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# DESCRIPTION

## OBJECT OF THE INVENTION

**[0001]** The present invention relates to a wind turbine with a concrete tower and a method for the assembly of the wind turbine with a concrete tower.

**[0002]** The object of the present invention is a wind turbine with a concrete tower comprising internal platforms within the segments of the sections of the concrete tower allowing to carry out the assembly of said sections and the execution of connections between joints of sections, the internal platforms being detachable, stackable and transportable.

## BACKGROUND OF THE INVENTION

**[0003]** During the field assembly of the concrete towers for wind turbines, a series of platforms need to be arranged inside the tower sections formed by segments to be assembled so that technical staff can carry out the appropriate connections between the different sections.

**[0004]** Upon completion of the tasks to connect the sections, either by injecting mortar between joints for connections between concrete sections, or by installing connecting bolts between sections in bolted connections, or by any other attachment method used between wind turbine tower sections disclosed in the prior art, the platforms are installed in the central shaft of the tower, leaving a small space to house the elevator.

**[0005]** The main problem of this system is that, being absolutely necessary in order to erect the tower, it is expensive and only useful during the construction stage and of little use in the operation stage of the wind turbine. In addition, joining the platforms to each segment is a complex task that involves numerous resources since it requires drilling the segment at several points and arranging anchoring elements between the latter and the platform.

**[0006]** The concrete tower for a wind turbine and method of assembly of a concrete tower for a wind turbine solve all the above drawbacks.

**[0007]** Documents US 2013/174509 A1 and EP 1 544 376 disclose a wind turbine with a concrete tower having a platform system.

**[0008]** Document US2008/040983A1 discloses a structure and assembly procedure for the wind turbine concrete towers which consists of a procedure for erecting the concrete towers consisting of various stages or phases which may be developed at the same time in the different towers of a wind farm, including erection and pre-assembly activities of the sections of each tower of a wind generator in which each section of the tower structure may be composed

of a different number of segments or longitudinal sections depending on the situation of that section in the height of the tower. This process comprises two differentiated sequences, one of pre-assembly for each tower section and the erection of said sections, including a pre-assembly phase for each section, a process divided into the following stages, for each section comprising different segments, wherein each segment can comprise a platform.

## DESCRIPTION OF THE INVENTION

**[0009]** The present invention relates to a wind turbine according to claim 1 with a concrete tower, wherein the tower comprises a plurality of sections formed by segments and a platform system comprising a plurality of platforms, wherein the platform system is configured to allow access to junction areas between sections from where the attachment between adjacent sections can optionally be carried out.

**[0010]** The platform system is further configured to be at least partially anchored in a detachable manner to an inner wall of the section, inner wall meaning the wall of the section located inside the tower once erected.

**[0011]** The platforms of the platform system are anchored to the wall of the section situated inside the tower once erected, in an area or at a height that allows the access to the joining surface connecting the section immediately above, so that technical staff located on the platforms can help to guide the section or segment, depending on the assembly procedure, to the correct position and perform any necessary work on them such as carrying out the execution of the joints between adjacent sections (pouring mortar, applying resin, tightening nuts, etc.)

**[0012]** The concrete tower sections comprise at least a first anchoring element attached to the wall of the section inside the tower once erected, the platform system being configured to be at least partially anchored in a detachable manner to at least the first anchoring element attached to the wall of the section inside the tower once erected.

**[0013]** Each platform of the platform system is arranged internally in each section of the tower at the height of the joint between adjacent sections, these platforms being accessible by stairs and / or an elevator arranged inside the wind turbine tower, in order to perform from such platforms all work necessary during the assembly and securing together of two adjacent sections of the tower by means of any of the procedures known in the prior art, i.e. guiding the upper section to slot it into the lower section, bolting the section joint flanges, installing the fasteners required to secure the attachment between sections, guiding the steel bars and pouring concrete into the junction area between sections, and extracting samples during curing stage to verify the correct execution in the event of concreted joints, etc.

**[0014]** The wind turbine with a concrete tower thus constituted makes it possible to remove from the platform system those platforms that are not necessary for the normal operation of

the wind turbine and leave installed those platforms that are necessary to access areas regularly used to effect operation and maintenance tasks.

