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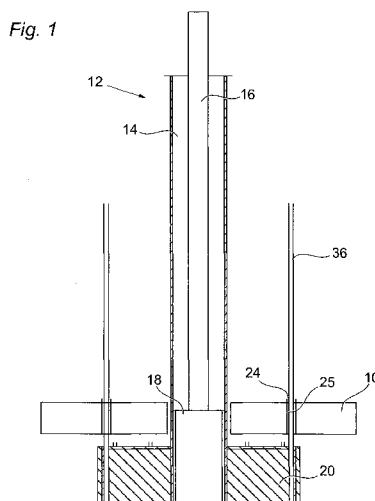
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(54) Title: TRANSPORTATION DEVICE AND METHOD



(57) Abstract: A transportation apparatus for transporting a structure between a first location and a second location comprises a pontoon (10) comprising at least two segments (26,28) selectively connectable together around at least a portion of a structure, at least one support member (36), the pontoon being mounted on the support member and means for moving the pontoon along the support member whereby the relative position of the pontoon along the support member(s) can be adjusted to alter the height of the pontoon relative to the structure being transported.



“Transportation Device and Method ”

FIELD OF INVENTION

5 This invention relates to transportation devices and methods of transporting structures from one location to another and more particularly to the field of transportation pontoons and in particular to pontoons for the use of transporting tower structures, e.g. offshore wind turbine tower structures. In particular the present invention relates to pontoons for the
10 transportation of assembled wind turbines including base structures and also relates to methods of transporting such structures particularly to an off-shore location.

INTRODUCTION

15 Conventional wind turbines and the like comprise a tower structure to which the turbine is attached and which raises the turbine above ground or sea level. Such towers are typically manufactured as a large cylindrical structure. These structures may be made of a multiple of smaller
20 cylindrical pieces comprising flanges at each end which are bolted together end on end to produce a static tower which is then moved and installed as one piece.

Wind turbines and the like intended to be located offshore are typically
25 produced onshore in order to reduce the environmental impact on sea life associated with assembly offshore.

Turbine towers for wind turbines can be very tall structures. The taller the tower structure the more difficult it is to move to its installation position e.g.
30 if shipped offshore, larger boats or pontoons are required to transport the

tower, larger cranes are needed to lift the tower structure and more manpower may also be required. It is well known that movement of such towers is difficult and time consuming, incurring large costs.

- 5 At present, once constructed onshore, heavy lifting equipment mounted on a boat structure, e.g. a jack-up barge, is required to lift the tower structure into place at the desired offshore location.

10 A fundamental problem associated with the development of deep water wind farms is the need for relatively large tower structure support frameworks. Greater water depths require more substantial foundations with corresponding increases in cost.

15 Existing offshore wind turbine tower structures have to date been developed mainly in relatively shallow water and use a mono pile driven into the seabed to provide a firm foundation for the tower structure and the turbine. Installation using a mono pile requires further heavy lifting equipment mounted on barges, e.g. jack-up barges, which position the mono pile. As wind farms move further offshore this method of installation
20 becomes increasingly impractical and expensive.

SUMMARY OF INVENTION

25 In one aspect, the present invention provides a transportation apparatus for transportation of a structure between locations, the apparatus comprising a pontoon comprising at least two segments selectively connectable together around at least a portion of the structure; at least one support member, the pontoon being mounted on the support member and means for moving the pontoon along the support member.

Optionally the pontoon forms a collar which is adapted to selectively surround a structure for transportation.

5 Preferably, the pontoon comprises buoyancy means capable of floating the pontoon and a structure to which it is mounted.

10 Preferably the pontoon comprises a material which has natural buoyancy in water or is designed to have an overall configuration which effectively displaces an amount of water to enable the pontoon to be buoyant. For example, the underside (in use) of the pontoon preferably includes a hull portion such as a dory hull or a displacement hull or another hull shape known to the skilled man to increase buoyancy. Preferably, the pontoon is made of steel.

15 Preferably a hinge is provided between the at least two segments of the pontoon and the segments are closable around the outer circumference of at least a portion of a structure.

20 Preferably, the pontoon comprises drive means to selectively open and close the at least two segments of the pontoon about the hinge. Preferably the drive means comprises a motor. Preferably also the drive means further comprises a ram such as a hydraulic or pneumatic ram.

25 Advantageously, the pontoon further comprises locking means which are actuatable to selectively lock the at least two segments around at least a portion of the tower structure. In one embodiment the drive means may operate the locking means.

30 Preferably, the pontoon is a jack-up pontoon. Preferably the length of the support members is adjustable.

Conveniently an aperture is provided through the pontoon through which aperture the support member extends. Preferably a plurality of apertures are provided through the pontoon and the apparatus comprises a plurality of support members each extending through one of the plurality of apertures in the pontoon.

