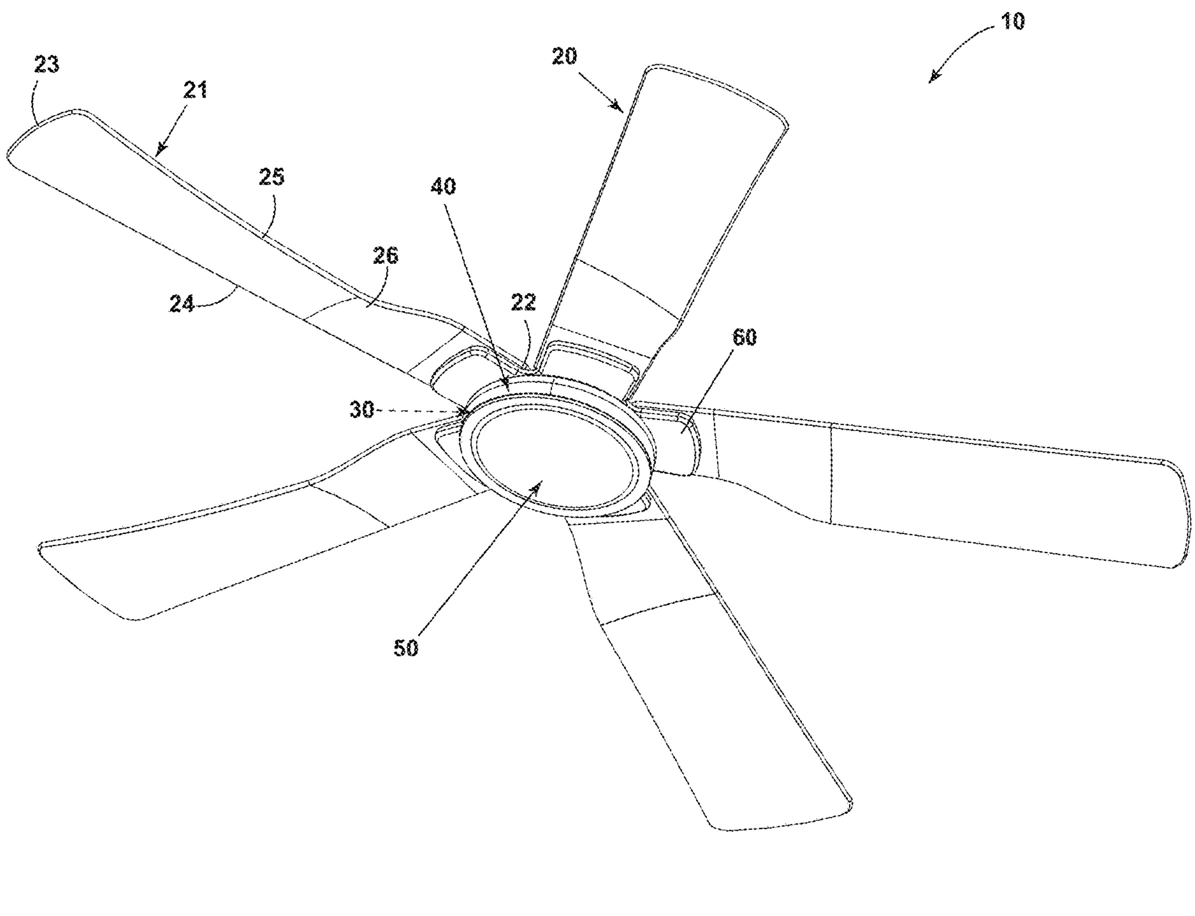
(57) **ABSTRACT**

A ceiling fan includes a motor housing and a motor enclosed by the motor housing. A set of blades can extend from the motor housing and be operably coupled to the motor. The motor can include a rotor assembly and a stator assembly. The motor further includes a stationary motor shaft about which the rotor assembly rotates. A bearing rotatably supports the rotor assembly to the stationary motor shaft.



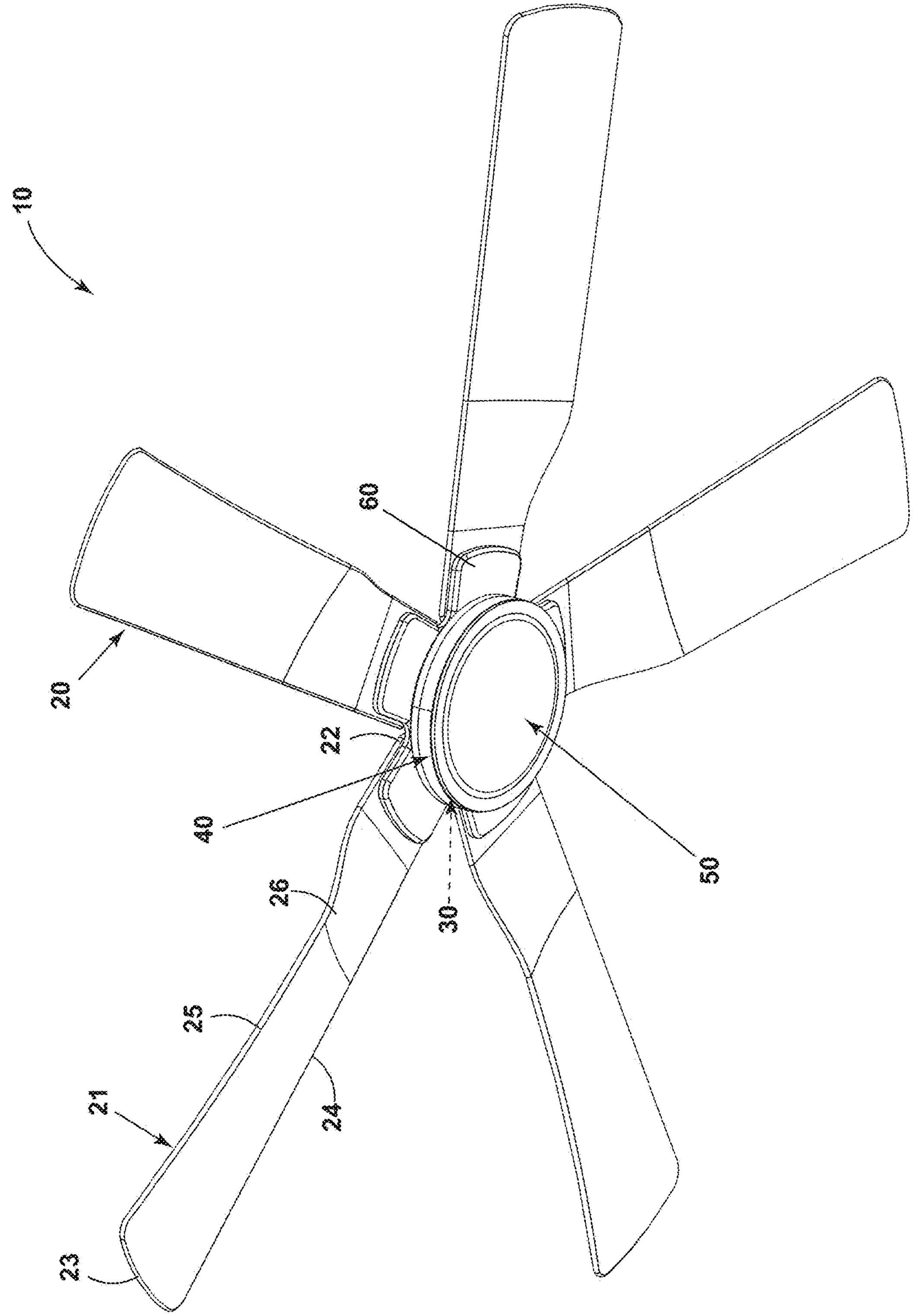



FIG. 1

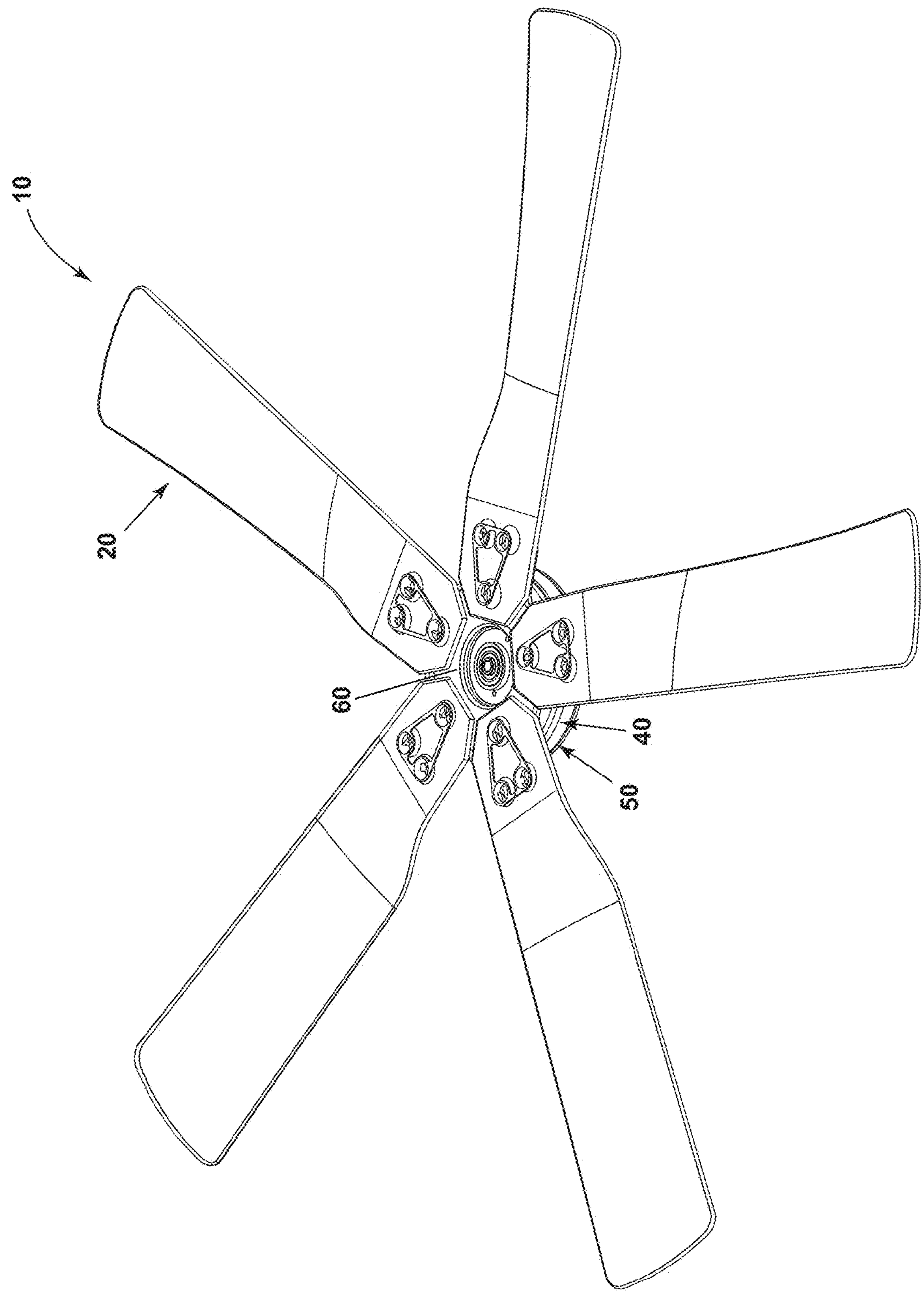
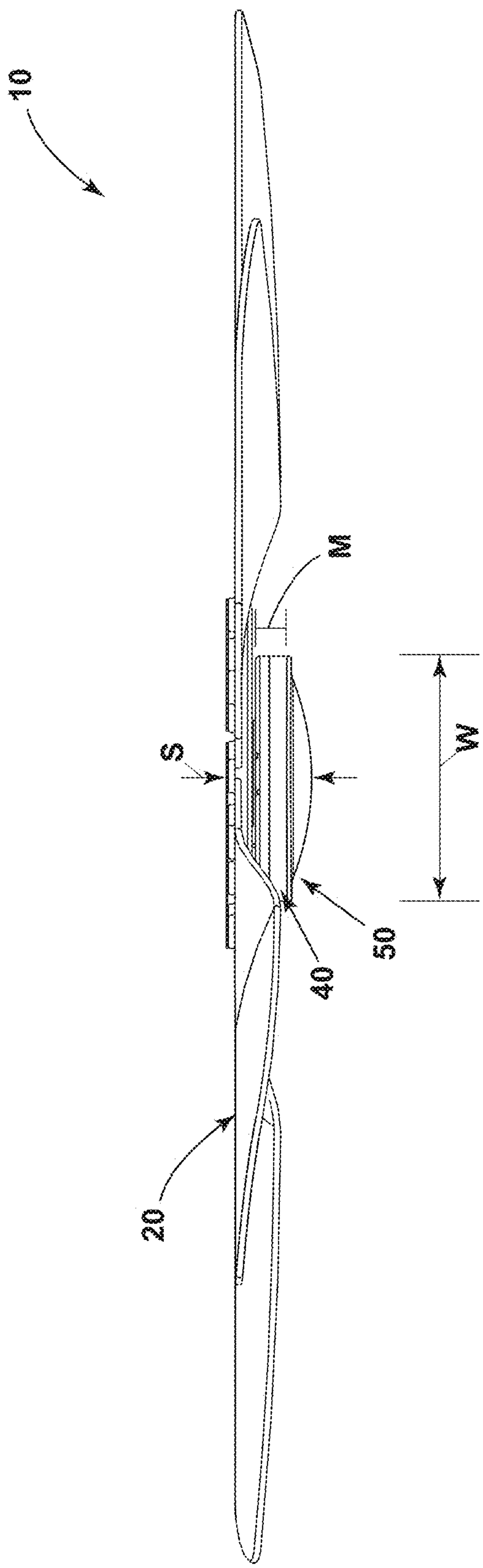



FIG. 2

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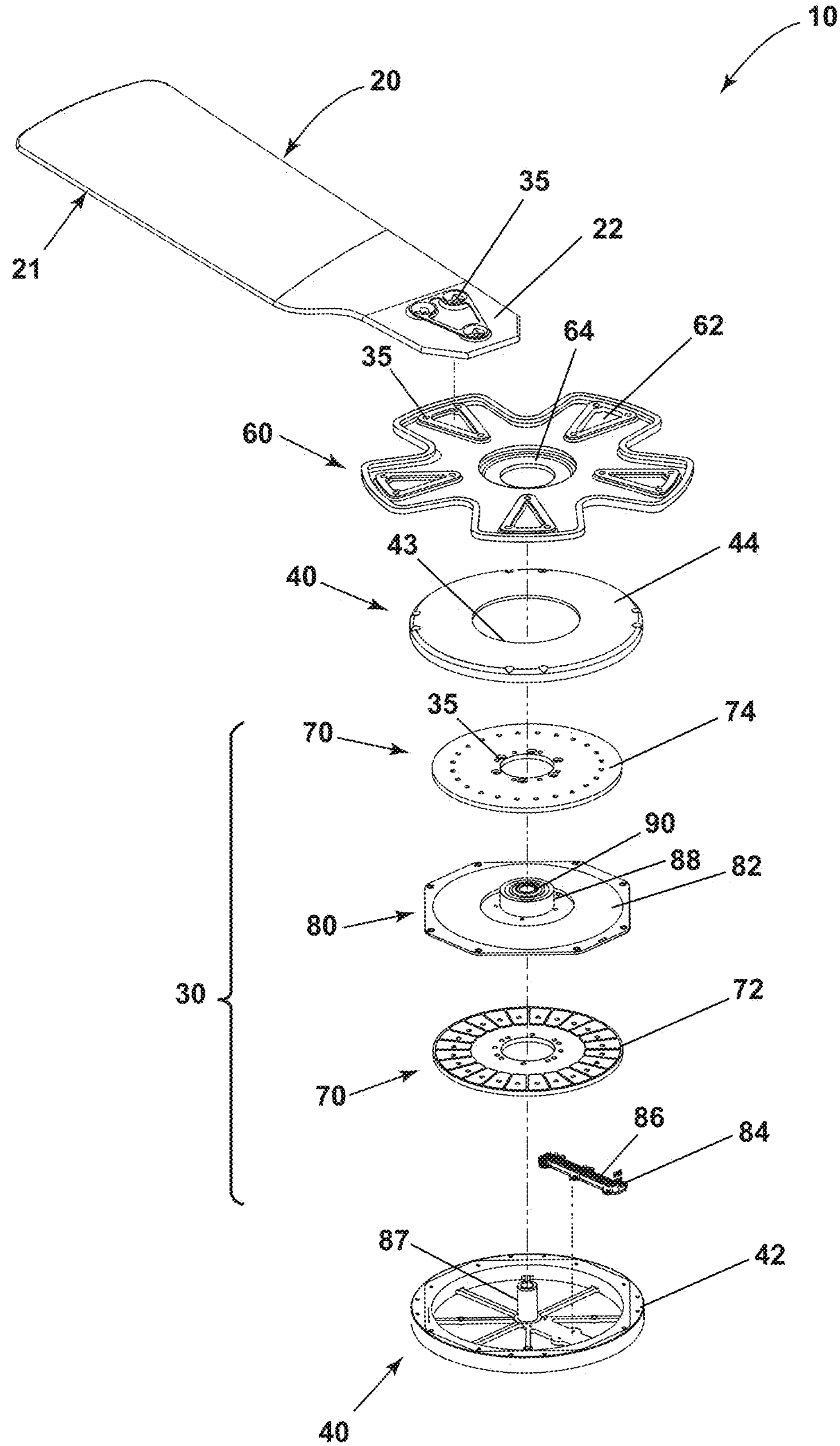
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FIG. 4