**[0015]** In addition, the platforms of the system platforms comprise a set of modules that are configured to be taken down through the interior of the wind turbine tower, allowing their extraction through a tower door. These modules can be folding modules.

**[0016]** Preferably, the wind turbine with a concrete tower of the present invention proposes at least one platform module per segment, wherein the module or modules can be coupled to said first segment preferably by means of two first anchoring elements attached to the wall of the segment situated inside the tower once erected. These modules are disconnected from the segment and lowered to the base of the tower, where they can be folded to be extracted through the tower door.

**[0017]** This enables the modules to be pre-assembled on certain segments at the factory or wind-farm, before forming the sections. Thus, part of the work can be done before assembling the wind turbine. However, if there are fewer modules than segments in each section, the modules should be anchored to more than one segment and therefore assembly would be much more complicated.

**[0018]** The platform system, being configured to be anchored at least partially in a detachable manner to at least the first anchoring element attached to the wall of the section inside the tower once erected, makes it possible to not detach, after erecting the tower, some of the platforms of the platform system, preferably the top ones, as these are necessary to carry out maintenance on the junction area between the tower and a nacelle of the wind turbine.

**[0019]** The geometry of each module is such that on forming a tower section, a continuous platform is obtained along its entire interior perimeter, except for a space configured for the passage of an elevator and / or stairs, wherein continuous platform means that despite being modular, allows the passage of a technician around the whole perimeter of the section except for the space configured for the passage of the elevator and / or stairs.

**[0020]** The platforms of the platform system comprise at least one second anchoring element which assists the first anchoring element to anchor, in a detachable manner, the platform system to the wall of the section situated inside the tower once erected.

**[0021]** Optionally, the modules comprise a base and a safety rail, wherein the base and safety rails are collapsible so that, during assembly, both remain in the folded position so as not to interfere with the work of assembling the segments to form the tower section. The geometry of the base and the safety rail are such that they prevent interference between different bases and lifting slings during disassembly.

**[0022]** The geometry of the base is that of an annulus sector, wherein the radius of the greater arc of a circumference is slightly smaller than the inner radius of the segment in the section in

which said base is arranged, preferably 5 cm smaller. The arc lengths forming the base geometry are such that, complying with the above premise, they cover the length of the chord of the section in which they are installed except for a stretch, preferably of 2.5 cm. Thus, regardless of the position of the second anchoring elements of the platforms, the base is formed almost continuously covering a horizontal surface which allows access to the perimeter of the section of the segment wherein said base is installed.

**[0023]** Additionally, in the bases adjacent to the elevator shaft of the tower, the arc length is such that, covering the maximum chord length of the segment in the section in which the base is installed, it allows the passage of the tower elevator. In these cases the gap between the elevator and the base will be less than 10 cm, preferably 5 cm.

**[0024]** The distance between the arcs of a circumference is determined by the length of two straight sides of the annulus sector and defines the width of the base. This length is such to allow the passage of a person walking on the base of the module, being for example 800 mm.

**[0025]** In this way the platforms of the platform system of the wind turbine with a concrete tower of the present invention are removable, detachable, stackable and transportable for their reuse in the assembly of other wind turbines.

**[0026]** The invention also relates to the method according to claim 9 of assembly of a wind turbine with a concrete tower comprising a plurality of sections formed by segments and platform system comprising a plurality of platforms, wherein the platform system is configured to allow access to junction areas between adjacent sections, and wherein the method comprises the following steps:

- a step of connecting a platform system comprising a plurality of platforms to a wall of a plurality segments being situated in the interior of the tower once erected, which form sections of the concrete tower;
- a step of pre-assembly of the sections of the concrete tower wherein for each section a plurality of segments are joined together;
- a step of lifting and stacking of the plurality of sections that make up the concrete tower;
- a step of executing joints between adjacent sections; and
- a step of detaching the platform system, at least partially, from the segments which form the sections of the concrete tower.

**[0027]** Preferably, the method for assembling the wind turbine with a concrete tower of the present invention proposes the connection of at least one platform module per segment during the connecting step prior to the tower section pre-assembly step. Thus, the platform module or modules are joined to the wall of the segment situated inside the tower once erected, while said segment is still in a horizontal position before carrying out the step of pre-assembly of the sections.

