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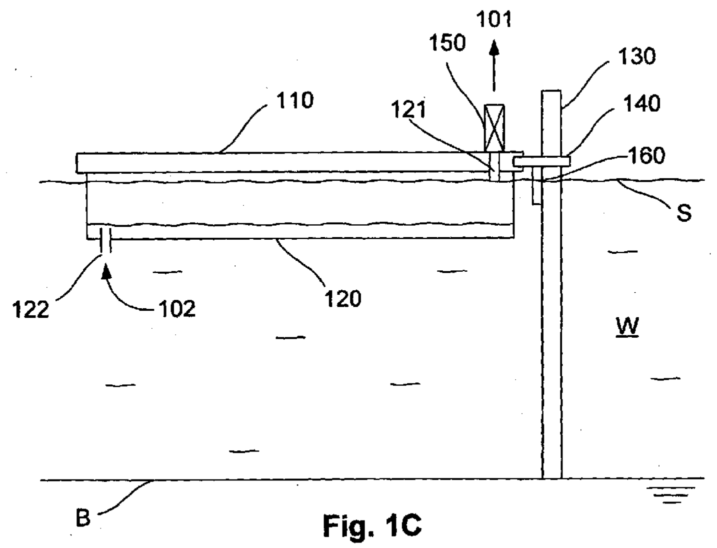

Fig. 1C

(57) **Abstract**: A docking apparatus for positioning in a water body having a water level. In one aspect, the docking apparatus includes: a platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts; and at least one flotation chamber for buoyantly supporting the platform when the at least one flotation chamber contains gas, wherein when the water level rises above a predetermined level relative to the posts, the gas is discharged from the at least one flotation chamber via a first opening and water enters the at least one flotation chamber via a second opening to thereby cause the platform to be submerged in the water body.

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SUBMERSIBLE DOCKING APPARATUS

Background of the Invention

[001] The present invention relates to docking apparatus which can be submerged for protection against damage or loss due to high water levels caused by floods, tsunamis, or the like.

Description of the Prior Art

[002] The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that the prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

[003] Marine docking apparatus are commonly provided in the form of floating docks, also known as pontoons, in which buoyant floats are used to support a platform above the surface of a body of water. The use of buoyant floats allows the docking apparatus to accommodate large variations in water levels whilst maintaining a fixed relationship between the platform and docked marine craft.

[004] The platform is usually connected to upright posts in such a way that the platform is restrained horizontally by the posts but is free to rise and fall with the tide as required. One problem with this arrangement, however, is that when the water level rises above the height of the posts, usually set based on the spring high tide mark or similar predicted maximum water level, the platform will become disengaged from the posts and thus no longer held in position relative to the main land. Although the platform is often also 'secured' to the main land by means of a steel cable, this cable may ultimately fail due to loading applied to the platform. This may allow the floating platform to drift with the prevalent current at that time.

[005] Extreme rises in water level, beyond those commonly accounted for in the selection of post level, may occur during floods or tsunamis, for example. Typically these events will be

accompanied by increased water currents which can cause an unrestrained docking platform to be washed away, after which the platform may be lost, damaged, or otherwise rendered unrecoverable. Additionally, the unrestrained docking platform may become a safety liability further downstream, for example it may cause impact damage to bridges and the like.

[006] Of course, docking apparatus posts can be provided with increased heights selected to accommodate such extreme events, and means can additionally or alternatively be provided atop the posts to stop the docking platform from rising above a predetermined level. However, such measures result in further problems. Not only will the use of higher posts be more costly, but as the level of the posts increases the position of the docking platform relative to the base of the post (i.e. the bottom of the body of water) during extreme events will be greater. As a result, the bending moment generated at the base of the post due to drag on the docking platform increases accordingly. It is also noted that higher posts may have an undesirable aesthetic result.

[007] In extreme events as discussed above, drag loading on the docking platform due to increased water flows can be of a considerable magnitude, and these maximum loads will need to be accounted for in the design of the docking apparatus. If stops are provided atop the posts, the docking platform may become submerged and drag loading will be increased even further as a result of water also flowing across the upper surface of the platform. These design considerations will generally lead to the use of larger posts or stronger construction methods, further adding to the cost of installing the docking apparatus.

[008] There have been proposals in the prior art to provide submersible docking apparatus, but these have their own shortcomings.

[009] For example, US 6,409,431 discloses a submersible floating dock which can be sunk beneath the water line in the event of the approach of a violent storm for protection of the dock against wave action, storm surge, and high winds. A dock with a deck supported on hollow flotation chambers is attached to pilings by rings. The rings allow the dock to move up and down in response to changes in the water level. As a storm approaches water is allowed to enter the hollow flotation chambers which are ordinarily filled with air. This

causes the dock and deck to sink beneath the water line making it resistant to damage from storm surge, wave action, and high winds. After the storm has passed, pressurized air is introduced into the flotation chambers forcing the water in the flotation chambers out of the chamber. The air increases the buoyancy of the flotation chambers, hence, of the dock so that it rises above the water line for use by an owner after the danger of storm surge, high winds, and waves has passed.

[010] However, this arrangement requires a user to manually perform the sinking operation, and so can only be effective if the user is nearby whilst the water level is rising or has the foresight to sink the floating dock in advance of a storm. Furthermore, this system does not account for the substantially increased loading of the posts that will result from submerging the docking platform, particularly in events where increased water flow accompanies the increased water level. Accordingly, the docking platform may still be lost if the posts fail due to their design being inadequate to withstand the drag increased loading.

[011] US 4,938,629 discloses a floatable and sinkable concrete modular structure for making a wharf. The wharf is made of adjacent hollow shells in which water can be introduced or withdrawn by a low air pressure blower. The shells are fluidly interconnected by a piping system between the bottom of one shell with the upper part of the adjacent shell for progressingly tilting the wharf.

[012] However, in this system, the structure is disconnected from its supporting posts before being sunk and its only connection to the mainland is via a connecting line to a separate sinkable anchor. Accordingly, the structure will be prone to being swept away by severe currents in the even the sinkable anchor does not hold. The above system also requires manual intervention to initiate the sinking operation, in this case through the disconnection from the supporting posts, removal of a plug, and connection of a pump for forcefully removing air from the hollow shells.

[013] Submersible pontoons are also known for use in ship building and related large scale applications. In these applications, the pontoons are submerged, positioned under an object needing raising, and then pumped full of air to buoyantly raise the object. However, such

systems are specialised and expensive and would not generally be suitable for use in common docking apparatus.

Summary of the Present Invention

[014] In a first broad form the present invention seeks to provide a docking apparatus for positioning in a water body having a water level, the docking apparatus including:

a) a platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts; and,
b) at least one flotation chamber for buoyantly supporting the platform when the at least one flotation chamber contains gas, wherein when the water level rises above a predetermined level relative to the posts, the gas is discharged from the at least one flotation chamber via a first opening and water enters the at least one flotation chamber via a second opening to thereby cause the platform to be submerged in the water body.

[015] Typically the docking apparatus includes an activation mechanism for causing the gas to be discharged from the at least one flotation chamber and causing the water to enter the at least one flotation chamber when the water level rises above the predetermined level.

[016] Typically the activation mechanism includes a normally closed valve on one of the openings, the activation mechanism causing the valve to open when the water level rises above the predetermined level.

[017] Typically the valve is provided on the first opening such that the valve is used to control the discharge of gas from the at least one flotation chamber and the discharge of gas causes the water to enter the at least one flotation chamber.

[018] Typically the valve is provided on the second opening such that the valve is used to control the entry of water into the at least one flotation chamber and the entry of water causes the gas to be discharged from the at least one flotation chamber.

[019] Typically the activation mechanism includes a sensor for sensing when the water level rises above the predetermined level.

[020] Typically the sensor is one of:

a) a water pressure switch;
b) a float switch;
c) a switch actuated by axial movement of the platform.

[021] Typically the sensor is provided on one of the posts.

[022] Typically the first opening is connected to a tube for discharging the gas from the at least one flotation chamber, the tube having a terminal end positioned on one of the posts to allow access to the terminal end of the tube when the platform is submerged.

[023] Typically the terminal end of the tube is configured to allow the connection of a pump for pumping air into the at least one flotation chamber when the platform is submerged, such that air pumped into the at least one flotation chamber causes water to be expelled from the flotation chamber and causes the platform to float once a sufficient amount of air is pumped.

[024] Typically the activation mechanism causes the platform to tilt when the water level rises above the predetermined level, the tilting of the platform allowing the gas to be discharged from the at least one flotation chamber via the first opening and water to enter the at least one flotation chamber via the second opening.

[025] Typically each of the posts includes a stop for preventing the connections between the platform and the posts from moving upwardly after the water level rises above the predetermined level.

[026] Typically only one side of the platform is connected to the posts and the connections between the platform and the posts include hinges to allow the platform to tilt at an angle from the hinges when the water level rises above the predetermined level.

[027] Typically the first and second openings are provided on an underside of the at least one flotation chamber such that the openings are normally positioned in the water body when the water level is below the predetermined level.

[028] Typically the second opening is positioned near the side of the platform that is connected to the posts and the first opening is positioned near the opposite side of the platform, such that when the platform tilts at a predetermined angle the first opening becomes positioned above the water body, to thereby allow the gas to be discharged from the at least one flotation chamber via the first opening and the water to enter the at least one flotation chamber via the second opening.

[029] Typically the platform is configured to tilt to an orientation parallel with the posts when the platform is submerged.

[030] Typically the platform includes a locking mechanism for engaging with at least one of the posts and retaining the platform in the orientation parallel with the posts when the platform is submerged.

[031] Typically the docking apparatus further includes a gas supply for supplying gas into the flotation chambers when the platform is submerged to thereby displace water filling the flotation chambers and cause the platform to float.

[032] Typically the gas supply includes at least one of:

a) a container of compressed gas;
b) a gas generator; and,
c) a pump for pumping air.

[033] Typically the gas supply is adapted to supply the gas into the at least one flotation chamber when the water level subsides below a second predetermined level.

[034] Typically the gas supply is provided inside the at least one flotation chamber.

[035] Typically the flotation chamber includes a normally closed maintenance opening for allowing access to the gas supply.

[036] Typically the docking apparatus includes a plurality of gas supplies which can be activated in a sequence for controlling the supply of gas into the at least one flotation chamber.

[037] Typically the docking apparatus is adapted to sink to the bottom of the water body when the platform is submerged.

[038] Typically the docking apparatus includes spikes for engaging with the bottom of the body of water when the platform is submerged.

[039] Typically the docking apparatus includes a plurality of flotation chambers.

[040] Typically each flotation chamber is connected to at least one other flotation chamber by a fluid communication passageway.

[041] In a second broad form the present invention seeks to provide a docking apparatus for positioning in a water body having a water level, the docking apparatus including:

a) a platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts, only one side of the platform being connected to the posts and the connections between the platform and the posts including hinges to allow the platform to tilt at an angle from the hinges;
b) at least one flotation chamber for buoyantly supporting the platform;
c) at least one restraint for restraining the platform from moving axially relative to the posts when the water level rises above a predetermined level relative to the posts, wherein the at least one restraint causes the platform to tilt when the water level rises above the predetermined level, the tilting allowing the platform to become at least partially submerged in the water body.

[042] Typically the apparatus includes a stop on a respective post for providing one of the at least one restraint, the stop being for preventing the connections between the platform and the posts from moving upwardly after the water level rises above the predetermined level.

[043] Typically the apparatus includes a line anchored to the water body bed at a first end and attached to one of the connections between the platform and the posts at an opposing second end, a position of the line anchor and a length of the line being selected to provide one of the at least one restraint.

[044] Typically the line is a chain.

[045] Typically the line anchor is positioned upstream of the connection so as to provide additional restraint against the platform moving laterally in a downstream direction after the water level rises above the predetermined level.

[046] Typically the platform is configured to tilt to an orientation parallel with the posts when the water level rises above the predetermined level by a sufficient amount.

[047] Typically the platform includes a locking mechanism for engaging with at least one of the posts and retaining the platform in the orientation parallel with the posts when the platform is at least partially submerged.