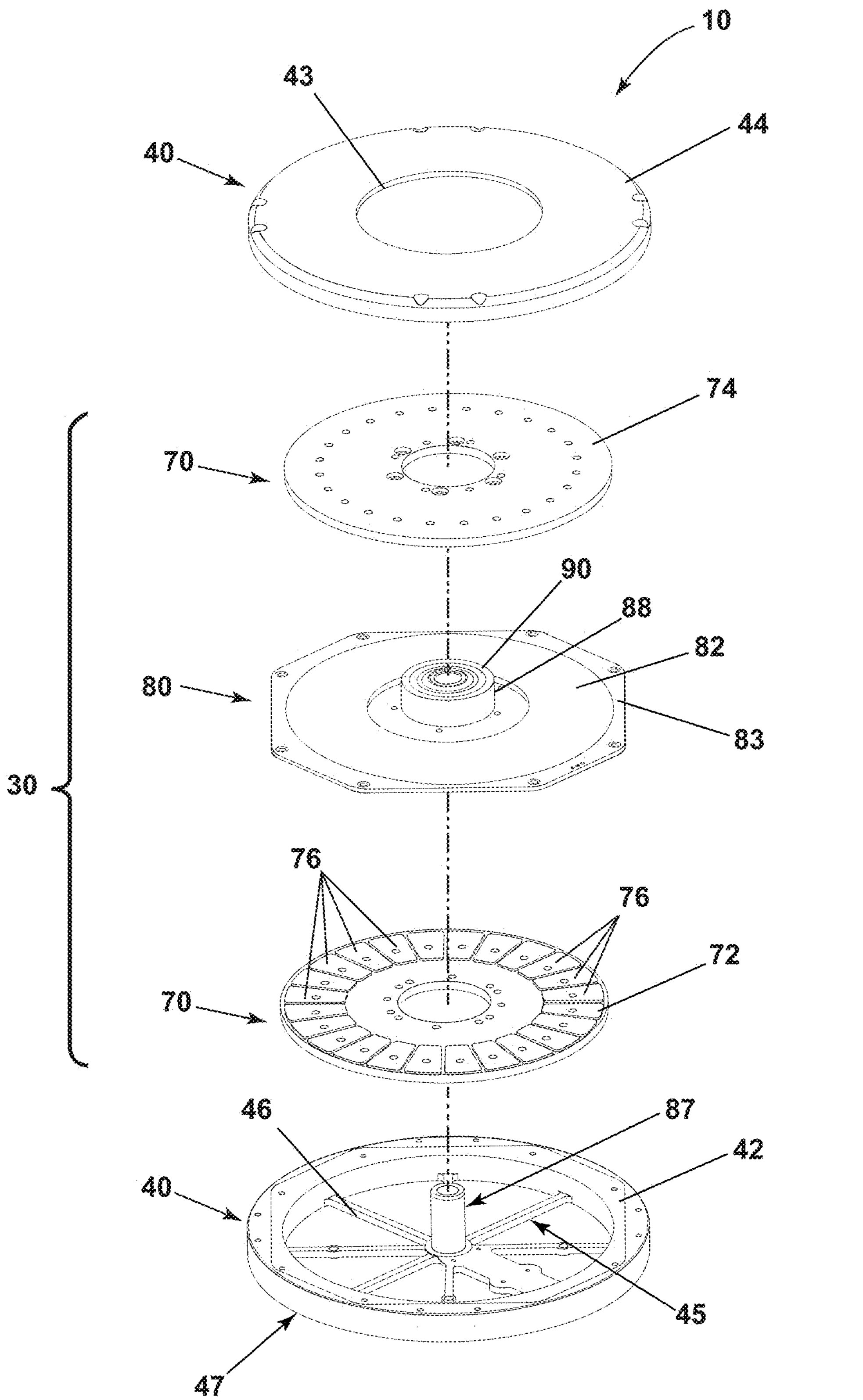


FIG. 5

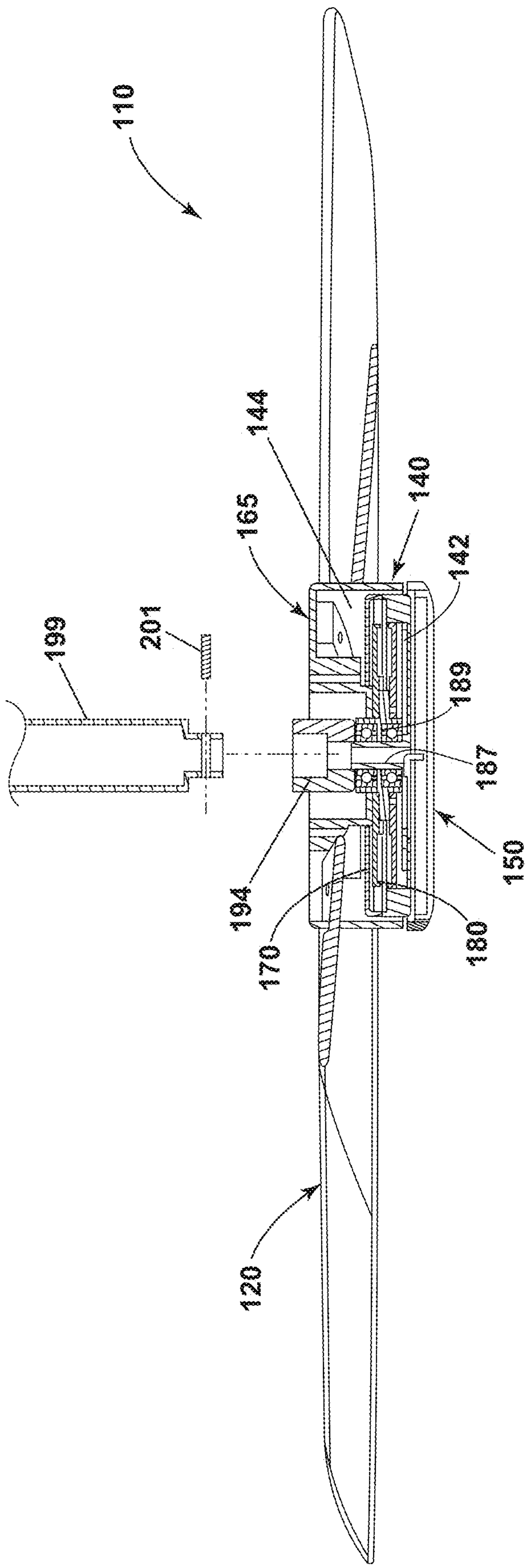


FIG. 6

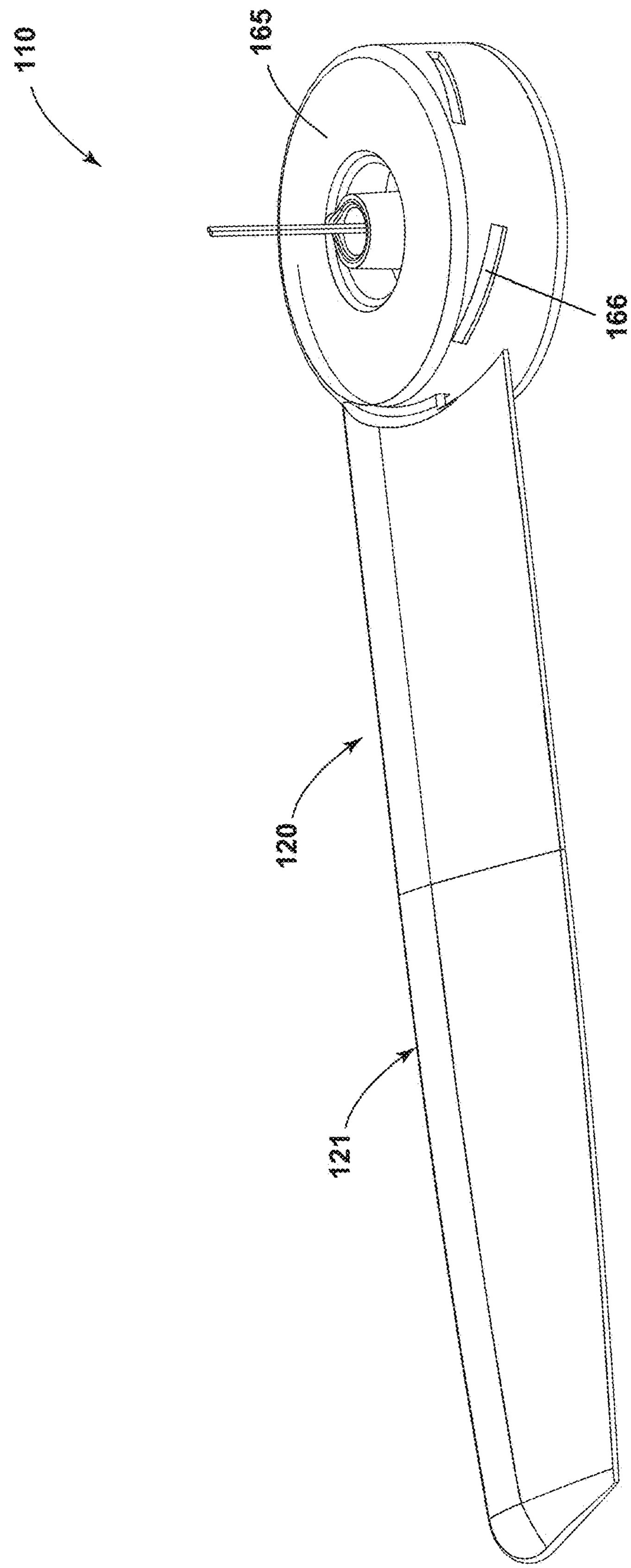


FIG. 7

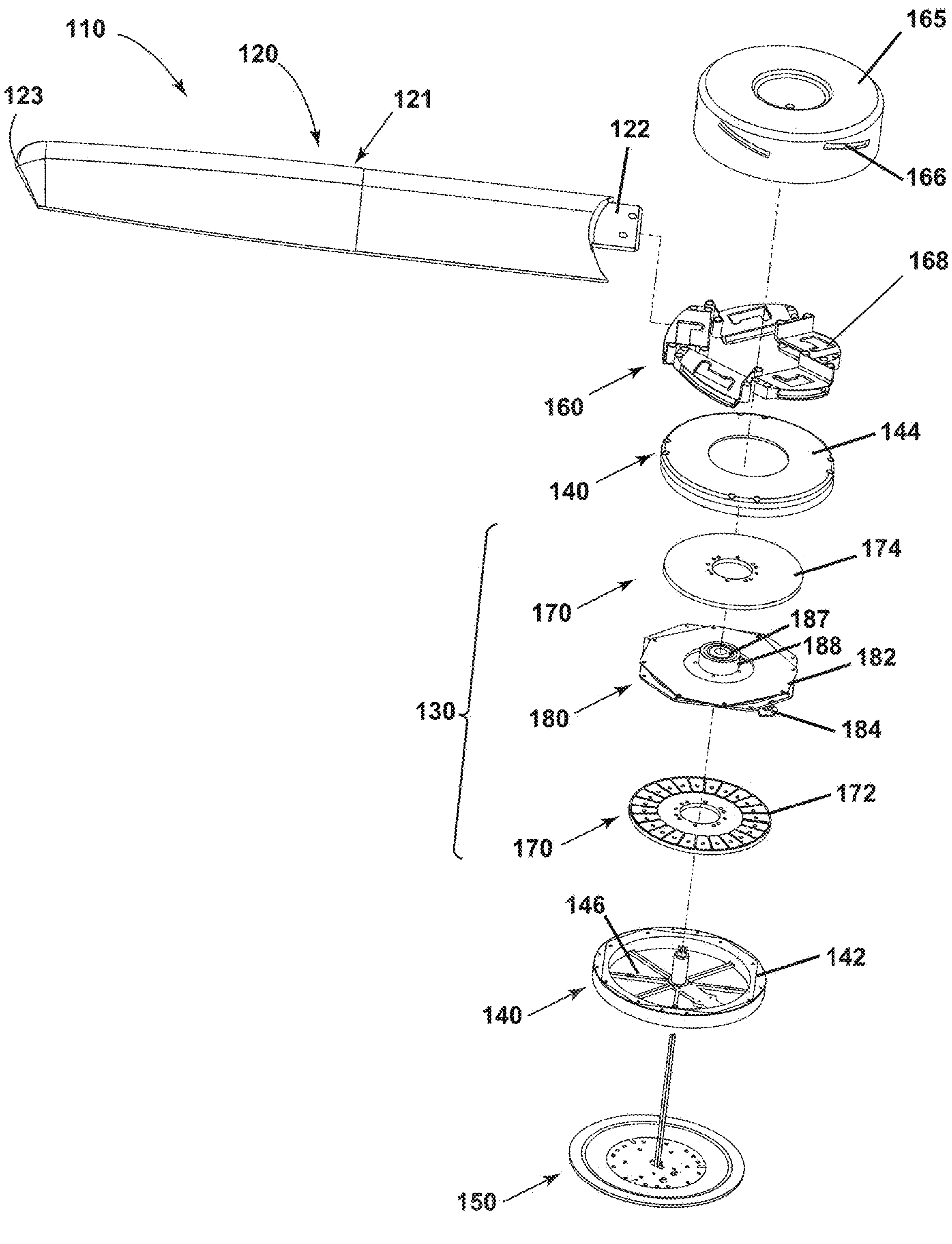
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FIG. 8