**[0028]** This step of pre-assembly of the sections comprises performing the positioning of the segments adjacently and executing the connections between them, whether temporary or permanent joints, prior to the step of lifting and stacking of the plurality of sections forming the concrete tower.

**[0029]** Thus, the method for assembly of a wind turbine with a concrete tower of the present invention, the step of detaching at least partially from the platform system the segments which form the sections of the concrete tower, allows at least part of platform system platforms to be detached from the segment and transferred and assembled in other wind turbines.

**[0030]** Following the step of detaching at least partially the platform system from the segments which form the sections of the concrete tower, the method comprises a step of disassembly of at least one platform from the platform system. Preferably this step of disassembly of at least one platform from the platform system comprises the disassembly of a plurality of platforms, more preferably of all the platforms except at least the top platform.

**[0031]** This step of disassembly of at least one platform from the platform system is accomplished by firstly disassembling the platform disposed at the lower part of the tower, and then, proceeding upwards disassembling the other platforms.

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

##### **[0032]**

Figure 1 shows a perspective view of a segment of a section of the concrete tower wherein a platform module of the platform system has been anchored, prior to the step of preassembly of the sections of the concrete tower.

Figure 2 shows a schematic elevation view of the concrete tower of the wind turbine of the present invention wherein the platform system platforms are depicted after the step of lifting and stacking of the plurality of sections forming the concrete tower;

Figure 3 shows a sectional view AA of Figure 2.

Figure 4 shows a detail B of Figure 2.

Figure 5 shows a perspective view of the first anchoring element attached to the wall of the section situated inside the tower once erected.

Figure 6 shows a perspective view of the second anchoring element attached to the platform.

#### **PREFERRED EMBODIMENT OF THE INVENTION**

**[0033]** Described below in detail is the wind turbine with a concrete tower of the present invention, wherein the tower (1) comprises a plurality of sections (2) formed by segments (3) and a platform system comprising a plurality of platforms (4) configured for the carrying out of the assembly of said sections (2), the connection between the adjacent sections (2) and to be anchored at least partially in a detachable manner to a wall (6) of the section (2) situated inside the tower once erected or inner wall (6).

**[0034]** The sections (2) of the concrete tower (1) comprise at least one first anchoring element (7) attached to the inner wall (6) of the section (2) where a second anchoring element (8) on the platforms (4) of the platform system is detachably attached.

**[0035]** The wind turbine comprises an elevator (10) arranged inside the tower (1), wherein each of the platforms (4) of the platform system comprises a set of folding modules (9) substantially arranged along the entire inner perimeter of the section (2), except in a section occupied by the elevator (10), wherein each module (9) is detachably attached to a segment (3) of the section (2).

**[0036]** Each module (9) can be coupled to the said segment (3) by two first anchoring elements (7) attached to the inner wall (6) of the segment (3) comprising two second anchoring elements (8).

**[0037]** The folding modules (9) comprise a base (11) and a safety rail (12), wherein the base (11) and safety rail (12) are foldable so that, during assembly, both (11, 12) remain in the folded position so as not to interfere with the assembly work on the segments (3) to form the section (2) of the tower (1).

**[0038]** The safety rail (12) is also adjustable in height, so that during tower section preassembly and stacking manoeuvres, the rails (12) are at a greater height to comply with all safety regulations, while during the lifting and placing of the platform module (9) they are at a lower height to prevent lifting slings from touching the rail (12) and bending it. Once the platform is assembled (4) on the segment (3) and the section (2) has been formed, the rail (12) is lifted to its highest level to comply with the 1100-mm height set by safety regulations.

**[0039]** In a first embodiment, the first anchoring element (7) and the second anchoring element (8) which enable the detachable anchoring of the platform system to the inner wall (6) of the section (2) form a joint with one degree of freedom and the platforms (4) of the platform system comprise at least one support element between said platforms (4) and the wall (6) of the section (2) situated inside the tower (1) once erected.

