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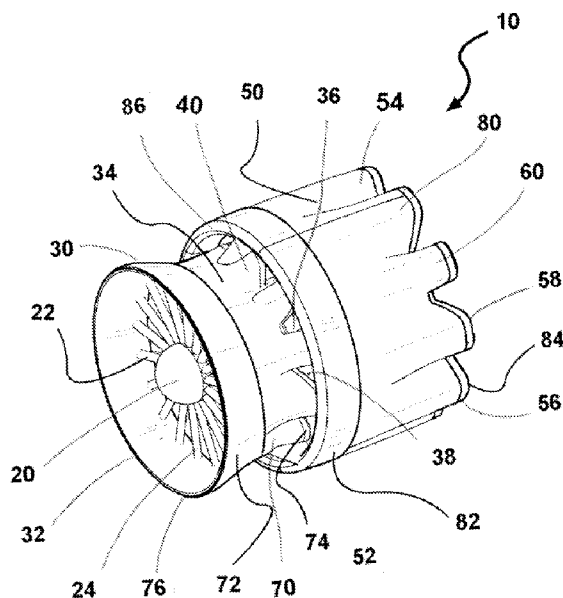


Fig. 1

(57) Abstract: A wind turbine has an impeller surrounded by a turbine shroud and/or an ejector shroud, wherein the turbine shroud and/or the ejector shroud include inflatable portions and/or flexible inflatable portions. In some embodiments, the turbine shroud and/or the ejector shroud include internal rib members whose shape or length can be changed to alter the characteristics of the wind turbine.



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## INFLATABLE WIND TURBINE

### BACKGROUND

**[0001]** This application claims priority to U.S. Provisional Patent No. 61/191,358, filed on September 8, 2008. The provisional application is hereby fully incorporated by reference.

**[0002]** The present disclosure relates to wind turbines, particularly systems using inflatable components.

**[0003]** Conventional wind turbines used for power generation generally have two to five open blades arranged like a propeller, the blades being mounted to a horizontal shaft attached to a gear box which drives a power generator. Such turbines are generally known as horizontal axis wind turbines, or HAWTs. Although HAWTs have achieved widespread usage, their efficiency is not optimized. In particular, they will not exceed the Betz limit of 59.3% efficiency in capturing the potential energy of the wind passing through it.

**[0004]** Conventional wind turbines have three blades and are oriented or pointed into the wind by computer controlled motors. These turbines typically require a supporting tower ranging from 60 to 90 meters in height. The blades generally rotate at a rotational speed of about 10 to 22 rpm. A gear box is commonly used to step up the speed to drive the generator, although some designs may directly drive an annular electric generator. Some turbines operate at a constant speed. However, more energy can be collected by using a variable speed turbine and a solid state power converter to interface the turbine with the generator.

**[0005]** Several problems are associated with HAWTs in both construction and operation. The tall towers and long blades are difficult to transport. Massive tower construction is required to support the heavy blades, gearbox, and generator. Very tall and expensive cranes and skilled operators are needed for installation. In operation, HAWTs require an additional yaw control mechanism to turn the blades toward the wind. HAWTs typically have a high angle of attack on their airfoils that do not lend themselves to variable changes in wind flow. HAWTs are difficult to operate in near ground, turbulent winds. Ice build-up on the nacelle and the blades can cause power reduction and safety issues. Tall HAWTs may affect airport radar. Their height also makes them obtrusively visible across large areas, disrupting the

appearance of the landscape and sometimes creating local opposition. Finally, downwind variants suffer from fatigue and structural failure caused by turbulence.

**[0006]** It would be desirable to reduce the mass and size of wind turbines.

### **SUMMARY**

**[0007]** The present disclosure describes wind turbines of reduced mass and size. In particular, the wind turbines include a shroud and/or ejector having inflatable components. Such wind turbines are lighter. An inflated shroud and/or ejector would allow the turbine to change its aerodynamics / shape to accommodate changes in fluid flow. It would also allow for less substantial supports in the turbine body, and also allow the inflated portions to be deflated and stored if needed due to adverse weather conditions. The inflated portions of the turbine do not actively rotate to aid in energy extraction or power production.

**[0008]** Disclosed in embodiments is a wind turbine comprising: an impeller; and a turbine shroud disposed about the impeller, the turbine shroud comprising an inflatable member. The inflatable member may have the shape of a ring airfoil.

**[0009]** The turbine shroud may further comprise a first rigid structural member connected to the inflatable member. The shroud first rigid structural member may comprise a hollow interior into which the shroud inflatable member can be inserted. In some embodiments, the shroud first rigid structural member defines a leading edge of the turbine shroud.

**[0010]** The turbine shroud may further comprise a second rigid structural member connected to the shroud inflatable member opposite the shroud first rigid structural member, where the second rigid structural member defines a trailing edge of the turbine shroud.

**[0011]** The shroud second rigid structural member can be shaped to provide the turbine shroud with a plurality of lobes. Alternatively, the shroud inflatable member is shaped to provide a plurality of lobes around a trailing edge thereof.

**[0012]** The wind turbine may further comprise an ejector shroud disposed concentrically about the turbine shroud, the ejector shroud comprising an inflatable member. The ejector shroud may further comprise a first rigid structural member connected to the ejector inflatable member. Again, the ejector first rigid structural member can comprise a hollow interior into which the ejector inflatable member can

be inserted. The ejector first rigid structural member may also define a leading edge of the ejector shroud.

**[0013]** The ejector shroud may further comprise a second rigid structural member connected to the ejector inflatable member opposite the ejector first rigid structural member, the second rigid structural member defining a trailing edge of the ejector shroud. The ejector second rigid structural member can be shaped to provide the ejector shroud with a plurality of lobes.

**[0014]** The ejector inflatable member can be configured so that when the ejector inflatable member is partially inflated, a trailing edge of the ejector inflatable member circumscribes an area which is less than an area circumscribed by a leading edge of the ejector inflatable member. The ejector inflatable member may also be shaped to provide a plurality of lobes around a trailing edge thereof.

**[0015]** Disclosed in other embodiments is a wind turbine comprising: a turbine shroud; and an ejector shroud disposed concentrically about the turbine shroud; the turbine shroud comprising a shroud circular member, a plurality of shroud first rib members engaging the shroud circular member, and a shroud exterior film, wherein the shroud circular member and the plurality of shroud first rib members define an intake end and an exhaust end of the turbine shroud; and the ejector shroud comprising an ejector circular member, a plurality of ejector first rib members engaging the ejector circular member, and an ejector exterior film, wherein the ejector circular member and the plurality of ejector first rib members define an intake end and an exhaust end of the ejector shroud.

**[0016]** The turbine shroud may further comprise a plurality of shroud second rib members. Each shroud second rib member extends between the shroud circular member and the ejector circular member. Together, the plurality of shroud first rib members and the plurality of shroud second rib members define a plurality of mixer lobes at the exhaust end of the turbine shroud.

**[0017]** The ejector shroud may further comprise a plurality of ejector second rib members engaging the ejector circular member. Together, the plurality of ejector first rib members and the plurality of ejector second rib members define a plurality of mixer lobes at the exhaust end of the ejector shroud.

**[0018]** The ejector first rib member may comprise a stationary member and an actuated member joined together at a pivot to alter an angle between the stationary member and the actuator member.

**[0019]** The ejector first rib member may alternatively comprise a stationary member and an actuated member joined together so that the length of the ejector first rib member can be altered.

**[0020]** Also disclosed is a wind turbine comprising: an impeller; a turbine shroud disposed about the impeller and having a plurality of mixing lobes disposed about an exhaust end; and an ejector shroud disposed about the turbine shroud, the ejector shroud comprising an inflatable member.

**[0021]** These and other non-limiting features or characteristics of the present disclosure will be further described below.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0022]** The following is a brief description of the drawings, which are presented for the purposes of illustrating the disclosure set forth herein and not for the purposes of limiting the same.

**[0023]** **FIGURE 1** is a perspective view of a first exemplary embodiment of the present disclosure.

**[0024]** **FIGURE 2** is a perspective view of a second exemplary embodiment of the present disclosure.

**[0025]** **FIGURE 3** is a perspective view of a third exemplary embodiment of the present disclosure.

**[0026]** **FIGURE 4** is a perspective view of a fourth exemplary embodiment of the present disclosure.

**[0027]** **FIGURE 5** is a partial perspective view of a fifth exemplary embodiment of the present disclosure.

**[0028]** **FIGURE 6A** is a side view of a sixth exemplary embodiment of the present disclosure.

**[0029]** **FIGURE 6B** is a perspective view of a sixth exemplary embodiment of the present disclosure.

**[0030]** **FIGURES 7A-7D** are perspective views showing various stages of the construction process for additional exemplary embodiments of the present disclosure.

**[0031]** **FIGURES 8A-8C** are side views of various internal rib members which can be used in exemplary embodiments of the present disclosure.

[0032] **FIGURES 8D-8E** show wind turbines before and after the use of various internal rib members such as those shown in **FIGURES 8A-8C**.

[0033] **FIGURE 9** is a perspective view of an eighth exemplary embodiment of the present disclosure.

[0034] **FIGURE 10** is a perspective view of a ninth exemplary embodiment of the present disclosure.

### **DETAILED DESCRIPTION**

[0035] A more complete understanding of the processes and apparatuses disclosed herein can be obtained by reference to the accompanying drawings. These figures are merely schematic representations based on convenience and the ease of demonstrating the existing art and/or the present development, and are, therefore, not intended to indicate relative size and dimensions of the assemblies or components thereof.

[0036] Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of the embodiments selected for illustration in the drawings, and are not intended to define or limit the scope of the disclosure. In the drawings and the following description below, it is to be understood that like numeric designations refer to components of like function.

[0037] Generally, the present disclosure comprises a wind turbine which includes inflatable components. This provides a wind turbine which has a lower mass compared to a HAWT.

