(19) DANMARK

(10) DK/EP 2501929 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *F 03 D 9/00 (2006.01)* *E 04 H 12/12 (2006.01)* *E 04 H 12/16 (2006.01)*
F 03 D 1/00 (2006.01) *F 03 D 11/04 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2014-12-08**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2014-10-01**

(86) Europæisk ansøgning nr.: **10776720.4**

(86) Europæisk indleveringsdag: **2010-11-15**

(87) Den europæiske ansøgnings publiceringsdag: **2012-09-26**

(86) International ansøgning nr.: **EP2010067431**

(87) Internationalt publikationsnr.: **WO2011058158**

(30) Prioritet: **2009-11-16 IT MI20092007**

(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: **WILIC S.AR.L, 1, Boulevard de la Foire, 1528 Luxembourg, Luxembourg**

(72) Opfinder: **PABST, Otto, Frazione Maranza 124, I-39037 Rio Di Pusteria, Italien**

(74) Fuldmægtig i Danmark: **HØIBERG A/S, Store Kongensgade 59A, 1264 København K, Danmark**

(54) Benævnelse: **Vindkraftanlæg til produktion af elektrisk energi og tilhørende pylonkonstruktionsfremgangsmåde**

(56) Fremdragne publikationer:
WO-A1-92/01850
WO-A1-03/069099
WO-A2-2009/056969
DE-U1-202007 003 842
JP-A- 2007 321 710
JP-A- 2008 101 363

Description

TECHNICAL FIELD

[0001] The present invention relates to a wind power plant for producing electric energy.

[0002] More specifically, the present invention relates to a wind power plant comprising a reinforced-concrete foundation; a pylon extending along a vertical axis and comprising at least one portion made of panels assembled to one another on site; an electric generator mounted on top of the pylon; and a blade assembly for driving the generator.

BACKGROUND ART

[0003] The technique of constructing pylons from panels is normally used for exceptionally large pylons that are difficult to transport and handle. The documents listed below relate to wind power plants comprising pylons made from panels, and which, to the Applicant's knowledge, represent the state of the art in this regard :

Document DE 10 2007 018 025 A1 relates to a wind power plant comprising a truncated-cone- or truncated-pyramid-shaped pylon made of curved or angled steel panels.

Documents DE 20 2006 009 554 U1 and EP 1 262 614 A2 relate to wind power plant pylons made partly of reinforced concrete and partly of steel.

Documents EP 1 876 316 A1, JP 2008 101363 A, JP 2009 57713 A, US 2006/0272244 A1, US 2007/0294955 A1, US2005/0129504, WO 2008/110309 A2, and WO 2009/056898 A1 relate to wind power plant pylons made of steel or reinforced-concrete panels.

[0004] Obviously, the smaller the panels, the lighter they are, they are easier to handle and transport, and can be made in modular or standard sizes, regardless of the upward-tapering cross section of the pylon. On the other hand, small panels involve a large number of joints, which must be made on site by skilled workmen working at considerable heights, and must be checked cyclically for safety reasons. Consequently,

the best solution is to use relatively large panels to reduce the number of joints, but not large or heavy enough to make them difficult to transport or handle.

[0005] In the case of high-power plants with exceptionally heavy generators, the current practice is to construct pylons in which at least the bottom portion, i.e. the portion resting directly on the foundation, is made of prefabricated reinforced-concrete panels, which are lighter than corresponding steel portions.

DISCLOSURE OF INVENTION

[0006] It is an object of the present invention to provide a wind power plant of the above type, comprising a pylon which is easy to construct and, at the same time, structurally strong.

[0007] Another object of the present invention to provide a wind power plant of the above type, comprising a pylon made at least partly of assembled panels that are easy to produce, and the size of which can be altered easily when necessary.
According to the present invention, there is provided a wind power plant for producing electric energy according to claim 1, the wind power plant comprising a foundation; a pylon extending along a given axis; an electric generator mounted on top of the pylon; and a blade assembly for driving the generator; the pylon comprising at least one portion made of flat, reinforced-concrete, adjacent panels assembled so the portion has a polygonal cross section, wherein each panel comprises an outer face, an inner face, and two lateral faces, is fixed by the lateral faces to the adjacent panels, and comprises a main body of reinforced concrete; and lateral plates integral with the main body and at least partly defining the lateral faces of the panel; the lateral plates preferably defining the whole of the lateral faces of the panel.

[0008] Using only flat, reinforced-concrete panels, as opposed to curved or angled panels, the panels can be made using a vibrating machine, with no need for complex molds; the size of the panels can be altered easily when necessary; and, being simple in shape, the panels can even be produced at the wind power system erection site.

[0009] In a preferred embodiment of the present invention, each panel is in the form of an isosceles trapezium, the height of which is greater than its mean width; said height being at least three times, and preferably six times, the mean width.

[0010] Relatively long panels can thus be produced, to construct long pylon portions and so speed up construction of the pylon as a whole and reduce the number of joints.

[0011] Another object of the present invention is to provide a straightforward, low-cost method of constructing a wind power plant pylon.

[0012] According to the present invention, there is provided a method of constructing a pylon of a wind power plant according to claim 11, wherein the wind power plant comprises a foundation; the pylon, which extends along a given axis; an electric generator mounted on top of the pylon; and a blade assembly for driving the generator; the pylon comprising at least one portion made of flat, reinforced-concrete, adjacent panels assembled so the portion has a polygonal cross section; and the method comprising the steps of :

a) pouring concrete into a mold at least partly forming an integral part of said panel;

b) producing a number of panels as in step a);

c) arranging said number of panels about the axis, so each panel is adjacent to two panels;

d) joining the adjacent panels,

wherein the mold is defined by a table of a vibrating machine, by lateral plates, by a top plate, and by a bottom plate; the lateral plates, the top plate, and the bottom plate being joined to the main body and forming an integral part of the panel.