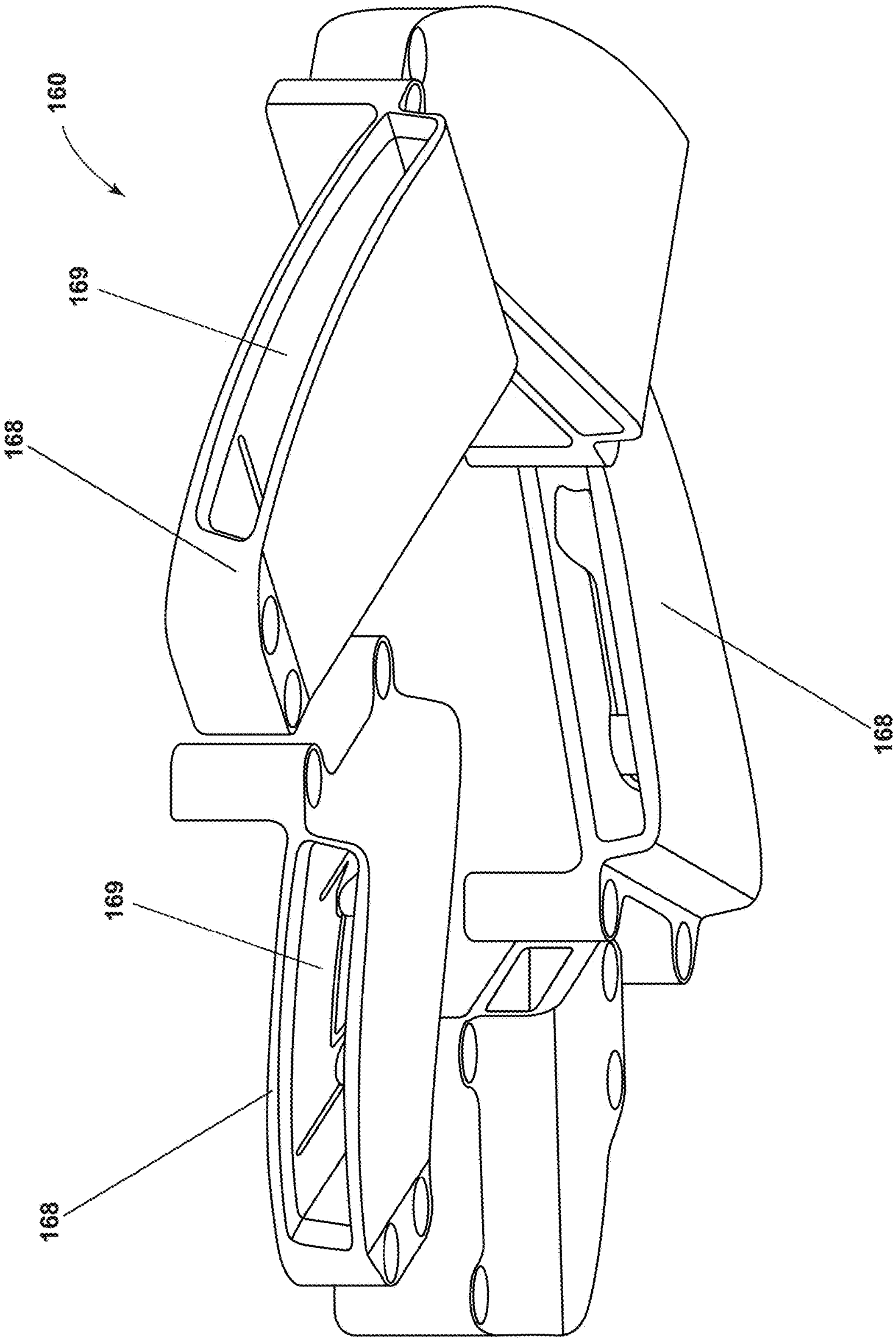


FIG. 9

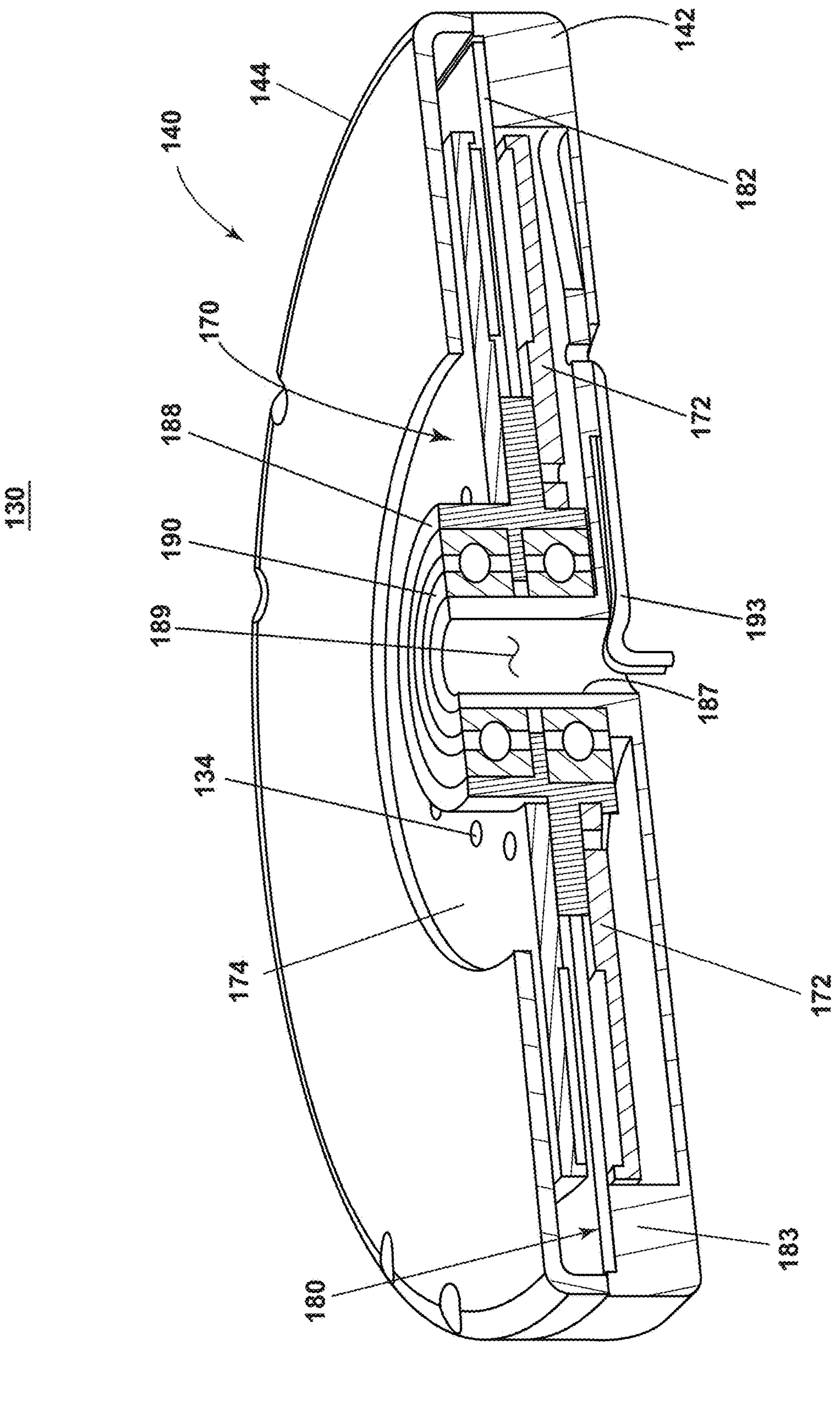
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FIG. 10

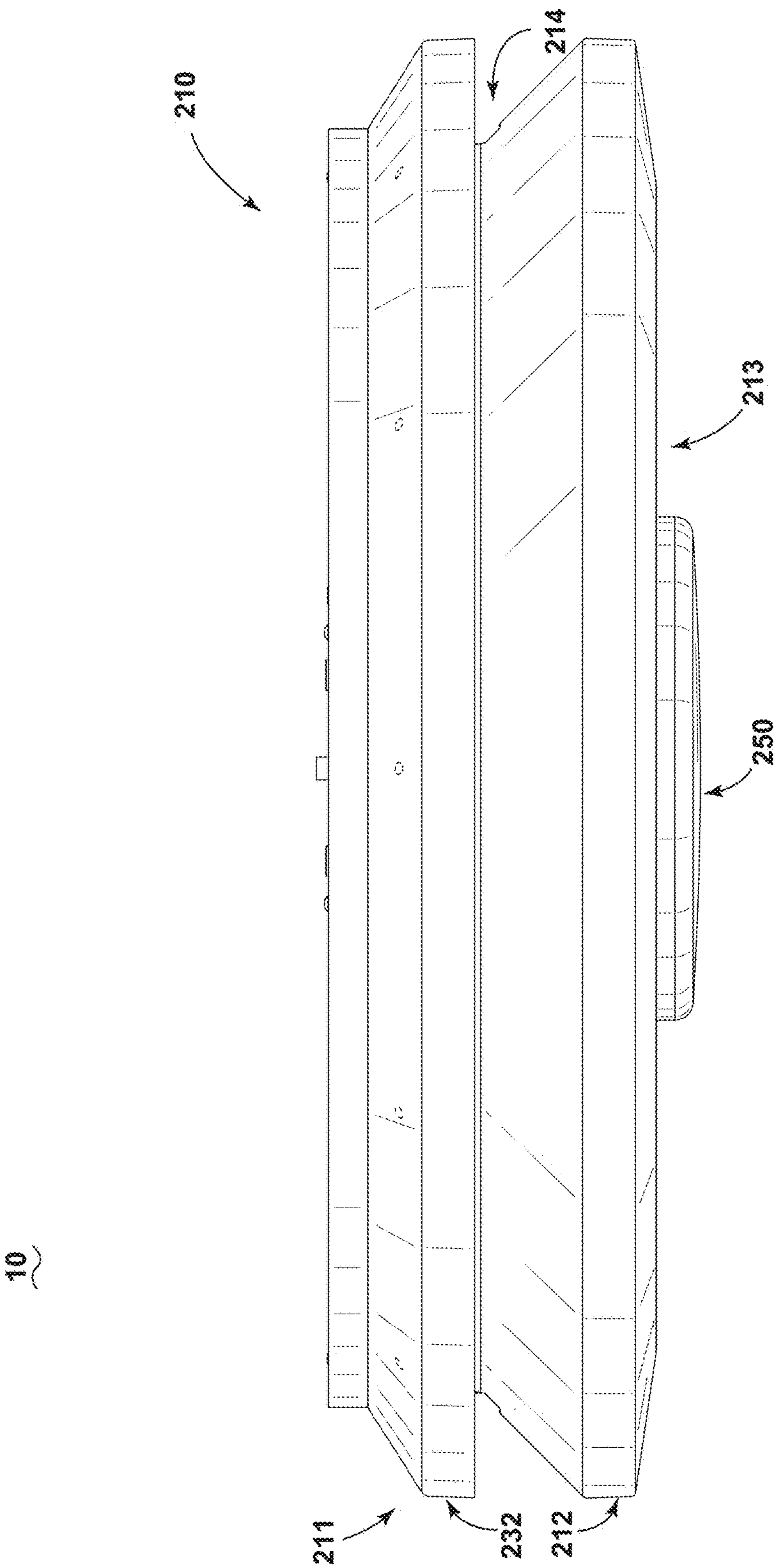


FIG. 11

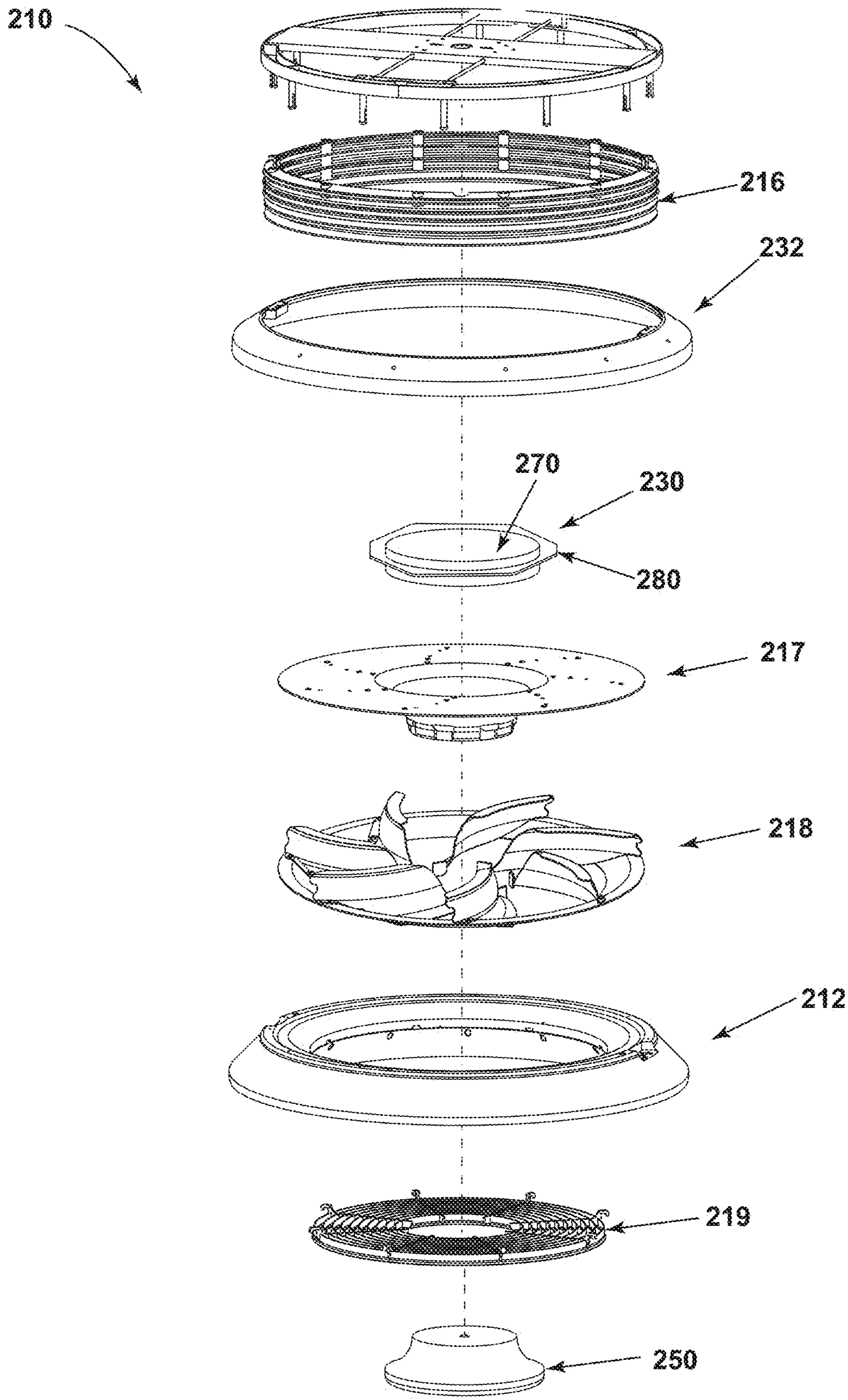


FIG. 12

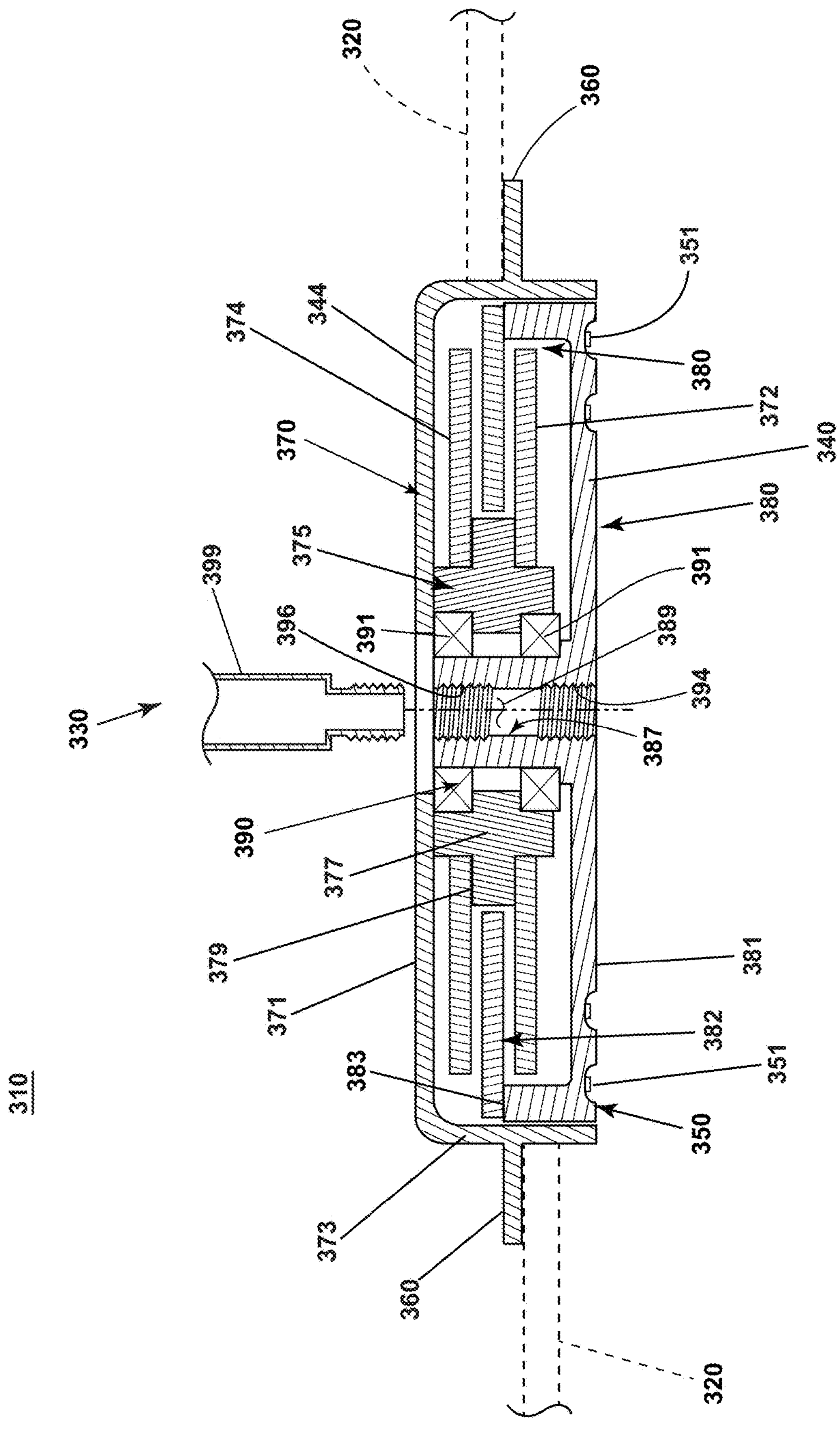
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FIG. 13

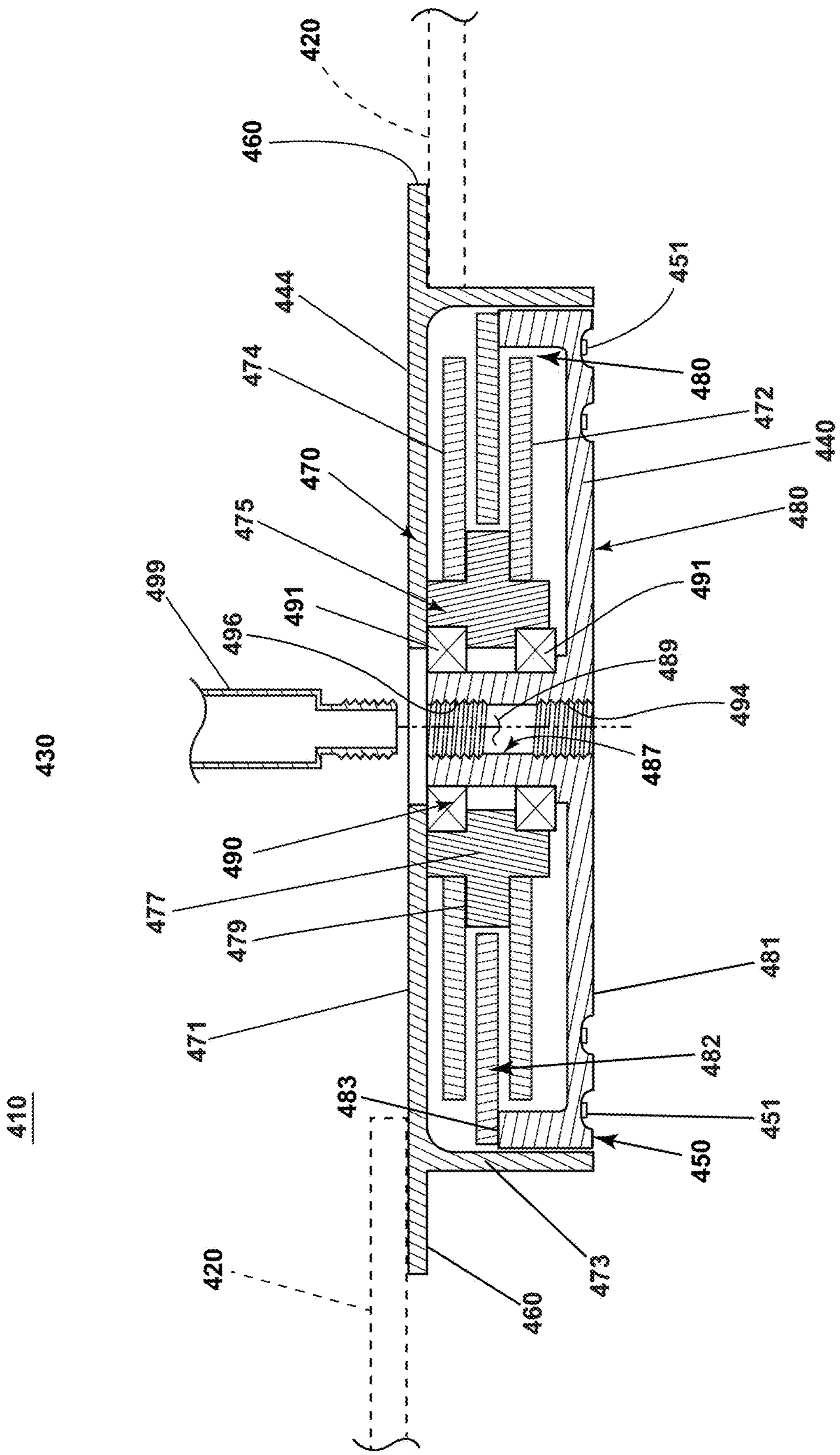
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FIG. 14

