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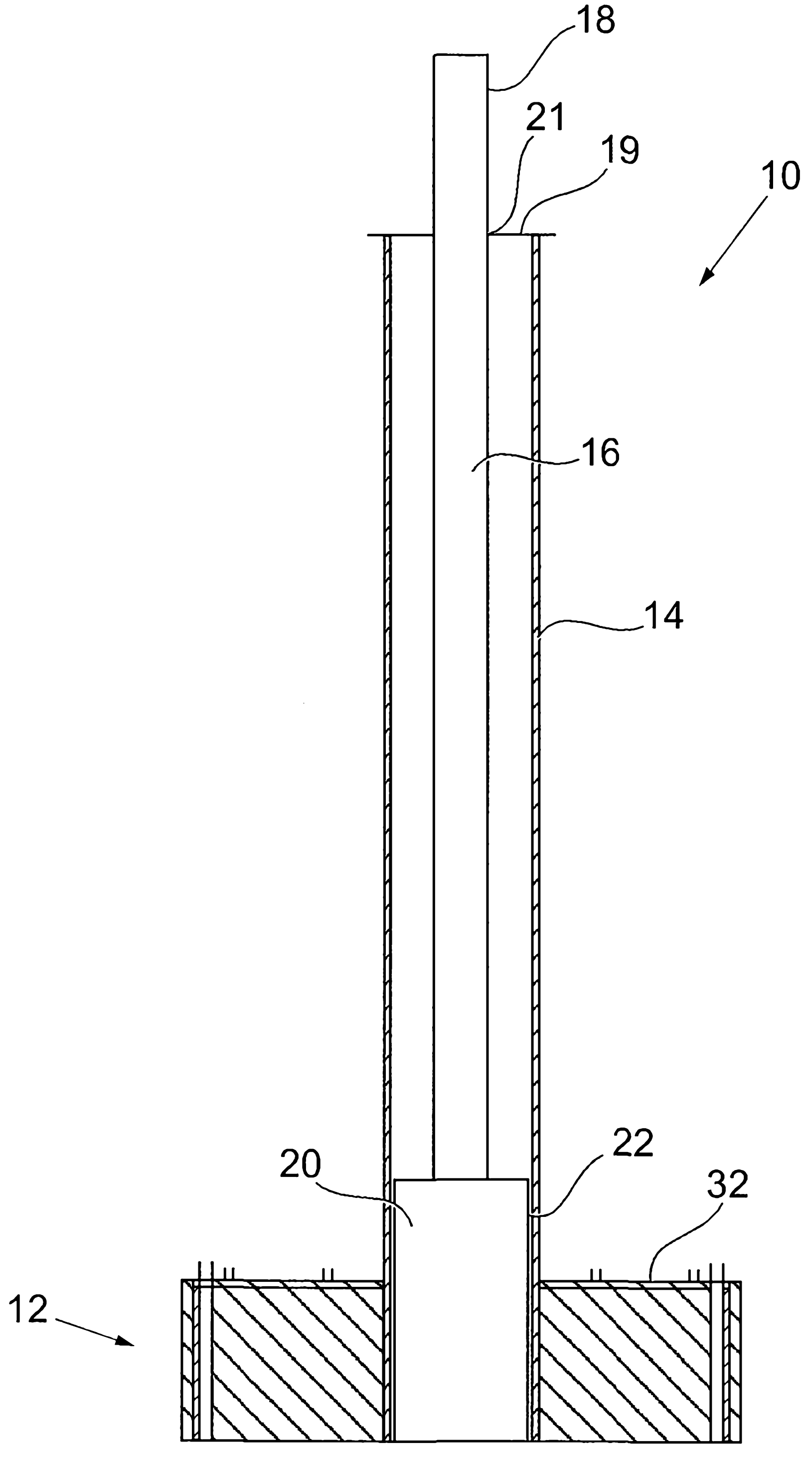

