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(51) INT CL:
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(56) Documents Cited:
GB 2454585 A **WO 2011/083021 A1**
FR 002887900 A1

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INT CL **B63B, E02B, F03D**
Other: **EPODOC, WPI**

(54) Title of the Invention: **A submersible dynamic flotation tank mountable to a base of an offhore wind turbine assembly**
Abstract Title: **A submersible dynamic floatation tank mountable to a base of an offshore wind turbine assembly**

(57) A submersible dynamic floatation tank 21 which is mountable to a base 11 of a wind turbine assembly, may include adjustable buoyancy tanks 26 and 29 and thrusters 25 and 28 operable to adjust the buoyancy, position and attitude of the tank and the base. A method of lowering the centre of gravity of column members 33 and 34 is also disclosed. The column members may comprise a wind turbine mounting, to enable the steps of mounting the column 30 to the base 11 and mounting a nacelle 35 to the column and transporting the base and installing the base resting on a seabed 32 or submerged floating and anchored, using a submersible dynamic floatation tank mounted to the base. The method may include a later step whereby walls of the column members 33 and 34 initially partly of hollow construction are filled with material to form walls of solid construction to enable the delivery of the base and the erection of the column using a submersible dynamic floatation tank.

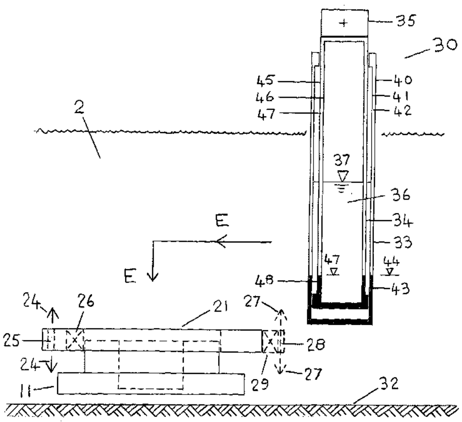


Fig 10

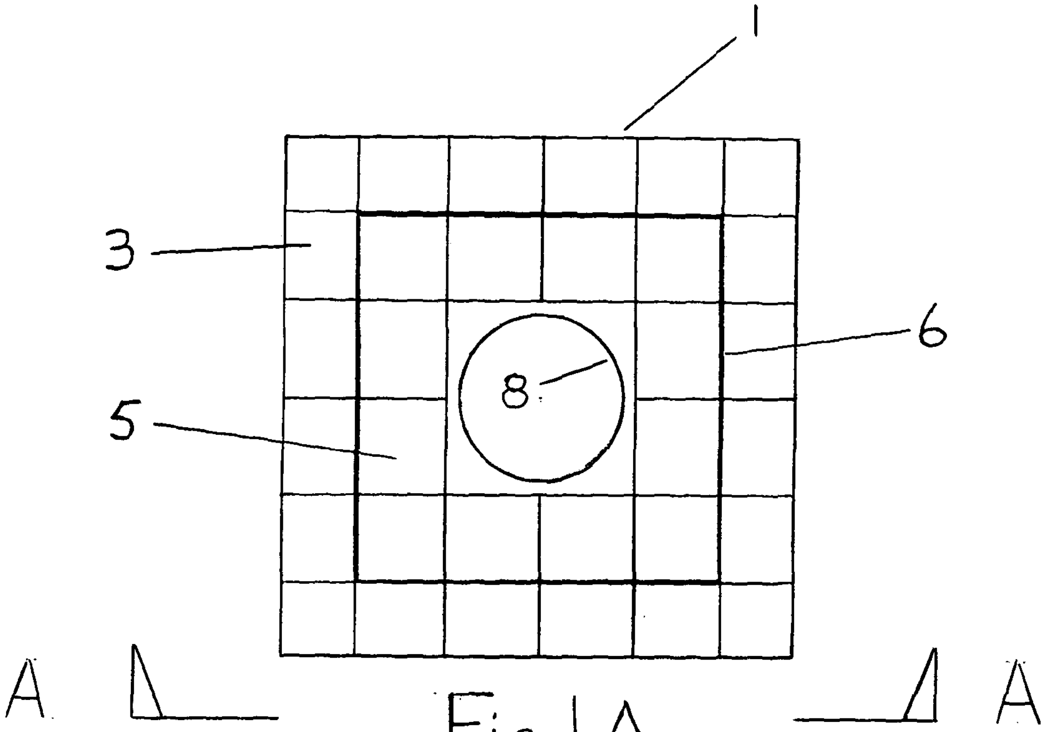


Fig 1A

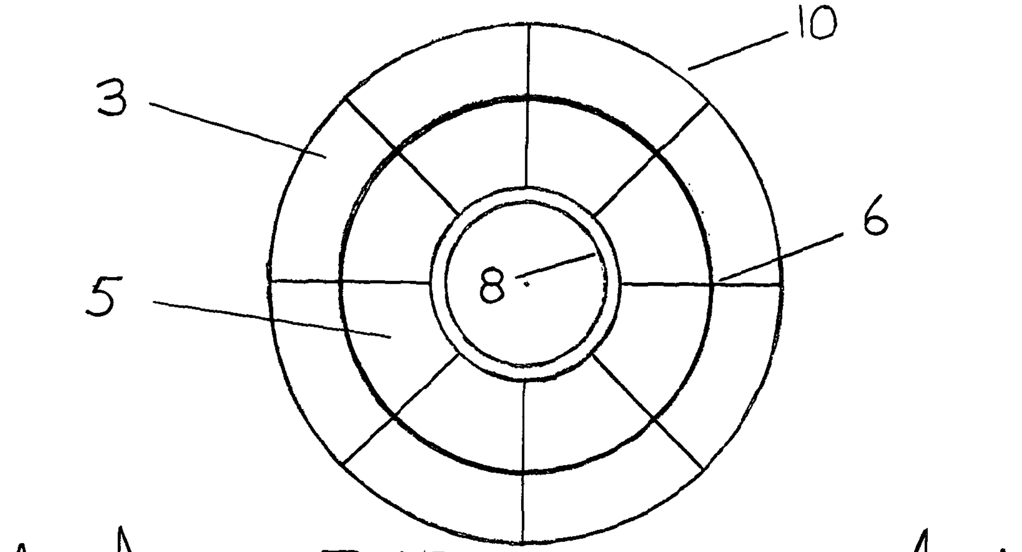


Fig1B

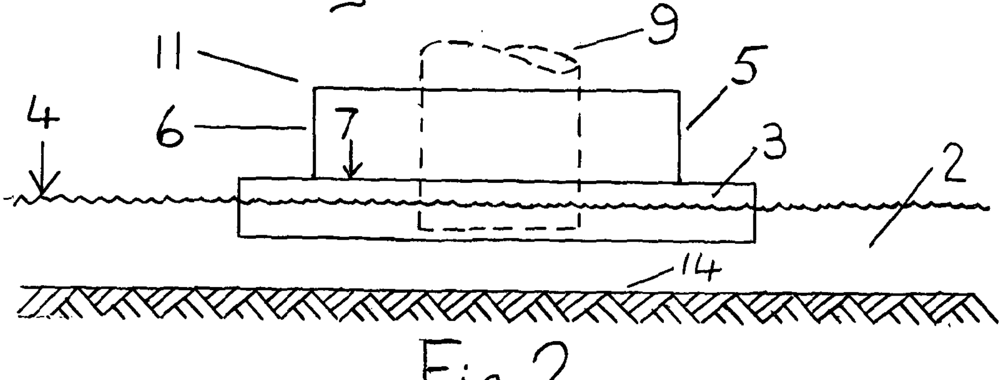
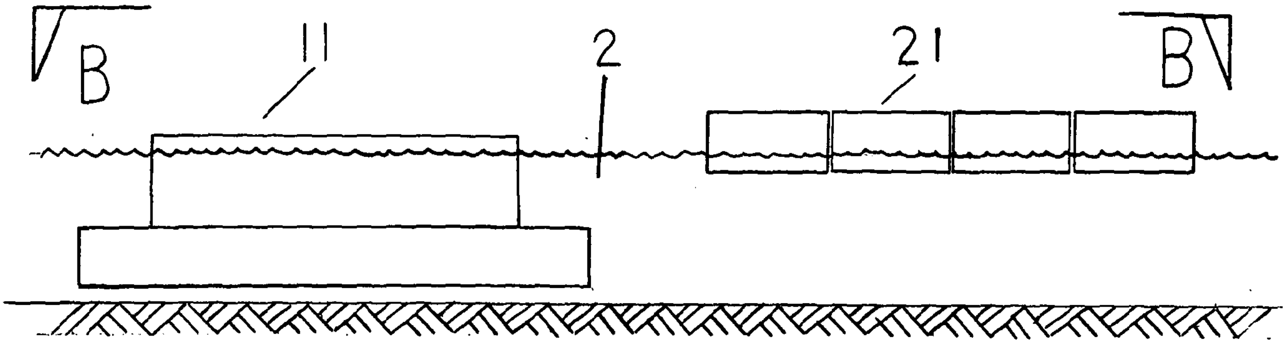


Fig 2



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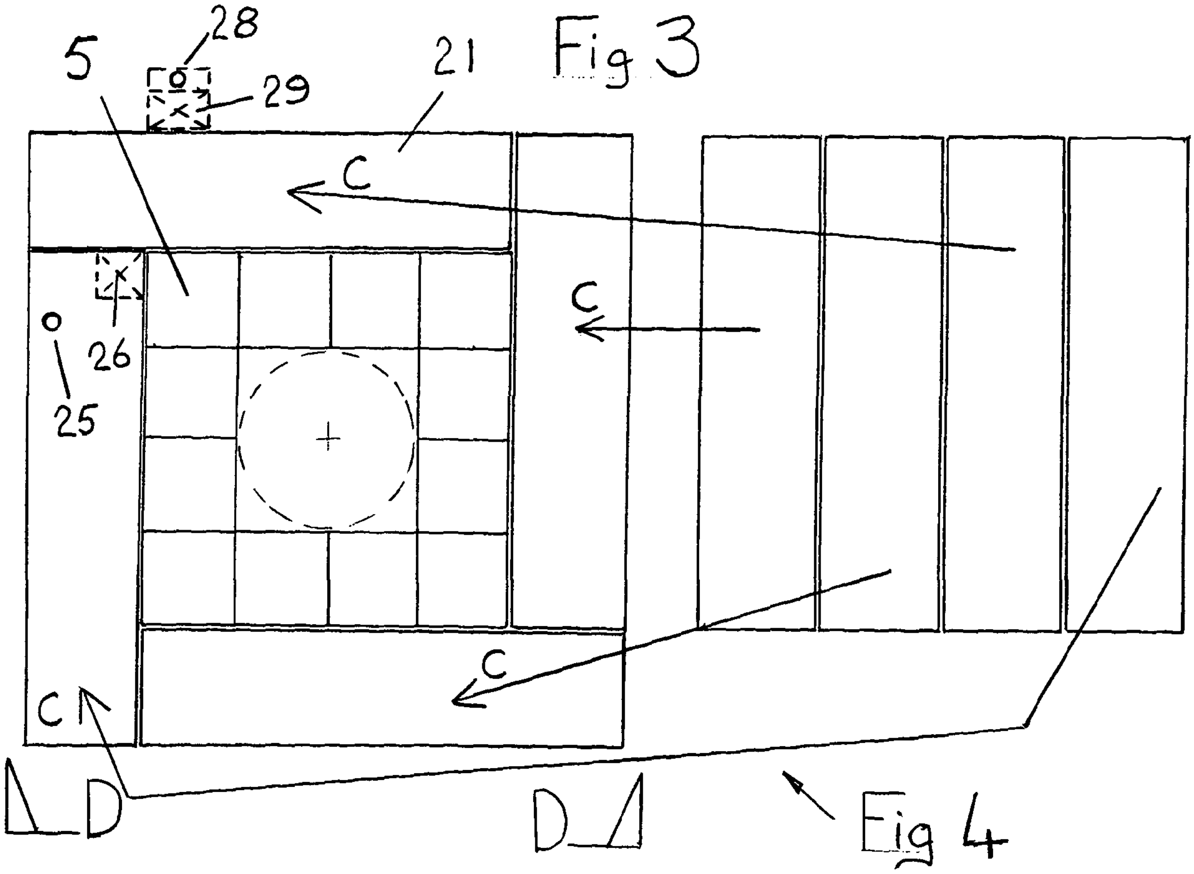