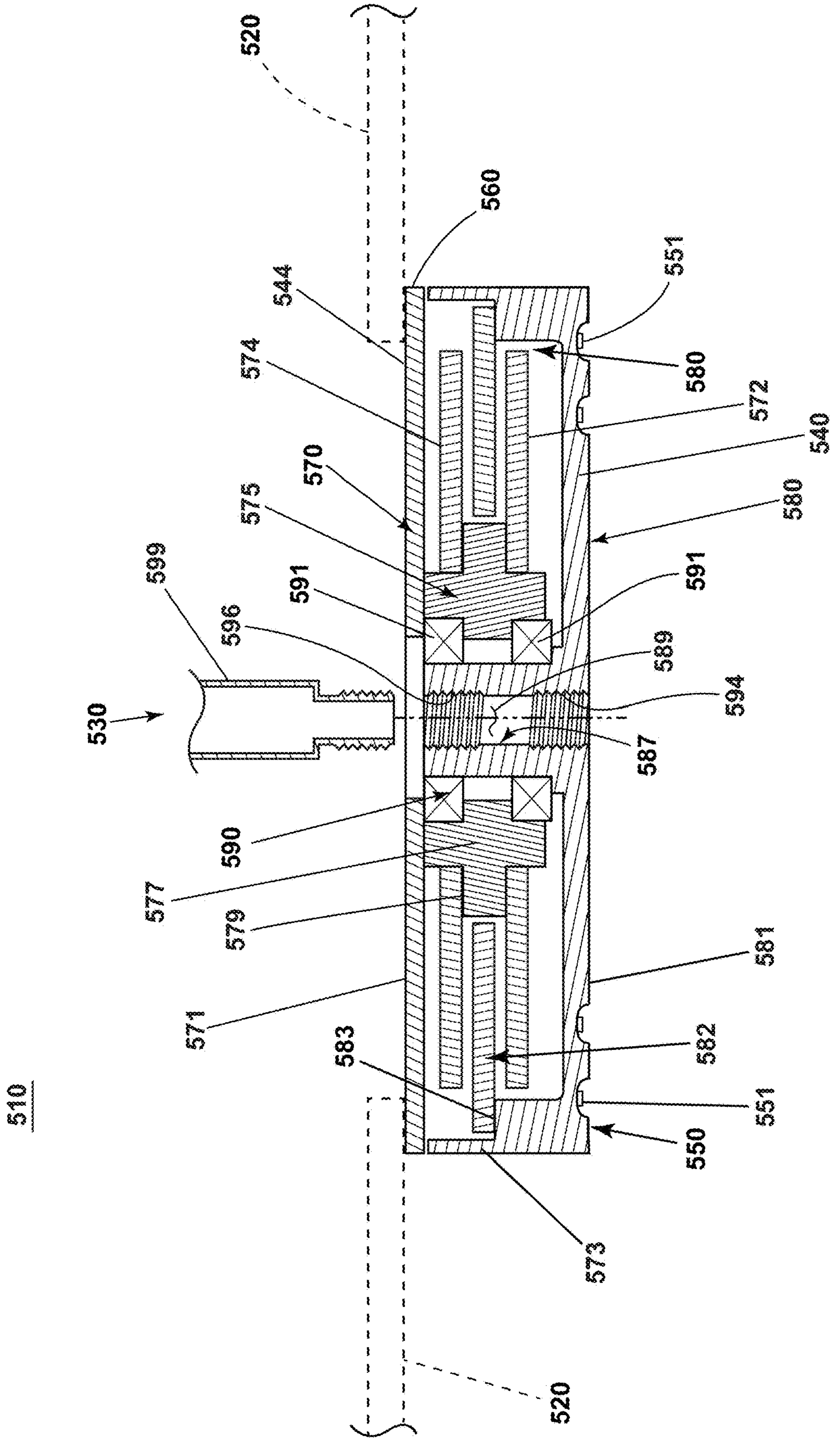
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FIG. 15

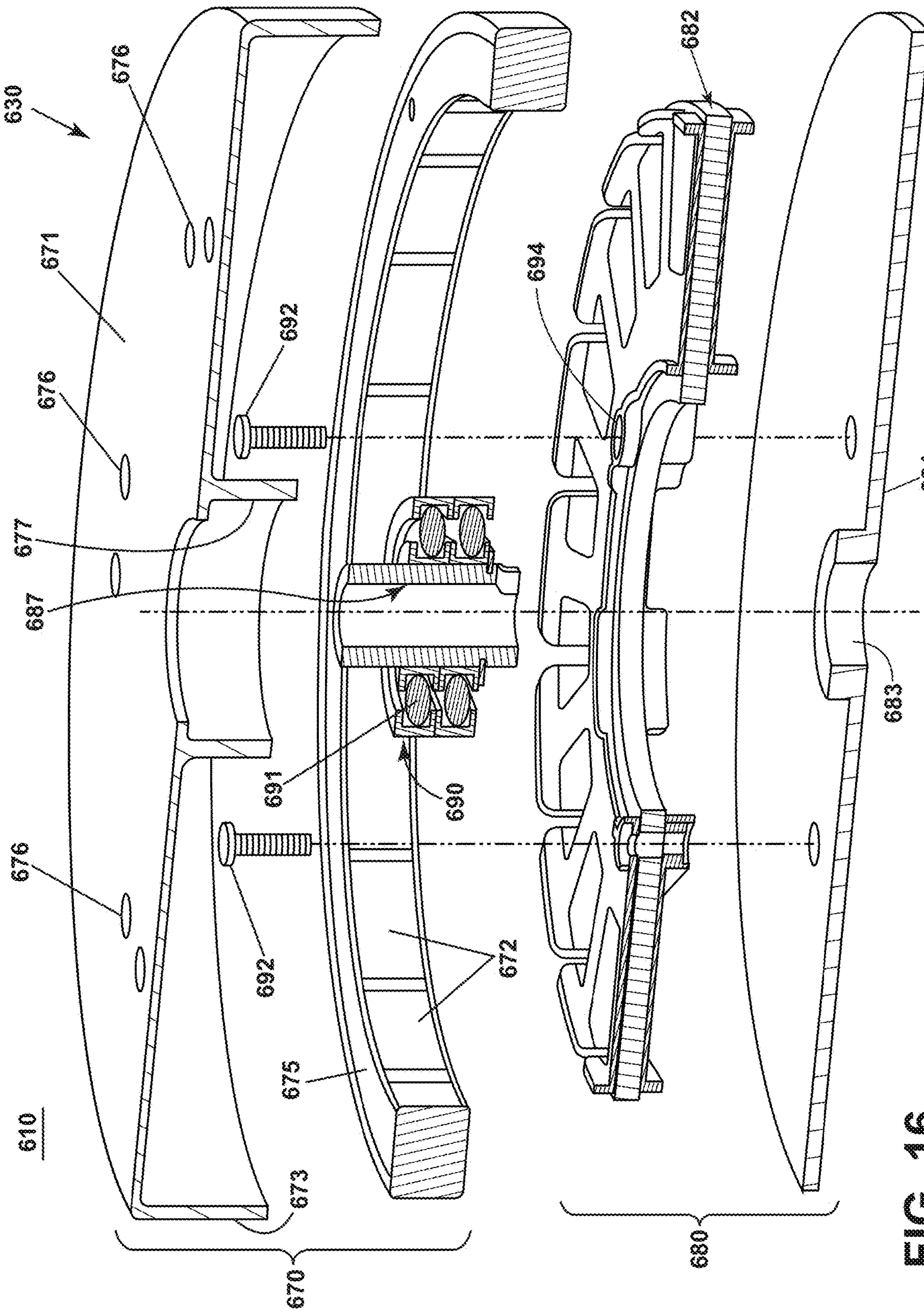
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FIG. 16

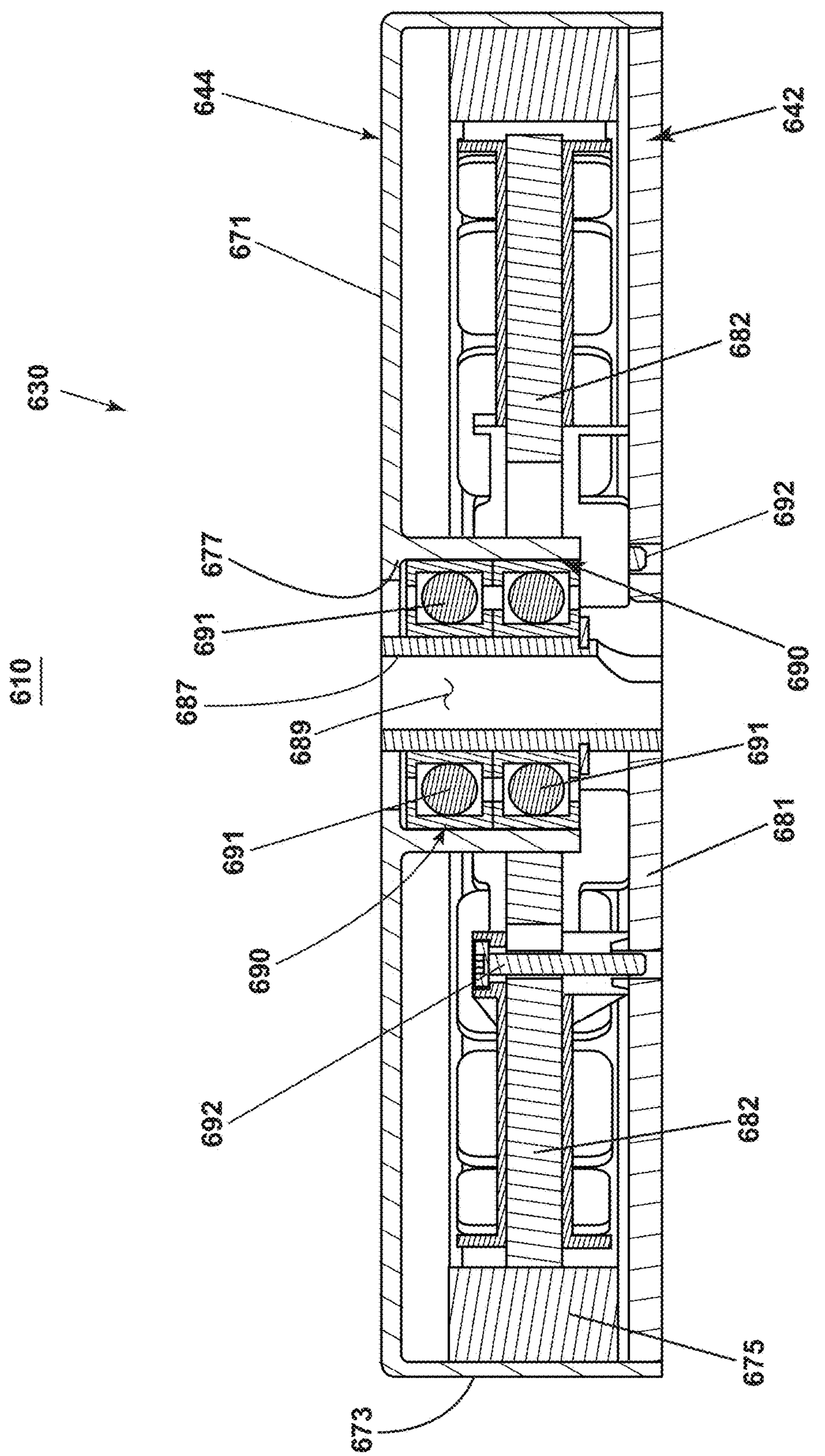
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FIG. 17

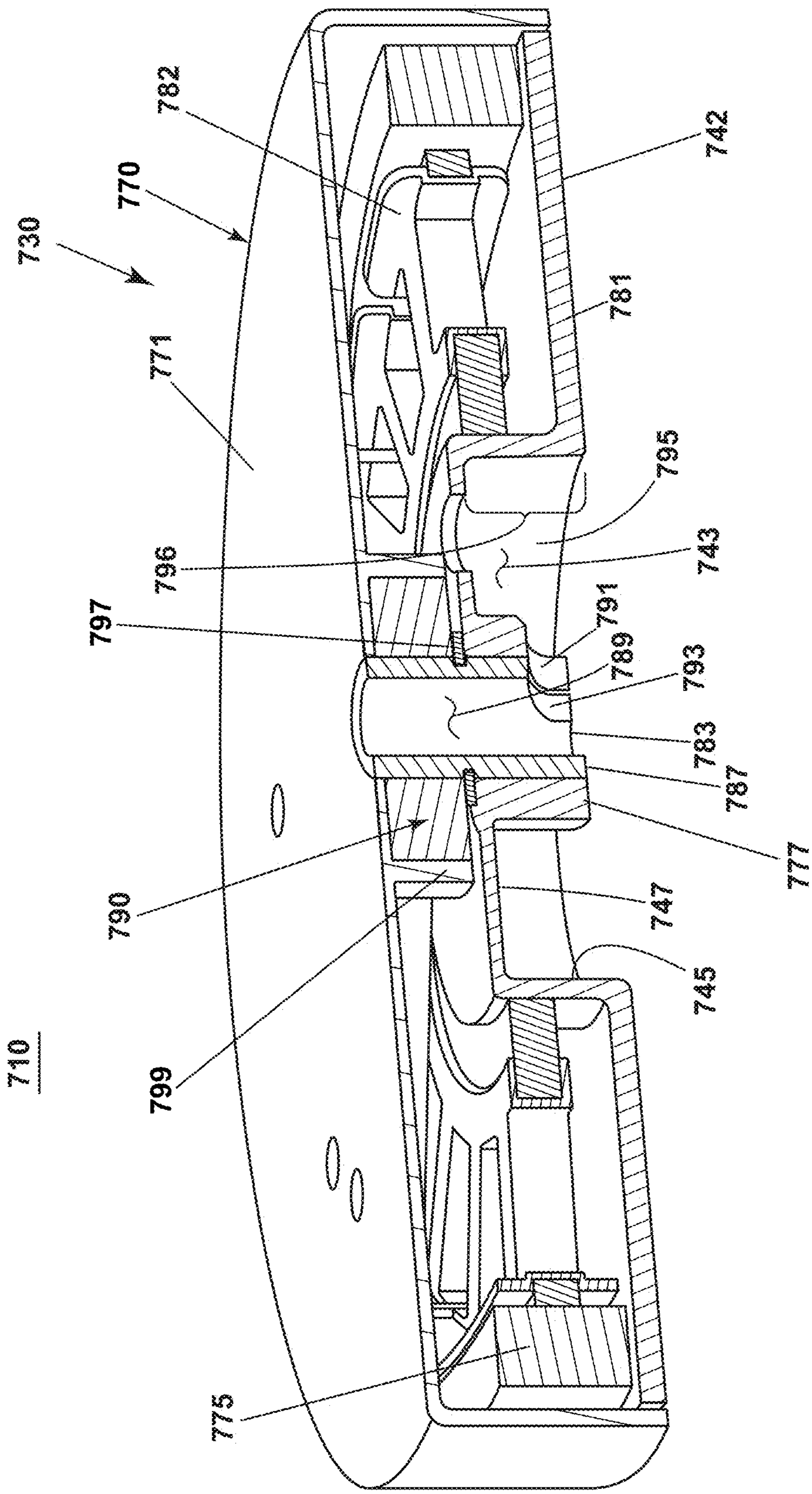
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FIG. 18