Advantageously the support member(s) extends between the pontoon and a structure being transported therein.

Conveniently, the pontoon has sufficient buoyancy and is of suitable design such that it can carry the weight of a tower structure of a wind turbine and the support members in order to transport the tower structure from the shore to an offshore location.

Preferably, the drive means moves the pontoon with respect to a structure supported therein. Subsequently, if required, the pontoon is raised along the length of the support members to reach a desired height relative to the water depth. Therefore the relative positions of the pontoon and the support member and of the pontoon and the structure are altered during travel of the pontoon along the support member. Preferably, the pontoon is positioned above the height of the high water mark when a structure being transported reaches its destination.

Conveniently, a rack and pinion arrangement is provided between the pontoon and the support member(s) to lower and raise the pontoon along the support member(s). For example, the or each support member has racks with teeth (e.g. each support member having two sets of teeth oppositely arranged) welded onto each side of the variable length connector. The racks are preferably positioned 180° degrees apart.

Pinion or gear mechanisms located on the pontoon typically mesh with the teeth and operation of the gear mechanism by means known to the person skilled in the art moves the pontoon along the support members.

5

Advantageously, further drive means are provided for moving the apparatus through a body of water. Preferably the further drive means comprises one or more motors, propellers, impellers or thrusters mounted around the circumference of the pontoon which enable the apparatus, and any structure supported thereon to be orientated together through 360 degrees.

10

Preferably the further drive means comprises one or more azimuth thrusters.

15

Preferably control means are provided for operation of the drive means. Advantageously the control means are provided within a housing or control room on the pontoon.

20

According to a further aspect of the present invention there is provided a method of transporting a structure from a first location to a second location, the method comprising the steps of mounting a pontoon to the structure, connecting one or more support members between the pontoon to the structure and adjusting the relative position of the pontoon along the support member(s) to alter the height of the pontoon relative to the structure.

25

Preferably the method further comprises the step of towing the pontoon between locations via a marine vessel, more preferably via a tug.

30

Preferably also the method further comprises the step of orienting the pontoon through 360 degrees horizontally.

5 Advantageously the relative position of the pontoon along the support member(s) is altered during transportation between locations. In this way, a structure being transported can be lowered in the water as the pontoon travels through deeper waters thereby providing stability to the pontoon. This allows a fully constructed wind turbine to be transported safely and securely into a deep water location.

10

Conveniently the pontoon comprises two segments which are hinged together and the method further comprises the step of operating the hinge to open the two segments and mount the pontoon around a structure.

15

Advantageously the segments are locked in position surrounding the structure to be transported.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

20

Fig. 1 is a side view of an apparatus in accordance with one aspect of the present invention configured around a tower structure, where the pontoon is shown in a lowermost configuration relative to the tower structure suitable for floating the tower structure out to an offshore wind farm;

25

Fig. 2a is a side view of the pontoon in a raised configuration with the tower structure in a collapsed configuration;

Fig. 2b is a side view of the pontoon in a raised configuration with the tower structure in an erected configuration;

30

Fig. 3 is a top view of the pontoon of Figs. 1 and 2a, and 2b;

Fig. 4 is a side view of the pontoon of Figs. 1, 2a, 2b and 3 illustrating thrusters; and

Fig. 5 is top view of a base structure which forms part of the tower structure.

5

DETAILED DESCRIPTION

As shown in Fig. 1, in a first embodiment, an apparatus in accordance with a first aspect of the present invention comprises a pontoon 10 which is adapted for mounting around a structure 12 to be transported from a first location to a second location. In the embodiment shown, the pontoon is mounted around a tower structure of a wind turbine which is intended to be transported by sea to an off-shore wind farm.

15 The pontoon is substantially annular in form and comprises two substantially semi-circular segments 26,28. Each segment has a substantially semi-circular central aperture 31 formed into the planar edge 33 such that when the two segments are closed together along the planar edges, a substantially circular aperture 32 is formed between the segments.

20

A hinge 30 is provided between the two segments at one end of the planar edges such that the segments can be hinged apart and together in order to provide access to the central aperture as will be described further below.

25

The pontoon is formed of a material which is naturally buoyant in water and may include a hull portion (not shown) on the underside to improve stability or buoyancy. The hull portion may be any standard hull design

suitable for use with the pontoon 10 known to the person skilled in the art. Preferably, the pontoon comprises steel.

5 Drive means (not shown) are provided for moving the two segments 26,28 relative to one another such that the segments can be driven apart by opening the hinge or drawn together by closing the hinge 30. The drive means comprises a motor such as for example a hydraulic or pneumatic motor and in some embodiments the motor may drive one or more rams which are connected to the pontoon segments such that as the rams are
10 extended the segments are driven apart and as they are retracted the segments are drawn together.

