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(71) Applicant(s): L&T TECHNOLOGY SERVICES LIMITED

(72) Inventor(s): Murugesan, Hariharan
Vadivel, Sundara M

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(54) Title: TELESCOPIC TYPE TIP DESIGN FOR WIND TURBINE ROTOR BLADE USING LINK MECHANISM

(57) Abstract: A blade (100) of a wind turbine is disclosed. The blade (100) may include a stationary portion (102) having a first end and a second. The stationary portion (102) may have a hollow region extending from the second end of the stationary portion (102) towards the first end of the stationary portion (102). The blade (100) may further include a retractable portion (104) movable between a retracted position and an extended position through the second end of the stationary portion (102). In the retracted position, the retractable portion (104) may be positioned substantially inside the hollow region of the stationary portion (102). In the extended position, the retractable portion (104) may be positioned substantially or completely outside the hollow region of the stationary portion (102). In the extended position, the retractable portion (104) coordinates with the stationary portion (102) to form the full-length of the blade (100).

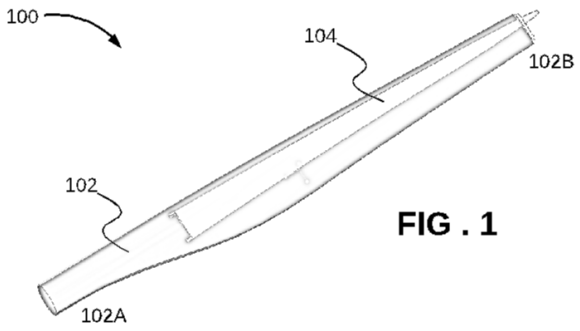

FIG . 1

FORM 2

THE PATENTS ACT 1970

(39 OF 1970)

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The Patent Rules, (200)3

Complete Specification

(See Section 10 and Rule 13)

1. TITLE OF THE INVENTION

Telescopic Type Tip Design For Wind Turbine Rotor Blade using Link Mechanism

2. APPLICANT(S)

(a) NAME : **L&T TECHNOLOGY SERVICES LIMITED**

(b) NATIONALITY : **INDIAN**

(c) ADDRESS : DLF IT SEZ Park, 2nd Floor – Block 3,
1/124, Mount Poonamallee Road
Ramapuram, Chennai – 600 089,
INDIA

3. PREAMBLE TO THE DESCRIPTION

COMPLETE

The following specification particularly describes the invention and the manner in which it is performed.

DESCRIPTION

Technical Field

[001] The present invention relates to wind turbine blades, and in particular, to a collapsible blade including a retractable portion.

BACKGROUND

[002] The global energy demand is on the rise due to various reasons including population growth, changing lifestyles, etc. In order meet this energy demand, renewable resources of energy like wind energy play a crucial role. As such, harnessing wind energy has assumed importance lately. As it will be generally understood, the power generated by a wind turbine is directly proportional to the rotor blade surface area. Although, the blade length may vary from 15 meters to 200 meters depending on the energy output demand, for greater power generation from a single wind turbine, longer blades prove more effective. However, longer blades may have specialized storage and transportation requirements. As a result, storage and transportation of these blades becomes expensive, time consuming, and labor intensive. Further, the storage and transportation of such blades may involve high risk of damage to the blade. Moreover, owing to the longer length and higher weight of these blade, installation to the hub height of the wind turbine becomes time consuming and labour intensive. Additionally, unless wind conditions are completely favourable, blade installations may also be accident prone due to longer size of the blades.

[003] Therefore, an effective wind turbine blade design that overcomes the above problems is desired.

SUMMARY OF THE INVENTION

[004] A blade for a wind turbine is disclosed, in accordance with an embodiment of the present disclosure. In an embodiment, the blade may include a stationary portion having a first end and a second end. The blade may be configured to be installed on a rotor of the wind turbine via the first end of the stationary portion. The stationary portion may have a hollow region extending from the second end of the stationary portion towards the first end of the stationary portion. The blade may further include a retractable portion movable between a retracted position and an extended position through the second end of the stationary portion. In the retracted position, the retractable portion may be configured to be positioned substantially inside the hollow region of the

stationary portion. In the extended position, the retractable portion may be configured to be positioned substantially or completely outside the hollow region of the stationary portion. In the extended position, the retractable portion may coordinate with the stationary portion to form the full-length of the blade.

[005] A method of installing a blade of a wind turbine in the wind turbine is disclosed, in accordance with an embodiment of the present disclosure. In an embodiment, the method may include receiving the blade at a wind turbine site. The blade may include a stationary portion having a first end and a second end. The blade may be configured to be installed on a rotor of the wind turbine via the first end of the stationary portion. The stationary portion may have a hollow region extending from the second end of the stationary portion towards the first end of the stationary portion. The blade may further include a retractable portion movable between a retracted position and an extended position through the second end of the stationary portion. In the retracted position, the retractable portion may be configured to be positioned substantially inside the hollow region of the stationary portion. In the extended position, the retractable portion may be configured to be positioned substantially or completely outside the hollow region of the stationary portion. The blade may be received at a wind turbine site with the retractable portion in the retracted position. The method may further include triggering the retractable portion to move from the retracted position to the extended position and coordinate with the stationary portion to form the full-length of the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

[006] The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles.

[007] **FIG. 1** illustrates a perspective view of a blade in its retracted configuration, in accordance with an embodiment of the present disclosure.

[008] **FIG. 2** illustrates a perspective view of the blade of FIG. 1 in its extended configuration, in accordance with an embodiment of the present disclosure.

[009] **FIG. 3** illustrates a perspective view of a blade including a drive unit, in retracted state of the blade, in accordance with an embodiment of the present disclosure.

[010] **FIG. 4** is a schematic diagram of a linkage assembly of the drive unit in contracted state, in accordance with an embodiment of the present disclosure.

[011] **FIG. 5** is a schematic diagram of the linkage assembly of the drive unit in expanded state, in accordance with an embodiment of the present disclosure.

[012] **FIG. 6** illustrates a partial view of a blade with lateral flaps and side flaps in open position, in accordance with an embodiment of the present disclosure.

[013] **FIG. 7** illustrates a partial view of the blade with the lateral flaps and the side flaps in closed position, in accordance with an embodiment of the present disclosure.

[014] **FIG. 8** illustrates a front view of a plurality of blades for a wind turbine, with their respective retractable portions in retracted position, in accordance with an embodiment.

[015] **FIG. 9** illustrates a front view of the plurality of blades for the wind turbine, with their respective retractable portion(s) in extended position, in accordance with an embodiment.

[016] **FIG. 10** illustrates a flowchart of a method of installing a blade on a wind turbine, in accordance with an embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

[017] Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims. Additional illustrative embodiments are listed below.

[018] Referring to FIG. 1, a perspective view of a blade 100 in its retracted configuration is illustrated, in accordance with an embodiment of the present disclosure. The blade 100 may include a stationary portion 102 having a first end 102A and a second end 102B. In some embodiments, the blade 100 may be configured to be installed on a rotor (not shown in FIG. 1) of the wind turbine via the first end 102A of the stationary portion 102. The stationary portion may have a hollow region extending from the second end 102B of the stationary portion towards the first end 102A of the stationary portion 102.

[019] The stationary portion 102 portion of the blade may be made of may material known in the art for the making wind turbine blades, including, but not limited to a metal, an alloy, plastic, composite materials, and the like.

[020] In some embodiments, the blade 100 may further include a retractable portion 104. The retractable portion 104 may be movable between a retracted position and an extended position through the second end 102B of the stationary portion 102. In the retracted position, the retractable portion 104 may be positioned substantially inside the hollow region of the stationary portion 102, as shown in the FIG. 1. Further, in the extended position, the retractable portion 104 may be positioned substantially or completely outside the hollow region of the stationary portion 102 (this is shown in FIG. 2). It should be noted that in the extended position, the retractable portion 104 may coordinate with the stationary portion 102 to form the full-length of the blade 100.

