

(19) **DANMARK**

(10) **DK/EP 3660242 T3**



(12)

Oversættelse af europæisk patentskrift

Patent- og
Varemærkestyrelsen

-
- (51) Int.Cl.: **E 04 H 12/00 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2023-10-16**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2023-08-02**
- (86) Europæisk ansøgning nr.: **18209091.0**
- (86) Europæisk indleveringsdag: **2018-11-29**
- (87) Den europæiske ansøgnings publiceringsdag: **2020-06-03**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
- (73) Patenthaver: **General Electric Company, 1 River Road, Schenectady, NY 12345, USA**
- (72) Opfinder: **Voss, Stefan, Holsterfeld 16, Salzbergen, 48499 Lower Saxony, Tyskland**
Paura, Ingo, Holsterfeld 16, Salzbergen, 48499 Lower Saxony, Tyskland
- (74) Fuldmægtig i Danmark: **COPA COPENHAGEN PATENTS K/S, Rosenørns Allé 1, 2. sal, 1970 Frederiksberg C, Danmark**
- (54) Benævnelse: **BOLTFORBINDELSE TIL FORBINDELSE AF TO FLANGER**
- (56) Fremdragne publikationer:
EP-A1- 0 299 324
WO-A1-2015/156664
CN-A- 108 035 852
GB-A- 1 156 629
GB-A- 2 206 938
US-A- 3 298 725
US-A- 4 033 222
US-A- 4 102 036
US-A- 4 776 600

DESCRIPTION

FIELD OF THE INVENTION

[0001] This invention deals with a bolt connection according to claim 1 for connecting two flanges, and in particular with a bolt connection for horizontal flanges of sections of a segmented steel tower, and a method according to claim 19 of connecting two flanges.

BACKGROUND OF THE INVENTION

[0002] A wind power plant often has a tubular steel tower that carries the nacelle and the rotor. The tower is sometimes conical (i.e. with a diameter increasing towards the base) in order to increase their strength and stiffness and to save materials the same time. It is difficult or in some areas even impossible to transport such a tubular steel tower in one piece if its diameter exceeds a certain limit (typically 4.3 m). Therefore, a steel tower may be horizontally split into sections of 10 to 40 meters which are split into a number of vertical segments which can be transported to the desired place of assembly. Each segment has a flange and two segments can be reconnected via a vertical joint. After a field assembly test of such a section, it has been determined that it may be difficult to meet the limits for the horizontal flange waviness for separated flanges like they are used for segmented steel. Once the steel tower has been assembled, gaps remain between the horizontal flanges. The flange waviness leads to a reduction of the bolt prestress and therefore has an impact on the fatigue life of the bolts.

[0003] In order to solve the problem of flange misalignment/waviness, additional measures need to be taken during manufacturing and assembly of the tower sections which lead to an increase of manufacturing time and cost and make it unattractive to use segmented steel towers. Alternatively, on site milling of the flange surface after assembly in the field may be performed combined with shimming of the affected areas. This means that shims are introduced from outside into flange gaps. It has also been suggested to mill the assembled steel tower from outside and to fill liquid material into the gap and cure the liquid material. However, these procedures are not very robust and costly such that other approaches are desirable and should be envisaged.

[0004] US 8,393,118 B2 shows a friction damping bolt connection for a wind tower lattice structure. It does not teach to use an anti-fatigue sleeve to connect two flanges of a segmented steel tower.

[0005] US 4102036 A relates to a system and method for precisely locating a combined sleeve bolt in an opening located in a plurality of materials adapted to be connected together. The adjustable nut is constructed in two parts and rotatably attached to each other. The first part contains an internal thread for accepting one end of the sleeve bolt and a bearing surface for

bearing only on one end of the projecting outer sleeve. The second portion of the nut has a greater diameter for bearing against the bottommost portion of the materials adapted to be connected together. The two portions of the nut being independently adjustable allow the sleeve bolt to be positioned within the hole regardless of any variations in the length of the sleeve. Once the desired position is achieved, the two portions are locked together, preferably by a set screw, and the tapered bolt is pulled into the hole while the adjustable nut holds the sleeve in the desired and pre-adjusted position.

[0006] US 3298725 A relates to a fastener which will exhibit a minimum of internal stress, reduce stress concentration in the material being joined, and apply an evenly distributed radial pre-stress to the material being joined.