In the illustrated embodiment the drive means comprises one or more outboard motors, propellers or thrusters 38 mounted around the outer
15 edge of the segments to manoeuvre the pontoon during operation and to manoeuvre the segments around a structure. Preferably, two thrusters and more preferably two azimuth thrusters are mounted on each segment 26, 28 of the pontoon 10 so that the pontoon 10 can be moved through 360 degrees on a substantially horizontal plane. The thrusters may be
20 mounted in channels, recesses or apertures 39 in the underside of the pontoon as shown in fig. 4.

Locking means (not shown) are provided for securing the two segments 26,28 together in the closed position. The locking means may comprise
25 any suitable fixing member such as a clasp on one segment and a bolt extending from the other segment which is received in the clasp to lock the two segments in the closed position.

A housing 34 is mounted on the upper surface of the pontoon to
30 accommodate control means and/or drive means which may include the

drive means for opening and closing the segments of the pontoon. The control means will be described further below.

5 The housing may be movably mounted on the pontoon. For example the housing may be mounted on rollers to allow the housing to be moved around the upper surface of the pontoon to assist operators transporting the structure and manoeuvring the pontoon during transportation.

10 One or more apertures 24 are provided in the segments of the pontoon. The apertures extend through the pontoon and provide channels 25 to receive support members 36, one of which extends through each channel. In the illustrated embodiment the apertures are provided in a ring around or adjacent to the outer edge of the segments but can be provided at any suitable location on the segments.

15 The support members 36 preferably comprise elongate rods or legs. The relative position of the pontoon along the support members is adjustable by raising or lowering the pontoon along the length of the support means.

20 For example a rack and pinion arrangement (not shown) may be provided between the pontoon 10 and the support members 36 with one of the rack and pinion mounted on the pontoon, such as within the channels 25, and the other provided on the support members 36, e.g. on the external surface of the support members. In one embodiment a rack is welded or
25 integrally formed on the outer surface of the support members and the co-operating pinion is provided within the channels through the pontoon. Drive means are provided for driving the pontoon along the length of the support members to adjust the relative position of the pontoon and support members. The drive means may comprise a gear mechanism and the

associated control means may be located within the housing on the pontoon.

5 In the illustrated embodiment the apparatus is shown mounted around a tower structure 12 of a wind turbine. The lower end of the wind turbine is formed as a substantially circular flanged base 20. The support members 36 of the transport apparatus may extend into cooperating apertures 40 in the base of the tower structure or may simply be adapted to rest on the sea bed.

10

The operation of the apparatus will now be described with reference to the transportation of a tower structure of a wind turbine, the tower structure having a flanged base portion.

15 The pontoon 10 is manoeuvred adjacent a tower structure 12 which is intended to be transported to an off-shore wind farm. The drive means are operated to open the two segments 26,28 of the pontoon around the hinge 30 such that the pontoon can be moved into position with the tower structure within the central aperture 32 of the pontoon. The drive means
20 are then operated to close the segments of the pontoon around the tower structure and the locking means are activated to lock the segments in position around the tower.

25 In this configuration the pontoon forms a collar surrounding the tower structure.

Where the tower is provided with a flanged base 20 with apertures 40 to receive the support members 36 of the pontoon, the thrusters 38 are operated to rotate the pontoon in order to bring the support members into
30 alignment with the apertures in the base and the lower end of the support

members are inserted into the apertures in the base and may be retained in position by suitable locking members (not shown).

Advantageously the preparatory work can be done at a shore based facility. Therefore the structures 12 can be transported by road or rail to the appropriate shore based facility closest to the intended off shore location and stored or put together prior to transportation off shore.

A towing line is then connected from a vessel such as a tug to the pontoon 10 and the pontoon is towed to the required offshore location. The buoyancy and design of the pontoon 10 allows the pontoon 10 to float and to support the weight of the tower structure 12, including the base structure 20 and the support rods 22.

Upon leaving the shore, the pontoon 10 and tower structure 12 and support members 36 are in the configuration shown in Fig.1 where the pontoon 10 is in a lower position relative to the support members 36 and is in close proximity to the base structure 20. Upon entering deeper and deeper water, the drive means controlling the relative position of the pontoon along the support members is activated and the pontoon 10 can be raised along the support members to a configuration which more closely resembles that of Figs. 2a and 2b. Increasing the distance between the base structure 20 and the pontoon 10 lowers the centre of gravity of the pontoon 10 plus the tower structure and base structure and therefore increases the overall stability of the pontoon 10 in deeper water.

Once the tower structure 12, base structure 20 and pontoon 10 have been towed close to the installation location, the thrusters 38 on the pontoon 10 can be used in place of the tug to move the tower structure 12 and base

structure 20 to the final installation position, preferably using dynamic positioning.