[021] The retractable portion 104 of the blade may be made of may material known in the art for the making wind turbine blades, including, but not limited to a metal, an alloy, plastic, composite materials, and the like.

[022] Therefore, as it will be understood, the blade 100 is implemented as an assembly of two portions, that may be reconfigured to obtain the full-length of the blade 100 for operation of the wind turbine. Further, by way of retracting the retractable portion 104 within the hollow region of the stationary portion 102, the effective length of the blade 100 is reduced, when the blade 100 is non-operational, for example, during storing or transportation of the blade 100.

[023] Referring to FIG. 2, a perspective view of the blade 100 in its expanded configuration is illustrated, in accordance with an embodiment of the present disclosure. As mentioned above, the blade 100 may include the stationary portion 102 having the first end 102A and the second end 102B. The stationary portion may have a hollow region extending from the second end 102B towards the first end 102A of the stationary portion 102. Further, the blade 100 may include the retractable portion 104 movable between the retracted position and the extended position through the second end 102B of the stationary portion 102. As shown in the FIG. 2, in the extended position, the retractable portion 104 may be positioned substantially or completely outside the hollow region of the stationary portion 102. As such, as it can be seen in the FIG. 2, in the extended position, the retractable portion 104 may coordinate with the stationary portion 102 to form the full-length of the blade 100.

[024] It may be noted that the blade 100 may be received at the wind turbine site with the retractable portion 104 being in the retracted position. Thereafter, the blade 100 may be reconfigured to cause the retractable portion 104 to move into the extended position. It may be further noted that this may done after or before installing the blade 100 on the wind turbine. For example, the blade 100 may be installed on the wind turbine, with the retractable portion 104 being in the retracted position. Once the blade is installed on the wind turbine, the blade 100 may be reconfigured to cause the retractable portion 104 to move into the extended position, thereby causing the retractable portion 104 to coordinate with the stationary portion 102 to form the full-length of the blade 100. Alternately, before installing on the wind turbine, the blade 100 may be reconfigured to cause the retractable portion 104 to move into the extended position, thereby causing the retractable portion 104 to coordinate with the stationary portion 102 to form the full-length of the blade 100. Thereafter, the blade 100 in its extended configuration may be installed on the wind turbine.

[025] It should be noted that the blade 100 may not be limited to one stationary portion 102 and one retractable portion 104. In other words, the blade 100 may include multiple (i.e., two or more) stationary portions (similar to the stationary portion 102) and multiple (i.e., two or more) retractable portions (similar to the retractable portion 104). For example, in some embodiments, the blade 100 may include the stationary portions 102 and multiple (i.e., two or more) retractable portions similar to the retractable portion 104. As such, each of the multiple retractable portions may be configured to move between a retracted position and an extended position. It may be further noted that in such embodiments, the blade may include one or more drive units. For example, the single drive unit 106 may drive the multiple retractable portions to move them between the retracted position and the extended position. Alternately, each retractable portion of the multiple retractable portions may be driven by a separate dedicated drive unit, to move the retractable portion between the retracted position and the extended position. Therefore, in the extended position of each of the multiple retractable portions, the multiple retractable portions may coordinate with the stationary portion to form the full-length of the blade 100.

[026] Referring now to FIG. 3, a perspective view of the blade 100 including a drive unit, in retracted state of the blade is illustrated, in accordance with an embodiment of the present disclosure. The blade 100 includes a stationary portion 102 having a first end 102A and a second end 102B. The blade 100 may be configured to be installed on a rotor (not shown in FIG. 3) of the

wind turbine via the first end 102A. Further, the stationary portion 102 may have a hollow region extending from the second end 102B towards the first end 102A of the stationary portion 102.

[027] The blade 100 may further include a retractable portion 104. The retractable portion 104 may be movable between a retracted position and an extended position through the second end 102B of the stationary portion 102. In the retracted position, the retractable portion 104 may be positioned substantially inside the hollow region of the stationary portion 102, as shown in the FIG. 3. In the extended position (now shown in FIG. 3), the retractable portion 104 may be positioned substantially or completely outside the hollow region of the stationary portion 102. In the extended position, the retractable portion 104 may coordinate with the stationary portion 102 to form the full-length of the blade 100.

[028] Further, as shown in FIG. 3, the blade 100 may further include a drive unit 106. The drive unit 106 may be positioned inside the stationary portion 102 of the blade 100. The drive unit 106 may be coupled to the retractable portion 104. The drive unit 106 may be configured to move the retractable portion 104 between the retracted position and the extended position.

[029] In some embodiments, the drive unit 106 may include a driving source (not shown in FIG. 3). For example, the driving source may be an electric motor. The driving source of the drive unit 106 may, therefore, be powered by an external power source (e.g., electric supply), to power the driving source, and therefore enable the drive unit 106 to move the retractable portion 104 between the retracted position and the extended position. In some embodiments, the driving source may be permanently fitted in the blade 100. Alternately, the driving source may be coupled to the blade 100 as per the requirement, for example, for moving the retractable portion 104 from the retracted position to the extended position during blade installation. And, once the retractable portion 104 is moved to the extended position, the driving source may be removed from the blade 100.

[030] In some embodiments, in order to enable the drive unit 106 to move the retractable portion 104 between the retracted position and the extended position, the drive unit 106 may include a linkage assembly 108. This is explained in conjunction with FIGS. 4-5.

[031] With reference to FIG. 4, a linkage assembly 108 of the drive unit 106 in contracted state is illustrated, in accordance with an embodiment of the present disclosure. With reference to FIG. 5, the linkage assembly 108 of the drive unit 106 in expanded state is illustrated, in accordance with an embodiment of the present disclosure.

[032] The linkage assembly 108 may be coupled to the retractable portion 104 (now shown in FIGS. 4-5) of the blade 100. As shown in FIGS. 4-5, the linkage assembly 108 may include a plurality of linkages 110(1), 110(2), 110(3), … 110(n) (hereinafter, collectively referred to as plurality of linkages 110). The plurality of linkages 110 may be interconnected. The linkage assembly 108 may be configurable between a contracted state and an expanded state, by movement of the plurality of linkages 110.

[033] The linkage assembly 108 may further include a plurality of rollers 112(1), 112(2), 112(3), … 112(n) (hereinafter, collectively referred to as plurality of rollers 112). As shown in FIGS. 4-5, each of the plurality of rollers 112 may be coupled to each of the plurality of linkages 110, such that each of the plurality of rollers 112 is free to rotate about its axis.

[034] The linkage assembly 108 may further include at least one cord member 114. The at least one cord member 114 may be coupled to the driving source. The at least one cord member 114 may be configured to interconnect the plurality of rollers 112. To this end, each of the plurality of rollers 112 may have a surface (e.g., like a pulley) configured to allow the at least one cord member 114 to pass over and therefore interconnect the plurality of rollers 112.

[035] During operation, in order to reconfigure the linkage assembly into the expanded state from the contracted state, the driving source may cause to release the at least one cord member 114. As a result, the plurality of linkages 110 may start moving away from each, for example, under influence of a spring. The plurality of linkages 110 may continue moving away from each other, until the driving source stops releasing the at least one cord member 114, to thereby expand the linkage assembly 108. Once the plurality of linkages 110 have moved away from each to a maximum predefined limit, the driving source may cause to stop release of the at least one cord member 114, to thereby stop the movement of the plurality of linkages 110. At this point, the linkage assembly 108 is reconfigured into the expanded state, as shown in the FIG. 5.