Fig 4

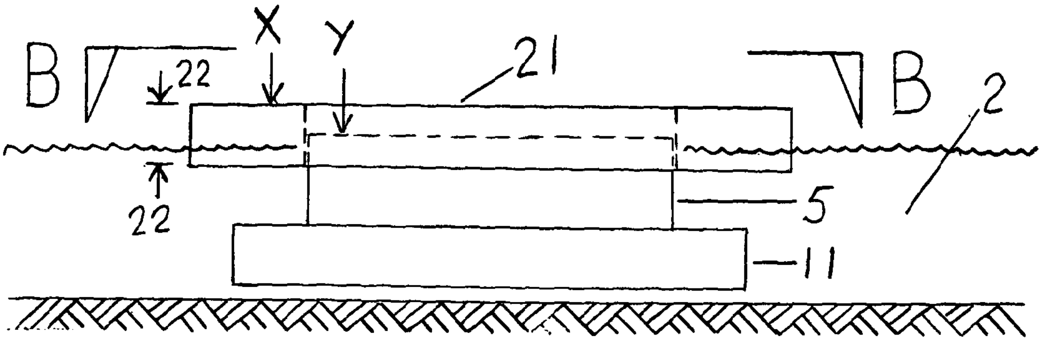


Fig 5

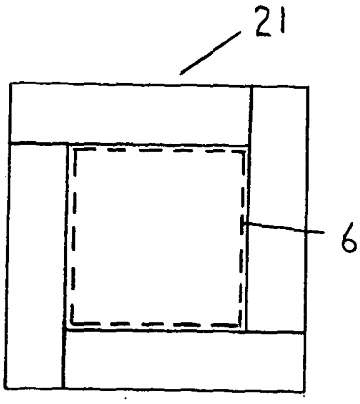


Fig 6A

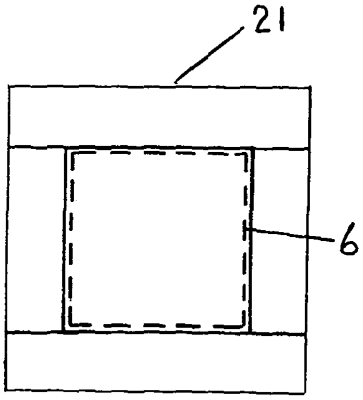


Fig 6B

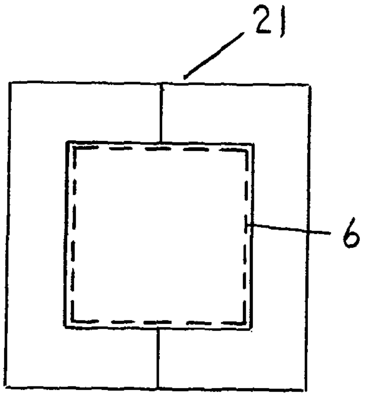
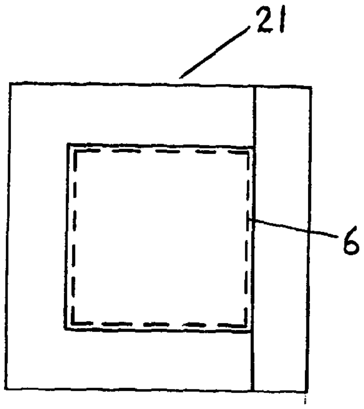


Fig 6C



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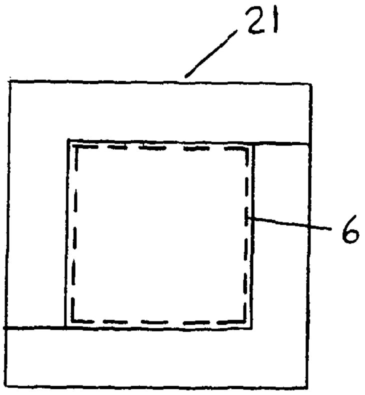


Fig 6E

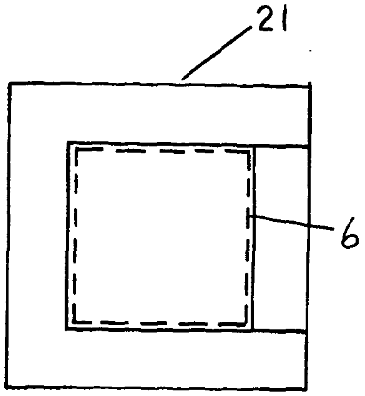
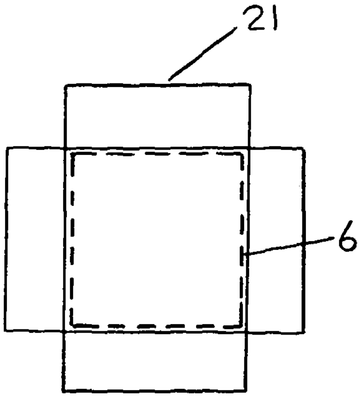


Fig 6F



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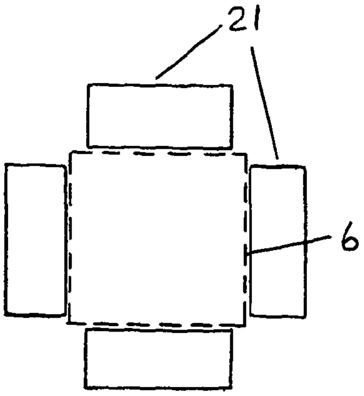

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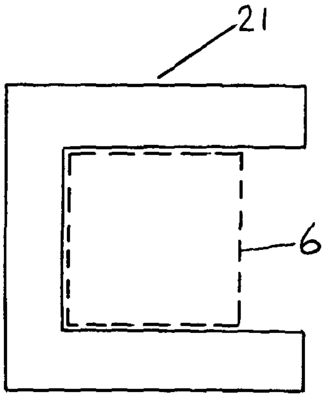

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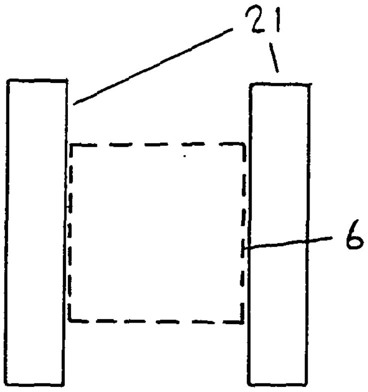

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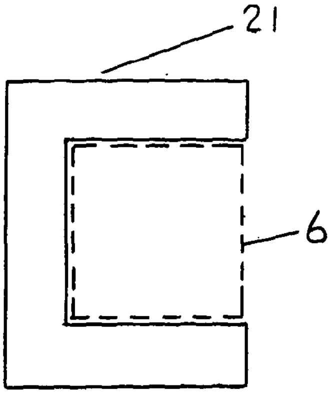

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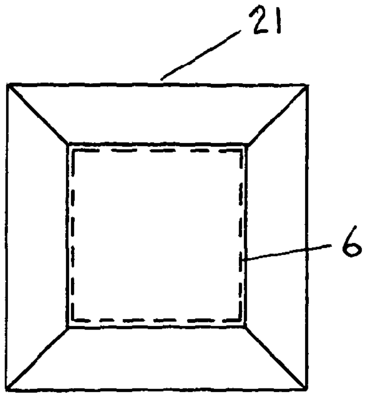


Fig 7F

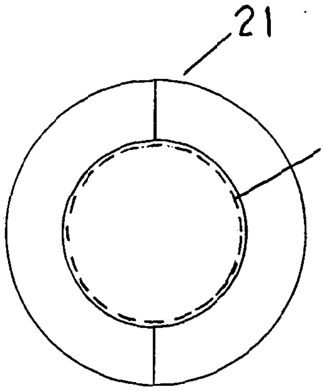
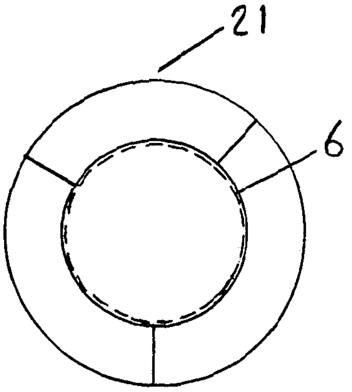


Fig 8A



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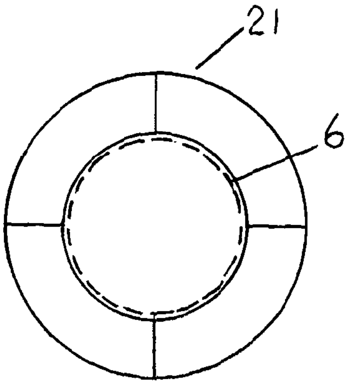

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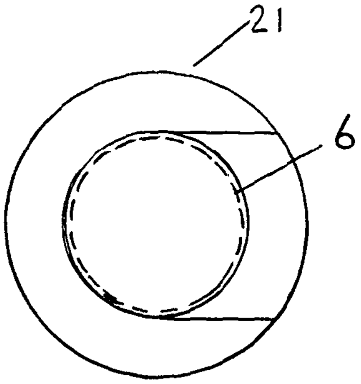

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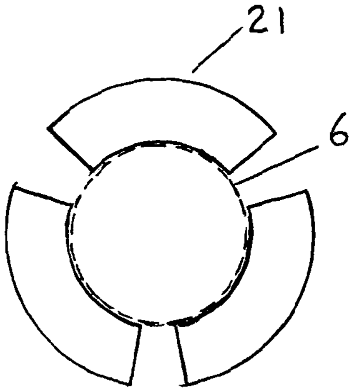

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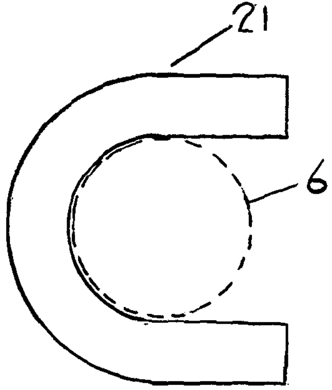

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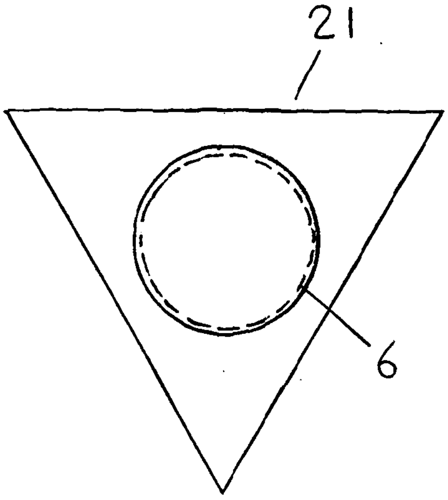
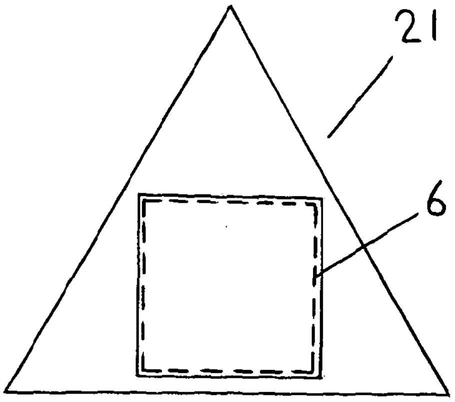


Fig 9A



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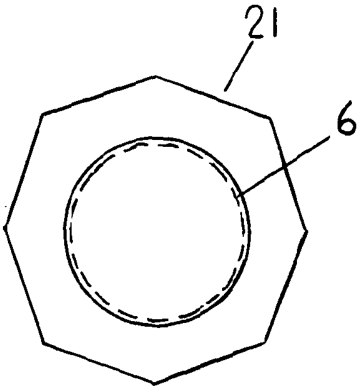

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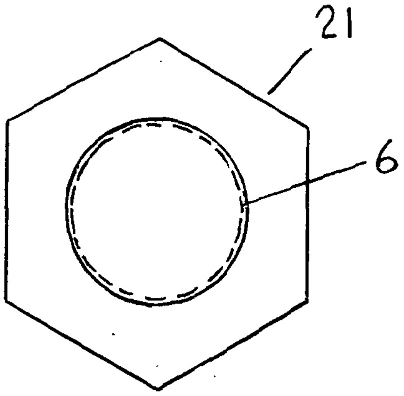

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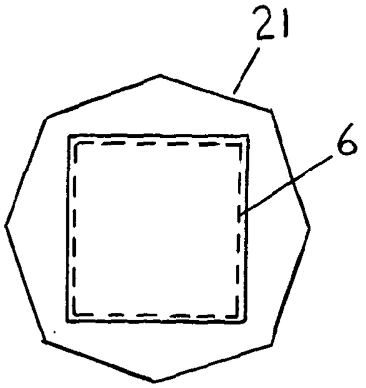