Fig. 1

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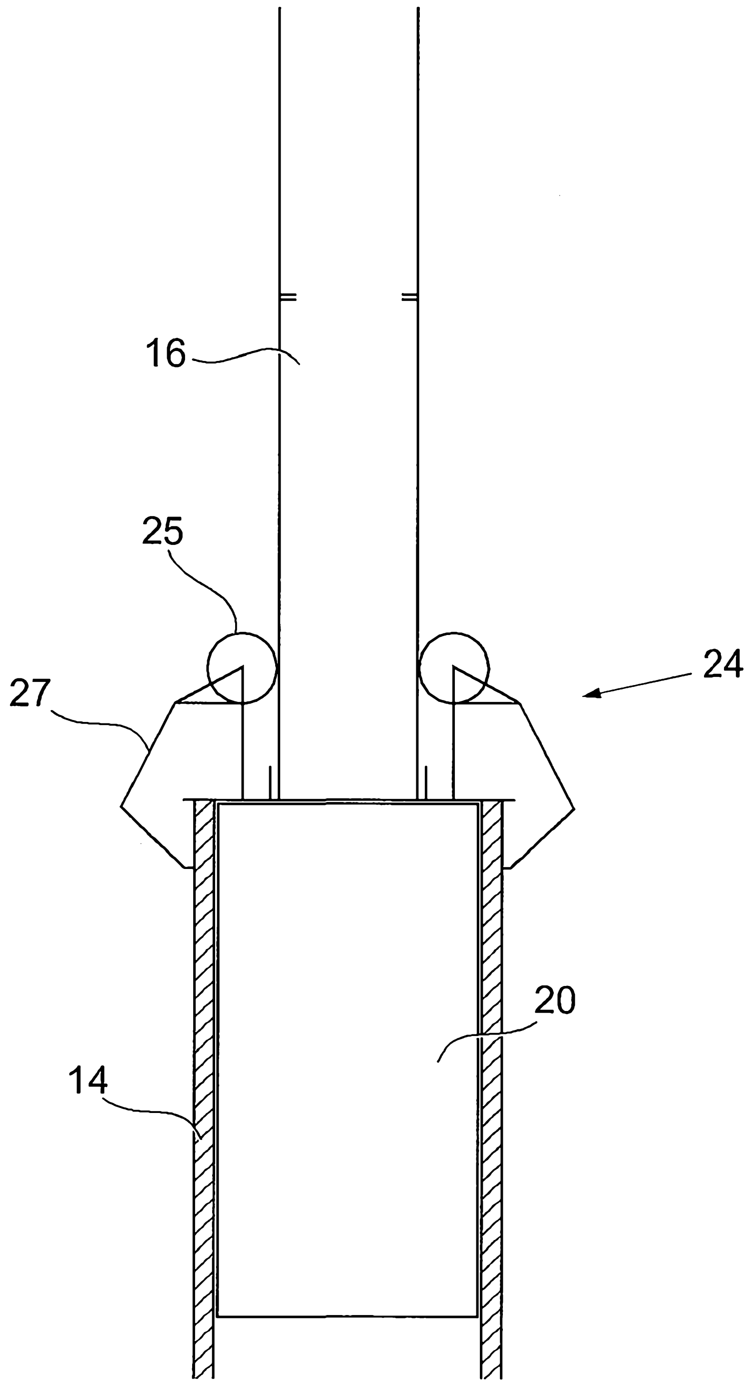