[036] As it will be understood, the contracted state of linkage assembly 108 may correspond to the retracted position of the retractable portion 104 of the blade 100. Further, the expanded state of linkage assembly 108 may correspond to the extended position of the retractable portion 104 of the blade 100. In other words, when the linkage assembly 108 is in contracted state, the linkage assembly 108 may have caused to move the retractable portion 104 of the blade 100 to the retracted position of the retractable portion 104. Once the linkage assembly 108 is reconfigured into the

expanded state, the linkage assembly 108 may have caused to move the retractable portion 104 of the blade 100 into the extended position of the retractable portion 104.

[037] It should be noted that the linkage assembly 108, i.e., the plurality of linkages 110 may be configured to act as stiffeners for the blade 100, when the retractable portion 104 is in the extended position. In the extended position of the retractable portion 104, the plurality of linkages 110 may be distributed across the length of the stationary portion 102 and the retractable portion 104 of the blade 100. As such, the plurality of linkages 110 may act as ribs for the stationary portion 102 and the retractable portion 104 of the blade 100 for imparting additional strength to the blade 100.

[038] Further, it should be noted that the above linkage assembly 110 is only one way of moving the retractable portion 104 between the retracted position and the extended position. In other embodiments, any other such mechanism may be used as well. For example, one such mechanism may be using telescopic hydraulic-based cylinders, such that one of the cylinders may correspond to the stationary portion 102, and another cylinder corresponding to the retractable portion 104 is configured to telescopically move inside the first cylinder.

[039] With reference to FIG. 6, a partial view of the blade 100 with lateral flaps 116 and side flaps 118 in open position is illustrated, in accordance with an embodiment of the present disclosure. With reference to FIG. 7, a partial view of the blade 100 with lateral flaps 116 and side flaps 118 in closed position is illustrated, in accordance with an embodiment of the present disclosure.

[040] In some embodiments, the blade 100 may include at least one lateral flap 116. For example, as shown in FIGS. 6-7, the blade 100 may include two lateral flaps 116. In some embodiments, the at least one lateral flap 116 may be coupled to the stationary portion 102. For example, the at least one lateral flap 116 may be hinged to the stationary portion 102, so that the at least one lateral flap 116 is configured to rotate about the hinge to assume an open position or a closed position. Further, as shown in FIGS. 6-7, the one of the at least one lateral flap 116 may be coupled to a first lateral surface (upper surface) of the stationary portion 102 of the blade 100, and another one of the at least one lateral flap 116 may be coupled to a second lateral surface (lower surface) of the stationary portion 102 of the blade 100.

[041] In the extended position of the retractable portion 104, the at least one lateral flap 116 may be configured to open and lock with the retractable portion 104. This is shown in FIG. 7. In order to open or close a lateral flap 116, each lateral flap 116 may be operable by a first actuator

(not shown in FIGS. 6-7). The first actuator may cause the at least one lateral flap 116 to open or close, for example, upon receiving a trigger. By way of an example, the first actuator may be a servo motor, a solenoid, or the like. As such, when the first actuator is provided a trigger, the first actuator may cause the associated lateral flap to open or close. For example, the trigger may be provided using an electrical switch.

[042] In the extended position of the retractable portion 104, once each of the at least one lateral flap 116 is opened, each of the at least one lateral flap 116 may then lock with retractable portion 104. As a result, the lateral flap 116 may cover any lateral gap between the stationary portion 102 and the retractable portion 104, when the retractable portion 104 is in the extended position. Therefore, the lateral flaps 116 provide for a continuous and smooth surface along the full length of the blade 100, when the retractable portion 104 is in extended position.

[043] In some embodiments, the blade 100 may include at least one side flap 118. For example, as shown in FIGS. 6-7, the blade 100 may include two side flaps 118. In some embodiments, the at least one side flap 118 may be coupled to the retractable portion 104. For example, the at least one side flap 118 may be hinged to the retractable portion 104, so that the at least one side flap 118 is configured to rotate about the hinge to assume an open position or a closed position. Further, as shown in FIGS. 6-7, the one of the at least one side flap 118 may be coupled to a first side surface (left surface) of the retractable portion 104 of the blade 100, and another one of the at least one side flap 118 may be coupled to a second side surface (right surface) of the retractable portion 104 of the blade 100.

[044] In the extended position of the retractable portion 104, the at least one side flap 118 may open and lock with the stationary portion 102. This is shown in FIG. 7. In order to open or close a side flap 118, each side flap 118 may be operable by a second actuator. The second actuator may cause the at least one side flap 118 to open or close, for example, upon receiving a trigger. By way of an example, the second actuator may be a servo motor, a solenoid, and the like. As such, when the second actuator is provided a trigger, the second actuator may cause the associated side flap 118 to open or close. For example, the trigger may be provided using an electrical switch.

[045] In the extended position of the retractable portion 104, once each of the at least one side flap 118 is opened, each of the at least one side flap 118 may then lock with stationary portion 102. As a result, the side flap 118 may cover any side gap between the stationary portion 102 and the retractable portion 104, when the retractable portion 104 is in the extended position. Therefore, the

side flaps 118 further provide for a continuous and smooth surface along the full length of the blade 100, when the retractable portion 104 is in extended position.

[046] In some alternate embodiments, the at least one lateral flap 116 may be coupled to the retractable portion 104, i.e., the at least one lateral flap 116 may be hinged to the retractable portion 104, so that the at least one lateral flap 116 is configured to rotate about the hinge to assume an open position or a closed position. As such, in the extended position of the retractable portion 104, the at least one lateral flap 116 may be configured to open and lock with the stationary portion 102, to provide for a continuous and smooth surface along the full length of the blade 100. Further, in such embodiments, the at least one side flap 118 may be coupled to the stationary portion 102, i.e., the at least one side flap 118 may be hinged to the stationary portion 102, so that the at least one side flap 118 may be configured to rotate about the hinge to assume an open position or a closed position. Therefore, in the extended position of the retractable portion 104, the at least one side flap 118 may open and lock with the retractable portion 104, to further provide for a continuous and smooth surface along the full length of the blade 100, when the retractable portion 104 is in extended position.

[047] It may be noted that each of the at least one lateral flap 116 and the at least one side flap 118 may be made of same material as the material of the blade 100, or any other material known in the art for the making wind turbine blades. As such, each of the at least one lateral flap 116 and the at least one side flap 118 may be made of a metal, an alloy, plastic, composite materials, and the like.

[048] With reference to FIG. 8, a front view of a plurality of blades 100A, 100B, 100C (hereinafter, collectively referred to as plurality of blades 100) for a wind turbine, with their respective retractable portion(s) 104 in retracted position is illustrated, in accordance with an embodiment. With reference to FIG. 9, a front view of the plurality of blades 100 for a wind turbine, with their respective retractable portion(s) 104 in extended position is illustrated, in accordance with an embodiment.

[049] It may be noted that, in some embodiments, the plurality of blades 100 may be mounted on the wind turbine with the retractable portion 104 of the blade 100 in the retracted position, as shown in FIG. 8. As such, once the plurality of blades 100 are installed on the wind turbine, the retractable portion of each of the plurality of blades 100 may be caused to move from the retracted position to the extended position.

[050] Referring now to FIG. 10, a flowchart of a method 1000 of installing a blade 100 of a wind turbine on the wind turbine is illustrated, in accordance with an embodiment. At step 1002, the blade 100 may be received at a wind turbine site. As mentioned earlier, the blade 100 may include the stationary portion 102 having the first end 102A and the second end 102B. It should be noted that the blade 100 may be configured to be installed on a rotor of the wind turbine via the first end of the stationary portion 102. The stationary portion 102 may have the hollow region extending from the second end 102B of the stationary portion 102 towards the first end 102A of the stationary portion 102. The blade 100 may further include the retractable portion 104 movable between a retracted position and an extended position through the second end 102B of the stationary portion 102. In the retracted position, the retractable portion 104 may be configured to be positioned substantially inside the hollow region of the stationary portion 102. Further, in the extended position, the retractable portion 104 may be configured to be positioned substantially or completely outside the hollow region of the stationary portion 102. It should be noted that the blade 100 may be received at a wind turbine site with the retractable portion 104 in the retracted position.