[0007] GB 1156629 A relates to a resilient fastening assembly, e.g. for a pipe joint subjected to thermal shocks, or a machine mounting, comprises a rod, e.g. a bolt 12, having means to place the rod in tension to clamp the members 8 and 9 together, e.g. a nut 14, and a garter spring 15 extending around the rod so that it is axially compressed when the members are clamped. The spring 15 is secured between two rigid washers by a sleeve (21), Fig. 2, not shown, spun over at (22). The cross-section of the wire from which the spring is made is square, but before coiling it is trapezoidal. The rigid washers may be secured together by a snap ring (26), Fig. 3, not shown. A second garter spring can be placed inside the first.

[0008] GB 2206938 A relates to a fastener assembly for joining a panel to a sub-panel comprising a receptacle assembly having a threaded stud secured to the undersurface of the sub-panel. The assembly includes a bolt having an enlarged head at one end and a nose at the other end. The panel has a countersunk opening aligned with an opening in the sub-panel. The bolt is threaded for threaded engagement to the stud. The head of the bolt has a countersunk opening configured to a tool for rotating the same. This opening includes a releasable plug which is moved downwardly upon insertion of the tool to permit rotation thereof, then returns to a position flush with the exterior of the head of the bolt surrounding the opening.

[0009] US 4033222 A relates to a multiple sleeve blind fastener having a relatively large bearing surface on the blind side of the material in which the fastener is to be mounted, such as the skin of an aircraft or the like. The fastener includes a nut on the driving side of the mating hole in the skin into which the fastener is to be inserted. The nut is threaded onto a core bolt which extends into the mating hole and terminates in a head on the blind side. A plurality of sleeves are rotatably mounted on the core bolt between the head and the nut, the sleeves being disposed on the blind side when the fastener is inserted into the mating hole. The nut includes a tapered body portion which also extends through the mating hole from the driving side into the blind side thereto. In operation, when the core bolt is tightened, the first sleeve rides onto the tapered body portion of the nut and the successive sleeves ride onto and over the preceding sleeves thereby forming a relatively large bearing surface on the walls surrounding the mating hole, this surface depending upon the total number of sleeves and thicknesses thereof.

[0010] CN 108035852 A relates to a tower barrel section, a combined type tower barrel and a wind generating set. The wind generating set comprises the combined tower barrel and a unit fixed to the combined type tower barrel. The combined type tower barrel comprises at least two tower barrel sections. The tower barrel section comprises at least two barrel body fragments, is defined by the barrel fragments in the circumferential direction, and further comprises connecting pieces; flange fragments which are connected to the vertical adjacent tower barrel sections are arranged at the bottom edges and/or the top edges of the barrel body fragments; and each connecting piece comprises transverse connecting sections, wherein the two ends of the transverse connecting sections are connected to the flange fragments on the two adjacent barrel body fragments. The tower barrel section, the combined type tower barrel and the wind generating set have the beneficial effects that the connecting pieces are additionally arranged so as to connect and fix every two adjacent flange fragments on the top edges and the bottom edges of the barrel body fragments, so that an integral disc-shaped flange can be formed so as to provide a circumferential framework support for the tower barrel, the overall structural strength of the tower barrel can be improved, and the overall stability of the structure of the tower barrel can be enhanced.

SUMMARY OF THE INVENTION

[0011] The invention is defined by the independent claims. Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms as disclosed by the appended claims.

[0012] According to a first aspect, a bolt connection according to claim 1 for connecting two flanges is provided. The bolt connection includes a threaded bar extending through a hole of a first flange and a hole of a second flange, the first flange abutting the second flange; an anti-fatigue sleeve; and a nut. The anti-fatigue sleeve is disposed on the threaded bar on the side of the first flange between the nut and the first flange, the nut is configured to be screwed onto the threaded bar and is configured to press the anti-fatigue sleeve against the first flange to fasten the first flange and the second flange together.

[0013] According to a second aspect, it is described to use of the bolt connection according to the first aspect to connect sections of a steel tube tower.