5 The thrusters 38 may also be used to orientate the entire tower structure 12 and base structure 20 to move the base structure 20 onto a more secure position on the sea bed. Debris and the like may be removed from the seabed by extension of legs (not shown) from the (in use) underside of the base structure 20 which move against the seabed floor and remove matter from the seabed floor when rotation of the tower structure 12 and 10 base structure 20 is achieved by movement of the thrusters 38. By careful movement and positioning of the tower structure 12 using the thrusters 38 and dynamic positioning known to the person skilled in the art, any small undulations on the seafloor can be levelled out allowing the base structure 20 to rest on a level sea bed floor before final piling into position. Use of 15 thrusters 38 capable of dynamic positioning allows the pontoon 10 to hold its position during installation of the tower structure 12.

Once towed to the off-shore location, the base of the tower structure is lowered onto the seabed by any suitable means or mechanism generally 20 know to the person skilled in the art.

Once the base structure 20 is correctly positioned on the seabed the pontoon 10 can be raised to a desired height and/or be disconnected from the support means 36 and disconnected from the tower structure 12 by 25 opening the hinge portion 30.

The pontoon can be raised along the support members out of the water to provide a platform for work to be carried out on the structure at an elevated position.

30

Additionally, the thrusters 38 may function as the drive means for opening and closing the two portions 26, 28 of the pontoon 10 to allow docking and undocking of the pontoon 10 around the tower structure 12.

- 5 Once disconnected from the tower structure 12, the pontoon 10 together with the support members 36 may return to shore under its own power or by the aid of a tug or other marine vessel and may be re-used with another tower structure 12. Alternatively the support members may be left in a retracted position attached to the structure.

10

The present invention has been shown in the process of transporting a tower structure 12 which comprises a first column 14 and a second column 16, the second column 16 being connected at its lowermost (in use) end to a movement mechanism 18. The tower structure 12 includes a base
15 structure 20 to stabilise the tower structure 12.

20

The tower structure 12 is preferably a tower structure suitable for use as a support structure for a wind turbine or the like. Preferably the first column 14 is connected to the base structure 20 which supports the tower structure 12 on the sea bed floor (not shown). The second column 16 is preferably telescopically mounted within the first column 14. A wind turbine (not shown) is attached to an uppermost (in use) portion of the second column 16. The second column 16 is extended out of first column 14 in order to raise the wind turbine to a suitable height by the movement
25 mechanism 18 which may be a flotation device, e.g. a flotation can. The flotation device has sufficient buoyancy that it floats on or in fluid introduced into a space between the first column 14 and the second column 16. The height of the wind turbine is proportional to the amount of fluid introduced or withdrawn from the space between the first column 14
30 and the second column 16. Fluid may be inserted into the space between

the first column 14 and the second column 16 via pipes and the like which are connected to the tower structure 12 via an access platform (not shown).

- 5 Alternatively, hydraulic rams may be used to raise and lower the tower structure 12 and base structure 20.

Figs. 2a, 2b and 5 demonstrate the secure attachment of the support members 36 to apertures 40 in the base structure 20.

10

As shown in Figs. 2a and 2b, the pontoon 10 (when disposed around a portion of the first column 14 of the tower structure 12) does not inhibit extension of the second column 16 out of the first column 14.

- 15 Fig. 3 is a top view of the pontoon 10 and illustrates formation of the pontoon 10 from two substantially semicircular segments 26, 28. It will be understood by the person skilled in the art that the pontoon 10 could be made of more than two segments and from any suitably shaped segments. Additional buoyancy devices may be mounted on or connected
20 to the pontoon.

Modifications and deviations from the invention may be envisaged without departing from the scope of the invention.

- 25 For example the support members 36 may be height adjustable to allow for operation in deeper waters. In some embodiments the support members may be telescopic to provide for compact storage of the support members.

The present invention has been described as having two segments 26,28 connected together via a hinge 30 at one side and a locking member at the other. Alternatively locking mechanisms may be provided at both sides. Furthermore, other numbers of segments are envisaged such as
5 for example three or four.

As will be appreciated by the person skilled in the art, many different types of base structures may be used with the tower structure 12. For example, concrete bases, gravity bases, piled bases, bases with suction anchors or
10 combinations of these.

The person skilled in the art will understand that the base structure could be replaced with any suitable means for placing the tower structure on the seabed floor. Further, means to connect the tower structure or base
15 structure to the seabed may comprise steel ropes and bolts or other suitable moorings. Mono piles or piling may also be used.

Additionally, the pontoon or the transportation apparatus may be adapted to return to the shore under its own power rather than requiring a vessel or
20 tug to return the apparatus to the shore based facility. The thrusters 38 may be operated to drive the pontoon or apparatus between locations.