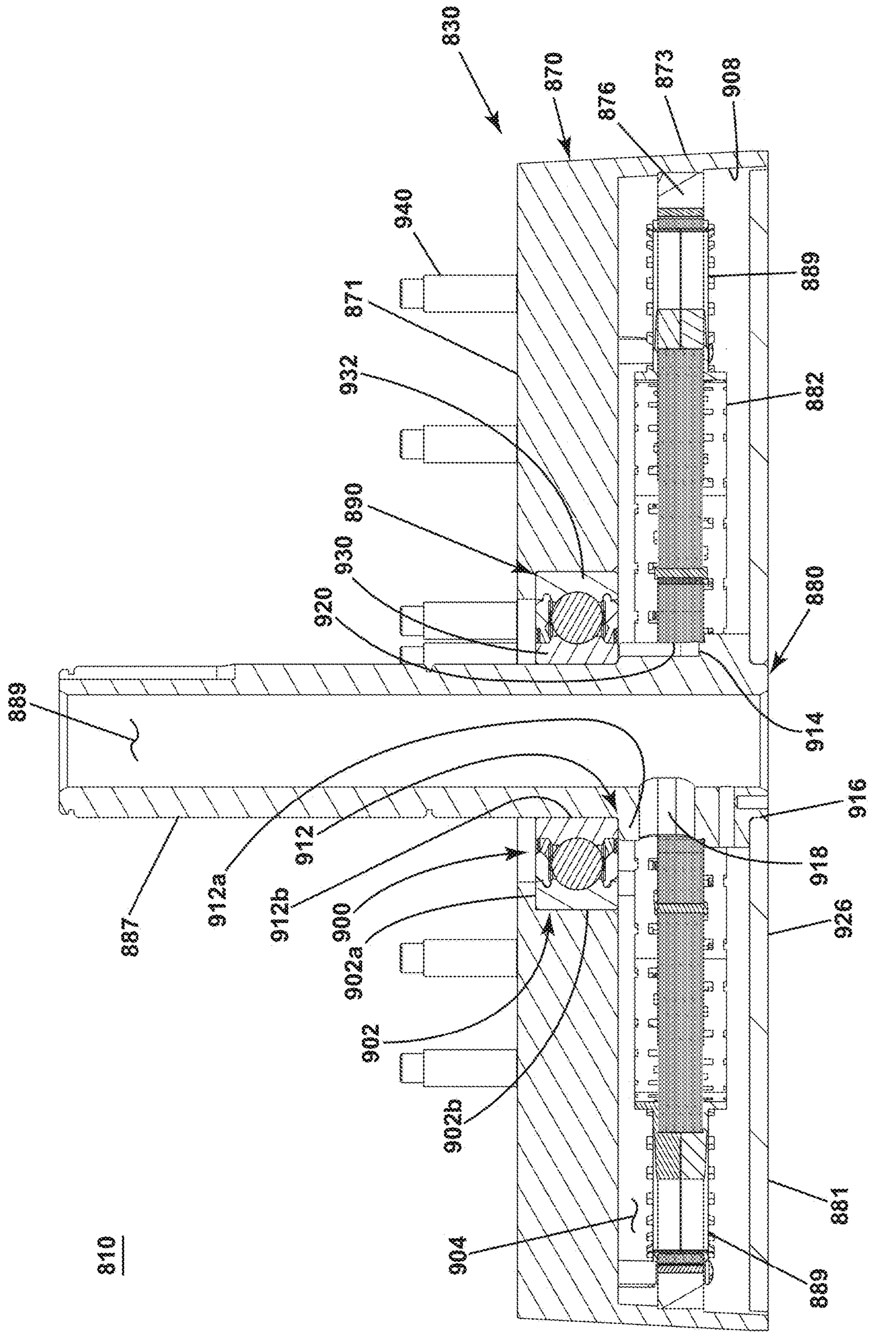
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FIG. 19

# CEILING FAN

## CROSS-REFERENCE TO RELATED APPLICATION(S)

**[0001]** This application is a continuation in part of U.S. patent application Ser. No. 18/244,598, filed Sep. 11, 2023, which claims the benefit of U.S. Provisional Patent Application No. 63/405,970, filed Sep. 13, 2022, both of which are incorporated herein by reference in their entirety.

## TECHNICAL FIELD

**[0002]** This disclosure relates to the field of ceiling fans, and more specifically to low-profile ceiling fans and fan motors.

## BACKGROUND

**[0003]** Ceiling fans can include a set of fan blades rotatably coupled to a motor assembly to rotate the set of blades. Rotation of the fan blades drives a volume of fluid, typically ambient air, within a space for cooling or circulation. The fan blades can be rotatably driven by a centralized motor enclosed in a motor housing.

**[0004]** Typically, ceiling fans are mounted to an overhead surface by way of a downrod, housing, or the like. When assembled, the ceiling fan can be suspended within the area at appropriate distances from the overhead surface and the floor to provide for optimum spacing for driving air as well as overhead clearance with respect to occupants or items in the space below the fan.

## SUMMARY

**[0005]** In one aspect, the description relates to a ceiling fan comprising: a set of blades extending between a root and a tip; a motor assembly comprising: a stator assembly comprising a stationary motor shaft and a stator coupled to the stationary motor shaft, a rotor assembly comprising a rotor operably coupled to the root of the blades, and a bearing assembly having a single bearing rotationally coupling the stationary motor shaft to the rotor assembly.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** In the drawings:

**[0007]** FIG. **1** is a bottom perspective view of a ceiling fan illustrating blades, a motor housing, and a light kit in accordance with various aspects described herein.

**[0008]** FIG. **2** is a top perspective view of the ceiling fan of FIG. **1**.

**[0009]** FIG. **3** is a side view of the ceiling fan of FIG. **1**.

**[0010]** FIG. **4** is an exploded view illustrating internal components of the ceiling fan of FIG. **1** including the motor housing and a motor in accordance with various aspects described herein.

**[0011]** FIG. **5** is an exploded view of the motor of FIG. **4** illustrating a pair of rotors and a stator in accordance with various aspects described herein.

**[0012]** FIG. **6** is a side cross-sectional view of another ceiling fan in accordance with various aspects described herein.

**[0013]** FIG. **7** is a perspective view of a portion of the ceiling fan of FIG. **6** illustrating a blade housing in accordance with various aspects described herein.

**[0014]** FIG. **8** is an exploded view illustrating internal components of the ceiling fan of FIG. **6** including a motor and blade mounts in accordance with various aspects described herein.

**[0015]** FIG. **9** is a perspective view of the blade mounts of FIG. **8**.

**[0016]** FIG. **10** is a cross-sectional view of the motor of FIG. **8**.

**[0017]** FIG. **11** is a perspective view of another ceiling fan illustrating another blade, motor housing, and light kit in accordance with various aspects described herein.

**[0018]** FIG. **12** is an exploded view illustrating internal components of the ceiling fan of FIG. **11** in accordance with various aspects described herein.

**[0019]** FIG. **13** is a cross-sectional view of an alternative low-profile motor similar to those of FIGS. **1** and **6**.

**[0020]** FIG. **14** is a cross-sectional view of another alternative low-profile motor similar to those of FIGS. **1**, **6**, and **13**.

**[0021]** FIG. **15** is a cross-sectional view of another alternative low-profile motor similar to those of FIGS. **1**, **6**, **13**, and **14**.

**[0022]** FIG. **16** is an exploded view of another alternative low-profile motor similar to those of FIGS. **1**, **6**, **13**, and **14**.

**[0023]** FIG. **17** is a cross-sectional view of the low-profile motor of FIG. **16**.

**[0024]** FIG. **18** is a cross-sectional view of a low-profile motor with a storage recess.

**[0025]** FIG. **19** is a cross-sectional view of a variant of the low-profile motor of FIG. **19** without the storage recess, with a full length motor shaft, and still using a single bearing.

## DETAILED DESCRIPTION

**[0026]** The present disclosure generally relates to a low-profile or low-stack-height ceiling fan, as well as a ceiling fan motor. For example, low-profile fans are known for use in spaces where the ceiling or overhead surface is generally close to the floor, where a traditional ceiling fan may otherwise project into the space by an undesired amount. Any reduction in size for such fans may be limited based on internal components of the fan, such as the motor, controller, or light kit.

**[0027]** Aspects of the disclosure provide for an ultra-low-profile or ultra-low-stack-height ceiling fan, in some examples having a total height of between 1-3 inches. In some implementations, aspects of the disclosure provide for an ultra-low-stack-height fan that can be secured to a downrod and have a shortened or flattened visual appearance. Aspects further provide for an improved ceiling fan motor with a printed circuit board (PCB) stator assembly and magnetic-plate rotor assembly. Aspects further provide for an improved ceiling fan motor with a PCB rotor assembly and magnetic stator assembly. The ceiling fan motor can have an overall shorter or flattened profile, providing for a shorter or more flattened ceiling fan than typical fans in the art.

**[0028]** Electric motors are typically one of axial flux or radial flux. Axial flux motors have their magnetic flux lines parallel to the rotation axis, whereas radial flux motors have their magnetic flux lines radial/perpendicular to the rotation axis. Radial flux motors are historically more common. Axial flux motors have a higher power density than radial flux motors. The power density of an axial flux motor is often 30% or more than a similarly sized radial flux motor.

However, axial flux motors have been disfavored because of their higher costs, especially when using laminations.

**[0029]** One form of an axial flux motor uses a printed circuit board (PCB) at the stator and the windings are formed by printed traces on the circuit board. These motors are referred to as PCB stator motors or just PCB motors. A PCB motor will typically have two rotors in the form of permanent magnets located both above and below the PCB stator. While one could get by with only one rotor, either above or below the stator, two rotors are often used because that configuration yields greater power (watts/horsepower) and takes advantage of the magnetic field emanating from both sides of the PCB stator.

**[0030]** Electric motors also can have either an internal rotor or an external rotor. For many ceiling fan applications, and external rotor is beneficial because the motor shaft is stationary and serves as a mounting point for the motor to a stationary object, like a ceiling or wall, via a downrod connecting the stationary drive shaft to the stationary object. Internal and external rotor configurations, especially in the ceiling fan art, result in different structural configurations, which does not always make it possible to transfer technology between the two configurations. For example, in the ceiling fan art, a light is often mounted to the ceiling fan. It is not desirable for the light to rotate and electricity must be supplied to the light and to electric motor. Given that the power supply is normally in the wall or ceiling, the downrod and stationary motor shaft are hollow and the light is mounted directly or indirectly to the stator/motor shaft, and the power cable is passed through the hollow interior of the downrod and the stationary motor shaft. The stator is mounted directly/indirectly to the stationary shaft while the rotor rotates relative to the shaft, and the blades are mounted to the rotor, not the shaft.

**[0031]** All directional references (e.g., radial, axial, proximal, distal, upper, lower, upward, downward, left, right, lateral, front, back, top, bottom, above, below, vertical, horizontal, clockwise, counterclockwise, upstream, downstream, forward, aft, etc.) are only used for identification purposes to aid the reader's understanding of the present disclosure, and do not create limitations, particularly as to the position, orientation, or use of aspects of the disclosure described herein. A generally downward direction can be defined as a direction that is directed more away from the ceiling or structure from which the ceiling fan suspends, than in a direction toward the ceiling. Connection references (e.g., attached, coupled, connected, and joined) are to be construed broadly and can include intermediate members between a collection of elements and relative movement between elements unless otherwise indicated. As such, connection references do not necessarily infer that two elements are directly connected and in fixed relation to one another. The exemplary drawings are for purposes of illustration only and the dimensions, positions, order and relative sizes reflected in the drawings attached hereto can vary. As used herein, the term "set" or a "set" of elements can be any number of elements, including only one.

**[0032]** FIG. **1** illustrates a bottom perspective view of a ceiling fan **10**. In the non-limiting example shown, the ceiling fan **10** includes a set of blades **20**, a motor **30** (visible in FIG. **4**), a motor housing **40**, and optionally, a light kit **50**. In non-limiting examples, the ceiling fan **10** can also include one or more of a controller, a wireless receiver, a ball mount, a hanger ball, a light glass, a light cage, a spindle, a finial, a switch housing, blade irons, blade forks, blade tips or blade caps, or the like. In addition, the ceiling fan **10** can be in the form of a low-profile fan having a short or flattened vertical profile. In some exemplary implementations, the ceiling fan **10** can be secured to a downrod and extend from an overhead surface. In some exemplary implementations, the ceiling fan **10** can be mounted directly to an overhead surface to form a low profile extending away from the overhead surface.

**[0033]** The set of blades **20** can extend radially from the ceiling fan **10** and can be rotatable to drive a volume of fluid such as air. While five blades are illustrated, the set of blades **20** can include any number of blades. A blade mount **60** can be provided for coupling the set of blades **20** to the motor **30**. It is also contemplated that the set of blades **20** can be directly secured, fastened, coupled, or the like to the motor **30** without an intervening blade mount. The blade mount **60** can be attached (directly or indirectly) to or integrally formed with a rotor of the motor or motor housing.

**[0034]** A blade **21** in the set of blades **20** can include any suitable fan blade and extend between a root **22** and a tip **23** in a span-wise direction, and between a leading edge **24** and a trailing edge **25** in a chord-wise direction. In the example shown, the leading edge **24** can extend linearly outward from the motor housing **40**, and the trailing edge **25** can include a vertical dip or scalloped portion **26** as shown. It can also be appreciated that a blade **21** can include any number of cross-sectional blade profiles and shapes to achieve the desired performance.

**[0035]** FIG. **2** illustrates a top perspective view of the ceiling fan **10** and illustrating one possible mounting of the blades. Mounting hardware such as bolts, screws, or the like can be provided for securing the set of blades **20** to the blade mount **60**. The set of blades **20** and the blade mount **60** can be coupled to a top surface of the motor housing **40** and form an uppermost surface of the ceiling fan **10**.

**[0036]** FIG. **3** illustrates a side view of the ceiling fan **10**. A motor height (denoted "M") can be defined as a vertical height of the motor housing **40**. In a non-limiting example, the motor height M can be between 0.5-2 inches, including between 1-2 inches, including between 1.25-2 inches, in non-limiting examples. In addition, a stack height (denoted "S") of the ceiling fan **10** can be defined as a total vertical height of the ceiling fan **10** including all components therein. It is contemplated that the stack height S can be between 0.5-5 inches, or between 0.5-4 inches, or between 1-3 inches, in non-limiting examples. In addition, a total width W of the motor housing **40** is indicated, which can also define a diameter of the motor housing **40**. It is contemplated that the total width W can be between 2-10 inches, or between 4-9 inches, or between 6-7 inches, in non-limiting examples.

**[0037]** The light kit **50** can be secured to the motor housing **40** using any suitable coupling mechanism. In some implementations, the light kit **50** can be mounted by way of a spring-loaded connector, such as a pogo pin connector. In such a case, the spring-loaded connector can bias the engaged pin components and provide for a secure connection, counteracting any vibrational or oscillating motions at the connection point, during operation of the ceiling fan **10**. The light kit **50** can also be connected by a snap-lock connection between the light kit **50** and the motor housing **40** or a bayonet-type rotational lock, for example.

**[0038]** Referring to FIG. **4**, exploded views of the ceiling fan **10** are shown including a single blade, such as the blade **21**, for visual clarity. The motor housing **40** can be in the form of a two-part housing and include a lower housing **42** and an upper housing **44** as shown. The blade mount **60** can be arranged above the upper housing **44**, and the set of blades **20** can be arranged above the blade mount **60**. In another example, the upper housing **44** can be omitted and the blade mount **60** can form a rotatable housing for the motor **30**. Another way to think of this is that the blade mount **60** can be integrated with the upper housing **44**. Other arrangements of the housing **40** and blade mount **60** are contemplated. The lower motor housing **42** is illustrated with a hub/spoke/rim configuration, with a stationary motor shaft **87** extending upward from the hub. A bearing assembly can be located within the hub and rotation couple to the motor shaft. The motor **30** defines an outer periphery, which defines the exterior of the motor. As illustrated the upper and lower housings **44**, **42** collectively define the outer periphery.

**[0039]** The motor height, M, is the greatest vertical dimension between the outer surfaces of the upper and lower housings **40**. In some motors, the housings does not necessarily conform to the shape of the rotor/stator and are more ornate. In the motor **30**, the housings **40** do conform more to the shape of the rotor/stator to reduce the overall height of the motor.

**[0040]** The motor **30** can be enclosed by the motor housing **40**. The motor **30** can be in the form of an axial flux, permanent magnet motor including a rotor assembly **70** and a stator assembly **80**. The rotor assembly **70** can include a lower rotor **72** and an upper rotor **74**. The stator assembly **80** can include a PCB stator **82**, bearing assembly **90** located in a central hub or collar **88**. The motor shaft **87** can carry the bearing assembly **90** and support part of the PCB stator **82**. An arm **84** carrying a set of electrical components **86** can be supported by the lower housing **42**.

**[0041]** The set of electrical components **86** can include wired or wireless connections between components of the ceiling fan **10**. In the illustrated example the set of electrical components **86** includes multiple wires extending through the arm **84**, such as for providing power to the light kit **50** (FIG. **3**) in a non-limiting example. Any number of rotors and stators can be provided in the motor **30**. For instance, an alternating-stack arrangement can be formed such as a rotor-PCB stator-rotor-PCB stator-rotor-PCB stator-rotor arrangement, in one non-limiting example.