**[0040]** Preferably, the first anchoring element (7) comprises a rod (16) insertable into the wall (9) of the segment (3) situated inside the tower (1) once erected and a head (13) protruding from said rod, wherein the rod (16) is disposed inside the section (2) once lifted and stacked, while the second anchoring element (8) comprises a pivoting fitting (14) with a longitudinal

groove (15) so that the fitting (14) is supportable on the rod (16) of the first anchoring element (7).

**[0041]** The longitudinal groove (15) of the fitting is of greater width than the diameter of the rod (16) of the first anchoring element (7) but narrower than the diameter of the head (13) so the module (9) is anchored to the segment (3). This anchoring system allows an easy disassembly of the platform system once they are no longer needed by simply applying a vertical upward force once removed the safety clamps present in said anchoring system.

**[0042]** Preferably, the modules (9) of each section (2) which are adjacent to the elevator are not detachably anchored to the section (2).

**[0043]** At least one platform (4) is not modular, namely, it is not composed of modules (9) preferably being arranged in the upper section (2) of the concrete tower (1)

**[0044]** The invention also relates to the method for the assembly of a wind turbine with a concrete tower comprising a plurality of sections (2) formed by segments (3) and a platform system comprising a plurality of platforms (4), wherein the platform system is configured to allow access to junction areas between adjacent sections (2), and wherein the method comprises the following steps:

- a step of connecting a platform system comprising a plurality of platforms (4) to a wall (6) of a plurality segments (3) situated inside the tower (1) once erected, wherein the segments (3) form sections (2) of the concrete tower (1);
- a step of pre-assembly of the sections (2) of the concrete tower (1) wherein for each section (2) a plurality of segments (3) are joined together;
- a step of lifting and stacking of the plurality of sections (2) forming the concrete tower (1);
- a step of executing joints between adjacent sections (2), preferably forming coupling joints between sections;
- a step of installation of the nacelle on the concrete tower (1) performed before or after the step of executing the joints between the adjacent sections (2); and
- a step of detaching the platform system, at least partially, from the segments (3) forming the sections (2) of the concrete tower (1).

**[0045]** Preferably, in the step of connecting the platform system, the connection of one platform (4) module (9) per segment (3) is carried out, so that the platform (4) module (9) is attached to the wall (6) of the segment (3) situated inside the tower (1) once erected, while said segment (3) is still in the horizontal position before carrying out the step of pre-assembly of the sections (2).

**[0046]** Following the step of detaching at least partially the platform system from the segments (3) forming the sections (2) of the concrete tower (1), the method comprises a step of

disassembly of at least one platform (4) from the platform system, wherein preferably a plurality of platforms (4), more preferably of all platforms (4) are disassembled, except at least the top platform (24).

[0047] This step of disassembly of at least one platform (4) of the platform system is accomplished by firstly disassembling the platform (4) arranged in the lower part of the tower, and then, proceeding upwards, disassembling the other platforms (4) except the top platform (24).

## REFERENCES CITED IN THE DESCRIPTION

### Cited references

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## PATENTKRAV

1. Vindmølle med et betontårn (1), hvor tårnet (1) omfatter en flerhed af afsnit (2), der er dannet af segmenter (3), og et platformssystem, der omfatter en flerhed af platforme (4), hvor platformssystemet er konfigureret til at tillade adgang  
5 til overgangsområder mellem nabostillede afsnit (2), **kendetegnet ved, at** platformssystemet yderligere er konfigureret til, på en udløselig måde, at være mindst delvist forankret til en væg (6) af afsnittet (2), som befinder sig inde i tårnet (1), når først det er opstillet;

hvor afsnittene (2) af betontårnet (1) omfatter mindst ét første  
10 forankringselement (7), der er fastgjort til den væg (6) af afsnittet (2), som er placeret inde i tårnet (1), når først det er opstillet, idet platformssystemet er konfigureret til, på en udløselig måde, at være mindst delvist forankret til mindst det første forankringselement (7), der er fastgjort til den væg (6) af afsnittet (2), som er placeret inde i tårnet (1), når først det er opstillet;