It will be appreciated that the apparatus can be reused in order to facilitate transportation of a number of structures such as wind turbines from an on
25 shore facility to an off-shore site for installation and operation. Each structure is loaded into the apparatus at the on shore facility and transported safely and securely through deep water where necessary and installed in the required location before the apparatus is disengaged and returned to the shore based facility to transport the next structure.

30 Therefore the present invention provides an effective reusable

transportation device and transportation method which can reduce the cost of the installation process for such structures.

CLAIMS:

- 5 1. A transportation apparatus for transporting a structure between a first location and a second location, the apparatus comprising a pontoon comprising at least two segments selectively connectable together around at least a portion of a structure, at least one support member, the pontoon being mounted on the support member and means for moving the pontoon along the support member.
- 10 2. An apparatus as claimed in claim 1 wherein, the apparatus comprises a plurality of support members.
- 15 3. An apparatus as claimed in claim 1 or claim 2, wherein the pontoon comprises buoyancy means to facilitate floating the pontoon and a structure around which it is connected.
- 20 4. An apparatus as claimed in any preceding claim, wherein the pontoon comprises material which has natural buoyancy in water.
- 25 5. An apparatus as claimed in any preceding claim, wherein the pontoon comprises a hull portion.
6. An apparatus as claimed in any preceding claim, wherein the pontoon comprises steel.
7. An apparatus as claimed in any preceding claim, wherein a hinge is provided between the at least two segments of the pontoon.

8. An apparatus as claimed in claim 7 further comprising drive means to open and close the at least two segments of the pontoon about the hinge.
- 5 9. An apparatus as claimed in claim 8, wherein the drive means comprises a motor.
- 10 10. An apparatus as claimed in claim 8 or 9 wherein the drive means comprises one or more propellers or thrusters around the circumference of the pontoon.
11. An apparatus as claimed in claim 10 wherein the or each thruster is an azimuth thruster.
- 15 12. An apparatus as claimed in any preceding claim wherein locking means are provided to secure the at least two segments together.
- 20 13. An apparatus as claimed in any preceding claim, wherein the pontoon is a jack-up pontoon.
- 25 14. An apparatus as claimed in any preceding claim wherein the or each support members is height adjustable.
15. An apparatus as claimed in any preceding claim one or more apertures are provided in the pontoon through which the or each support member extends
- 30 16. An apparatus as claimed in any preceding claim wherein the means for moving the pontoon along the support member(s) comprises a motor.

17. An apparatus as claimed in claim 16, wherein the means for moving the pontoon along the support member(s) further comprises a rack and pinion mechanism.

5 18. An apparatus as claimed in any preceding claim, further comprising control means.

19. An apparatus as claimed in claim 18 wherein the control means is provided within a housing on the pontoon.

10

20. An apparatus substantially as described herein and with reference to and as shown in the accompanying figures.

15

21. A method of transporting a structure from a first location to a second location, the method comprising the steps of mounting a pontoon to the structure, connecting one or more support members between the pontoon and the structure and adjusting the relative position of the pontoon along the support member(s) to alter the height of the pontoon relative to the structure.

20

22. A method as claimed in claim 21 wherein the method further comprises the step of towing the pontoon between locations via a marine vessel.

25

23. A method as claimed in claim 21 or 22 wherein the method further comprises the step of orienting the pontoon through 360 degrees horizontally.

24. A method as claimed in any of claims 21-23 wherein the relative position of the pontoon along the support member(s) is altered during transportation of a structure between locations.

