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(54) Benævnelse: **TÅRNKONSTRUKTION OMFATTENDE EN TÅRNFLANGE**

(56) Fremdragne publikationer:
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DESCRIPTION

FIELD OF THE INVENTION

[0001] The present invention relates generally to wind turbines, and more particularly, to tower flanges for wind turbines that can accommodate foundations or turbines of varying sizes with one common tower.

BACKGROUND OF THE INVENTION

[0002] Wind power is considered one of the cleanest, most environmentally friendly energy sources presently available, and wind turbines have gained increased attention in this regard. A modern wind turbine typically includes a tower, a generator, a gearbox, a nacelle, and one or more rotor blades. The rotor blades capture kinetic energy from wind using known airfoil principles and transmit the kinetic energy through rotational energy to turn a main shaft coupling the rotor blades to a gearbox, or if a gearbox is not used, directly to the generator. The generator then converts the mechanical energy to electrical energy that may be deployed to a utility grid. US 2015/376859 A1 relates to a fatigue resistant foundation. A tower receiving component comprises an embedded cylindrical metal tower section with means for connecting to a tower section such as a flange. EP 2 009 202 A2 relates to a tower of a wind turbine, including a tower section made from steel connectable to a tower section made of concrete material. The tower section made of concrete material includes a head section. A flange is provided in the foot of the tower section made of steel.

[0003] The wind turbine tower typically includes a base tower section secured to a foundation and one or more upper tower sections secured atop the base tower section. The foundation may be a concrete slab foundation, an anchor cage foundation, or any other suitable foundation capable of supporting loads produced by the wind and/or gravitational forces. For typical wind turbines, the base tower section may be secured directly to the foundation. Alternatively, e.g. where the manufacturer of the foundation and the tower are different, such as in a repower situation, a tower base adapter may be required since the bolt holes of the base tower section and the foundation do not align. In other words, for each different tower configuration, either a separate tower adaptor and/or a redesign of the base tower section are required.

[0004] Accordingly, an improved tower flange for a wind turbine tower that addresses the aforementioned issues would be desired in the art. Thus, the present disclosure is directed to a tower flange for a wind turbine tower that can accommodate machine heads (i.e. nacelles) or foundations of varying sizes.

BRIEF DESCRIPTION OF THE INVENTION

[0005] Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

[0006] In one aspect, the present disclosure is directed to a tower assembly according to claim 1. A tower assembly for securing a tower of a wind turbine to a foundation includes a base tower section and a tower flange integral with the base tower section. The tower flange includes a substantially cylindrical wall defining an outer diameter and an inner diameter separated by a radial thickness. Further, the radial thickness is oversized to accommodate foundations of varying sizes. The tower assembly also includes a foundation having a base portion and a mounting portion embedded within the base portion. The mounting portion defines an outer diameter and an inner diameter separated by a radial thickness. Further, the tower flange is secured to the mounting portion of the foundation. Thus, a radial offset is defined between the outer diameter of the tower flange and the outer diameter of the foundation.

[0007] In one embodiment, the radial thickness of the tower flange is greater than the radial thickness of the foundation. In another embodiment, the cylindrical wall of the tower flange further defines a height. More specifically, in certain embodiments, the height may be oversized as a function of material stress requirements so as to accommodate the radial offset.

[0008] In additional embodiments, the outer diameter of the tower flange is greater than the outer diameter of the mounting portion of the foundation. In alternative embodiments, the outer diameter of the tower flange is less than the outer diameter of the mounting portion of the foundation.

[0009] In further embodiments, the tower flange is further configured to accommodate a variety of bolt hole patterns. In other words, by having a larger radial thickness, the tower flange is able to accommodate a wide range of bolt hole patterns such that a chosen bolt holt pattern can be machined into the tower flange to align with bolt hole pattern of the foundation without changing the forged tower flange.

[0010] In another aspect, the present disclosure is directed to a tower assembly for a wind turbine according to independent claim 5. A tower assembly for a tower of a wind turbine includes a first tower section, a second tower section, and a tower flange integral with each of the first tower section and the second tower section. The tower flange has a substantially cylindrical wall defining an outer diameter and an inner diameter separated by a radial thickness. Further, the radial thickness of one of the flanges is oversized to accommodate tower sections of varying sizes. Thus, the tower assembly also includes a radial offset defined between the outer diameter of the tower flange and an outer diameter of at least one of the first tower section or the second tower section. It should be understood that the tower flange assembly may further include any of the additional features and/or embodiments as described herein.

[0011] In a non-claimed aspect, the present disclosure is directed to a wind turbine. The wind turbine includes a tower having at least one upper tower section. The upper tower section has a tower flange integral therewith. The tower flange has a substantially cylindrical wall defining an outer diameter and an inner diameter separated by a radial thickness. The radial thickness is oversized to accommodate yaw bearings of varying sizes. The wind turbine also includes a nacelle configured atop the tower and a yaw bearing coupled to the tower flange and the nacelle to permit rotation of the nacelle about a yaw axis. Thus, a radial offset is defined between the outer diameter of the tower flange and an outer diameter of the yaw bearing. It should be understood that the wind turbine may further include any of the additional features as described herein.