[0038] **FIGURE 1** is a perspective view of a first embodiment of a wind turbine of the present disclosure, in a form also known as a mixer-ejector wind turbine (MEWT). The MEWT is a new type of wind turbine that uses a shrouded impeller, prop, or rotor/stator to improve the efficiency of a wind turbine such that more power may be extracted for a turbine having the same area than other current types of wind turbines. The MEWT accomplishes this by drawing air from a larger area than the most common type of wind turbine, the horizontal-axis wind turbine (HAWT).

[0039] A wind turbine can theoretically capture at most 59.3% of the potential energy of the wind passing through it, a maximum known as the Betz limit. The amount of energy captured by a wind turbine can also be referred to as the efficiency of the turbine. The MEWT may exceed the Betz limit.

[0040] Referring to **FIGURE 1**, the turbine **10** comprises an impeller **20** located at an intake end **32** of a turbine shroud **30**. The impeller may generally be any assembly in which blades are attached to a shaft and able to rotate, allowing for the generation of power or energy from wind rotating the blades. As illustrated here, the impeller **20** is a rotor-stator assembly. The stator **22** engages the turbine shroud **30**, and the rotor (not shown) engages a motor/generator (not shown). The stator **22** has non-rotating blades **24** which turn the air before it reaches the rotor. The blades of the rotor then rotate, generating power in the generator. The shroud **30** comprises a ringed airfoil **34**, or in other words is approximately cylindrical and has an airfoil shape, with the airfoil configured to generate relatively lower pressure within the turbine shroud (i.e. the interior of the shroud) and relatively higher pressure outside the turbine shroud (i.e. the exterior of the shroud). Put another way, the ringed airfoil has a cross-section shaped like an aircraft wing, as can be seen in Figures 4, 7, 12, 14, 17, and 19 of U.S. Patent Publication No. 2009/0087308, the entire disclosure of which is hereby incorporated by reference in its entirety. The impeller and the motor/generator are contained within the turbine shroud. The turbine shroud **30** may also have mixer lobes **40** around an outlet or exhaust end of the shroud. The mixer lobes are generally uniformly distributed around the circumference of the exhaust end. The mixer lobes generally cause the exhaust end **36** of the turbine shroud, where air exits, to have a generally peak-and-valley shape about its circumference. Put another way, the lobes **40** are located along the trailing edge **38** of the shroud.

[0041] The turbine **10** also comprises an ejector shroud **50**, which is engaged with the turbine shroud. The ejector shroud comprises a ringed airfoil **54**, or in other words is approximately cylindrical and has an airfoil shape, with the airfoil configured to generate relatively higher pressure within the ejector (i.e. between the turbine shroud **30** and the ejector shroud **50**) and relatively lower pressure outside the ejector shroud **50**. The ejector shroud may also have mixer lobes **60**, in which case the wind turbine is a mixer-ejector wind turbine. The mixer lobes generally cause the exhaust end of the ejector **56**, where air exits, to have a generally peak-and-valley shape about its circumference. Put another way, the mixer lobes are located along the trailing edge **58** of the ejector shroud **50**.

[0042] The ejector shroud **50** has a larger diameter than the turbine shroud **30**. The turbine shroud **30** engages the ejector shroud **50**. Put another way, the exhaust end **36** of the turbine shroud fits within the intake end **52** of the ejector shroud, or the



intake end **52** of the ejector shroud surrounds the exhaust end **36** of the turbine shroud. The turbine shroud **30** and ejector shroud **50** are sized so that air can flow between them. Phrased another way, the ejector shroud **50** is concentrically disposed about the turbine shroud **30** and is downstream of the shroud **30**. The impeller **20**, turbine shroud **30**, and ejector shroud **50** all share a common axis, i.e. are coaxial to each other.

**[0043]** The mixer lobes **40**, **60** allow for advanced flow mixing and control. The turbine shroud and ejector shroud are different from similar shapes used in the aircraft industry because in the MEWT, flow path provides high-energy air into the ejector shroud. The turbine shroud provides low-energy air into the ejector shroud, and the high-energy air outwardly surrounds, pumps, and mixes with the low-energy air.

**[0044]** The motor/generator may be employed to generate electricity when the wind is driving the rotor. The generator on the turbine may also be used as a motor to drive the impeller **20**, and thus draw air into and through the turbine **10**, when the wind is insufficient to drive the rotor.

**[0045]** Referring again to **FIGURE 1**, the turbine shroud **30** comprises an inflatable member **70**, a first rigid structural member **72**, and a second rigid structural member **74**. The first rigid member defines the leading edge **76** of the shroud **30** and the second rigid member **74** defines the trailing edge **38** with a plurality of lobes **40** around the circumference of the trailing edge. The rigid members **72**, **74** are connected to the inflatable member **70** opposite each other, i.e. on opposite sides of the inflatable member. The first rigid structural member **72** is annular. The first rigid structural member **72** provides a structure to support the impeller **20** and also acts as a funnel to channel air through the impeller. The inflatable member **70** is made up of a thin film material, as discussed later. The rigid members **72**, **74** may be flexible, and are considered rigid relative to the inflatable member **70**.

**[0046]** The ejector shroud **50** also comprises an inflatable member **80**, a first rigid structural member **82**, and a second rigid structural member **84**. The first rigid member defines the leading edge **86** of the ejector **50** and the second rigid member **84** defines the trailing edge **58** with a plurality of lobes **60** around the circumference of the trailing edge. The rigid members **82**, **84** are connected to the inflatable member **80** opposite each other, i.e. on opposite sides of the inflatable member. Again, the rigid members **82**, **84** may be flexible, and are considered rigid relative to

the inflatable member **80**. The inflatable members **70**, **80** may contain one large pocket to be inflated, or may contain multiple pockets that can be separately inflated / deflated.

**[0047]** **FIGURE 2** shows another exemplary embodiment of the turbine. The turbine **110** has an impeller **120**, turbine shroud **130**, and an ejector shroud **150**. In this embodiment, the turbine shroud **130** comprises a first rigid structural member **132** connected to an inflatable member **134**. The first rigid member **132** defines the leading edge **136** of the shroud **130**. The shroud inflatable member **134** is shaped to provide a plurality of lobes **140** around the trailing edge **138** of the turbine shroud. In contrast to the embodiment of **FIGURE 1**, only one rigid member is present to which the inflatable member is connected. Similarly, the ejector **150** comprises a first rigid structural member **152** connected to an inflatable member **154**. The first rigid member **152** defines the leading edge **156** of the ejector shroud **150**. The ejector inflatable member **154** is shaped to provide a plurality of lobes **160** around the trailing edge **158** of the ejector shroud. Put another way, in this embodiment there is no rigid member defining the lobes on the inflatable turbine shroud **130** and/or inflatable ejector shroud **150**.

**[0048]** **FIGURE 3** shows another exemplary embodiment of the turbine. The turbine **110** has an impeller **120**, turbine shroud **130**, and an ejector shroud **150**. In this embodiment, the turbine shroud **130** comprises an inflatable member, and the ejector shroud **150** comprises an inflatable member. Put another way, there are no rigid structural members on the leading or trailing edge of either the turbine shroud or the ejector shroud.

**[0049]** **FIGURE 4** shows another exemplary embodiment. Here, a turbine shroud **130** and ejector shroud **150** are formed of inflatable materials and form a sub-assembly configured for retrofitting on an existing turbine or propulsion device.

**[0050]** **FIGURE 5** shows another exemplary embodiment of the present disclosure. Here, the turbine **200** includes an impeller **210**, turbine shroud **220**, and ejector shroud **230**. The impeller **210** is a rotor-stator assembly. The stator **212** has a plurality of blades **214**. The turbine shroud **220** comprises a rigid structural member **222** which surrounds the stator **212** and has a substantially circular shape and defines the leading edge of the turbine shroud. The ejector shroud **230** similarly comprises a rigid structural member **232** also having a substantially circular shape and defining the leading edge of the ejector shroud. Struts **224** join the shroud rigid

member **222** and the ejector rigid member **232** together. The turbine shroud **220** also comprises an inflatable member (not shown), and the ejector shroud **230** also comprises an inflatable member **234**. In this embodiment, the inflatable member is designed to deflate and compress to alter the shape of the turbine for protection in high wind situations or ice storms. The shroud rigid structural member **222** includes a hollow interior into which the inflatable member may be drawn. It should be understood that in this figure, the hollow interior is on the trailing edge **226** of the shroud rigid member **222** and is not visible. The turbine shroud **220** is shown here with the inflatable member fully compressed and stored in the shroud rigid member **222**. Similarly, the ejector inflatable member **234** may also be deflated and stored in a hollow interior in the ejector rigid structural member **232**.

**[0051] FIGURES 6A and 6B** are two views of another exemplary embodiment. Again, the turbine **300** includes a turbine shroud **310** and an ejector shroud **320**. The turbine shroud comprises a rigid structural member **312** and an inflatable member **314**, shown here fully inflated. The ejector shroud also comprises a rigid structural member **322** and an inflatable member **324**. Here, however, the ejector inflatable member **324** has sufficient flexibility that it can take different forms or shapes depending on the degree of inflation. Here, the inflatable member **324** is shown as only partially inflated, such that the area of the exhaust end **326** is reduced. As shown here, this reduced area constricts the flow of air through the turbine, reducing air flow and thus reducing any stress on the impeller or rotor-stator assembly which might occur in high wind situations. Put in different words, the ejector inflatable member **324** is configured so that upon partial inflation, the area **330** circumscribed by the trailing edge **332** of the ejector inflatable member is less than the area circumscribed by the leading edge **334** of the ejector shroud. Please note that the area circumscribed by the leading edge refers to the entire area defined by the leading edge, not only the annular area between the turbine shroud **310** and ejector shroud **320**.

