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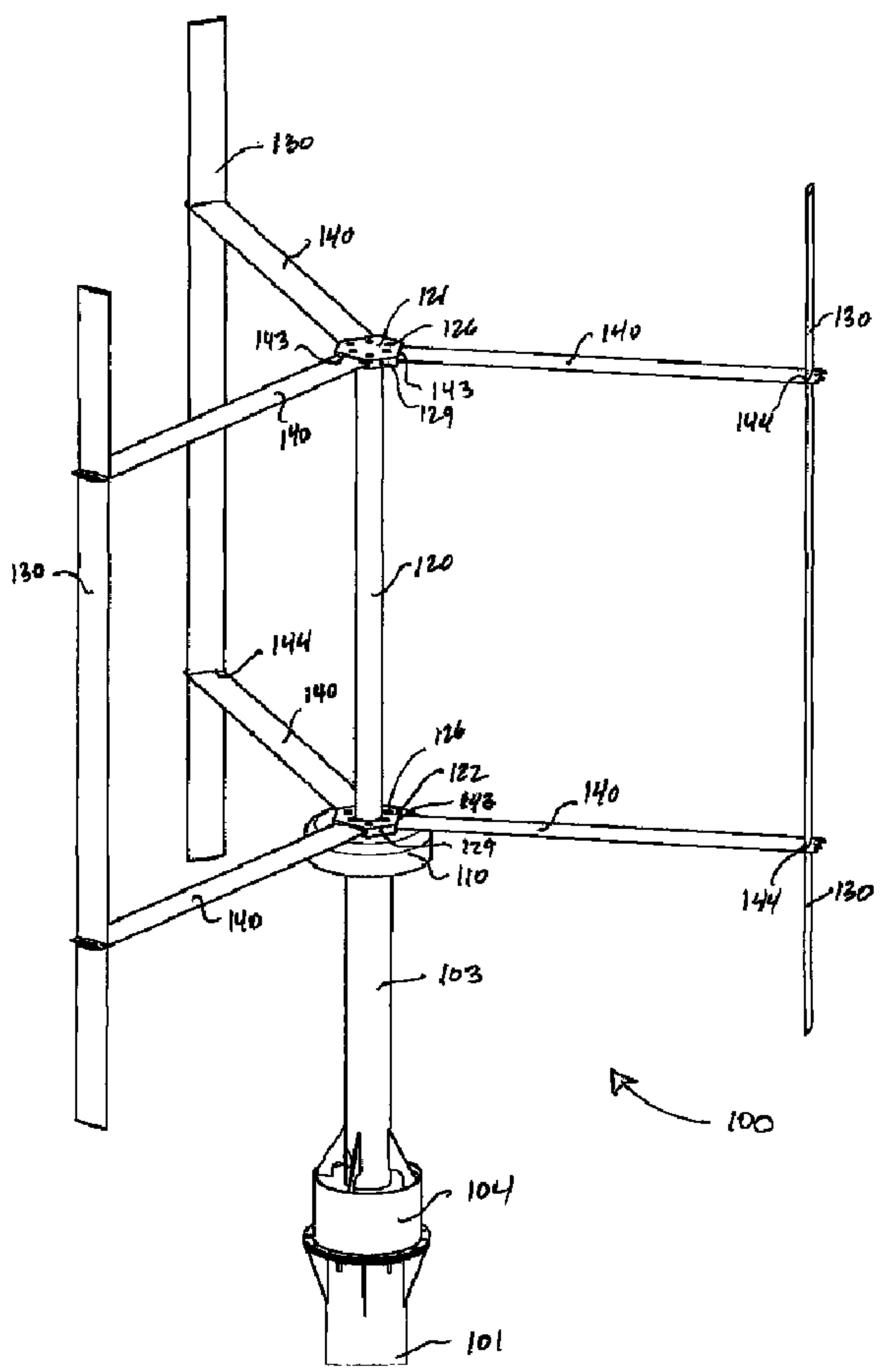
(54) Title: WIND TURBINE STRUCTURE AND METHOD OF ASSEMBLY



(57) Abrégé/Abstract:
There is provided a vertical axis wind turbine comprising a generally vertical tower, a generally vertical rotatable shaft co-extending from the tower, a plurality of generally vertical aerofoil-shaped blades, a plurality of elongated supporting arms and a plurality of

(57) Abrégé(suite)/Abstract(continued):
elongated tensioning members, wherein each of said arms defines at least one axial cavity for receiving at least one of said tensioning members connecting said blade to said shaft while submitting said arm to a compression stress The wind turbine may further comprise a shaft stabilizing assembly comprising at least three wheels having a compliant outer layer, said wheels being rotatably mounted on the tower for rotatably and radially supporting the shaft. The invention is further concerned with a method of assembly of the turbine.

ABSTRACT OF THE DISCLOSURE

There is provided a vertical axis wind turbine comprising a generally vertical tower, a generally vertical rotatable shaft co-extending from the tower, a plurality of generally vertical aerofoil-shaped blades, a plurality of elongated supporting arms and a plurality of elongated tensioning members, wherein each of said arms defines at least one axial cavity for receiving at least one of said tensioning members connecting said blade to said shaft while submitting said arm to a compression stress The wind turbine may further comprise a shaft stabilizing assembly comprising at least three wheels having a compliant outer layer, said wheels being rotatably mounted on the tower for rotatably and radially supporting the shaft. The invention is further concerned with a method of assembly of the turbine.

TITLE OF THE INVENTION

WIND TURBINE STRUCTURE AND METHOD OF ASSEMBLY

FIELD OF THE INVENTION

[0001] The present invention generally relates to wind motors with rotation axis substantially at right angle to wind direction. More specifically, but not exclusively, the present invention is concerned with a Darrieus Giromill-type vertical axis wind turbine having a structure adapted for cost effective construction and maintenance and efficient vibration damping. The invention is further concerned with a method of assembly of the wind turbine.

BACKGROUND OF THE INVENTION

[0002] Many vertical axis wind turbine structures have been taught in the prior art, based on the early concept of Darrieus patented in 1931. The turbine according to this concept consists of a number of generally vertical aerofoil blades mounted on a vertical rotating shaft. Although this type of structure has some advantages over the propeller type, some difficulties tend to limit usage.

[0003] One problem encountered with the Darrieus turbine is the high centrifugal forces on the structure, since the majority of the mass of the rotating mechanism is at the periphery rather than proximal to the shaft. Therefore, many structures of the prior art have been trying to improve strength by using heavier parts and a plurality of struts and/or tie wires which increase weight and aerodynamic drag, leading to lower efficiency and higher costs. For example, Lux, in patent application No WO2008/131519, discloses a structure wherein exposed cables encircle the turbine to keep blades and arms in a pre-stressed condition. Another common approach is to curve the blades into a so called "egg-beater" shape so that they are self supported, do not require heavy supports and mountings and bring the center of mass of the mechanism nearer to the shaft and to the axis of the central tower. However, such a structure has the down side of reducing the torque resulting by the lift force vector of the blade on the shaft, whereby in turn reducing efficiency.

[0004] Another problem arising is the sinusoidal pulsing torque due to the changing angle of attack as the turbine spins. This causes vibration and risks of resonance and breakage at different speeds. Also, since vertical wind turbines are mostly permanently mounted using welded or riveted assemblies and sealed ball or roller bearings for the shaft, repairs are complex and expensive. In addition, broken portions of the rotating parts such as blades and arms may become loose and hazardous for the surrounding structures and people.

[0005] An object of the present invention is therefore to provide a vertical wind turbine structure and a related method of assembly that obviate the limitations and drawbacks of the prior art wind rotors and methods. Namely, it is an object of the present invention to provide improved resistance to centrifugal forces and vibrations, cost effective packaging, transport and maintenance, and lower risk of having broken parts becoming loose and hazardous for the environment.

SUMMARY OF THE INVENTION

[0006] More specifically, in accordance with the present invention, there is first provided a vertical axis wind turbine comprising a generally vertical tower, a generally vertical rotatable shaft co-extending from the tower, a plurality of generally vertical aerofoil-shaped blades, a plurality of elongated supporting arms and a plurality of elongated tensioning members, wherein each of said arms defines at least one axial cavity for receiving at least one of said tensioning members connecting said blade to said shaft while submitting said arm to a compression stress.

[0007] According to an aspect of the present invention, the blades may be removably assembled to the tensioning members. The tensioning members and the supporting arms may also be removably assembled to the shaft.