[0012] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

FIG. 1 illustrates a perspective view of one embodiment of a wind turbine according to the present disclosure;

FIG. 2 illustrates an elevation view of one embodiment of a tower flange assembly securing a base tower section of a wind turbine to a foundation according to the present disclosure;

FIG. 3 illustrates a detailed view of the tower flange assembly of FIG. 2;

FIG. 4 illustrates a top view of one embodiment of a tower flange assembly according to the present disclosure, particularly illustrating a tower flange that can be configured with a plurality of different bolt hole patterns; and

FIG. 5 illustrates a perspective view of one embodiment of a wind turbine according to the present disclosure, particularly illustrating a tower flange assembly at a mid-tower location and a tower flange assembly coupled to a yaw bearing atop the tower; and

FIG. 6 illustrates a detailed view of one embodiment of the tower top tower flange assembly according to the present disclosure;

FIG. 7 illustrates a detailed view of another embodiment of the tower top tower flange assembly according to the present disclosure;

FIG. 8 illustrates a detailed view of a non-claimed tower top tower flange assembly according to the present disclosure, particularly illustrating the tower flange connected to a yaw bearing via a first bolt hole pattern; and

FIG. 9 illustrates a detailed view of another non-claimed tower top tower flange assembly according to the present disclosure, particularly illustrating the tower flange connected to the yaw bearing via a second bolt hole pattern.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

[0015] Generally, the present disclosure is directed to a tower flange for a wind turbine that can accommodate nacelles or foundations of varying sizes. For example, the tower flange of the present disclosure can adapt a common tower to foundations of various sizes. Alternatively, the tower flange of the present disclosure can adapt a common tower to machine heads with various size yaw bearings. Conventional tower flanges are typically sized to optimize the amount of material needed for manufacturing, i.e. due the costs associated with steel. The load path of the structural tower wall is radially aligned keeping stresses and material usage low. Structural connection bolts are placed quite close to the shell wall, which keeps the radial thickness of the typical tower flange small. In contrast, the tower flange of the present disclosure is intentionally oversized such that the flange has a wide horizontal surface and can be used in many different sized bolt patterns within the same forged flange. Thus, the larger radial thickness of the tower flange allows the flange to adapt a standard tower to foundations of various sizes or to machine heads with various size yaw bearings. More specifically, the larger radial flat land space, i.e. referred to herein as the radial thickness, allows the tower flange to be machined to many possible bolt hole patterns. In addition, the tower flange may be thicker, i.e. having an increased vertical height, to handle non-ideal structural geometries, e.g. where the main load path is radially offset due to the diameter of the mating component being larger or smaller. Such a tower flange enables a single or few tower designs (e.g. structure and/or internals) to potentially be used with a range of mating parts (e.g. a foundation, yaw bearing, or mid-height tower sections).

[0016] Referring to the drawings, FIG. 1 illustrates a perspective view of one embodiment of a wind turbine 10 according to the present disclosure. As shown, the wind turbine 10 includes a tower 12 extending from a foundation 14 that sits upon a support surface, a nacelle 16 mounted on the tower 12, and a rotor 18 coupled to the nacelle 16. The tower 12 includes a base tower section 15 and at least one upper section 13. The rotor 18 includes a rotatable hub 20 and at least one rotor blade 22 coupled to and extending outwardly from the hub 20. For example, in the illustrated embodiment, the rotor 18 includes three rotor blades 22. However, in an alternative embodiment, the rotor 18 may include more or less than three rotor blades 22. Each rotor blade 22 may be spaced about the hub 20 to facilitate rotating the rotor 18 to enable kinetic energy to be transferred from the wind into usable mechanical energy, and subsequently, electrical energy.

[0017] As shown in FIGS. 2 and 3, various embodiments of a tower assembly 24 secured to the foundation 14 according to the present disclosure are illustrated. FIG. 2 illustrates a partial, elevation view of one embodiment of the tower assembly 24 secured to the foundation 14. FIG. 3 illustrates a detailed view of the tower assembly 24 of FIG. 2. More specifically, as shown, the tower assembly 24 includes the base tower section 15 and a tower flange 25 that is integral with the base tower section 15. Further, as shown, the foundation 14 includes a base portion 39 and a mounting portion 27. For instance, as shown, the base portion 39 corresponds to a concrete slab foundation, whereas the mounting portion 37 corresponds to a steel mounting ring that is embedded into the base portion 39. Further, as shown particularly in FIG. 3, the tower flange 25 of the base tower section 15 may be secured to the foundation 14 by anchor bolts 32. It should be understood that the anchor bolts 32 may be located outside of the tower, inside the tower (as shown), or both. In addition, the tower assembly 24 may be secured to the foundation 14 using any other suitable means in addition to the anchor bolts 32.