Brief Description of the Drawings

[048] An example of the present invention will now be described with reference to the accompanying drawings, in which: -

[049] Figure 1A shows a schematic plan view of a first example of a submersible docking apparatus and its positioning in a water body relative to land;

[050] Figure 1B shows a schematic side view of the first example of a submersible docking apparatus of Figure 1A, where the water level is within normal predicted limits;

[051] Figure 1C shows a schematic side view of the apparatus of Figure 1B where the water level has risen above a predetermined level;

[052] Figure 1D shows a schematic side view of the apparatus of Figure 1B where the apparatus is submerged below the water surface;

[053] Figure 1E shows a schematic side view of the apparatus of Figure 1B where the apparatus is fully submerged and has come to rest at the bottom of the water body;

[054] Figure 2A shows a schematic plan view of a second example of a submersible docking apparatus;

[055] Figure 2B shows a schematic side view of the apparatus of Figure 2A, where the water level is within normal predicted limits;

[056] Figures 2C shows a schematic side view of the apparatus of Figure 2A indicating gas and water flows as the apparatus is submerged below the water surface;

[057] Figure 3A shows a schematic side view of a third example of a submersible docking apparatus during normal use, where the water level is within normal predicted limits;

[058] Figure 3B shows a schematic side view of the apparatus of Figure 3A where the water level has risen above a predetermined level;

[059] Figure 3C shows a schematic side view of the apparatus of Figure 3A where the apparatus is being submerged below the water surface;

[060] Figure 3D shows a schematic side view of the apparatus of Figure 3A where the apparatus is fully submerged and has become engaged with the posts in a vertical orientation;

[061] Figure 4A shows a schematic side view of a fourth example of a submersible docking apparatus during normal use, where the water level is within normal predicted limits;

[062] Figure 4B shows a schematic side view of the apparatus of Figure 4A where the water level has risen above the predetermined level;

[063] Figure 4C shows a schematic side view of the apparatus of Figure 4A where the apparatus is being submerged below the water surface;

[064] Figure 4D shows a schematic side view of the apparatus of Figure 4A where the apparatus has become engaged with the posts in a vertical orientation;

[065] Figure 5A shows a schematic plan view of a fifth example of a submersible docking apparatus and its positioning in a water body relative to land;

[066] Figure 5B shows a schematic side view of the apparatus of Figure 4A where the water level is below a predetermined level;

[067] Figure 5C shows a schematic side view of the apparatus of Figure 4A where the water level has risen to the predetermined level;

[068] Figure 5D shows a schematic side view of the apparatus of Figure 4A where the water level has risen above the predetermined level; and,

[069] Figure 5E shows a schematic side view of the apparatus of Figure 4A where the water level has risen above the predetermined level and the apparatus has become engaged with the posts in a vertical orientation.

Detailed Description of the Preferred Embodiments

[070] An example of a submersible docking apparatus, generally designated with reference numeral 100, will now be described with reference to Figures 1A to 1E.

[071] As can be seen in Figure 1A, the docking apparatus 100 is positioned in a water body W and provides a platform 110 on the water body W for access to deeper water beyond the

water line on land L. The platform 110 can be used to support persons and equipment and can further be used to allow marine craft such as boats to be docked.

[072] In broad terms, the docking apparatus 100 includes a platform 110 and at least one flotation chamber 120 (shown in Figure 1B) for buoyantly supporting the platform 110 when the flotation chamber 120 contains a gas.

[073] The docking apparatus 100 is usually positioned with an offset from the land L, such that a walkway ramp R or similar means are provided to allow access to the platform 110 from the land L. The ramp R is typically provided with a pivoted connection to the land and is supported on the platform 110 by rollers to accommodate relative movement between the land and the platform 110 under the influence of tides and when the platform 110 is submerged as will be discussed further below. It will be appreciated that any means of providing access to the platform 110 may be used. In any event, the configuration of the ramp R is outside of the scope of the present invention and will not be discussed further herein.

[074] As can be seen in Figure 1B, the water body W has a water surface S and a water body bed B which may be a river bed, lake bed or ocean floor, for example. The platform 110 is connected to posts 130 anchored to the water body bed B. Connections 140 between the platform 110 and the posts 130 cause the platform 110 to be substantially restrained from moving laterally relative to the posts 130, but allow the platform 110 to move axially relative to the posts 130. The skilled person will appreciate that numerous suitable connections 140 of this type are already known in the art for use in floating docks.

[075] Figure 1A shows the use of a single platform 110 connected to two posts 130 on the landward side of the platform 110, which is a common simple configuration for a floating dock. It will be appreciated, however, that the present invention may be applicable to other more complex configurations of one or more platforms 110 and posts 130, by applying the following techniques.

[076] It is also noted that the floating docking apparatus 100 can be easily transported from place to place in the water body W as required, prior to connection to the posts 130, to allow simple deployment to a desired position on the water body W.

[077] The water level is defined as the height of the water surface S above the water bed B, and can be conveniently gauged by the axial position of the water surface S relative to the posts 130. It will be understood that the above discussed arrangement allows the platform 110 to accommodate variations in the water level, due to tidal actions or the like, such that the platform 110 will generally have a constant position relative to the water level, under normal water level conditions. In other words, under normal use the platform 110 will float on the water surface S and will be able to rise and fall relative to the posts 130 during tidal variations.

[078] Normal water level conditions are assumed to cover ranges of water level which can be expected to occur in the water body W throughout typical fluctuations of the water level in the water body W, and will at least extend to the spring high tide mark representing a predicted maximum water level for the water body W.

[079] In one embodiment, the platform 110 may be provided as a concrete slab mounted on a structural framework securing a plurality of flotation chambers 120 beneath the slab. The main structure of the docking apparatus 100 may be similar to existing floating dock or pontoon designs, and the skilled person will appreciate that numerous other structural configurations may otherwise provide the platform 110 and flotation chambers 120 of the docking apparatus 100. For example, the platform 110 and flotation chambers 120 may be of integral construction such that the flotation chambers 120 are formed inside the structure of the platform 110.

[080] In any event, the flotation chambers 120 are suitably lined with a gas impermeable material to allow air or any other suitable gas to be contained therewithin. The flotation chambers 120 should be sized such that sufficient buoyancy is provided to cause the docking apparatus 100 to float in the water body W when the flotation chambers 120 are filled with the gas.

[081] The flotation chamber 120 includes openings 121, 122 for allowing fluid communication into and out of the flotation chamber 120. Under normal conditions, the docking apparatus 100 floats on the surface S of the water body and the openings 121, 122 are configured in such a way that the gas is not allowed to escape the openings 121, 122.

[082] The particular positioning and configuration of openings 121, 122 may vary depending on the particular embodiment of the invention, but in general terms, the openings 121, 122 include a first opening 121 for allowing gas to be discharged from the flotation chamber 120 and a second opening 122 for allowing water to enter the flotation chamber 120.

[083] In particular, the docking apparatus 100 is configured so that when the water level rises above a predetermined level relative to the posts 130, the gas is discharged from the flotation chamber 120 via the first opening 121 and water enters the flotation chamber 120 via the second opening 122 to thereby cause the docking apparatus 100, and particularly the platform 110, to be submerged in the water body W. Such a configuration allows the platform 110 to automatically sink when the water level exceeds a particular level.

[084] The predetermined level is suitably set at a water level substantially above the maximum water level expected to be encountered under normal conditions, so that the platform 110 will not be submerged under normal conditions. Typically, the predetermined level will be set at levels which will only be encountered during extreme conditions, such as during floods, tsunamis, or other events which may result in unusually high water levels posing a risk of damage to or loss of floating docks.

[085] In order to control the flow of gas or water into or out of the flotation chamber 120 and thus ensure the platform 110 only submerges when the water level rises above the predetermined level, one or more of the openings 121, 122 may be fitted with a valve 150 or any other suitable mechanism for controlling gas/water flow. Alternatively, one or more of the openings 121, 122 may be always open but positioned on the flotation chamber 120 in such a way as to prevent gas or water flow.

[086] Embodiments of the docking apparatus 100 may include an activation mechanism for causing the gas to be discharged from the flotation chamber 120 and causing the water to enter the flotation chamber 120 when the water level rises above the predetermined level. Different forms of the activation mechanism can be used depending on the particular embodiment. Different embodiments of the docking apparatus 100 will have different particular configurations of the openings 121, 122 and different methods of operation, as will be exemplified in the following examples.

[087] Figures 1B to 1E illustrate a first example configuration and corresponding mode of operation, which will now be described in detail.

[088] In this example, the first opening 121 is fitted with a normally closed valve 150 for controlling gas discharge through the first opening 121, and the first opening 121 is provided in an upper portion of the flotation chamber 120 to allow substantially all of the gas contained in the flotation chamber 120 to be discharged when the valve 150 is opened. The second opening 122 is provided in an always open configuration and is positioned in a lower portion of the flotation chamber 120. When the first opening 121 is closed by the valve 150, water is generally unable to enter the flotation chamber 120 via the second opening 122 because there is no escape path for the gas and thus the gas cannot be displaced from the flotation chamber 120 by the water.

[089] It will be appreciated that in this example the valve 150 forms part of the activation mechanism. Accordingly, the activation mechanism operates by controllably opening the normally closed valve 150 when the water level rises above the predetermined level.

[090] The skilled person will understand that other configurations may be used whilst operating on a similar principle. For instance, a valve may instead be provided on the second opening 122 such that the valve is used to control the entry of water into the flotation chamber 120 and the entry of water causes the gas to be discharged from the flotation chamber through an always open first opening 121. Other variations may include providing normally closed valves on both openings 121, 122 and selectively opening both valves to submerge the platform 110.

[091] In any event, the valve 150 should only be opened when the water level rises above the predetermined level. In order to allow the valve 150 to be controlled based on the predetermined level, the activation mechanism may further include a sensor 160 for sensing when the water level rises above the predetermined level.

[092] In the example configuration depicted in Figures 1B to 1E, the sensor 160 is provided on one of the posts 130 and is positioned at a height on the post 130 corresponding to the predetermined level. The sensor 160 may operate using any suitable sensing principle which allows a control input to be provided to the valve 150 when the predetermined level has been reached.

[093] For example, the sensor 160 may be in the form of a water pressure switch, such that the valve 150 can be controllably opened when the sensor 160 is exposed to water pressure exceeding a threshold corresponding to the predetermined level. A water pressure switch can be suitably configured for placement at a height on the post 130 which is equal to the predetermined level, so that the switch is only triggered once the water level reaches the switch. Figure 1B shows such a configuration, where the sensor 160 is positioned above the water surface S under normal conditions. Alternatively, a water pressure switch can be positioned lower on the post 130 and may be configured to be triggered when the water pressure exceeds a pressure threshold determined by a height above the water pressure switch by which water is allowed to rise before the predetermined level is reached.

[094] Examples of other forms of the sensor 160 include a float switch which can be triggered when a float is caused to move upwardly by water rising above the predetermined level, or a mechanical contact switch actuated by axial movement of the platform 110 above a position on the posts 130 corresponding to the predetermined level. Other suitable forms of sensors 160 will be readily apparent to the skilled person.

[095] A control signal from the sensor 160 to the valve 150 can be provided in any suitable manner, including wireless signal transmission, electrical connection via a wire, and the like. In the event the sensor 160 is provided on one of the posts 130, the relative motion between the platform 110 and the posts 130 should be accommodated in the method of control signal

transmission. For instance, a wired connection between the sensor 160 on a post 130 and the valve 150 on the platform 110 will require sufficient slack length of wire to allow the platform 110 to be fully submerged without unduly straining the wire.

[096] In one particularly suitable embodiment, the sensor 160 and valve 150 can be collocated on a post 130 in an integrated activation mechanism which eliminates the need for transmitting the control signal between discrete components. Such an embodiment may instead include a tube connected to the first opening 121 and extending to the sensor 160 and valve 150 of the activation mechanism. Further details of an example of this embodiment will be described further below with reference to Figures 2A to 2C.

[097] To allow the operation of the docking apparatus 100 to be better understood, an illustrative method of operation will be described with reference to Figures 1B to 1E.

[098] As mentioned above, Figure 1B shows the docking apparatus 100 under normal conditions. In this example the sensor 160 is a water pressure switch which is triggered when it is submerged as the water level rises above the predetermined level. The water surface S can fluctuate under normal tidal variations without activating the sensor 160 and during such normal conditions the platform 110 floats on the water surface S and is free to rise and fall with the tides.

[099] The valve 150 is normally closed and thus prevents the discharge of gas from the flotation chamber 120 through the first opening 121, and water is not allowed to enter the second opening 122, despite it being always open, due to the closure of the first opening 121.

[100] Figure 1C illustrates a scenario in which the water level has risen to the predetermined level, as is evidenced in this example by the water surface S having reached the sensor 160.

[101] When the sensor 160 is triggered by the rise in water level, the sensor 160 provides a control signal (via signal transmission means not shown) to the normally closed valve 150. This causes the valve 150 to open and thus allows the discharge of gas from the flotation

chamber 120 via the first opening 121. Arrow 101 indicates the direction of flow of the discharged gas.