[0014] According to a third aspect, a method according to claim 19 is provided of connecting two flanges. The method includes placing a threaded bar through a hole of a first flange and a hole of a second flange. The first flange abuts the second flange. An anti-fatigue sleeve is placed onto the threaded bar on the side of the first flange between a nut, disposed on the threaded bar, and the first flange. The nut is screwed onto the threaded bar such that it presses the anti-fatigue sleeve against the first flange to fasten the first flange and the second

flange together.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 shows a segmented steel tower in which a bolt connection according to embodiments of the invention can be used to connect horizontal flanges;

Fig. 2 shows a bolt connection according to embodiments of the invention in which an anti-fatigue sleeve and a nut are disposed on the side of the first flange only;

Fig. 3 shows a bolt connection according to embodiments of the invention in which an anti-fatigue sleeve and a nut are each disposed on the side of the first flange and on the side of the second flange; and

Fig. 4 shows a flowchart for illustrating a method for connecting flanges according to embodiments of the invention.

DESCRIPTION OF THE EMBODIMENTS

[0016] Detailed example embodiments are disclosed herein. However, specific structural and functional details disclosed herein are merely representative for purposes of describing example embodiments. Example embodiments may, however, be embodied in many alternate forms, and should not be construed as limited to only the embodiments set forth herein.

[0017] Accordingly, while example embodiments are capable of various modifications and alternative forms, embodiments thereof are illustrated by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit example embodiments to the particular forms disclosed, but to the contrary, example embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of example embodiments.

[0018] The terminology used herein is for describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "includes" and/or "including", when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0019] Reference will now be made in detail to the various embodiments, one or more example of which are illustrated in the figures. Each example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment

[0020] Fig. 1 shows a segmented steel tower 100 in which a bolt connection according to embodiments of the invention can be used to connect flanges of sections. However, before continuing with the description of Fig. 1, a few items of the invention will be discussed.

[0021] The solution to overcome the above-mentioned problem of loss of bolt fatigue life resulting from flange misalignment/waviness is to use longer threaded bars with an anti-fatigue sleeve pressed against the horizontal flange which exceeds the waviness requirements which have to be met in order to be able to connect the flanges. The technical effect of the invention is that the impact of a flange misalignment is much lower on a longer clamp length because the relative loss of pre-stress is lower. Therefore, the impact on the lifetime of the threaded bar resulting from the flange misalignment is negligible. The threaded bar with a long anti-fatigue sleeve leads to an increase of the clamp length. The flange misalignment therefore leads to a much smaller relative loss of bolt tension, increasing the lifetime of the bolt connection. This flange connection method enables the use of segmented steel tower sections. It was detected that it is difficult to fulfill the requirements for the horizontal flange waviness. The bolt connection according to embodiments of the invention is robust against this waviness.

[0022] In some of the embodiments, a bolt connection is provided for connecting two flanges. The bolt connection includes a threaded bar extending through a hole of a first flange and a hole of a second flange, the first flange abutting the second flange; an anti-fatigue sleeve; and a nut. The anti-fatigue sleeve is disposed on the threaded bar on the side of the first flange between the nut and the first flange. The nut is configured to be screwed onto the threaded bar and is configured to press the anti-fatigue sleeve against the first flange to fasten the first flange and the second flange together. Thereby, the bolt connection can be used with flanges which have a waviness that would normally not allow the flanges to be connected.

[0023] In some of these embodiments, an end piece of the threaded bar abuts the second flange.

[0024] In some of these embodiments, a washer is disposed between at least one of the anti-fatigue sleeve and the first flange, the end piece and the second flange and the anti-fatigue sleeve and the nut.

[0025] In other embodiments, the nut is a first nut and the anti-fatigue sleeve is a first anti-fatigue sleeve. The embodiment includes a second nut and a second anti-fatigue sleeve. The second anti-fatigue sleeve is configured to be placed onto the threaded bar on the side of the second flange between the second nut and the second flange. The second nut is configured to be screwed onto the threaded bar and is configured to press the second anti-fatigue sleeve

against the second flange.

[0026] In some of these embodiments, a washer is disposed between at least one of the first anti-fatigue sleeve and the first flange, the second anti-fatigue sleeve and the second flange, the first anti-fatigue sleeve and the first nut and the second anti-fatigue sleeve and the second nut.

[0027] In some embodiments, the length of the anti-fatigue sleeve is at least twice the thickness of the first flange and the second flange.