15 hvor platformssystemets platforme (4) omfatter mindst ét andet forankringselement (8), der understøtter det første forankringselement (7), med henblik på at opnå den udløselige forankring af platformssystemet til den væg (6) af afsnittet (2), som er placeret inde i tårnet (1), når først det er opstillet; og

hvor det første forankringselement (7) omfatter en stang (16), der kan  
20 indsættes i den væg (9) af segmentet (3), som er placeret inde i tårnet (1), når først det er opstillet, og et hoved (13), der rager frem fra stangen, hvor stangen (16) er anbragt inde i afsnittet (2), når først det er løftet og stablet, mens det andet forankringselement (8) omfatter et drejebeslag (14) med en langsgående rille (15), således at drejebeslaget (14) kan understøttes på stangen (16) af det første  
25 forankringselement (7).

2. Vindmølle med et betontårn (1) ifølge krav 1, **kendetegnet ved, at** platformssystemets platforme (4) omfatter et sæt moduler (9), der er konfigureret til at blive nedtaget gennem det indre af vindmøllens tårn (1) og udtrukket gennem tårnets (1) dør.

3. Vindmølle med et betontårn (1) ifølge krav 2, **kendetegnet ved, at** platformssystemets platforme (4) omfatter mindst ét modul (9) pr. segment (3).
4. Vindmølle med et betontårn (1) ifølge krav 3, **kendetegnet ved, at** den omfatter en elevator (10) og/eller trapper, der er anbragt inde i tårnet (1), og hvor
- 5 modulerne (9) danner en kontinuerlig platform (4) for hvert afsnit (2) af tårnet (1), undtagen i et rum, der er konfigureret til passage af elevatoren (10) og/eller trapperne.
5. Vindmølle med et betontårn (1) ifølge et hvilket som helst af kravene 2 til 4, **kendetegnet ved, at** modulerne (9) kan sammenfoldes og omfatter en basis (11) og et sikkerhedsrækværk (12).
- 10 6. Vindmølle med et betontårn (1) ifølge krav 5, **kendetegnet ved, at** basen (11) kan sammenfoldes, og sikkerhedsrækværket (12) kan højdejusteres.
7. Vindmølle med et betontårn (1) ifølge krav 1, **kendetegnet ved, at** det første forankringselement (7) og det andet forankringselement (8), der implementerer den udløselige forankring af platformssystemet til den væg (6) af
- 15 afsnittet (2), som er placeret inde i tårnet (1), når først det er opstillet, danner en forbindelse med én frihedsgrad, og platformssystemets platforme (4) omfatter mindst ét understøtningsselement mellem platformene (4) og den væg (6) af afsnittet (2), som er placeret inde i tårnet (1), når først det er opstillet.
8. Vindmølle med et betontårn (1) ifølge krav 4, **kendetegnet ved, at**
- 20 modulerne (9) af hvert afsnit (2), der er nabostillet til elevatoren og/eller trapperne, ikke er udløseligt forankret til afsnittet (2).
9. Fremgangsmåde til montage af en vindmølle ifølge et af de foregående krav med et betontårn, der omfatter en flerhed af afsnit (2), som er dannet af segmenter (3), og et platformssystem, der omfatter en flerhed af platforme (4),
- 25 hvor platformssystemet er konfigureret til at tillade adgang til overgangsområder mellem nabostillede afsnit (2), og hvor fremgangsmåden omfatter følgende trin:
- et trin til forbindelse af et platformssystem, der omfatter en flerhed af platforme, (4) med en væg (6) af en flerhed af segmenter (3), som er placeret inde i tårnet (1), når først det er opstillet, hvilke segmenter (3) danner afsnit (2) af
- 30 betontårnet (1);

- et trin til formontage af afsnit (2) af betontårnet (1), hvor en flerhed af segmenter (3) for hvert afsnit (1) sammenføjes;
  - et trin til løftning og stabling af flerheden af afsnit (2), hvilket danner betontårnet (1);
- 5 • et trin til udførelse af forbindelser mellem nabostillede afsnit (2);