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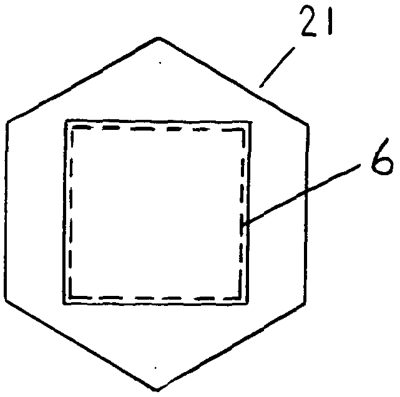

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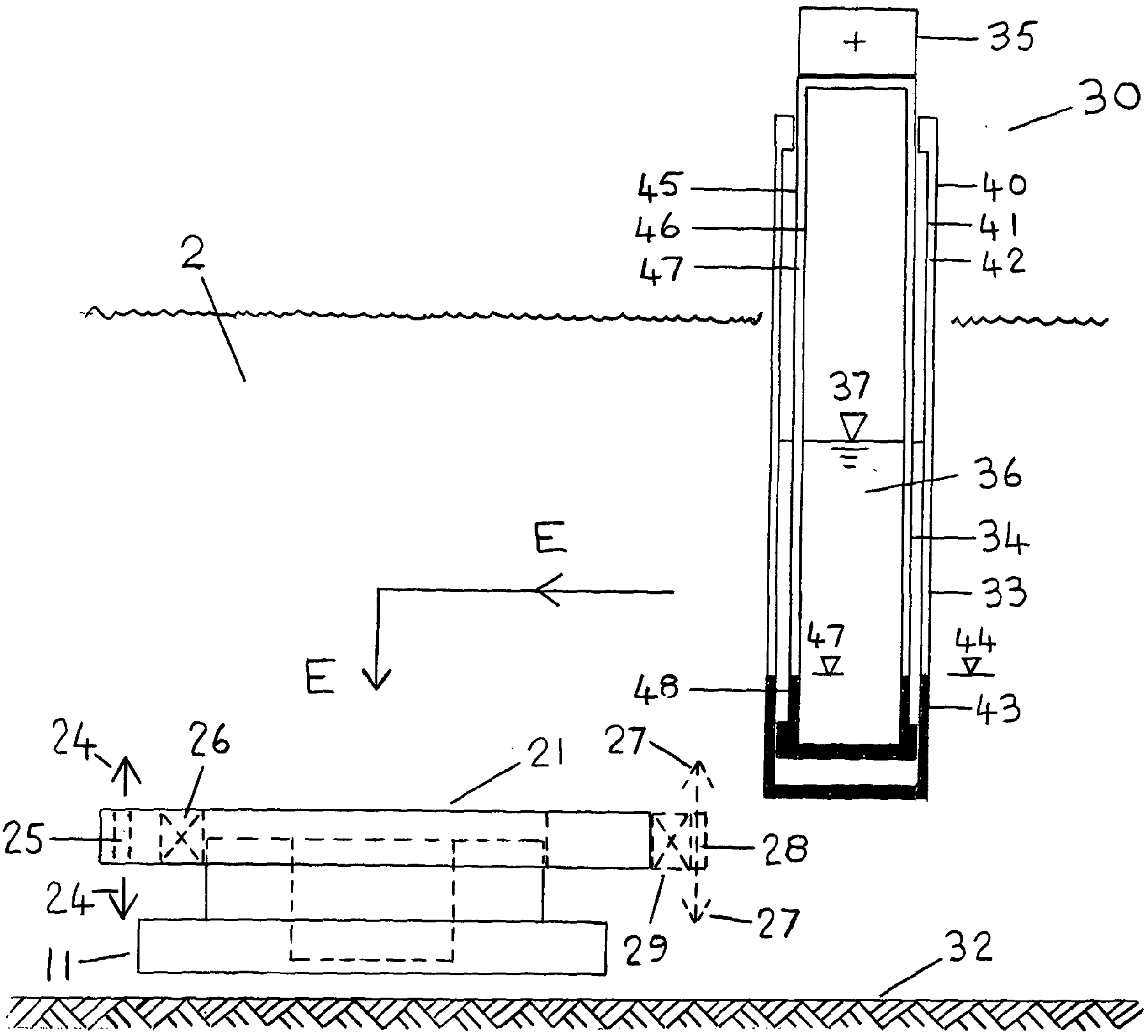
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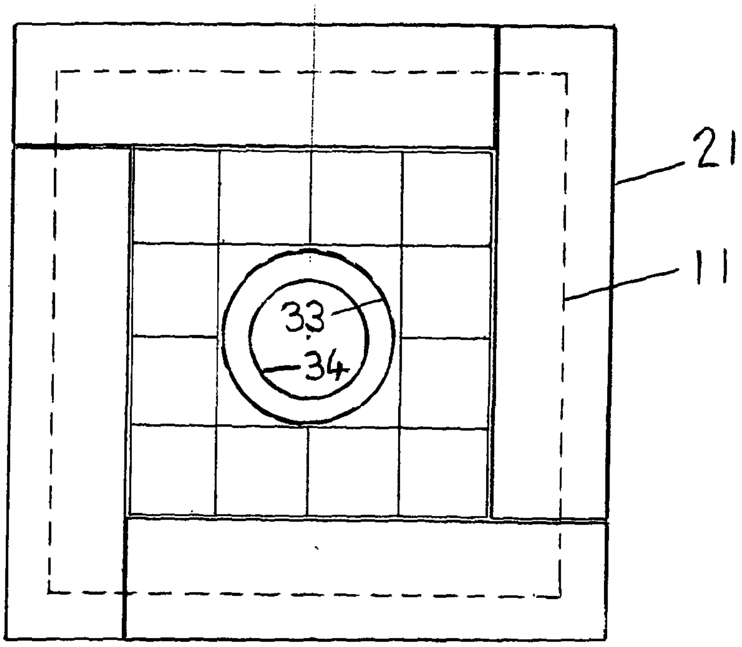
Fig 10



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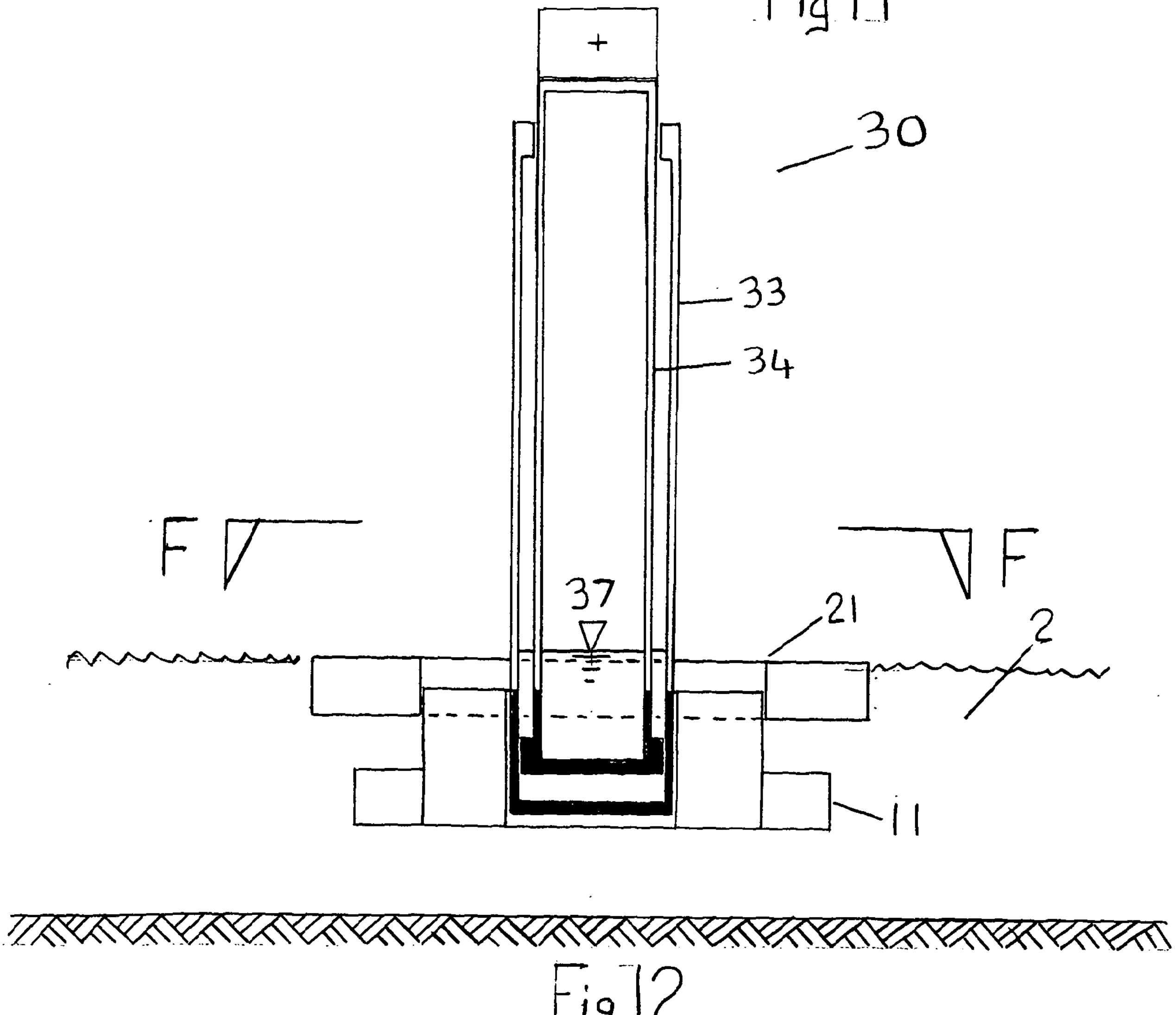