[0018] Referring particularly to FIG. 3, the tower flange 25 may include a substantially cylindrical wall 26 defining an outer diameter 28 and an inner diameter 27 separated by a radial thickness 29. Similarly, the mounting portion 37 of the foundation 14 may include an outer diameter 21 and an inner diameter 19 separated by a radial thickness 23. Thus, as shown, the radial thickness 29 of the tower flange 25 may be greater than the radial thickness 23 of the mounting ring 37 so as to accommodate foundations of varying sizes. Therefore, as mentioned, the larger radial thickness of the tower flange 25 allows the flange 25 to fit most foundation sizes. In addition, as shown, a radial offset 33 in the structural load path of the tower 12 may be defined between the outer diameter 28 of the tower flange 25 and the mounting portion 37 of the foundation 14.

[0019] In addition, as shown in FIG. 3, the cylindrical wall 26 of the tower flange 25 further defines a vertical height 30. More specifically, the height 30 of the tower flange 25 may be oversized (i.e. thicker) to accommodate the radial offset 33 of the varying-sized foundations which are non-ideal structural geometries, e.g. where the main load path is radially offset due to the diameter of the mating component being larger or smaller.

[0020] Referring now to FIG. 4, a top view of one embodiment of the tower flange 25 according to the present disclosure is illustrated, particularly illustrating a plurality of different bolt hole patterns 34 that may be machined therein to accommodate foundations of varying sizes. For example, as shown, the tower flange 25 may accommodate three separate rows of bolt holes 36 capable of aligning with a plurality of tower sections, foundation configurations, and/or yaw bearings. Thus, as mentioned, by having a larger radial thickness 29, the tower flange 25 is able to accommodate a wide range of bolt hole patterns such that the machined bolt hole pattern can be made to align with bolt hole pattern of the foundation without changing the forged tower flange. For example, as shown, the bolt hole pattern 34 may include varying spacing between bolt holes 36 and or varying diameters of bolt holes. Thus, as mentioned, the multiple bolt hole patterns 34 provide a one-size-fits-most tower flange 25.

[0021] Referring now to FIG. 5, further embodiments of the tower assembly 24 of a wind turbine 10 according to the present disclosure are illustrated. More specifically, in one embodiment, the tower assembly 24 may include the larger tower flange 25 located at a mid-height location. As used herein, a "mid-height location" generally refers to any intermediate location along the vertical height of the tower 12 between the foundation 14 and the tower top. Thus, as shown, the large or mega tower flange 25 may be located at an intermediate location equal to about half of the tower height 40. In such embodiments, the radial thickness 29 of the tower flange is oversized to accommodate tower sections of varying sizes. More specifically, a radial offset 43 is defined between the outer diameter of the tower flange 25 and an outer diameter of the first tower section 13. Further, as mentioned, the radial thickness 29 of the tower flange 25 (FIG. 3) is greater than the radial thicknesses of the first tower section 13 so as to accommodate tower sections of varying sizes.

[0022] Referring now to FIGS. 5 and 6, the tower flange 25 may also be located uptower, e.g. integral with the upper tower section 13 of the wind turbine tower 12. More specifically, as shown in FIGS. 5, 8, and 9, the tower flange 25 may be bolted to a yaw bearing 38 that is coupled to the nacelle 16 of the wind turbine 10 to permit rotation of the nacelle 16 about a yaw axis 42. Like the other embodiments described herein, the radial thickness 29 of the tower flange 25 is greater than the radial thicknesses of conventional tower flanges so as to accommodate yaw bearings of varying sizes. Thus, as shown in FIG. 8, the tower flange 25 is bolted to the yaw bearing 38 via a first bolt hold pattern. Alternatively, as shown in FIG. 9, the tower flange 25 is bolted to the yaw bearing 38 via a second bolt hold pattern. As, FIGS. 8 and 9 illustrate how a single tower flange 25 can be machined to accommodate yaw bearings 38 of varying sizes.

[0023] Referring particularly to FIGS. 6 and 7, the tower flange 25 may also be used with a tower adaptor 44 (or an additional tower section) such that the flange 25 can be easily coupled to the nacelle 16. In addition, as shown, the tower flange 25 of the present disclosure may accommodate multiple tower flanges 46, 48 or flanges of varying sizes. More specifically, FIG. 6 illustrates a detailed view of one embodiment of the tower top tower flange assembly 24 according to the present disclosure, particularly illustrating a tower flange 46 having a smaller diameter. In contrast, FIG. 7 illustrates a detailed view of another embodiment of the tower top tower flange assembly 24 according to the present disclosure, particularly illustrating a tower flange 48 having a larger diameter. Further, as shown, the tower flange 25 may be machined to accommodate at least two different bolt hole patterns to accommodate a first smaller tower section 46 and a second, larger tower section 48.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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- US2015376859A1 **[0002]**
- EP2009202A2 **[0002]**

KRAV

1. En tårnkonstruktion (24), der omfatter:

en bundtårnsektion (15);
en tårnflange (25), der er integreret med bundtårnsektionen (15), hvor tårnflangen (25) omfatter en i det væsentlige cylindrisk væg (26), der definerer en ydre diameter (28) og en indre diameter (27) adskilt af en radial tykkelse (29), hvor den radiale tykkelse (29) er overdimensioneret for at kunne rumme fundamenter af varierende størrelser; og
et fundament (14) der omfatter en bunddel (39) og en monteringsdel (37) indlejret i bunddelen (39), hvor monteringsdelen (37) definerer en ydre diameter (21) og en indre diameter (19) adskilt af en radial tykkelse (23), hvor tårnflangen (25) er fastgjort til monteringsdelen (37) af fundamentet (14),
hvor en radial forskydning (33) er defineret mellem den ydre diameter (28) af tårnflangen (25) og den ydre diameter (21) af monteringsdelen (37) af fundamentet (14); og
hvor den radiale tykkelse (29) af tårnflangen (25) er større end den radiale tykkelse (23) af monteringsdelen (37) af fundamentet (14).