[0008] According to a another aspect of the invention, the at least one cavity may comprise at least a first cavity for receiving a first tensioning member and a second cavity for receiving a second tensioning member.

[0009] According to another aspect of the invention, the tensioning members may comprise rods having threaded end portions. According to a further aspect, tensioning members may comprise wires.

[0010] According to a further aspect of the invention, the turbine may further comprise safety wires and the blades may define axial cavities, whereby safety wires may be routed through at least some of the blade and/or arm cavities for retaining blade or arm portions secured together and possibly to the shaft in case of breakage.

[0011] According to a further aspect of the invention, supporting arms may define an aerofoil shape. The arms may also define the same profile as the blades. The arms and the blades may also be fabricated from a similar elongated member, which may be obtained by extrusion of metallic or thermoplastic material, or pultrusion or molding of composite material.

[0012] According to a still further aspect of the invention, the turbine may further comprise at least three wheels having a compliant outer layer, said wheels being rotatably mounted on the tower for rotatably and radially supporting the shaft.

[0013] According to a further aspect of the present invention, there is provided a method for assembling a wind turbine, the method comprising: i) providing a shaft having a connecting hub; a turbine blade; an elongated tensioning member and at least one elongated supporting arm defining an axial cavity for receiving the tensioning member; and ii) removably securing a first end of the tensioning member to the hub; iii) inserting the tensioning member throughout said arm through said cavity; iv) removably securing the blade to a second end of the tensioning member, whereby the blade and the arm are compressed between the hub and the second end of the tensioning member. The method may further comprise the step: v) adjusting a tension in said tensioning member for compressing the blade and the arm with a predetermined stress.

[0014] Therefore, the structure and the associated method of assembly of the present invention may provide a wind turbine that can be easily assembled and disassembled, can withstand high operating stress, can be easily and cost effectively maintained and repaired, and can remain safe even if some parts fail.

[0015] The foregoing and other objects, advantages and features of the present invention will become more apparent upon reading of the following non-restrictive description of an illustrative embodiment thereof, given by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Similar parts are identified by identical or similar numbers throughout the drawings. In the appended drawings:

[0017] Figure 1 is a general isometric view of a wind turbine structure according to an embodiment of the present invention;

[0018] Figure 2 is an enlarged isometric view of the top portion of the wind turbine structure of Figure 1, to show details of the turbine mechanism;

[0019] Figure 3 is an isometric view showing details of a top connecting hub and assembly of the turbine structure of Figures 1 and 2;

[0020] Figure 4 is an isometric view of the top assembly of Figure 3, with tensioning rods secured to the hub;

[0021] Figures 5a and 5b are isometric views as seen respectively from a proximal and a distal end of the top assembly of Figure 4, with a blade supporting arm mounted on the tensioning rods;

[0022] Figure 6 is an isometric view of the top assembly of Figure 5, showing a blade mounted at an end of the tensioning rods;

[0023] Figures 7a and 7b are isometric views of the top assembly of Figure 6, showing a blade conforming securing sleeve (figure 7a) and an end cap (Figure 7b);

[0024] Figures 8a and 8b are isometric views showing internal details of a shaft stabilizing assembly according to an aspect of the invention. In Figure 8b, a supporting arm has been removed to show details of a lower connecting hub of the wind turbine.

DETAILED DESCRIPTION

[0025] Referring principally to Figures 1 and 2, the non-restrictive illustrative embodiment of the present invention is first basically concerned with wind turbine structure **100** comprising a central tower **101** defining a base section **102**, a top section **103** and an intermediate generator section **104**. The top tower section is terminated by a shaft stabilizing assembly **110**, being shown in greater detail at Figures 8a and 8b.

[0026] The turbine structure **100** further comprises a generally vertical shaft **120** extending from the top section **103** of the tower **101** and rotatably coupled thereto and to the generator section **104** in a manner that will be described hereinafter. The shaft **120** is provided with a top connecting hub **121** and a lower connecting hub **122** strongly secured thereto to transmit a heavy torque. Hubs **121** and **122** are adapted for removably securing a plurality of straight generally vertical blades **130** and a plurality of upper and lower blade supporting arms **140** to the shaft **120**.

[0027] According to the Darrieus concept, the blades **130** are provided with an aerofoil shape so to generate a lift force thereon when being stricken by the wind, in turn generating a torque causing rotation of the shaft **120**. Straight vertical blades are provided pursuant to the Giromill type of rotor for optimal efficiency for a given turbine diameter. In addition, in order to minimize aerodynamic drag, the blade supporting arms **140** are also provided with an aerofoil shape. Actually, in a preferred embodiment of the invention, blades **130** and arms **140** are fabricated from similar elongated members, which may be obtained by extrusion of metallic material such as aluminum. Extrusion of a thermoplastic material or pultrusion or molding of composite material may also be contemplated. As shown in Figures 5a and 5b, arms **140**, and similarly blades **130**, have a hollow cross section defining a plurality of elongated cylindrical through cavities such as channels **141** and circular cavities **142**.

[0028] Turning now more specifically to the top assembly of Figure 3, the top connecting hub **121** defines a generally hexagonal plate having three similar arm connecting faces such as **125**. A pair of holes **126** is provided across the plate in front of each face **125**. A second pair of holes **127** is drilled from the face **125** to open up in the holes **126**. The hub **121** further comprises a pair of ridges **128** projecting from the face **125** and having a shape and size adapted to conform to and snugly fit into the channels **141** of the arms **140**. It is to be noted that the lower hub **122** has a similar structure to that of hub **121** for securing arms **140** thereto, except that the plate has an annular shape to be traversed by the shaft **120**. Securing threaded holes such as **129** are further provided to secure the hub **122** to the shaft **120** using set screws (not shown).

[0029] Referring now to Figure 4, the wind turbine **100** further comprises a plurality of tensioning members such as rods **150**, having a first threaded end **151** adapted to be snugly inserted into holes **127** and extend into holes **126** to be screwed into a threaded hole provided in a side wall of a generally cylindrical barrel **153** axially sled into hole **126**. Thereby, a rod **150** may be accurately assembled without having to provide lateral blind threaded holes in the hubs **121** and **122** for receiving the rod ends **151**.

[0030] As shown in Figure 5a and 5b, the arms **140** may then be mounted on the rods **150** by inserting the rods through the circular cavities **142**. When the end **143** of the arm **140** abuts on the face **125** of the hub **121**, ridges (not shown) projecting from the surface **125** may penetrate into the channels **141** to lock the arm and prevent rotation about its longitudinal axis. A total of six arms **140** are similarly mounted on top hub **121** and lower hub **122** using twelve rods.

[0031] Turning now to Figure 6, there is shown that blades **130** are provided with upper and lower pairs of through holes **135** adapted to snugly receive the second ends **152** of the rods **150**. The distal ends of the arms **144** are shaped to conform to the aerofoil profile of the blades **130** so that each blade can be inserted on the ends **152** of the top and lower pairs of rod **150** and stably rest against arm distal ends **144**. Alternatively, the ends **144** may be cut straight and molded shape adapting spacers comparable to part **160** shown in Figure 7a may be inserted on the rod ends **152** between the arm ends **144** and the blades **130**. The blades **130** are secured in place as seen from Figure 7a, using a shape conforming end sleeve **160** and fasteners such as nuts (not shown) fastened on threaded portions of rod ends **152**. An end cap **161** may be further mounted on the sleeve **160** to provide a clean finish as shown in figure 7b. An important aspect of the invention is that fastening of the nuts is performed to yield a desired tension in the tensioning rods **150**, in turn compressing the blades **130**, the arms **140** and the sleeves **160** between the hubs **121, 122** and the rod ends **152** terminated by removable fasteners. Given the thus provided pre-stressed assembly, the mechanism better withstands centrifugal forces and vibrations to keep the wind turbine **100** rigid without the help of external struts or tie wires adding weight and aerodynamic drag to the turbine.

[0032] Referring to Figures 8a and 8b, a shaft stabilizing assembly **110** will now be described. The assembly **110** is devised to provide radial rotary support about the shaft **120** as a ball or roller bearing would do, but with major improvements. The stabilizing assembly **110** is mainly comprised of at least three wheels **111**, each having a low friction center hub **112**, rotatably mounted on shafts **113** projecting upwardly from the support ring **114**. The hubs **112** may comprise permanently lubricated bushings or ball bearing couplings. Each wheel **111** is further provided with a peripheral layer of compliant material **115** such as rubber or an elastomeric material such as polyurethane or neoprene. The wheels **111** are equally distributed about a circular path concentric with the shaft **120** and so assembled to contact the shaft to provide radial rotary support thereof. Thanks to the compliant material a soft coupling with the shaft is enabled, thereby preventing any gap therebetween and providing shaft vibration damping. Moreover, maintenance of the assembly **110** is facilitated since wheels **111** may be easily replaced without removing the shaft **120**.