[0013] Construction of the pylon portion is thus easier, and can be carried out even entirely on site.

[0014] The molds are thus easy to make and, above all, the plates perform important functions within the panel: the lateral plates define the lateral mating faces and connecting portions of adjacent panels, and impart flexural strength to the panel even before it is stressed; and the top and bottom plates define the top and bottom mating faces of the panel, and serve to distribute compressive stress evenly in the main body.

[0015] In a preferred embodiment of the present invention, the method comprises the step of lifting each panel from a substantially horizontal position to a substantially vertical position using a structure hinged to the foundation and for housing the panel.

[0016] Unlike methods in which panels are lifted using a crane, the panel is thus guided into position by a structure that prevents it from oscillating, thus making the job safer, reducing the risk of damage to the panel, while at the same time positioning the panel faster and so speeding up construction of the pylon as a whole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which :

Figure 1 shows a side view, with parts removed for clarity, of a wind power plant in accordance with the present invention;

Figure 2 shows a plan view, with parts removed for clarity, of a detail of Figure 1;

Figure 3 shows a cross section, with parts removed for clarity, along line III-III of the Figure 1 plant;

Figure 4 shows a larger-scale detail of the Figure 3 cross section;

Figures 5 and 6 show larger-scale sections, with parts removed for clarity, of a detail of the Figure 1 plant in two different planes;

Figure 7 shows a view in perspective of a panel during construction and positioned on a vibrating machine in accordance with the method according to the present invention;

Figures 8 and 9 show two sections of respective steps in assembling a panel in accordance with the method according to the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] Number 1 in Figure 1 indicates as a whole a wind power plant for producing electric energy, and which comprises a reinforced-concrete foundation 2; a pylon 3 extending along a vertical axis A1; an electric generator 4 mounted on top of pylon 3; and a blade assembly 5 for driving generator 4 and which rotates about an axis A2.

[0019] Generator 4 is fixed to a nacelle 6 which rotates with respect to pylon 3 about axis A1; and blade assembly 5 comprises a hub 7 integral with the rotor (not shown) of generator 4, and three blades 8, of which only two are shown in Figure 1.

[0020] In the Figure 1 example, pylon 3 is defined by flat, reinforced-concrete panels 9 evenly distributed about axis A1 and connected to one another; and by a ring 10 on the top end of panels 9. Panels 9 are identical, and are isosceles-trapezium-shaped so pylon 3 tapers upwards once they are assembled.

[0021] The height of each panel is greater than its mean width, and is at least three times and, in the example shown, ten times the mean width.

[0022] In the example shown, pylon 3 comprises ten identical panels 9, so it has a cross section in the form of a regular decagon tapering upwards. The number of ten panels 9 arranged in a circle about axis A1 obviously in no way limits the present invention.

[0023] In the Figure 1 example, the pylon is defined by one portion comprising panels 9 and ring 10, though the present invention also extends to embodiments (not shown) in which the pylon is defined by a portion comprising panels 9 and ring 10, and by steel portions fixed to ring 10, or is defined by a number of reinforced-concrete portions comprising respective panels and respective rings.

[0024] Once panels 9 are assembled to one another, each is compressed by cables 11 housed inside and extending the full height of panel 9. Cables 11 are anchored to foundation 2 and to ring 10, as shown more clearly in Figure 5, and serve to precompress panel 9 to enable the concrete to withstand tensile/bending stress.

[0025] Foundation 2 comprises a platform 12 for supporting panels 9. As shown in

Figure 2, platform 12 has a top face 13; and a seat 14 (Figures 5 and 6)which extends about axis A1 on top face 13, and serves to house panels 9. As shown in Figure 1, platform 12 comprises a lateral face 15, in which are formed a number of cavities 16 equally spaced about axis A1 in the example shown. As shown more clearly in Figures 5 and 6, seat 14 communicates with each cavity 16 along holes 17 - in the example shown, four holes 17 - through which respective cables 11 extend. Each cable 11 is anchored to foundation 2 by a terminal 18 integral with the bottom end of cable 11 and resting against a face of one of cavities 16. Similarly, each cable 11 is anchored to ring 10 by a terminal 18 integral with the top end of cable 11 and resting against a face of ring 10.

[0026] As shown in Figure 5, seat 14 has flared lateral faces 19; and a bottom face 20, along which depressions 21 are formed at holes 17. Once panels 9 are inserted inside seat 14, the rest of seat 14 is filled with mortar 22, as shown in Figure 5.

[0027] With reference to Figure 3, each panel 9 comprises an outer face 23; an inner face 24; two lateral faces 25; a top face 26 (on the right in Figure 2); and a bottom face 27 (Figure 5).

[0028] With reference to Figure 4, panels 9 are connected to one another along lateral faces 25 by means of fastening devices 28 which, in the example shown, are bolted joints. Each panel 9 comprises a main body 29; lateral plates 30; a top plate 31 (Figure 2); and a bottom plate 32 (Figures 5 and 6). Main body 29 is made of concrete, and incorporates reinforcement 33 - in the example shown, two metal mats - and four tubes 34 located between the metal mats of reinforcement 33 and for guiding cables 11 inside panel 9. Main body 29 defines outer face 23 and inner face 24, which are flat and parallel. And cavities 35 are formed along inner face 24, are partly defined by lateral plates 30, and serve to allow insertion of and access to fastening devices 28, which are inserted through lateral plates 30 of adjacent panels 9.