[102] As gas is discharged from the flotation chamber 120, water is now allowed to enter the flotation chamber 120 via the second opening 122. Arrow 102 indicates the direction of water flow. Thus the flotation chamber 120 starts to be filled with water and its buoyancy begins to reduce accordingly.

[103] The flotation chamber 120 continues to be filled with water as the gas is discharged, and as the flooding of the flotation chamber 120 progresses, the buoyancy of the docking apparatus 100 will eventually be insufficient to support the platform 110 and thus the platform 110 will become submerged in the water body W, as shown in Figure 1D. This may occur before all of the gas contained within the flotation chamber 120 is discharged, but the discharge of gas will nevertheless be allowed to continue even after the platform 110 becomes submerged.

[104] The platform 110 and flotation chamber 120 should be of a sufficient density such that the platform 110 and flotation chamber 120 can sink to the water body bed B when substantially all of the gas is discharged from the flotation chamber 120, as shown in Figure 1E. Ballast weight may also be provided on the platform 110 to ensure sinking is complete.

[105] Once the platform 110 and flotation chamber 120 have fully sunk, the docking apparatus 100 will come to rest on the water body bed B and engage with the materials of the water body bed B. This results in a highly stable position that is able to withstand severe water flow conditions as may be seen in river flooding, for example.

[106] When the platform 110 is sunk in this manner, the water body bed B helps to provide additionally lateral restraint to the assembly, such that the platform 110 can remain in place upon the water body bed B even under high water currents. Drag loads acting on the platform 110 are reduced compared to when the platform 110 is only submerged partway, as water is only allowed to flow over the top of the platform 110 and not underneath it. Furthermore, the water body bed B absorbs a portion of the drag loads acting on the platform 110, and

therefore the loading of the posts 130 will be lower than would be the case if the platform 110 had not been sunk. The applied moment on the base of the posts 130 is greatly reduced because the offset between the drag loading on the platform 110 and the base is minimised when the platform 110 rests on the water body bed.

[107] It will therefore be appreciated that sinking the platform 110 can allow more extreme conditions to be survived by the platform 110 and posts 130 than in conventional floating docks. Furthermore, by sinking the platform 110, the risk of the platform 110 floating higher than the top of the posts 130, and hence becoming unrestrained laterally, is eliminated. Accordingly, the above described arrangement helps to mitigate damage or loss of the platform 110 under extreme conditions such as floods.

[108] The submersible docking apparatus 100 also provides benefits over previously proposed submersible floating docks because the docking apparatus 100 can be sunk automatically in response to an unacceptable rise in the water level, for example, flash flooding.

[109] After the extreme conditions have passed, the platform 110 can be refloated by filling the flotation chamber 120 with gas and thus displacing the water flooding the flotation chamber, to restore the buoyancy of the flotation chamber 120. This may be performed in a manual procedure, or alternatively, the platform 110 can be automatically refloated when the water level subsides below the predetermined level (or a lower different predetermined level reflecting a return to normal conditions).

[110] In one example, air can be pumped into the flotation chamber 120 to refloat the platform 110. The air can be conveniently pumped into the same first opening 121 from which the gas was discharged, via a tube which extends above the water surface S. This arrangement is shown in the example embodiment of Figures 2A to 2C, and will be described in further detail in due course.

[111] In other example embodiments, the docking apparatus 100 may further include a gas supply (not shown) for supplying gas into the flotation chamber 120 whilst the platform 110

is submerged. The gas supplied into the flotation chamber 120 displaces the water filling the flotation chamber 120 and causes the platform 110 to float.

[112] Suitable forms of gas supply include a container of compressed gas such as nitrogen or air, a gas generator (i.e. similar to those used in automotive airbags), or an integral pump for pumping air sourced from above the water surface S.

[113] The gas supply can be configured to allow manual supply of the gas into the flotation chamber, which may be initiated using a signal provided remotely by an operator. For example, the gas supply initiation signal can be transmitted wirelessly to a receiver provided on the gas supply, or via a wire extending above the water surface S. In the event wiring is already provided between the valve 150 and the sensor 160, this wiring can also include a wire for providing a gas supply initiation signal. Depending on the form of the gas supply and the configuration of the openings 121, 122, it may be necessary to close the valve 150 before the platform 110 can be refloated, and in such cases collocation of the gas supply initiation signal and valve control signal wiring will be particularly convenient to allow the necessary coordination of signals.

[114] In some particular examples, the gas supply can be provided inside the flotation chamber 120. This provides for a highly compact and convenient arrangement. A suitably selected gas supply will allow for extended operation of the docking apparatus 100 under normal conditions, yet be available for refloating the platform 110 from within the flotation chamber 120 with minimal maintenance requirements. Nevertheless, the flotation chamber 120 can include a normally closed maintenance opening for allowing access to an internal gas supply. It will be appreciate that a corresponding maintenance opening may also need to be provided in the platform 110 to allow access to the maintenance opening in the flotation chamber 120.

[115] Irrespective of the manner used to refloat the platform 110, once the platform 110 is refloated the valve 150 should be reset as required to return the docking apparatus 100 to a state for retaining the gas within the flotation chamber 120, allowing the platform 110 to continue floating on the water surface S under normal conditions, as depicted in Figure 1B.

[116] A second detailed example of a submersible docking apparatus 100 will now be described with reference to Figures 2A to 2C.

[117] In this example, the docking apparatus 100 includes a plurality of flotation chambers 120, and in Figure 2A the platform 110 has been hidden (with dashed outline) to allow further details of the flotation chambers 120 to be observed.

[118] The posts 130 are generally of standard construction, and the connections 140 for connecting the platform 110 to the posts 130 are in the form of brackets which surround the posts 130 to thereby provide lateral restraint to the platform 110 whilst retaining the capability to slide axially along the posts 130. Such sliding may be promoted by providing rollers (not shown) in the connections 140.

[119] The flotation chambers 120 are provided in a rectangular array, and it will be appreciated that the particular arrangement of flotation chambers 120 will be selected depending on the size of the platform 110, and other design requirements.

[120] In this example, the platform 110 is a concrete slab mounted on top of the flotation chambers 120 via a structural framework 270. The framework 270 supports the flotation chambers 120 in a fixed relationship and provides mounting points 271, on lugs or the like, for allowing the platform 110 to be fastened to the framework 270.

[121] It is possible for each flotation chamber 120 to operate independently in the same manner as described above for the single flotation chamber 120 shown in Figures 1B to 1E, and in this case each flotation chamber 120 may have respective first and second openings 121, 122. However, it is generally more convenient to have the plurality of flotation chambers 120 cooperate as a single effective flotation chamber. This can be achieved by connecting each flotation chamber 120 to at least one other flotation chamber 120 by a fluid communication passageway.

[122] In the present example, a tube network 280 is used to interconnect the flotation chambers 120 and provide a fluid communication passageway. In use, gas is allowed to flow

to/from each flotation chamber 120 into or out of the tube network 280 via tube apertures 281, which in this case are positioned at upper corners of each flotation chamber 120. Intermediate transfer tubes 282 provide the connections between each flotation chamber 120. This arrangement of the tube network 280 means that a single first opening 121 can be used to allow gas to be discharged from all of the flotation chambers 120 when the platform 110 is to be submerged, and conversely to allow gas to be supplied into all of the flotation chambers 120 when the platform 110 is to be refloated.

[123] In this example, the first opening 121 is provided in one of the flotation chambers 120 (the top right flotation chamber 120 of Figure 2A) and an extension tube 283 extends from the first opening 121. The extension tube 283 has a terminal end 284 positioned on one of the posts 130, and this allows access to the terminal end 284 of the extension tube 283 when the platform 110 is submerged. The arrangement of the extension tube 283 can be better appreciated with reference to Figure 2B.

[124] As can be seen in Figure 2B, the tube network 280 is provided in upper portions of the flotation chambers 120, and this allows the maximum amount of air to be discharged from each of the flotation chambers 120 when the platform 110 is submerged.

[125] The first opening 121 extends upwardly through the platform 110 and is connected to the extension tube 283. The terminal end 284 of the extension tube 283 is provided near the top of one of the posts 130. This allows the terminal end 284 to be accessed even when the platform 110 is fully submerged and the water level has risen to submerge a substantial length of the post 130. The extension tube 283 is fixed on the post 130 near the terminal end 284, but at least a portion of the extension tube 283 is not fixed on the post 130 to thereby allow a length of slack 285 in the extension tube 283 for accommodating movement of the platform 110 under variations in the water level. The overall length of the extension tube 283 should be selected to allow the platform 110 to sink to the water bed B without unduly straining the extension tube 283.

[126] The terminal end 284 of the extension tube 283 is configured to allow the connection of a pump (not shown) for pumping air into flotation chambers 120 when the platform 110 is

submerged. As air is pumped into the flotation chambers 120, this causes water to be expelled from the flotation chamber 120 and causes the platform 110 to float once a sufficient amount of air is pumped. A pump may be permanently fixed to a post 130; however, it may be more cost effective to simply allow connection of a general purpose air pump to the extension tube 283 as required. This allows one pump to be used to refloat a number of docking apparatus 100 and thus eliminates the expense of providing a pump for each docking apparatus 100.

[127] Nevertheless, if a dedicated pump is provided for the docking apparatus 100, then the pump can also be used to assist in the discharge of air from the flotation chambers 120 when the platform 110 is being submerged. The pump can be controlled in the same manner as the opening of the valve 150 when the water level rises above the predetermined level.

[128] In this example, an activation mechanism 260 including an integral valve 150 (not shown in Figures 2A to 2C) and water pressure switch sensor 160 (also not shown in Figures 2A to 2C) is provided towards the terminal end 284 of the extension tube 283, for controlling the discharge of gas from the flotation chambers 120. As per the above discussed example, the valve 150 is normally closed and is controllably opened when the water level rises above a predetermined level, which is detected by the sensor 160. The collocation of the valve 150 and sensor 160 within the activation mechanism 260 removes the need to transmit a control signal between the sensor 160 and the valve 150, and thus eliminates the need for wiring, or wireless transmission devices.

[129] An optional solar panel 290 may be provided at an elevated position on one of the posts 130 to provide a power source for the docking apparatus 100. Power generated by the solar panel 290 can have several uses. The solar panel 290 can be used to maintain charge in a battery for powering the sensor 160 and for actuating the valve 150 as required, in the event these components are of a powered type. In Figure 2B, power from the solar panel 290 is transmitted through power wire 291. It should be noted however, that passive sensor 160 and valve 150 components can also be used in which case a power source will not be required.

[130] In any event, a solar panel 290 may still be of use to provide a power source for other equipment that may be used in conjunction with the docking apparatus 100. For example,

power generated by the solar panel can be stored and used to power a pump for pumping air into the flotation chambers 120 to thereby refloat a submerged platform 110 when the water level has subsided.

[131] The solar panel 290 can also provide a general purpose power supply which can be useful for supplying power to docked marine craft, such as to recharge batteries or to power other services whilst the craft is docked. This can remove the need to run a separate power supply to the docking apparatus 100 from the mainland.

[132] As seen in Figure 2B, the second openings 122 are positioned at the end of downward extensions 223 from lower portions of the flotation chambers 120 such that the second openings 122 are offset downwardly from the flotation chambers 120 by a significant distance. This arrangement helps to reduce unintended entrance of water into the flotation chambers 120 during normal floating operation of the docking apparatus 100.

[133] The downward extensions 223 also serve an additional purpose of providing means for improving engagement with the water body bed B when the platform 110 is sunk.

[134] Alternatively, dedicated downwardly extending engagement members (separate from the second openings 122), such as spikes 224 (shown in dashed lines) can be optionally provided on the docking apparatus 100 for helping to secure the docking apparatus 100 to the water body bed B when the platform 110 is sunk. In use, these spikes 224 would penetrate the water body bed B and increase the degree of lateral restraint provided by the water body bed B to secure the sunk platform 110.

[135] It will be appreciated that the example docking apparatus 100 as shown in Figures 2A to 2C operates in a similar fashion as described with reference to Figures 1B to 1E.

[136] However, since this example involves a plurality of chambers 120, the flows of gas and water as the platform 110 is submerged will be described with reference to Figure 2C, in order to aid understanding. It should be noted that Figure 2C has been presented to allow visualisation of the gas and water flows only, and is not intended to reflect the actual amount

of water required to sink the platform 110. This example assumes that the valve 150 is in an open state, caused by the water surface S rising above the sensor 160 of the activation mechanism 260.