[0033] The lower end of the shaft **120** is directly connected to and supported by the upwardly projecting shaft of an electrical power generator (not shown) mounted into the generator compartment **104**. It is worth mentioning however that thanks to the aerofoil profile of the arms **140,** proper angular tilting of the arms with respect to wind direction may create a vertical lift transferred to the shaft **120**, in turn lowering the axial load and friction on the generator shaft bearing device in compartment **104** to improve efficiency and prevent wear.

[0034] According to another aspect of the present invention, the wind turbine **100** may be provided with an additional feature to further improve a safety aspect. Indeed, given the hollow structure of the blades **130** and the arms **140** provided with longitudinal channeling cavities such as **141**, safety wires may be routed through the inside of the structure to provide a safety linkage between the parts, so to hold to the shaft any portion of a part becoming loose following breakage. For example, cables may have a first end connected to the hub **121**, be routed through the arms **140** and blades **130**, and have a second end connected to the hub **122**, or through the shaft **120** to form a loop. Wires may advantageously run from one end of each blade **120** to the other to retain all part attached in case of failure at the connection with the arms.

[0035] It is also contemplated that tensioning rods may be substituted by other tensioning members such as wires by providing appropriate fastening means to connect to the hubs **121**, **122** and end caps **160**. Such wires may in addition provide the safety securing function by connecting together blade and arm parts that are subject to failure.

[0036] There is further provided a method for assembling a wind turbine. The exemplary method first comprises the step of providing a shaft having a connecting hub; a turbine blade; an elongated tensioning member and at least one elongated supporting arm defining an axial cavity for receiving the tensioning member. A second step comprises removably securing a first end of the tensioning member to the hub as illustrated in Figure 4. Step 3: inserting the tensioning member throughout said arm through said cavity as shown in Figures 5a and 5b. Step 4: removably securing the blade to a second end of the tensioning member, as illustrated in Figures 6, 7a and 7b, whereby the blade and the arm are compressed between the hub and the second end of the tensioning member. The method may further comprise a fifth step comprising adjusting a tension in said tensioning member for compressing the blade and the arm with a predetermined stress.

[0037] It can be easily appreciated that the above-described non-restrictive illustrative embodiment of the wind turbine structure and method of assembly according to the present invention obviates the above-discussed limitations and drawbacks of the prior art wind rotors and methods. More specifically, the wind turbine according to the present invention is better adapted to withstand the effects of centrifugal stresses and vibrations, is more reliable, easier and less expensive to maintain, and is safer.

[0038] Although the present invention has been described hereinabove by way of non-restrictive, illustrative embodiments thereof, these embodiments can be modified at will within the scope of the appended claims without departing from the spirit and nature of the subject invention.

WHAT IS CLAIMED IS:

1. A vertical axis wind turbine comprising a generally vertical tower, a generally vertical rotatable shaft co-extending from the tower, a plurality of generally vertical aerofoil-shaped blades, a plurality of elongated supporting arms and a plurality of elongated tensioning members, wherein each of said arms defines at least one axial cavity for receiving at least one of said tensioning members connecting said blade to said shaft while submitting said arm to a compression stress.

2. A vertical axis wind turbine according to claim 1, further comprising a shaft stabilizing assembly comprising at least three wheels having a compliant outer layer, said wheels being rotatably mounted on the tower for radially and rotatably supporting the shaft.

3. A method for assembling a wind turbine, the method comprising: i) providing a shaft having a connecting hub; a turbine blade; an elongated tensioning member and at least one elongated supporting arm defining an axial cavity for receiving the tensioning member; and ii) removably securing a first end of the tensioning member to the hub; iii) inserting the tensioning member throughout said arm through said cavity; iv) removably securing the blade to a second end of the tensioning member, whereby the blade and the arm are compressed between the hub and the second end of the tensioning member.