[0029] Lateral faces 25 extend along lateral plates 30, which have holes for fastening devices 28 to connect adjacent lateral plates 30 and, therefore, adjacent panels 9. Lateral plates 30, top plate 31, and bottom plate 32 (Figures 5, 6) are joined to main body 29 by known fasteners (not shown) which extend inside main body 29. As opposed to

being joined directly to one another to form a frame, lateral plates 30, top plate 31, and bottom plate 32 are preferably connected to one another by the main body.

[0030] With reference to Figures 5 and 6, bottom plate 32 has projections 36 located at the holes through which cables 11 are threaded; and projections 36 engage respective depressions 21 to position panels 9 perfectly inside seat 14.

[0031] Reinforcement 33 is also not connected directly to lateral plates 30, top plate 31, and bottom plate 32; and tubes 34 are preferably connected to top plate 31 and bottom plate 32.

[0032] Lateral plates 30 preferably extend along the whole of panel 9 to stiffen and enhance the flexural strength of panel 9.

[0033] Figure 7 shows a panel 9 during construction and positioned on a vibrating machine 37, which is used to make concrete parts and comprises a vibrating table 38, on which the molds containing cement for thickening by vibration are placed.

[0034] In the Figure 7 example, the mold is defined by table 38, lateral plates 30, top plate 31, and bottom plate 32. Plates 30, 31, 32 are positioned to form a frame on table 38, and are kept in a more or less sloping position with respect to table 38 by preferably adjustable sloping supports 39.

[0035] Reinforcement 33 and tubes 34 are held in position by supports not shown in Figure 7, while bodies 40 are positioned contacting lateral plates 30 to complete the mold. Once the mold is formed, and the reinforcement, defined by mats 33, tubes 34, and bodies 40 are positioned inside the mold, concrete is poured over the reinforcement and tubes 34, and partly around bodies 40, to form body 29.

[0036] Once the concrete is set, panel 9 is ready for assembly to foundation 2 and to other similarly made panels 9 to form pylon 3.

[0037] For easy assembly and handling of panels 9, which are extremely long and subject to severe bending stress, an elongated structure 41 (Figure 9) is used to form a cradle attachable to panel 9, and is hinged about an axis A3 parallel to the portion of

seat 14 into which panel 9, supported by elongated structure 41, is inserted. Panel 9 is substantially positioned on elongated structure 41 so that, when elongated structure 41 rotates about axis A3, panel 9 is lifted into a substantially vertical position with the aid of a lifting machine (not shown) and possibly a harness 42.

[0038] In other words, panel 9 is rotated from a substantially horizontal position (Figure 8) to a substantially vertical position (Figure 9) by elongated structure 41 hinged to foundation 2 and for housing panel 9.

[0039] Scaffolding (not shown) may be erected on platform 12 to support panel 9 in a substantially vertical position and enable workers to work at different heights to connect panels 9.

[0040] As will be clear from the detailed description of the preferred embodiment of the present invention, the main advantages lie in greatly simplifying manufacture and assembly of the panels, and also in enabling easy alterations to the size of the panels.

[0041] Moreover, the lateral, top and bottom plates form part of the mold, and perform important structural functions within the finished panel.

[0042] Clearly, changes may be made to the wind power plant and method as described herein without, however, departing from the scope of the accompanying Claims.

PATENTKRAV

1. Vindkraftanlæg til produktion af elektrisk energi, hvilket vindkraftanlæg (1) omfatter et fundament (2); en pylon (3), som strækker sig langs med en given akse (A1); en elektrisk generator (4), som er monteret oven på pylonen (3); og en bladsamling (5) til at drive generatoren (4); hvilken pylon (3) omfatter mindst én del, som er fremstillet af flade, tilgrænsende paneler (9) af armeret beton, som er samlet således, at delen har et polygonalt tværsnit, hvor hvert panel (9) omfatter en ydre flade (23), en indre flade (24) og to laterale flader (25), er fastgjort ved hjælp af de laterale flader (25) til de tilgrænsende paneler (9) og omfatter en hoveddel (29) af armeret beton; og laterale plader (30), som er ud i ét med hoveddelen (29) og i det mindste delvist definerer de laterale flader (25) af panelet (9); idet de laterale plader (30) fortrinsvis definerer helheden af de laterale flader (25) af panelet (9).

2. Vindkraftanlæg ifølge krav 1, hvor delen af pylonen (3) er fremstillet af identiske paneler (9).

3. Vindkraftanlæg ifølge krav 1 eller 2, hvor hvert panel (9) er i form af et ligebenet trapez, hvis højde er større end dets middelbredde; hvilken højde er mindst tre gange og fortrinsvis seks gange middelbredden.

4. Vindkraftanlæg ifølge et hvilket som helst af de foregående krav og omfattende en række fastgørelsesindretninger (28), som hver går i indgreb med et par af laterale kontaktplader (30) af to tilgrænsende paneler (9).

5. Vindkraftanlæg ifølge krav 4, hvor hver hoveddel (29) har hulrum (35), der grænser op til de laterale plader (30); idet hvert hulrum (35) delvist huser en fastgørelsesindretning (28) til fastgørelse af to tilgrænsende laterale plader (30); og hulrummene (35) fortrinsvis er ligeligt fordelt langs med panelet (9) og delvist afgrænset af én af de laterale plader (30).

6. Vindkraftanlæg ifølge et hvilket som helst af de foregående krav, hvor fundamentet (2) har et polygonalt sæde (14) omkring aksen (A1) til at huse panelerne (9).