[0028] In some embodiments, the anti-fatigue sleeve has a length of at least 300 mm. Typically, anti-fatigue sleeves have a length much smaller than 300 mm such that anti-fatigue sleeves of this length are not known from the prior art. Moreover, the use of anti-fatigue sleeves for connecting flanges of sections of steel towers is also not known from the prior art. In some of the embodiments, the anti-fatigue sleeve has a diameter between 25 mm and 100 mm.

[0029] In some embodiments, the threaded bar has a length of at least 500 mm. In some of the embodiments, the threaded bar has a diameter between 20 mm and 80 mm. In some embodiments, each of the first and second flanges has a thickness of at least 100 mm.

[0030] In some embodiments, the first flange and the second flange are horizontal flanges of sections of a segmented steel tower.

[0031] In some embodiments, the first flange and the second flange are circumferential flanges.

[0032] In some embodiments, the connecting areas of the first flange and the second flange exceed given waviness requirements for sufficient fatigue strength of the flange connection.

[0033] In some embodiments, the first flange and the second flange are exposed to high dynamic stress as it typically occurs at the towers of wind power plants.

[0034] Some embodiments relate to the use of the bolt connection of any one of the preceding embodiments to connect segments of a steel tube tower.

[0035] Some embodiments refer to a steel tube tower which includes sections. The bolt connection of any one of the embodiments described above is used to reconnect sections when assembling the tower. The first flange is part of a first section of the steel tube tower and the second flange is part of a second section of the steel tube tower.

[0036] In some of the embodiments, the first flange and the second flange are horizontal flanges.

[0037] In some of the embodiments, the connecting areas of the first flange and the second flange exceed given waviness requirements for sufficient fatigue strength of the flange connection.

[0038] In some of the embodiments, a section of the steel tube tower has a diameter of above 4.3 m. Typically, steel tube sections with a diameter below 4.3 m can be transported in one piece, while steel tube sections above this diameter have to be split into segments in order to be able to be transported.

[0039] In some of the embodiments, the steel tube tower is a tower of a wind power plant.

[0040] Some of the embodiments relate to a method of connecting two flanges. The method includes placing a threaded bar through a hole of a first flange and a hole of a second flange. The first flange abuts the second flange. Then, an anti-fatigue sleeve is placed onto the threaded bar on the side of the first flange between a nut, disposed on the threaded bar, and the first flange. The nut is screwed onto the threaded bar such that it presses the anti-fatigue sleeve against the first flange to fasten the first flange and the second flange together.

[0041] In some of these embodiments, the nut is a first nut and the anti-fatigue sleeve is a first anti-fatigue sleeve. The method further includes placing a second anti-fatigue sleeve onto the threaded bar on the side of the second flange between a second nut disposed on the threaded bar and the second flange. The second nut is screwed onto the threaded bar and presses the second anti-fatigue sleeve against the second flange.

[0042] It should be mentioned that the features disclosed with regard to the bolt connection may also be used in the embodiments relating to the steel tower and the method of connecting two flanges.

[0043] Returning now to Fig. 1 which shows a segmented steel tower 100 that has a mid-section C 110, a mid-section D 120, a door-section 130 and a tower base ring (TBR) 140. Each section is further divided into a number of segments.

[0044] Fig. 2 shows the encircled part of the segmented steel tower 100 in greater detail and shows a bolt connection which allows to connect a tower segment 210 of mid-section C 110 to a tower segment 220 of mid-section D 120 and a tower segment 230 of mid-section D 120. Due to the waviness of the first flange 260 and the second flange 270 (which do not comply with waviness requirements), a flange gap 240 exists between the tower segment 220 and the tower segment 210. However, this flange gap 240 is not problematic due to the bolt connection which has a long threaded bar 250 which extends through and beyond the holes of the first flange 260 and the second flange 270. A nut 280 is screwed onto the threaded bar 250 and presses an anti-fatigue sleeve 290 against the first flange 260. An end piece 300 of the threaded bar 250 abuts the second flange 270 and is pressed onto it. Moreover, a washer 310 is disposed between the anti-fatigue sleeve 290 and the first flange 260. A further washer (not shown) could be placed between the end piece 300 and the second flange 270 and/or

between the nut 280 and the anti-fatigue sleeve 290.