**[0042]** It is contemplated that the blade mount **60** can be in the form of a singular component with multiple coupling portions **62** configured to couple to corresponding blades in the set of blades **20**. The blade mount **60** can also be secured to a portion of the rotor assembly **70**, such as the upper rotor **74**, for driving the set of blades **20**. In the example shown, the blade mount **60** includes a central recess **64**. Mounts **35** can be provided in any or all of the blades **21**, coupling portions **62**, or the upper rotor **74**. Such mounts **35** can include apertures, fasteners, snap-fit connectors, dovetail connectors, or the like. The blade **21** can be coupled to the coupling portion **62** by way of the mounts **35**. In addition, the central recess **64** of the blade mount **60** can extend through an opening **43** in the upper motor housing **42** and be coupled to the upper rotor **74** by way of the mounts **35**. In this manner, the set of blades **20** and the blade mount **60** can be secured to and co-rotate with the upper rotor **74**. In another non-limiting example, the set of blades **20** and blade mount **60** can be coupled to the lower rotor **72**, such that the motor housing **40** is positioned above the set of blades **20**. In such a case, it is understood that components or arrangements of the motor **30** and motor housing **40** can be modified, inverted, or the like to provide for coupling the set of blades **20** to the lower rotor **72**. It is also possible to couple the blades to both the upper and lower motor housings **42**, **44**. It is also contemplated that the upper and lower rotors **74**, **72** can be configured so as to perform the role of the housing **40**, negating the need for any housing **40**, and the blades would be directly/indirectly mounted to one or both of the upper and lower rotors **74**, **72**.

**[0043]** The blade mount **60** being on top of the upper housing **44** increases the stack height, S, of the motor, resulting in the stack height, S, being greater than the motor height, M. The additional of the blades **20** mounting to the top of the blade mount **60** further increases the stack height, H.

**[0044]** FIG. **5** illustrates the motor **30** and motor housing **40** in further detail. The upper rotor **74** and the lower rotor **72** can include a corresponding set of permanent magnets **76**, each of which defines a magnetic pole. The PCB stator **82** can be positioned centrally between the upper and lower rotors **72**, **74**. The PCB stator **82** can have a portion **83** extending radially beyond the upper rotor **74** or the lower rotor **72** as shown. The portion **83** can form a mounting fixture point to the motor housing **40**, such as the lower housing **42** or the upper housing **44**. While the PCB stator **82** is shown sandwiched between two rotors **74**, **72**, it is contemplated that a single rotor can be used.

**[0045]** It is further contemplated that the motor housing **40** can form a heat sink **46** for the motor **30**. As shown, the heat sink **46** is provided with the lower housing **42** of the motor housing **40** though this need not be the case. The heat sink is in the form of a hub **43**, spoke **45**, and rim **47**, with the hub **43** having the motor shaft **87**, which can support the PCB stator **82**, thereby thermally conductively coupling to the PCB stator **80**. In this way, a thermal conductive path is formed from the PCB stator **80**, to the shaft **87**, to the hub **43**, to the spokes **45**, and to the rim **47**. Another thermal conductive path is created by the outer periphery of the PCB stator **80** resting on the rim **47**. Heat from the PCB stator **80** can transfer along either or both conductive paths where it can be dissipated by radiation and/or convection to the surrounding environment. The spokes **45** can be replaced with a sheet and/or there can be added fins or other suitable cooling structures.

**[0046]** One or more heat sinks can be provided with the upper housing **44** or the lower housing **42**. In some implementations, the motor housing **40** can be formed of thermally conductive materials such that heat can be distributed through all portions of the housing **40**. In some implementations, the motor housing **40** can include thermally conductive materials for at least the heat sink **46** and can also include thermally insulating materials in other portions of the housing **40**, such as the upper housing **44**. In this manner, heat generated within the motor **30** during operation can be selectively directed to at least the heat sink **46** and dissipated into the surrounding environment.

**[0047]** Referring generally to FIGS. **1-5**, during operation of the ceiling fan **10**, the upper rotor **74** and lower rotor **72** can rotate with the collar **88** with respect to the stationary PCB stator **82**. The set of blades **20** can be driven by and co-rotate with the upper rotor **74** by way of the blade mount **60** as described above. The leading edge **24** of each blade in the set of blades **20** can direct adjacent air over the corresponding scalloped portion **26** such that air flows downward with rotation of the set of blades **20**. In this manner, the ceiling fan **10** can operate with an ultra-low profile formed by a very small stack height S as described above.

**[0048]** Turning to FIG. **6**, another ceiling fan **110** is illustrated in accordance with various aspects described herein. The ceiling fan **110** is similar to the ceiling fan **10**; therefore, like parts will be identified with like numerals beginning with **100**, with it being understood that the description of the like parts of the ceiling fan **10** applies to the ceiling fan **110**, unless otherwise noted.

**[0049]** The ceiling fan **110** is illustrated in a side sectional view and includes a set of blades **120**, a motor housing **140**, and a light kit **150**. One difference compared to the ceiling fan **10** is that the ceiling fan **110** can include a rotatable blade housing **165**. The blade housing **165** can receive the set of blades **120** and form an outer cover over the motor housing **140**. The rotatable blade housing **165** is attached to the upper rotor **74** in a manner similar to how the blade mount **60** passes through the opening **43** of the upper housing **44** and attaches to the mounts **35**. In this way, the upper housing **44** is stationary while the upper rotor **74** rotates to rotate the blade housing **165** and the blades **120** attached to the rotatable housing. In some examples, the blade housing **165** can be a unitary, one-piece housing receiving that receives the set of blades **120**. When assembled, the set of blades **120** can be vertically spaced from the motor housing **140** as shown. The light kit **150** can be integrated with the lower housing **42** or attach to the lower housing **42**. The mounting of the light kit **150** to the lower housing **42** means the light kit **150** does not rotate.

**[0050]** A motor adapter **194** is shown attached to a stationary motor shaft **187**. The motor adapter **194** is mounted to a downrod **199**. The downrod **199** and motor adapter **194** can have complementary threads such that the downrod **199** is threaded into the motor adapter **194**. Alternatively, the downrod **199** can be received within the motor adapter **194** and a pin is then passed through aligned openings in the downrod **199** and motor adapter **194** in the traditional manner.

**[0051]** The blade housing **165** extends above the upper housing **144** resulting in the blade housing **165** increasing the stack height, S, and making the stack height, S, greater than the motor height, M.

**[0052]** FIG. **7** illustrates a perspective view of the ceiling fan **110**. For clarity, one blade **121** in the set of blades **120** is shown. Any number of blades can be provided in the set of blades **120**. The blade housing **165** can also include slots **166** through which the set of blades **120** can extend. Electrical wires **167** are shown extending into the stationary motor shaft. The electrical wires can supply power or communication to the motor **130**.

**[0053]** Turning to FIG. **8**, an exploded view of the ceiling fan **110** illustrates the blade housing **165**, the blade **121**, the motor housing **140**, and the light kit **150** in a stacked arrangement. The blade **121** can extend between a root **122** and a tip **123** as shown.

**[0054]** The motor housing **140** can include a lower housing **142** and an upper housing **144** as shown. The motor **130** can include a rotor assembly **170** and a stator assembly **180**. The rotor assembly **170** can include a lower rotor **172**, an upper rotor **174**, and a set of magnets **176** coupled to the lower and upper rotors **172**, **174**. The stator assembly **180** can include a PCB stator **182**, a central shaft **187**, and a collar or central hub **188**. When assembled, the set of magnets **176** can confront the PCB stator **182** from each of the lower and upper rotors **172**, **174**

**[0055]** A heat sink **146** can be provided in the ceiling fan **110**. The heat sink **146** can be provided with either or both of the lower housing **142** or the upper housing **144**. In the example shown, the heat sink **146** is provided with the lower housing **142**. In some examples, the lower housing **142** can define the heat sink **146** as a unitary component. In some examples, the heat sink **146** can be a separate component and coupled to the lower housing **142**.

**[0056]** When assembled, the PCB stator **182** can be positioned between the lower rotor **172** and the upper rotor **174**. The lower housing **142** and upper housing **144** can enclose the rotor assembly **170** and the stator assembly **180**. The blade mount **160** can be positioned above the upper housing **142**. The blade housing **165** can enclose the blade mount **160** and the motor housing **140**. The light kit **150** can be positioned below and adjacent the blade housing **165**. In this manner, the blade housing **165** can form an uppermost surface of the ceiling fan **110**, and the light kit **150** can form a lowermost surface of the ceiling fan **110**. In an example where no light kit is provided, it is appreciated that the lower housing **142** can form a lowermost surface of the ceiling fan **110**.

**[0057]** Another difference compared to the ceiling fan **10** is that the blade mount **165** can be in the form of multiple individual mounts **168** coupled to the blade housing **165**. Turning to FIG. **9**, the mounts **168** are shown in further detail. Each mount **168** can include a pocket **169** configured to receive the root **122** of each blade **121** (FIG. **7**). Still another difference is that the mount **168** can form a snap-fit connection with the root **122** (FIG. **7**). For example, the mount **168** can include interior projections configured to snap onto a recess on the blade root **122** (FIG. **7**). Such a snap-fit connection can provide for improved assembly or removal of the set of blades **120** (FIG. **7**). It is contemplated that the snap-fit connection can fully secure the set of blades **120** to the mounts **168** without need of additional threaded fasteners. Additionally or alternatively, fasteners can be provided in combination with the snap-fit connection.

**[0058]** FIG. **10** illustrates a cross-sectional view of the motor **130**. The motor **130** can include a set of apertures **134** in either of the lower rotor **172** or the upper rotor **174**. In the example shown, the set of apertures **134** is provided with the upper rotor **174**. The set of apertures **134** can be configured to directly or indirectly couple to each mount **168** (FIG. **9**), such as by way of a suitable fastener, like a threaded bolt. For example, the set of apertures **134** can provide for coupling the rotor assembly **170** to the blade housing **165**, and the blade housing **165** can be secured, fastened, or the like to each mount **168**. In this manner, rotation of the rotor assembly **170** can drive rotation of the set of blades **120**. The set of apertures **134** can be threaded or tapped to receive suitable fasteners. Electrical wires **193** can supply power or data to the motor **130** and/or a light kit.

**[0059]** Referring now to FIG. **11**, another ceiling fan **210** is illustrated in accordance with various aspects described herein. The ceiling fan **210** is similar to the ceilings fan **10** and **110**; therefore, like parts will be identified with like numerals beginning with **200**, with it being understood that the description of the like parts of the ceiling fans **10** and **110** applies to the ceiling fan **210**, unless otherwise noted.

**[0060]** The ceiling fan **210** can be in the form of an impeller fan with a body **211** that includes an inlet housing **212** and a deflector **232**. In the non-limiting example shown, the inlet housing **212** and the deflector **232** can each have an annular shape. The inlet housing **212** can define an inlet **213** for drawing airflow into the body **211**. An outlet **214** can be provided on one side of the body **211**. The deflector **232** can be moveable relative to the inlet housing **212**. More specifically, the deflector **232** can be movable relative to the outlet **214** to control the direction of the air emitted through the outlet **214**.

**[0061]** A light kit **250** can be carried by the body **211** in some exemplary implementations. For instance, the light kit **250** can be suspended from the inlet housing **212**. In one example, a controller (not shown) can be provided within the inlet housing **212**, which can be utilized for controlling or operating the ceiling fan **210**. In alternative non-limiting examples, a controller can be provided remote from the ceiling fan **210**, such as a wall-mounted controller or a wireless controller.

**[0062]** Turning to FIG. **12**, the major components of the ceiling fan **210** can be seen in a partially exploded view and include, in stacked arrangement, an outlet frame **215**, a set of guide vanes **216**, the deflector **232**, a motor **230**, a shroud **217**, an impeller **218**, the inlet housing **212**, an optional inlet grill **219**, and the light kit **250**.

**[0063]** The outlet frame **215** can be configured to secure the body **211** to a structure, such as a ceiling. The set of guide vanes **216** can include spaced, stationary foils, louvers, airfoils, or the like. In the example shown, the set of guide vanes **216** includes a set of louvers in the form of vertically stacked, slanted rings. The deflector **232** can be movable relative to the inlet housing **212** to form variable flow angles for air exiting the outlet **214** (FIG. **11**). The impeller **218** includes a set of blades mounted to an outer ring and configured to draw air into the inlet **213** (FIG. **11**).

**[0064]** The motor **230** can drive rotation of the impeller **218**. The motor **230** is similar to the motor **30**, **130** and can include a rotor assembly **270** having a lower rotor **272** and an upper rotor **274**, as well as a stator assembly **280** including a PCB stator **282** as shown.

**[0065]** The rotor assembly **270** can couple to a portion of the shroud **217** to effect rotation of the shroud **217**. Since the impeller **218** is mounted to the shroud **217**, rotation of the shroud **217** effects rotation of the impeller **218**.

**[0066]** Referring generally to FIGS. **11-12**, during operation, air is drawn into the inlet **213** by the impeller **218**. Depending on a relative positioning of the deflector **232** and the inlet housing **212**, air can exit through the outlet **214** with a variable exit angle to form various exit air flows, including a generally horizontal air curtain adjacent the body **211**, or a downward air flow away from the body **211**, in non-limiting examples.

**[0067]** FIG. **13** illustrates a cross-sectional view of an alternative ceiling fan **310**, with a DC, axial flux, ceiling fan motor **330**, which is generally similar to the prior ceiling fan motors **30**, **130**, and **230**. Therefore, like parts will be identified with like numerals beginning with **300**, with it being understood that the description of the like parts of the ceiling fans **10**, **110**, **210** applies to the ceiling fan **310**, unless otherwise noted. The ceiling fan motor **330** differs from the motors **30**, **130** in that blade mounts are integrated with the rotor. Also, the upper and lower housings are now integrated with the rotor and stator assemblies, negating the need for a separate housing to cover the rotor and stator.

**[0068]** More specifically, the motor **330** has a stator assembly **380** and a rotor assembly **370** rotationally mounted to the stator assembly **380** by a bearing assembly **390**. The stator assembly **380** includes a PCB stator **382** carried by a stator or lower housing **340**. A motor shaft **387** projects upwardly from the lower housing **340**. The bearing assembly **390** has as pair of spaced bearings **391** that rotationally couple the rotor assembly **370** to the motor shaft **387**. Blade mounts **360** extend from the rotor assembly **370** and mount the blades **320**.

**[0069]** Looking in more detail at the stator assembly **380**, the lower housing **340** is illustrated as a lower wall **381** with a rim **383** on which the PCB stator **382** rests or seats. It is contemplated that the lower wall **381** is in the form of a disk and the rim **383** is an annular ring. However, the lower wall **381** need not be a wall, let alone a solid wall, and it can have many pass-through openings, which can advantageously be used for heat transfer. Alternatively, instead of a wall with openings, a hub/spoke/rim configuration could be used where the lower wall **381** is in the form of a hub and spoke, with the rim **383** forming the rim of the hub/spoke/rim arrangement. The shaft **387** could be mounted to the hub in this configuration. The lower wall **381** also need not be planar. It can be concave, convex or have any other desired cross-sectional shape. Whatever the form and cross-sectional shape of the lower wall **381**, it will have an outer surface with an uppermost point and a lowermost point, which can be the same point or different points.

**[0070]** The shaft **387** can be integrally formed with the lower wall **381**, separate from the lower wall **381**, or attached to the lower wall **381**. For example, the shaft **387** can be pressed-fit into an opening in the lower wall **381** or threaded into a tapped opening in the lower wall **381**. The shaft **387** can have a hollow interior **389** through which other elements of the fan may pass, such as electrical wiring, for power and/or data, and connectors.

**[0071]** The rotor assembly **370** comprises a rotor or upper housing **344** with an upper wall **371** from which extends a peripheral wall **373**. The size of the upper wall **371** is illustrated being great enough such that the peripheral wall **373** lies radially beyond the lower wall **381** and rim **383**. The peripheral wall **373** is illustrated as extending down to the lower surface of the lower wall **381** to provide a flush or continuous transition from the upper wall **371** to the peripheral wall **373**. The peripheral wall **373** need not terminate flush with the lower surface of the upper wall **371**. The peripheral wall **373** can extend beyond the upper wall **371** or may just partially overlap with at least one or both of the lower wall **381** and rim **383** to at least partially hide them from view. Regardless of the extent of the peripheral wall **373**, the upper wall **371**, peripheral wall **373**, and the lower wall **381** visually form an exterior of the motor **330** and the entire fan.

**[0072]** The rotor assembly **370** further includes sets of permanent magnets **372**, **374** with one of the sets **372** located below the PCB stator **382** and the other set **374** located above the PCB stator **382**. The rotor assembly **370** includes a carriage **375** for securing the sets of permanent magnets **372**, **374**. The carriage **375** is illustrated as having a collar **377** depending from the upper wall **371** with an annular spacer **379** separating the sets of permanent magnets **372**, 374, which are illustrated as disks, but need not be. The spacer 379 is aligned with and thicker than the PCB stator 382 to affect a vertical spacing of the sets of permanent magnets 372, 374 relative to the PCB stator 382. The spacer 379 is illustrated integrally formed with the collar 377, but it can be a separate piece, such as a snap-ring or multiple snap rings that rest in one or more grooves in the collar 377. The relative spacing of the rim 383 and spacer 379 controls the relative, vertical proximity of the sets of permanent magnets 372, 374 and the PCB stator 382.