Fig 12

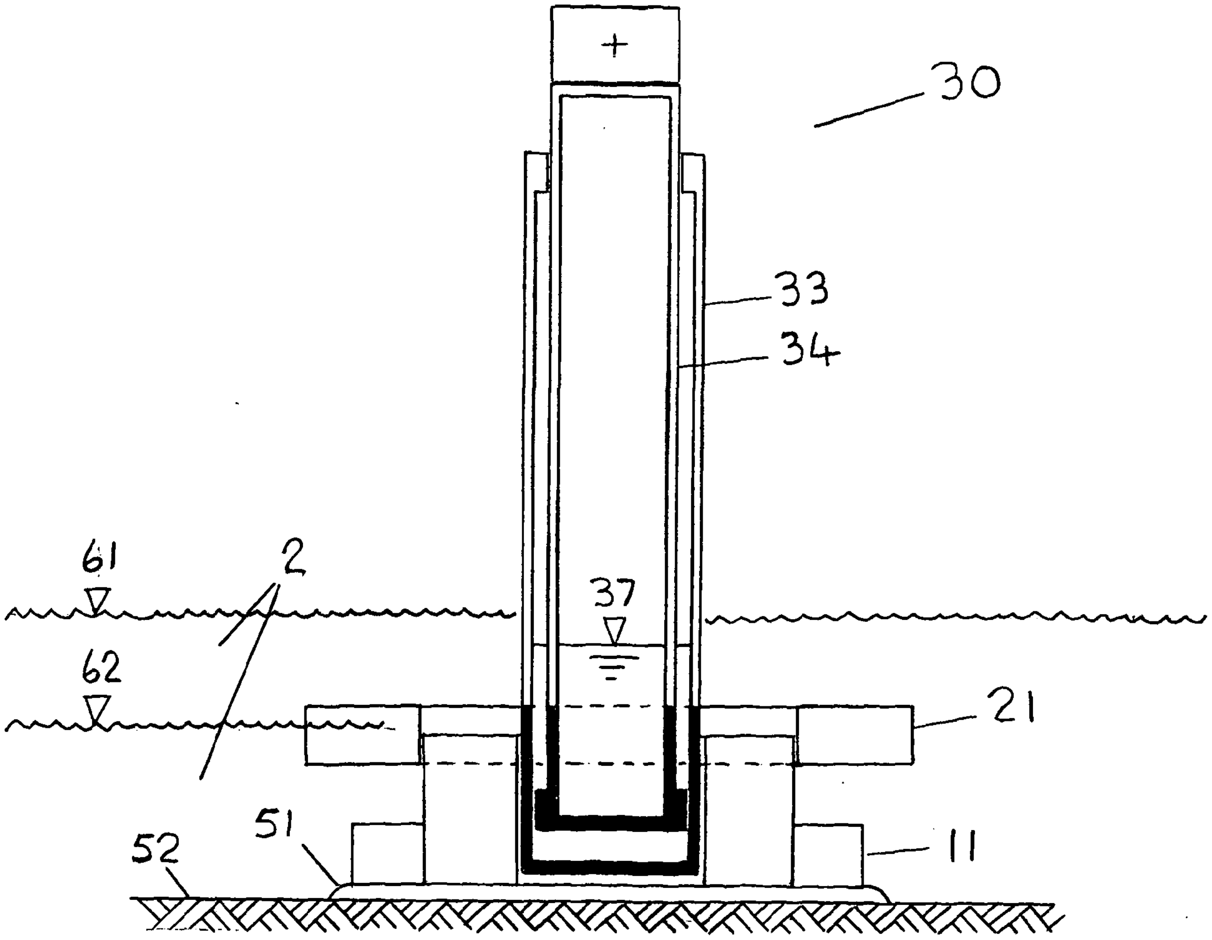

Fig 13

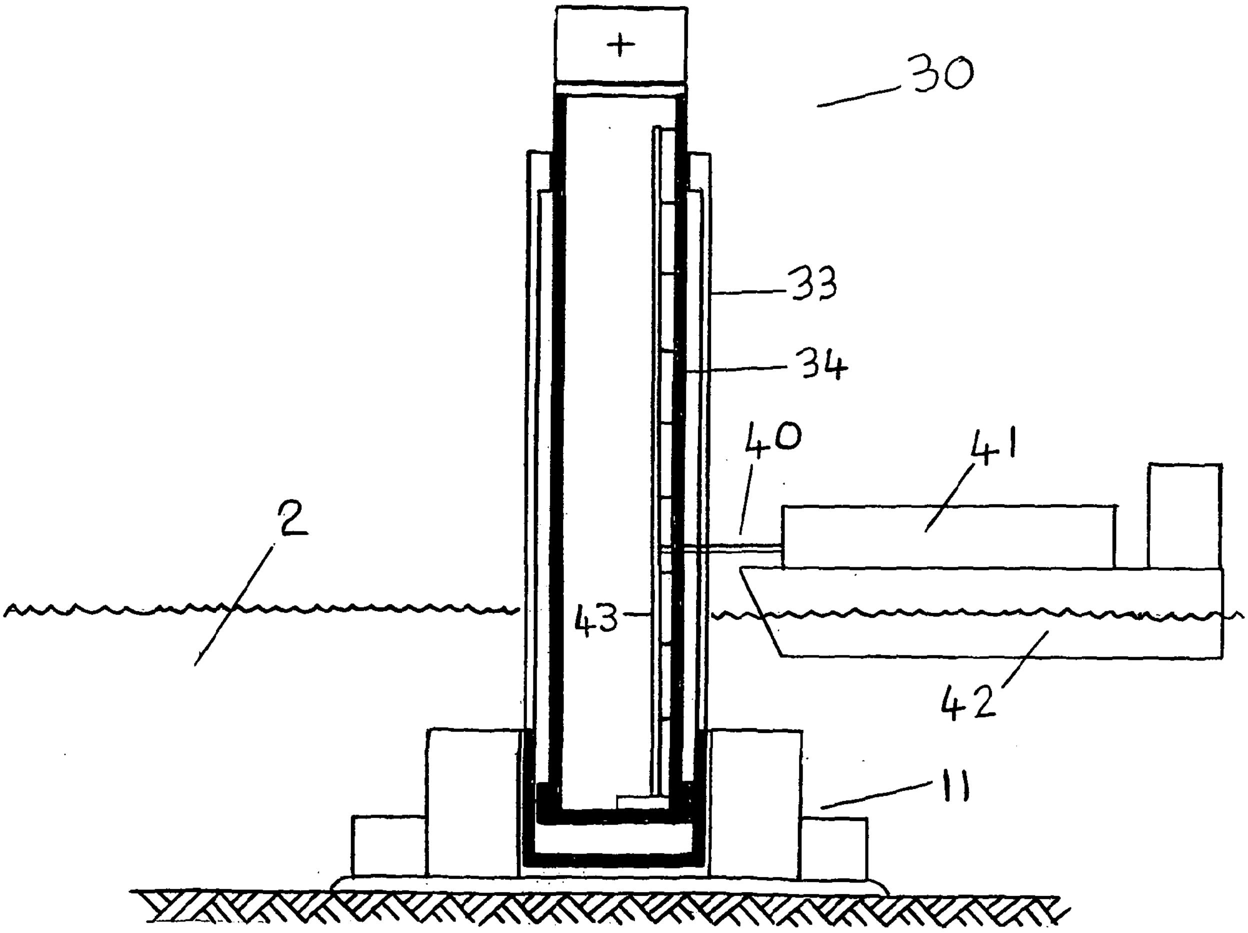

Fig 14

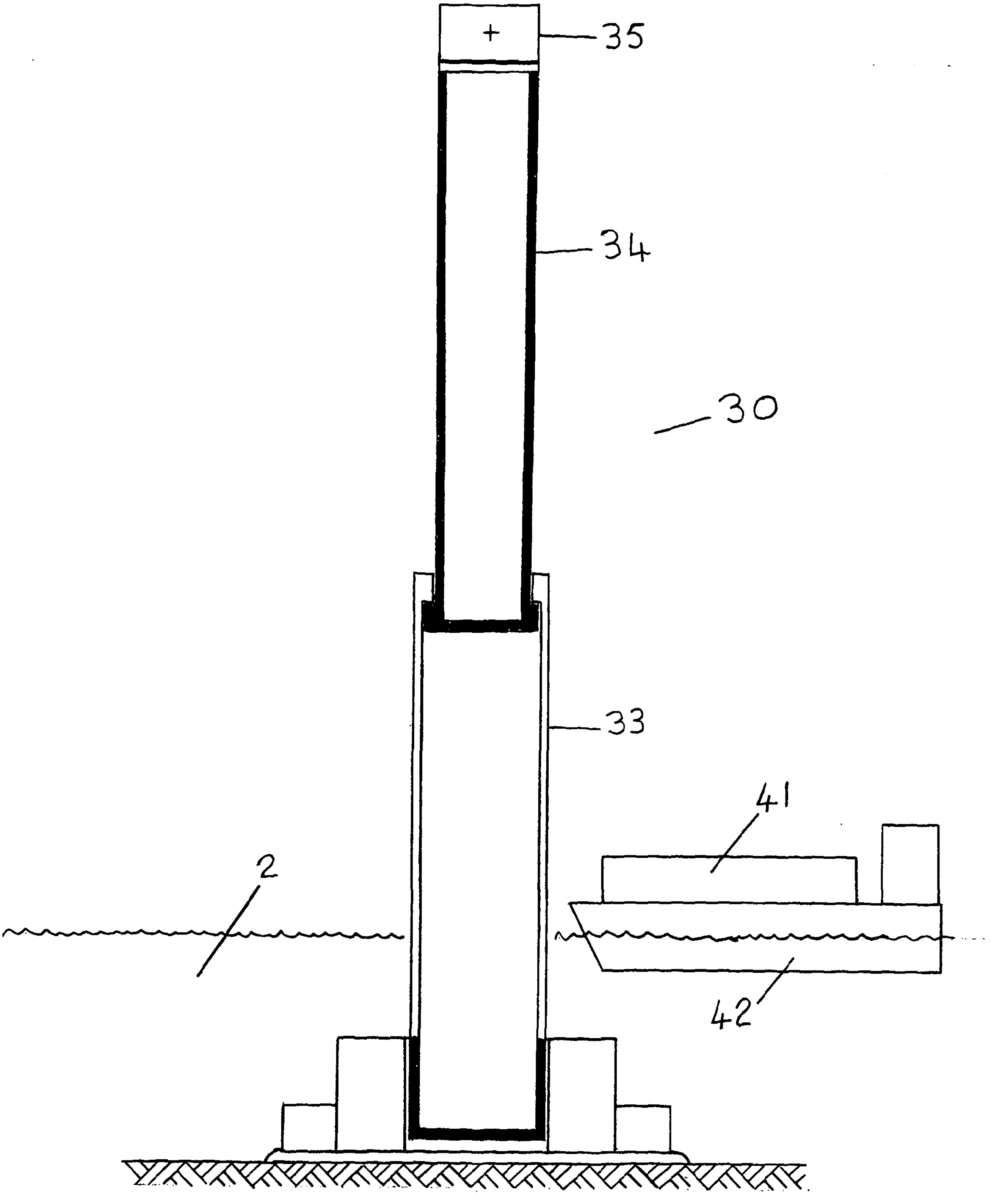

Fig 15

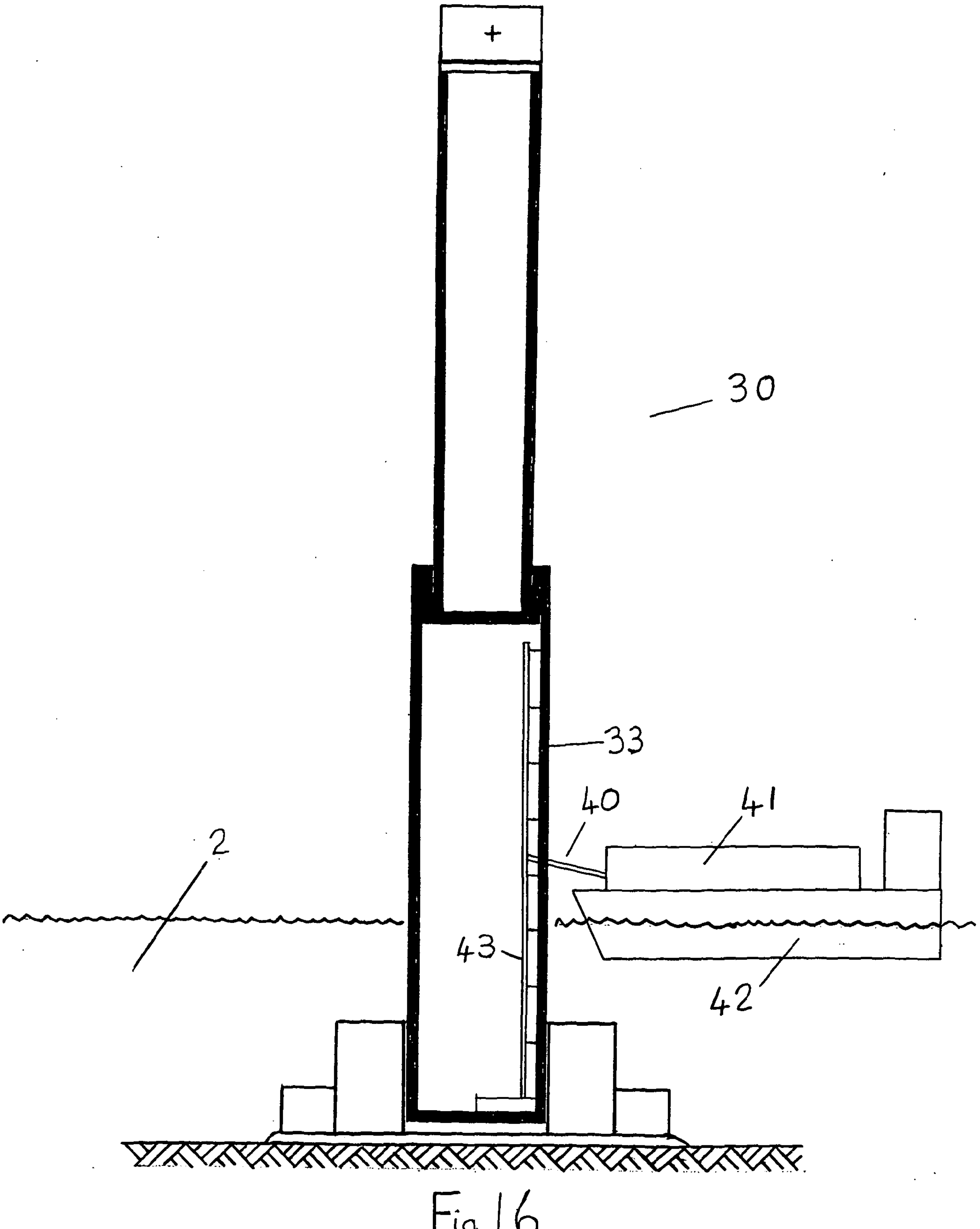

Fig 16

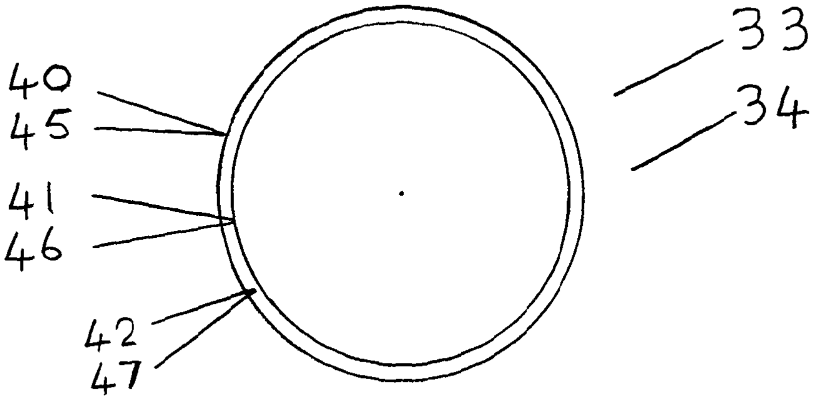

Fig 17

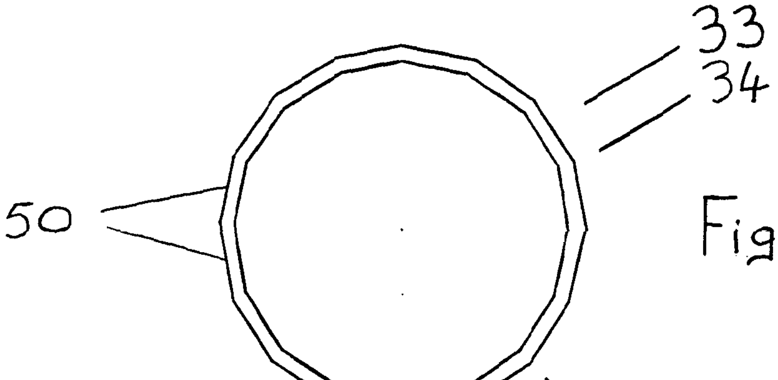

Fig 18

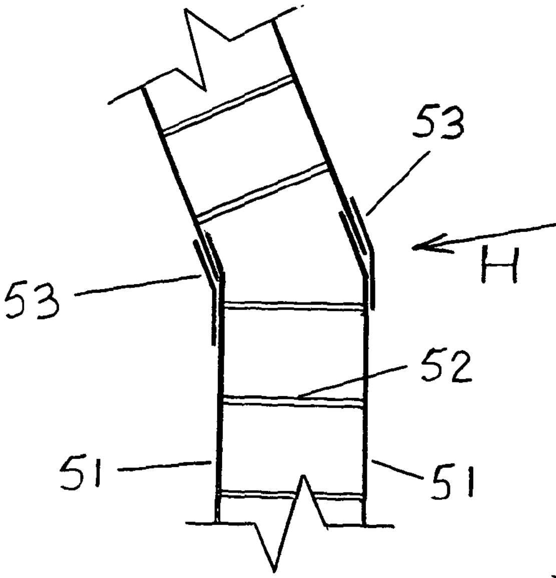

Fig 20

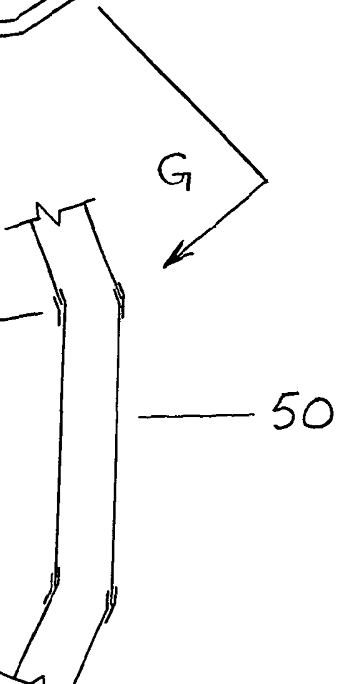

Fig 19

A submersible dynamic floatation tank mountable to a base of an offshore wind turbine assembly

The present invention relates to submersible dynamic floatation tanks, particularly but not exclusively mounted to offshore wind turbine assemblies comprising a base and a column and methods enabling the assembly and delivery and installation of offshore wind turbine assemblies using a submersible dynamic floatation tank.

Gravity bases are one type of foundation for offshore wind turbine assemblies. These bases are spread footings and rest on the seabed. The seabed may be reinforced with piling, or the base may be fully supported by piling. The base supports a column mounted to the base to which is mounted a wind turbine. Another type of foundation for offshore wind turbine assemblies are submerged floating bases that are anchored to the seabed floating at an intermediate level between the seabed and the surface. Both types of foundation base are usually of heavy substantial reinforced concrete or steel or hybrid concrete and steel construction.

Both the gravity type of base, with or without piling, and the submerged floating anchored base can be constructed onshore in a dry dock or on a slipway or on a quayside construction site or they can be formed already floating in water. The bases are then moved to the required location of the offshore wind farm where the construction of the whole wind turbine assembly is completed. For delivery the bases are either floated in the sea using their own inherent buoyancy or using their own inherent buoyancy plus additional buoyancy or the bases are carried on a barge and off loaded at the wind farm site or at an intermediate location for assembly of the wind turbine.

Existing prior art buoyancy devices currently used to enable the delivery of the bases comprising offshore wind turbine assemblies are simple passive floatation tanks and are limited in their application and require greater water depths for their operation than the present invention because of the following reasons.

Existing prior art buoyancy devices may have beam or floor parts that pass under the gravity base to pick up and support the base. Typically these parts have a structural depth of the order of up to 2m and this structural depth has to be added to the required depth of water for floatation of the base. This is because to accommodate the beams or floor the base has to be higher relative to the bed under the water in which the base is floating.

Existing prior art buoyancy devices include floatation tanks the depth of which is greater than their width on plan, this determines the depth of water required for flotation and deeper floatation tanks require deeper water for their operation.

The above disadvantageous features of existing prior art buoyancy devices mean that such devices require typically 8m to 12m depth of water at the launch site for today's typical bases and wind turbine assemblies. The present invention avoids these drawbacks, even for bases several times heavier than current designs and can be operated for launching current and future larger bases in less than 4m depth of water.

Operating in less than 4m of water depth is a very important capability when it is noted that the typical tidal range available along the East Coast of England for example is also about 4m. The present invention will enable bases of any currently foreseeable size to be launched in the shallow waters occurring at key East Coast of England sites for manufacturing wind turbines. This capability is not available with existing prior art buoyancy devices. These benefits will also apply at any shallow water coastal sites, not just at the East Coast of England.

The floatation tanks of existing prior art buoyancy devices and associated bases of wind turbine assemblies are not fully submersible because thrusters are not provided to control descent and ascent of the assembly if submerged. Therefore if the existing prior art buoyancy devices and bases manufactured in accordance with current prior art designs were fully submerged they would be uncontrollable because once the buoyancy of the tank and base is reduced so that the assembly becomes fully submerged then there is no force available to stop it sinking. The assembly will not sit stably at any chosen depth.

However if thrusters are provided then the assembly can be operated like a submarine by balancing negative or positive buoyancy with thrust forces to manoeuvre the base up or down or hold steady. Without this facility to fully submerge the base and the floatation tank the existing prior art buoyancy devices are limited to simple delivery tasks operating on the surface of water, they cannot be used for the mounting of columns to bases using flotation methods requiring the column to pass over the base and the flotation tank.

The existing prior art designs for the columns of wind turbine assemblies do not provide for the method included in the present invention whereby the centre of gravity of the column can be made initially lower to enable stability to be maintained during the mounting of the column to the base and during the delivery of the wind turbine assembly to the final wind farm location and final installation.

Due to the fundamental instability of tall slender elements, such as wind turbine columns with or without the addition of a heavy nacelle mounted on top, when floating elongately vertically in water, the facility of being able to lower the initial centre of gravity of the column is essential to enable the column to be mounted to a base comprising a wind turbine assembly using flotation methods.

The main changes of buoyancy required for the operation of the present invention are provided by the filling of the flotation tank or tanks with water or other ballast or air.
To enable small adjustments of buoyancy there are smaller adjustable buoyancy tanks provided within the main floatation tanks or such tanks are mounted to the floatation tank.

Adjustments to the total buoyancy of the whole assembly consisting of the submersible dynamic floatation tank plus the base and the column mounted to the base are also made by adding or removing water or other ballast to or from the base and column and so reducing or increasing the volume of air within the base and column and so changing the total weight of the base and column plus ballast.