[0045] Fig. 3 shows another embodiment of a bolt connection which allows to connect a tower segment 210 of mid-section C 110 to a tower segment 220 of mid-section D 120 and a tower segment 230 of mid-section D 120. In this embodiment, the threaded bar 250 is even longer than in the embodiment shown in Fig. 2. Instead of the end piece 300, a second anti-fatigue sleeve 320 is pressed by means of a second nut 330 against the second flange 270. Washers 310 are placed between the first and second flanges 260, 270 and the anti-fatigue sleeves 290. Further washers (not shown) could be placed between the anti-fatigue sleeves 290 and the nuts 280.

[0046] Fig. 4 shows a flowchart for illustrating the method of connecting two flanges. At 410, a threaded bar with an end piece is placed through a hole of a first flange and a hole of a second flange. The first flange abuts the second flange. At 420, an anti-fatigue sleeve is placed onto the threaded bar on the side of the first flange between a nut, disposed on the threaded bar, and the first flange. At 430, the nut is screwed onto the threaded bar such that it presses the anti-fatigue sleeve.

[0047] The foregoing description of various aspect of the invention has been presented for purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and many modifications and variations are possible. Such modifications and variations that may be apparent to an individual in the art are included within the scope of the invention defined by the accompanying claims.

[0048] This written description uses examples to disclose the invention and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- [US8393118B2 \[0004\]](#)
- [US4102036A \[0005\]](#)
- [US3298725A \[0006\]](#)
- [GB1156629A \[0007\]](#)
- [GB2206938A \[0008\]](#)
- [US4033222A \[0009\]](#)
- [CN108035852A \[0010\]](#)

KRAV

1. En boltforbindelse, der forbinder to flanger, omfattende
5 en gevindstang (250) der strækker sig gennem et hul i en første flange (260) og et
 hul i en anden flange (270), hvor den første flange ligger an mod den anden flange;
 en antitræthedsmuffe (290) (eng: anti-fatigue sleeve); og
 en møtrik (280);
 hvor antitræthedsmuffen (290) er anbragt på gevindstangen (250) på siden af den
10 første flange (260) mellem møtrikken (280) og den første flange (260), idet møtrikken
 (280) er konfigureret til at blive skruet på gevindstangen (250) og er konfigureret til
 at presse antitræthedsmuffen (290) mod den første flange (260) for at fastgøre den
 første flange (260) og den anden flange (270) til hinanden,
 hvor en spændeskive (310) er anbragt mellem antitræthedsmuffen (290) og den
15 første flange (260),
 hvor en længde af antitræthedsmuffen (290) er mindst to gange en tykkelse af den
 første flange (260) og den anden flange (270).
2. Boltforbindelse ifølge krav 1, hvor et endestykke (300) af gevindstangen (250) støder op til
20 den anden flange (270).
3. Boltforbindelse ifølge krav 2, hvor en yderligere spændeskive (310) er anbragt mellem
 mindst én af en gruppe der omfatter: endestykket (300) og den anden flange (270); og
 antitræthedsmuffen (290) og møtrikken (280).
- 25 4. Boltforbindelse ifølge krav 1 eller krav 2, hvor møtrikken (280) er en første møtrik og
 antitræthedsmuffen (290) er en første antitræthedsmuffe, yderligere omfattende en anden
 møtrik (330) og en anden antitræthedsmuffe (320), hvor den anden antitræthedsmuffe er
 konfigureret til at blive placeret på gevindstangen (250) på siden af den anden flange (270)
 mellem den anden møtrik (330) og den anden flange (270), idet den anden møtrik (330) er
30 konfigureret til at blive skruet på gevindstangen (250) og er konfigureret til at presse den
 anden antitræthedsmuffe (320) mod den anden flange (270).
5. Boltforbindelse ifølge krav 4, hvor en spændeskive (310) er anbragt mellem mindst én af en
 gruppe der omfatter: den første antitræthedsmuffe (290) og den første flange (260); den
35 anden antitræthedsmuffe (320) og den anden flange (270); den første antitræthedsmuffe

(290) og den første møtrik (280); og den anden antitræthedsmuffe (320) og den anden møtrik (330).