**[0052] FIGURES 7A-7C** show various stages of the construction of other exemplary embodiments of a shroud and/or ejector useful for a wind turbine of the present disclosure. The impeller is not shown in these figures. Here, the combination shroud/ejector **390** comprises a circular member **400** and a plurality of shroud first rib members **410** which together define an intake end **402** and an exhaust end **404** for the turbine shroud. The circular member **400** and the plurality of

shroud first rib members **410** are then covered by an exterior film material **406** to complete the turbine shroud. The exhaust end **404** of the turbine shroud may have a smaller area than the intake end **402**. Similarly, the ejector shroud comprises a circular member **420** and a plurality of ejector first rib members **430** which together define an intake end **422** and an exhaust end **424** for the ejector shroud. The circular member **420** and the plurality of ejector first rib members **430** are then covered by an exterior film material **426** to complete the ejector shroud. In some embodiments, the shroud circular member **400** and ejector circular member **420** are also connected to each other by the shroud first rib members **410**.

**[0053]** In additional embodiments, the turbine shroud may include a plurality of shroud second rib members **440**. The shroud second rib members **440** connect the shroud circular member **400** and ejector circular member **420** together. Together, the shroud first rib members **410** and shroud second rib members **440** define a plurality of mixer lobes **442** at the exhaust end **404** of the shroud. Generally, the shroud first rib members **410** and shroud second rib members **440** have different shapes. Similarly, in additional embodiments, the ejector shroud may include a plurality of ejector second rib members **450**. Together, the ejector first rib members **430** and ejector second rib members **450** define a plurality of mixer lobes **452** at the exhaust end **424** of the ejector. Generally, the ejector first rib members **430** and ejector second rib members **450** have different shapes.

**[0054]** As seen in **FIGURE 7A**, shroud first rib member **410** and ejector first rib member **430** connect to ejector circular member **420** at the same location. Similarly, shroud second rib member **440** and ejector second rib member **450** connect to ejector circular member **420** at the same location. This connection at the same location for the various rib members is not required.

**[0055]** Alternatively, as described in **FIGURE 7D**, the combination shroud/ejector **390** can be considered as comprising a first circular member **400**, a second circular member **420**, a plurality of first internal ribs **460**, and a plurality of second internal ribs **470**. The combination of the two circular members, first internal ribs, and second internal ribs define the shape of the turbine shroud, lobes on the turbine shroud, the ejector shroud, and lobes on the ejector shroud. The turbine shroud is defined by the area between the two circular members **400** and **420**, while the ejector shroud is located downstream of the second circular member **420**. Compared to **FIGURE 7A**, first internal rib **460** can be considered a one-piece

combination of shroud first rib member **410** and ejector first rib member **430** while second internal rib **470** can be considered a one-piece combination of shroud second rib member **440** and ejector second rib member **450**.

**[0056]** **FIGURES 8A-8C** are side views of various embodiments of internal ribs suitable for use in various embodiments as shown in **FIGURES 7A-7C**. In **FIGURE 8A**, the rib **500** comprises an arcuate member **510** and a transverse member **520** integrally formed together to form a generally rigid rib. The members are generally lightweight and can be considered as beams **502** joined together by struts **504**. The arcuate member **510** defines the shape of the turbine shroud, while the transverse member **520** defines the shape of the ejector shroud.

**[0057]** Referring to **FIGURE 8B**, the rib **500** comprises a stationary member **530** and an actuated member **540**. The stationary member **530** defines the shape of the turbine shroud, while the actuated member **540** defines the shape of the ejector shroud. The stationary member **530** and actuated member **540** are joined together along a bottom edge **508** by a pivot **550**, which defines an angle between them. The stationary member **530** and actuated member **540** are joined together along a top edge **506** by a sleeve or linear motion member **560**. An actuator **570** engages both the stationary member **530** and actuated member **540** so as to change the angle between them, thus changing the shape of the shroud and/or ejector. The solid outline shows a shortened or linear position, while the dashed outline shows a lengthened or angled position. This ability to change shape allows the overall skeleton of the turbine shroud or ejector shroud to move / change shape as well.

**[0058]** Referring to **FIGURE 8C**, the stationary member **530** and actuated member **540** are joined together at both the top and bottom edges **506**, **508** by a sleeve or linear motion member **560** which, together with the actuator **570**, changes the length of the rib **500**.

**[0059]** **FIGURE 8D** shows a turbine **580** with turbine shroud **582** and ejector shroud **584**. Here, the rib members of the ejector (not shown) are in their shortened position. In **FIGURE 8E**, the rib members of the ejector shroud are in their lengthened position, resulting in an ejector of greater length and different air flow characteristics. Thus, the flexible nature of the rib members in the wind turbine enables changes in configuration to accommodate different wind conditions.

**[0060]** In **FIGURE 9**, the wind turbine **600** has an impeller shown as a propeller **602** mounted on a power generator **604** and which is supported on a pole **606**. An

inflatable shroud **608** is disposed about the propeller **602**. Thus, the inflatable shroud may be employed with an existing type of wind turbine.

**[0061]** **FIGURE 10** is an alternate embodiment wherein the turbine **600** is not supported by a pole. Instead, the inflatable shroud **608** has been inflated with a gas that is lighter than air, such as hydrogen, helium, ammonia, or methane. This provides sufficient buoyancy for the turbine **600** to ascend freely. The turbine **600** is tethered by a tether line or cable **610** which is connected to a controller which may lengthen or shorten the tether **610**. Thus, no supporting structure other than the tether **610** is required. The base **612** may contain a reel or spool for controlling the length of the tether **610**. This feature provides a simple and rapidly responsive means of lowering the turbine **600** in the event of excessively high winds.

**[0062]** The inflatable members described here may include several internal chambers within for controlling the amount of lift or the degree of inflation. These internal chambers may be arranged around the circumference of the inflatable member, or from one end of the inflatable member to the other end, as suitable.

**[0063]** The thin film material used for forming the inflatable member for the shroud and/or ejector as well as the exterior film may be generally formed of any polymeric or fabric material. Exemplary materials include polyurethane, polyfluoropolymers, and multi-layer films of similar composition. Stretchable fabrics, such as spandex-type fabrics, may also be employed.

**[0064]** Polyurethane films are tough and have good weatherability. The polyester-type polyurethane films tend to be more sensitive to hydrophilic degradation than polyether-type polyurethane films. Aliphatic versions of these polyurethane films are generally ultraviolet resistant as well.

**[0065]** Exemplary polyfluoropolymers include polyvinylidene fluoride (PVDF) and polyvinyl fluoride (PVF). Commercial versions are available as KYNAR and TEDLAR. Polyfluoropolymers generally have very low surface energy, which allow their surface to remain somewhat free of dirt and debris, as well as shed ice easier compared to materials having a higher surface energy.

**[0066]** Film/fabric composites are also contemplated along with a backing, such as foam, for making the inflatable member or exterior film.

**[0067]** The inflatable members could also be composed of urethane film bladders with a woven or braided cover over the bladder to give it strength and durability. The woven or braided materials may be polyester, pre-stressed polyester, aromatic

polyester (trade name VECTRAN® manufactured by Kuraray of Japan), *p*-phenylene terephthalamide (PpPTA) (trade name Twaron from Akzo), PPTA (poly-paraphenylene terephthalamide) (trade name Kevlar from DuPont), and polytrimethylene terephthalate (trade name Corterra from Shell). The exterior of the woven or braided cover may be coated with various polymers such as cis-polyisoprene, polyurethane, epoxy or polyvinyl chloride. This protects the woven or braided fibers from environmental attack, such as UV or abrasion from sand or other materials that could damage the fibers. Manufacturers include Federal Fabrics-Fibers of Lowell, MA; Warwick Mills of New Ipswich, NH; Vertigo Inc of Lake Elsinore, CA; and ILC Dover of Frederica, DE. The inflatable members may also be partially or completely stiffened through the use of reactive polymer infusion through vacuum assisted resin transfer molding (VARTM) or the curing of previously impregnated polymers such as unsaturated polyesters, epoxy, acrylates or urethanes that are cured through radiation, free radical initiation, or crosslinking with isocyanate.

**[0068]** The inflatable construction of the shroud and/or ejector in the wind turbines of the present disclosure allows the turbine to be substantially lighter than conventional turbines. Thus, a less substantial supporting tower may be used.

**[0069]** The systems and methods of the present disclosure have been described with reference to exemplary embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the exemplary embodiments be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

**CLAIMS:**

1. A wind turbine comprising:  
an impeller; and  
a turbine shroud disposed about the impeller, the turbine shroud comprising an inflatable member.
2. The wind turbine of claim 1, wherein the turbine shroud further comprises a first rigid structural member connected to the inflatable member.
3. The wind turbine of claim 2, wherein the shroud first rigid structural member comprises a hollow interior into which the shroud inflatable member can be inserted.
4. The wind turbine of claim 2, wherein the shroud first rigid structural member defines a leading edge of the turbine shroud.
5. The wind turbine of claim 2, wherein the turbine shroud further comprises a second rigid structural member connected to the shroud inflatable member opposite the shroud first rigid structural member, the second rigid structural member defining a trailing edge of the turbine shroud.
6. The wind turbine of claim 5, wherein the shroud second rigid structural member is shaped to provide the turbine shroud with a plurality of mixing lobes.
7. The wind turbine of claim 1, wherein the shroud inflatable member is shaped to provide a plurality of mixing lobes around a trailing edge thereof.
8. The wind turbine of claim 1, further comprising an ejector shroud disposed concentrically about the turbine shroud, the ejector shroud comprising an inflatable member.



9. The wind turbine of claim 8, wherein the ejector shroud further comprises a first rigid structural member connected to the ejector inflatable member.

10. The wind turbine of claim 9, wherein the ejector first rigid structural member comprises a hollow interior into which the ejector inflatable member can be inserted.

11. The wind turbine of claim 9, wherein the ejector first rigid structural member defines a leading edge of the ejector shroud.

12. The wind turbine of claim 9, wherein the ejector shroud further comprises a second rigid structural member connected to the ejector inflatable member opposite the ejector first rigid structural member, the second rigid structural member defining a trailing edge of the ejector shroud.

13. The wind turbine of claim 12, wherein the ejector second rigid structural member is shaped to provide the ejector shroud with a plurality of mixing lobes.