The present invention describes an additional buoyancy device and method that enables gravity bases and submerged floating anchored bases comprising the foundations of offshore wind turbine assemblies to be launched, manoeuvred, assembled and transported and installed at an offshore wind farm site within a wide range of water depths, by way of example only, from 3m depth to 50m water depth or more. Floating submerged anchored bases are more practical for deep water beyond the range of spread footing or piled base designs. There are other prior art floatation devices available but they cannot accommodate the wide operational range of water depths and increasingly larger and heavier offshore wind turbine bases and wind turbine assemblies accommodated by the present invention.

The present invention includes the steps of moving a base to one or more intermediate locations between the location where the base is manufactured and the final location of the wind turbine assembly at a wind farm. At the intermediate locations the column, comprising one or more column members, can be mounted to the base.

The essential operating principle that all buoyancy devices must obey is that the centre of lift of the combined buoyancy device and the item being lifted has always to be effectively above the centre of gravity of the combined mass of the buoyancy device and the item being lifted. In the case of a floating offshore wind turbine assembly comprising a component with an elongate vertical orientation, such as a column mounted to a base including an additional buoyancy device, then if this condition is not maintained at all times with a sufficient margin the combined assembly of the buoyancy device and the item being lifted will become increasingly inclined away from an elongate vertical orientation.

If the centre of lift of the combined buoyancy device and the item being lifted becomes coincident with or moves below the centre of gravity of the combined mass of the buoyancy device and the item being lifted then the whole assembly will become unstable and may capsize.

The current invention provides for and enables this essential operating requirement for stability when used for the delivery of an offshore wind turbine assembly comprising a column mounted to a base, over a wide range of water depths by providing two sets of essential features which are incorporated within the submersible dynamic floatation tank and the column members mounted to the base.

The first set of these essential features is the provision of a floatation tank the depth of which is less than the width of the tank on plan and has a centre of lift above the centre of gravity of the base to which it is mounted and the floatation tank is designed to be fully submerged at times and dynamically operable using water thrusters mounted to or incorporated in the floatation tank as described later in this text.

The second set of essential features is the provision of initially partially hollow walls for the column members comprising the column mounted to the base. The partially hollow walls are later filled solid after the delivery of the column members mounted to the base forming a wind turbine assembly to the final location of the wind turbine assembly. The partially hollow wall features provide a lower centre of gravity of the column comprising a wind turbine assembly during mounting to the base and during the later delivery of the wind turbine assembly to the final location of the wind turbine assembly.

The depth of the floatation tank is less than the width in plan, by way of example only, the structural depth could be 4m and the overall width could be 40m. The delivery, manoeuvring and sinking of the gravity base could involve changes of depth of the base, by way of example only, of up to 70m or more. Therefore, because the floatation tank is rigidly mounted to the gravity base at high level and is initially immersed in water to provide initial floatation, the changes of depth that occur will fully submerge the floatation tank, hence the floatation tank has to be submersible and controllable when submerged.

The characteristics described above of the submersible dynamic floatation tank and the partially hollow walls for the column members later filled solid are novel and have not been incorporated in other prior art floatation devices.

The present invention does not include the base and column members referred to in the present invention text and shown in the figures because these components are covered by prior art and are only mentioned in the text because the apparatus and method of the present invention relates to these wind turbine assembly components.

The present invention includes a submersible dynamic floatation tank and the method of using partially hollow walls forming column members and the later filling of partially hollow walls forming column members to make them solid walls to enable the delivery and assembly and installation of wind turbine assemblies.

There are a further two dynamic aspects of the present invention that enable the principles for floatation described above to be applied even more effectively by the present invention.

Firstly, the height of the centre of gravity and the height of the centre of buoyancy of the floatation tank relative to the base can also be adjusted by changing the level relative to the base at which the submersible dynamic floatation tank is mounted to the base adding to the extent of control and range of operation available.

Secondly, there are additional adjustable buoyancy tanks incorporated in the flotation tank or mounted to the floatation tank and there are thrusters incorporated in the flotation tank or mounted to the floatation tank that provide an effective method of changing the position and level of the base in addition to adjustments of the weight of ballast carried.

It should be noted that adjustment to the weight of ballast alone can only adjust the level at which the base floats when it is floating on the surface of water or it can cause the base to sink to rest on the bed below the water or lift off the bed below the water if the base is resting on the bed. Adjustment to the weight of ballast carried does not enable control of the base when submerged at intermediate depths between the surface of the water and the bed under the water.

The thrusters are used to prevent submersion resulting in uncontrolled sinking of the base and de-ballasting resulting in uncontrolled floatation of the base. The absence of thrusters in other prior art floatation devices limits their capabilities because these devices are not able to provide for controlled total submergence during operation. They cannot hold a submerged base steady at an intermediate depth between the surface of the water and the bed under the water.