- 5 6. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor antitræthedsmuffen (290; 320) har en længde på mindst 300 mm.
7. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor gevindstangen (250) har en længde på mindst 500 mm.
- 10 8. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor hver af den første og den anden flange (260; 270) har en tykkelse på mindst 50 mm.
- 15 9. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor den første flange (260) og den anden flange (270) er vandrette flanger af segmenter (210; 220; 230) af et segmenteret ståltårn (100).
10. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor den første flange (260) og den anden flange (270) er periferiske flanger.
- 20 11. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor forbindelsesområderne af den første flange (260) og den anden flange (270) overstiger givne bølgethedskrav (eng: waviness requirements) til en holdbar forspændt forbindelse mellem den første flange (260) og den anden flange (270).
- 25 12. Boltforbindelse ifølge et hvilket som helst af de foregående krav, hvor den første flange (260) og den anden flange (270) er udsat for høj dynamisk belastning.
13. Anvendelse af boltforbindelsen ifølge et hvilket som helst af de foregående krav til at forbinde sektioner (110; 120; 130) af et stålrørstårn.
- 30 14. Stålrørstårn omfattende sektioner, hvor boltforbindelsen ifølge et hvilket som helst af kravene 1 til 12 er anvendt til at genforbinde sektioner (110; 120; 130) ved samling af tårnet (100), hvor den første flange (260) er en del af en første sektion af stålrørstårnet og den anden flange (270) er en del af en anden sektion af stålrørstårnet.

15. Stålrørstårn ifølge krav 14, hvor den første flange (260) og den anden flange (270) er vandrette flanger.
- 5 16. Stålrørstårn ifølge krav 14 eller krav 15, hvor forbindelsesområderne af den første flange (260) og den anden flange (270) overstiger givne bølgethedskrav til en holdbar forspændt forbindelse af den første flange og den anden flange.
- 10 17. Stålrørstårn ifølge et hvilket som helst af kravene 14 til 16, hvor en sektion (110; 120; 130) af stålrørstårnet har en diameter på over 4,3 m.
18. Stålrørstårn ifølge et hvilket som helst af kravene 14 til 17, hvor stålrørstårnet er et tårn i et vindkraftværk.
- 15 19. Fremgangsmåde til forbindelse af to flanger, hvilken fremgangsmåde omfatter:
anbringelse (410) af en gevindstang gennem et hul i en første flange og et hul i en anden flange, hvor den første flange ligger an mod den anden flange;
anbringelse (420) af en antitræthedsmuffe på gevindstangen på siden af den første flange mellem en møtrik, der er anbragt på gevindstangen, og den første flange; og
20 at skrue (430) møtrikken på gevindstangen, så den presser antitræthedsmuffen mod den første flange for at fastgøre den første flange og den anden flange til hinanden, hvor en spændeskive (310) er anbragt mellem antitræthedsmuffen (290) og den første flange (260),
hvor en længde af antitræthedsmuffen (290) er mindst to gange tykkelsen af den første flange (260) og den anden flange (270).