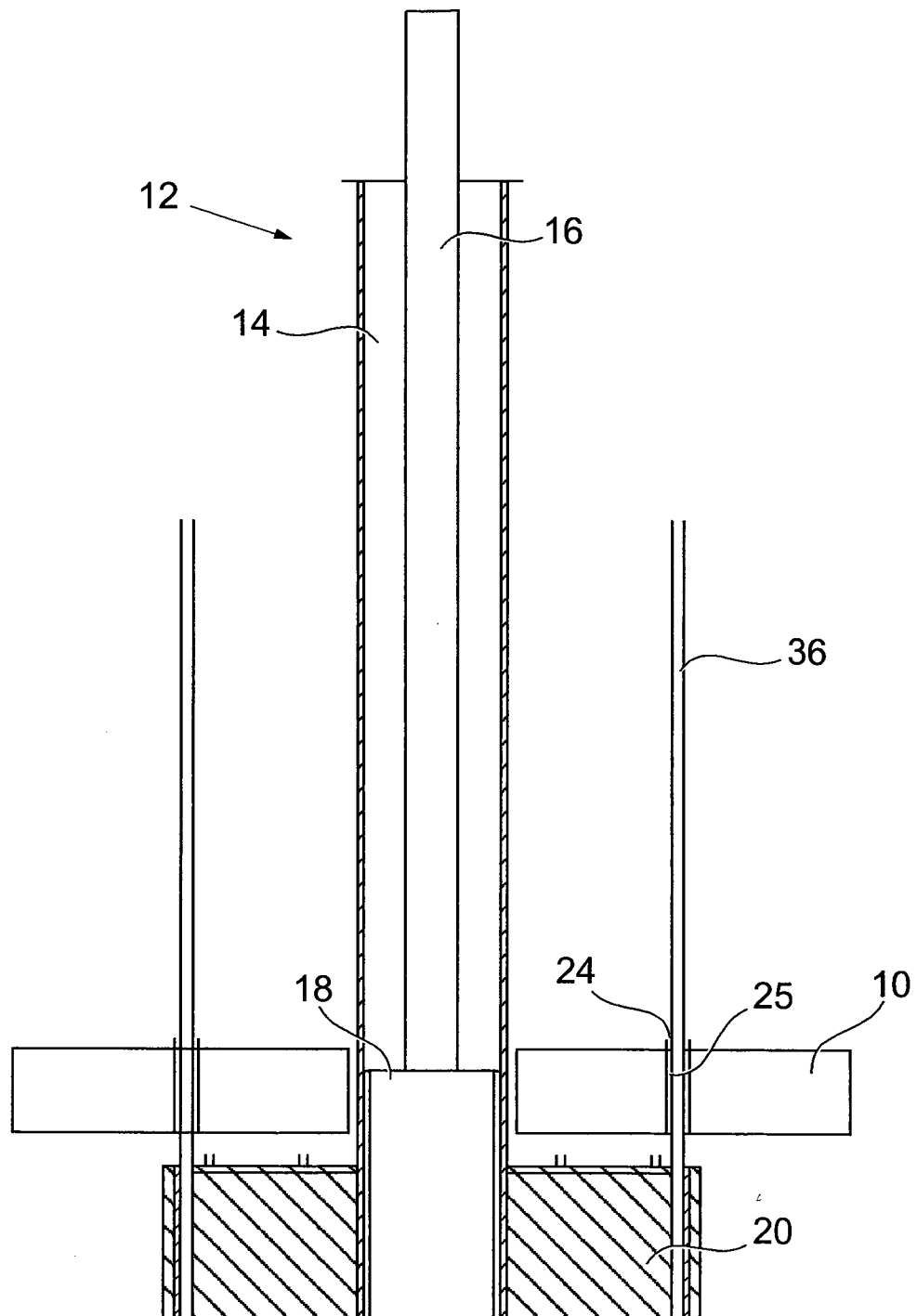
5 25. A method as claimed in any of claims 21-24 further comprising hingedly mounting the pontoon around a structure.

26. A method as claimed in any of claims 21-25 further comprising locking the pontoon in position around the structure.

10

27. A method as claimed in any of claims 21-26 further comprising floating the pontoon between locations and supporting the weight of a structure to be transported by the pontoon.

15 28. A method of transporting a structure from a first location to a second location substantially as hereinbefore described.