Fig. 2

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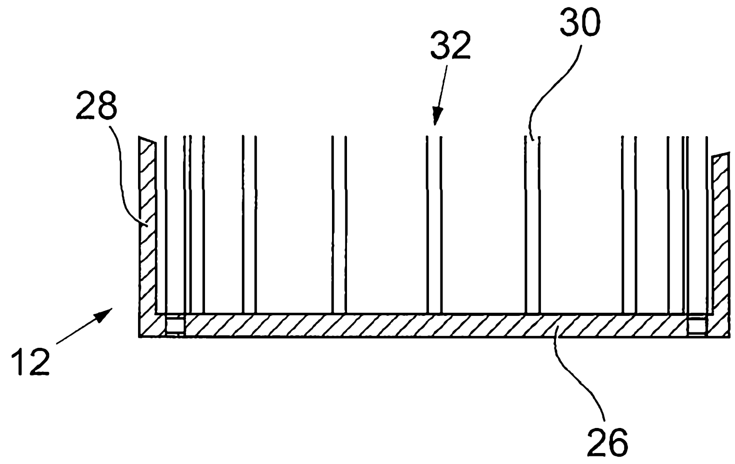

Fig. 3A

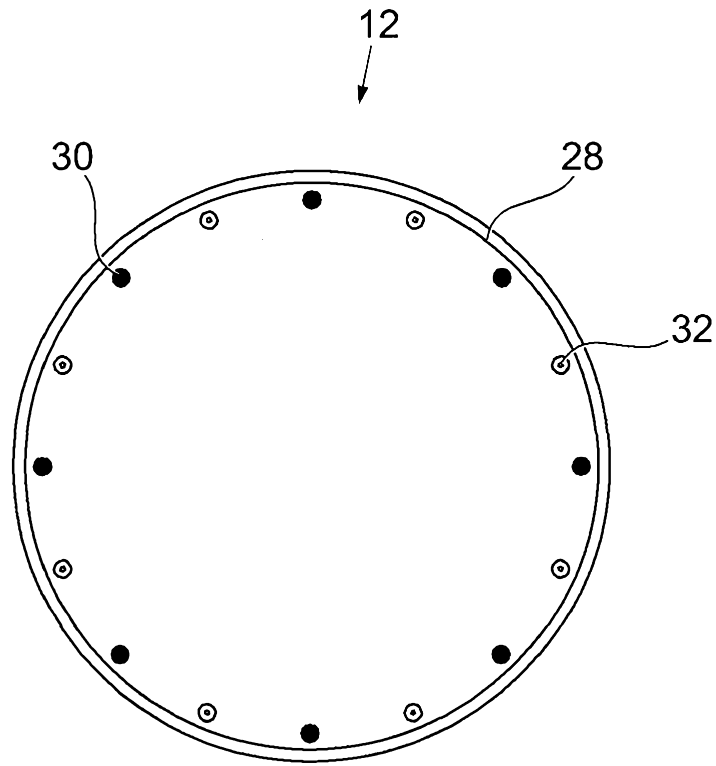

Fig. 3B

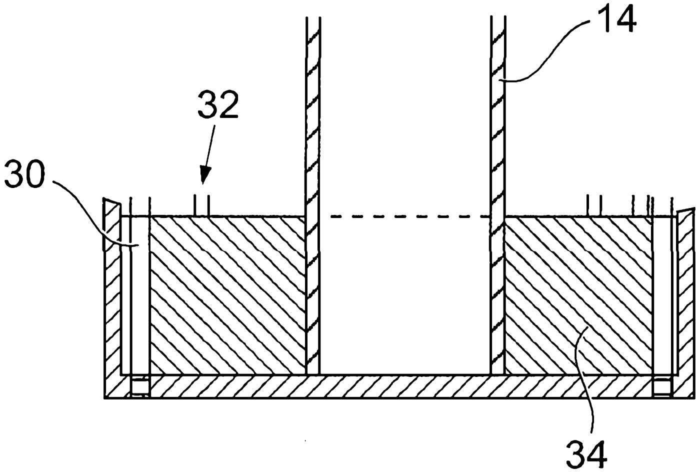

Fig. 4A

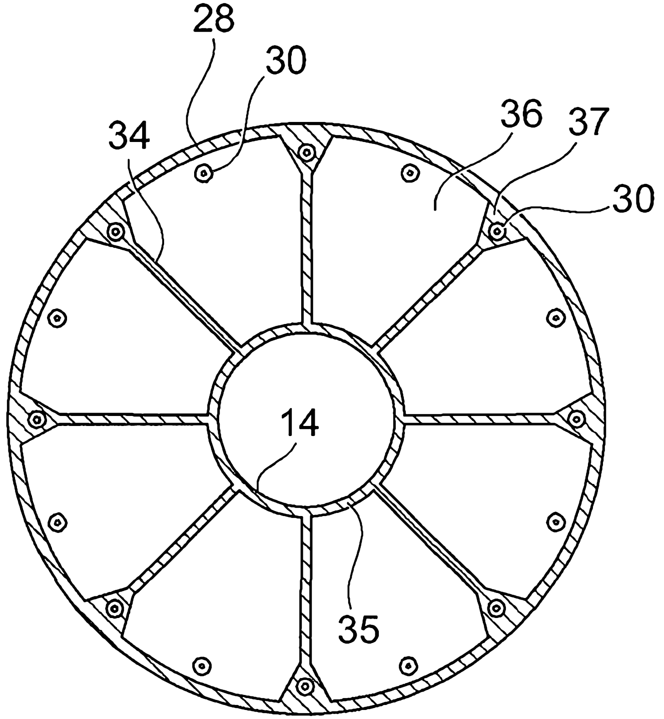

Fig. 4B

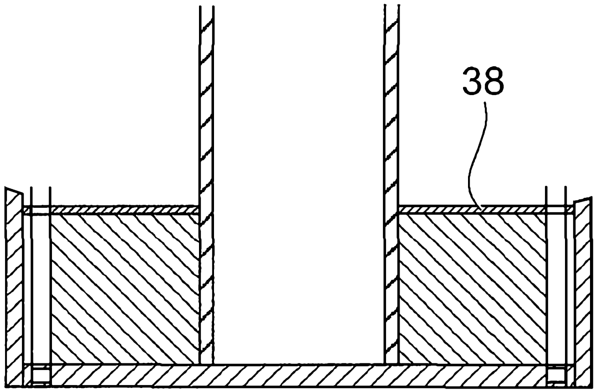

Fig. 5A