14. The wind turbine of claim 8, wherein the ejector inflatable member is configured so that when the ejector inflatable member is partially inflated, a trailing edge of the ejector inflatable member circumscribes an area which is less than an area circumscribed by a leading edge of the ejector inflatable member.

15. The wind turbine of claim 8, wherein the ejector inflatable member is shaped to provide a plurality of mixing lobes around a trailing edge thereof.

16. The wind turbine of claim 1, wherein the inflatable member is in the shape of a ring airfoil.

17. A wind turbine comprising:  
a turbine shroud; and  
an ejector shroud disposed concentrically about the turbine shroud;  
the turbine shroud comprising a shroud circular member, a plurality of shroud first rib members engaging the shroud circular member, and a shroud exterior film, wherein the shroud circular member and the plurality of shroud first rib members define an intake end and an exhaust end of the shroud; and  
the ejector shroud comprising an ejector circular member, a plurality of ejector first rib members engaging the ejector circular member, and an ejector exterior film, wherein the ejector circular member and the plurality of ejector first rib members define an intake end and an exhaust end of the ejector shroud.

18. The wind turbine of claim 17, wherein the turbine shroud further comprises a plurality of shroud second rib members, each shroud second rib member extending between the shroud circular member and the ejector circular member; and

wherein the plurality of shroud first rib members and the plurality of shroud second rib members together define a plurality of mixer lobes at the exhaust end of the turbine shroud.

19. The wind turbine of claim 17, wherein the ejector shroud further comprises a plurality of ejector second rib members engaging the ejector circular member; and

wherein the plurality of ejector first rib members and the plurality of ejector second rib members together define a plurality of mixer lobes at the exhaust end of the ejector shroud.

20. The wind turbine of claim 17, wherein the ejector first rib member comprises a stationary member and an actuated member joined together at a pivot to alter an angle between the stationary member and the actuator member.

21. The wind turbine of claim 17, wherein the ejector first rib member comprises a stationary member and an actuated member joined together so that the length of the ejector first rib member can be altered.

22. A wind turbine comprising:
- an impeller;
  - a turbine shroud disposed about the impeller and having a plurality of mixing lobes disposed about an exhaust end; and
  - an ejector shroud disposed about the turbine shroud, the ejector shroud comprising an inflatable member.

