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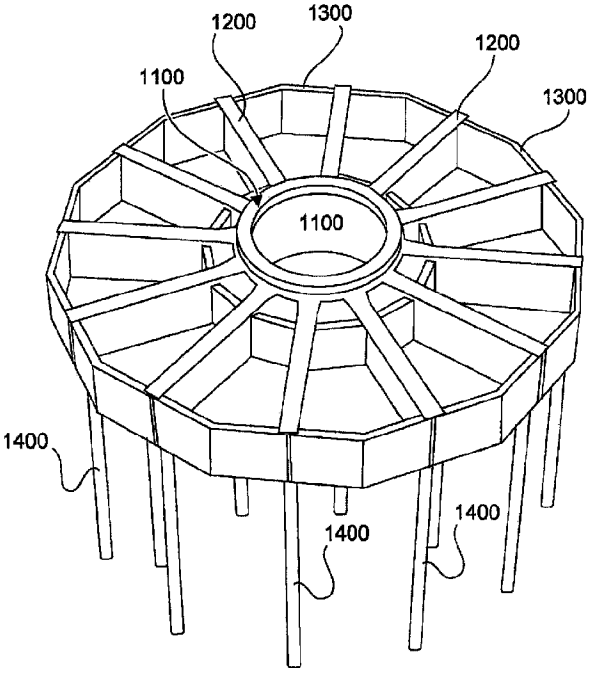

(57) Abrégé/Abstract:
The invention concerns a wind power installation foundation (1000) having a cylindrical central unit (1100), a plurality of steel carriers (1200) which are arranged radially around the central unit (1100) and which respectively have a first and a second end (1210, 1220), and a plurality of foundation piles (1400). The first ends (1210) of the steel carriers (1200) are fixed to the central unit (1100) so that the second ends (1220) of the steel carriers (1200) are in the form of free ends. The second free ends (1220) of the steel carriers (1200) are respectively placed on one of the foundation piles (1400).

Abstract

The invention concerns a wind power installation foundation (1000) having a cylindrical central unit (1100), a plurality of steel carriers (1200) which are arranged radially around the central unit (1100) and which respectively have a first and a second end (1210, 1220), and a plurality of foundation piles (1400). The first ends (1210) of the steel carriers (1200) are fixed to the central unit (1100) so that the second ends (1220) of the steel carriers (1200) are in the form of free ends. The second free ends (1220) of the steel carriers (1200) are respectively placed on one of the foundation piles (1400).

(Figure 1)

Wind power plant foundation and wind power plant

The present invention concerns a wind power installation foundation and a wind power installation.

Any wind power installation requires a foundation, on which a pylon of the wind power installation can be placed. Very specific demands are made on foundations of wind power installations as the foundation has to reliably carry forces and torques acting on the wind power installation. Those forces and torques are produced both by the wind which acts on the wind power installation and also due to rotation of the rotor of the wind power installation.

In the German patent application from which priority is claimed the German Patent and Trade Mark Office searched the following documents: DE 2013 216 342 A1 and US 2014/0115978 A1.

Therefore an object of the present invention is to provide a wind power installation foundation and a wind power installation, which permits a more efficient construction for the foundation under different weather conditions.

That object is attained by a wind power installation foundation in accordance with one or more aspects of the present invention, by a wind power installation in accordance with one or more aspects of the present invention and by a method in accordance with one or more aspects of the present invention.

Thus there is provided a wind power installation foundation having a cylindrical central unit, a plurality of steel carriers which are arranged radially around the central unit and which respectively have a first and a second end, and a plurality of foundation piles. The first ends of the steel carriers are fixed to the central unit so that the second ends of the steel carriers are in the form of free ends.

The second free ends of the steel carriers are respectively placed on one of the foundation piles.

According to an aspect of the present invention the wind power installation foundation has a plurality of leveling plates which are arranged on the foundation piles and which are after suitable leveling receive the second free ends of the steel carriers.

According to a further aspect of the present invention the wind power installation foundation has a plurality of precast concrete parts which are respectively placed between adjacent steel carriers so that the precast concrete parts and the adjacent steel carriers afford a trough which can be filled for example with concrete.

According to a further aspect of the present invention the central unit has a first end and a second end, wherein a lower pylon segment of a wind power installation or a pylon section can be placed on the second end of the central unit.

According to a further aspect of the present invention in the region of its second ends the steel carrier has reinforcing struts.

According to a further aspect of the present invention the foundation piles in the region of their upper end respectively have a foundation anchor for fixing the respective second ends of the steel carriers.

According to a further aspect of the present invention the foundation piles have a first, second and third portion, wherein the diameter of the third portion is larger than that of the first or second portion.

According to a further aspect of the present invention the first, second and third portions of the foundation piles are each in the form of a tube.

According to a further aspect of the present invention the foundation piles respectively have a plurality of struts or bars extending in the longitudinal direction and at least one coil.

According to a further aspect of the present invention the foundation piles are filled with concrete.

The invention also concerns a wind power installation having a wind power installation foundation as described above.

The second free ends of the steel carriers are respectively placed on one of the foundation piles.

The invention also concerns a method of producing a wind power installation foundation, in particular for permafrost grounds. A cylindrical central unit is placed and a plurality of steel carriers is arranged radially around the central unit. The steel carriers have a first and a second end, wherein the first ends of the steel carriers are fixed to the central unit so that the second ends are in the form of free

ends. A plurality of foundation piles is at least partially placed in or driven into the ground. The second free ends of the steel carriers are respectively placed on the ends, projecting out of the ground, of the foundation piles.

Advantages and embodiments by way of example of the invention are described in greater detail hereinafter with reference to the drawings.

Figure 1 shows a diagrammatic perspective view of a foundation of a wind power installation according to a first embodiment,

Figure 2 shows a plan view of a foundation of a wind power installation according to a second embodiment,

Figure 3A shows a sectional view of a foundation of a wind power installation according to a third embodiment,

Figure 3B shows a sectional view of a portion of the foundation of the wind power installation according to the third embodiment,

Figure 3C shows a perspective diagrammatic view of a part of a foundation of a wind power installation according to the third embodiment,

Figure 4A shows a sectional view of a foundation pile of a foundation according to the invention,

Figure 4B shows a diagrammatic sectional view of a tube of the foundation pile of Figure 4A,

Figures 4C-4E each show a sectional view of the pile of Figure 4A,

Figure 4F shows a diagrammatic arrangement of the foundation piles in a foundation according to the invention,

Figure 5A shows a sectional view of a central unit of a foundation of a wind power installation,

Figure 5B shows a diagrammatic plan view of the steel carrier of the foundation according to the invention,

Figure 5C shows a further plan view of a steel carrier of the foundation according to the invention of Figure 5B,

Figure 5D shows a plan view of an end of a steel carrier as shown in Figure 5A,

Figure 5E shows a plan view of an end of a steel carrier as shown in Figure 5A,

Figure 5F shows a diagrammatic view of a portion of a foundation of a wind power installation according to the invention,

Figure 5G shows a diagrammatic view of a portion of a foundation of a wind power installation according to the invention, and

Figures 6A-6H show various views of precast concrete parts of the foundation of the wind power installation according to the invention.

The wind power installation foundation according to the invention is essentially a steel foundation having a cylindrical central unit and steel arms or steel carriers projecting radially therefrom. The central unit and the steel arms together form a foundation star. The free ends of the steel arms respectively rest on a foundation pile. Precast concrete parts are placed between adjacent steel arms so that the adjacent steel arms and the precast concrete parts afford a trough which can be filled with concrete, gravel and/or earth. As an alternative thereto the trough can also be filled with prefabricated concrete parts. Thus the wind power installation foundation according to the invention represents a pile foundation. The foundation according to the invention represents a hybrid foundation consisting of a combination of steel carriers and precast concrete parts.

The foundation according to the invention is suitable in particular for permafrost grounds.

Figure 1 shows a diagrammatic perspective view of a foundation of a wind power installation according to a first embodiment. The wind power installation foundation according to the invention has a cylindrical central unit 1100 and a plurality of radially extending steel arms or steel carriers 1200. A first end of the steel arms is fixed to the cylindrical central unit 1100 while the other second free end of the steel arms or steel carriers 1200 rests on a respective foundation pile 1400. In other words only the second free ends of the radially extending steel arms 1200 rest on the foundation piles 1400.

Precast concrete parts 1300 are placed between the steel arms 1200 so that a trough is formed.