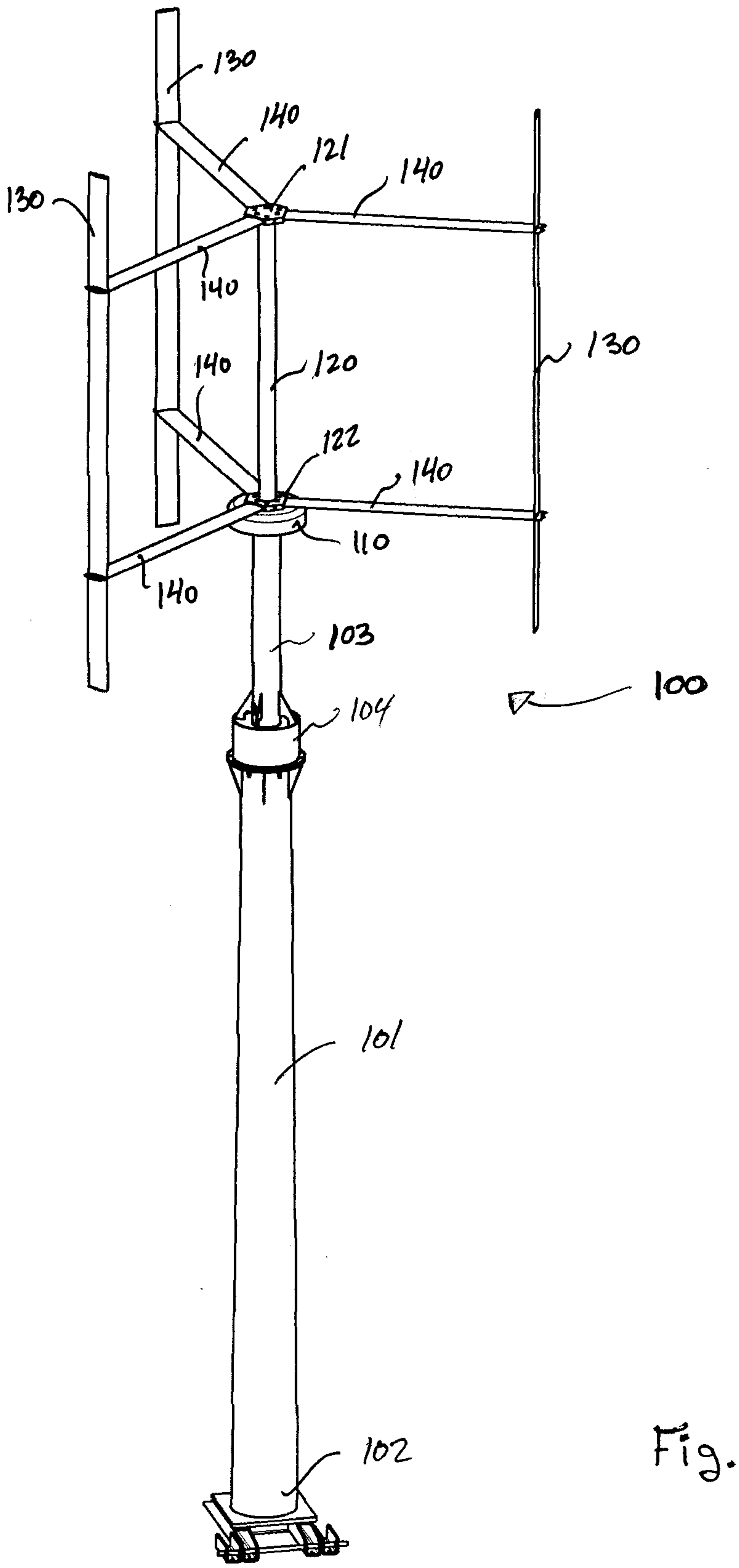

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Fig. 1

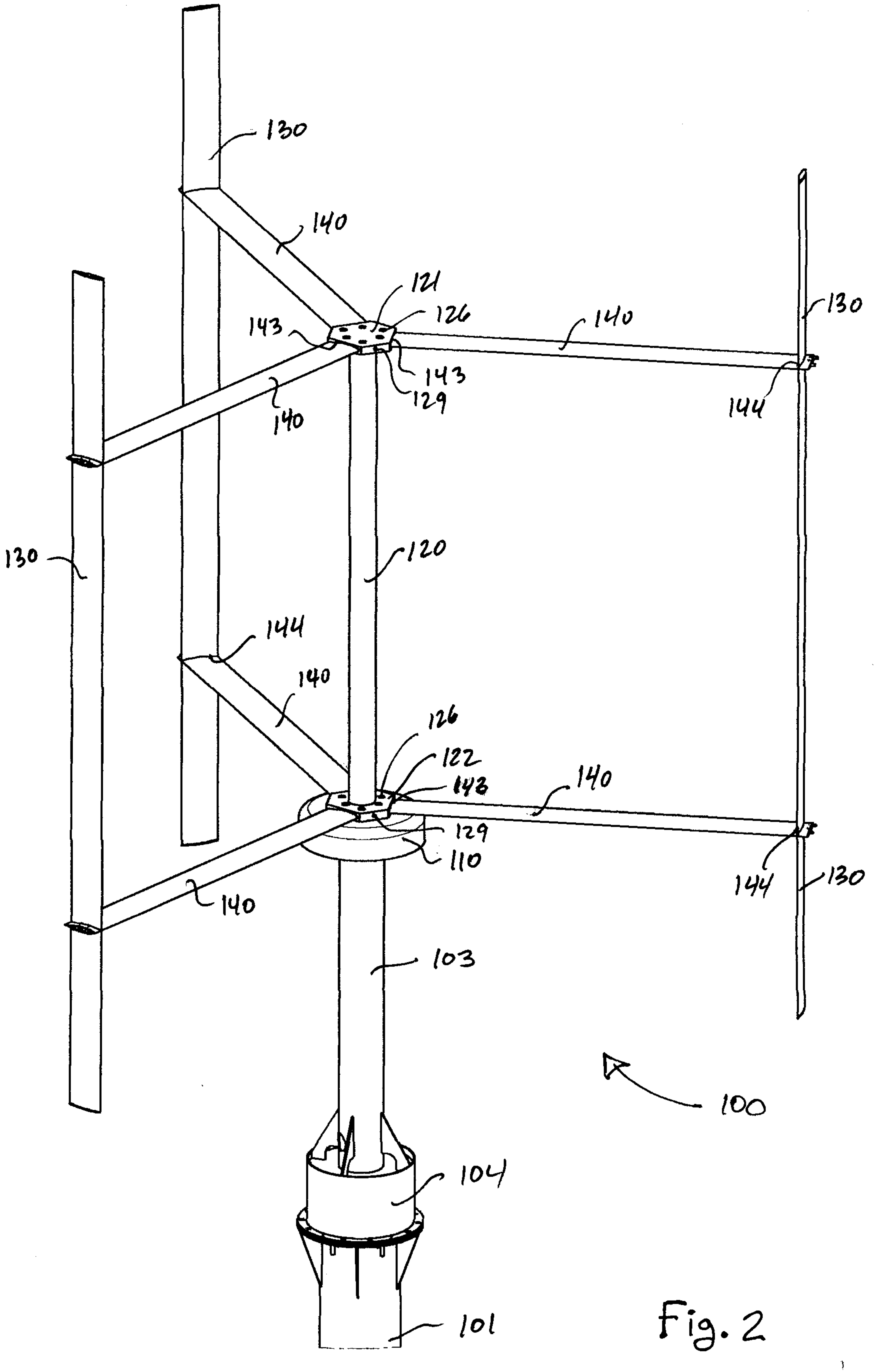
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Fig. 2

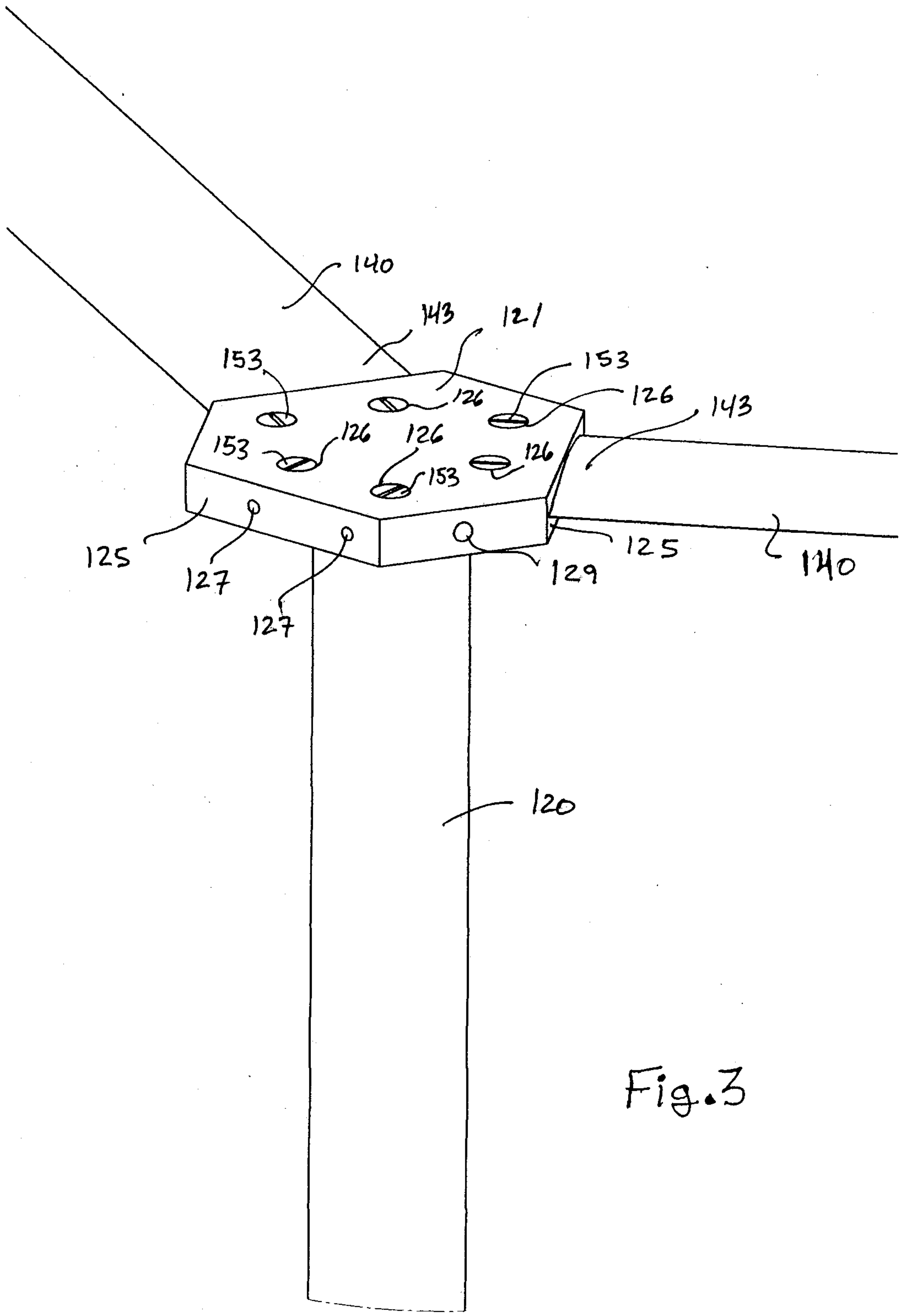
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Fig.3