7. Vindkraftanlæg ifølge krav 4, hvor hvert panel (9) omfatter en hoveddel (29) af armeret beton; og hvor en bundplade (32) definerer en bundflade (27) af panelet (9), som er huset inde i sædet (14).

8. Vindkraftanlæg ifølge krav 5, hvor hvert sæde (14) har en lige del til at huse et respektivt panel (9); idet den lige del af sædet (14) og bundpladen (32) af panelet (9) har respektive positionsindikatorer til at positionere panelet (9) i forhold til fundamentet (2); og idet positionsindikatorerne fortrinsvis omfatter fordybninger (21) og fremspring (36).

9. Vindkraftanlæg ifølge et hvilket som helst af de foregående krav, hvor hvert panel (9) omfatter en hoveddel (29) af armeret beton; og en topplade (31), som definerer en topflade (26) af panelet (9).

10. Vindkraftanlæg ifølge et hvilket som helst af de foregående krav, hvor hvert panel (9) er udsat for belastning af kabler (11), som strækker sig mellem fundamentet (2) og toppen af panelet og er forankret til fundamentet og til en ring (10) oven på panelerne (9).

11. Fremgangsmåde til konstruktion af en pylon (3) af et vindkraftanlæg (1) ifølge krav 1, hvor vindkraftanlægget (1) omfatter et fundament (2); en pylon (3), som strækker sig langs med en given akse (A1); en elektrisk generator (4), som er monteret oven på pylonen (3); og en bladsamling (5) til at drive generatoren (4); hvilken pylon (3) omfatter mindst én del, som er fremstillet af flade, tilgrænsende paneler (9) af armeret beton, som er samlet således, at delen har et polygonalt tværsnit; og hvor fremgangsmåden omfatter følgende trin:

a) der hældes beton i en støbeform, som i det mindste delvist udgør en integreret del af panelet (9);
b) der fremstilles et antal paneler (9) som i trin a);
c) antallet af paneler (9) anbringes omkring aksen (A1), således at hvert panel (9) grænser op til to paneler (9);
d) de tilgrænsende paneler (9) sammenføjes, hvor støbeformen er defineret af et bord (38) af en vibreringsmaskine (37), af laterale plader (30), af en topplade (31) og af en bundplade (32); idet de laterale plader (30), toppladen (31) og

bundpladen (32) er sammenføjet med hoveddelen (29) og udgør en integreret del af panelet (9).

12. Fremgangsmåde ifølge krav 11, hvor støbeformen omfatter elementer (40), som grænser op til de laterale plader (30) og er til at definere hulrum (35) i panelet (9).

13. Fremgangsmåde ifølge krav 11 eller 12 og omfattende et trin, hvor hvert panel (9) hæves fra en i det væsentlige vandret position til en i det væsentlige lodret position ved hjælp af en struktur (41), som er hængslet til fundamentet (2) og huser panelet (9).

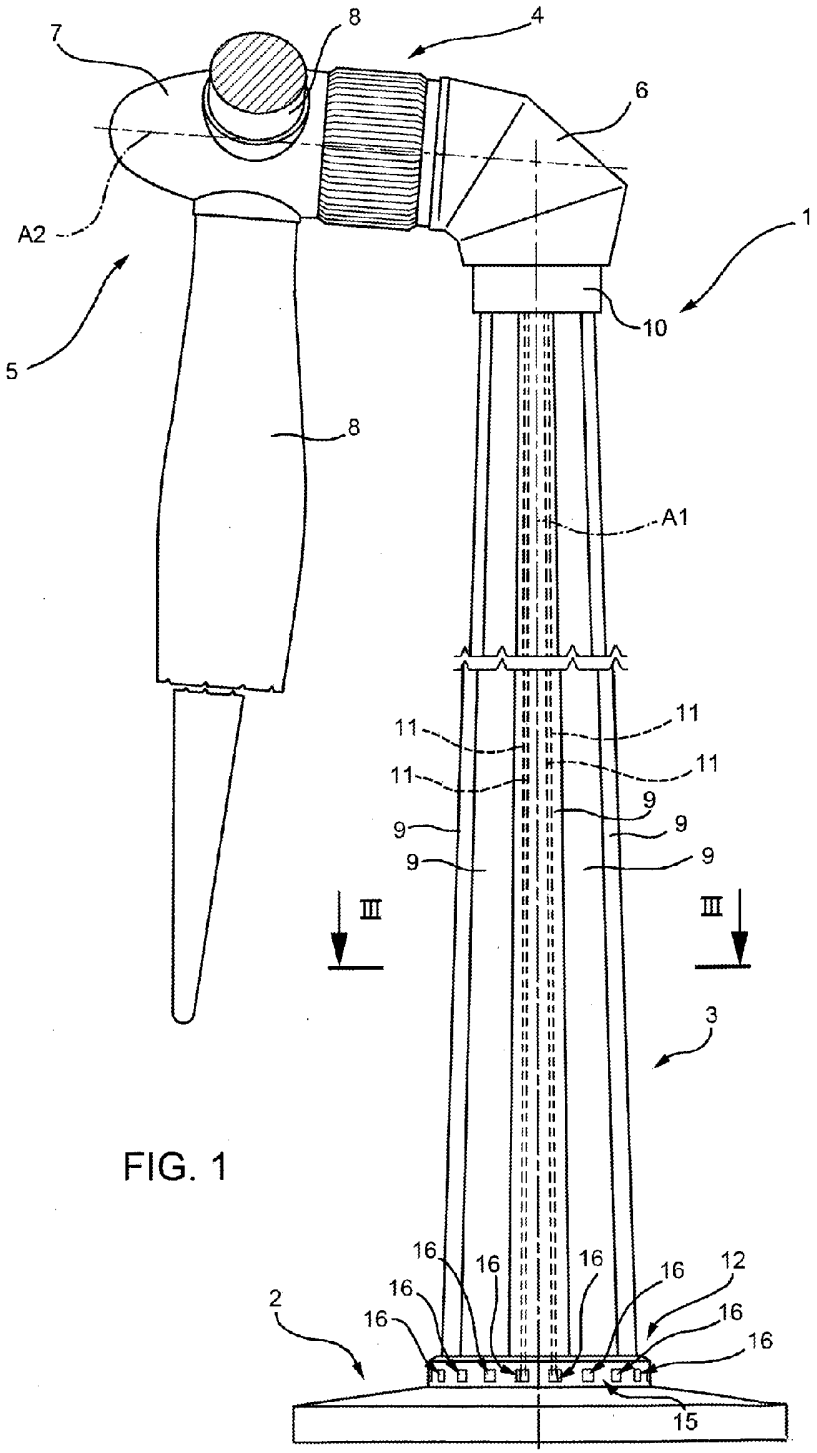
7
8
4
6
A2
1
5
10
8
A1
11
11
11
11
9
9
9
9
9
III
III
3
16
16
16
16
12
16
16
16
2
15