[137] The flow of air is indicated in Figure 2C.When the valve 150 of the activation mechanism 260 is opened, air is allowed to flow from the flotation chambers 120 into the tube network 280 via the tube apertures 281. The tube network 280 allows air to flow between each of the flotation chambers 120 via the transfer tubes 282. The air is discharged from the flotation chambers 120 via a single first opening 121 extending from the tube network 280. Air then flows through the extension tube 283, past the open valve 150 in the activation mechanism 260, and is released into the environment via the terminal end 284 of the extension tube 283, as indicated by arrow 101.

[138] As air is allowed to discharge from the flotation chambers 120, water is allowed to enter the flotation chambers 120 via the second openings 122. Each flotation chamber 120 has a respective second opening 122 to allow water to enter into the flotation chambers 120, as indicated by arrows 102, in an even manner to ensure stable submergence of the platform 110. As the water floods the flotation chambers 120, water pressure at the second openings 122 helps to drive the air from the flotation chambers 120, until substantially all of the air is discharged and the platform 110 has sunk to the water body bed B.

[139] The aforementioned examples involve the use of a valve 150 as part of the activation mechanism for causing the platform 110 to be submerged when the water level rises above a predetermined level. However, alternative forms of the docking apparatus 100 can be provided which do not require a valve 150. An example of such an arrangement will now be described with reference to Figures 3A to 3D.

[140] It will be appreciated that the overall structure of the docking apparatus 100 in the example of Figures 3A to 3D shares a number of common features as those described above. The platform 110 is supported by flotation chambers 120 and is connected to the posts 130 by a connector 140.

[141] In this example, there are two flotation chambers 120 which are interconnected by a passageway 380 for allowing fluid to be transferred between the flotation chambers 120 in a similar manner as the tube network 280 described above, although in this case the passageway 380 is also used for transferring water between flotation chambers 120.

[142] The main differences compared to the previous examples lie in the configuration of the first and second openings 121, 122, and in the activation mechanism, which is provided through the particular configuration of the connections 140 and their interactions with the posts 130. The arrangement of this example allows a different mode of submergence to be achieved, whilst resulting in a similar outcome of submerging the platform 110 in response to a rise in water level above a predetermined level.

[143] In particular, in this example the activation mechanism causes the platform 110 to tilt when the water level rises above the predetermined level. The tilting of the platform 110 allows the gas to be discharged from the flotation chambers via the first opening 121 and water to enter the flotation chambers via the second opening 121, without necessarily requiring a valve 150.

[144] This tilting action is triggered passively through the interaction of the connections 140 and the posts 130. Specifically, each of the posts 130 includes a stop 331 for preventing the connections 140 from continuing to move upwardly after the connections 140 engage the stops 331.

[145] As the water level rises above the predetermined level (usually set at a water level higher than the level at which the connections 140 engage the stops 331), the connections 140 will not be able to travel further upwardly along the posts 130. Tilting of the platform 110 is facilitated by having only one side of the platform 110 connected to the posts 130 (as shown in Figures 3A to 3D, and having the connections 140 include hinges 341 to allow the platform 110 to tilt at an angle from the hinges 341 when the water level rises above the predetermined level.

[146] The first and second openings 121, 122 are each provided on the underside of the flotation chambers 120 such that the openings 121, 122 are normally positioned in the water body W when the water level is below the predetermined level. Accordingly, when the platform 110 is floating on the water surface S under normal conditions, as depicted in Figure 3A, there is no pathway for gas to escape from the flotation chambers 120 and thus water will be prevented from entering the flotation chambers 120. Water can be further prevented from unintentionally entering the flotation chambers 120 by providing the openings on downwards extensions as previously described with reference to Figure 2B.

[147] The openings 121, 122 are preferably configured such that tilting of the platform 110 causes gas to be discharged from the flotation chambers 120 via the first opening 121 and water to enter the flotation chambers 120 via the second opening 122.

[148] Accordingly, the second opening 122 is suitably positioned near the side of the platform 110 that is connected to the posts 130 (typically the landward side as shown in Figure 1A) and the first opening 121 is positioned near the opposite side of the platform 110.

[149] Such positioning of the openings 121, 122 means that when the platform 110 tilts at a predetermined angle the first opening 121 becomes positioned above the water body W, to thereby allow the gas to be discharged from the flotation chambers via the first opening 121 and the water to enter the flotation chambers 120 via the second opening 122. The passageway 380 allows gas and water to be transferred between separate flotation chambers 120 as the platform 110 is submerged.

[150] The initiation of this submerging procedure is illustrated in Figure 3B.

[151] As can be seen, the rising water level has caused the platform 110 to float upwardly to a point where the connections 140 have engaged with the stops 331 provided on the posts 130, thereby preventing further upward movement of the connections. However, as the water level continues to rise above the predetermined water level, the buoyancy of the flotation chambers 120 causes the platform 110 to attempt to float higher on the water surface S.

[152] Since the connections 140 prevent further upward motion on the side of the platform 110 connected to the posts 130, the platform 110 starts to tilt from the hinges 341 of the connections 140. Eventually, the platform 110 will tilt an angle relative to the water surface S which causes the first opening 121 to be exposed above the water surface S. Once this occurs, gas is allowed to escape from the flotation chambers 120 via the first opening 121 as indicated by arrow 101. Simultaneously, water is now allowed to enter the flotation chambers 120 via the second opening 122, as indicated by arrow 102.

[153] As water continues to flood the flotation chambers 120, this will shift the centre of gravity of the platform 110 towards the posts 130, which will have the effect of further exaggerating the tilt angle relative to the water surface. This will promote the continued discharge of gas from the flotation chambers 120 and entry of water into the flotation chambers 120.

[154] Figure 3C shows the docking apparatus 100 when the platform 110 is further along the process of submerging. As can be seen, the tilt angle of the platform 110 has increased as more of the gas previously contained within the flotation chambers 120 has been replaced by water.

[155] Water has been allowed to flow between the flotation chambers 120 via the passageway 380. Since the flotation chambers now contain a reduced volume of gas, the buoyancy of the flotation chambers 120 has reduced such that the platform 110 no longer floats. As the platform 110 sinks towards the water body bed B, the connections 140 move downwardly along the posts 130, but the platform 110 remains tilted from the hinges 341 due to the distribution of air and water causing a tilting moment on the platform 110.

[156] The tilt angle of the platform 110 increases until the platform 110 has an orientation parallel with the posts 130. An additional buoyant chamber (not shown) may be installed near the outer side of the platform 110 (i.e. the edge opposite to the edge connected to the posts 130) to facilitate this process. When the platform 110 assumes this orientation a locking mechanism 311 extending from the platform can be used to engage with at least one of the

posts 130 and retain the platform 110 in the parallel orientation when the platform 110 is submerged.

[157] The platform 110 continues to submerge until the connection 140 reaches the water body bed B. If a locking mechanism 311 is used as described above, the sunk platform 110 will eventually reach a final state as shown in Figure 3D.

[158] It will be appreciated that the platform 110 may act as a brace to further strengthen the posts 130, whilst in the state shown in Figure 3D. This bracing effect will particularly be enhanced in cases where the platform 110 is engaged with each post 130 using respective locking mechanisms 311.

[159] After the water level has subsided to safer levels, the sunk platform 110 can be refloated using similar techniques as described above.

[160] In some cases, the end of the platform 110 having the first opening 121, being positioned uppermost, may be exposed above the water surface S when the water level subsides. In these cases, it can be a straightforward matter to connect a pump to the first opening 121, usually via a connecting tube, and pump air into the flotation chambers 120 to thereby displace the water from the flotation chambers 120 and restore buoyancy. The locking mechanism 311 should be disengaged from the post at the same time to allow the platform 110 to resume a normal orientation relative to the water surface S, and this can also be manually performed if the locking mechanism 311 is exposed above the water surface S.

[161] In scenarios where the length of the platform 110 remains fully submerged beneath the water surface S even after the water level subsides, it is necessary to provide additional means for allowing the platform 110 to be refloated. In one example, an air tube (not shown) may be fitted to one of the flotation chamber 120 in such a way that the air tube is accessible even when the platform 110 is fully submerged. An end of the air tube may be fitted with a floating buoy or the like so that the end of the air tube is accessible above the water surface S at all times. Remote means for disengaging the locking mechanism 311 can also be provided, and this may involve a wireless unlocking device, or mechanical means provided on the

respective post 130 to allow the locking mechanism 311 to be disengaged by accessing the top of the post 130, for example.

[162] Another option for refloating the platform 110 is to use gas supplies integrated with the docking apparatus 100, as previously described. For instance, gas generators may be installed inside the flotation chambers 120 and the supply of gas into the flotation chambers 120 may be triggered manually, or automatically after the water level subsides below a safe level. When a plurality of flotation chambers 120 are used, a corresponding plurality of gas supplies can be provided, which can be activated in a predetermined sequence for controlling the supply of gas into the flotation chambers 120, to thereby allow the platform 110 to be refloated in a controlled manner.

[163] In one example, the docking apparatus 100 includes a monitoring device for monitoring the status of equipment such as sensors, valves, gas supplies, batteries or the like, depending on the particular configuration of the docking apparatus 100.

[164] Furthermore, it may be desirable to incorporate additional wireless functionalities into the monitoring device, particularly in the event that a wireless device is used to control the operation of a valve 150, a gas supply, or the like. It will be appreciated that a wireless monitoring device would allow a user to receive indications of the equipment status without needing to access the docking apparatus 100. This can help to reduce the need for routine checking and maintenance of the docking apparatus 100. A wireless remote control device can be used in a similar fashion to allow monitoring and control of equipment.

[165] As mentioned above, the docking apparatus 100 may be used for docking boats or other marine craft. Often, boats will be relocated to safer harbours or retrieved from the water body in the event of approaching flood waters or other extreme events, in which case the docking apparatus 100 can operate to submerge the platform 110 without concern for the boat's survival.

[166] However, if it is intended to leave a boat docked with the docking apparatus 100 during extreme rises in water level, it will be necessary to take account of this in the design of

the docking apparatus 100 so that the boat is not damaged when the platform 110 is sunk. Accordingly, one example solution for accommodating docked marine craft will be outlined below.

[167] Typically, docks for boats and other marine craft include one or more mooring bollards, to which a boat can be secured by rope or other securing means. If a standard mooring bollard was fixed to the platform 110 of the docking apparatus 100, a secured boat would be pulled downwardly with the bollard as the platform 110 was submerged, risking damage to the boat or even capsizing if the boat remains secured when the platform 110 sinks.

[168] In view of the above, mooring bollards should be mounted on the platform 110 of the submersible docking apparatus 100 in such a way as to allow the boat to remain secured during normal conditions but to not pull the boat downwards when the platform 110 sinks. This may be achieved by having each bollard mounted in a receptacle which allows the bollard to disengage from the receptacle only when the platform 110 sinks. The bollards may be of a floating type to retain a fixed relationship with the boat after disengagement from the platform.

[169] The bollards should be separately secured to the posts 130 or to the mainland to continue to restrain the boat in position after the platform has sunk. For example, each bollard may be attached to the mainland using one or more cables. In one example, the cables are retractable using cable reels which are tensioned to a particular force and release length. By appropriate selection of the cable reel parameters, the boat can be restrained in position relative to the mainland after the bollards are disengaged from a sunk platform 110, even under high current flow conditions.

[170] When the platform 110 is to be refloated after the water level subsides, the boat can be repositioned to ensure it is outside of the region in which the platform 110 will resurface, and the bollards can be remounted in the corresponding receptacles.

[171] In another aspect, alternative forms of docking apparatus may be provided which allow the platform to become at least partially submerged in the water body without necessarily requiring the flotation chambers to be filled with water, by employing a tilting functionality similar to that described above with reference to Figures 3A to 3D. This can allow conventional docking apparatus to be retrofitted to improve their survivability during rising water levels without the need to replace or significantly modify their flotation chambers.

[172] Figures 4A to 4D illustrate an example of such a docking apparatus 400 in which a generally conventional floating dock has been retrofitted to allow tilting and at least partial submergence when the water level has risen above a predetermined level. Features similar to those described in previous examples have been assigned similar reference numerals.

[173] In particular, the docking apparatus 400 in this example includes a platform 110 and at least one flotation chamber 120 for buoyantly supporting the platform 110. It is noted that the flotation chamber 120 may not include means for discharging gas or having water enter the flotation chamber 120 as per previous examples. Hence the flotation chamber 120 may have a fixed buoyancy in this example. Furthermore the flotation chamber 120 may be filled with buoyant foam materials or the like and does not necessarily need to be filled with a gas.