Figure 2 shows a plan view of a foundation of a wind power installation according to a second embodiment. The wind power installation foundation 1000 according to the second embodiment can correspond to the wind power installation foundation according to the first embodiment. The wind power installation foundation 1000 has a cylindrical central unit 1100. A plurality of steel arms or steel carriers 1200 are fixed with their first end to the central unit 1100. The steel arms or steel carriers 1200 extend radially from the central unit 1100. Optionally the angle between two adjacent steel carriers or steel arms 1200 is 30° so that for example there are 12 steel arms or steel carriers 1200. Precast concrete parts 1300 are provided between two adjacent steel arms or steel carriers 1200. In particular there are respectively provided three precast concrete parts 1310, 1320, 1330. The first precast concrete part 1310 is provided at the exterior and has a wall. The second precast concrete part 1320 is provided in the centre and the third precast concrete part 1330 is towards the central unit 1100 and can have a further wall. A trough is defined by the three precast concrete parts and the two adjacent steel carriers.

Figure 3A shows a sectional view of a foundation of a wind power installation according to a third embodiment. A plurality of steel arms or steel carriers 1200 is provided around the cylindrical central unit 1100. The free ends of the steel carriers 1200 rest on foundation piles 1400. Each foundation pile 1400 has a first lower portion 1410, a second central portion 1420 and a third upper portion 1430. The steel arms or steel carriers 1200 in that case rest on the third portion 1430. The free ends 1220 of the steel arms 1200 can be fixed for example by segment anchors 1440 and rods like for example threaded rods 1450 to the third portions 1430 of the foundation piles 1400. Provided between the steel arms 1200 are the precast concrete parts 1310, 1320 and 1330, the first concrete parts 1310 having an outside wall and the third precast concrete parts 1330 having an inside wall. Thus a trough which can be filled by sand, earth, gravel or concrete 2000 is defined by the first through third precast concrete parts and the two adjacent steel arms 1200.

Figure 3B shows a sectional of a portion of the foundation of the wind power installation according to the third embodiment. The wind power installation

foundation according to the invention has a cylindrical central unit 1100 with a plurality of steel arms or steel carriers 1200 fixed thereto and extending radially therefrom. Provided between the steel carriers are precast concrete parts 1300 which together with the steel carriers form a trough into which sand, earth, gravel, concrete 2000 can be filled. The precast concrete parts 1310, 1320, 1330 can have drainage openings 1301.

The free ends 1220 of the steel arms 1200 rest on the third portions 1430 of the foundation piles 1400. The second (free) ends 1220 of the steel arms can be respectively fixed to one of the foundation piles 1400 by way of foundation anchors 1400 and foundation anchors 1450. The first ends 1210 of the steel carriers 1200 are respectively fixed to the central unit 1100.

The central unit 1100 has a first (lower) side 1110 and a second (upper) side 1120. Placed on the second (upper) side 1120 is a lower pylon segment 102 or pylon section of the wind power installation.

Figure 3C shows a diagrammatic perspective view of a part of a foundation of a wind power installation according to the third embodiment. Figure 3C shows the foundation of the wind power installation without the precast concrete parts. In that way it is possible to see in particular the cylindrical central unit 1100 as well as the radially extending steel arms or steel carriers 1200, that is to say the foundation star. In this case the free ends 1220 of the steel carriers respectively rest on a foundation pile 1400 so that this arrangement provides a pile foundation.

Figures 4A-4F show various views of the foundation piles according to the invention.

Figure 4A shows a sectional view of a foundation pile of a foundation according to the invention. The foundation pile 1400 has a first, second and third portion 1410, 1420, 1430. In that arrangement the first portion 1410 is the lowermost portion while the second portion 1420 represents the central portion. The third portion 1430 is the upper portion on which the free ends 1220 of the steel carriers 1200 rest. Provided in the third portion 1430 are a respective segment anchor 1440 and two threaded bolts 1450. The threaded bolts 1450 can be disposed within a PU foam tube 1451.

Provided on the top side of the third portion 1430 is a respective leveling plate 1470. The third portion 1430 of the foundation pile 1400 can be fixed by means of the threaded bolts 1450 to a lower end of the steel arm or steel carrier 1200. Before the steel carriers 1200 are fixed in place the respective leveling plates 1470 of the respective foundation piles 1400 can be leveled so that the undersides of the respective steel carriers or steel arms 1200 are leveled, whereby the central unit is also leveled. Leveling of the central unit 1100 is highly important because a lower pylon segment or pylon section 102 can be placed on the second side 1120 of the central unit 1100. The pylon 102 of the wind power installation can be oriented exactly vertically only when the second (upper) side 1120 of the central unit 1100 is oriented exactly horizontally. That exact horizontal orientation is achieved by placement and orientation of the leveling plates 1470 on the upper ends of the third portions 1430 of the foundation piles 1200.

The third portion 1430 of the foundation pile 1400 has a steel tube 1431 and a coil or spiral 1434.

The threaded bolts 1450 according to the invention can have a thread at least at their two ends. No thread has to be provided in the region therebetween, that is to say in the central portion.

Provided between the first and second portions 1430, 1420 is a steel funnel-shaped portion 1460 which reduces the diameter of the third portion 1430 to the diameter of the second portion 1420.

The second portion 1420 also has a steel tube 1421 and a second coil or spiral 1423.

The first portion 1410 also has a steel tube 1411 which is of the same diameter as the steel tube 1421 of the second portion. A coil or spiral 1412 is provided within the steel tube 1411.

Figure 4B shows a diagrammatic sectional view of a tube of the foundation pile of Figure 4A. Figure 4B shows the first, second and third portions 1410, 1420, 1430 and the funnel-shaped portion 1460 between the second and third portions. The funnel-shaped portion 1460 serves to adapt the diameter of the third portion 1430 to the diameter of the second portion 1420. The first portion 1410 has a first

steel tube 1411, the second portion 1420 has a second steel tube 1421 and the third portion 1430 has a third steel tube 1431.

Figure 4C shows a sectional view along section line 1-1 in Figure 4A in the region of the third portion 1430. The third portion 1430 has a steel tube 1431, for example sixteen bars 1432, a coil or spiral 1434 and two bores 1435 serving to receive the threaded bolts 1450. The steel tube 1431 can for example be filled with concrete.

Figure 4D shows a sectional view along section line 2-2 in Figure 4A in the region of the second portion 1420 of the foundation pile 1400. The second portion 1420 has a second steel tube 1421, a coil or spiral 1423 and for example sixteen bars 1422.

The steel tube 1421 of the second portion 1420 can for example be filled with concrete.

Figure 4E shows a sectional view along section line 3-3 in Figure 4A in the region of a first portion 1410 of the foundation pile 1400.

Figure 4F shows a diagrammatic view of the arrangement of 12 foundation piles 1400a-l. The free ends of the steel carriers or steel arms 1200 are placed on those piles.

Figure 5A shows a sectional view of a central unit of a foundation of a wind power installation. The central unit 1100 is of a cylindrical configuration and has a first (lower) end 1110, a second (upper) end 1120, a first portion 1140 and a second portion 1150. A flange 1130 having a plurality of bores 1131 is provided between the first and second portions 1140 and 1150.

A flange having a plurality of bores 1111 is also provided at the first (lower) end 1110. The second (upper) end 1120 also has a plurality of bores 1121. Provided in the region of the first portion 1140 at the outside is a plurality of fixing portions 1160 which serve to provide that the respective first sides (1210) of the steel arms or steel carriers 1200 are fixed or welded thereto.

Figure 5B shows a diagrammatic plan view of a steel carrier of the foundation according to the invention. The steel arm or steel carrier 1200 has a first end 1210 and a second end 1220, the first end 1210 being fixed to the central unit and in particular to the fixing portion 1160. The second ends 1220 have support struts

1121 on both sides. The steel carrier or steel arm 1200 has a first (lower) side 1223 and a second (upper) side 1222. Optionally the respective first ends 1210 of the steel carriers 1200 can be welded to the fixing portions 1160 of the central unit 1100. The steel carriers 1200 each have a central portion 1230 extending between the first and second sides 1223, 1222. The central portion 1230 can be for example in the form of a steel plate.

Figure 5C shows a further plan view of an arm of the foundation according to the invention of Figure 5B. Figure 5C shows in particular the first (lower) side 1223. A fixing weld portion 1223a is provided in the region of the first side 1210 of the steel carrier 1200. A plate 1223b is provided in the region of the second side 1220 of the steel carrier 1200.