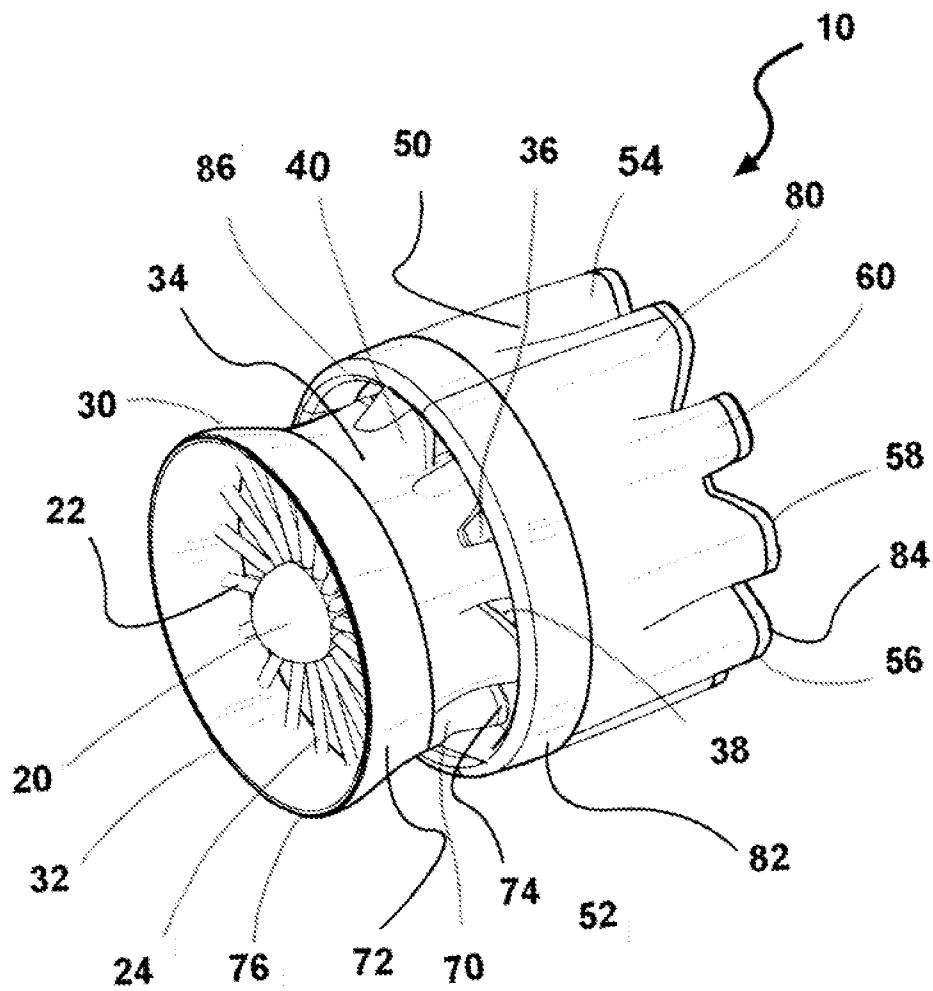


Fig. 1

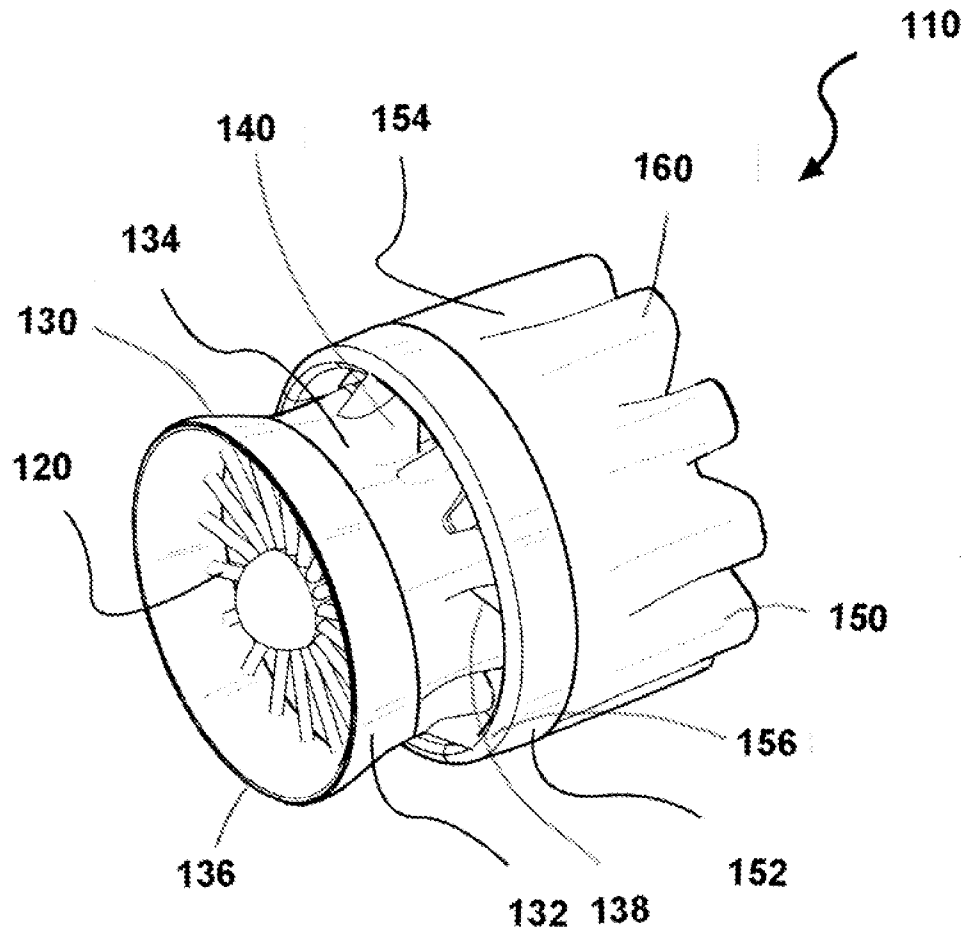


Fig. 2

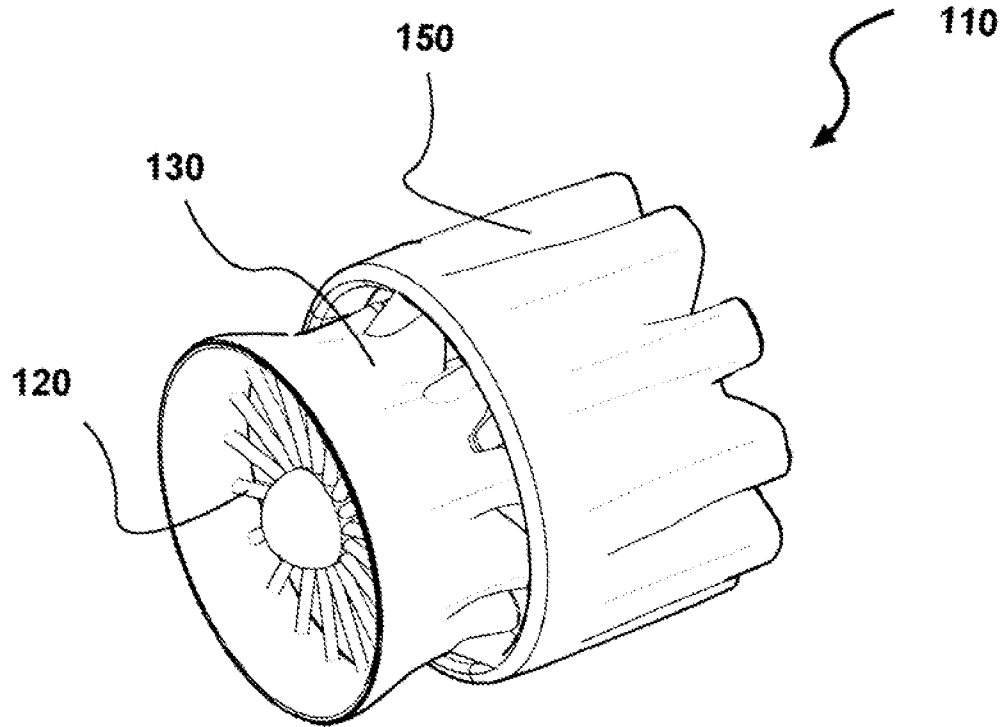