[174] The platform 110 is connected to posts 130 anchored to a water body bed B such that the platform 110 is substantially restrained from moving laterally relative to the posts 130 and the platform 110 is allowed to move axially relative to the posts 130, as per previous examples. Only one side of the platform 110 is connected to the posts 130, and the connections 140 between the platform and the posts including hinges 341 to allow the platform 110 to tilt at an angle from the hinge in a similar fashion to the previous tilting embodiment shown in Figures 3A to 3D.

[175] The docking apparatus 400 further includes at least one restraint for restraining the platform 110 from moving axially relative to the posts 130 when the water level rises above a predetermined level. In use, the at least one restraint causes the platform 110 to tilt when the water level rises above the predetermined level, in a similar manner as described for Figures

3A to 3D. The tilting allows the platform 110 to become at least partially submerged in the water body. The degree of submergence will generally depend on the amount the water level rises.

[176] In this specific example, the restraint is provided in the form of a stop 331 provided on at least one of the posts 130. Typically a stop 331 will be provided on each post 130. The stops 331 prevent the connections 140 between the platform 110 and the posts 130 from moving upwardly after the water level rises above the predetermined level, as was the case in the previous example.

[177] An example scenario illustrating the operation of the docking apparatus 400 throughout a significant rise in the water level will now be outlined with reference to Figures 4A to 4D.

[178] In Figure 4A, the water level has risen to the predetermined level at which the stop 331 will engage with the connection 140 and prevent further upward movement if the water level rises further. At this water level (and at water levels below the predetermined levels), the platform 110 will be supported above the water surface S without significant tilting about the hinges 341.

[179] In Figure 4B, the water level has risen substantially above the predetermined level and this has caused the stop 331 to act as a restraint and thus prevent further upward movement of the connection 140. With the connection 140 unable to travel upwardly, but the same buoyancy force supporting the platform due to the fixed buoyancy of the flotation chamber 120, the platform 110 will tilt and assume an angled orientation in which part of the platform 110 may be partially submerged, in order to statically balance the buoyancy force.

[180] As the water level rises, the tilt angle of the platform 110 will increase, as depicted in Figure 4C. If the water level continues to rise, it may eventually reach a level sufficient to cause the platform 110 to tilt to an orientation parallel with the posts 130. The platform 110 may then assume a generally vertical orientation as shown in Figure 4D. It is noted that such an orientation of the platform 110 may occur in advance of the platform 110 being

completely submerged by water, and the platform 110 may in fact never become completely submerged. Nevertheless, the platform 110 may be subjected to reduced drag loading due to the flow of water in its tilted orientation.

[181] Importantly, the platform 110 will be prevented from floating above the top of the posts 130 due to the action of the stop 331. Accordingly, this can mitigate loss of the platform 110 in the event of an extreme rise in the water level.

[182] As per the previous example, the platform 110 may also include a locking mechanism 311 for engaging with at least one of the posts 130 and retaining the platform 110 in the orientation parallel with the posts 130 when the platform is at least partially submerged. As shown in Figures 4A to 4D, the locking mechanism may be provided at a position on the platform 110 based on the height of the post above the stop 331, such that the locking mechanism 311 will engage with the post 130 below the top of the post 130. As can be seen in Figure 4D, the height of the post 130 may be selected such that the top of the post 130 may be underwater whilst still allowing the post 130 to be engaged by an appropriately positioned locking mechanism 311.

[183] Suitable restraints can be provided in other forms, and a different type of restraint will now be described with reference to a further example of a docking apparatus 500 shown in Figures 5A to 5E. Again, similar reference numerals will be used to identify features similar to those described in previous examples.

[184] In this example, and as can be seen in Figure 5A, the docking apparatus 500 includes one or more lines 501 anchored to the water body bed B at a first end, using a suitable line anchor 502, and attached to one of the connections 130 between the platform 110 and the posts 130 at an opposing second end. The position of the line anchor 502 and the length of the line 501 are each selected to provide a suitable restraint against upward movement of the platform 110 when the water level rises above the predetermined level. The line 501 may conveniently be provided as a chain having sufficient strength for supporting the buoyancy of the flotation platform 120 along with any further loading that may need to be reacted due to the action of water flow, waves or the like.

[185] In this regard, the line anchor 502 may be positioned upstream of the connection 140, as shown in Figure 5A where the water flow direction is indicated by arrow 503, so as to provide additional restraint against the platform 110 moving laterally in a downstream direction after the water level rises above the predetermined level. It will be understood that this can relieve loads applied to the posts 130 and thus further mitigate against failure of the posts 130 or their respective anchors under extreme conditions.

[186] With reference to Figure 5B, which shows the docking apparatus 500 when the water level is significantly below the predetermined level, it can be seen that the line 501 is in a slack configuration between the anchor 502 and the connection 140 and thus incapable of providing any restraint on the connection 140 at this stage. The platform 110 is thus free to move axially relative to the post 130 whilst the water level is within normal predicted limits (i.e. not exceeding the predetermined level).

[187] When the water level reaches the predetermined level, as depicted in Figure 5C, the line 501 will become taught and thereby be capable of providing a restraining force via tension in the line 501, which will be reacted into the water body bed B via the anchor 502. The length of the line 501 and the position of the anchor 502 should be selected to ensure that the line 501 becomes taught at the predetermined level.

[188] As the water level continues to rise, the taught line 501 will act as a restraint in a similar manner to the stop 341 of the previous example docking apparatus 400, and thus prevent further upward movement of the connection 140 relative to the post 130. Thus, the line 501 will cause the platform 110 to tilt about the hinges 341 as shown in Figure 5D, in a similar manner to the tilting action described in the previous example.

[189] The tilting of the platform 110 will proceed as the water level rises, due to the restraint provided by the line 501, until the platform 110 assumes an orientation parallel with the posts 130, with the platform 110 at least partially submerged. As mentioned above, the line 501 may not only provide a restraint against upward movement, but can also restrain against lateral movement of the platform, supplementing the lateral restraint provided by the posts 130. Thus, the line 501 may at least partially relieve the loading on the posts 130.

[190] It will be appreciated that embodiments of the docking apparatus may include a combination of different types of restraints. For example, stops 341 and lines 501 may be used together to provide some redundancy in case of failure of one form of restraint, or to reduce the load on any single restraint.

[191] In some embodiments, a sacrificial restraint may be used which are designed to fail when a particular restraining capability is exceeded, after which an additional restraint will take over the full restraining functionality. For instance, a stop 341 may be used as the restraint under moderately high water levels but may be configured to fail under more extreme water levels in which case a line 501 in the form of a heavy duty chain will become taught and act as the restraint.

[192] In any case, it will be understood that existing conventional floating docks may be retrofitted to provide tilting docking apparatus 400, 500 as described above by modifying the connections 140 to the posts 130 to include suitable hinges 341 and using suitable restraints. Accordingly, this can allow conventional floating docks to have a tilting functionality for allowing the platform 110 to become at least partially submerged, and thus avoid situations where the platform 110 would otherwise be allowed to float above the top of the posts 130 and become disengaged and potentially be lost in extreme rises of the water level.

[193] Persons skilled in the art will appreciate that numerous variations and modifications will become apparent. All such variations and modifications which become apparent to persons skilled in the art, should be considered to fall within the spirit and scope that the invention broadly appearing before described.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1) A docking apparatus for positioning in a water body having a water level, the docking apparatus including:
   a) a platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts; and,
   b) at least one flotation chamber for buoyantly supporting the platform when the at least one flotation chamber contains gas, wherein when the water level rises above a predetermined level relative to the posts, the gas is discharged from the at least one flotation chamber via a first opening and water enters the at least one flotation chamber via a second opening to thereby cause the platform to be submerged in the water body.
2) A docking apparatus according to claim 1, wherein the docking apparatus includes an activation mechanism for causing the gas to be discharged from the at least one flotation chamber and causing the water to enter the at least one flotation chamber when the water level rises above the predetermined level.
3) A docking apparatus according to claim 2, wherein the activation mechanism includes a normally closed valve on one of the openings, the activation mechanism causing the valve to open when the water level rises above the predetermined level.
4) A docking apparatus according to claim 3, wherein the valve is provided on the first opening such that the valve is used to control the discharge of gas from the at least one flotation chamber and the discharge of gas causes the water to enter the at least one flotation chamber.
5) A docking apparatus according to claim 3, wherein the valve is provided on the second opening such that the valve is used to control the entry of water into the at least one flotation chamber and the entry of water causes the gas to be discharged from the at least one flotation chamber.
6) A docking apparatus according to any one of claims 2 to 5, wherein the activation mechanism includes a sensor for sensing when the water level rises above the predetermined level.
7) A docking apparatus according to claim 6, wherein the sensor is one of:

a) a water pressure switch;
b) a float switch;
c) a switch actuated by axial movement of the platform.

8) A docking apparatus according to claim 6 or claim 7, wherein the sensor is provided on one of the posts.

9) A docking apparatus according to any one of claims 1 to 8, wherein the first opening is connected to a tube for discharging the gas from the at least one flotation chamber, the tube having a terminal end positioned on one of the posts to allow access to the terminal end of the tube when the platform is submerged.

10) A docking apparatus according to claim 9, wherein the terminal end of the tube is configured to allow the connection of a pump for pumping air into the at least one flotation chamber when the platform is submerged, such that air pumped into the at least one flotation chamber causes water to be expelled from the flotation chamber and causes the platform to float once a sufficient amount of air is pumped.

11) A docking apparatus according to claim 2, wherein the activation mechanism causes the platform to tilt when the water level rises above the predetermined level, the tilting of the platform allowing the gas to be discharged from the at least one flotation chamber via the first opening and water to enter the at least one flotation chamber via the second opening.

12) A docking apparatus according to claim 11, wherein each of the posts includes a stop for preventing the connections between the platform and the posts from moving upwardly after the water level rises above the predetermined level.

13) A docking apparatus according to claim 12, wherein only one side of the platform is connected to the posts and the connections between the platform and the posts include hinges to allow the platform to tilt at an angle from the hinges when the water level rises above the predetermined level.

14) A docking apparatus according to claim 13, wherein the first and second openings are provided on an underside of the at least one flotation chamber such that the openings are normally positioned in the water body when the water level is below the predetermined level.

15) A docking apparatus according to claim 14, wherein the second opening is positioned near the side of the platform that is connected to the posts and the first opening is

positioned near the opposite side of the platform, such that when the platform tilts at a predetermined angle the first opening becomes positioned above the water body, to thereby allow the gas to be discharged from the at least one flotation chamber via the first opening and the water to enter the at least one flotation chamber via the second opening.

16) A docking apparatus according to any one of claims 11 to 15, wherein the platform is configured to tilt to an orientation parallel with the posts when the platform is submerged.

17) A docking apparatus according to claim 16, wherein the platform includes a locking mechanism for engaging with at least one of the posts and retaining the platform in the orientation parallel with the posts when the platform is submerged.

18) A docking apparatus according to any one of claims 1 to 17, wherein the docking apparatus further includes a gas supply for supplying gas into the flotation chambers when the platform is submerged to thereby displace water filling the flotation chambers and cause the platform to float.

19) A docking apparatus according to claim 18, wherein the gas supply includes at least one of:

a) a container of compressed gas;

b) a gas generator; and,

c) a pump for pumping air.

20) A docking apparatus according to claim 18 or claim 19, wherein the gas supply is adapted to supply the gas into the at least one flotation chamber when the water level subsides below a second predetermined level.

21) A docking apparatus according to any one of claims 18 to 20, wherein the gas supply is provided inside the at least one flotation chamber.

22) A docking apparatus according to claim 21, wherein the flotation chamber includes a normally closed maintenance opening for allowing access to the gas supply.

23) A docking apparatus according to any one of claims 18 to 22, wherein the docking apparatus includes a plurality of gas supplies which can be activated in a sequence for controlling the supply of gas into the at least one flotation chamber.

24) A docking apparatus according to any one of claims 1 to 23, wherein the docking apparatus is adapted to sink to the bottom of the water body when the platform is submerged.

25) A docking apparatus according to claim 24, wherein the docking apparatus includes spikes for engaging with the bottom of the body of water when the platform is submerged.

26) A docking apparatus according to any one of claims 1 to 25, wherein the docking apparatus includes a plurality of flotation chambers.

27) A docking apparatus according to claim 26, wherein each flotation chamber is connected to at least one other flotation chamber by a fluid communication passageway.

28) A docking apparatus, substantially as hereinbefore described.