*Fig. 1*

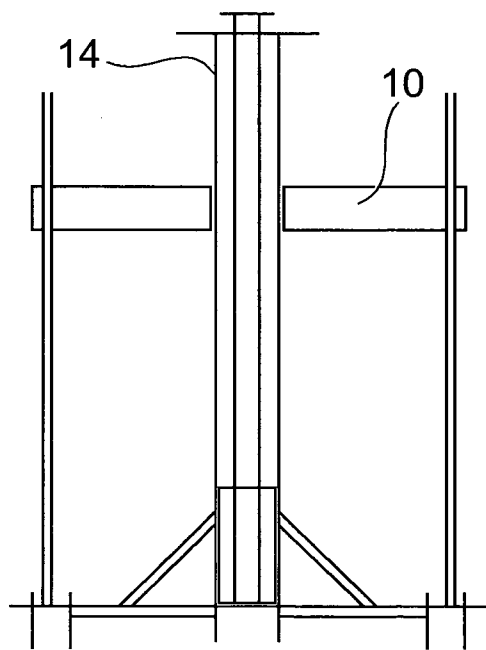


Fig. 2A

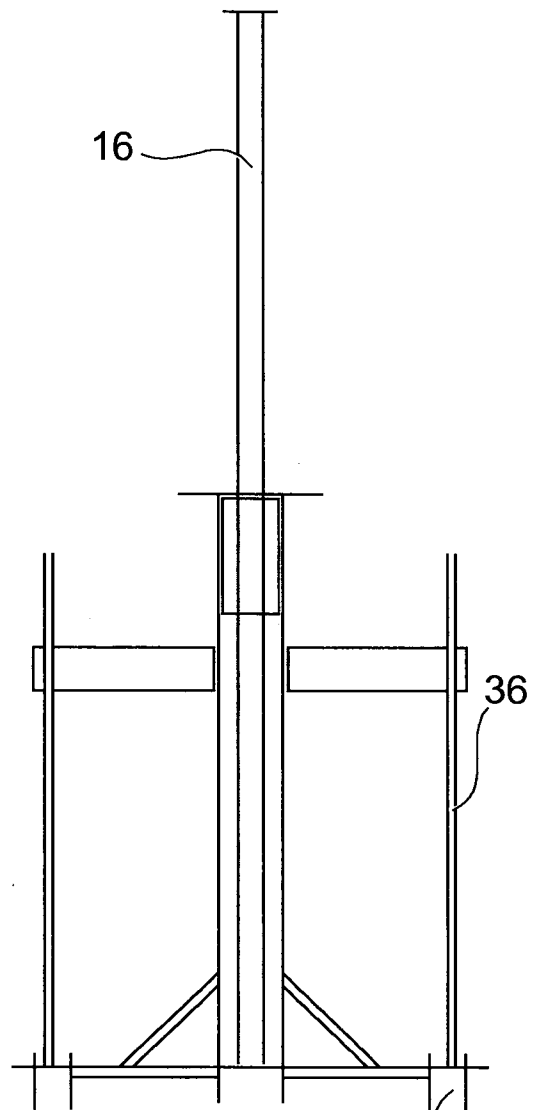


Fig. 2B