**[0073]** While two sets of permanent magnets are shown, it is contemplated only one be used. When a single set of permanent magnets is used, the set of permanent magnets could be mounted directly to or set up against the interior surface of the upper wall 371, which would provide a more vertically compact arrangement, reducing the motor height, H, and the corresponding stack height, S. The mounting of the set of permanent magnets to or against the interior surface could also be used in the case of multiple sets of permanent magnets. For example, the spacer 379 could be moved closer to the upper wall 371 so as to force the set of permanent magnets into abutment with the interior surface of the upper wall 371.

**[0074]** While only one combination of PCB stator 382 and corresponding sets of permanent magnets 372, 374 are shown, multiple sets could be used in a stacked arrangement, with or without a set of permanent magnets being shared between adjacent PCB stators, which is applicable to all the described motors. While stacking multiple PCB stators and corresponding magnets can be used for a variety of purposes, it is suitable for controlling the diameter of the motor housing, yet increasing the motor torque, while sacrificing stack height.

**[0075]** The bearing assembly 390 is illustrated as being integrated with the carriage 375 in that the spacer 379 lies on both the interior and exterior of the collar 377. However, the bearing assembly 390 can be separate from the carriage and even separate from the rotor assembly 370. The bearing assembly 390 can just as easily be integrated or affixed to the motor shaft 387. Similarly, the stator assembly 380 can have at least one bearing seat for holding at least one of the bearings 391.

**[0076]** The blade mounts 360 can be integrally formed with or affixed to the peripheral wall 373. One possible implementation is that the rotor assembly 370 is cast, injection molded, or 3-D printed as a single piece. The blade mounts 360 can have openings to receive fasteners, such as bolts, screws, grommets, etc., to secure the blades 320 to the blade mounts 360. The blade mounts 360 can be ramps oriented at an angle to provide the blade with an angle of attack. The angle of the ramps can be thought of as the pitch of the ramps relative to the axis of rotation of the rotor assembly 370. The blade mounts 360 can be such that the blades 320 can be mounted to either side of the blade mounts 360. In FIG. 13, one of the blades 320 is shown mounted to the top of the blade mount and another blade 320 is alternatively mounted to a bottom of the blade mount. Alternatively, the blade mounts 360 could slidably receive the blades and/or the blades could slide over the blade mounts 360. While the blade mounts 360 are shown as ramps, they could just as easily be the slots and blade attachments as shown in FIG. 6 by making room within the rotor assembly 370 for the slots and the corresponding blade attachment.

**[0077]** The blade mounts 360 are illustrated extending from the peripheral wall 373. To obtain the shortest stack height, S, the blade mounts would be located along the peripheral wall between the outer surface of the upper wall 371 and the outer surface of the lower wall 381. The blade mounts can also reside within the vertical extent of the rotor magnets and the stator coils. Optionally, the blade mounts can be located on the outer surfaces of one or both of the upper wall 371 and lower wall 381. The blade mounts 360 can be located along the peripheral wall 373 with the shape of the blade 320 in mind to ensure that during non-rotation, rotation, or both, of the blades 320, the blades remain within the motor height, M.

**[0078]** Optionally, a light kit 350 is provided with the stator assembly 380. The light kit 350 is illustrated as a plurality of LEDs 351 that are provided in the lower wall 381 and arranged as one or more concentric rings of LEDs. However, the LEDs 351 need not be provided in the lower wall 381 or arranged in rings. The LEDs could be mounted to the lower wall 381 and they could be in any desired pattern or randomly arranged. The LEDs 351 could have their own frame, housing, or similar structure that is affixed to the stator assembly 380. The light kit could, alternatively, be integrated in the upper wall 371. Although LEDs are the described light source, any suitable illumination source can be used.

**[0079]** An integrated motor adapter 394 is provided with the stator assembly 380. The motor adapter 394 can mount to a traditional downrod or ceiling bracket to secure the motor 330 to a structure, like a wall or ceiling. The motor adapter 394 is illustrated as the hollow interior 389 being tapped or threaded 396. A complementary downrod 399 has cooperating threads to be threaded into the threads 396. The direction of the threads 396 would be coordinated with the direction of rotation of the blades 320 to prevent an unthreading of the motor adapter 394 and downrod during normal use. Additionally, an anti-rotation device, such as spring-biased detent, could be provided between the motor adapter 394 and the downrod to prevent anti-rotation after the initial threading. While the threads are shown as internal threads, they could be externally located, with downrod thus having internal threads.

**[0080]** Motor adapter aside, the motor 330 can be mounted to any suitable surface using any one of the traditional downrod approaches. In such a configuration, a downrod would extend from the ceiling and be secured to the stationary motor shaft 387 in any suitable manner. Alternatively, a bracket, without a downrod, could secure the motor shaft 387 to the structure. In a "flipped" orientation from what is seen in FIG. 13, the stator assembly 380, instead of the rotor assembly 370, could face the structure, such as a ceiling, and the stator assembly 380 be secured to the structure either directly or indirectly with a bracket.

**[0081]** The integrated motor adapter 394 reduces the stack height, S, over traditional ceiling fans, where the motor adapter is affixed to the end of the stationary motor shaft 387 and would extend above the upper motor housing 344. The motor adapter 394 resides at least partially within the vertical extent of at least one of the magnets for the rotor and the coils of the stator, and the upper and lower surfaces of the lower and upper housings 342, 344, which yields an extremely compact, low-profile motor. The motor adapter 394 can be used on any of the described motors.

**[0082]** A heat conductive pathway is formed by the PCB stator **382** being in contact with the rim **383**. In this way, heat from the PCB stator is transferred to the lower wall **381** of the stator housing **340**. Heat dissipation structures, such as fins or the like, can be provided on the lower wall **381**, especially the exterior surface of the lower wall **381**, to aid in transfer of the conducted heat to the surrounding environment. Additionally, since the upper wall **371** and/or the spacer **379** are in contact with the motor shaft **387**, as second heat conductive path is formed from the PCB stator **382** to the upper wall **371** via the rim **383**, lower wall **381**, motor shaft **387** and, optionally, the spacer **379** of the carriage.

**[0083]** The configuration of the motor **330** provides a very low-profile motor for several reasons. First, the housing **340** is formed by or integral with the rotor assembly **370** and stator assembly **380**, which negates the need for a separate housing. Such a separate housing will typically increase the stack height, S, of the fan **310**. Second, the blade mounts **360** are located between the upper wall **371** and the lower wall **381** of the rotor assembly **370** and stator assembly **380**, respectively. The location of the blade mounts **360** along the peripheral wall **373** and the shape of the blades **320** can be coordinated so that the blades **320** reside entirely within the height M of the motor, which further reduces the stack height, S, to the motor height, M. Third, the light kit **350** being integrated within the lower wall **381** also locates the light kit **350** within the height M of the motor. Fourth, the motor adapter **394** being integrated with the housing **340** and/or at least partially within the vertical extent of the rotor assembly **370** and stator assembly **380**, further reduces the stack height, S, as motor adapters are typically located above the magnets/coils of the rotor/stator and above the motor housing **340**. Fifth, integrating the light kit **350** into the stator or lower housing **342** also further reduces the stack height, especially since light kits are normally affixed to and depend on the stator housing.

**[0084]** FIG. **14** illustrates a ceiling fan **410** with a motor **430**, which is a variant of the motor **330**, and mounts the blades to the top of the rotor housing. The ceiling fan **410** is similar to the ceiling fans **10**, **110**, **210**, and **310**; therefore, like parts will be identified with like numerals beginning with **400**, with it being understood that the description of the like parts of the ceiling fan **10**, **110**, **210** and **310** applies to the ceiling fan **410**, unless otherwise noted. The motor **430** is essentially the same as the motor **330**, except that the blade mounts **460** have been moved to the top of the peripheral wall **473**. The blades **420** can be mounted to either side of the blade mounts **460** and/or the blade mounts **460** can slidably receive the blade or be slidably received within the blade. The blade mounts **460** are illustrated as planar extensions from the upper wall **471**. Thus, the blade mounts **460** can be formed by making a wider or greater diameter upper wall **471** that overhangs the peripheral wall **473**. Alternatively, the blade mounts **460** can be discretely located at the desired locations providing the upper wall **471** with a castellated appearance when viewed from above. It also contemplated that the blades **420** could be mounted directly to the upper wall **471**, negating the need for a dedicated blade mount **460**.

**[0085]** In another variant, as seen in FIG. **15**, a ceiling fan **510** with motor **530**. The ceiling fan **510** is similar to the ceiling fans **10**, **110**, **210**, **310**, and **410**; therefore, like parts will be identified with like numerals beginning with **500**, with it being understood that the description of the like parts of the ceiling fan **10**, **110**, **210**, **310**, and **410** applies to the ceiling fan **510**, unless otherwise noted. The motor **530** is essentially the same as the motor **430** except that the blade mount **560** extends from the upper wall **571** or is an extension of the upper wall **571**, the peripheral wall can be replaced with a longer rim **583** that extends almost to the inner surface of the upper wall **571** with a seat **579** formed in the rim **583** to receive the PCB stator **582**. In such a configuration, if the blades **520** are mounted to the bottom of the blade mount **560**, the blades would at least partially visually hide any gap between the rim **583** and the upper wall **571**. The configuration of FIG. **15** can be applied to any of the motors described herein.

**[0086]** FIG. **16** illustrates another variant of a ceiling fan **610**, with a low-profile motor **630**. The ceiling fan **610** is similar to the ceiling fans **10**, **110**, **210**, **310**, **410**, and **510**; therefore, like parts will be identified with like numerals beginning with **600**, with it being understood that the description of the like parts of the ceiling fan **10**, **110**, **210**, **310**, **410**, and **510** applies to the ceiling fan **610**, unless otherwise noted. The motor **630** differs from the other motors is that it is a radial flux motor, as compared to an axial flux motor, and it uses wire-wound coils (not shown for clarity) in the stator, instead of coils printed as traces on a PCB stator. The motor **630** includes a rotor assembly **670** and a stator assembly **680**, which are relatively rotationally coupled by a bearing assembly **690**.

**[0087]** The rotor assembly **670** includes an upper wall **671**, with a collar **677**, and a peripheral wall **673**. A set of permanent magnets **672** are carried by one or both of the upper wall **671** and peripheral wall **673**. As illustrated, the permanent magnets **672** are discrete magnets arranged in an annular cage **675** to form an annular ring that abuts the peripheral wall **673**.

**[0088]** The permanent magnets **672** can be of any type or suitable shape. Back iron can be provided with the magnets to increase the magnetic field. The annular cage **675** can be any suitable structure to hold the magnets.

**[0089]** The stator assembly **680** includes a lower wall **681** and a stator core **682**, which is supported by the lower wall **681**, and a stationary motor shaft **687**, which is secured to or integrally formed with the lower wall **681**. The lower wall **681** includes a collar **683**, which, as illustrated, receives the motor shaft **687**. The motor shaft **687** can be attached to the collar **683** by press-fitting the motor shaft **687** into the collar **683**, threading the motor shaft **687** into the collar **683**, or any other suitable connection. When threaded, the collar **683** would be internally threaded and the shaft would be externally threaded, as illustrated, but the motor shaft **687** could just as easily be thread onto the exterior of the collar **683**.

**[0090]** The stator core **682** comprises a core **685** with multiple posts **689** about which wire is wound to form a coil, which forms a pole for the stator core **682**. The wound wire forming the coil is not shown for clarity. The stator core **682** is affixed to the lower wall **681** in any suitable manner. As illustrated, fasteners, such a bolts **692**, pass through corresponding bosses **694** in the stator core **682** and thread into the lower wall **681**.

**[0091]** Blades can be mounted to the rotor assembly **670** in the same manner as described for any of the other embodiments. For example, the blades can be directly fastened to the upper wall **674**, which does have tapped openings **675** for such a purpose. Alternatively, as with any of the other embodiments, a blade iron or similar blade mount structure can be secured to the upper wall **671** or peripheral wall **673** and the blades attached to the blade iron or blade mount **660**. For example, the blade mounts described for FIG. **13** can easily be used for the motor **630**.

**[0092]** Referring to FIG. **17**, the motor **630** is shown assembled where it can be seen that the bearing assembly **690** includes a pair of bearings **691** that encircle the motor shaft **687** and located between the motor shaft **687** and the collar **677**. The gap between the exterior of the motor shaft **687** and the interior of the collar **677** can be controlled such that the bearings **691** are pressed between the collar **677** and the motor shaft **687**. The motor shaft **687** can have a stop that limits the axial position of the bearings on the motor shaft **687**. As illustrated, a snap-ring is attached to a lower portion of the motor shaft **687** and functions as an axial stop.

**[0093]** The bearings **691** are axially spaced from one another and/or span a sufficient axial distance along the motor shaft **687** such that they retard the wobbling of the rotor assembly **670** relative to the motor shaft **687** and/or the stator assembly **680**, which enables tighter tolerances between the peripheral wall **673** and the periphery of the lower wall **681**, which negates the need for a decorative motor housing, and, instead, use the motor itself.

**[0094]** The radial flux motor **630** has an advantage over the axial flux motors previously described when it comes to having a low profile and that advantage is attributable to the permanent magnets being radially aligned with the stator coils, instead of being vertically arranged as in the axial flux motors. However, the axial flux motors have an advantage in that the PCB stator, all things being equal, is not as tall as the stator coils. The combined thickness, including the spacing between the PCB stator and its permanent magnets will be less than the height of the stator coils for the radial flux motor **630**. The axial flux motors also have the advantage in that the permanent magnets are affixed to the bearing assembly whereas in the radial flux motor, the permanent magnets are carried at the outer periphery of the rotor assembly, which creates a larger suspended mass, and a larger inertia. For a given output (watts or horsepower) motor, the PCB stator motor should yield a lower profile.

**[0095]** FIG. **18** illustrates another fan **710** having a variant DC, radial flux, motor **730**. The ceiling fan **710** is similar to the ceiling fans **10**, **110**, **210**, **310**, **410**, **510**, and **610**; therefore, like parts will be identified with like numerals beginning with **700**, with it being understood that the description of the like parts of the ceiling fan **10**, **110**, **210**, **310**, **410**, **510**, **610** applies to the ceiling fan **710**, unless otherwise noted. More specifically, the motor **730** is essentially identical to motor **730**, except that the stator or lower housing **742** defines a recess **743**, which can be used to receive one or more module/accessory for the fan, such as a fan controller (typically in the form of a PCB), a light kit, a remote-control unit, and/or another other desired accessory. As illustrated the recess is formed by a circular peripheral wall **745**, which can also be used to support the stator, especially the cage for the stator coils or permanent magnets if the stator were to use them. The recess **743** is further illustrated as being formed by a top wall **747**, from which a collar **777** depends, with the collar **777** receiving and securing the motor shaft **787** by means of a snap ring **797** received within a channel on the outer surface of the motor shaft **787** and resting on the collar **777**.

**[0096]** The motor shaft **787** has a hollow interior **789**. Complementary and aligned openings **791** and **793** are formed in the collar **777** and motor shaft **787** and permit electrical wires to pass from the recess **743** into the hollow interior **789**, which can be used to provide power or data to anything stored in the recess **743**. Such pass-through openings **791**, **793** can be used in any of the disclosed motors, even those without a recess.

**[0097]** As illustrated, the motor shaft **787** and collar **777** do not extend down to the same vertical extent as the lower wall **781**, which provides an uninterrupted space **795** within the recess **743**. The rest of the recess **743** has an annular shape **796**. Modules for the ceiling fan, such as remote control modules, wireless modules, light kits, PCBs, including the fan controller or motor controller, or both, can be formed in an annular or donut-like shape and received within the recess **743** above the uninterrupted space **795**. Alternatively, they can be formed to fit withing the uninterrupted space **795**. Multiple modules can fit within the recess. One or more can be donut-shaped, say, for example, a fan controller on a PCB, and another could be a light kit, say a plurality of LEDs placed within the uninterrupted space **795**.

**[0098]** The recess **743** can be formed in any of the described motors. The recess provides yet one more way in which the stack height, S, of the motor can be reduced for a lower profile. The recess **743**, as illustrated, extends at least partially within at least one of the coils/magnets for the stator/rotor. In this sense, the recess is at least partially located within the vertical extent of the coils/magnets of the stator/rotor and can be fully located within the vertical extent.

**[0099]** The rotor assembly **770** includes a top wall **771** in which is defined a bearing seat formed by an annular wall **799** in combination with the top wall **771** in which a single bearing **790** is received to rotationally secure the rotor **770** to that stationary motor shaft **787** is received. The snap ring **797** also can aid in positioning the bearing **790** within the bearing seat. The bearing seat can be sized such that the outer race of the bearing **790** is pressed within the bearing seat and bears against the annular wall **799** and the motor shaft **787** is pressed within the inner race of the bearing **790**.

**[0100]** FIG. **19** illustrates another fan **810** having a variant DC, radial flux, motor **830**. The ceiling fan **810** is similar to the ceiling fans **10**, **110**, **210**, **310**, **410**, **510**, **610**, and **710**; therefore, like parts will be identified with like numerals beginning with **800**, with it being understood that the description of the like parts of the ceiling fan **10**, **110**, **210**, **310**, **410**, **510**, **610**, **710** applies to the ceiling fan **810**, unless otherwise noted.

**[0101]** The motor **830** comprises a rotor assembly **870** rotationally coupled to a stator assembly **880** by a bearing assembly **890** and a stationary motor shaft **887**. The bearing assembly **890** rotationally couples the rotor assembly **870** to the motor shaft **887**. The motor shaft **887** provides a securing structure for many elements of the stator assembly **880**.