[051] At step 1004, the retractable portion 104 may be triggered to move from the retracted position to the extended position and coordinate with the stationary portion 102 to form the full-length of the blade 100. As mentioned above, the retractable portion 104 may be triggered to move from the retracted position to the extended position by the drive unit 106, that may be positioned inside the stationary portion 102. Further, the drive unit 106 may be coupled to the retractable portion 104, configured to move the retractable portion 104 between the retracted position and the extended position. In some embodiments, the drive unit 106 may include the linkage assembly 108 including the plurality of interconnected linkages 110. The linkage assembly 108 may be configurable between a contracted state and an expanded state by movement of the plurality of linkages 110. The linkage assembly 108 may be coupled to the retractable portion 104. As such, the contracted state of linkage assembly 108 may correspond to the retracted position of the retractable portion 104 of the blade 100, and the expanded state of linkage assembly 108 may correspond to the extended position of the retractable portion 104.

[052] It may be further noted that the blade 100 may be mounted on the wind turbine with the retractable portion 104 of the blade 100 in the retracted position or in the extended position. As such, in some embodiments, once the blade 100 is received at the wind turbine site, the blade 100

may be installed on the wind turbine, with the retractable portion 104 of the blade 100 in the retracted position.

[053] Additionally, at step 1006A, the at least one lateral flap 116 may be caused to lock with one of the retractable portion 104 or the stationary portion 102 of the blade 100 in the extended position of the retractable portion. As a result, a continuous and smooth surface along the full length of the blade 100 is obtained, when the retractable portion 104 is in extended position.

[054] Simultaneously, at step 1006B, the at least one side flap 118 may be caused to lock with one of the stationary portion 102 or the retractable portion 104 in the extended position of the retractable portion (104). As a result, a continuous and smooth surface along the full length of the blade 100 is obtained, when the retractable portion 104 is in extended position.

[055] For example, in some embodiments, the at least one lateral flap 116 may be coupled to the stationary portion 102. Further, the at least one side flap 118 may be coupled to the retractable portion 104. As such, in such embodiments, the at least one lateral flap 116 may be caused to lock with the retractable portion 104 of the blade 100. Further, the at least one side flap 118 may be caused to lock with the stationary portion 102 of the blade 100.

[056] Alternately, in some embodiments, the at least one lateral flap 116 may be coupled to the retractable portion 104. Further, the at least one side flap 118 may be coupled to the stationary portion 102. As such, in such embodiments, the at least one lateral flap 116 may be caused to lock with the stationary portion 102 of the blade 100. Further, the at least one side flap 118 may be caused to lock with the retractable portion 104 of the blade 100.

[057] The present disclosure discloses a reconfigurable blade of a wind turbine. This reconfigurable blade includes a retractable portion, a stationary portion, and a drive unit. The drive unit may be coupled with the retractable portion of the blade to cause the retractable portion to slide between a retracted position and an extended position. The above-mentioned blade provides a cost-effective solution for collapsing and transporting wind turbine blades in its retracted form, thereby making the transportation process and installation more convenient. Further, the above-mentioned blade provides for reduction in transportation complications, and ensures timely delivery of the blade to the installation site. Moreover, risks of damage to the integrity of the blade are minimized.

[058] It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

We claim:

1. A blade (100) for a wind turbine, the blade (100) comprising:

a stationary portion (102) having a first end and a second end, wherein the blade (100) is configured to be installed on a rotor of the wind turbine via the first end of the stationary portion (102), wherein the stationary portion (102) has a hollow region extending from the second end of the stationary portion (102) towards the first end of the stationary portion (102); and

a retractable portion (104) movable between a retracted position and an extended position through the second end of the stationary portion (102), wherein in the retracted position, the retractable portion (104) is configured to be positioned substantially inside the hollow region of the stationary portion (102), and in the extended position, the retractable portion (104) is configured to be positioned substantially or completely outside the hollow region of the stationary portion (102), and wherein in the extended position, the retractable portion (104) coordinates with the stationary portion (102) to form the full-length of the blade (100).

2. The blade (100) as claimed in claim 1, comprising:

a drive unit (106) positioned inside the stationary portion (102), wherein drive unit (106) is coupled to the retractable portion (104), and wherein the drive unit (106) is configured to move the retractable portion (104) between the retracted position and the extended position.

3. The blade (100) as claimed in claim 2, wherein the drive unit (106) comprises:

a linkage assembly (108) comprising a plurality of linkages (110), the plurality of linkages (110) being interconnected, wherein the linkage assembly (108) is configurable between a contracted state and an expanded state by movement of the plurality of linkages (110), wherein the linkage assembly (108) is coupled to the retractable portion (104), and wherein:

the contracted state of linkage assembly (108) corresponds to the retracted position of the retractable portion (104) of the blade (100), and

the expanded state of linkage assembly (108) corresponds to the extended position of the retractable portion (104) of the blade (100); and

a driving source coupled to linkage assembly (108) and configured to cause the linkage assembly (108) to be configured between the contracted state and the expanded state.

4. The blade (100) as claimed in claim 3, wherein the linkage assembly (108) further comprises:

a plurality of rollers (112), wherein each of the plurality of rollers (112) is coupled to each of the plurality of linkages (110); and

at least one cord member (114) coupled to the driving source, wherein the at least one cord member (114) is configured to interconnect the plurality of rollers (112).

5. The blade (100) as claimed in claim 3, wherein the driving source is an electric motor.

6. The blade (100) as claimed in the claim 1, comprising:

at least one lateral flap (116) coupled to one of the stationary portion (102) or the retractable portion (104), wherein in the extended position of the retractable portion (104), the at least one lateral flap (116) is configured to lock with one of the retractable portion (104) or the stationary portion (102), respectively; and

at least one side flap (118) coupled to one of the retractable portion (104) or the stationary portion (102), wherein in the extended position of the retractable portion (104), the at least one side flap (118) is configured to lock with the stationary portion (102) or the retractable portion (104), respectively.

7. The blade (100) as claimed in claim 6,

wherein the at least one lateral flap (116) is operable by a first actuator, wherein the first actuator causes the at least one lateral flap (116) to open or close,

wherein the at least one side flap (118) is operable by a second actuator, wherein the second actuator causes the at least one side flap (118) to open or close.

8. A method of installing a blade (100) of a wind turbine, the method comprising:

receiving the blade (100) at a wind turbine site, wherein the blade (100) comprises:

a stationary portion (102) having a first end and a second end, wherein the blade (100) is configured to be installed on a rotor of the wind turbine via the first end of the stationary portion (102), wherein the stationary portion (102) has a hollow region extending from the second end of the stationary portion (102) towards the first end of the stationary portion (102); and

a retractable portion (104) movable between a retracted position and an extended position through the second end of the stationary portion (102), wherein in the retracted position, the retractable portion (104) is configured to be positioned substantially inside the hollow region of the stationary portion (102), and in the extended position, the retractable portion (104) is configured to be positioned substantially or completely outside the hollow region of the stationary portion (102),

wherein the blade (100) is received at a wind turbine site with the retractable portion (104) in the retracted position; and

triggering the retractable portion (104) to move from the retracted position to the extended position and coordinate with the stationary portion (102) to form the full-length of the blade (100).

9. A method as claimed in claim 8, comprising:

mounting the blade (100) on the wind turbine, with the retractable portion (104) of the blade (100) in one of the retracted position or the extended position.