Figure 5D shows a plan view of an end of an arm as shown in Figure 5A. Figure 5D shows a side view of a steel carrier of a foundation according to the invention. The steel carrier has a first (lower) side 1223, a second (upper) side 1222 and a plate 1230 therebetween. Reinforcing struts 1221 are provided on both sides of the plate 1230.

Figure 5E shows a plan view of a first side of a steel carrier of a foundation according to the invention. The first side 1210 is welded in particular to a fixing portion 1160 of the central unit 1100.

Figures 5F and 5G each show a portion of a foundation according to the invention of a wind power installation. In particular Figure 5F shows a plan view of a second side 1220. The steel carrier 1200 has a first (lower) end 1223, a second (upper) end 1222 and a plate 1230 therebetween. Pressure pads 1227 for example of polymer can be provided between the plate 1230 and the precast foundation parts 1300.

Figure 5G does not have any pressure pads but spindles in a pocket 1228 between the precast concrete parts and the steel arm 1200.

Figures 6A-6H show various views of precast concrete parts of the wind power installation foundation according to the invention. The precast concrete parts 1300 are placed between adjacent steel carriers or steel arms 1200 of the foundation of the wind power installation according to the invention. The precast concrete parts 1300 are divided into three and thus have a first, a second and a

third part 1310, 1320, 1330. The first precast concrete parts 1310 is provided at the outer edge, the second precast concrete part 1320 in the middle and the third precast concrete part 1330 in the inside.

The first and second precast concrete parts 1310, 1320 each have a wall so that the precast concrete parts 1310-1330 and the adjacent steel carriers 1200 define a trough which can be filled by gravel, sand, earth, concrete 2000.

Figures 6B through 6D show various views of the first precast concrete part 1310. The first precast concrete part 1310 has a wall 1311, a bottom 1312 and a straight side 1313 disposed in opposite relationship to the wall 1311. In this case the wall 1311 is substantially at a right angle to the bottom 1312. The first precast concrete part 1310 is of a substantially pentagonal configuration, with a respective recess 1315 being provided at the two sides 1314.

Figures 6E and 6F show various views of the second precast concrete part. The second precast concrete part 1300 has a first and a second side 1321, 1323 which are arranged parallel to each other. The second precast concrete part 1320 also has two side surfaces 1324.

Figures 6G and 6H show various views of the third precast concrete part 1330. The third precast concrete part 1330 has a wall 1333 and a first side 1331 which are arranged parallel to each other. The third precast concrete part 1330 also has a bottom 1332 which is substantially at a right angle to the wall 1333.

CLAIMS

1. A wind power installation pile foundation, comprising:

a cylindrical central unit;

a plurality of steel carriers arranged radially around the central unit and having first and second ends, respectively,

wherein the first ends of the plurality of steel carriers are fixed to the central unit and the second ends of the steel carriers are free ends;

a plurality of foundation piles at least partially in a ground,

wherein the second free ends of the steel carriers are respectively placed on the plurality of foundation piles; and

a plurality of precast concrete parts between adjacent steel carriers so that the precast concrete parts and the adjacent steel carriers, respectively, form a trough configured to be filled with at least one of: concrete, gravel and earth.

2. The wind power installation pile foundation according to claim 1, further comprising:

a plurality of leveling plates arranged on the plurality of foundation piles and which, after suitable leveling, receive the second free ends of the plurality of steel carriers.

3. The wind power installation pile foundation according to claim 1 or claim 2 wherein

the central unit has a first end and a second end, wherein a lower pylon segment of a wind power installation or a pylon section is configured to be placed on the second end of the central unit.

4. The wind power installation pile foundation according to any one of claims 1 to 3 wherein

the plurality of steel carriers have reinforcing struts in a region of the second ends.

5. The wind power installation pile foundation according to any one of claims 1 to 4 further comprising a plurality of foundation anchors, wherein

the plurality of foundation piles have upper end regions and the foundation anchors are at the upper end regions and configured to fix the second ends of the plurality of steel carriers, respectively.

6. The wind power installation pile foundation according to claim 5 wherein

the plurality of foundation piles have first, second, and third portions, wherein a diameter of the third portion is larger than a diameter of the first portion or a diameter of the second portion.

7. The wind power installation pile foundation according to claim 6 wherein

the first, second, and third portions of the plurality of foundation piles are each a tube shape.

8. The wind power installation pile foundation according to claim 6 or claim 7 wherein

the plurality of foundation piles, respectively, have a plurality of struts or bars extending in the longitudinal direction and at least one coil.

9. The wind power installation pile foundation according to any one of claims 6 to 8 wherein

the plurality of foundation piles are filled with concrete.

10. A wind power installation, comprising:

a wind power installation pile foundation according to any one of claims 1 to 9.

11. A method of producing a wind power installation pile foundation, the method comprising:

providing a cylindrical central unit;

placing a plurality of steel carriers radially around the central unit,

wherein the plurality of steel carriers have first and second ends,

wherein the first ends of the plurality of steel carriers are fixed to the central unit and the second ends are free ends;

placing a plurality of foundation piles at least partially in a ground,

wherein the second free ends of the steel carriers are respectively placed on the ends, projecting out of the ground, of the foundation piles;

placing a plurality of precast concrete parts between adjacent steel carriers of the plurality of steel carriers so that at least one respective trough is formed by the precast concrete parts and the adjacent steel carriers; and

filling the at least one trough with at least one of concrete, gravel or earth.