Fig. 3

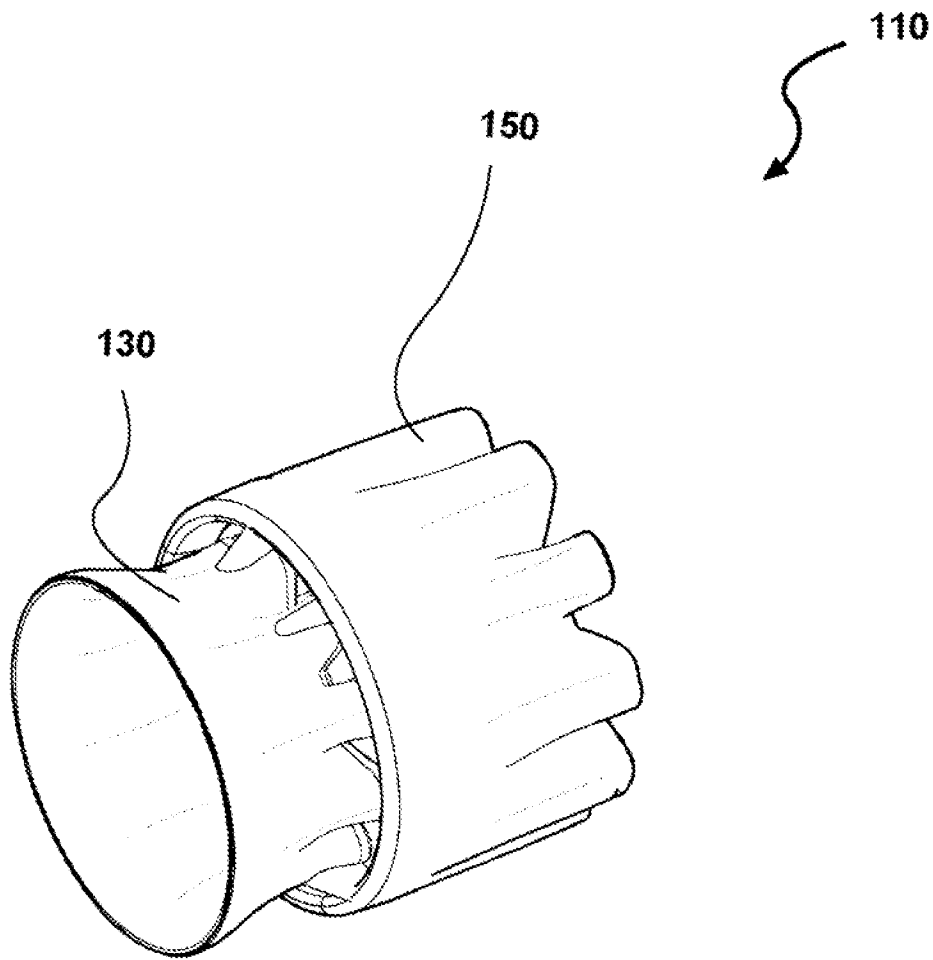


Fig. 4

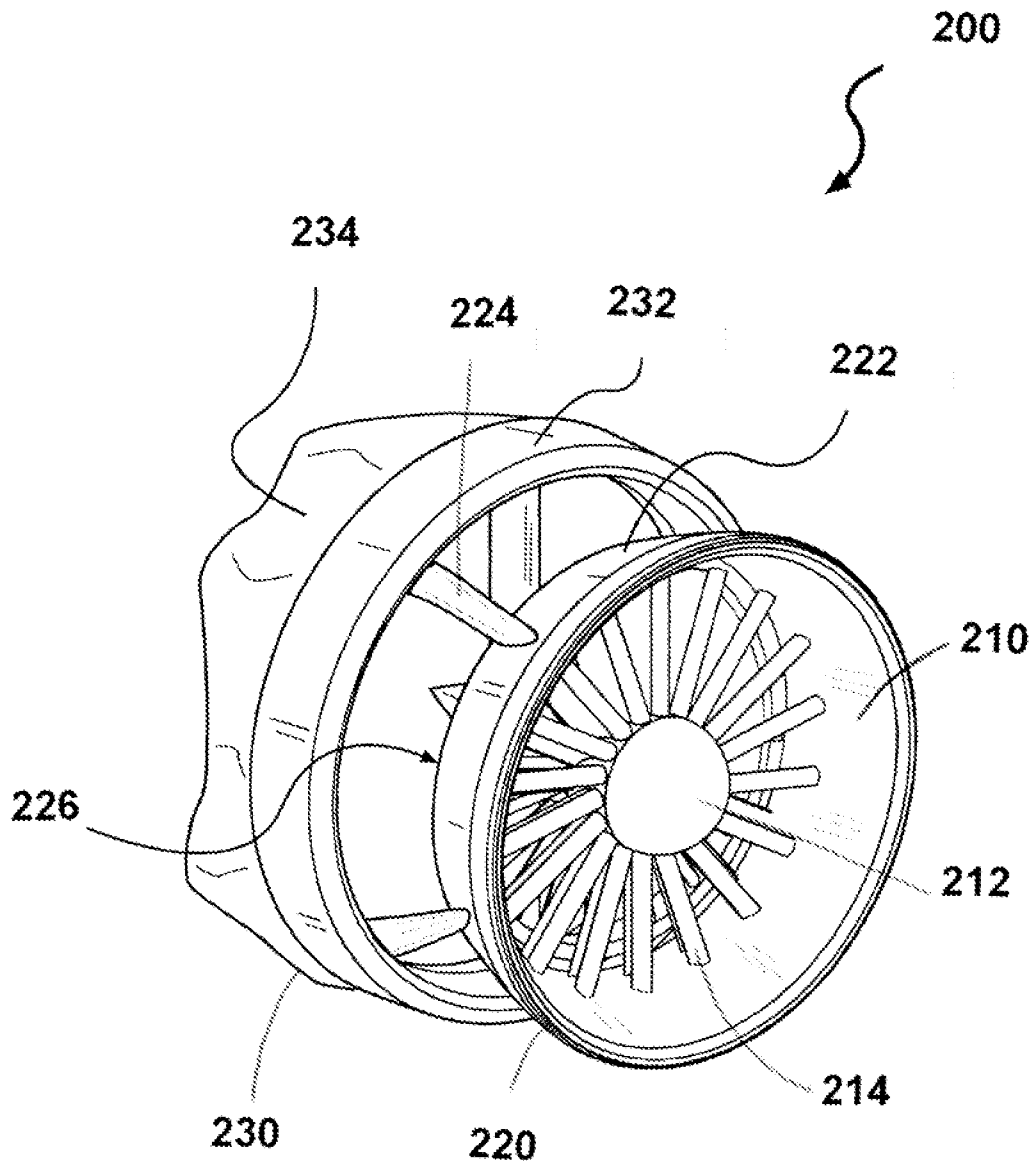
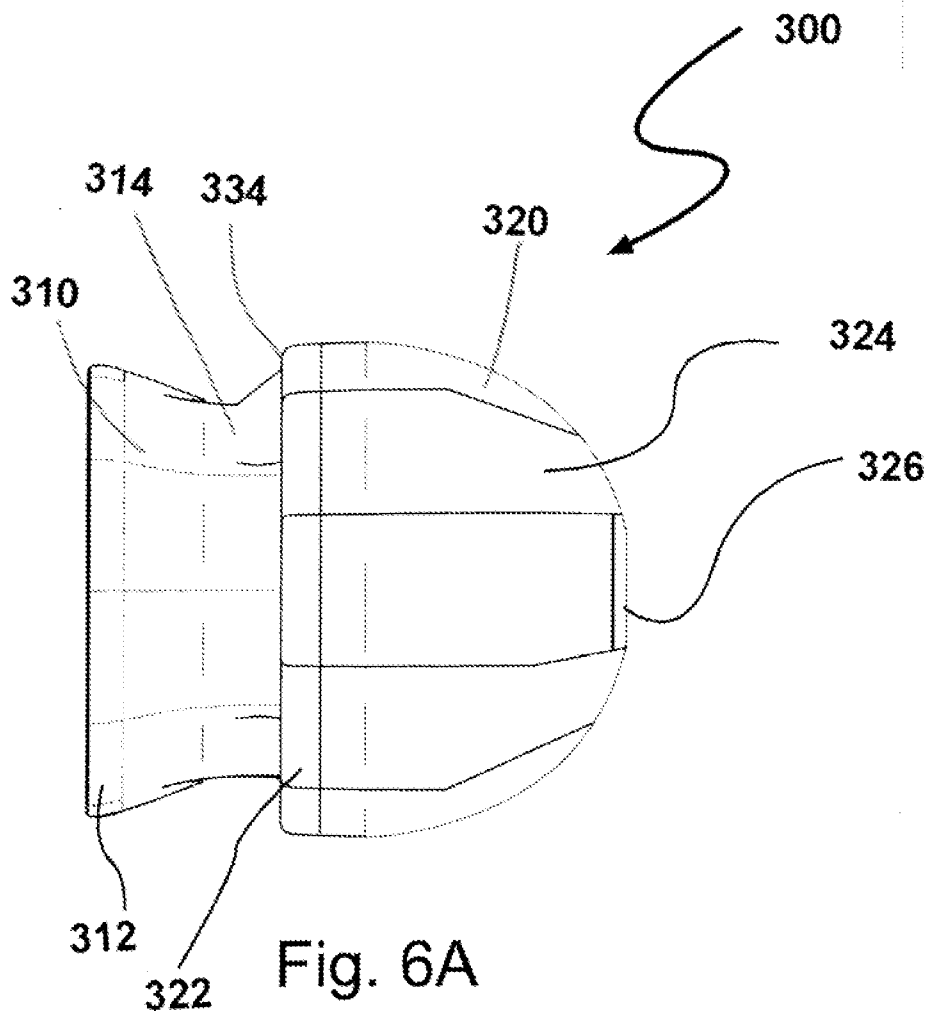