29) A docking apparatus, substantially as hereinbefore described with reference to the accompanying drawings.

30) A docking apparatus for positioning in a water body having a water level, the docking apparatus including:

a) a platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts, only one side of the platform being connected to the posts and the connections between the platform and the posts including hinges to allow the platform to tilt at an angle from the hinges;

b) at least one flotation chamber for buoyantly supporting the platform;

c) at least one restraint for restraining the platform from moving axially relative to the posts when the water level rises above a predetermined level relative to the posts, wherein the at least one restraint causes the platform to tilt when the water level rises above the predetermined level, the tilting allowing the platform to become at least partially submerged in the water body.

31) A docking apparatus according to claim 30, wherein the apparatus includes a stop on a respective post for providing one of the at least one restraint, the stop being for preventing the connections between the platform and the posts from moving upwardly after the water level rises above the predetermined level.

32) A docking apparatus according to claim 30, wherein the apparatus includes a line anchored to the water body bed at a first end and attached to one of the connections between the platform and the posts at an opposing second end, a position of the line anchor and a length of the line being selected to provide one of the at least one restraint.

33) A docking apparatus according to claim 32, wherein the line is a chain.

34) A docking apparatus according to claim 32 or claim 33, wherein the line anchor is positioned upstream of the connection so as to provide additional restraint against the platform moving laterally in a downstream direction after the water level rises above the predetermined level.

35) A docking apparatus according to any one of claims 30 to 34, wherein the platform is configured to tilt to an orientation parallel with the posts when the water level rises above the predetermined level by a sufficient amount.

36) A docking apparatus according to claim 35, wherein the platform includes a locking mechanism for engaging with at least one of the posts and retaining the platform in the orientation parallel with the posts when the platform is at least partially submerged.

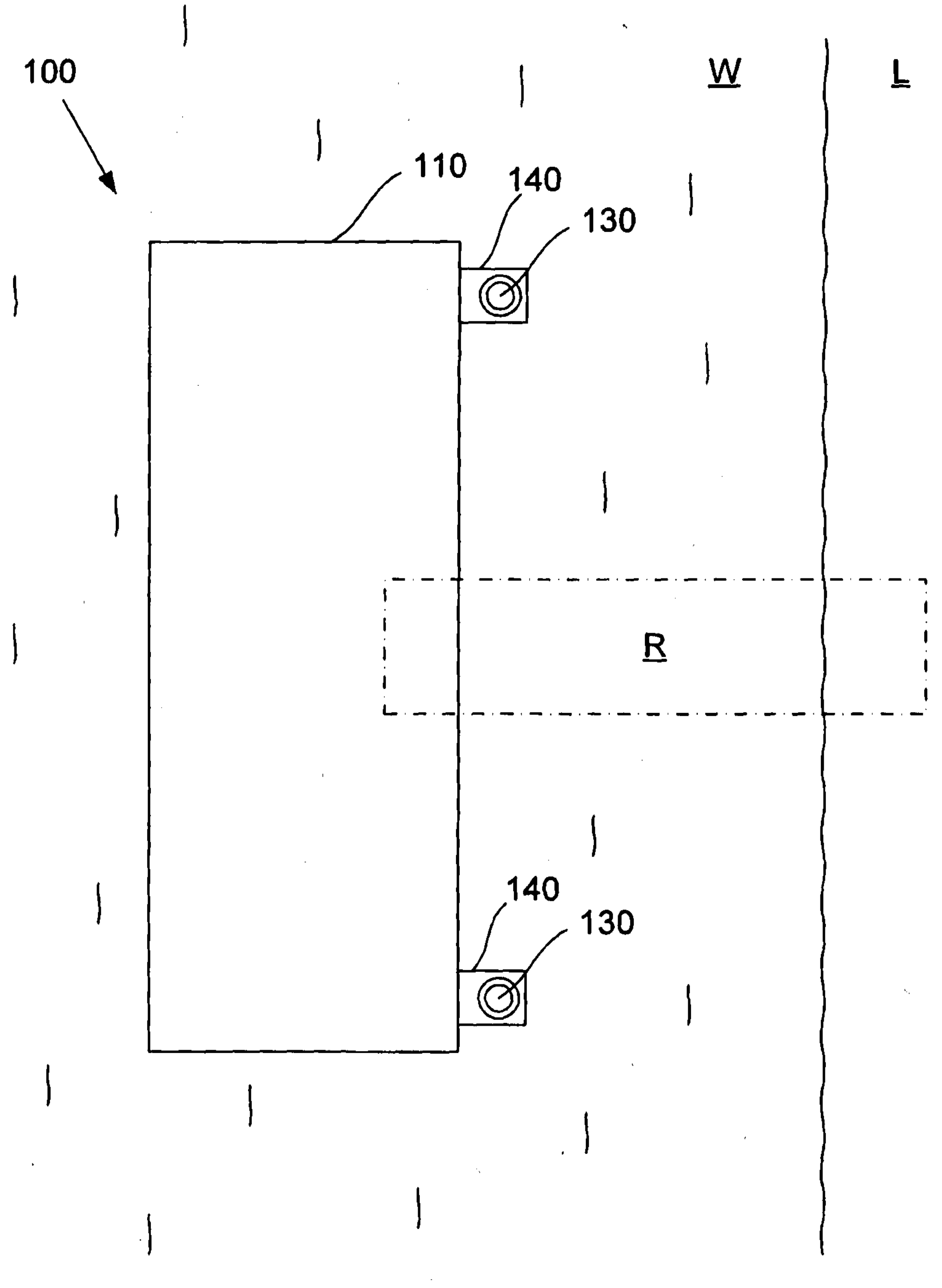

Fig. 1A

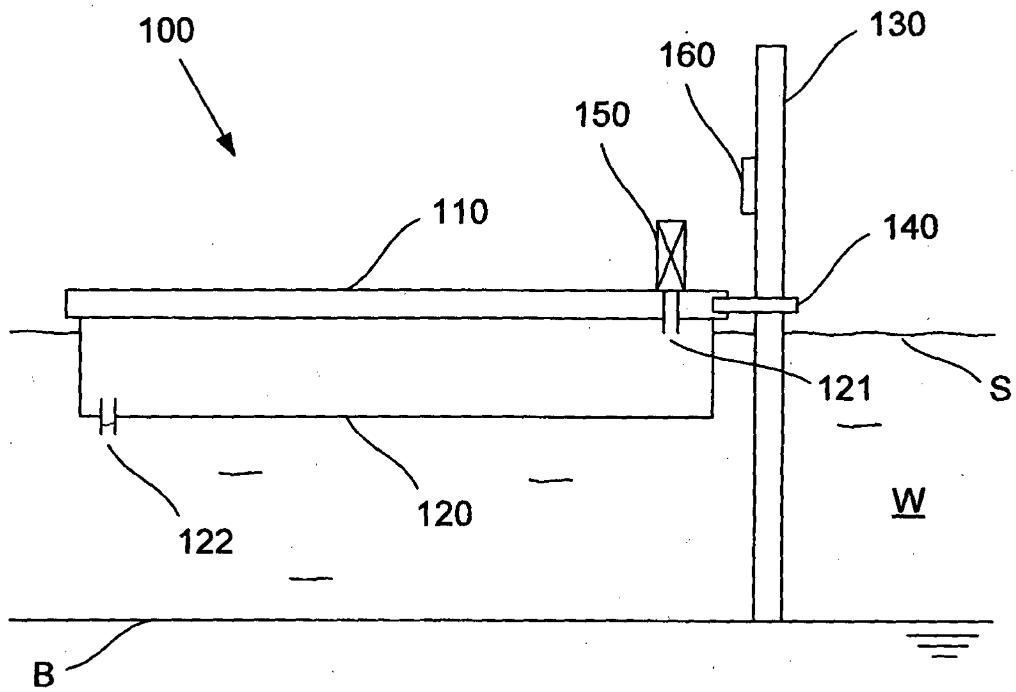
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Fig. 1B

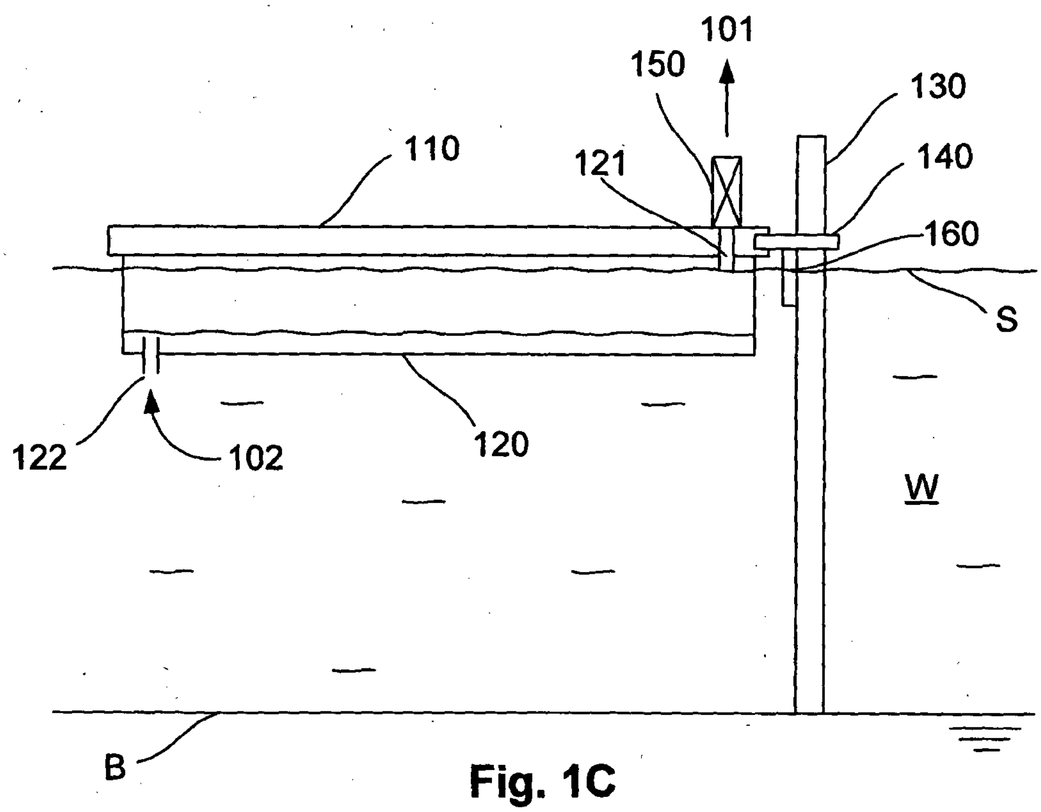
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Fig. 1C

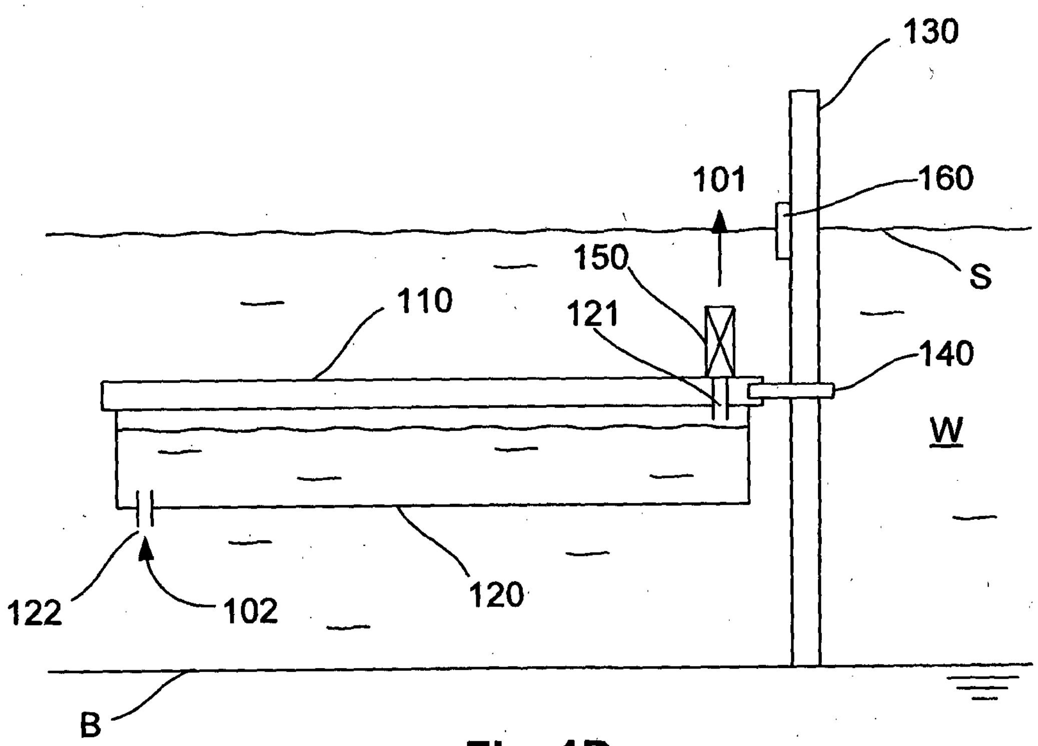
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Fig. 1D