2. Tårnkonstruktion (24) ifølge krav 1, hvor den ydre diameter (28) af tårnflangen (25) er større end den ydre diameter (21) af monteringsdelen (37) af fundamentet (14).

3. Tårnkonstruktion (24) ifølge krav 1, hvor den ydre diameter (28) af tårnflangen (25) er mindre end den ydre diameter (21) af monteringsdelen (37) af fundamentet (14).

4. Tårnkonstruktion (24) ifølge et hvilket som helst af de foregående krav, hvor tårnflangen (25) yderligere er konfigureret til at rumme flere forskellige skruehulsmønstre (ENG: bolt hole patterns), hvor et valgt skruehulsmønster til tårnflangen (25) er bearbejdet deri for at tilpasse det med (EN: align with) et skruehulsmønster af fundamentet (14).

5. Tårnkonstruktion (24) til en vindmølle (10), hvor tårnkonstruktionen (24) omfatter:

en første tårnsektion (13);
en anden tårnsektion (15);
en tårnflange (25), der er integreret med den anden tårnsektion (15), hvor tårnflangen (25) omfatter en i det væsentlige cylindrisk væg (26), der definerer en ydre diameter og en indre

diameter adskilt af en radial tykkelse, hvor den radiale tykkelse er overdimensioneret for at kunne rumme tårnsektioner af varierende størrelser,
hvor en radial forskydning (43) er defineret mellem den ydre diameter af tårnflangen (25) og en ydre diameter af den første tårnsektion,
hvor tårnflangen (25) er smedet, og hvor den radiale tykkelse af tårnflangen (25) er større end en radial tykkelse af den første tårnsektion (13).

6. Tårnkonstruktion ifølge krav 5, hvor den første tårnsektion (13) svarer til en øvre tårnsektion (13), og den anden tårnsektion svarer til en bundtårnsektion (15).

7. Tårnkonstruktion ifølge krav 5 eller 6, hvor den ydre diameter af tårnflangen (25) er større end den ydre diameter af den første tårnsektion (13).

8. Tårnkonstruktion ifølge krav 5 eller 6, hvor den ydre diameter af tårnflangen (25) er mindre end den ydre diameter af den første tårnsektion (13).

9. Tårnkonstruktion ifølge krav 5, 6, 7 eller 8, hvor den første og anden tårnsektion (13, 15) omfatter flugtende (EN: aligned) skruehulsmønstre.