Fig. 5





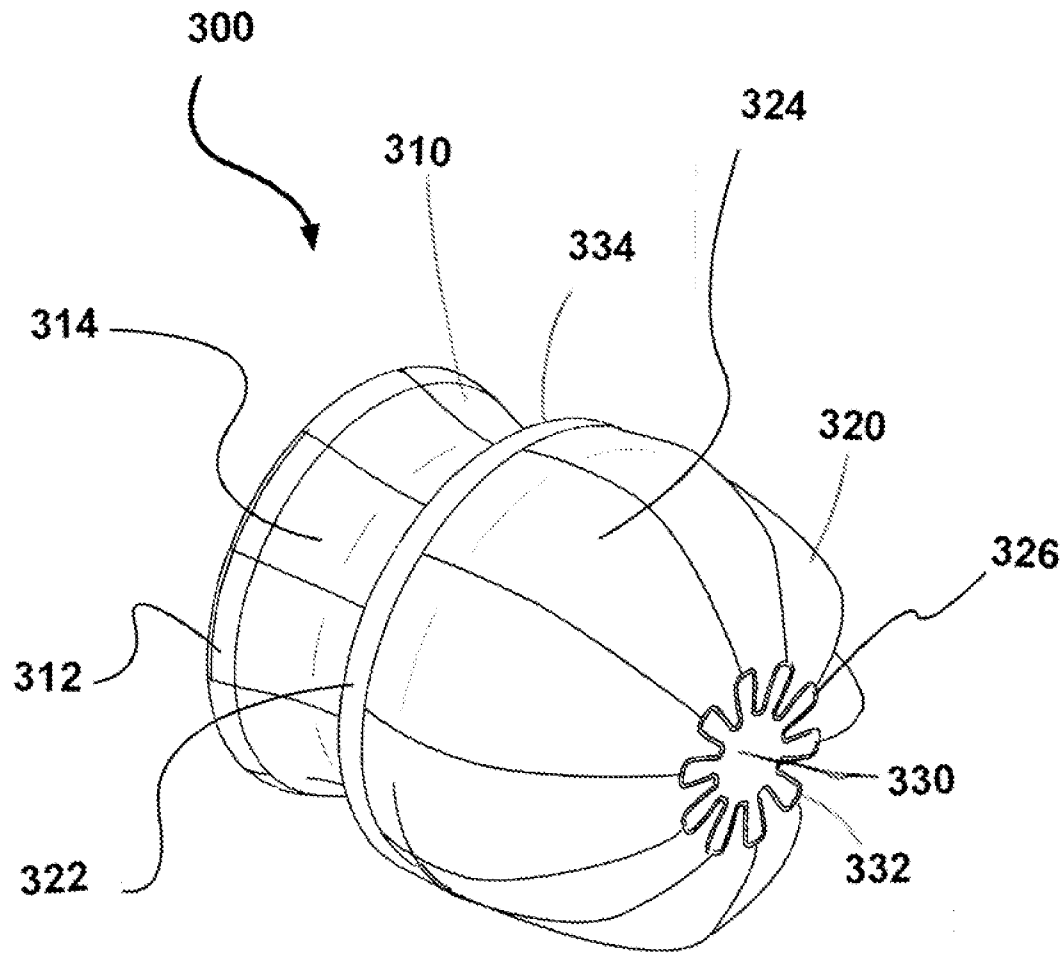


Fig. 6B

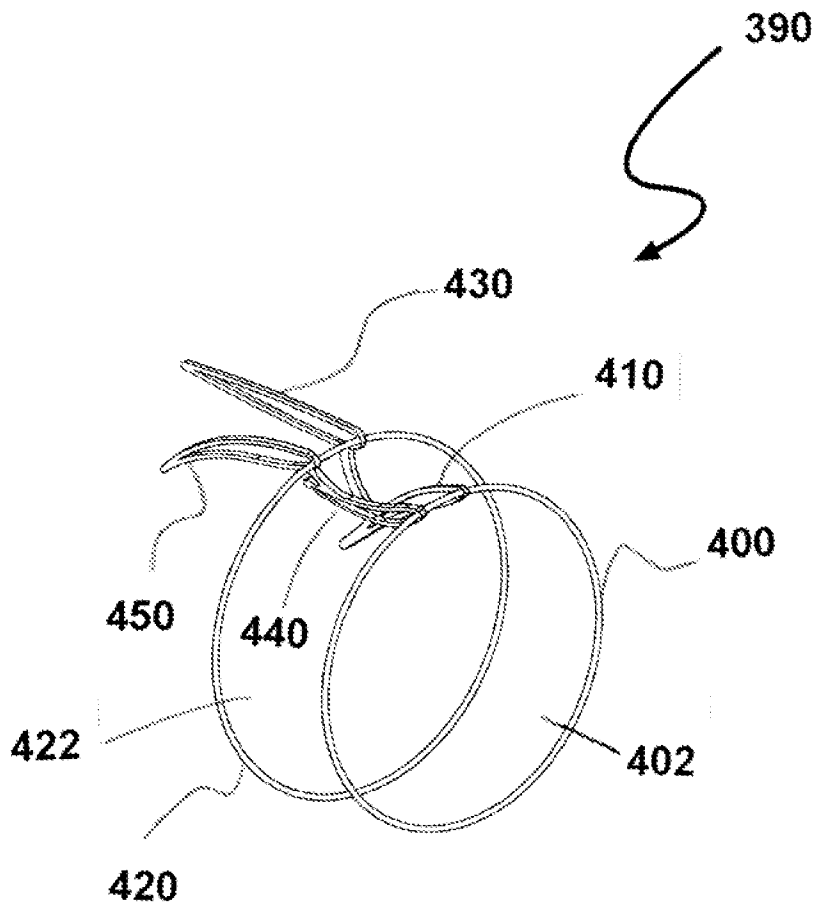


FIG. 7A

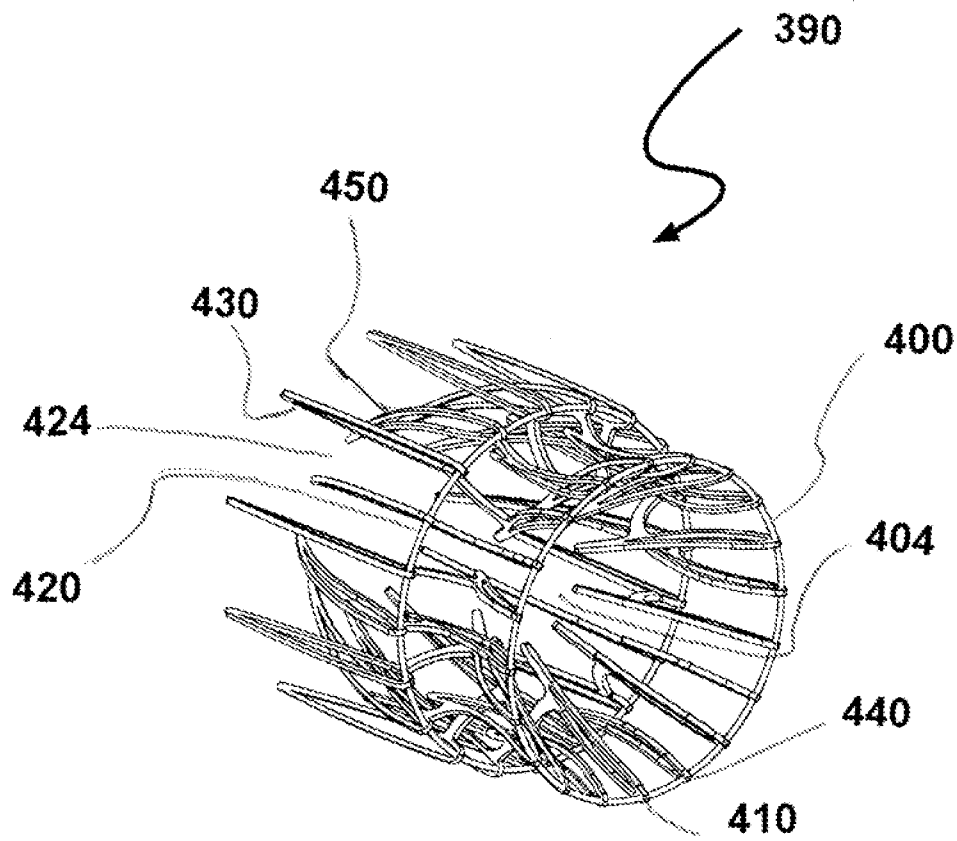


FIG. 7B

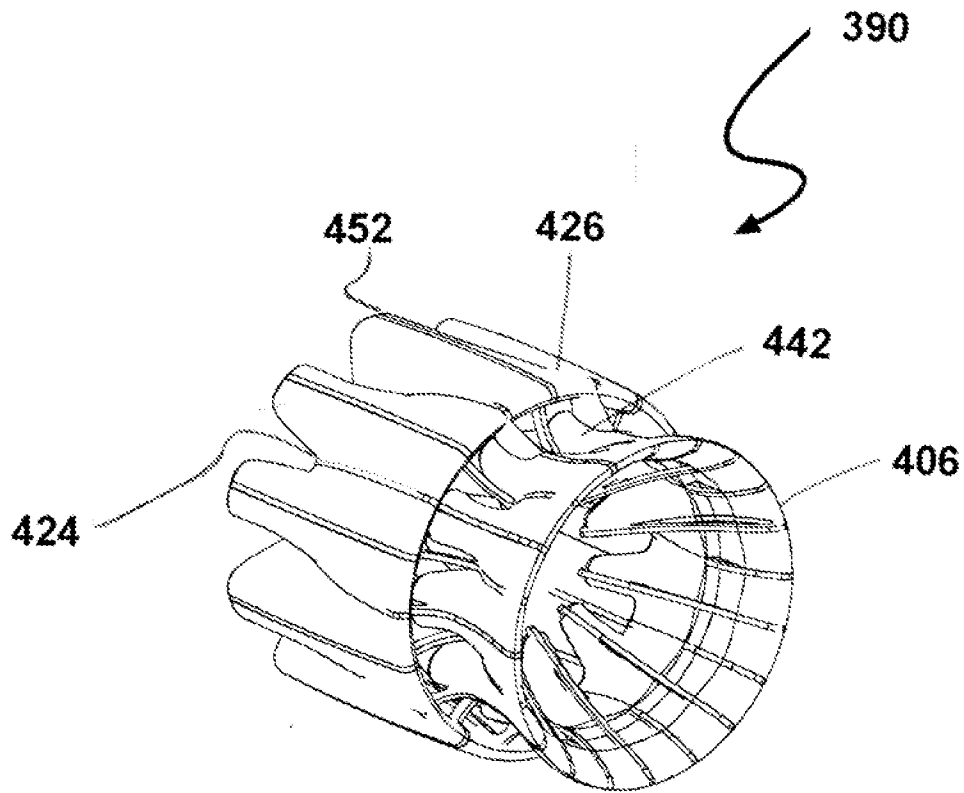


FIG. 7C

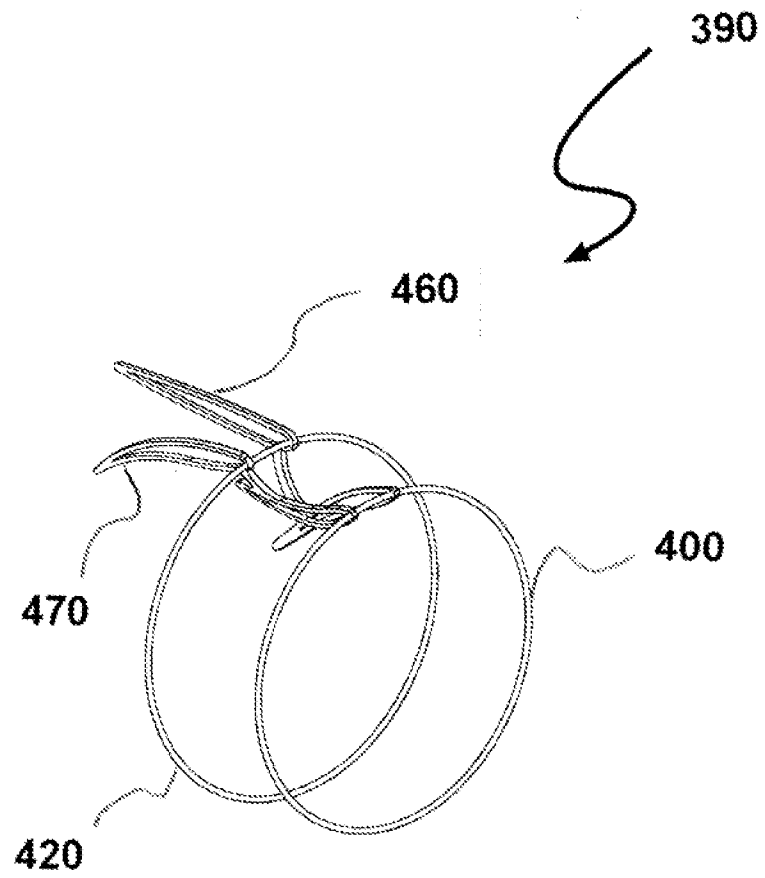
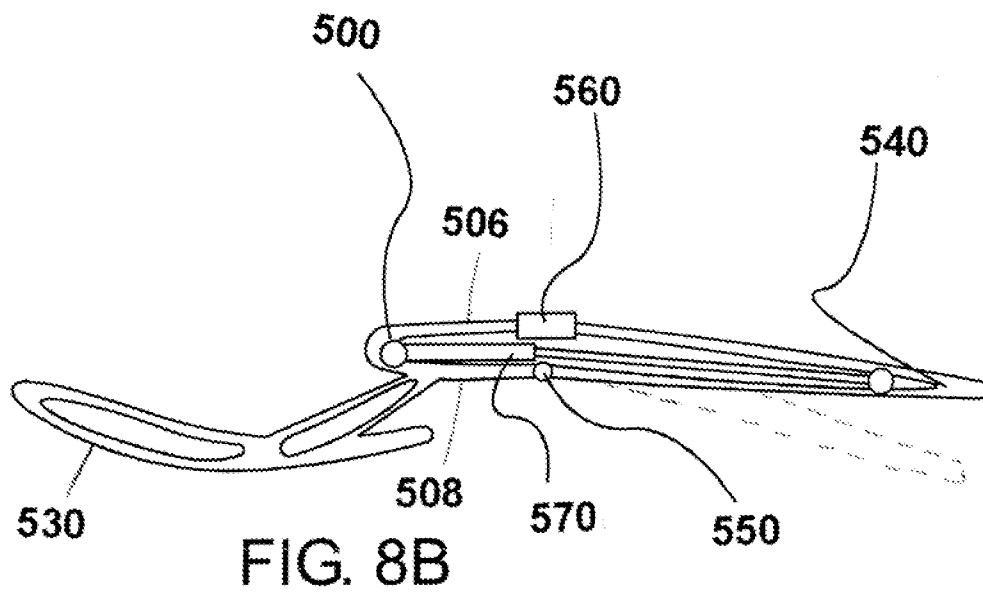
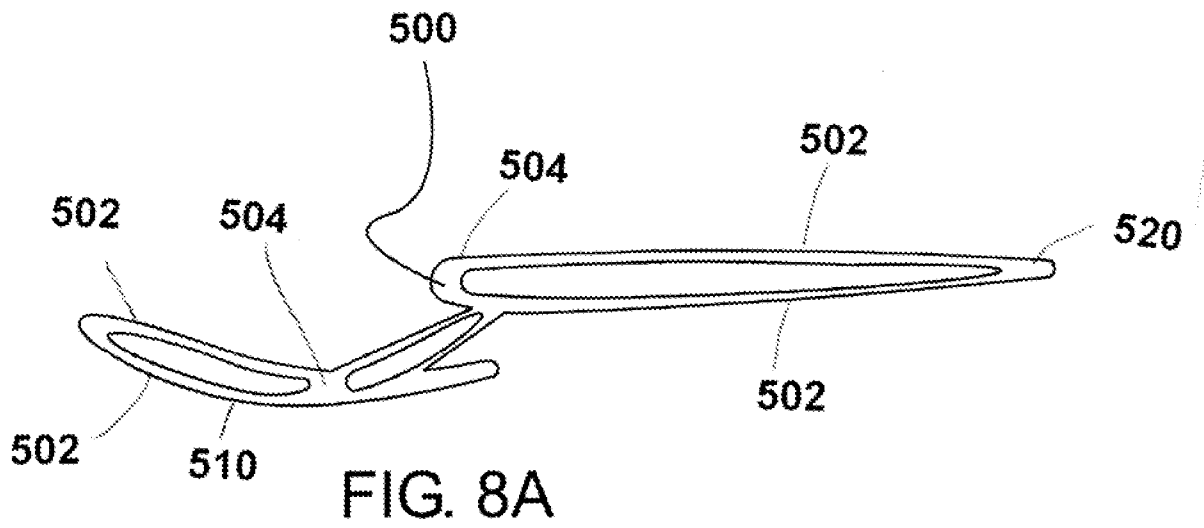