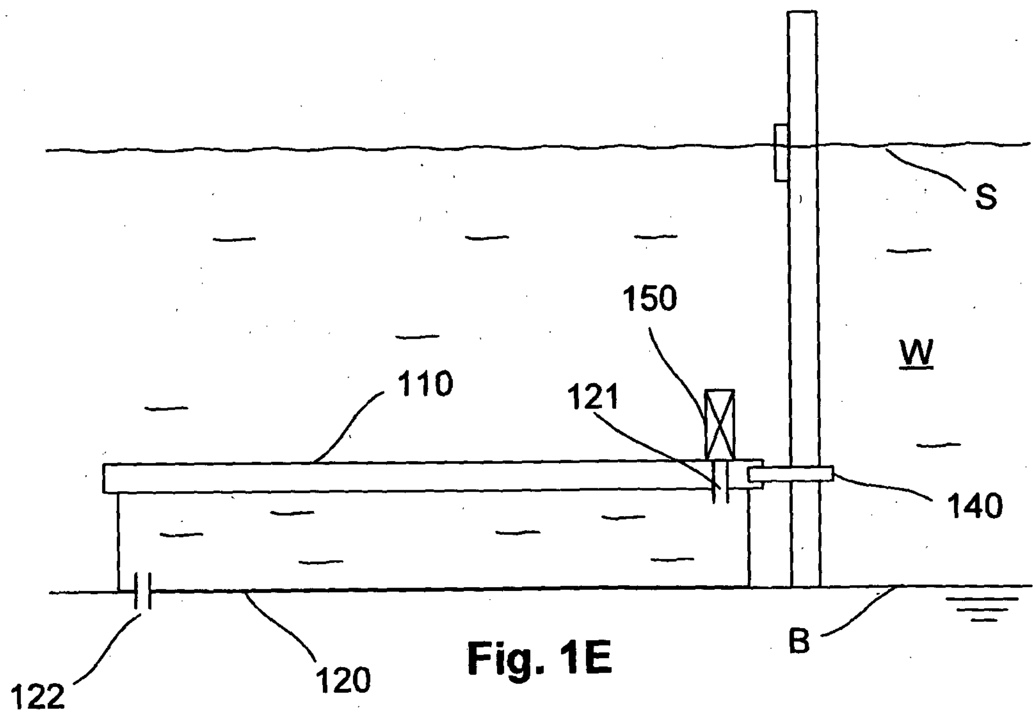
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Fig. 1E

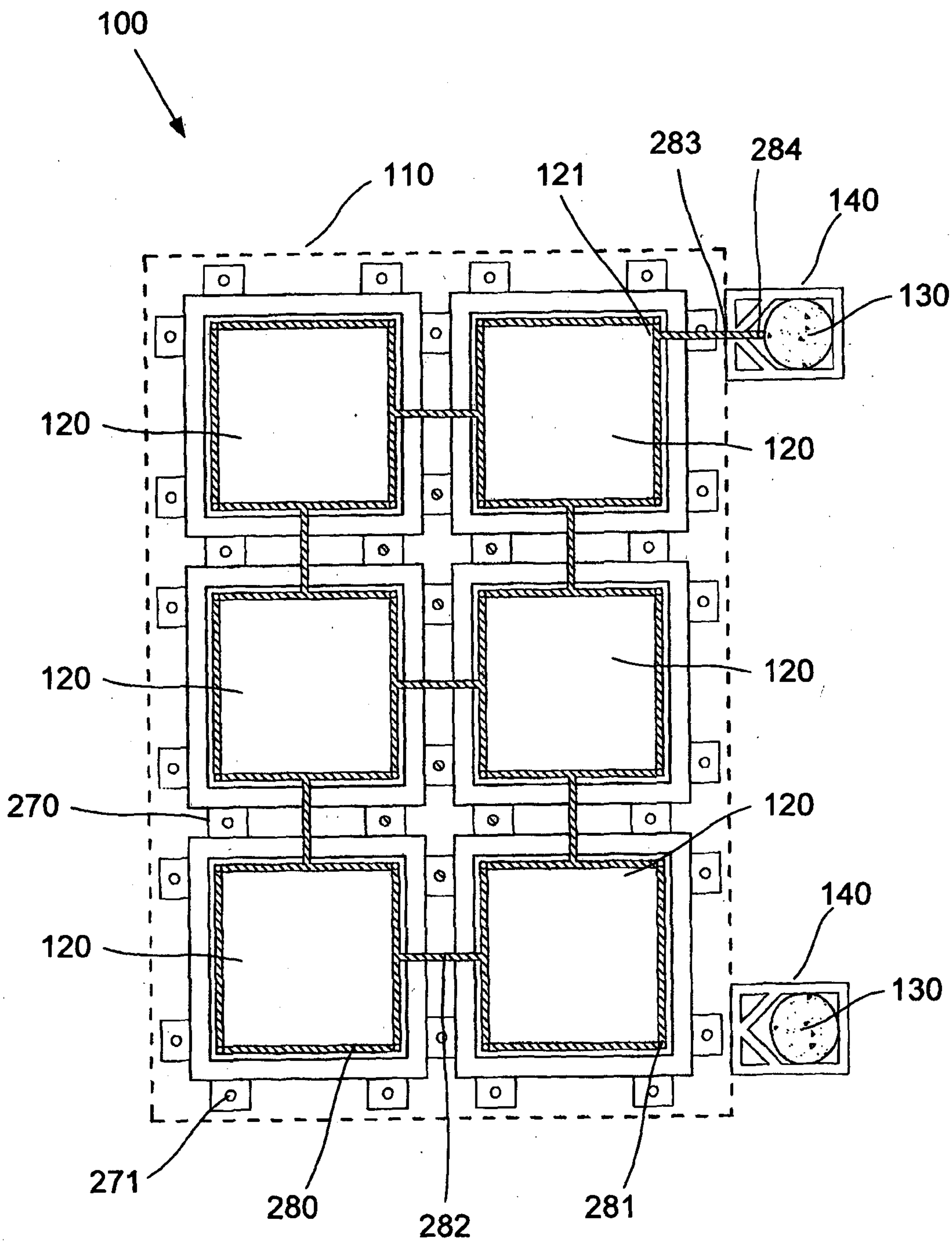
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Fig. 2A

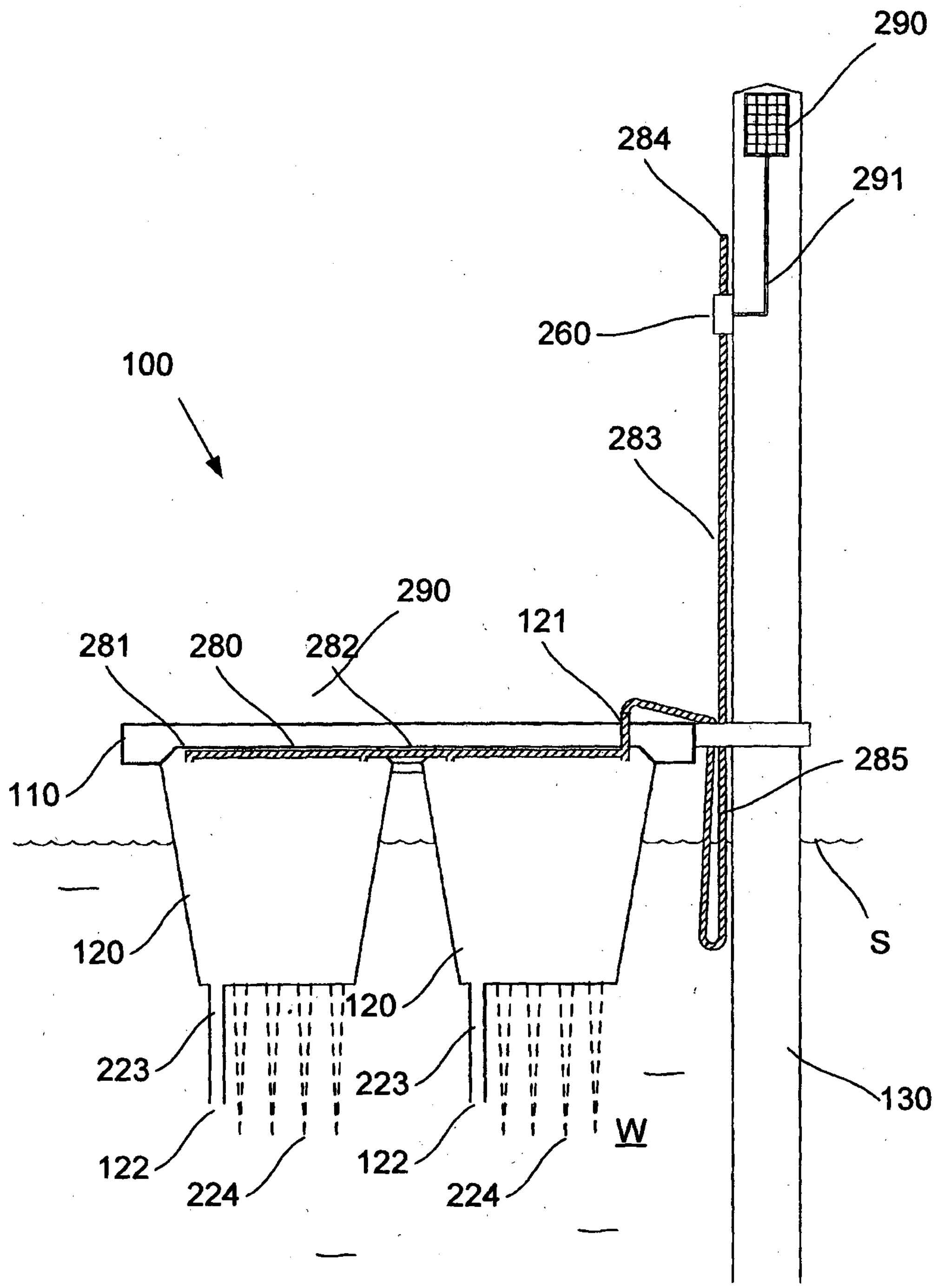
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Fig. 2B