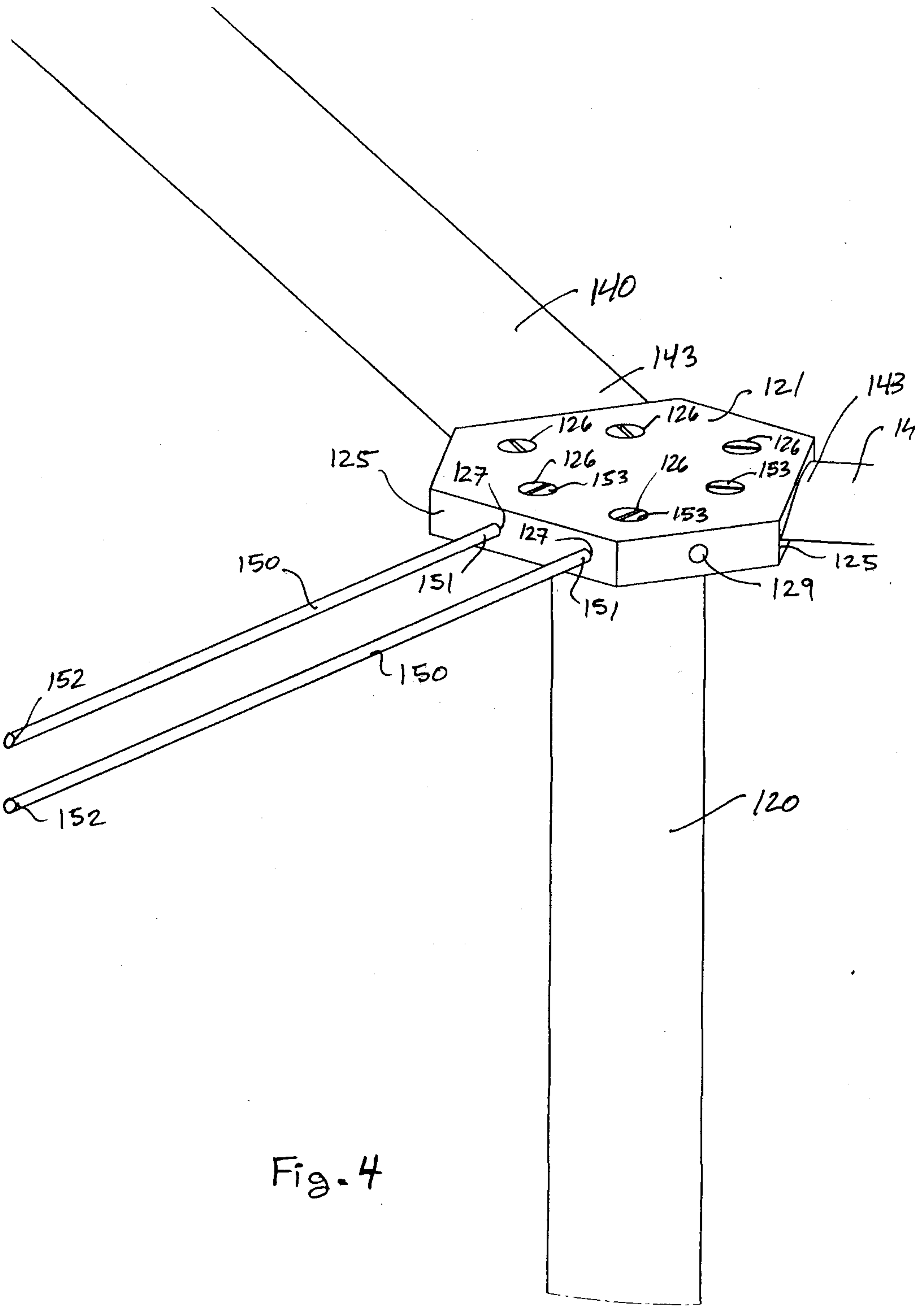
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Fig. 4

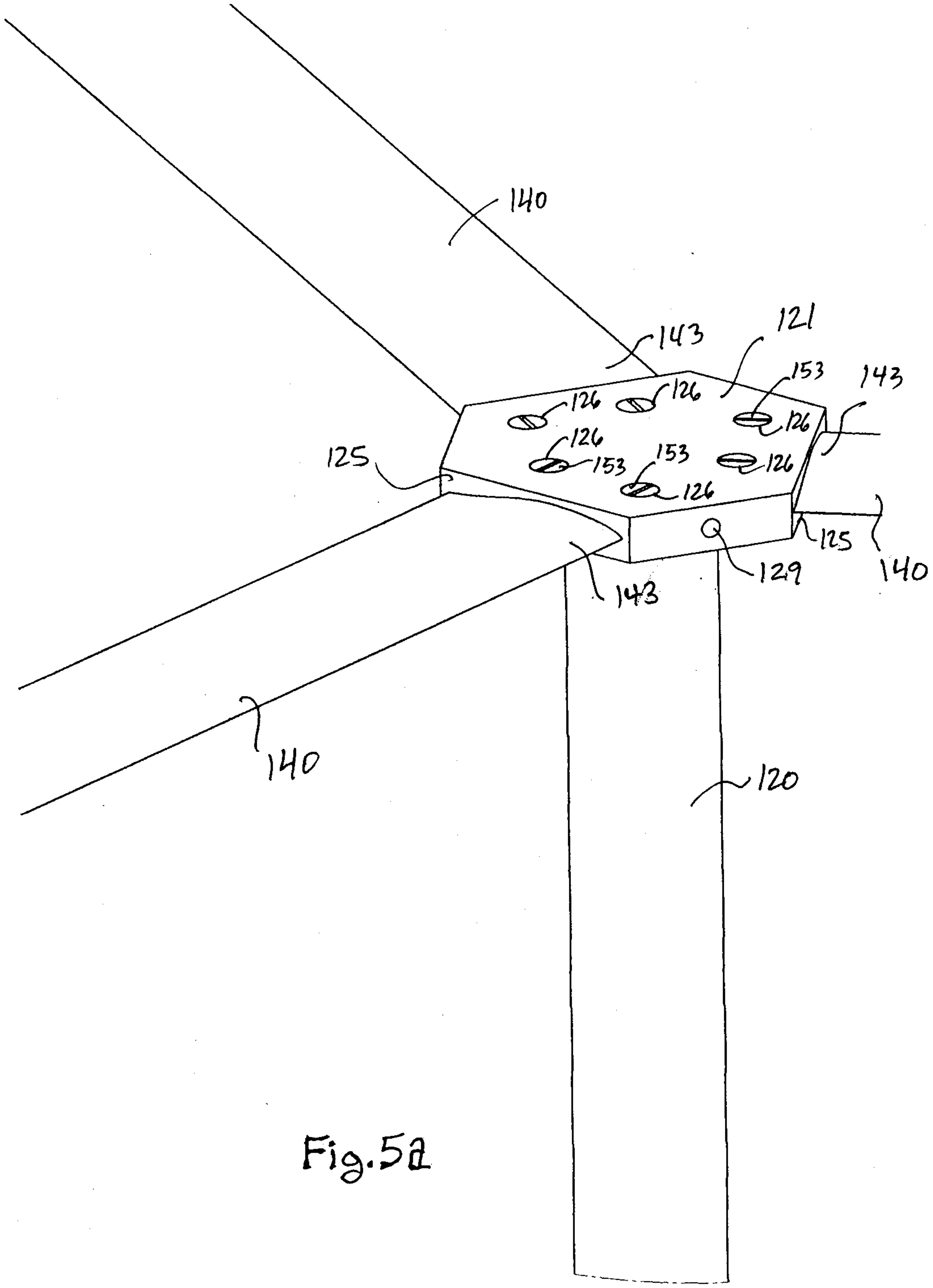
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Fig.5a