**kendetegnet ved, at** fremgangsmåden yderligere omfatter:

- et trin til mindst delvis frigørelse af platformssystemet fra segmenterne (3), der danner afsnittene (2) af betontårnet (1); og hvor
  - trinnet til forbindelse af et platformssystem, der omfatter en flerhed af platforme (4), med en væg (6) af en flerhed af segmenter (3), som er placeret inde i tårnet (1), når først det er opstillet; og
  - trinnet til mindst delvis frigørelse af platformssystemet fra segmenterne (3), der danner afsnittene (2) af betontårnet (1),
- 10 udføres ved hjælp af en stang (16), der kan indsættes i den væg (9) af segmentet (3), som er placeret inde i tårnet (1), når først det er opstillet, og et hoved (13), der rager frem fra stangen, hvor stangen (16) er anbragt inde i afsnittet (2), når først det er løftet og stablet, og ved hjælp af et drejebeslag (14) med en langsgående rille (15), således at drejebeslaget (14) kan understøttes på stangen (16).

10. Fremgangsmåde til montage af en vindmølle med et betontårn ifølge krav 9, **kendetegnet ved, at** trinnet til forbindelse af platformssystemet omfatter forbindelse af mindst ét modul (9) af en platform (4) pr. segment (3) inden trinnet til formontage af tårnets (1) afsnit (2).

11. Fremgangsmåde til montage af en vindmølle med et betontårn ifølge enten krav 9 eller 10, **kendetegnet ved, at** fremgangsmåden omfatter et trin til afmontering af mindst én platform (4) fra platformssystemet efter trinnet til frigørelse af platformssystemet.

12. Fremgangsmåde til montage af en vindmølle med et betontårn ifølge krav 11, **kendetegnet ved, at** trinnet til afmontering af mindst én platform (4) fra

platformssystemet omfatter afmontering af en flerhed af platforme (4), fortrinsvis af alle platformene (4), undtagen mindst én øverste platform (24).

13. Fremgangsmåde til montage af en vindmølle med et betontårn ifølge enten krav 11 eller 12, **kendetegnet ved, at** trinnet til afmontering af mindst én platform (4) fra platformssystemet opnås ved først at afmontere platformen (4), der er anbragt i den nedre del af tårnet (1), og derefter, i opadgående retning, at afmontere de andre platforme (4).

14. Fremgangsmåde til montage af en vindmølle med et betontårn ifølge et hvilket som helst af kravene 9 til 13, **kendetegnet ved, at** trinnet til formontage af afsnittene (2) omfatter udførelse af placeringen af segmenterne (3) nabostillet til hinanden og udførelse af forbindelser mellem dem, uanset om det er midlertidige eller permanente forbindelser, inden trinnet til løftning og stabling af flerheden af afsnit, der udgør betontårnet.