According to a first aspect of the present invention there is a submersible dynamic floatation tank that can be mounted to the base of a wind turbine assembly. Possibly the base is manufactured at a first location and floats at a limited depth with sufficient freeboard for safe floatation at that location and is then moved to a second location where the base floats at greater depth. Possibly the submersible dynamic floatation tank consists of more than one part that can be assembled around the base. Possibly the submersible dynamic floatation tank is assembled around the base at the first or second location and is fixed to the base in such a way and is operated in such a way that the tank exerts lift on the base and so enables further construction of the base that adds weight to the base whilst maintaining the required safe flotation depth and freeboard in the water in which the base is located. Possibly the base and the mounted submersible dynamic floatation tank can be moved to a third location.

According to a second aspect of the present invention a base including a submersible dynamic floatation tank mounted to the base is moved to a third location at which the submersible dynamic floatation tank is operated so as to become submerged and so lowers the base in a sufficient depth of water to enable column members comprising a column floating in an elongate vertical mode to pass over the top of the submersible dynamic floatation tank and over the top of the base and to be mounted to the base. The column may also comprise a nacelle already mounted to the top of the column using floatation methods.

According to a third aspect of the present invention the walls of the column members forming a column comprising an offshore wind turbine assembly mounted to a base are formed initially of partially hollow construction. Possibly the hollow construction reduces the weight of the upper parts of the column members positioned and floating in water in an elongate vertical mode so that the centre of gravity of the column members is lower than if the walls of the column members were of a solid construction throughout. Possibly the lower centre of gravity of the column enables the set of column members to float in an elongate vertical mode at a suitable depth to pass over a submerged base and a submersible dynamic demountable floatation tank and for the column to be mounted to the base.

Possibly the lower centre of gravity of the column enables an offshore wind turbine assembly consisting of a base to which a column is mounted and a submersible dynamic floatation tank mounted to the base to be moved to a fourth location in a stable manner without capsizing. Possibly this fourth location is the final location of the wind turbine assembly where the construction of the wind turbine assembly is completed.

According to a fourth aspect of the present invention the partially hollow walls of the column members are filled solid one at a time prior to or after each column member being erected telescopically or erected using any other method. In this way the column forming the wind turbine assembly is fully erected and completed with column walls that are solid as required for their function.

Embodiments of the present invention will now be described, by way of example only, and with reference to the accompanying drawings. The embodiments of the present invention described here and illustrated in the accompanying drawings comprise a telescopic column comprising two column members. Other embodiments of the current invention include columns comprising one or more than two column members that are erected telescopically or by other methods.

The embodiments of the present invention described here and illustrated in the accompanying drawings show the present invention being used to enable the assembly and delivery and installation of an offshore wind turbine assembly including a gravity base type of foundation resting on the seabed with or without piling. The same embodiments of the present invention would also enable the assembly and delivery and installation of an offshore wind turbine assembly including a submerged floating base type of foundation anchored to the seabed floating at an intermediate level between the seabed and the surface.

It will have been noted from the four aspects of the present invention described in the text above that the present invention applies over a series of two or more locations. The embodiment of the present invention described within the following drawings applies over four locations as follows:

Figures 1A, 1B and 2 show details of the base of a wind turbine assembly in accordance with prior art. The base is constructed at or adjacent to a first location and at this location the base is floated in water, with additional buoyancy provided if required to ensure adequate freeboard for safe floatation and moving to a second location.

The floating base is then moved to a second location. Figures 3, 4, and 5 apply at the second location where a submersible dynamic floatation tank is mounted to the base. In another embodiment of the present invention the submersible dynamic floatation tank could be mounted to the base at the first location where the base is constructed if the water depth was suitable at that location.

The base and the submersible dynamic floatation tank are then moved to a third location where a column is mounted to the base. Figure 10 applies at the third location. In another embodiment of the present invention the column could be mounted to the base at the first location or the second location if the water depths were suitable at those locations.

Figure 12 shows a base and a submersible dynamic floatation tank and a column mounted to the base in transit between locations. In the embodiment of the present invention described here the transit is between the third and a fourth location but the transit could be between a first and second location or a second and third location or any other locations.

Figures 13, 14, 15 and 16 apply to the final location of the base and column where the construction of the wind turbine assembly is completed.

The base and the submersible dynamic floatation tank and the wind turbine assembly described here are moved between locations using tug boats or any other suitable towing or pushing device or they are moved by the self-propelled motion of the submersible dynamic floatation tank if the submersible dynamic floatation tank is provide with means of self-propulsion.

A list of the drawings describing embodiments of the present invention now follows:

Figure 1A is a plan view of a rectangular base for an offshore wind turbine assembly.

Figure 1B is a plan view of a circular base for an offshore wind turbine assembly.

Figure 2 is an elevational view of both a rectangular and a circular base for a wind turbine assembly as shown in plan in figs. 1A and 1B as indicated by the arrows marked A-A on those two plans. The elevation shows the base floating in water at a first location.

On figs 1A and 1B the circle marked 8 indicates the location of the column comprising the wind turbine assembly when mounted to the base. The column members comprising the column may be circular as indicated by the circle 8 or faceted in horizontal plan section.

The line marked 6 is the perimeter of an upper part of the base 5 that is smaller in plan area than a lower part of the base 3. In this embodiment of the present invention the submersible dynamic floatation tank is mounted to this perimeter. This perimeter is marked as line 6 on the plans in the following figures. In another embodiment of the present invention possibly the submersible dynamic floatation tank is mounted to the perimeter of the lower part of the base 3 or possibly mounted to both the upper and lower parts of the base together, the upper part of the base may be the same size and shape in plan as the lower part of the base.

The design of the bases shown in figs. 1A, 1B and 2 is prior art and is not part of the claims for the present invention. The bases may include voids within their construction, the voids may be open topped, or the bases may be of solid construction.

Figure 3 is an elevation view showing a base of the same designs as shown in figs 1A, 1B and fig. 2 comprising a wind turbine assembly comprising a base floating in water at a second location and component parts forming a submersible dynamic floatation tank floating alongside the base. The required buoyancy floatation depth of the base may have been changed from that shown in figs 1A, 1B and 2 by additional construction weight and possibly adjusted by adding or removing ballast and the base floats at greater depth than in fig.2.

Figure 4 is a plan showing the component parts of a rectangular submersible dynamic floatation tank floating alongside a rectangular base being moved in accordance with the arrows C and assembled around the base and being mounted to the base. Fig. 4 is a plan view on figs. 3 and 5 at a level indicated by arrows B-B on figs. 3 and 5.

Figure 4 shows typical locations in plan of internal adjustable buoyancy tanks and thrusters incorporated in the construction of the floatation tank and also of additional adjustable buoyancy tanks and thrusters if required mounted to the floatation tank. Only one each of these items is shown whereas the present invention will be provided with more than one of each of these items.

Figure 5 is an elevation view showing a submersible dynamic floatation tank mounted to a rectangular base of a wind turbine assembly floating in water at a second location as shown in elevation and plan in figs.3 and 4 and indicated by view arrows D-D in fig. 4.

Figures 6A, 6B, 6C, 6D, 6E and 6F are plans showing 6 possible permutations of component parts forming a submersible dynamic floatation tank mountable to a base of a wind turbine assembly floating in water, the base being of a rectangular plan form as shown in fig. 1A

Figures 7A, 7B, 7C, 7D, 7E and 7F are plans showing a further 6 possible permutations of component parts forming a submersible dynamic floatation tank mountable to a base of a wind turbine assembly floating in water, the base being of a rectangular plan form as shown in fig. 1A.

Figures 8A, 8B, 8C, 8D, 8E and 8F are plans showing a further 6 possible permutations of component parts forming a submersible dynamic floatation tank mountable to a base of a wind turbine assembly floating in water, the base being of a circular plan form as shown in fig. 1B.

Figures 9A, 9B, 9C, 9D, 9E and 9F are plans showing a further 6 possible plan shapes of a submersible dynamic floatation tank mountable to a base of a wind turbine assembly floating in water, the base being of a rectangular or circular plan form as shown in figs. 1A and 1B. The submersible dynamic floatation tanks shown in plan will have to be divided into component parts to enable mounting to a base.

For the following figures the submersible dynamic floatation tank can be of a rectangular or circular plan shape to suit a rectangular or circular base of a wind turbine assembly.

Also a circular submersible dynamic floatation tank could be mounted to a square or rectangular base and a square or rectangular submersible dynamic floatation tank could be mounted to a circular base

Figure 10 is an elevation view of a submersible dynamic floatation tank mounted to a base of a wind turbine assembly submerged in water at a third location and a sectional view of column members positioned in a vertical elongate mode floating in water near to the submerged base and tank. An arrow marked E-E indicates the movement and mounting of the column members to the base. The column assembly is moved horizontally using tug boats and the depth of floatation of the column assembly over the base is adjusted by the addition or removal of ballast. To facilitate the location of the column assembly above the socket in the submerged base, guides will be provided mounted to the base to engage with the bottom of the column assembly which is lowered down into the base socket by further adjustment of the ballast within the column assembly.

Figure 10 shows typical locations in elevation of internal adjustable buoyancy tanks and thrusters within the submersible dynamic floatation tank and also of additional adjustable buoyancy tanks and thrusters if required mounted to the submersible dynamic floatation tank. Only one each of these items is shown whereas the present invention will be provided with more than one of each of these items.

Figure 11 is a plan view at the level indicated by the arrows F-F shown on Figure 12. The submersible dynamic floatation tank shown has the configuration of component parts shown in fig.6A. Fig.11 could also have the configuration of component parts shown in figs. 6B to 6F inclusive. Any other plan shape would change the details shown in fig 12.

If the base shown in fig. 11 were of a circular plan shape it would appear as shown in fig.1B and the submersible dynamic floatation tank would appear as one of the plan shapes for submersible dynamic floatation tanks shown in figs. 8A to 8D inclusive. Any other plan shape would change the elevational details shown in fig.12.

However a circular submersible dynamic floatation tank could be mounted to a square or rectangular base and a square or rectangular submersible dynamic floatation tank could be mounted to a circular base and this would not change the elevational details shown in fig.12.

To limit the total number of figures included in the present invention only the two most practical plan configurations for the submersible dynamic floatation tank and base have been illustrated by figures, for example figs.11 and 12. However the present invention is applicable to all possible floatation tank plan configurations and structural depths mounted to any plan shapes of bases.

Figure 12 is a sectional elevational view of column members mounted to a base and a submersible dynamic floatation tank mounted to the base comprising a wind turbine assembly floating in water in transit between a third location and a fourth location. In the embodiment of the present invention described here the transit is between the third and a fourth location but the transit could be between a first and second location or a second and third location or any other locations.

Figure 13 is a sectional elevation view of column members mounted to a base placed on a seabed under water at a fourth location. The column members comprise a telescopic column in a retracted position. A submersible dynamic floatation tank is shown mounted to the base and the submersible dynamic floatation tank is shown submerged under water level indicated by arrow 61. If the water level were as indicated by arrow 62 the submersible dynamic floatation tank would not be fully submerged.
The following figs.14, 15 and 16 are also all at a fourth location

Figure 14 is a section view of column members mounted to a base placed on a seabed under water. The column members comprise a telescopic column in a retracted position. The submersible dynamic floatation tank shown mounted to the base in the previous Figure 13 has been demounted and floated away. The walls of the inner column member have been filled solid.

Figure 15 is a section view of column members mounted to a base placed on a seabed under water. The column members comprising a telescopic column have been erected to an extended position.

Figure 16 is a section view of column members mounted to a base placed on a seabed under water. The column members comprising a telescopic column have been erected to an extended position. The walls of the outer column member have been filled solid and the turbine assembly awaits the mounting of the rotor blades and the completion of construction.

Figures 17, 18, 19 and 20 show details of the construction of the walls of the column members. The details apply to column members with horizontal plan perimeters that are circular or faceted.

There now follows a more detailed explanation of the figures:

The design details of the bases 1, 10 and 11 for a wind turbine assembly shown in figs. 1A, 1B and 2 are prior art and are not the subject of the claims of the present invention.

The bases are constructed at or adjacent to a first location. The bases can be constructed in any practical form using any suitable materials. The bases may include voids within their construction, the voids may be open topped, or the bases may be of solid construction. The upper part of the base may be the same size and shape in plan as the lower part of the base.

Figure 1A is a plan view of a base 1 of rectangular plan shape, not necessarily square, for an offshore wind turbine assembly to which a column is mountable according to prior art.

Figure 1B is a plan view of a base 10 of circular plan shape for an offshore wind turbine assembly to which a column is mountable according to prior art.