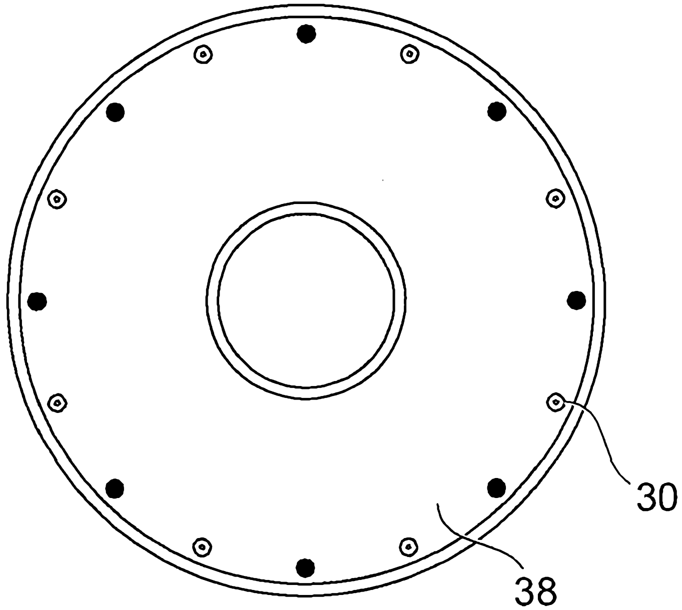

Fig. 5B

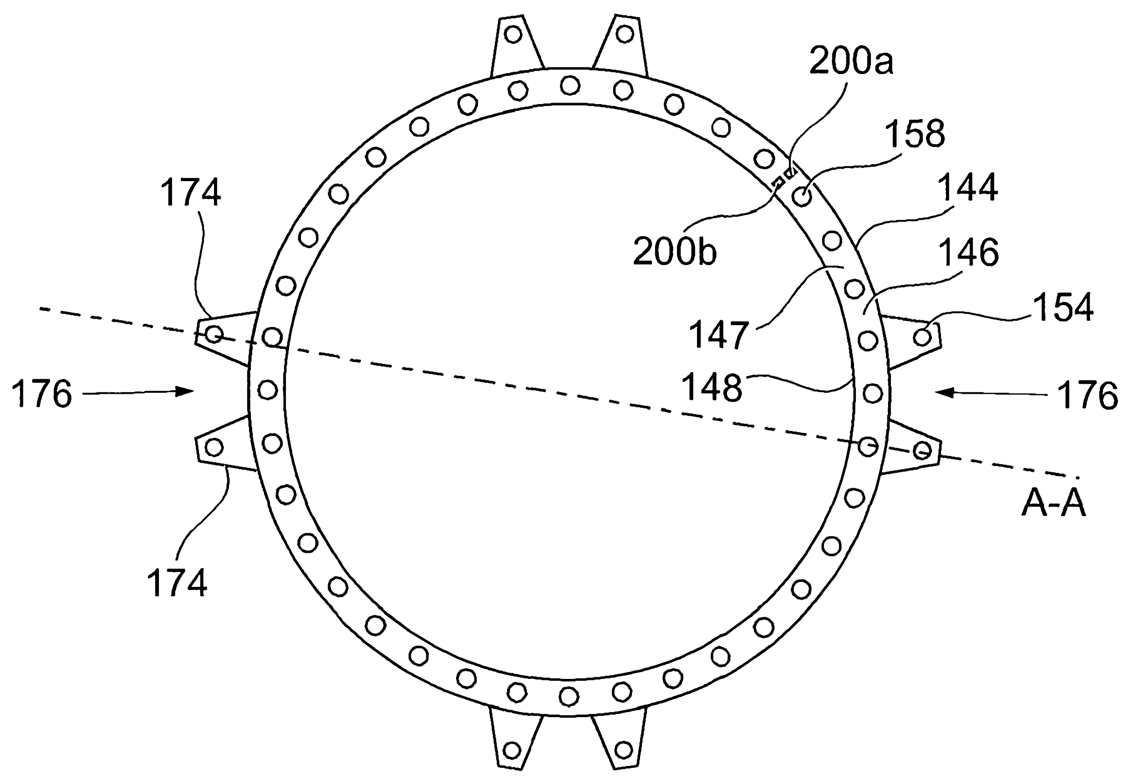

Fig. 7

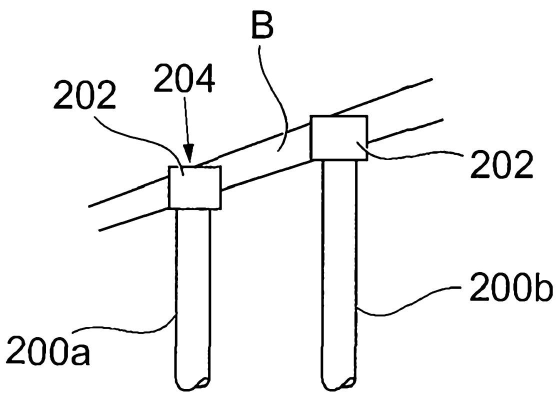

Fig. 8

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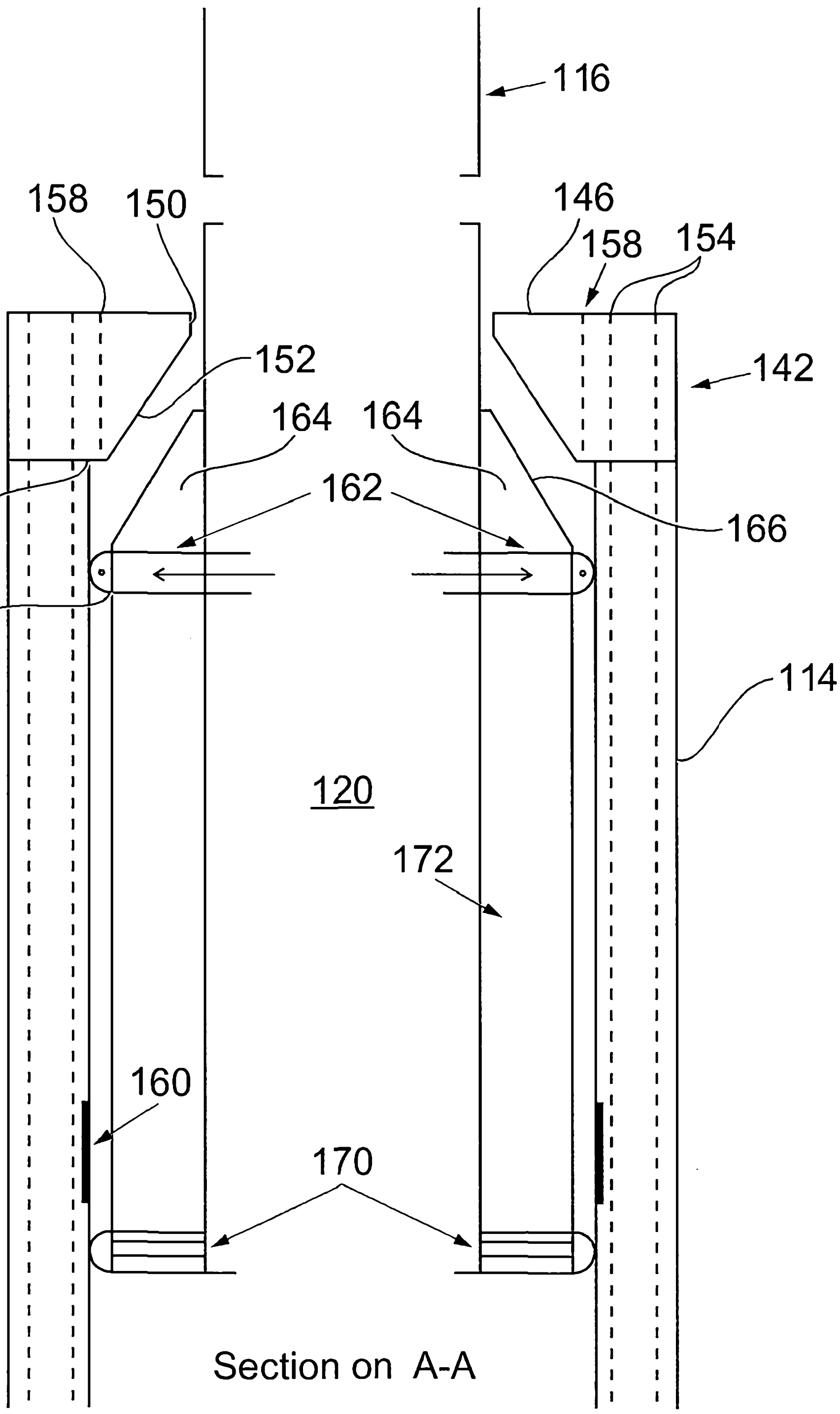
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Section on A-A

Fig. 6

"Tower Structure and Method of Raising and Lowering Said Structure "

FIELD OF INVENTION

This invention relates to a tower structure and a method of raising and lowering same, and more particularly to a height adjustable tower structure. The application more particularly relates to the field of turbine towers and the like, their installation, maintenance and repair. In particular, the present invention relates to turbine towers for wind turbines and finds particular application in the field of off-shore wind turbines..

INTRODUCTION

Current 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 plurality of smaller 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.