DRAWINGS

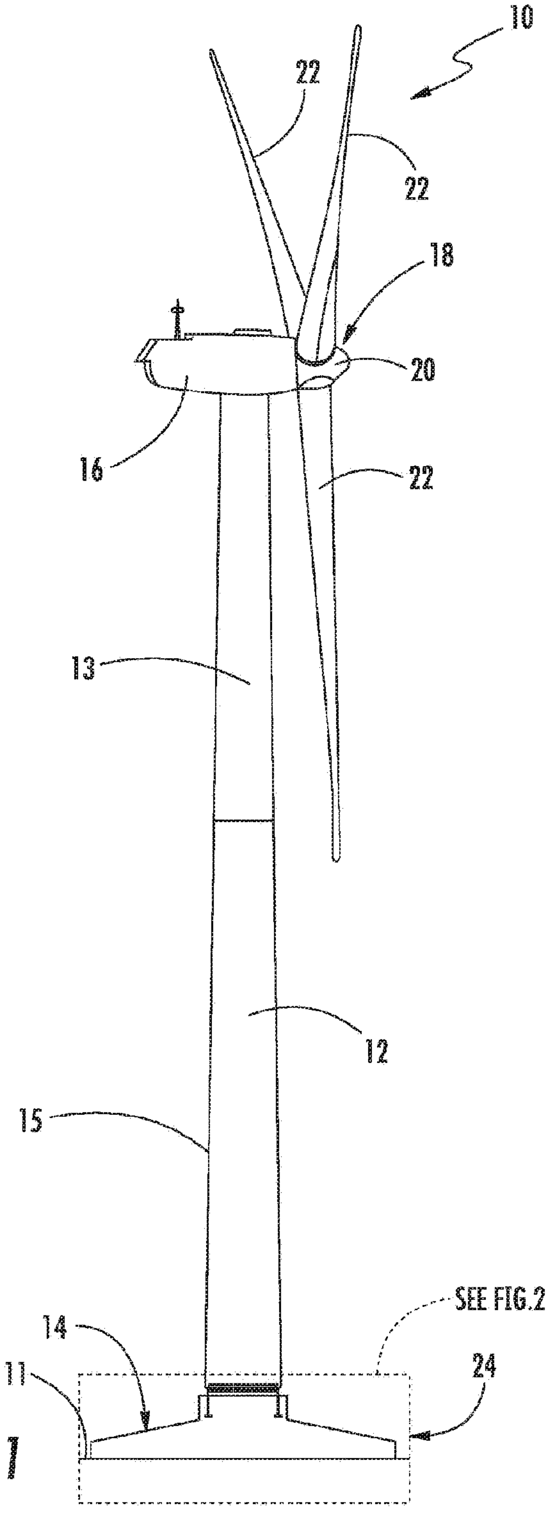

FIG. 1

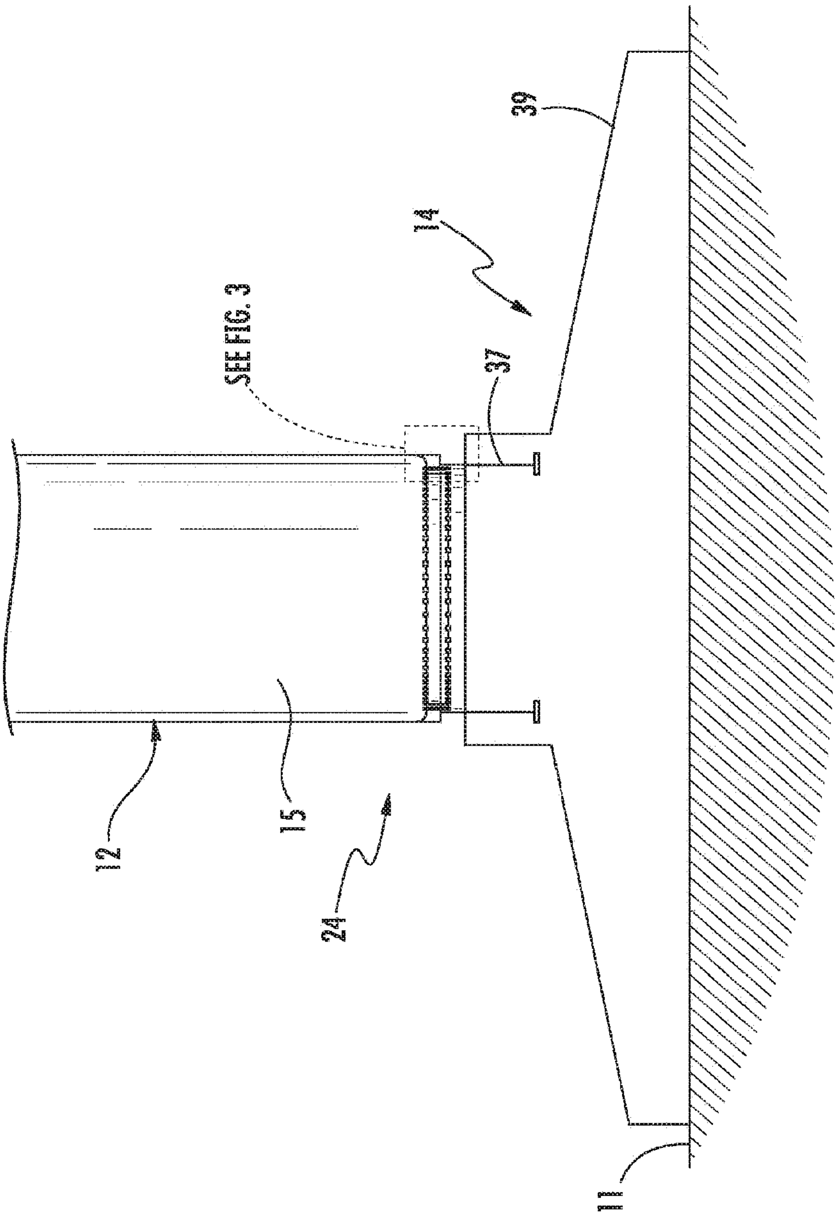

FIG. 2