In both figures 1A and 1B there is a circle 8 that indicates in plan section the location of, by way of example only, a circular column that is mountable to the base if the column were mounted to the base. The column location is also indicated by the dotted lines 9 in fig. 2. It will be noted that the column indicated by the dotted lines 9 extends into the base 11 to which the column is mounted. The column members comprising the column may be circular as indicated by the circle 8 or faceted in horizontal plan section. In another embodiment of the present invention the column mounted to the base may be connected to the top of the base without the column penetrating the base.

Figure 2 is an elevation view of the bases 1 and 10 and these bases are now shown with reference 11 on fig. 2 and in subsequent figures. The elevation in fig. 2 is indicated in figs. 1A and 1B by the arrows A – A on figs 1A and 1B.

In fig. 2 the base 11 is floating in water 2 at a first location adjacent to where the base 11 is constructed. The base is shown floating at a depth that allows the top 7 of the lower part of the base 3 to be above the surface level of the water 4 with sufficient freeboard for safe floatation. There is also shown an upper part to the base 5 that is of a smaller plan size than the lower part 3. Below water 2 there is shown bed 14 which may be a river bed, an estuary bed, a lake bed or a seabed.

Although the bases shown in figs.1A and 1B are of different plan shapes the side elevation as drawn in two dimensions in fig.2 will appear to be the same for both bases. This geometrical property enables the elevations in the following figures to show the details for a variety of offshore wind turbine assemblies with either rectangular bases or circular bases.

In figs. 1A, 1B and 2 the perimeter of the upper parts 5 of the bases 1, 10 and 11 is shown as a bold line 6

Figure 3 shows in elevation a base 11 as drawn in fig. 2 and now moved to a second location where it floats in water 2 that may be seawater. At this second location the depth of floatation of the base has increased possibly due to the addition of further construction weight or possibly due to the addition of ballast to the base so that the base is substantially but not completely submerged. There is sufficient freeboard above the top level of the upper part 5 of the base for safe floatation. This increase in the depth of floatation of the base facilitates the mounting of the submersible dynamic floatation tank 21 to the base 11 at the required level in relation to the upper part of the base 5.

In another embodiment of the present invention the submersible dynamic floatation tank could be mounted to the lower part of the base 3 or the tank could be mounted to both the upper and the lower part of the base together. The upper part of the base may be the same size and shape in plan as the lower part of the base.

The depth of water at the second location may be greater than the depth of water at the first location and it must be deep enough to accommodate the floating base 11. If the depth of water available at the first location is sufficient then the submersible dynamic floatation tank can be mounted to the base at the first location.

Also in fig.3 at the second location a floating submersible dynamic floatation tank 21 comprising component parts is shown positioned near to the base. By way of example only, the floating submersible dynamic floatation tank 21 is shown comprising four component parts and when mounted to the base 11 is arranged in a rectangular plan form around the base 11. The movement of the component parts of the floating submersible dynamic floatation tank 21 from the location of the group of four component parts as delivered to the locations where the component parts are mounted to the upper part 5 of the base 11 is indicated by the four arrows marked C shown on fig. 4.

Figure 4 is a plan view as indicated on figs. 3 and 5 by arrows B-B. Fig. 4 is a plan on the floating submersible dynamic floatation tank 21 as delivered in four parts and assembled around the upper part 5 of the base 11.

By way of example only, the submersible dynamic floatation tank 21 shown in figure 4 is rectangular in form, not necessarily square, and consists of 4 component parts. Each part is moved as indicated by arrows C to be located around the upper part 5 of the base 11. Each part of the floating submersible dynamic floatation tank 21 is mounted to the base 11 and each part may also be connected to the adjacent parts of the floatation tank to form a ring around the base. The component parts forming the submersible dynamic floatation tank 21 may be delivered to the second location in any arrangement and may be mounted to the base 11 using any suitable attachment method.

Figure 4 shows typical locations in plan of internal adjustable buoyancy tanks 26 and thrusters 25 and also of additional adjustable buoyancy tanks 29 and thrusters 28 if required mounted to the submersible dynamic floatation tank. Only one each of these items is shown whereas the present invention will be provided with more than one of each of these items.

Figure 5 is an elevation indicated on fig.4 by arrows D - D

Figure 5 shows a base 11 including a floating submersible dynamic floatation tank 21 floating in water 2 that may be seawater still at a second location as described in fig.3. For optimum stability the submersible dynamic floatation tank 21 has been mounted to base 11 with the top surface of the tank at a level X that is above or level with the level Y of the top of the base 11. Other arrangements could be adopted depending on the height of the upper part of the base 5 but the higher the floatation tank relative to the level of the base the more stable the assembly will be. The buoyancy of the floating submersible dynamic floatation tank 21 will be adjusted so that the base 11 is partially or wholly supported by the floating submersible dynamic floatation tank 21.

Base 11 and the floating submersible dynamic floatation tank 21 can now be moved to a third location where the water is deeper, this is shown in Figure 10.

In figs.3 and 5 the depth of the structure shown by arrows 22-22 of the submersible dynamic floatation tank 21 is shown constant in the figures but this is not essential. Any practical variable depth of structure may be provided over the plan area of the submersible dynamic floatation tanks 21 if required.

Figures 6A, 6B, 6C, 6D, 6E and 6F show various different plans for rectangular submersible dynamic floatation tanks 21, not necessarily square, incorporating different subdivisions of the submersible floatation tanks 21 into 2 or 4 component parts. Other subdivisions may be provided.

Figures 7A, 7B, 7C, 7D, 7E and 7F show further possible plans for rectangular submersible dynamic floatation tanks 21, not necessarily square, incorporating different subdivisions of the submersible floatation tanks 21 into 1, 2, or 4 component parts. Other subdivisions may be provided.

Figures 8A, 8B, 8C, 8D, 8E and 8F show various different plans for circular submersible dynamic floatation tanks 21, incorporating different subdivisions of the dynamic submersible floatation tanks 21 into 1, 2, 3 or 4 component parts. Other subdivisions may be provided.

Figures 9A, 9B, 9C, 9D, 9E and 9F show further possible plans for polygonal submersible dynamic floatation tanks 21, subdivisions of these submersible floatation tanks 21 into 2 or more component parts will be required to enable the mounting and demounting of the submersible dynamic floatation tank 21 to the base 11.

The various embodiments shown in figs. 6, 7, 8 and 9 show, by way of example only, plans of a wide range of different submersible dynamic floatation tanks 21, any other practical plan shape not shown in these figures can also be provided. The submersible dynamic floatation tanks 21 are shown mounted to square bases or in other cases mounted to circular bases. There are other possible combinations whereby submersible dynamic floatation tanks 21 of any plan shape can be mounted to any plan shape of base either square or circular or of any other practical shape.

The perimeter 6 of the upper part 5 (see figs. 2 and 5) of bases 11 is shown as a dotted line 6 on all the plans in figs. 6, 7, 8, and 9.

For all the following figs.10 to16 inclusive, there are shown two column members 33 and 34 comprising a telescopic column 30. In other embodiments of the present invention there can be one or more than two column members comprising a column and the column may not be telescopic.

In figures 10, 12, 13, 14 and 15 the level to which the hollow walls of the column members are initially filled solid with solid material as shown by solid shading is by way of example only and can be any suitable level to enable appropriate floatation depths and stability to be achieved.

Figure 10 shows the submersible dynamic floatation tank 21 mounted to the base 11 of a wind turbine assembly shown in fig. 5 and now moved to a third location.

At this third location the submersible dynamic floatation tank 21 mounted to base 11 is fully submerged in water 2 that may be seawater. The base 11 may be resting on bed 32 or floating submerged at a level above the level of the bed 32.

Figure 10 shows typical locations in elevation of internal adjustable buoyancy tanks 26 and thrusters 25 and also of additional adjustable buoyancy tanks 29 and thrusters 28 if required mounted to the submersible dynamic floatation tank. Only one each of these items is shown whereas the present invention will be provided with more than one of each of these items

The submergence of the base 11 and the submersible dynamic floatation tank 21 mounted to the base is achieved by adjusting buoyancy 26 and/or 29, adding ballast that may be water ballast to the submersible dynamic floatation tank 21 and operating the thrusters 25 and/or 28 generating thrusts 24 and/or 27 acting on the submersible dynamic floatation tank 21 and possibly by adding ballast to the base 11 if required. The power and direction of the thrusts 24 and 27 can be adjusted as required. By way of example only, the thrusters 25 and 28 could be ducted propeller generated water jets of variable power and would be reversible as indicated by the two points on each of the arrows 24 and 27 representing the thrusts 24 and 27 in fig. 10. The thrusts can be directed in any direction to manoeuvre and position the base as required

The depth of water at the third location is greater than the depth of water at the second location. The greater depth of water enables the column members 33 and 34 floating in an elongate vertical position to pass over the top of the sufficiently submerged submersible dynamic floatation tank 21 and base 11 and be mounted to the base 11 as indicated by the arrows E. If the water is deep enough at the first or second locations then the column could be mounted to the base at these locations.

The column assembly is moved horizontally using tug boats and the depth of floatation of the column assembly over the base is adjusted by the addition or removal of ballast 36. To facilitate the location of the column assembly above the socket in the submerged base, guides will be provided mounted to the base to engage with the bottom of the column assembly which is lowered down into the base socket by further adjustment of the ballast 36 within the column assembly.

There may be a nacelle 35 also mounted to the column members 33 and 34 prior to when they are delivered to the third location. Alternatively the nacelle 35 can be mounted to the column members 33 and 34 at the third location using floatation methods within the deep water available or any other suitable method.

Column members 33 and 34 are shown in fig. 10 in sectional elevation and nacelle 35 is shown mounted to the top of column member 34, all floating in an elongate vertical position near to the base 11. To achieve stability and the required depth of floatation the ballast reference 36, which may be water ballast, with surface level 37 is added to the interior of column member 34.

There is also provision if required for adding ballast 36, which may be water ballast, within the internal space between column members 33 and 34. The level of ballast 37 is adjusted to suit the floatation depth required for the column members and for the column members to be stable in the elongate vertical position and the level 37 shown on fig 10 is by way of example only. The level 37 is not necessarily the same within both column member 33 and the internal space between column members 33 and 34.

The provision of water ballast provides internal hydrostatic pressure within column members 33 and 34, this pressure is beneficial in that it will balance or partially balance the external hydrostatic water pressures applied to column members 33 and 34.

At the time of manufacture the walls of the column members 33 and 34 are of hollow construction each wall consisting of two separate faces 40 and 41, and 45 and 46, with an internal space 42 and 47 between.

It can be seen in fig.10 that after manufacture the internal spaces 42 and 47 of the walls of the column members 33 and 34 are partly filled with solid material 43 and 48, for example concrete, at the lower end of the column members. The level of filling of solid material 44 and 47 is adjusted to suit the floatation depth required for the column members to be mounted to the base and for the column members to be stable in the elongate vertical position and the level shown on fig 10 is by way of example only, the levels 44 and 47 are not necessarily the same.

Figure 11 shows a rectangular submersible dynamic floatation tank 21 in 4 parts assembled around and mounted to a rectangular base 11. The location of this plan view in fig.11 is indicated by the arrows F - F on fig.12.

A rectangular base 11, in the example shown the base is square, is shown in fig.11, however the submersible dynamic floatation tank could be not square or rectangular and could be circular or any other practical shape in plan.

The submersible dynamic floatation tank 21 is shown in figs. 10, 11, 12 and 13 with constant depth over the whole plan area but this is not essential, the submersible dynamic floatation tank 21 can be of variable depth if required.

Figure 11 shows a plan of one option for the arrangement of the component parts forming the submersible dynamic floatation tank 21, by way of example only the arrangement shown in fig. 6A has been shown. Also shown in plan section are column members 33 and 34. The horizontal plan perimeter of the walls of column members 33 and 34 is shown to be circular, but the horizontal plan perimeter can also be faceted.

The perimeter of the lower part of the base 11 is shown below the submersible dynamic floatation tank 21 by means of a dotted line 11. The upper part of the base may be the same size and shape in plan as the lower part of the base.

Figure 12 includes an elevational section view of the column 30 comprising column members 33 and 34 mounted to the base 11 floating in water that may be seawater in transit at an intermediate location between the third location of fig10 and another fourth location shown in the next fig 13.

In fig.12 the level of water ballast 37 inside column members 33 and 34 has been reduced from the level indicated in fig 10 to suit the stability requirements of the whole assembly of column members, base and floatation tank in transit. The transit of the whole assembly is mobilised by the use of one or more tugboats or other suitable means operated to tow or push the whole assembly between the third and fourth locations. Alternatively the submersible dynamic floatation tank 21 may be operated to move to a new fourth location independently in a self-propelled mode if a propulsion system is incorporated within the construction of the submersible dynamic floatation tank 21.