FIG. 1

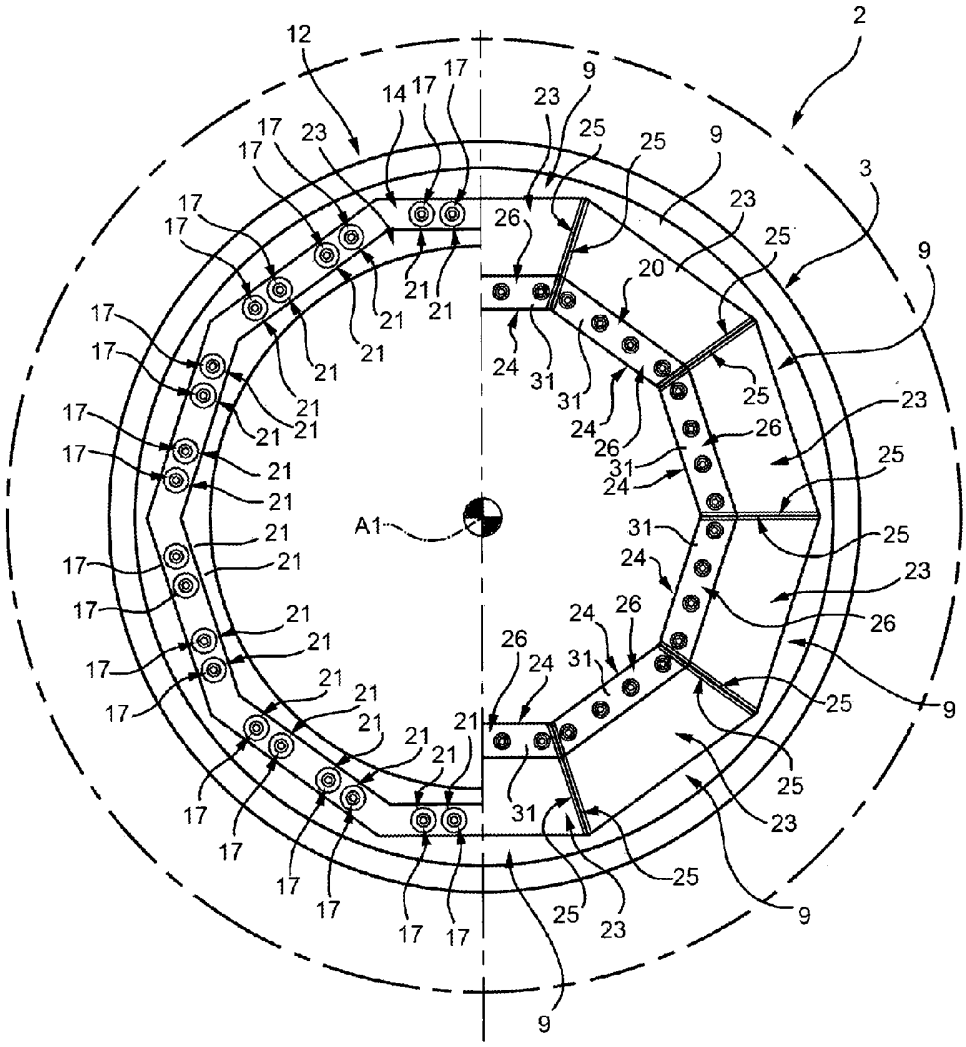

FIG. 2

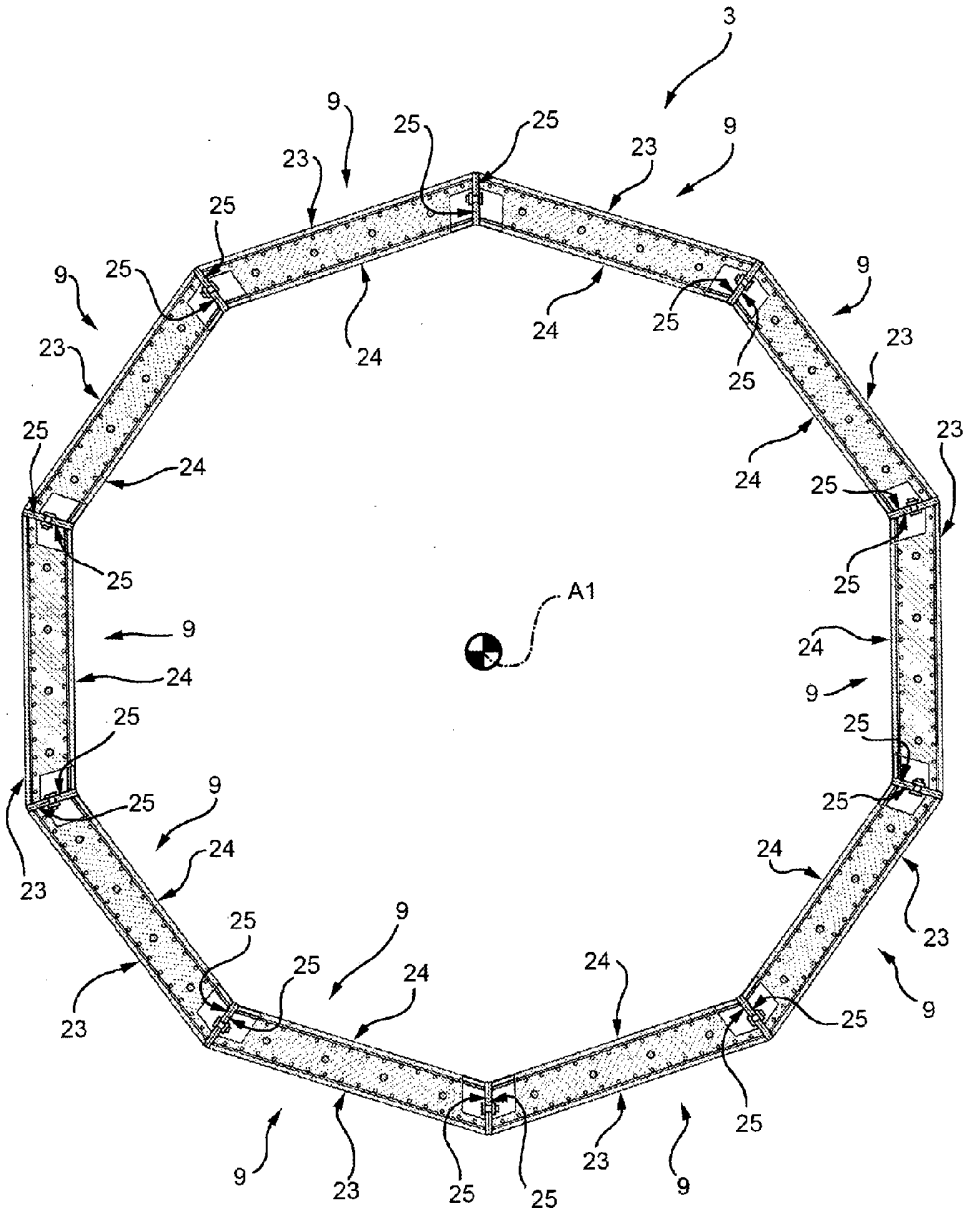

FIG. 3

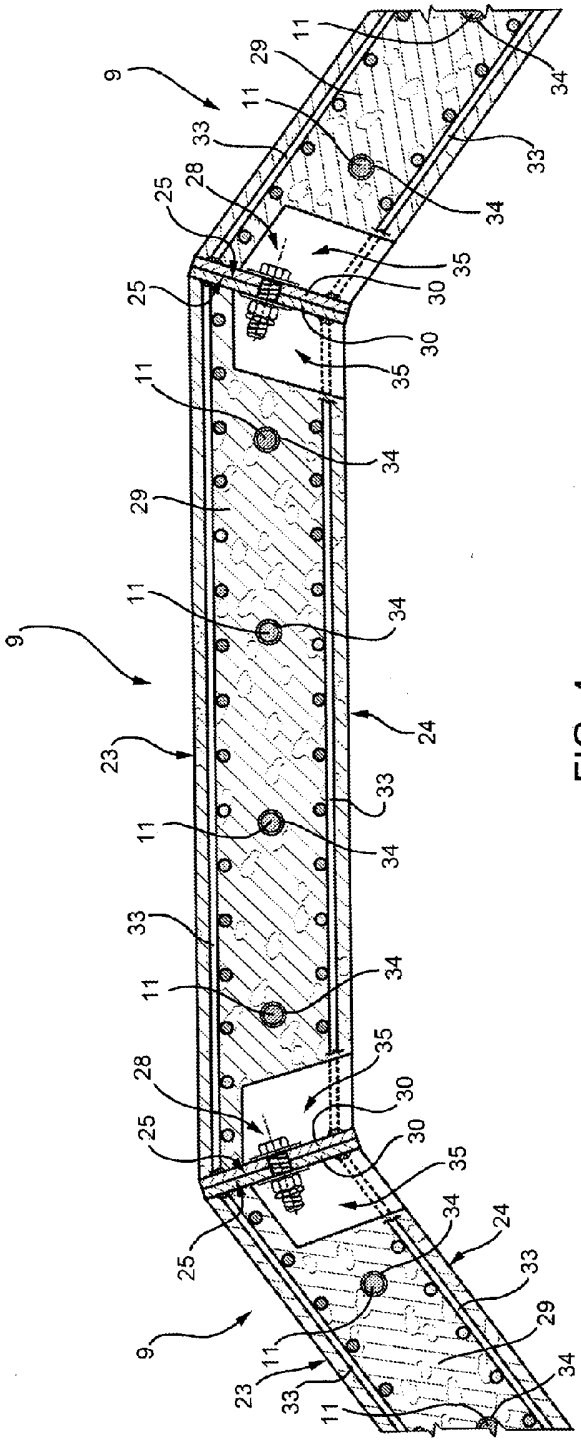