12. Use of a wind power installation pile foundation according to claim 1 in a permafrost ground.

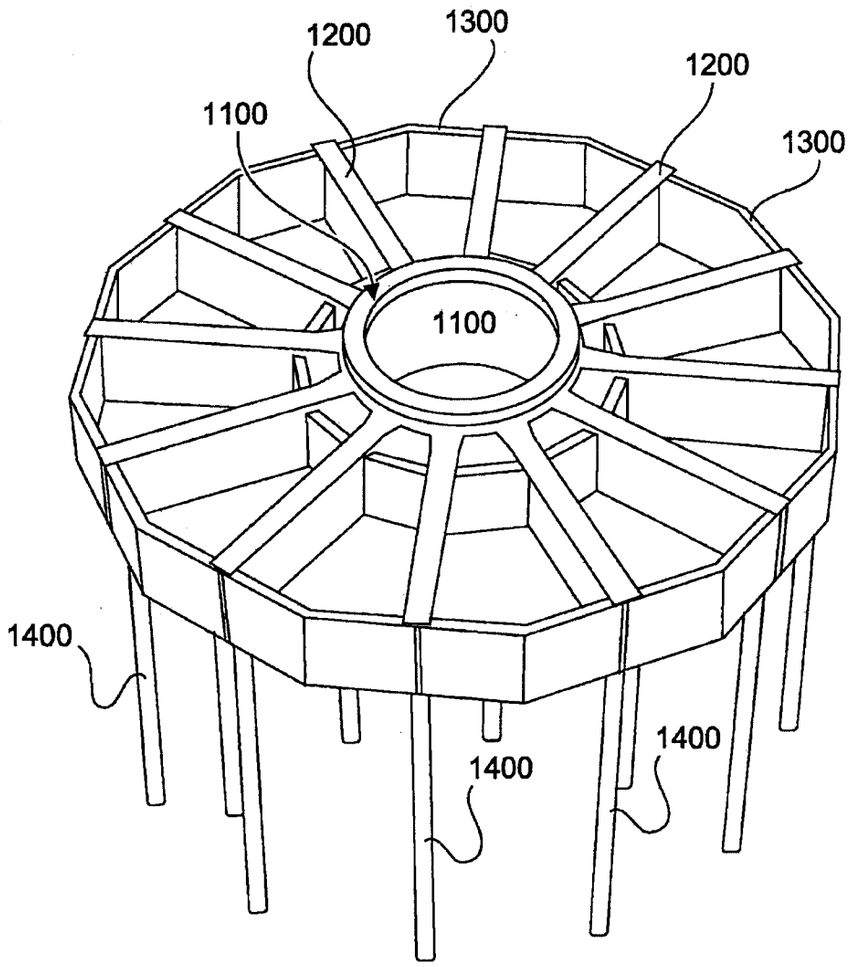

Fig. 1

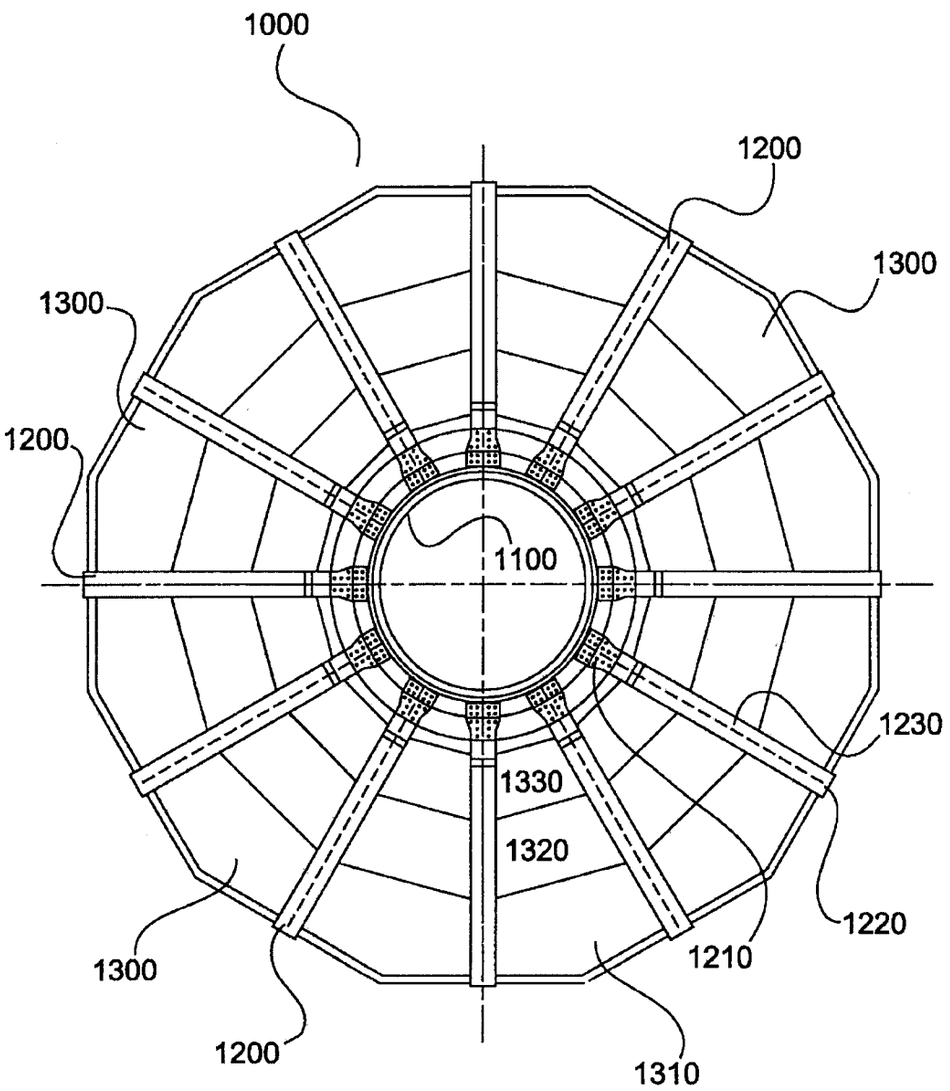
1000
1200
1300
1300
1200
1100
1230
1330
1320
1220
1300
1210
1200
1310

Fig. 2

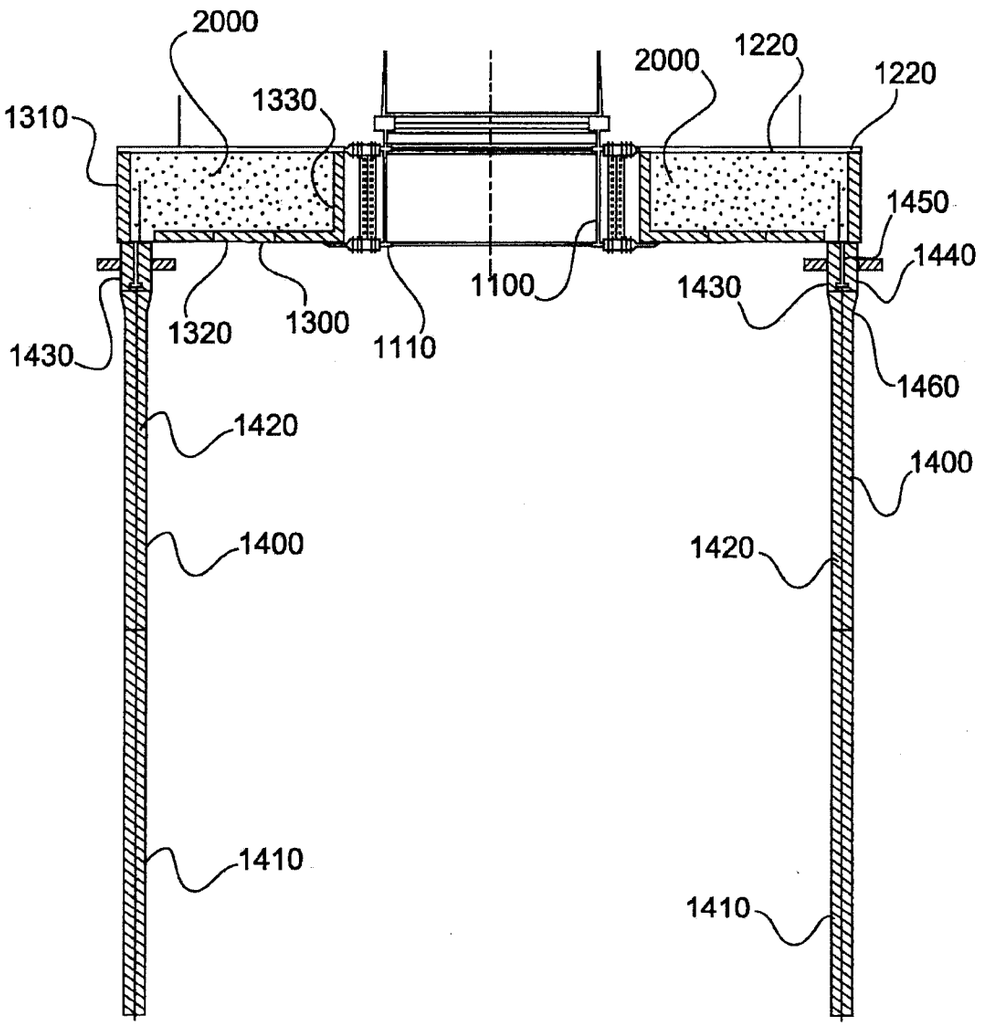
2000
1330
1310
2000
1220
1220
1450
1440
1100
1430
1320
1300
1110
1430
1460
1420
1400
1400
1420
1410
1410

Fig. 3A

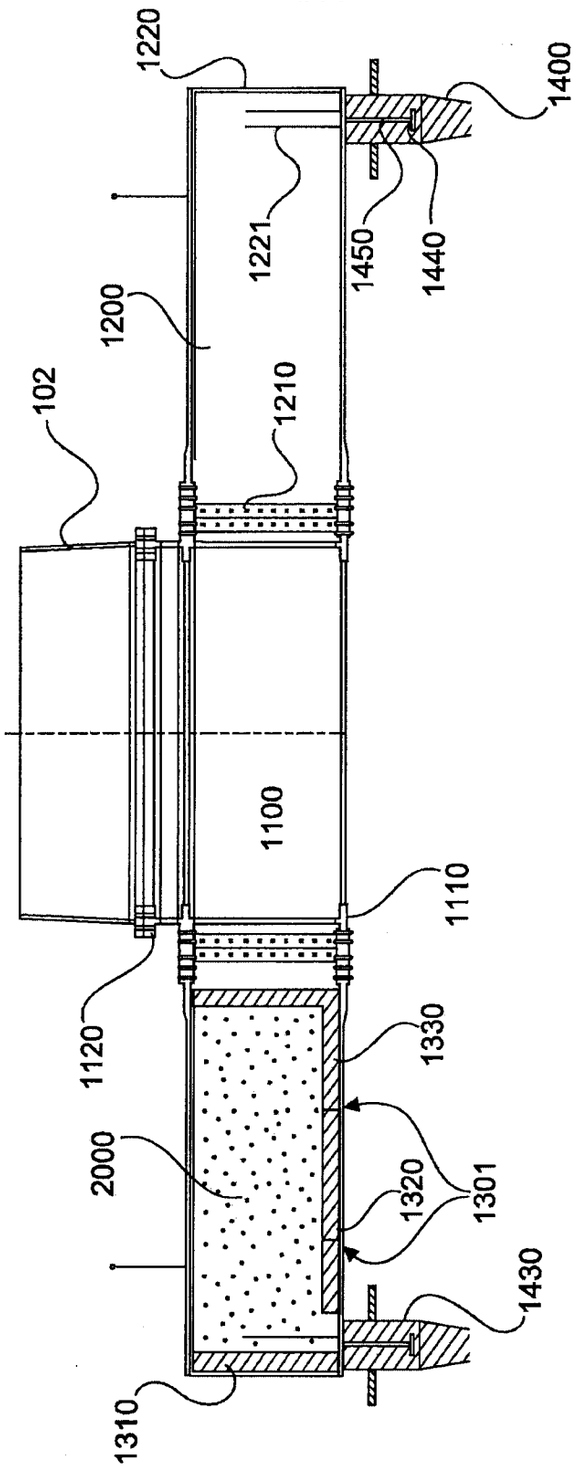
1220
1400
1221
1450
1440
1200
102
1210
1100
1110
1120
1330
2000
1320
1301
1430
1310