The depth of water reduces between the third and fourth locations and fig.12 indicates water of an intermediate depth. The fourth location would normally be the final location of the wind turbine assembly at an offshore wind farm in which case the water 2 in which the submersible dynamic floatation tank 21 and base 11 is floating will be sea water. If the wind turbine assembly is installed at a non-marine location then the water will not be seawater.

Figure 13 shows a base 11 of a wind turbine assembly and a submersible dynamic floatation tank 21 and column 30 comprising column members 33 and 34 moved to a fourth location and resting on a prepared bed 51 that rests on a bed 52 which may be a seabed. Piling may be provided to increase the load carrying capacity of the bed 52 if required or the base and the wind turbine assembly may be fully supported on piling.

The submersible dynamic floatation tank 21 is shown submerged to move the base 11 down to the required level resting on the prepared bed 51. To achieve the required submerged depth may require adjusting the level of the ballast 37 within column members 33 and 34. To achieve the required submerged depth will also require the adjustment of the adjustable buoyancy tanks incorporated within or mounted to the submersible dynamic floatation tank 21 as described for fig. 10. To maintain control of descent and stability during the submergence of the base will require the operation of the thrusters incorporated within the submersible dynamic floatation tank 21 or mounted to the submersible dynamic floatation tank 21 as described for fig. 10.

Figures 13, 14, 15 and 16 are all at the same fourth location.

The depth of water 2 shown in figs. 13, 14, 15 and 16 is by way of example only and could be within a range of up to 60m or more for example. The water level 61 shown on fig. 13 could be lower, for example the water level could be at a level indicated by arrow 62. The level of the points of attachment of the submersible dynamic floatation tank 21 relative to the base 11 and the amount of ballast level 37 within the column 30 and the amount of ballast added to the submersible dynamic floatation tank 21 are adjusted to suit the depth of water at the fourth location to enable the delivery and installation of the base using a submersible dynamic floatation tank 21.

Manoeuvring of the whole assembly comprising the submersible dynamic floatation tank, the base and the column mounted to the base is facilitated by the adjustment of the adjustable buoyancy tanks provided and by the operation of the thrusters provided.

In Figure 14 the submersible dynamic floatation tank 21 has been demounted from the base 11 and floated away, possibly for reuse launching a further wind turbine assembly.

The partially hollow walls of column member 34 have been filled with solid material, for example using concrete, to form solid walls. Also the ballast within the interior of column member 34 and within the internal space between column members 33 and 34 has been removed. The column member 34 is now ready to be telescopically erected inside column member 33 in accordance with prior art.

The material used for the filling of the hollow walls, by way of example only, could be concrete. This concrete could be delivered by a pumped concrete pipeline 40 and delivery manifold 43 from a concrete production plant 41 installed on an attendance ship or barge 42 positioned alongside the column members at the final location of the wind turbine assembly where the column members are telescopically erected as shown in figs. 14,15 and 16.

In Figure 15 the inner column member 34 has been fully erected and permanently jointed to the top of column member 33 supporting the nacelle 35 at operational height awaiting the mounting of wind turbine blades all in accordance with prior art. The outer column member 33 walls are still partially hollow.

In figure 16 the hollow walls of the outer column member 33 have been filled solid. By way of example only, the same methods of filling the hollow walls of column member 33 can be used for filling the hollow walls of column member 34 as described in fig. 14.

Figs. 17 and 18 are horizontal plan sections through column members 33 or 34 showing the hollow construction of the walls of the column members. The horizontal plan perimeter of the column member is shown as circular in fig. 17 and as faceted in fig 18. The same plan sections would apply to other column members where there are more than two column members comprising a column.

With reference to Figure 10: at the time of manufacture the walls of the column members 33 and 34 are of hollow construction each wall consisting of two separate faces 40 and 41, and 45 and 46, with an internal space 42 and 47 between. These same reference numbers have been applied to figs. 17 and apply also to fig.18 for a faceted column horizontal perimeter.

Fig. 19 shows in horizontal plan in enlarged detail the construction of a panel 50 forming the faceted column member wall shown in fig. 18 as indicated by arrow G.

Fig. 20 shows in horizontal plan in further enlarged detail the construction of the vertical joints between the panels forming the faceted column member wall shown in fig.19 as indicated by arrow H.

The details shown in figs. 19 and 20 are drawn for a faceted column member perimeter. The same details would apply for a circular column member perimeter but with curved plates and curved overlapping plates rather than the straight and cranked plates shown in figs. 18, 19 and 20.

By way of example only, the hollow walls of the column members 33 and 34 can be made of steel plates. Each of the column member walls is constructed using panels 50 that may consist of two steel plates 51 held rigidly apart by steel spacer rods 52 permanently fixed between the plates. The design of the twin steel plate material used for the construction of the column member walls is prior art which is not included in the claims of the present invention but the application of the twin plate material to form the column members is claimed as novel.

In fig. 17 the horizontal perimeter of the column member wall is shown circular and the twin steel plates forming the panels of the hollow walls of the column member would be curved to suit the required curvature of the walls of the column members.

In fig. 18 the horizontal perimeter of the column member wall is shown to be faceted. This is to enable the use of flat steel plate for forming the panels 50 of the hollow walls of the column members.

For both the circular and faceted designs of the column members the horizontal cross section perimeter of the wall of the column member consists of panels joined together with vertical joints to form horizontal rings with the required diameter and perimeter.

The required height (i.e. length) of the column member is provided by combining one or more horizontal rings of panels, one ring on top of another. The horizontal rings are joined together by horizontal joints with similar details to the vertical joints shown in figs 19 and 20.

By way of example only, a column member with an overall diameter of 10m could have a perimeter formed with 16 flat facets using 16 panels. In this case each facet would be approximately 2m wide and the angle between the faces of adjacent facets would be 22.5 degrees and therefore the 16 facets would form the required approximately circular perimeter. The number of facets provided to form the perimeter of a column member could vary according to the diameter of the column member and the practical design requirements of forming the column member. Column members 33 and 34 would not necessarily have the same number of facets. Column members with circular perimeters would be constructed using panels of a similar size to the panels for constructing column members with faceted perimeters.

The steel panels forming the column members are joined together on their vertical edges using proprietary methods such as welding or bolting. For bolted connections the adjacent steel plates forming the perimeter panels of the column member may overlap as shown and/or there may be additional overlapping flange plates 53 provided. If additional overlapping flange plates 53 of sufficient strength are provided then it would not be necessary for the edges of the plates forming the panel to overlap. Additional overlapping flange plates may be provided on both the inside face and the outside face of both of the plates forming each panel

Where the initially hollow walls of the column members are later filled solid with concrete, which will generally be the case, the vertical joint between wall panels may be reinforced using horizontal steel reinforcing bars passing across the joint with vertical binding lacers passing across and around the horizontal reinforcement bars parallel to the joint, within the concrete filling.

By way of example only, the twin steel plate panels forming the column member walls will be between 15m and 18m long to suit the required height (i.e. length) of the column member, for example a column member 70m long could be constructed using 4 rings of panels each 17.5m long. The horizontal joints between rings of panels are formed using proprietary methods which will be the same as the methods used for the vertical joints between individual panels as described above and there may be overlapping steel flange plates provided as for the vertical joints already described.

Where the walls of the column members are filled solid with concrete, which will generally be the case, the horizontal joint between rings of wall panels may be reinforced using vertical steel reinforcing bars passing across the joint with horizontal binding lacers passing across and around the vertical reinforcement bars parallel to the joint within the concrete filling.

The telescopic design and erection of the column members to form the mounting for the nacelle of the wind turbine assembly is all prior art and is not included in the claims of the present invention.

The methods described here for the present invention can also be used to enable the delivery of wind turbine assemblies and erecting columns comprising wind turbine assemblies in which the columns are not telescopic and are erected using different methods.

The invention provides any suitable combination of features of the apparatus, method steps and operation of any of the embodiments described.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features herein before referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

.1 A submersible dynamic floatation tank mountable to a base of an offshore wind turbine assembly comprising a column including one or more column members that is mountable to the base, used for the delivery and assembly and installation of offshore wind turbine assemblies.

.2 A submersible dynamic floatation tank in accordance with claim 1 that is formed in one or more parts that enables the submersible dynamic floatation tank to be mounted to the base of an offshore wind turbine assembly.

.3 A submersible dynamic floatation tank in accordance with claim 1 and 2 that can be demounted from a base of an offshore wind turbine assembly.

.4 A submersible dynamic floatation tank in accordance with all the previous claims including one or more adjustable buoyancy tanks incorporated in the construction of the submersible dynamic floatation tank or mounted to the submersible dynamic floatation tank that can be operated to adjust the buoyancy of the submersible dynamic floatation tank.

.5 A submersible dynamic floatation tank including adjustable buoyancy tanks all in accordance with all the previous claims including one or more thrusters incorporated in the construction of the submersible dynamic floatation tank or mounted to the submersible dynamic floatation tank each of which adjustable buoyancy tanks and thrusters can be operated to adjust the buoyancy and position and orientation, floating on the surface of water or submerged within water or resting on a bed below water, both vertically and horizontally of the submersible dynamic floatation tank and of the base to which the submersible dynamic floatation tank is mounted.

.6 A submersible dynamic floatation tank in accordance with all the previous claims including a floatation tank of any size and of any practical plan shape and of constant or variable construction depth.

.7 A submersible dynamic floatation tank in accordance with all the previous claims constructed using steel or concrete or hybrid steel and concrete or any other suitable materials.

.8 A submersible dynamic floatation tank in accordance with all the previous claims that is manoeuvred by external means such as tug boats or is self-propelled.

.9 A submersible dynamic floatation tank in accordance with all the previous claims which is operated and moved from one location to another location or at the same location floating on the surface of water or submerged within water or resting on a bed below water including any combination or sequence of these situations at any number and sequence of locations to enable the delivery and assembly of offshore wind turbine assemblies including a base and the installation of offshore wind turbine assemblies including a base at a location where the base sits on a seabed or floats submerged and anchored with or without piling,.

.10 A method of modifying a column member, the column member comprising an offshore wind turbine assembly including a column mounted to a base, whereby the initial position of the centre of gravity of a column member or members can be at a level to enable the steps of mounting the column to the base at a suitable location or locations and transporting the base including the column mounted to the base to another location and installing the base including the column mounted to the base at a location where the base sits on a seabed with or without piling, or floats submerged and anchored to be achieved using a submersible dynamic floatation tank mounted to the base.

.11 A step in accordance with claim 10 in which one or more column members comprising a column comprising a wind turbine assembly are mounted to a base.

.12 A step in accordance with claim 11 in which the wall of a column member comprising a column mounted to a base comprising a wind turbine assembly is in the form of hollow construction with inner and outer surface plates forming curved or faceted inner and outer perimeter surfaces with a space between a first part of which is filled solid with material at or close to the time of manufacture of the column member and a second part of which is later filled solid with material at some time after the column member has been mounted to the base to form column member walls made of solid construction throughout the column member.

.13 A step in accordance with claims 10, 11 and 12 including the step whereby the hollow wall parts of the column members are filled with material to become solid walls at a time to enable the delivery of the base and the assembly of the column and the mounting of the column to the base and the transport of the wind turbine assembly to another location and the installation of the wind turbine assembly at a location where the base sits on a seabed with or without piling, or floats submerged and anchored using a submersible dynamic floatation tank mounted to the base in accordance with claims 1 to 9 inclusive.

.14 A step in accordance with claims 10 to 13 inclusive to complete the construction of a wind turbine assembly at the final location of the wind turbine assembly.

.15 A step in accordance with claim 14 to generate electricity using a wind turbine assembly and a submersible dynamic floatation tank in accordance with claims 1 to 9 inclusive.

.16 A step in accordance with claim 15 to supply electricity to parties acquiring electricity.

Application No:	GB1110200.1	**Examiner:**	Richard Collins
Claims searched:	1 to 16	**Date of search:**	28 September 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4,6-11,14-16	FR2887900 A1 (FOGLIA) see the submersible floatation tanks 13 in figures 2E, 2F and 2G especially.
X,E	1,4,6-11,14-16	WO2011/083021 A1 (KRISTENSEN) see the submersible floatation tank 20 in the figures.
A	-	GB2454585 A (STUBLER) see the floatation tank 2 in the figures.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

B63B; E02B; F03D

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B63B	0035/00	01/01/2006
E02B	0017/00	01/01/2006
F03D	0001/00	01/01/2006
F03D	0011/04	01/01/2006