10. A method as claimed in claim 8, comprising:

causing to lock at least one lateral flap (116) with one of the retractable portion (104) or the stationary portion (102) of the blade (100) in the extended position of the retractable portion (104); and

causing to lock at least one side flap (118) with one of the stationary portion (102) or the retractable portion (104) in the extended position of the retractable portion (104).

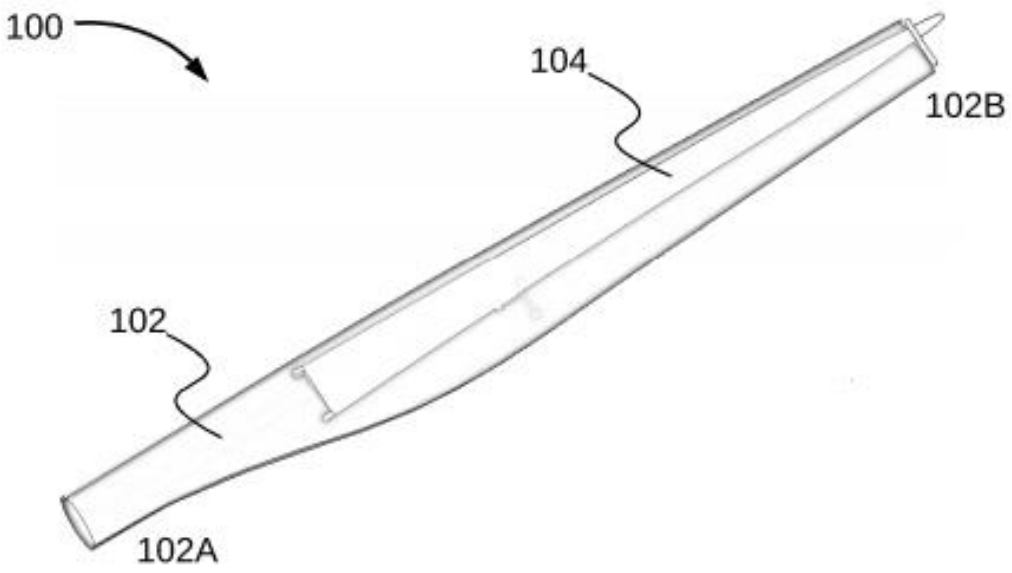
Dated this 31st Day of March 2020

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.
L&T Technology Services Limited
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai 600089.

TELESCOPIC TYPE TIP DESIGN FOR WIND TURBINE ROTOR BKADE USING LINK MECHANISM

ABSTRACT

A blade (100) of a wind turbine is disclosed. The blade (100) may include a stationary portion (102) having a first end and a second. The stationary portion (102) may have a hollow region extending from the second end of the stationary portion (102) towards the first end of the stationary portion (102). The blade (100) may further include a retractable portion (104) movable between a retracted position and an extended position through the second end of the stationary portion (102). In the retracted position, the retractable portion (104) may be positioned substantially inside the hollow region of the stationary portion (102). In the extended position, the retractable portion (104) may be positioned substantially or completely outside the hollow region of the stationary portion (102). In the extended position, the retractable portion (104) coordinates with the stationary portion (102) to form the full-length of the blade (100).