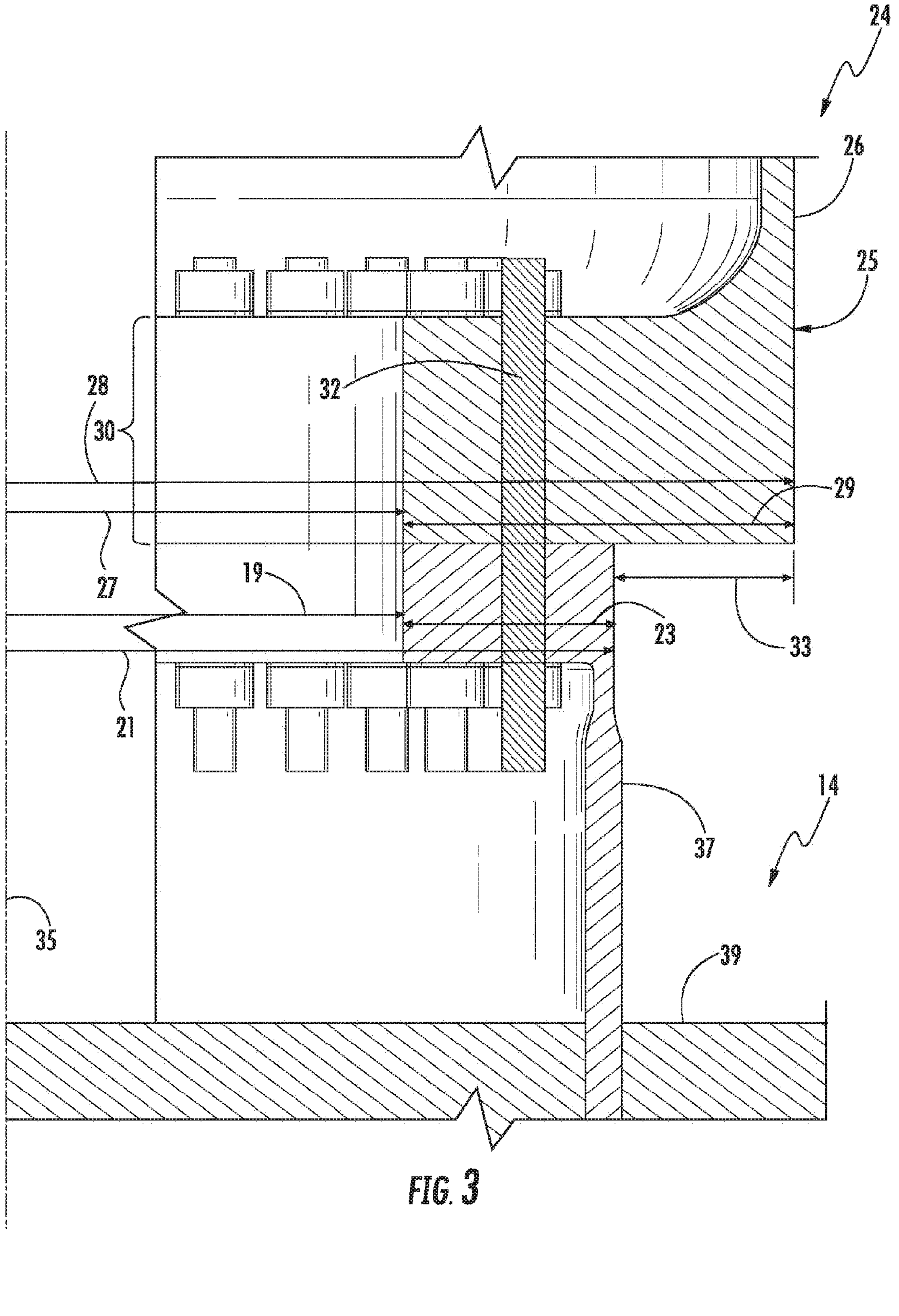

FIG. 3

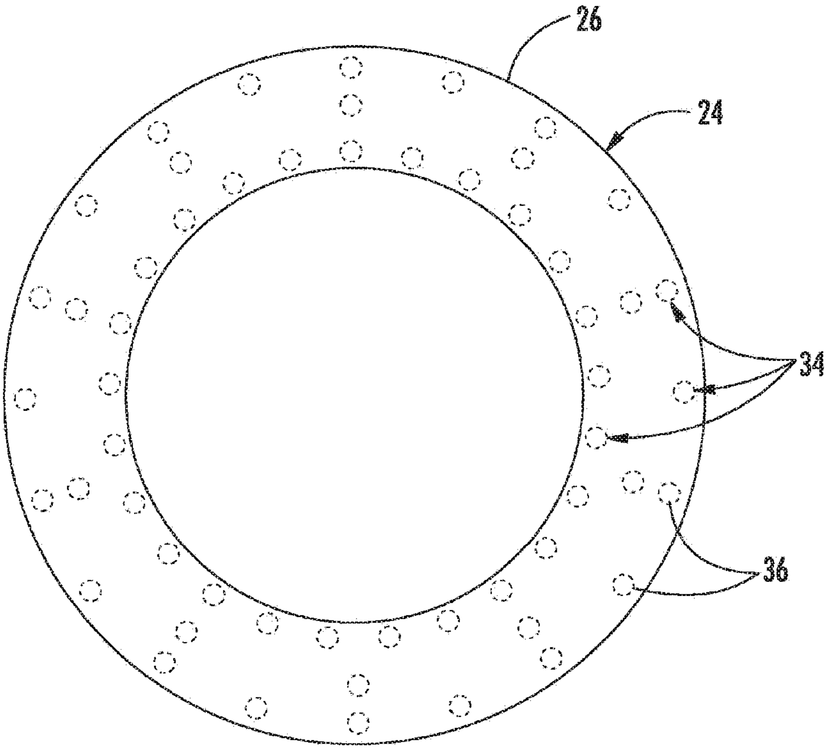

FIG. 4