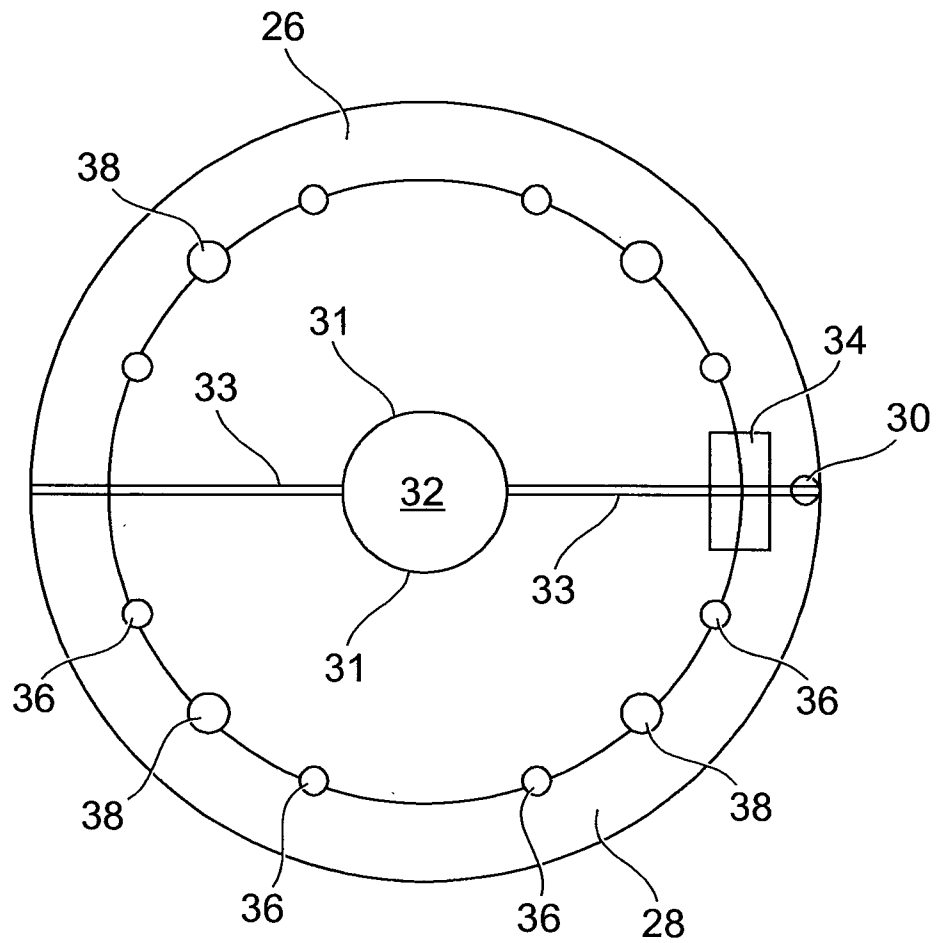


Fig. 3

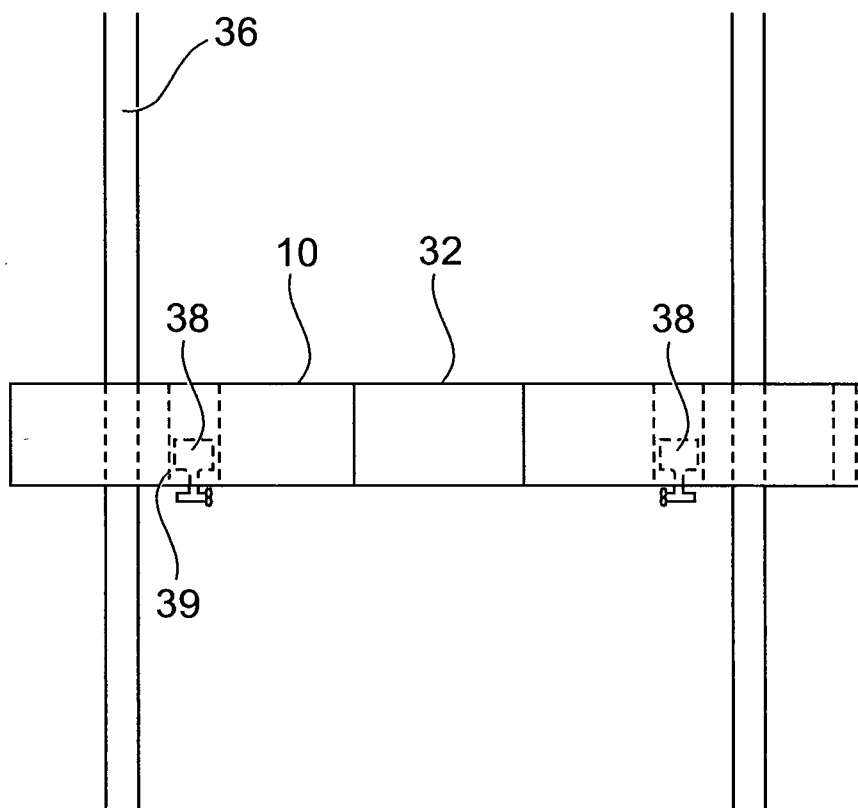
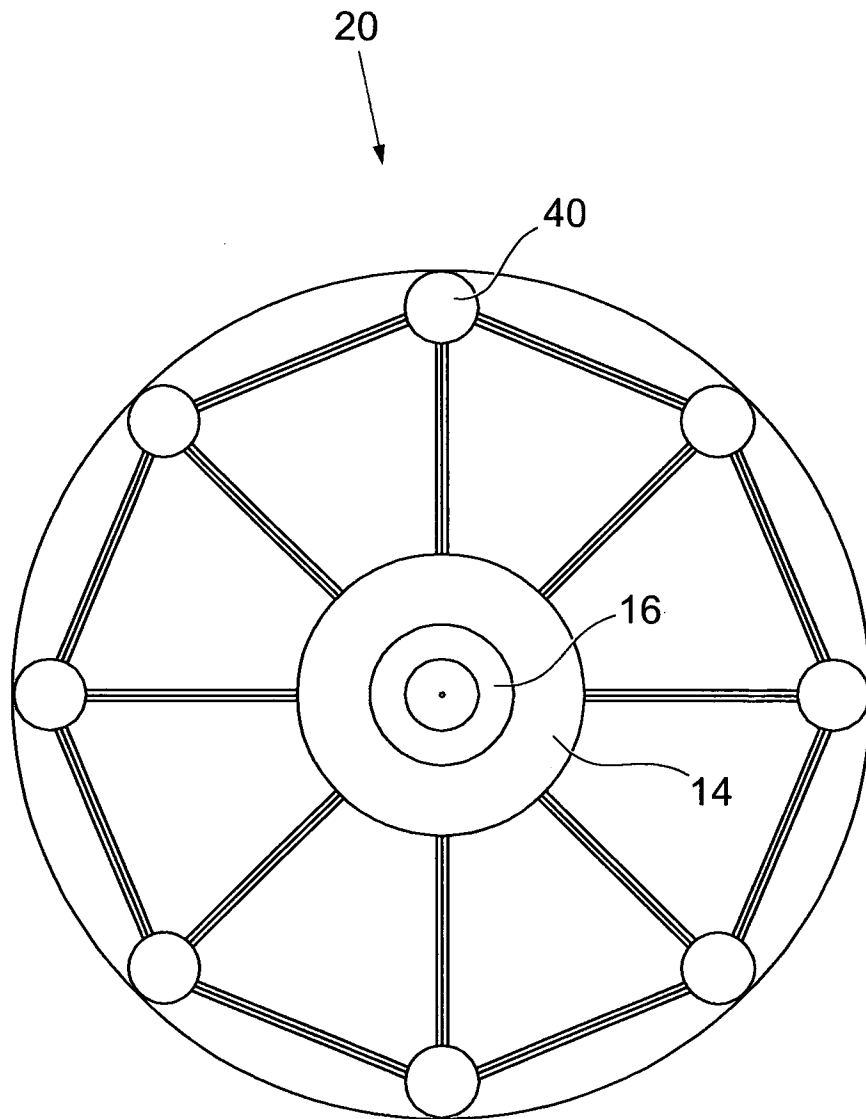


Fig. 4

*Fig. 5*