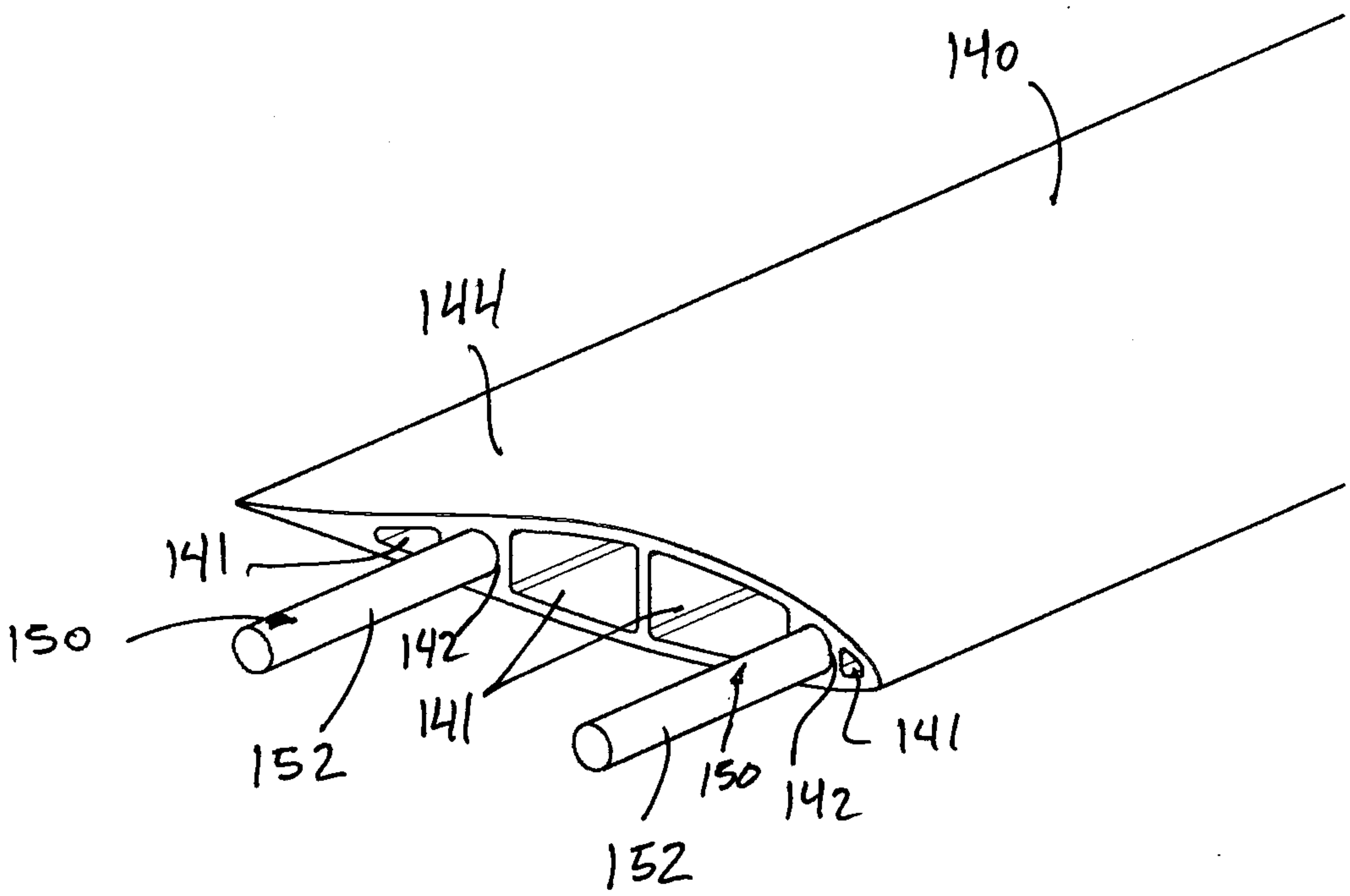

Fig. 5b

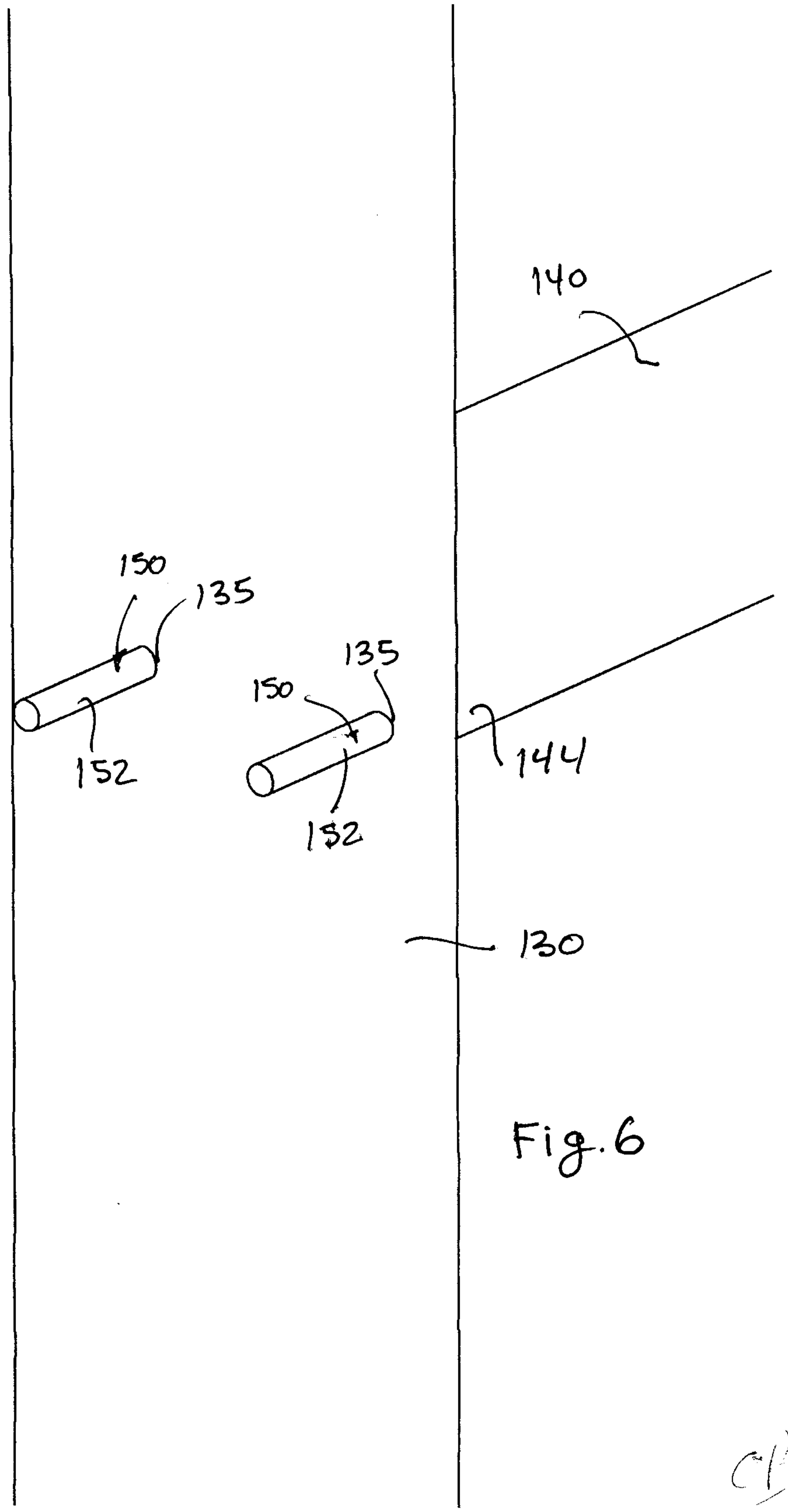

Fig. 6

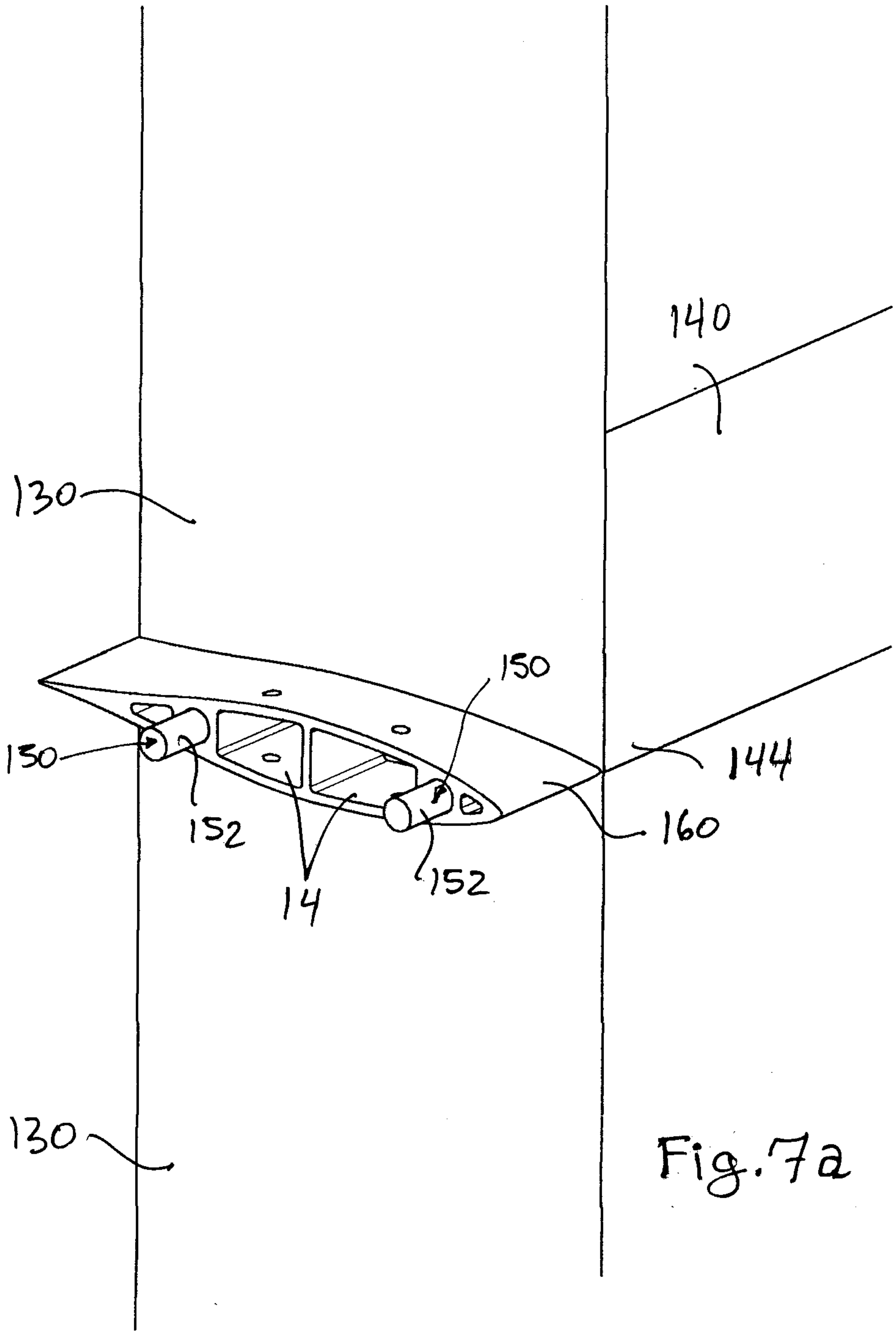

Fig.7a