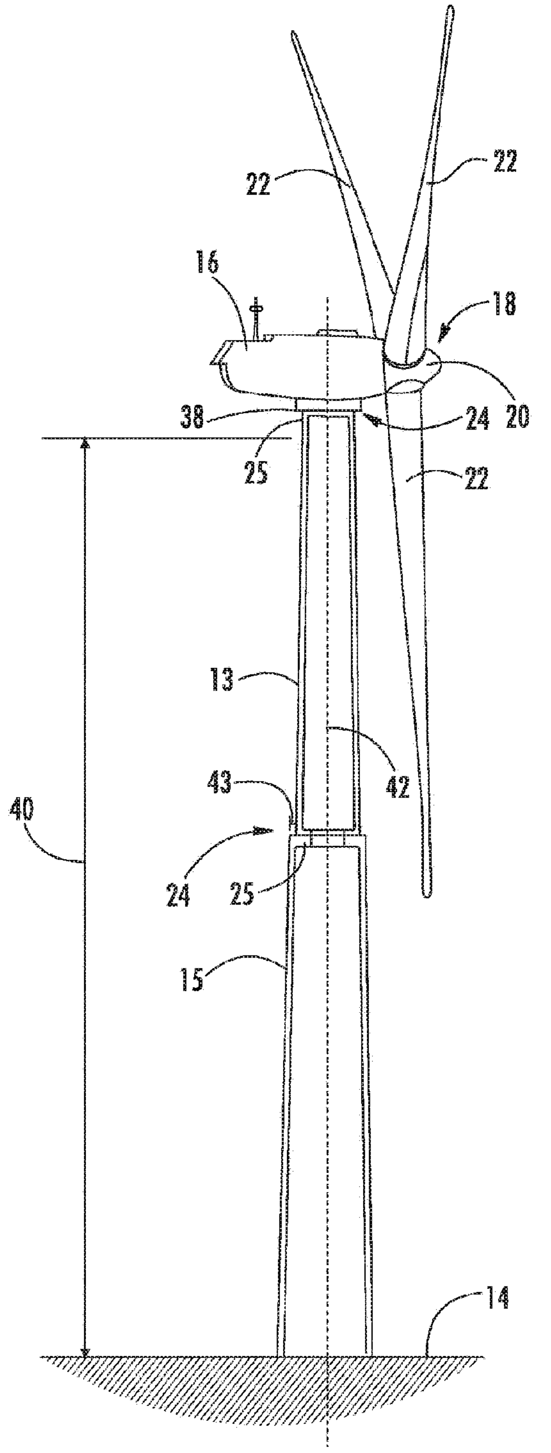

FIG. 5

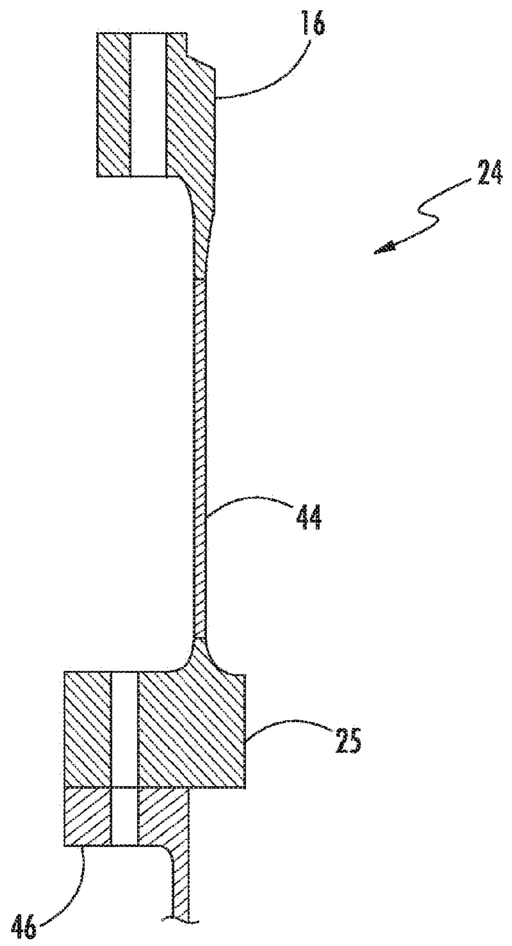

FIG. 6

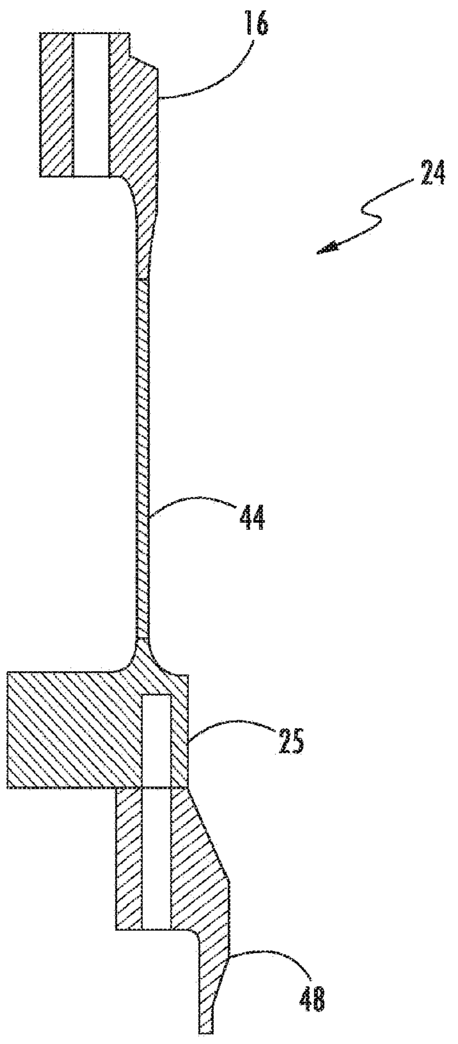