Fig. 3B

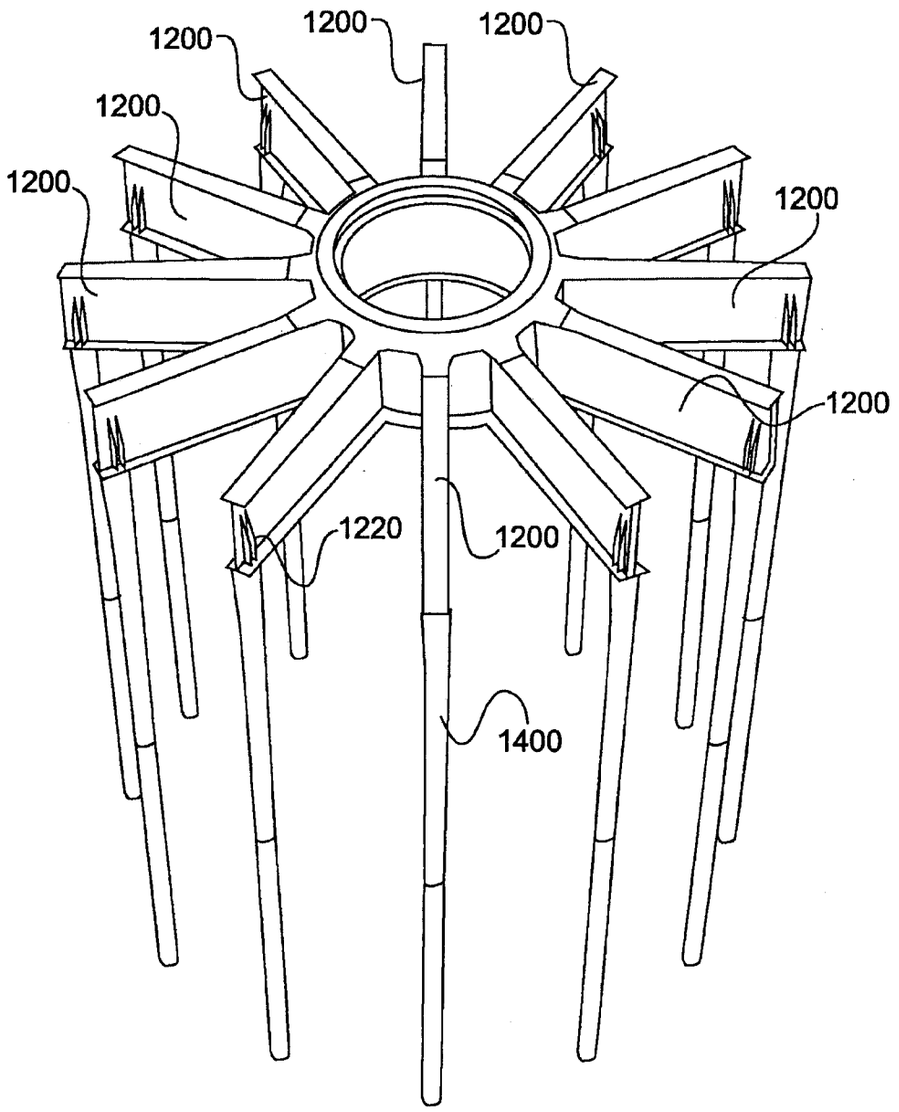

Fig. 3C

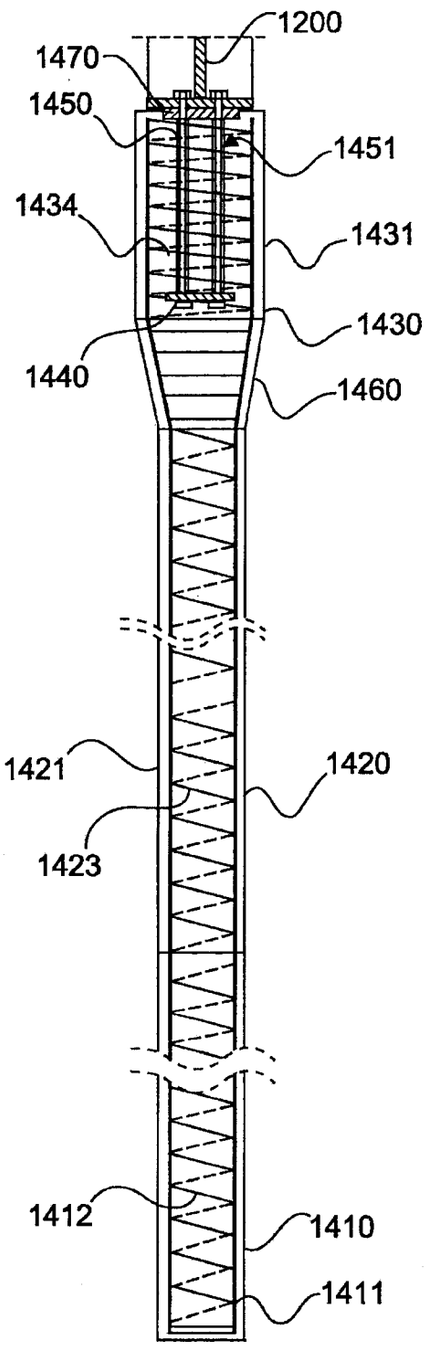
1200
1470
1450
1451
1434
1431
1430
1440
1460
1421
1420
1423
1412
1410
1411