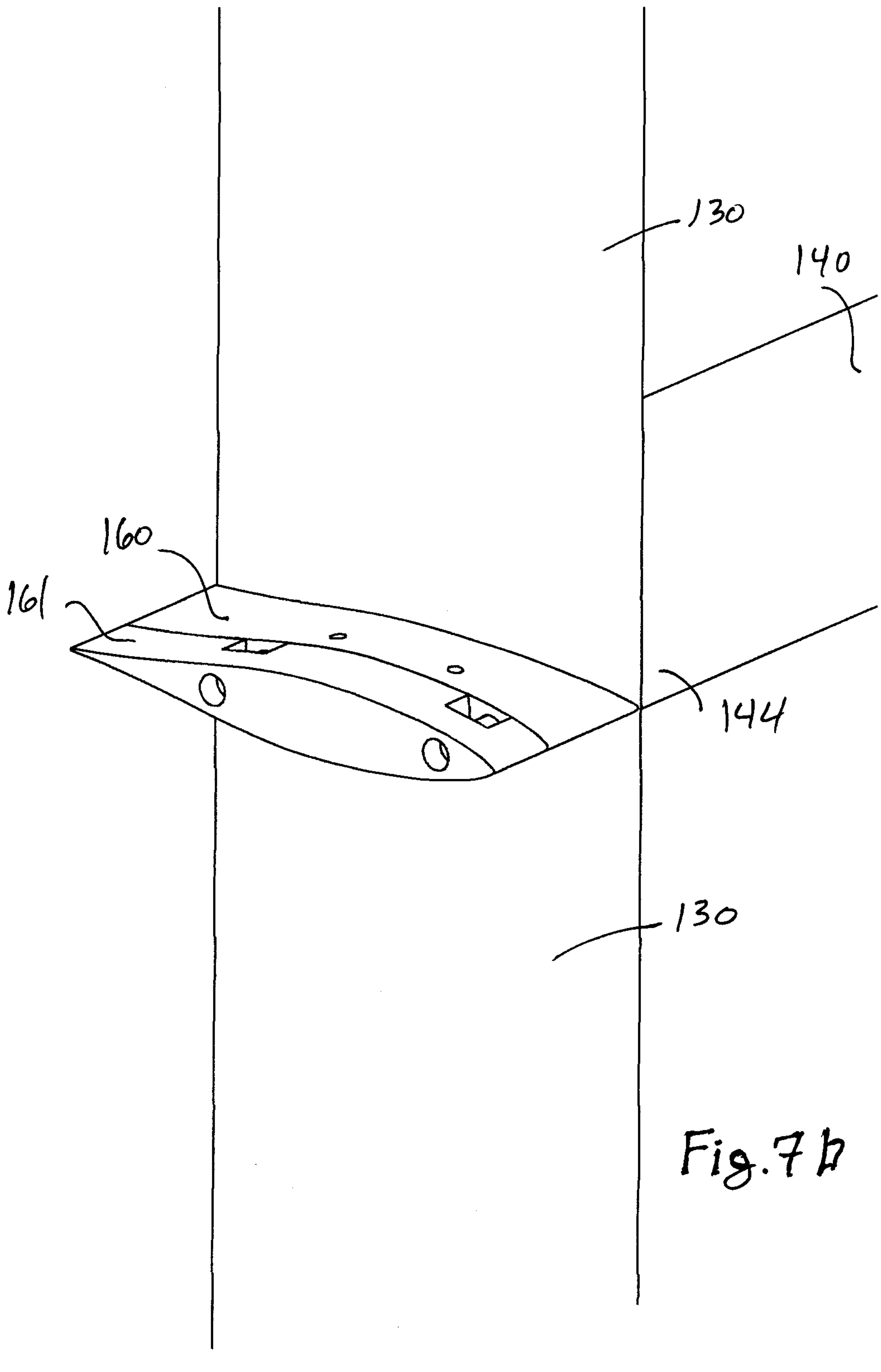

Fig.7b

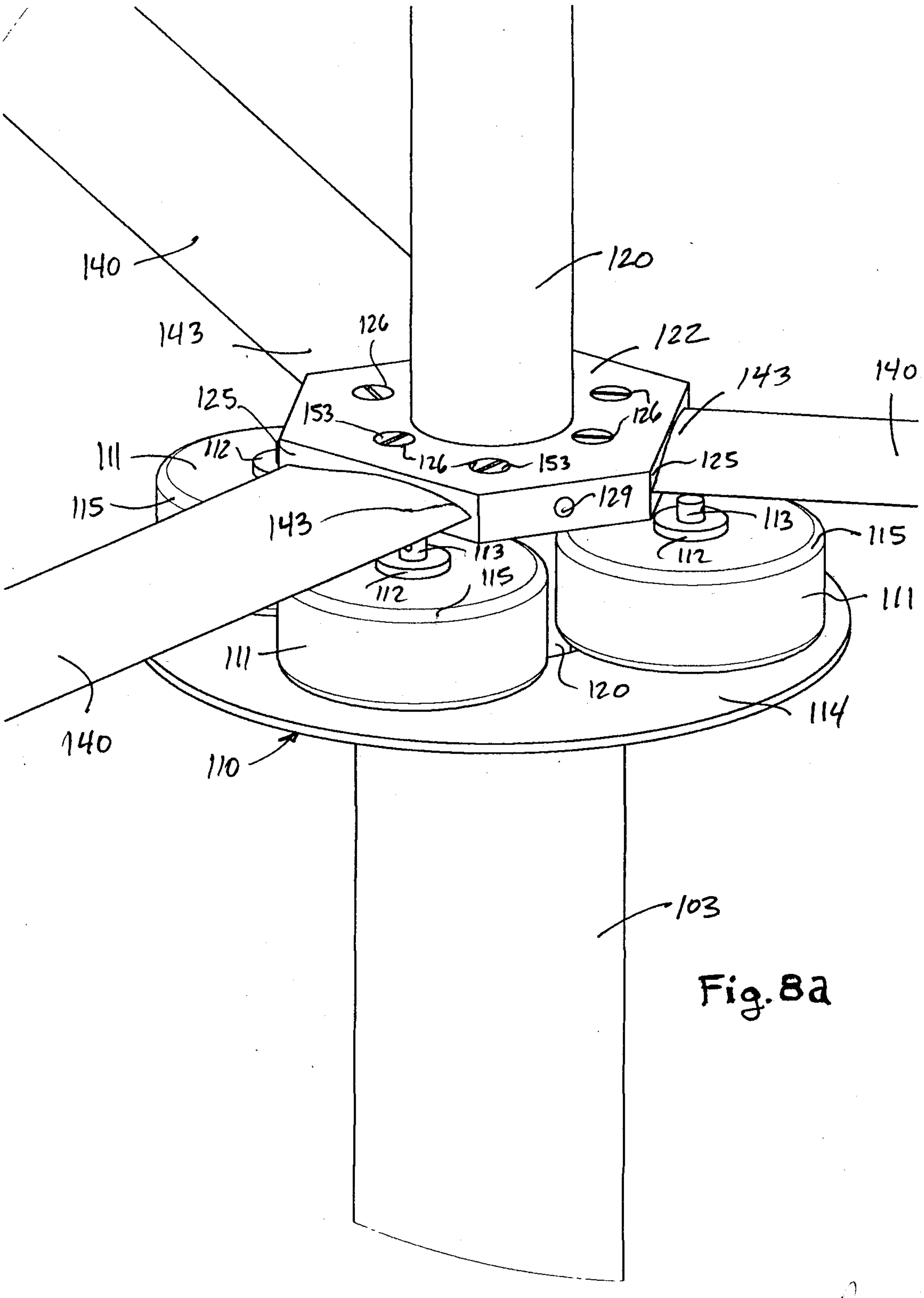
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Fig.8a