FIG. 4

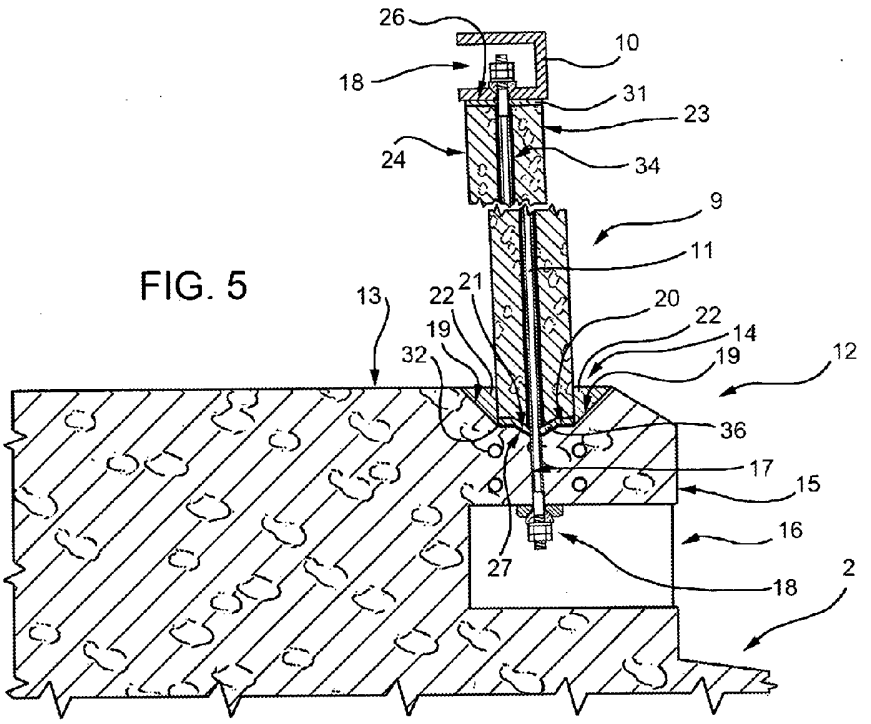
26
10
18
31
23
24
34
9
11
13
22
21
20
22
19
14
32
19
12
36
17
15
16
27
18
2

FIG. 5