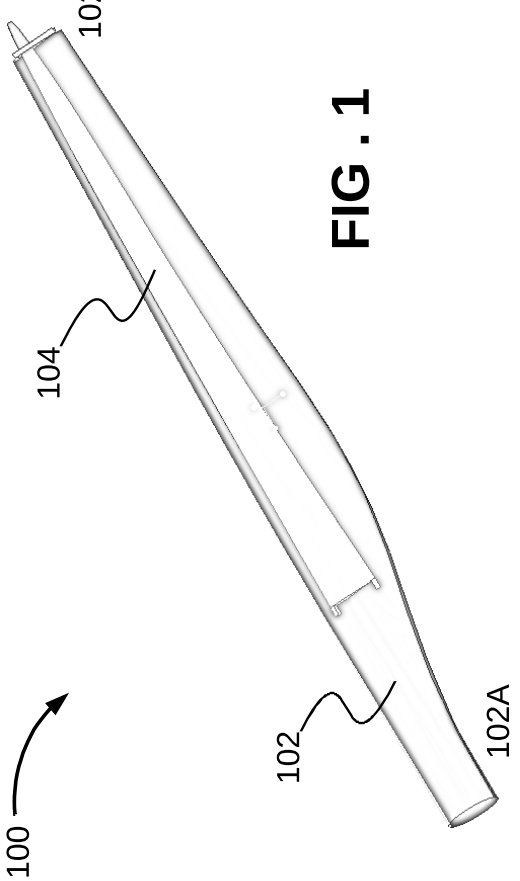


FIG . 1

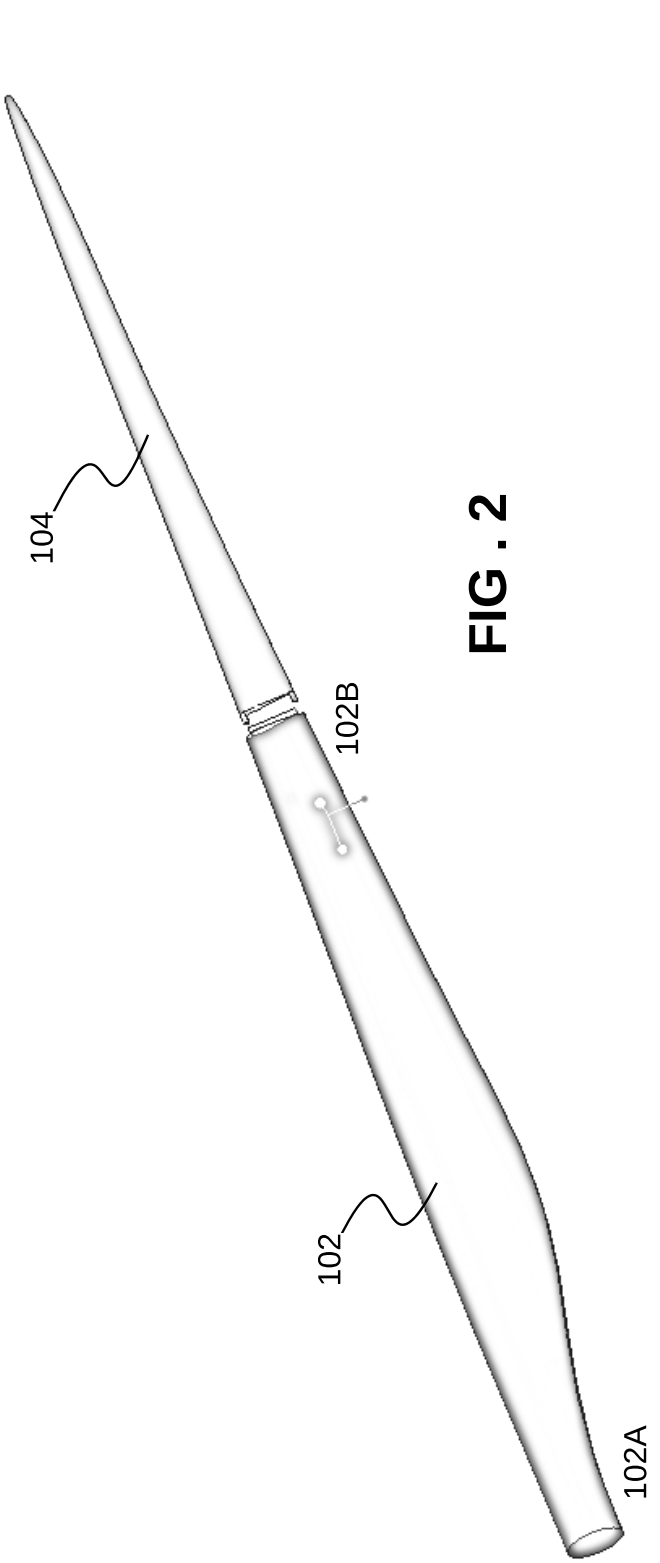


FIG . 2

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

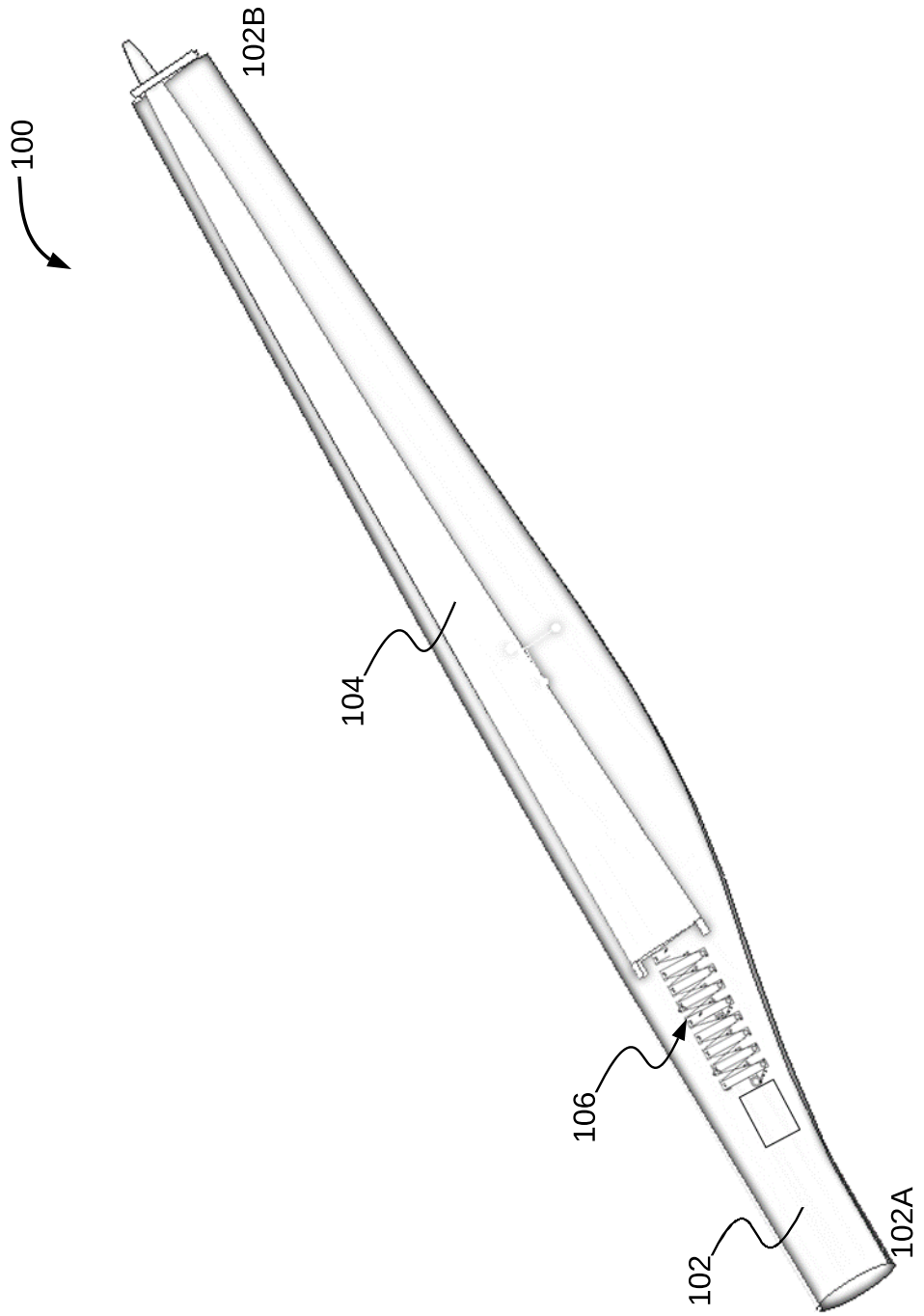


FIG . 3

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Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