# DRAWINGS

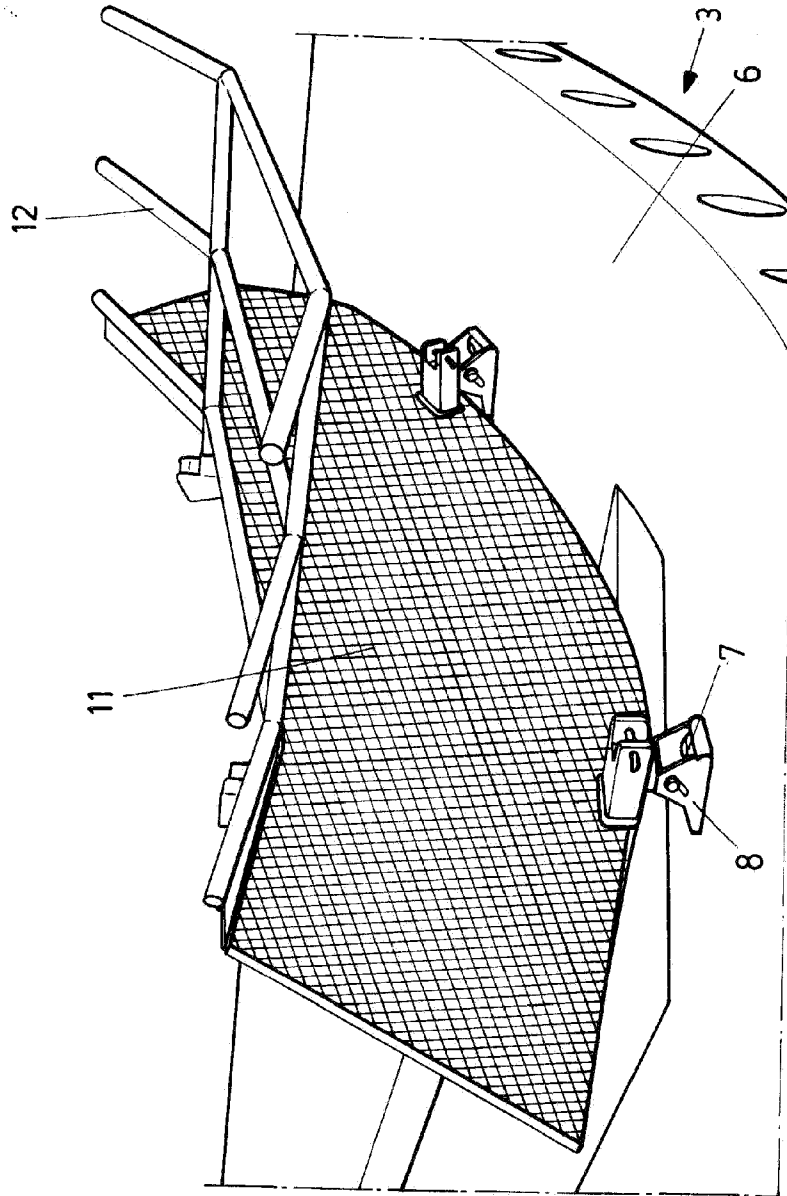
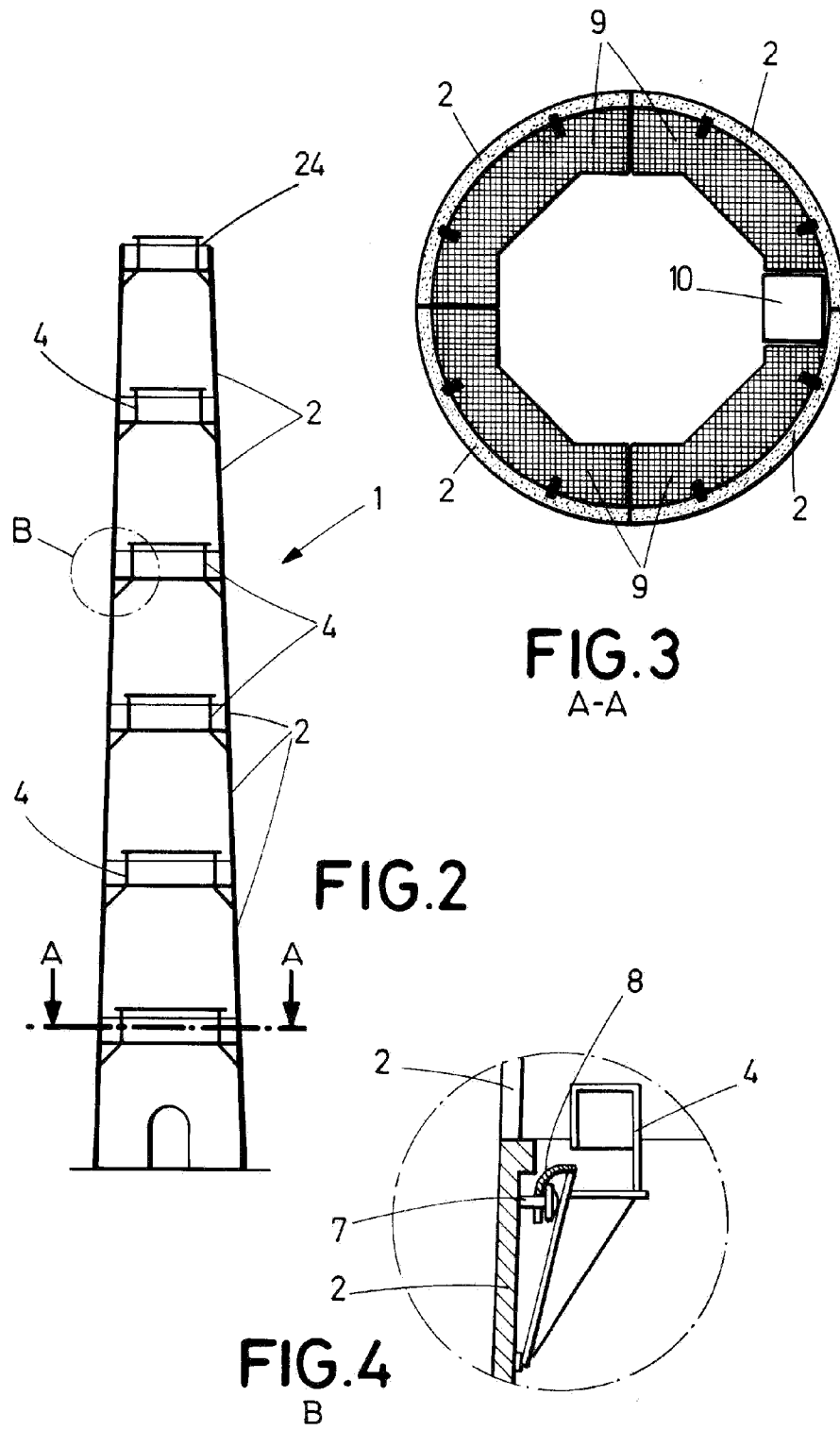