FIG. 7

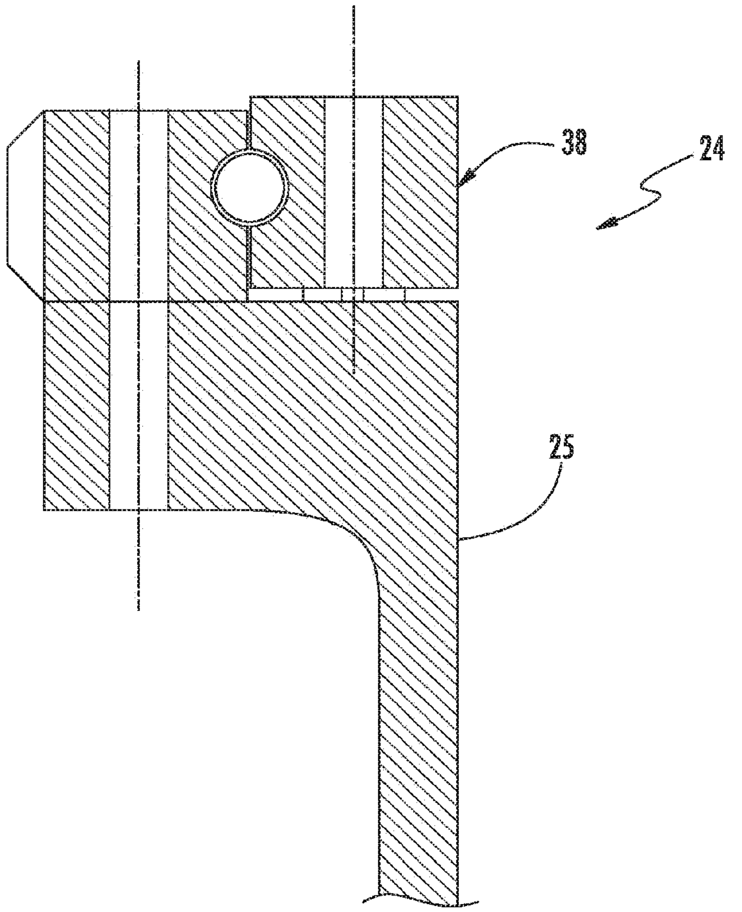

FIG. 8

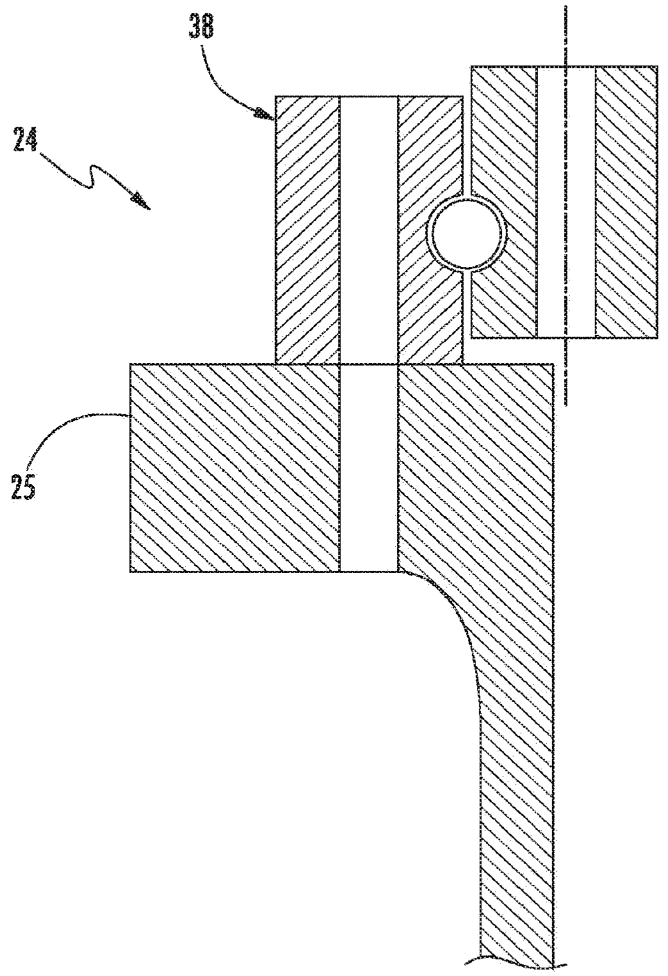

FIG. 9