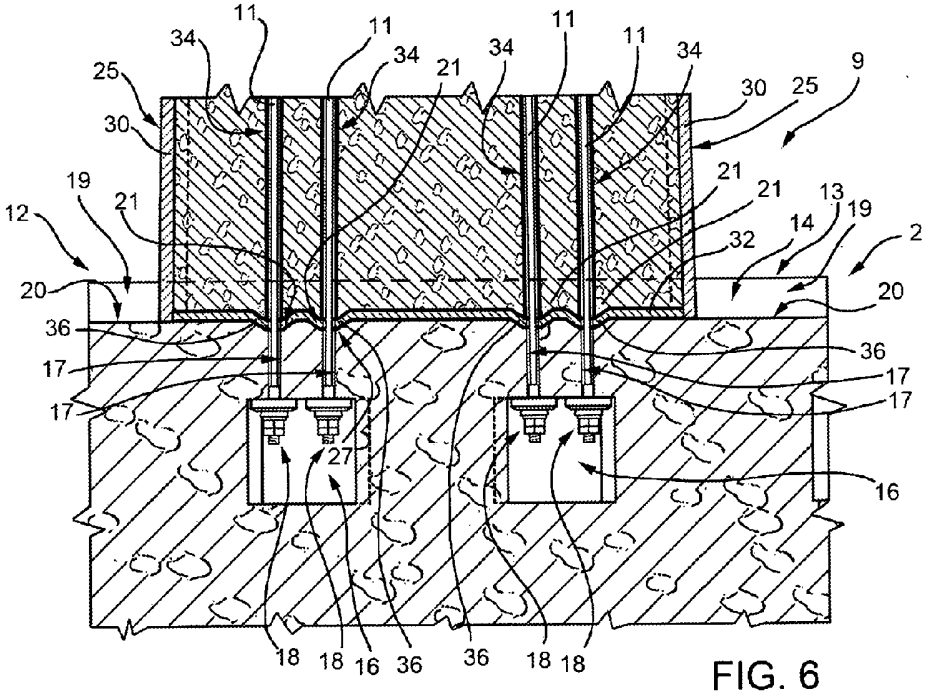
11
34
11
34
21
34
11
11
34
9
25
30
25
30
19
21
21
21
13
19
12
14
2
32
20
20
36
36
17
17
17
17
27
16
18
18
16
36
36
18
18