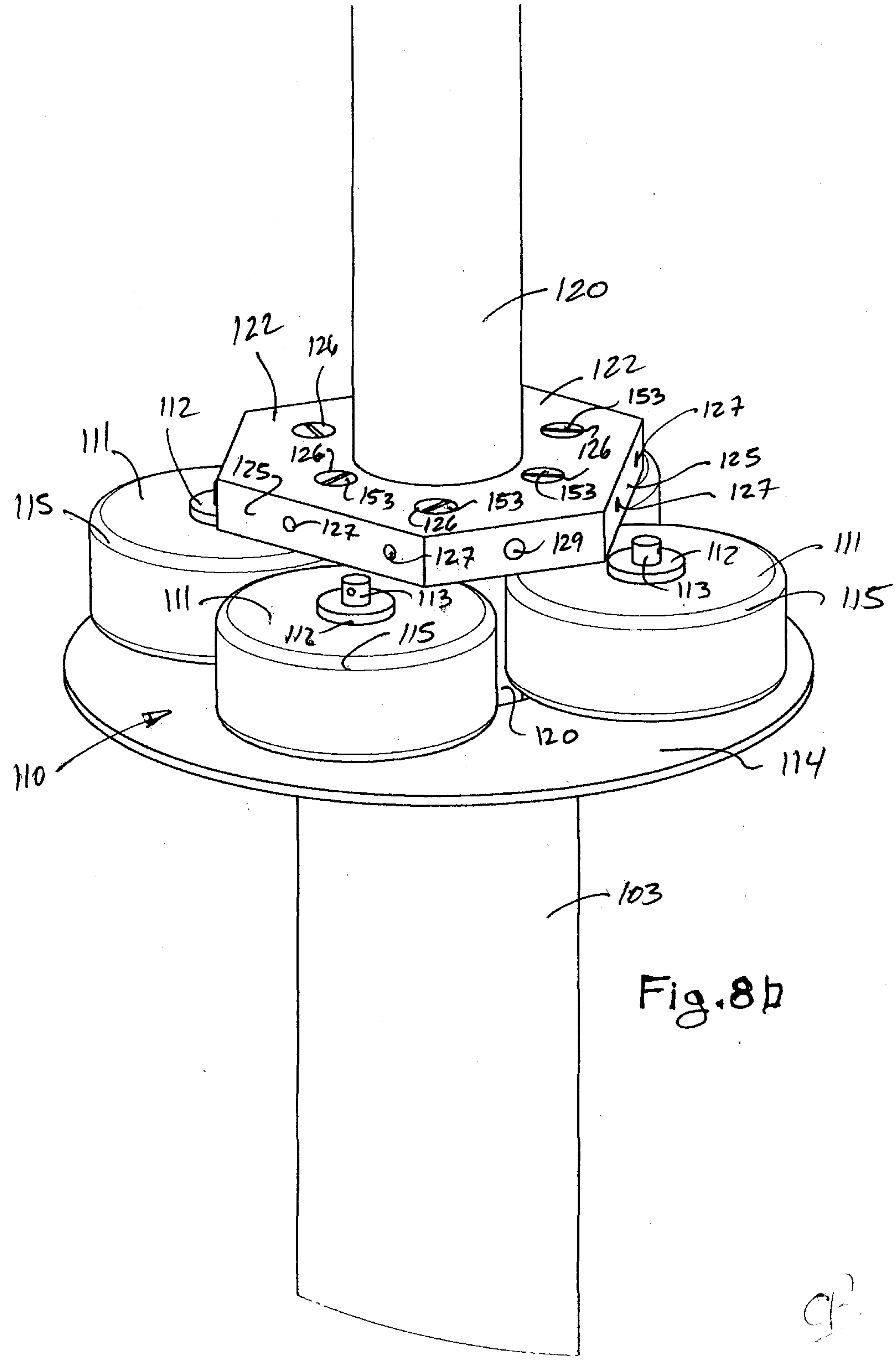
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Fig. 8b

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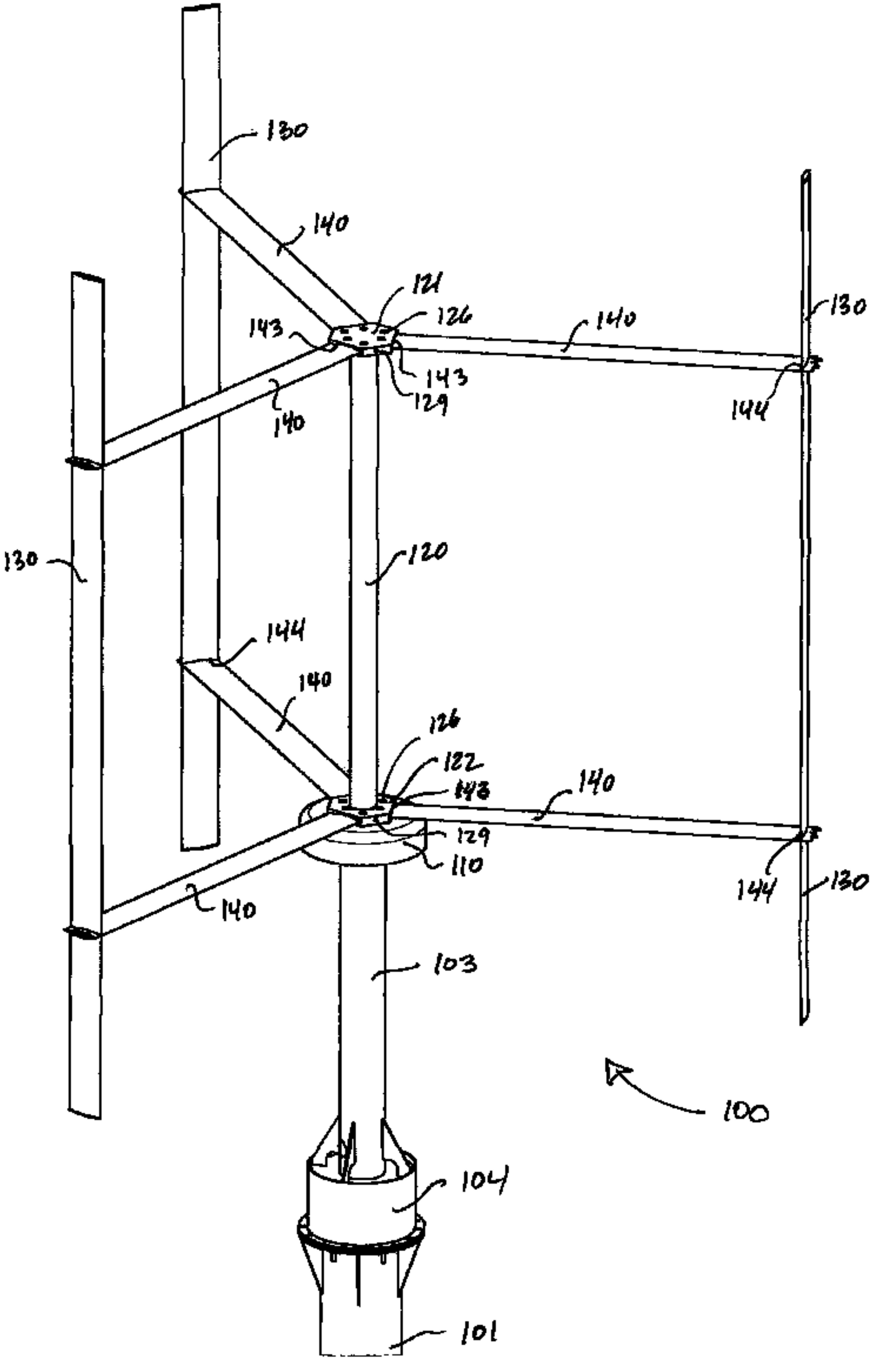
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