DRAWINGS

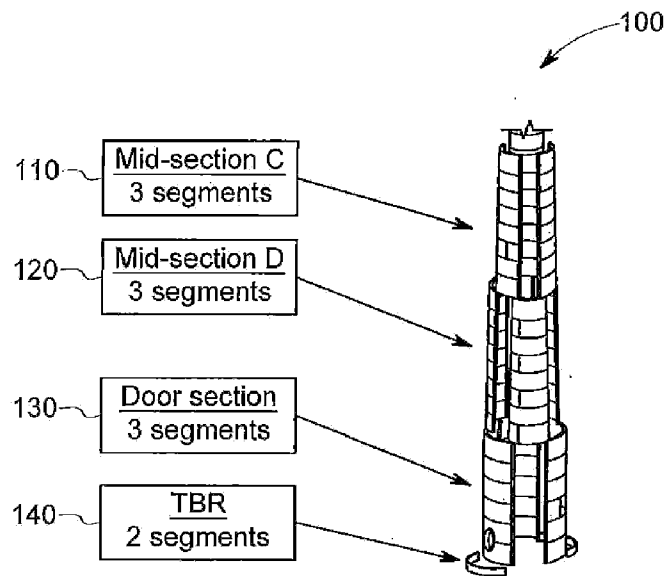


FIG. 1

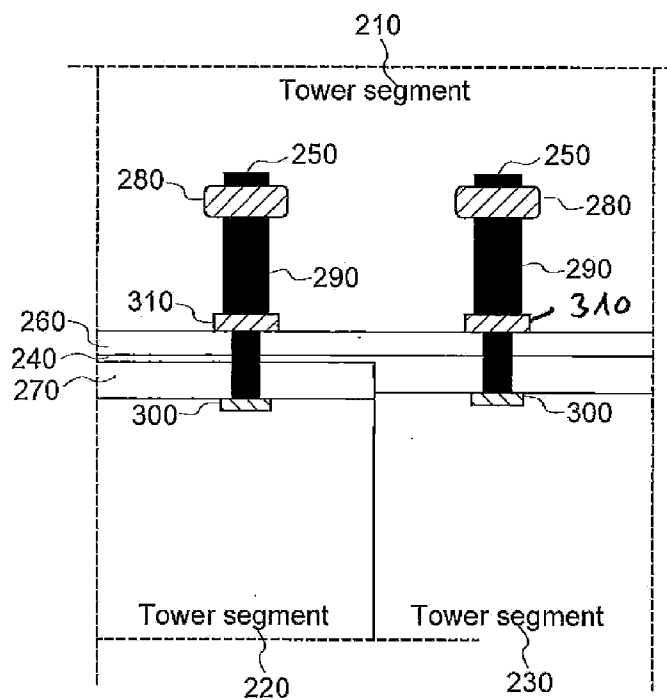


FIG. 2

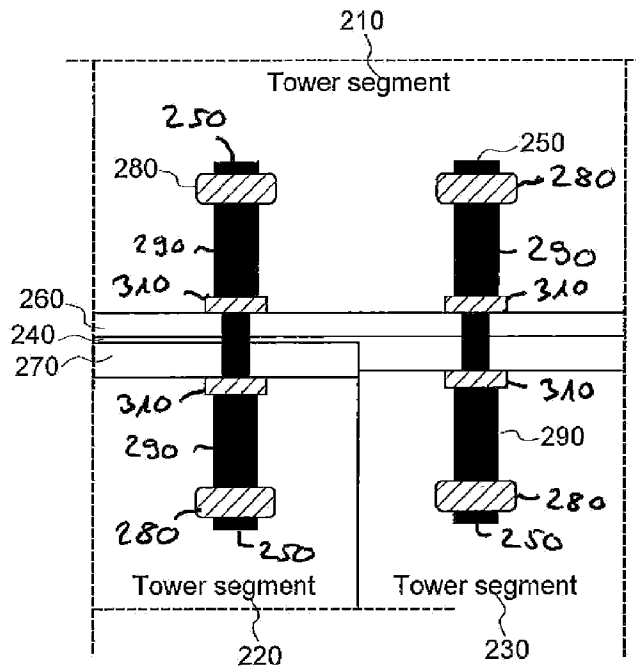


FIG. 3

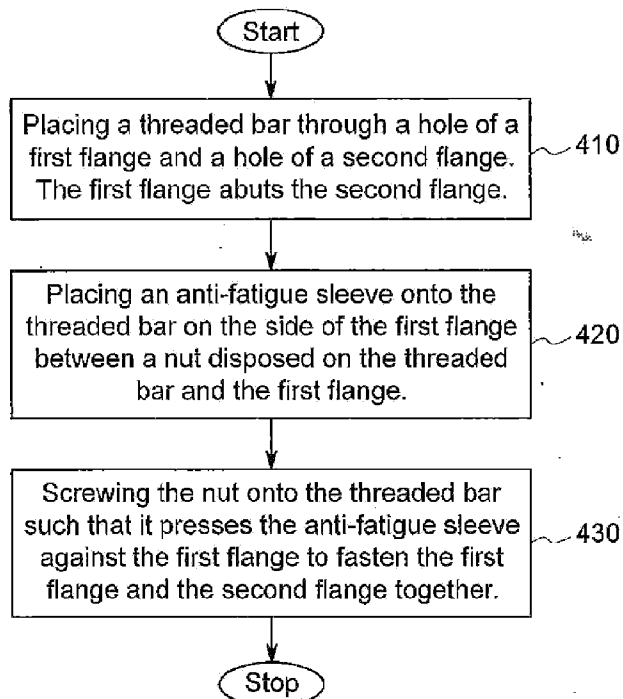


FIG. 4