Fig.4A

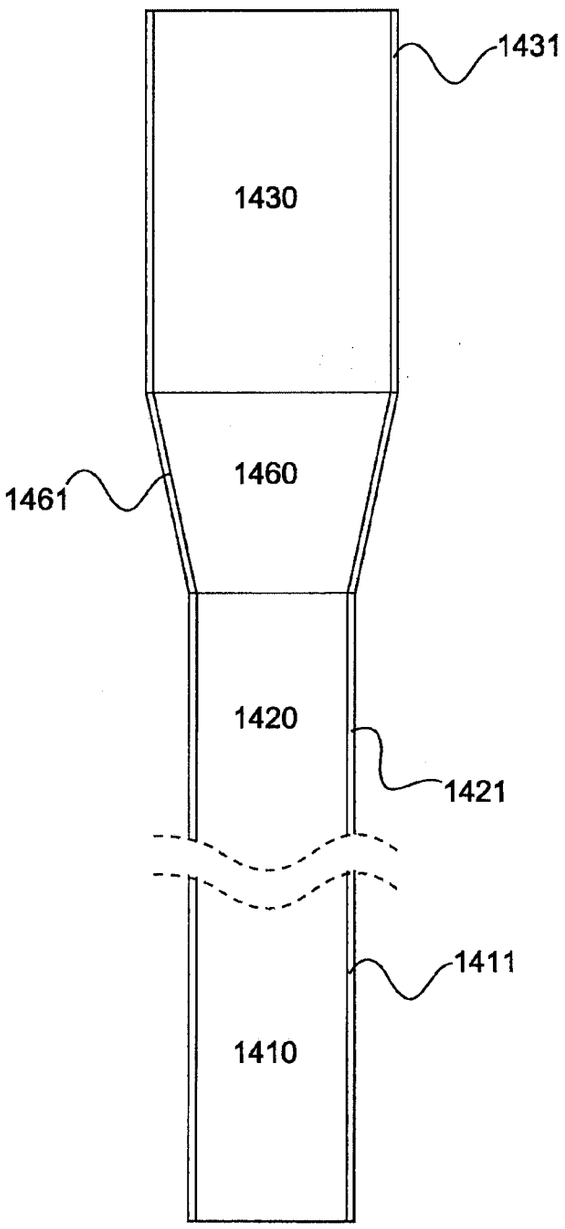

Fig.4B

Section 1-1

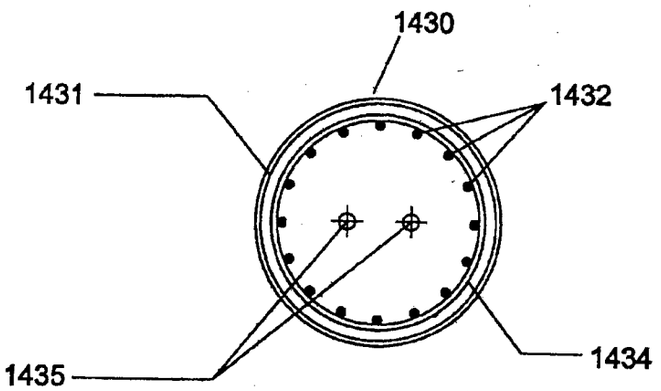

Fig.4C

Section 2-2

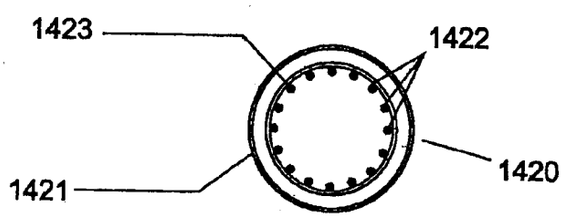

Fig.4D

Section 3-3

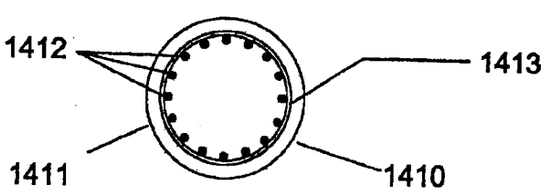

Fig.4E

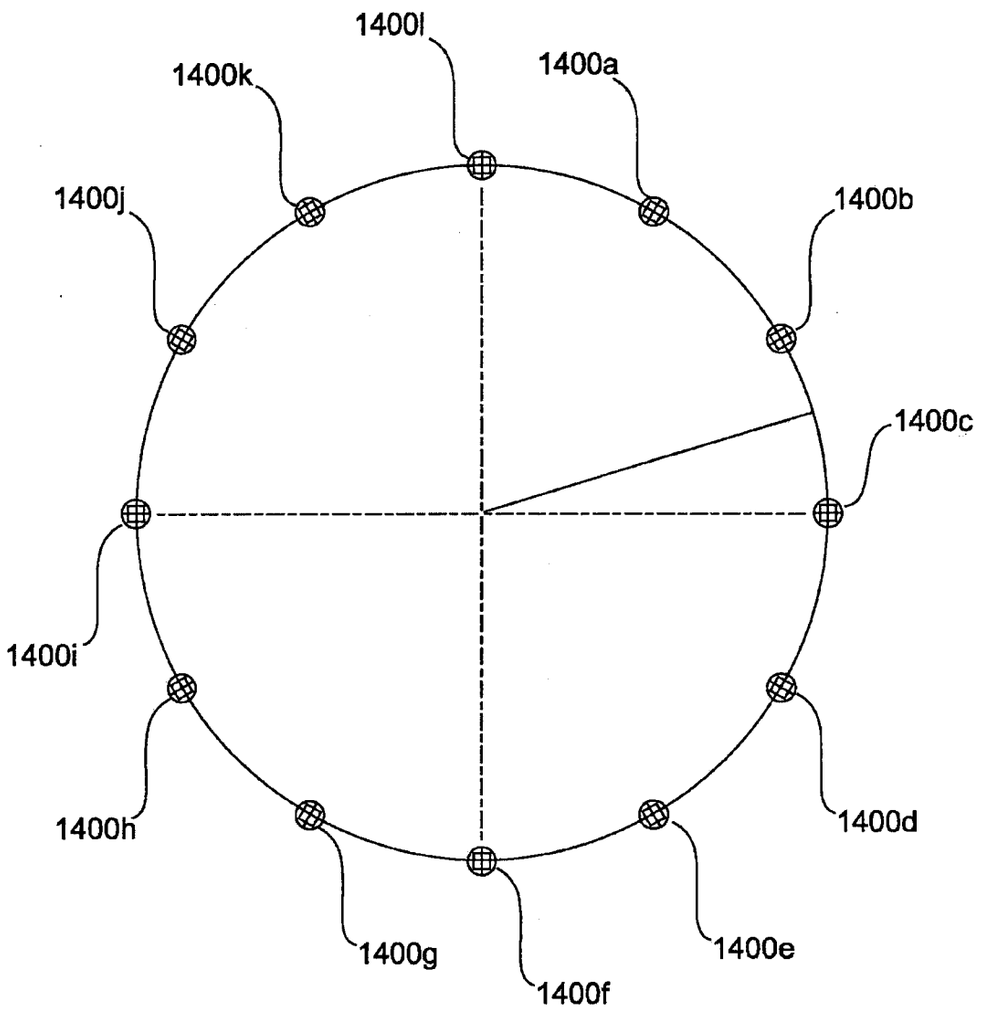
1400l
1400a
1400k
1400j
1400b
1400c
1400i
1400h
1400d
1400g
1400e
1400f

Fig.4F

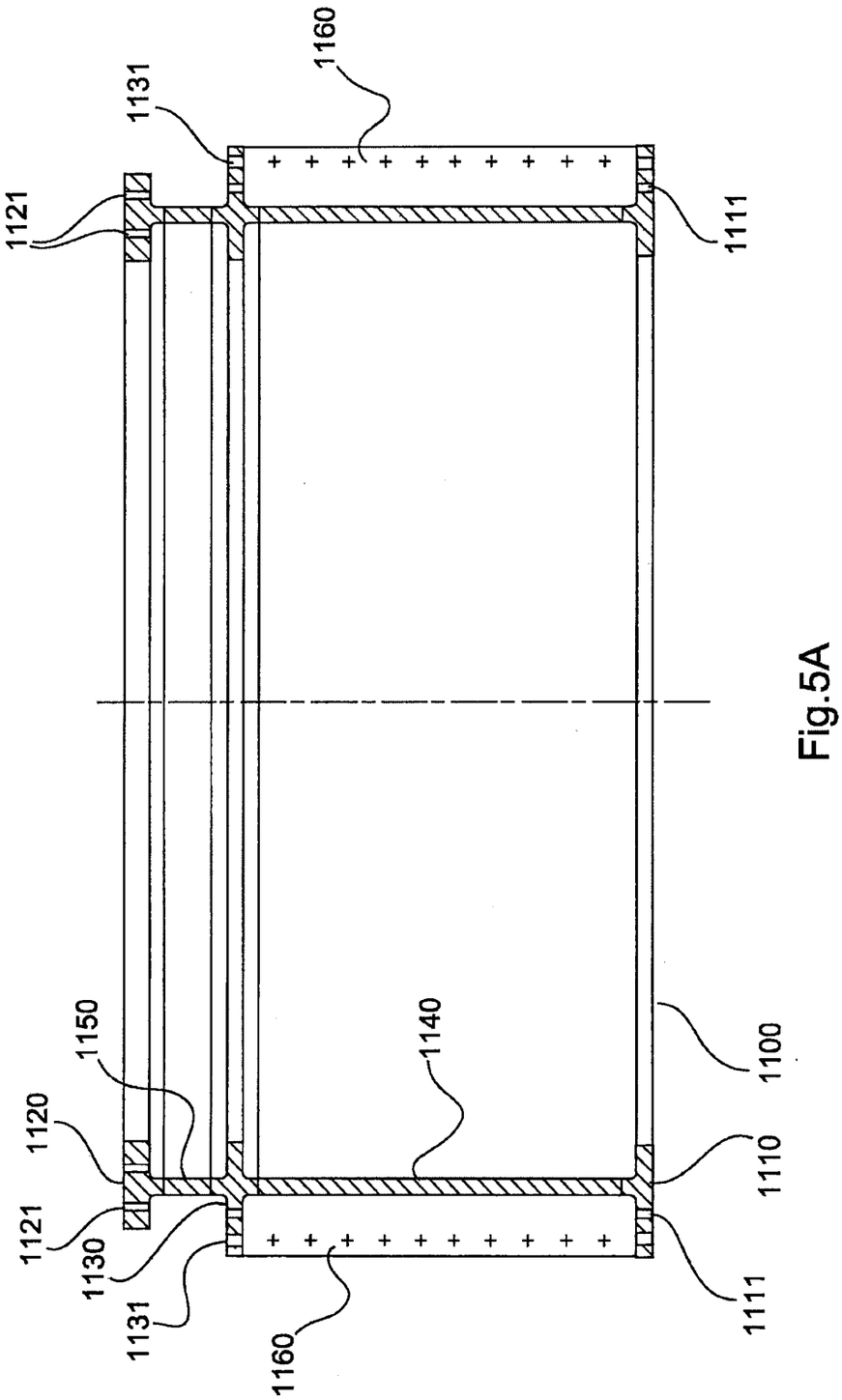
1160
1131
1121
1111
1150
1140
1100
1120
1110
1121
1130
1131
1160
1111