FIG.1



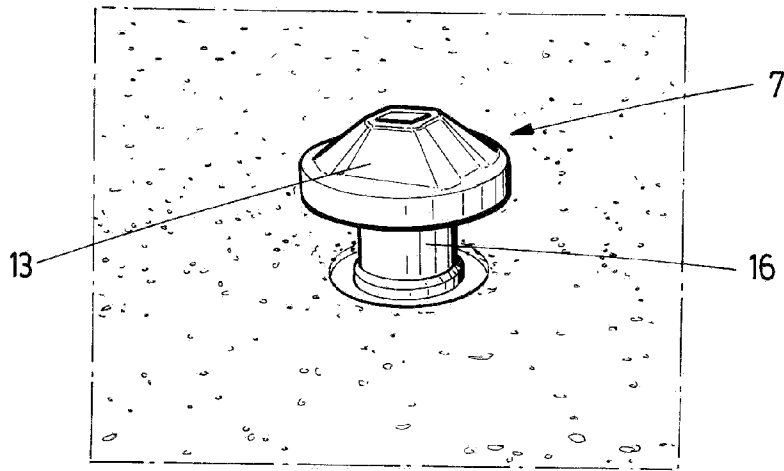


FIG. 5

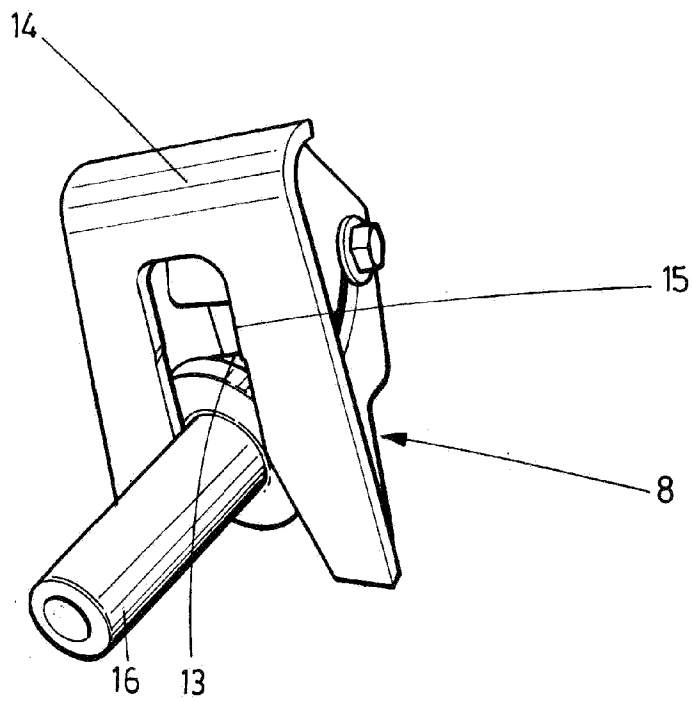


FIG. 6