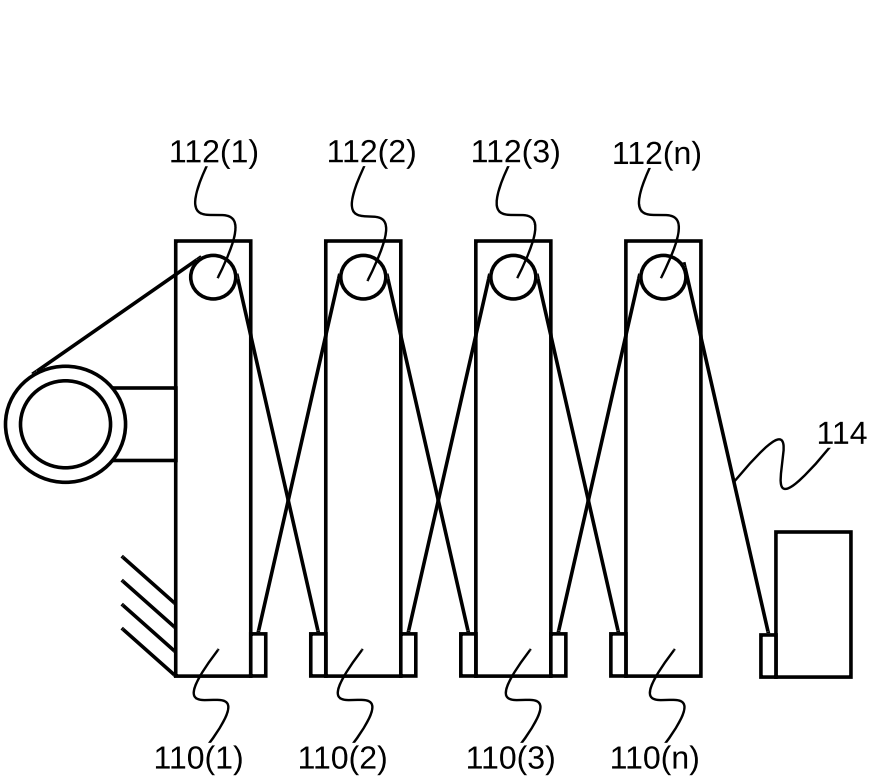

FIG. 4

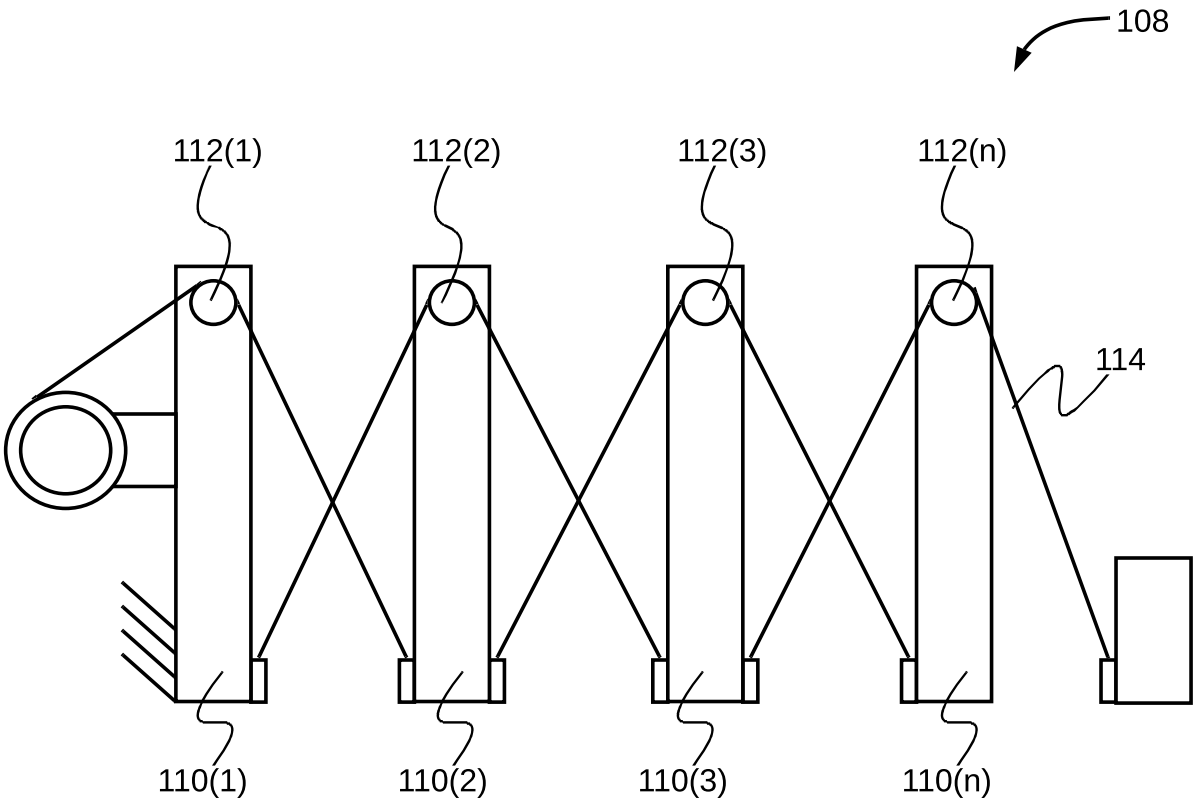

FIG. 5

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Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

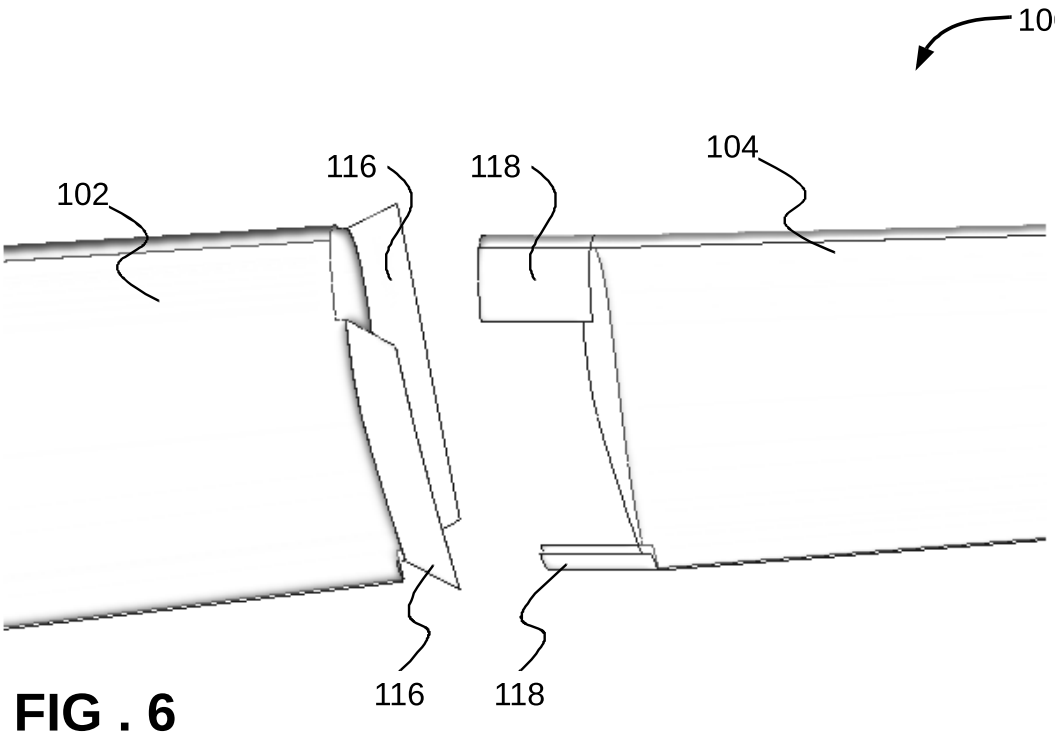

FIG . 6

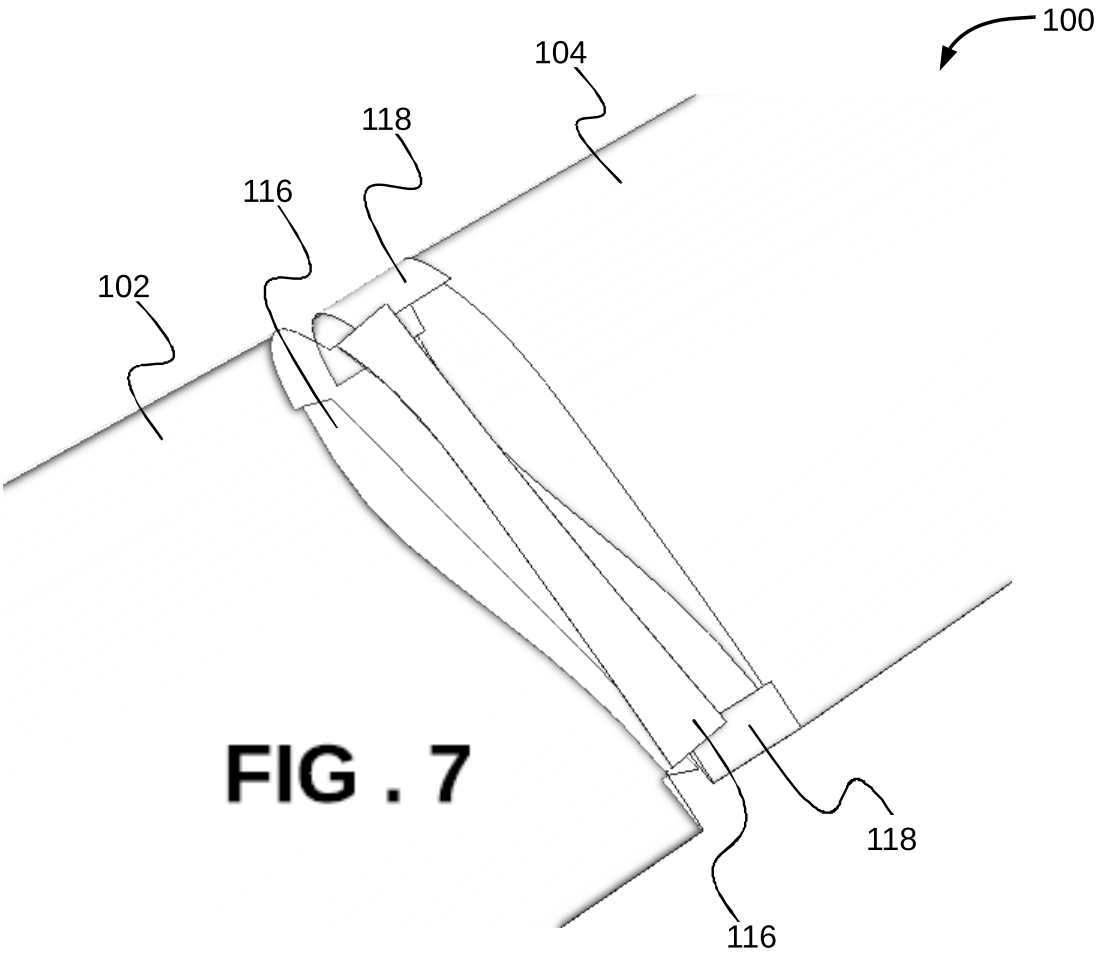

FIG . 7

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Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