FIG. 7D



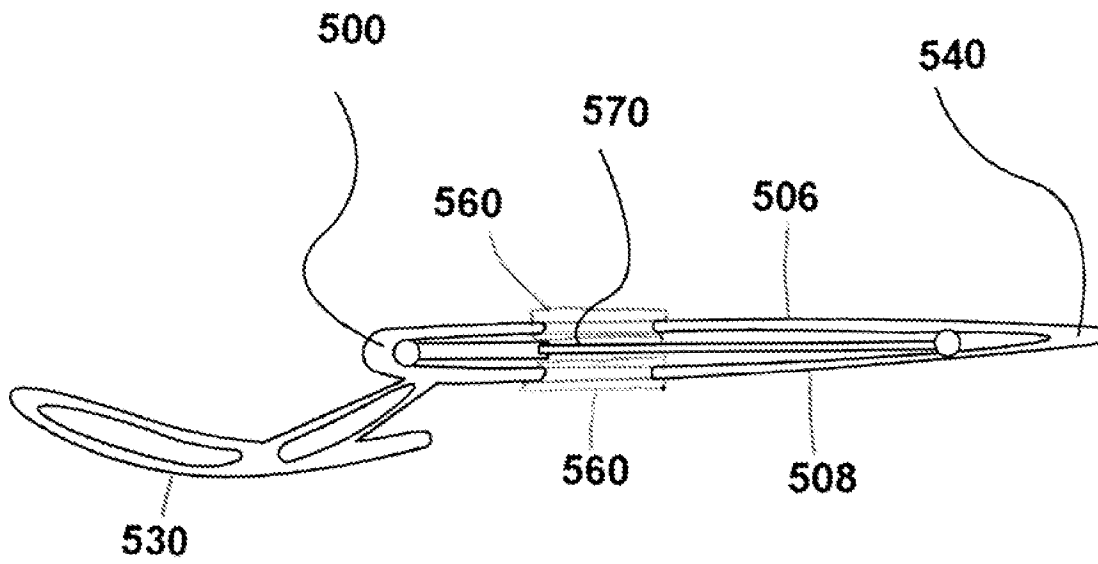


FIG. 8C

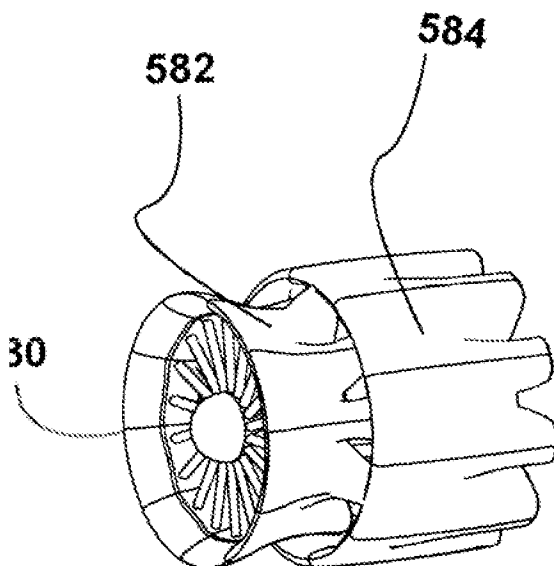


FIG. 8D



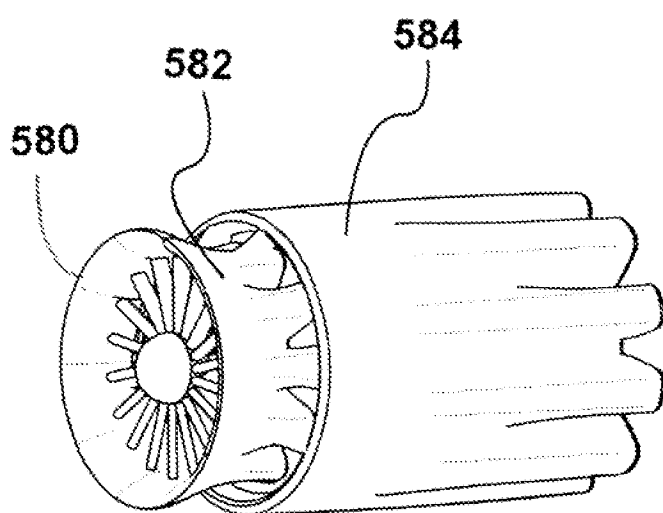


FIG. 8E

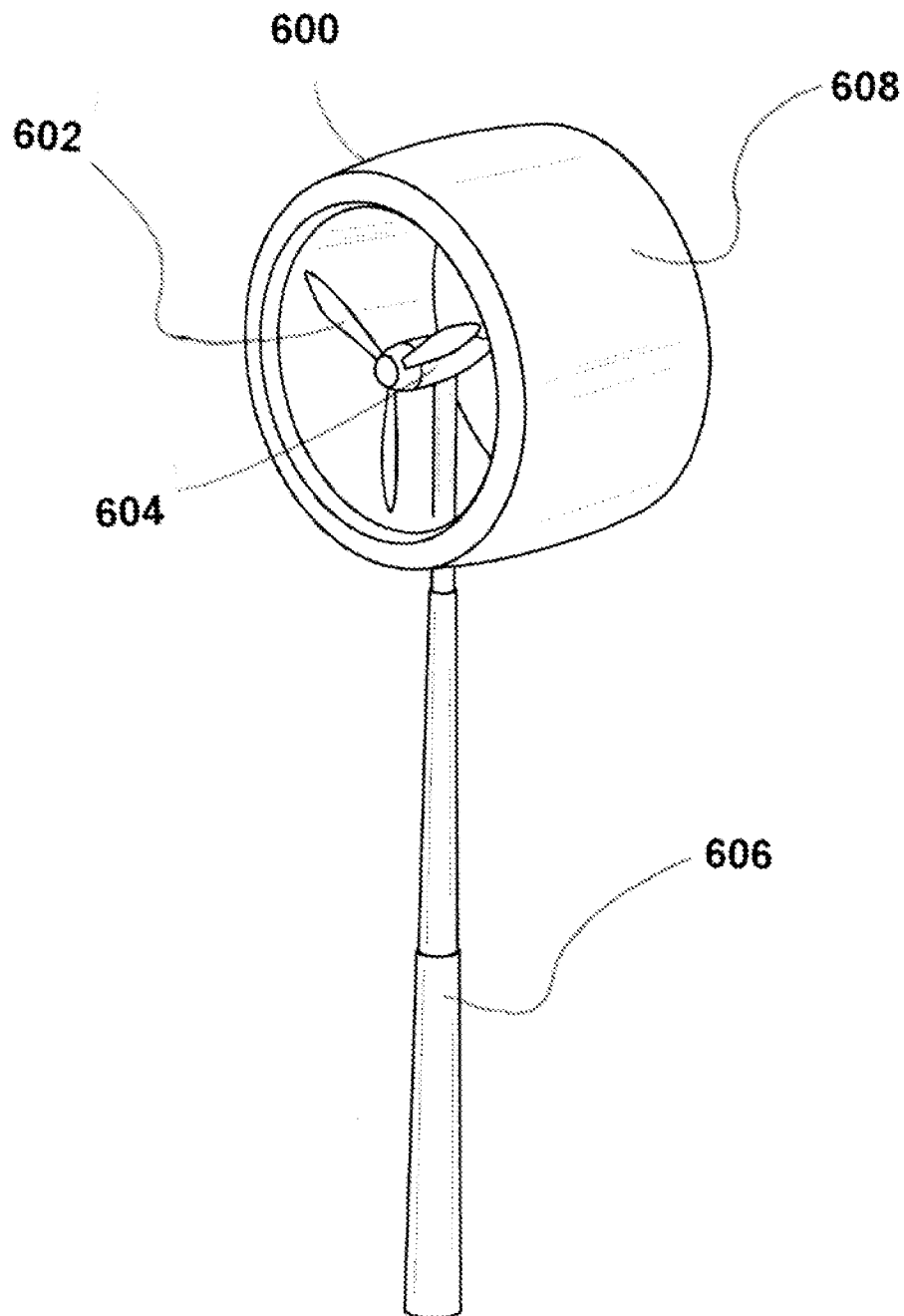


Fig. 9

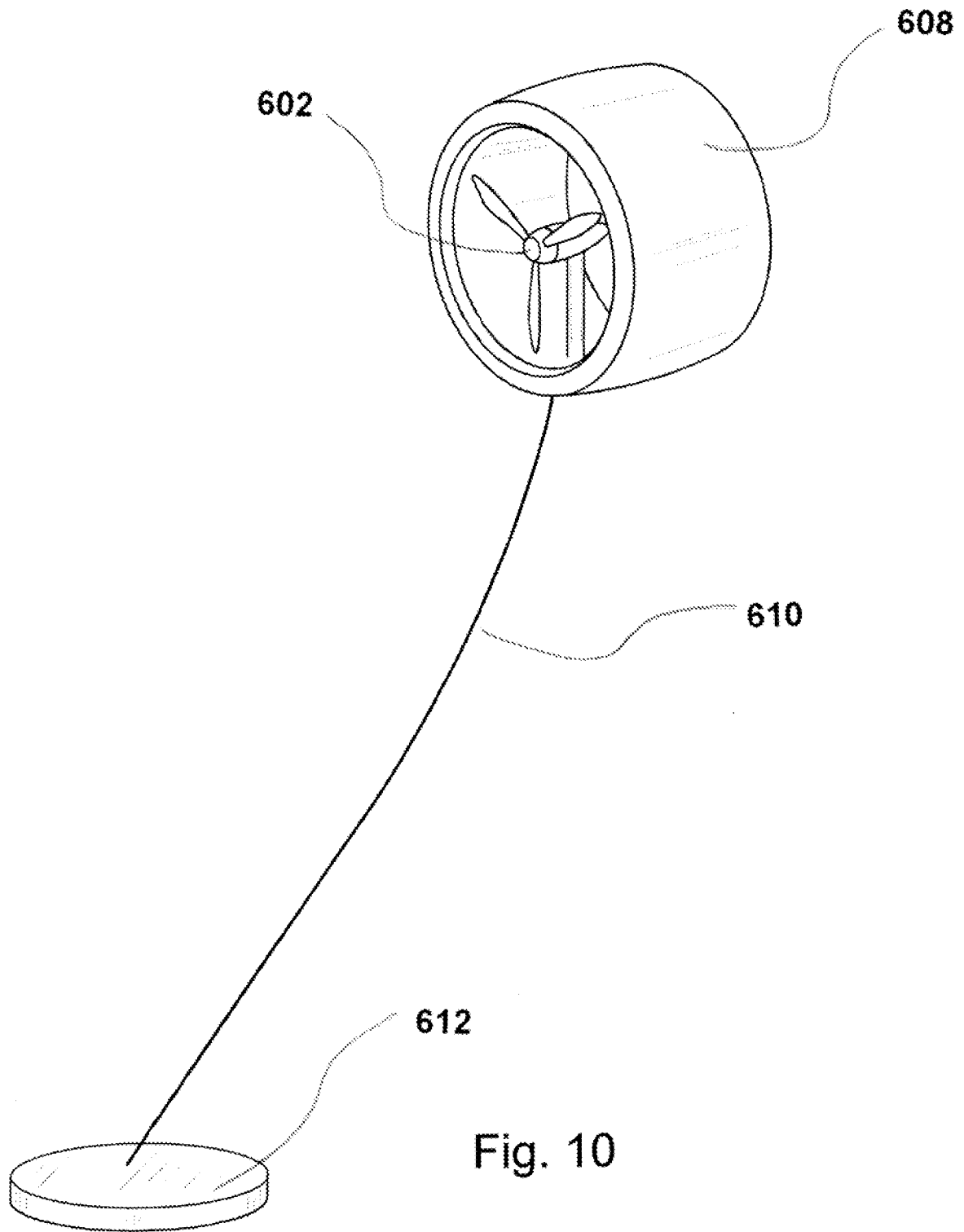


Fig. 10