Fig.5A

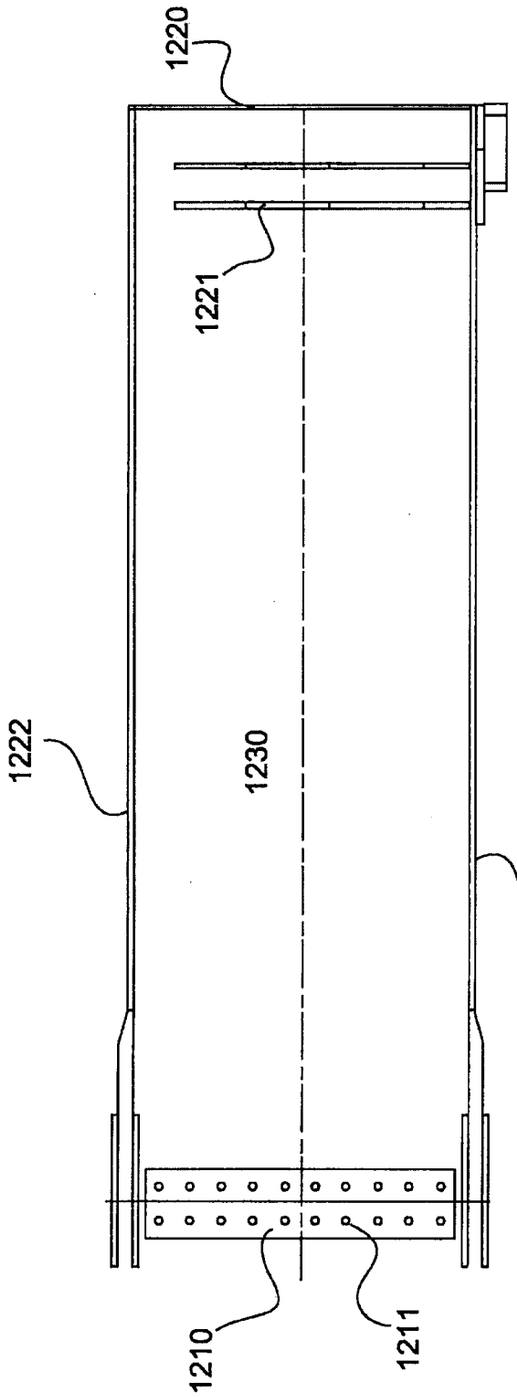
1220
1221
1222
1230
1223
1210
1211

Fig.5B

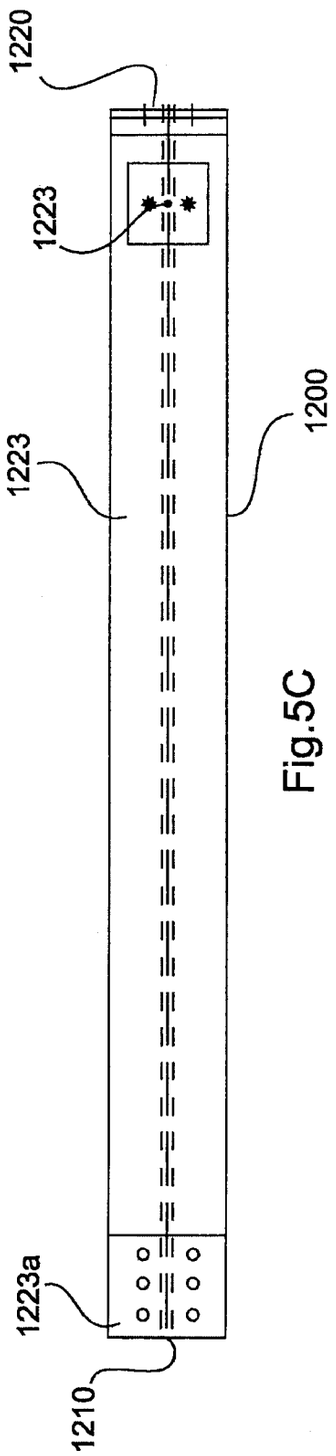
1220
1223
1223
1200
1223a
1210

Fig.5C

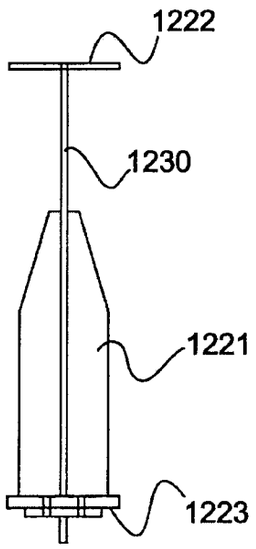

Fig.5D

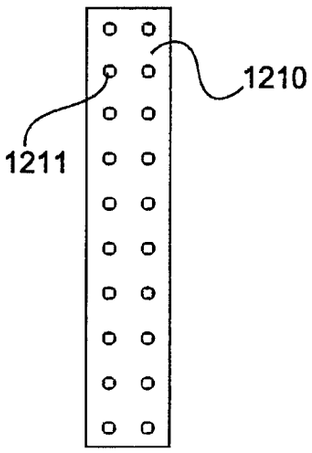

Fig.5E

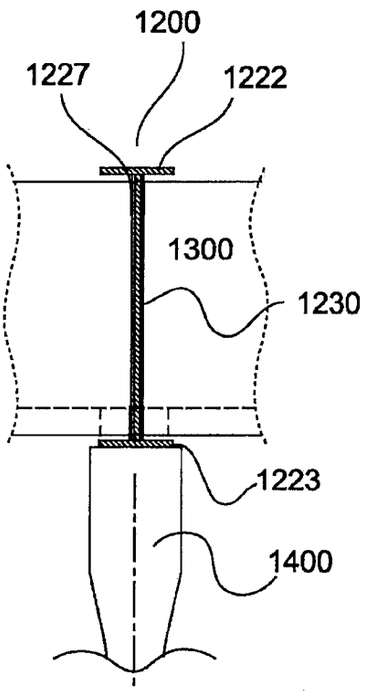

Fig.5F

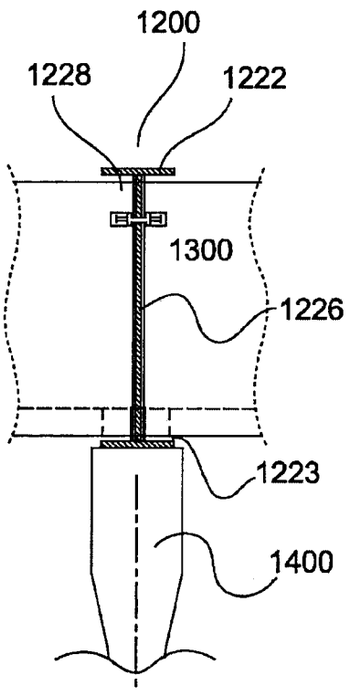

Fig.5G

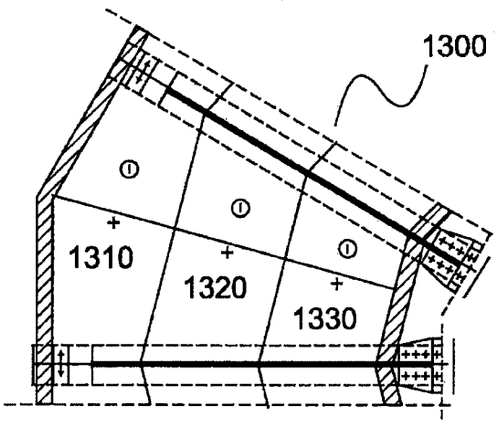