FIG. 6

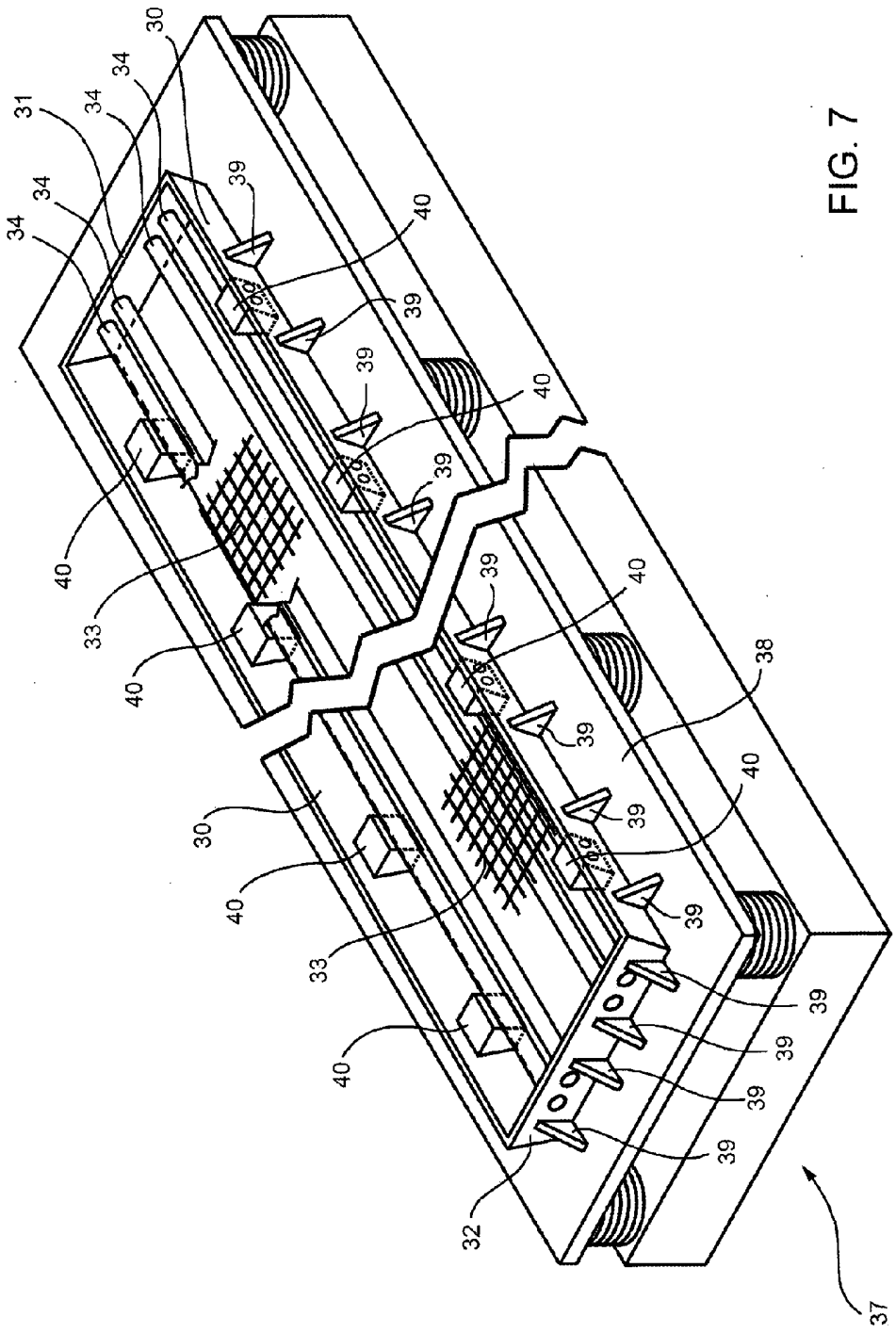
30
31
34
34
34
34
39
40
39
39
40
39
40
33
40
40
39
38
39
40
30
39
40
33
39
39
39
39
40
32
37

FIG. 7

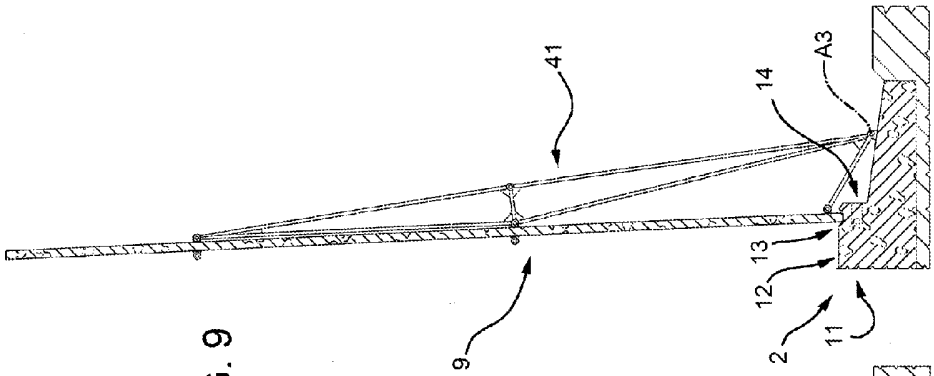

FIG. 9

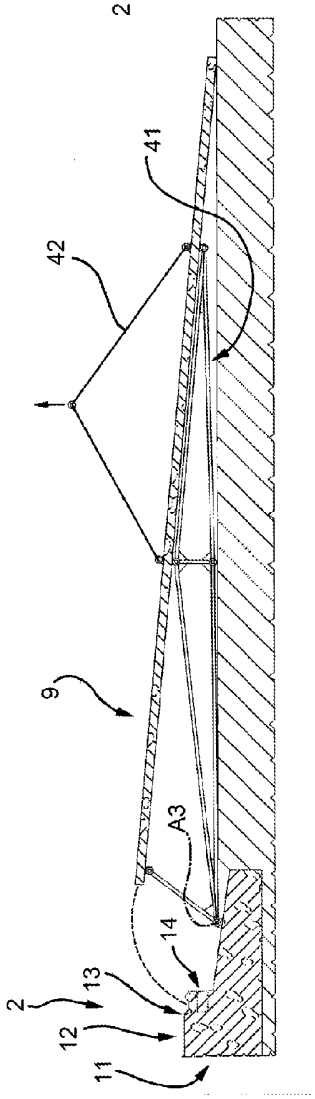

FIG. 8