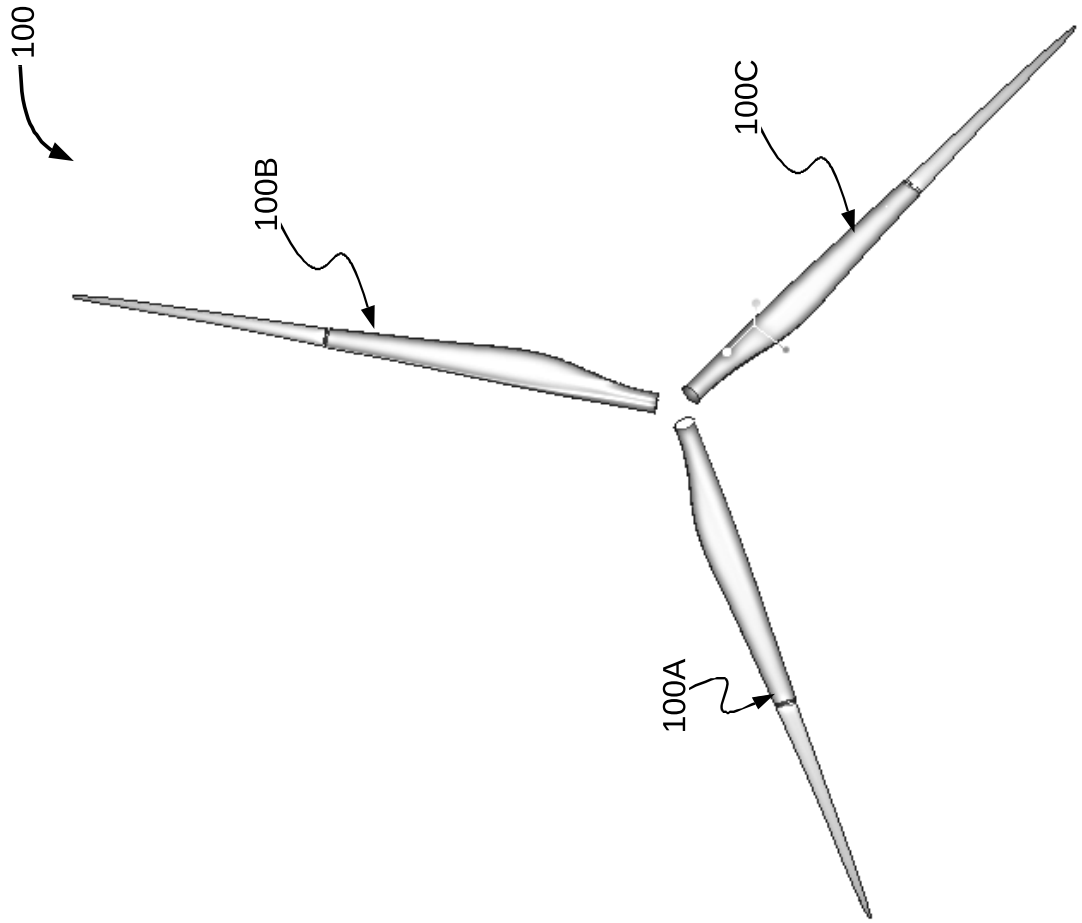

FIG . 9

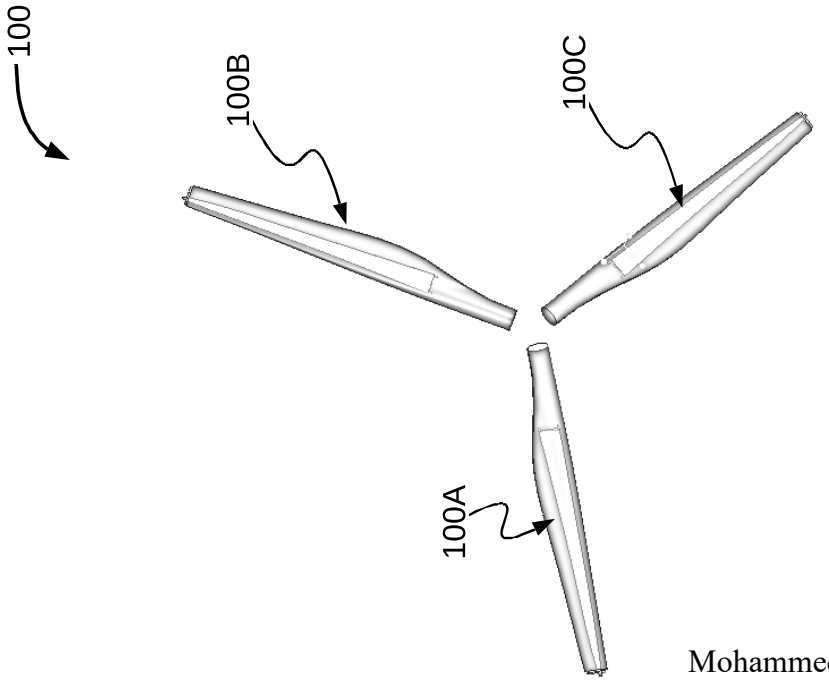

FIG . 8

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.

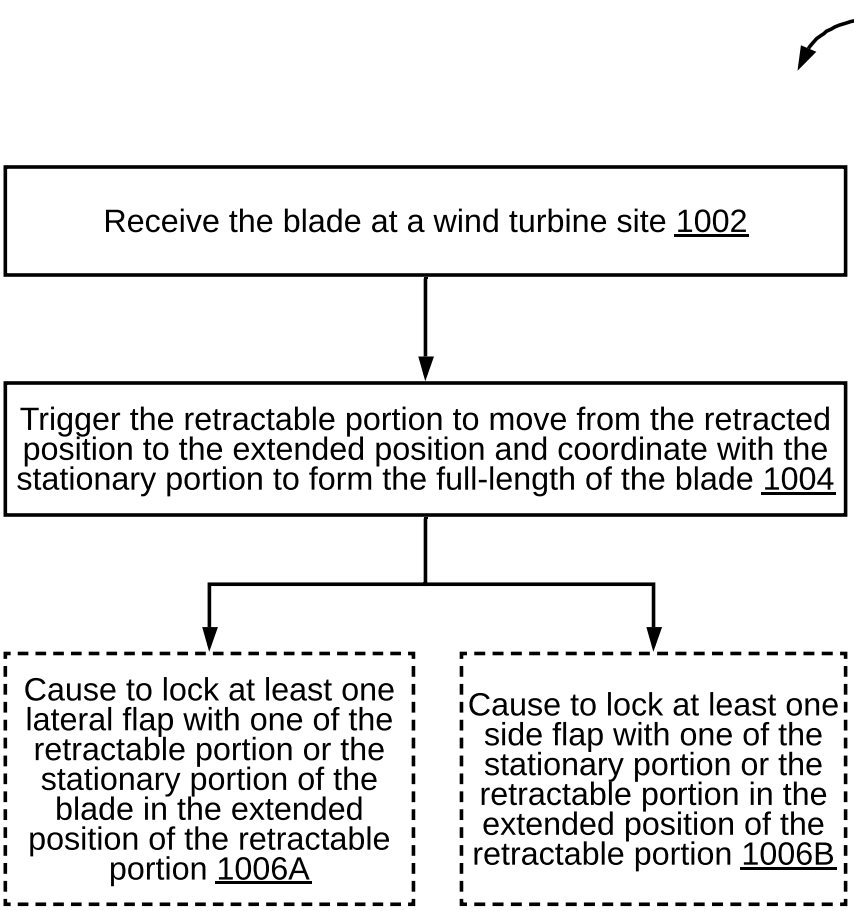

FIG . 10

Mohammed Faisal (INPA No: 1941)
Head, IPR Dept.,
L&T Technology Services Limited,
DLF 3rd Block, 2nd Floor,
Manapakkam, Chennai - 600089.