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. if shipped offshore, larger boats are required to transport the tower, larger cranes are needed to lift the tower structure and more man-power may also be required. It is well known that movement of such towers is difficult and time consuming, incurring large costs.

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.

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 becomes increasingly impractical and expensive.

Furthermore, a turbine or the like, when installed, is typically attached at a point along the tower structure, routinely at the (in use) uppermost end portion of the tower structure. The static nature of a conventional tower means maintenance and repair of the tower or the like is difficult, requiring complex structures to be built around the turbine to gain access to the turbine. Health and safety concerns associated with such maintenance and repair add to the cost of maintenance and the amount of time the turbine is non-functional renders the turbine less efficient.

SUMMARY OF INVENTION

In a first aspect, the present invention relates to a tower structure suitable for use with a wind turbine, the tower structure comprising at least a first portion and a second portion spaced therefrom, and a floatation device connected to one of the first or second portions whereby one of the first and second portions is moveable relative to the other by movement of the floatation device by fluid introduced to or withdrawn from the space between the first and second portions alone the relative movement causing the tower structure to move between a lowered and an elevated position and wherein the first and second portions comprise co-operating tapered surfaces which abut as the tower structure approaches the elevated position.

Preferably, one of the first or second portions are adapted to connect to a turbine, for example an offshore wind turbine.

Preferably the first and second portions are telescopically arranged, wherein the first and second portions are arranged co-axially and are longitudinally moveable with respect to one another.

Preferably the second portion is mounted within the first portion.

Preferably, the floatation device is coupled to one of the first and second portions.

Advantageously the tower structure further comprises means for introducing or extracting fluid from the space between the first and second portions.

Preferably the fluid is a liquid, for example water or seawater.

Preferably, the flotation device is connected to the second portion, optionally at the lowermost (in use) end of the second portion. Contact of the flotation device with fluid of higher density than the floatation device results in floating of the flotation device on or in the fluid. Introduction or withdrawal of the fluid into or from the space between the first and second portions therefore results in extension or retraction of the second portion relative to the first portion. Preferably, the first portion provides a vessel into which fluid can be inserted or withdrawn and in which the flotation device and second portion can float and can be raised and lowered depending on the amount of fluid inserted into or withdrawn from the first portion.

Preferably one of the first and second portions is adapted to be placed on or connected to the sea bed. Optionally, the tower structure further comprises a platform to enable access to the tower structure by personnel such as during maintenance or repair.

Conveniently, the means for introducing or extracting fluid from the space between the first and second portions may comprise pipework or ducting which may be mounted or connected to or accessed or controlled from the platform.

Conveniently the tower structure further comprises stabilising means to control the movement of one portion relative to the other. More preferably the stabilising means comprise guide means, for example rollers such as hydraulically operated rollers which may be mounted on the platform and which preferably act against the outer surface of the second portion.

Conveniently, the first portion comprises concrete, metal or metal alloy or alloys, for example steel, or a combination of these. Conveniently, the second portion comprises concrete, metal or metal alloy or alloys, for example steel, or a combination of these.

Preferably, the tower structure further comprises locking means which may be mounted on one or other or both of the first and second portions. The locking means may be operable to selectively retain the second portion in a fixed position relative to the first portion. In a preferred embodiment the locking means comprise bolts, and preferably apertures are provided in the first and second portions, said apertures aligning to enable the bolts to be passed therethrough to fix the portions in position relative to one another. In a less preferred but alternative embodiment, the locking means comprises collets mountable in slots which may be machined into one of the first and second

Preferably the tower structure further comprises a base portion. Said base portion preferably comprises a body having a greater width or diameter than the first and second portions and may preferably comprise a flange and preferably a radial flange. Connection points may be provided on the radial flange. . Said base section preferably connects to a lower part of the tower structure.

Optionally, the tower structure is for use with an offshore wind turbine and the base portion acts as a gravity base maintaining the position of the tower structure on the sea bed.