Fig.6A

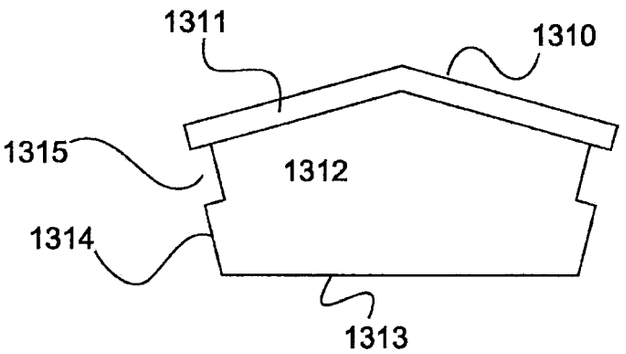

Fig.6B

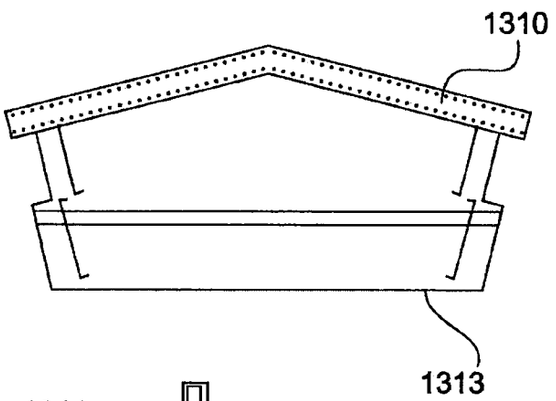

Fig.6C

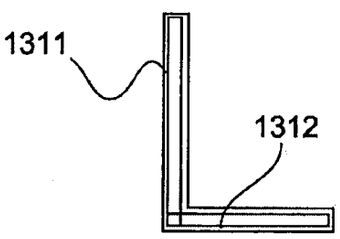

Fig.6D

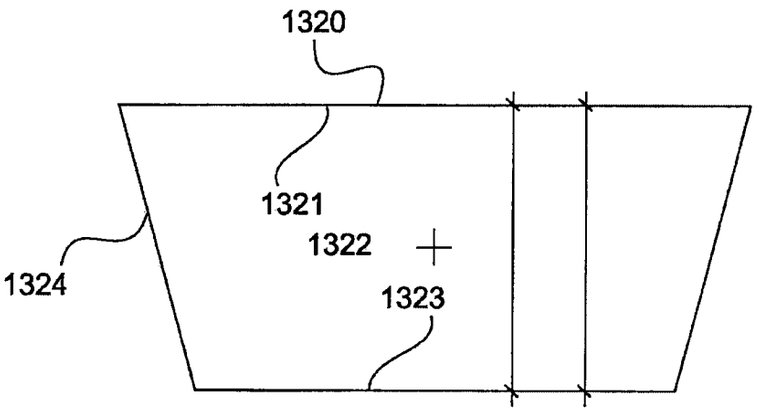

Fig.6E

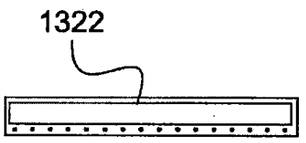

Fig.6F

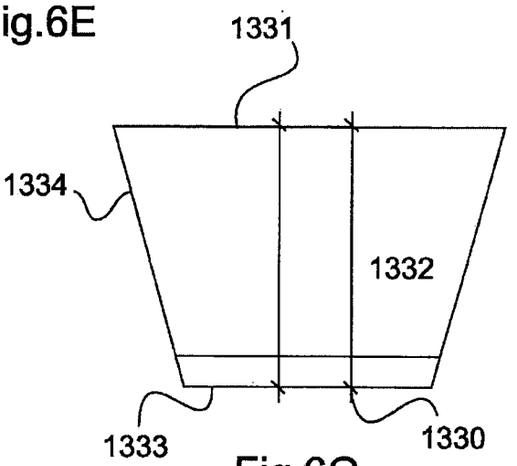

Fig.6G

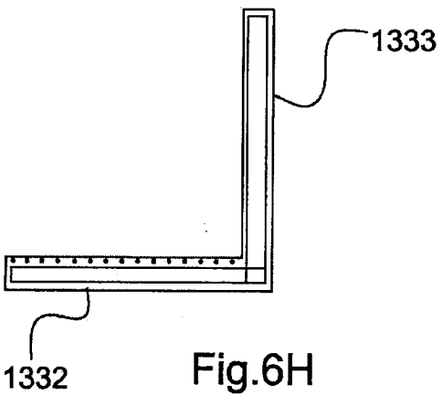

Fig.6H

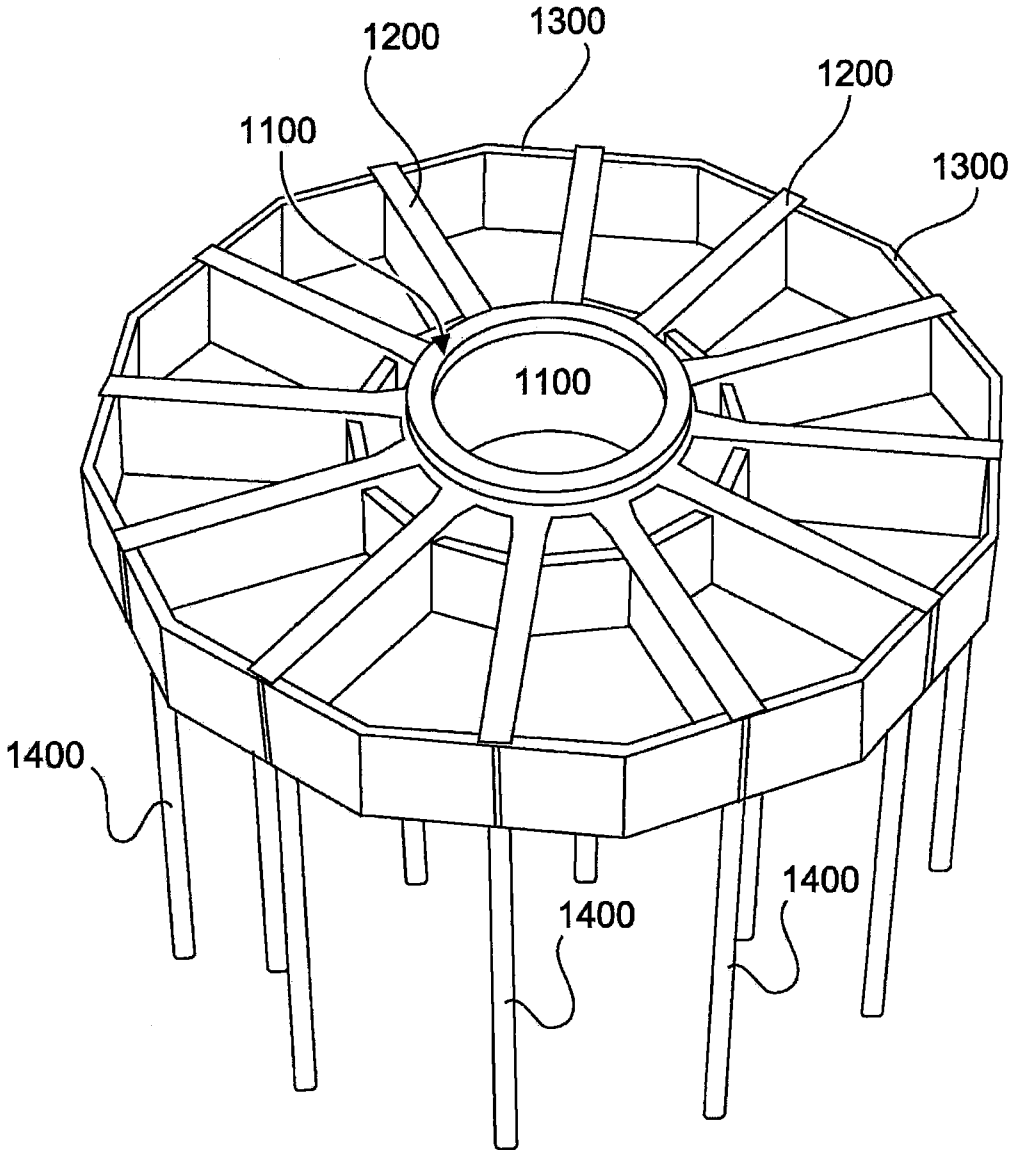

Fig. 1