**[0102]** The rotor assembly **870** is illustrated with a top wall **871** from which extends a peripheral wall **873**. A shaft opening **900** is formed in the top wall **871**. An outer bearing seat **902** circumscribes the shaft opening **900** and is illustrated as a recess formed in the thickness of the top wall **871**. However, other structures, such as a depending wall, could be used in place of the recess, especially when the top wall **871** is not as thick as illustrated. The outer bearing seat **902** comprises a lip **902*a*** and a peripheral wall **902*b***.

**[0103]** The peripheral wall **873** extends below the top wall **870** and defines in interior **904** in which all or a portion of the stator assembly **880** can be received. The peripheral wall **873** has an inner surface **908** on which is provided a magnet seat **910** supporting a plurality of magnets **876**, such as permanent magnets. The magnet seat **910** is illustrated as a ledge or step in the inner surface **908** and the magnets **876**, which form a ring, can be pressed into the step. However, the magnets **876** can be mounted to the magnet seat **910** in any manner desired.

**[0104]** The peripheral wall **873** is slightly tapered relative to the vertical in that it has a decreasing diameter as it extends in height. However, the taper is not material and the peripheral wall **873** need not have taper at all or could have the opposite taper as illustrated. The taper does provide for the formation of the step for the magnet seat **910** while still maintaining a general overall thickness for the peripheral wall **873**.

**[0105]** The stationary motor shaft **887** has a hollow interior **889**, which extends through the entire length of the motor shaft **887**, although it need not do so to perform its function. An inner bearing seat **912** is formed on the exterior of the motor shaft **887** and is illustrated as a collar or ledge **912***a* and a peripheral wall portion **912***b* of the motor shaft **887**, which amounts to a local increase in the diameter of the motor shaft **887**. Below the inner bearing seat **912** is a stator mounting seat **914** also in the form of a ledge or collar and provides a surface against which the stator can rest or abut.

**[0106]** The stationary motor shaft **887** terminates at a lower end in a neck **916**, which can have external threads. As illustrated, the neck **916** can be seen as an undercut to the collar forming the inner bearing seat **912**.

**[0107]** A passage **918** extends through the collar forming the inner bearing seat **912**. The passage establishes communication between the hollow interior **889** and the interior **904**, thereby creating a path through the hollow interior **904**, through the passage **918** to the stator assembly **880**. Electrical wiring, such as for power or data, can pass along this path, which can be used to supply power or data to the stator or to any nearby accessory. While the passage **918** is shown extending through the collar forming the inner bearing seat **912**, the passage need not be so located. The passage could be located anywhere along the length of the motor shaft **887**. There also can be multiple passages.

**[0108]** The stator assembly **880** comprises an annular core **885** with a central opening **920** defining an edge that rests on the stator mounting seat **914**. The core **885** includes multiple posts **889** about which wires can be wound to form electrical windings for the stator assembly **880**. The windings can be supplied electrical power by wiring passing through the hollow interior **889** and passage **918**.

**[0109]** The stator assembly also includes a closure **881** to close the open end of the rotor assembly **870** and cover the interior **904**. The closure **926** can be of any shape and is illustrated as a disc with a central aperture, which can be threaded to thread onto the neck **916** of the motor shaft **887**. However, the disc could also be pressed on or attached in other ways. The closure **881** can also be a light assembly, such as a disc with one or more sources of illumination, such as an array of LED lights, which are supplied electrical power by wires passing through the hollow interior **889** and/or the passage **918**. If the closure **881** is a light assembly, it can also include a globe or similar translucent or transparent cover over the illumination sources.

**[0110]** The bearing assembly **890** comprises an inner race **930** and an outer race **932**, with a plurality of rollers or bearings **934** located between the inner race **930** and outer race **932**. The inner race **930** seats within the inner bearing seat **912** and the outer race **932** seats within the outer bearing seat **902**.

**[0111]** More specifically, the inner race **930** sits on the ledge **912***a* and bears against the portion of the peripheral wall **912***b* of the motor shaft **887**. The ledge **912***a* functions as a stop to limit the axial movement and position of the inner race **930** along the motor shaft **887**. The outer race **932** catches the lip **902***a* and bears against the wall **902***b*.

**[0112]** When assembling the bearing assembly **890** to the motor shaft **887**, the bearing assembly **890** can be sized such that the inner race is press-fitted onto the motor shaft **887** as it abuts the ledge **912***a*. Similarly, the outer race **932** is press-fitted into the recess formed by the peripheral wall **902***b* and the lip **902***a* of the outer bearing seat **902**.

**[0113]** Most ceiling fan motors use a pair of axially spaced bearing assemblies to rotationally mount the rotor assembly **870** to the motor shaft **887** because the axial spacing provides two spaced contact points that reduce the tendency of the rotor assembly from wobbling as it would if there was only a single bearing with a single contact point. However, the two axially spaced bearings increase the height of the motor, which is not desirable in low profile configurations. A single bearing assembly **900** can be used and still prevent the wobbling about the single contact point because the bearing assembly **900** is in substantially full contact with the rotor assembly **870** and the motor shaft **887**. In other words, the substantial length or axial extent of the outer race **932** is in abutting contact with the peripheral wall **902***b* and the substantial length or axial extent of the inner race **930** is in contact with the portion **912***b* of the motor shaft **887**. This "full extent" contact makes it possible for a single bearing to be used in a ceiling fan environment as compared to multiple bearings.

**[0114]** For completeness, a plurality of mounting bolts **940** extend from the rotor assembly **870** and can be used to secure blades to the rotor housing. The mounting bolts **940** are just one structure for securing the blades to the rotor and the particular structure for mounting the blades is not germane to the motor. Any suitable mounting structure can be used.

**[0115]** It should be noted that for all of the described motors, the stator is illustrated as having windings, be it in the form of a winding printed on a PCB for the PCB stator or as a wound coil of wire in the radial flux, not permanent magnets, and the rotor is illustrated as having permanent magnets. The windings and permanent magnets form the various magnetic poles of the motor used for rotation of the rotor relative to the stator. It is within the scope of the disclosure for the windings and permanent magnets to be switched and the stator have the permanent magnets and the rotor have the windings. It can be appreciated that in an alternative, the rotor can comprise the PCB (PCB rotor) and the stator comprises the upper and lower sets of permanent magnets. For such a configuration, it would be beneficial for the blades to be coupled to an upper or lower housing instead of directly to the PCB rotor. It can further be appreciated that in another alternative, the rotor comprises the coil windings and the stator comprises the outer periphery of magnets. For such a configuration, the blades could be coupled to an upper or lower portion of the coil winding assembly. Further, all of the described motors are direct current or DC motors. However, AC motors could be used.

[0116] All of the previously described motors have a structure and arrangement of parts that will yield a low profile motor. A subset of the previously described motors, those without a motor housing and with the blades located between the upper/lower walls of the rotor and stator, will yield a lower profile where the stack height is one and the same as the motor height, which is possible motors with and without lights, especially when the lights are part of at least one of the walls of the motor, such as the embedded LEDS of FIGS. **13-18**.

[0117] The performance characteristics of the motor in the ceiling environment do impact the stack height. The power (watts or horsepower) of the motor and/or its torque will dictate, to some extent, the size and arrangement of the permanent magnets and/or coils needed to accelerate the motor at a desired rate and/or rotate the motor at a desired speed. The acceleration and/or rate of rotation are a function of desired airflow, which is a function of the blade shape, length, and mass. Assuming it is desired to maintain the blades within a certain vertical height relative to the fan, say within the stack height, at some point the blades will be too long and they will sag below the stack height. The rotation and lift forces acting on the blade may raise them some during operation, but there is a practical limit for any given limitation. Also, as the blades get longer, they have more mass, and the additional mass will impact acceleration, and more torque is needed to maintain a certain speed for a given airflow rate. For a desired stack height of 1-3 inches, the motor can have a width of 4.8 to 14.4 inches, a torque of 0.5-5 Nm (newton-meters), a motor height of 0.9 to 3 inches, a fan diameter of 30 to 96 inches (where the diameter is twice the distance from the rotational axis to a blade tip). Such ranges are very suitable for a ceiling fan.

[0118] Aspects of the disclosure provide for many other embodiments or implementations. For instance, a PCB can be provided with the rotor assembly, and magnetic plates can be provided with the stator assembly. In such a case, in one exemplary implementation, the upper and lower motor housings can each be rotatable with at least one PCB coupled thereto. The set of blades can be mounted directly to at least one of the upper motor housing and lower motor housing. During operation of the motor, the set of blades, the upper and lower motor housings, and at least one PCB can rotate while the magnetic plates remain stationary with the stator assembly.

[0119] Aspects of the disclosure provide for several benefits. The use of an axial flux motor provides for an ultra-lowprofile driving mechanism for the ceiling fan, which enables a lower overall stack height and a lower weight compared to fans with traditional motors. The reduction in stack height allows the fan to be positioned much closer to the ceiling or overhead surface, providing for a more compact form factor and improved safety in spaces with low ceilings. The scalloped portion of the blades described herein provides for improved aerodynamic performance with reduced need for overhead clearance of the fan. The snap-fit blade connection provides for improved access for assembly, disassembly, or servicing of the ceiling fan. The integral blade housing can provide for a streamlined assembly with reduced part complexity and shortened assembly times. The motor housing with integral heat sink can provide for cooling of the motor and the light kit, further reducing part complexity and assembly times, and also improving operating performance by dissipating heat during operation. Still another benefit is that the low-profile, lightweight motor provides for an improved consumer installation experience in securing the ceiling fan to an overhead surface.

[0120] Although aspects of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these aspects without departing from the principles and spirit of the disclosure. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

[0121] This written description uses examples to disclose the disclosure, including the best mode, and to enable any person skilled in the art to practice the disclosure, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the disclosure is defined by the claims, and can 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 languages of the claims.

[0122] Further aspects of the disclosure are provided by the following clauses:

[0123] A ceiling fan including a motor housing, a set of blades extending from the motor housing, a light kit coupled to the motor housing, and a motor enclosed by the motor housing, with the motor comprising an axial flux motor with upper and lower rotatable magnetic plates stacked with a centrally-located stator.

[0124] The ceiling fan of any preceding clause, wherein the stator comprises a PCB stator extending radially beyond the rotor plates within the motor housing.

[0125] The ceiling fan of any preceding clause, wherein the motor housing includes a two-part assembly with an upper portion and a lower portion enclosing the upper and lower magnetic plates, respectively.

[0126] The ceiling fan of any preceding clause, wherein the blades are coupled to, and co-rotate with, the upper magnetic plate or the lower magnetic plate.

[0127] The ceiling fan of any preceding clause, wherein the blades are operably coupled to, and spaced from, one of the upper magnetic plate or the lower magnetic plate.

[0128] The ceiling fan of any preceding clause, further comprising a blade housing enclosing the motor housing.

[0129] The ceiling fan of any preceding clause, wherein the blades are rotatably coupled to the hub via an opening defined in the blade housing.

[0130] The ceiling fan of any preceding clause, wherein the blades extend radially outward above the motor housing.

[0131] The ceiling fan of any preceding clause, wherein the blades extend radially outward below the motor housing.

[0132] The ceiling fan of any preceding clause, further comprising a plurality of discrete blade mounts enclosed by the blade housing.

[0133] The ceiling fan of any preceding clause, further comprising an outer body, an impeller within the body, and a flow path defined between an inlet of the body and an outlet of the body.

[0134] The ceiling fan of any preceding clause, wherein an overall stack height of the ceiling fan is between 1.5-3 inches.

[0135] The ceiling fan of any preceding clause, wherein a height of the motor housing is between 1-2 inches.

[0136] The ceiling fan of any preceding clause, wherein a height of the motor housing is between 1.25-2 inches.

[0137] A ceiling fan comprising: a motor having a stator assembly, with a stationary motor shaft, and a rotor assembly; a bearing assembly rotationally coupling the rotor assembly to the motor shaft; a motor housing enclosing at least a portion of one of the stator assembly and rotor assembly; a plurality of blades coupled to the rotor assembly; wherein a stack height of the motor and motor housing is between 1.0 inches and 3 inches.

[0138] The ceiling fan of any preceding clause wherein the motor housing is integrally formed with at least one of the stator assembly and rotor assembly.

[0139] The ceiling fan of any preceding clause wherein the blades are coupled to the rotor assembly within the stack height.

[0140] The ceiling fan of any preceding clause wherein the blades are completely located within the stack height.

[0141] The ceiling fan of any preceding clause wherein the motor has a width of 4.8 to 14.4 inches.

[0142] The ceiling fan of any preceding clause wherein the motor has a torque of 0.5 to 5 Nm.

[0143] The ceiling fan of any preceding clause wherein the motor has a height of 0.9 to 3.0 inches.

[0144] The ceiling fan of any preceding clause wherein the height is 1-2 inches.

[0145] The ceiling fan of any preceding clause wherein the fan has a diameter of 30 to 96 inches.

[0146] The ceiling fan of any preceding clause wherein: the motor has a width of 4.8 to 14.4 inches; the motor has a torque of 0.5 to 5 Nm; the motor has a height of 0.9 to 3.0 inches; and the fan has a diameter of 30 to 96 inches.

[0147] The ceiling fan of any preceding clause wherein the stator assembly comprises a PCB stator.

[0148] The ceiling fan of any preceding clause wherein the rotor assembly comprises two sets of permanent magnets, with one set located above the PCB stator and the other set located below the PCB stator.

[0149] The ceiling fan of any preceding clause wherein the stator assembly comprises a PCB stator.

[0150] The ceiling fan of any preceding clause wherein the rotor assembly comprises two sets of permanent magnets, with one set located above the PCB stator and the other set located below the PCB stator.

[0151] The ceiling fan of any preceding clause wherein the stator assembly comprises a lower wall supporting the PCB stator.

[0152] The ceiling fan of any preceding clause wherein the stationary motor shaft extends from the lower wall.

[0153] The ceiling fan of any preceding clause wherein the lower wall comprises a rim supporting the PCB stator.

[0154] The ceiling fan of any preceding clause wherein the rotor assembly comprises a carriage coupling to the bearing assembly.

[0155] The ceiling fan of any preceding clause wherein the carriage supports the sets of permanent magnets.

[0156] The ceiling fan of any preceding clause further comprising a light kit carried by the stator assembly and the light kit is located within the stack height.

[0157] The ceiling fan of any preceding clause wherein the stator comprises a lower wall and the light kit is integrated into the lower wall.

What is claimed is:

**1**. A ceiling fan comprising:

a set of blades extending between a root and a tip;

a motor assembly comprising:

a stator assembly comprising a stationary motor shaft and a stator coupled to the stationary motor shaft,

a rotor assembly comprising a rotor operably coupled to the root of the blades, and

a bearing assembly having a single bearing rotationally coupling the stationary motor shaft to the rotor assembly.

**2**. The ceiling fan of claim **1** wherein rotor assembly and the stationary motor shaft collectively define a bearing seat in which the single bearing resides.

**3**. The ceiling fan of claim **2** wherein the rotor comprises a first wall and a peripheral wall extending from the first wall, the rotor comprises a second wall, axially spaced from the first wall along the stationary motor shaft to define an interior at least partially bounded by the first wall, second wall, and peripheral wall, and the bearing seat is located within the interior between the first wall and the second wall.

**4**. The ceiling fan of claim **3** wherein the stationary motor shaft does not extend beyond the first wall.

**5**. The ceiling fan of claim **4** wherein the stationary motor shaft does not extend beyond the second wall.

**6**. The ceiling fan of claim **5** wherein the second wall at least partially defines a light kit.

**7**. The ceiling fan of claim **6** wherein the light kit comprises a plurality of light emitting diodes (LEDs) carried by the second wall.

**8**. The ceiling fan of claim **7** wherein the second wall defines an accessory recess.

**9**. The ceiling fan of claim **3** wherein the first wall comprises an annular wall located within the interior and partially defining the bearing seat.

**10**. The ceiling fan of claim **9** wherein the annual wall depends from the top wall and circumscribes the stationary motor shaft.

**11**. The ceiling fan of claim **10** wherein the annular wall depends a length as least as great as the single bearing such that the annular wall abuts the entire axial length of the single bearing.

**12**. The ceiling fan of claim **11** wherein the stationary motor shaft abuts the entire axial length of the single bearing.

**13**. The ceiling fan of claim **12** wherein the annular wall abuts an outer surface of the single bearing and the stationary motor shaft abuts an inner surface of the single bearing.

**14**. The ceiling fan of claim **13** further comprising a snap-ring attached to the stationary motor shaft and abutting a first axial end of the single bearing.

**15**. The ceiling fan of claim **14** wherein a second axial end of the single bearing abuts the first wall.

**16**. The ceiling fan of claim **3** wherein the peripheral wall axially overlaps at least a portion of the second wall.

**17**. The ceiling fan of claim **16** wherein the rotor comprises a plurality of circumferentially spaced permanent magnets carried by the peripheral wall.

**18**. The ceiling fan of claim **17** wherein the permanent magnets are located within the interior.

**19**. The ceiling fan of claim **18** wherein the stator comprises a core carried by the stationary motor shaft and having a plurality of circumferentially spaced windings confronting the permanent magnets.

**20**. The ceiling fan of claim **19** wherein the blades are mounted to the first wall.

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