In a second aspect of the present invention there is provided a method of changing the height of a tower structure as claimed in any preceding claim comprising the step of introducing or extracting fluid from the space between the first and second portions to alter the position of the floatation device and thereby alter the relative positions of the first and second portions to move the tower structure between a lowered and an elevated position.

Preferably the method further comprises the step of locking the first and second portions in a selected relative position. Conveniently, movement of the first or second portion is stabilised, and is preferably vertically stabilised during movement.

Preferably the fluid is pumped into or out of the space between the first and second portions. Preferably also, the height of the tower structure increases as fluid is pumped into the space and decreases as fluid is pumped out of the space.

In a preferred embodiment the fluid may be recycled.

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

Fig. 1 is a side view of a tower structure according to one aspect of the present invention in a collapsed configuration comprising a second portion telescopically mounted within a first portion;
Fig. 2 is a side view of the tower structure of Fig. 1 in an erected state showing optional guiding means;
Fig. 3a is a side view of a base for use with the tower structure of Fig. 1;
Fig. 3b is a top view of the gravity base of Fig. 3a;
Fig. 4a is a side view of the gravity base of Figs. 3a and 3b with additional dividing walls;
Fig. 4b is a top view of Fig. 4a;
Fig. 5a is a side view of the gravity base of Figs. 3a and 3b including a deck portion;
Fig. 5b is a top view of Fig. 5a;
Fig. 6 is a partial cross-section through a tower structure of a further embodiment of the present invention;
Fig. 7 is a end elevation of the first cylinder of the tower structure of Fig. 6;
Fig.8 is a schematic elevation view of the support members of Fig. 7.

DETAILED DESCRIPTION

As shown in Fig. 1, in a first embodiment the tower structure 10 in accordance with the invention is shown in a collapsed non-erected configuration.

The tower structure 10 is shown connected to a base structure 12 which acts to hold and maintain the tower structure 10 in position, e.g. on the seabed, and is described in detail subsequently. The base may be integrally connected to a lower end of the tower structure or may be coupled thereto by any suitable means.

In the embodiment shown in Fig. 1, the tower structure 10 comprises a first portion in the form of a hollow cylindrical column 14 and a second portion in the form of a second cylindrical column 16 which may be hollow and has an outer diameter which is less than the inner diameter of the first column 14.

The second column 16 is telescopically mounted within the first column 14 and the difference in diameter defines a space 22 between the first and second columns. The second column 16 preferably extends past the (in use) uppermost terminus of the first column 14 when in the collapsed configuration to allow for the attachment of a wind turbine (not shown) prior to installation. The wind turbine is preferably connected to column 16 at its upper end 18.

The upper most terminus of the first column is preferably closed by a cap 19 or cover which may be integrally formed with the column or may be mountable on the column to allow for selected access to the interior of the first column or the second column for inspection or repair. An aperture 21 is formed in the cap through which the upper end 18 of the second column extends.

It can therefore be seen that the interior of the first column 14 is selectively sealed from the external environment and particularly from seawater outside. The first column provides a receptacle into which fluids such as water or seawater can be pumped into or withdrawn from.

In this embodiment the first column 14 is mounted within a substantially circular base structure 26 which has a greater diameter than the outer diameter of the first column.

Locking means (not shown) are provided between the first and second columns to selectively lock the columns in a desired relative position. Preferred locking means are bolts or clamps known to the person skilled in the art. Apertures may be provided at selective positions along the first and second columns and bolts or other fixings may be provided which pass through the co-operating apertures to prevent movement of the second column with respect to the first. Alternatively bores may be provided through the second column and a locking pin may be inserted through one of the bores above the height of the cap 19 of the first column.

In a preferred embodiment, the first column 14 of the tower structure 10 is in the region of 30 to 70 meters in height and preferably is around 55 meters in height, and the second column 16 of the tower structure 10 when extended out of the first column 14 extends in the region of 15 to 75 meters above the first column 14 and more preferably extends around 55 meters above the first column 14.