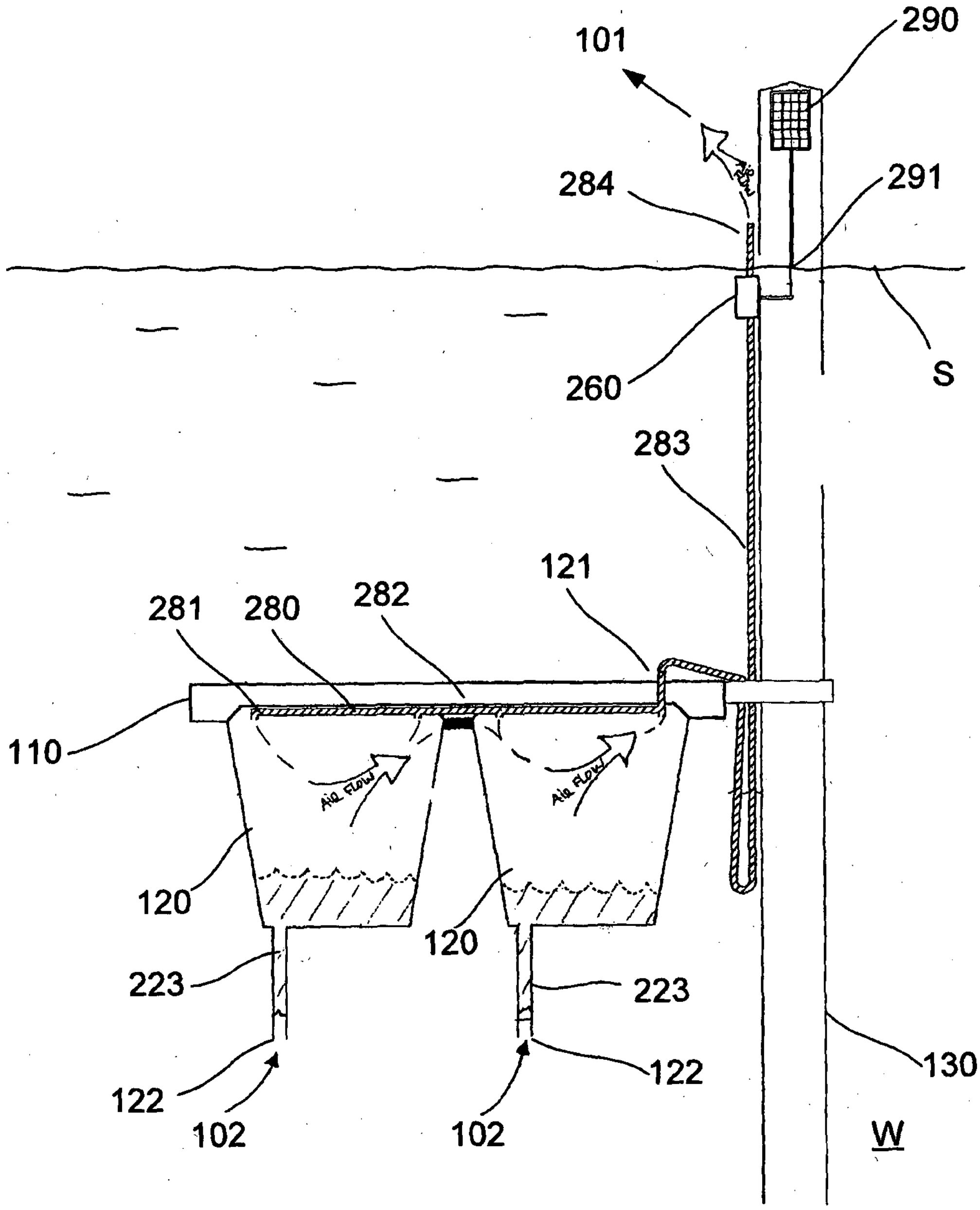
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Fig. 2C

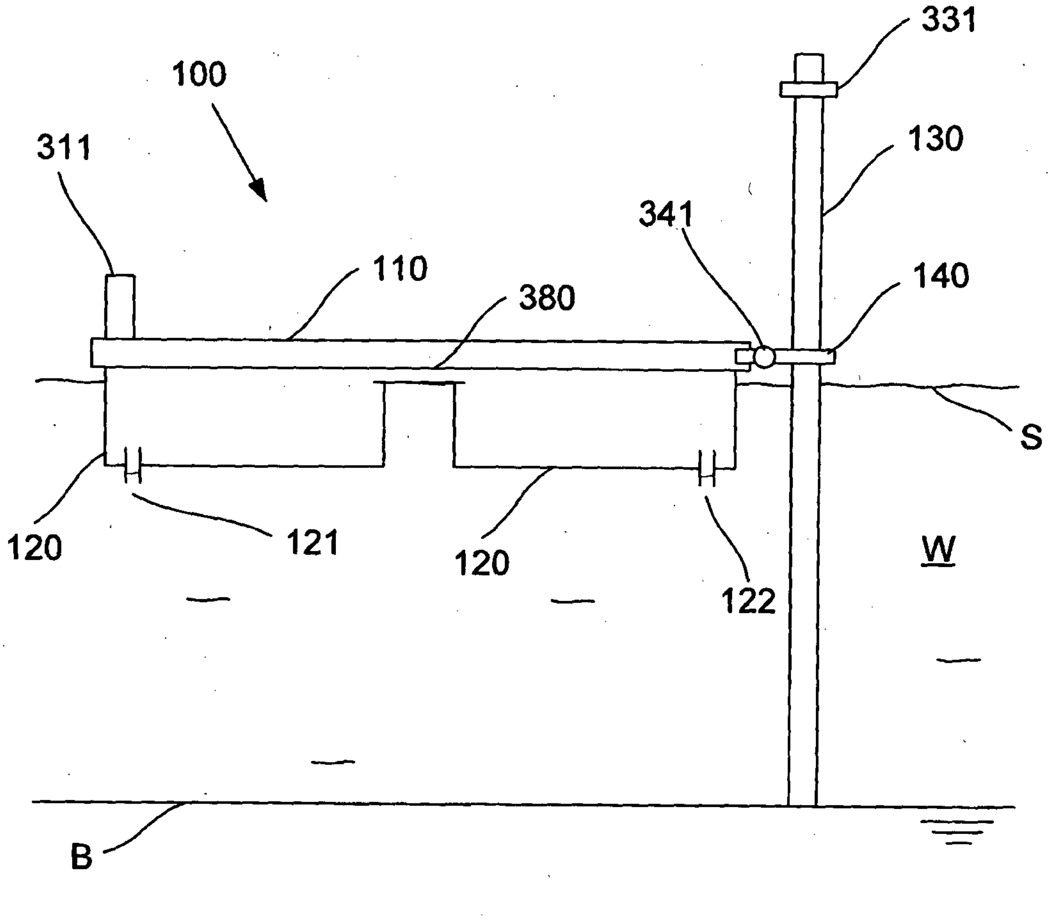

Fig. 3A

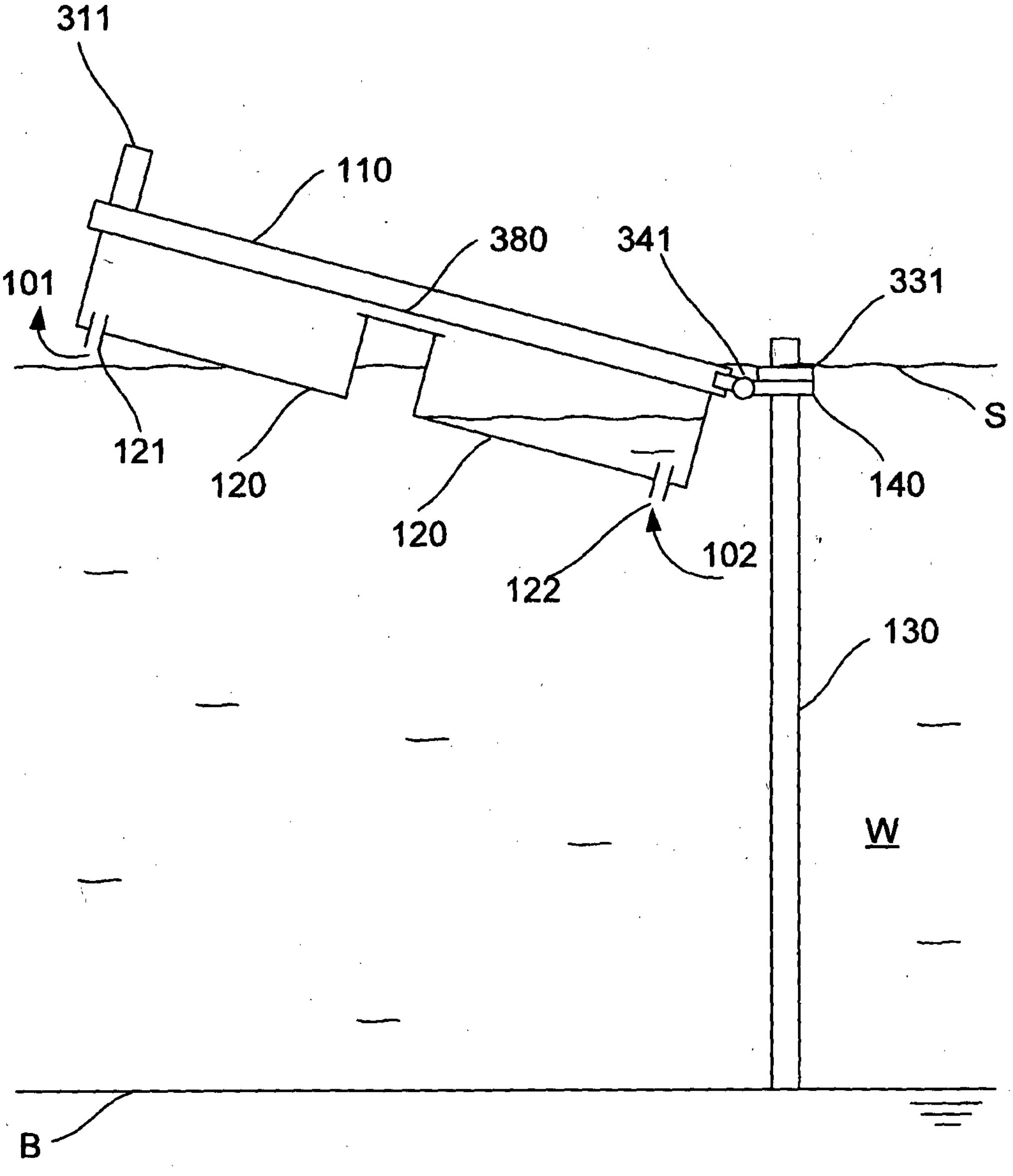

Fig. 3B

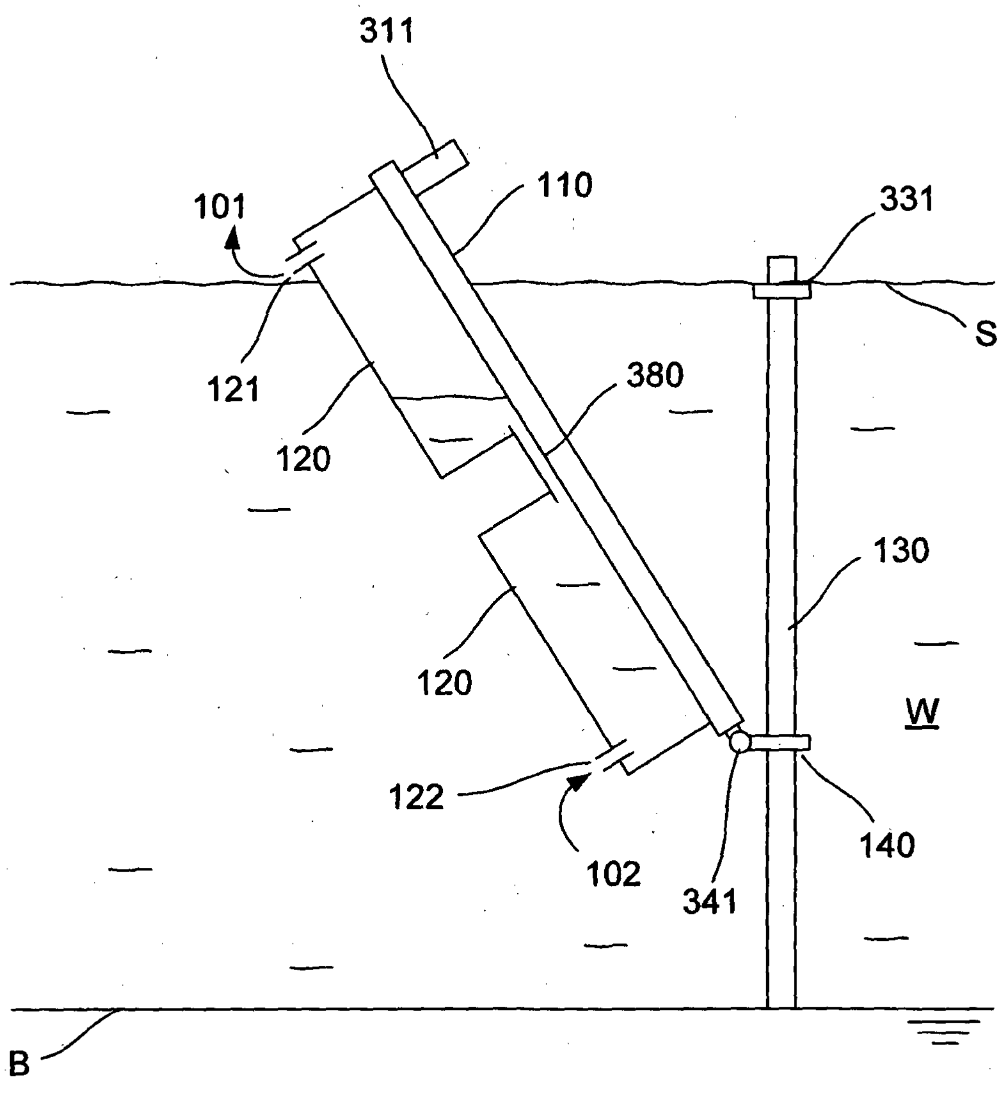

Fig. 3C

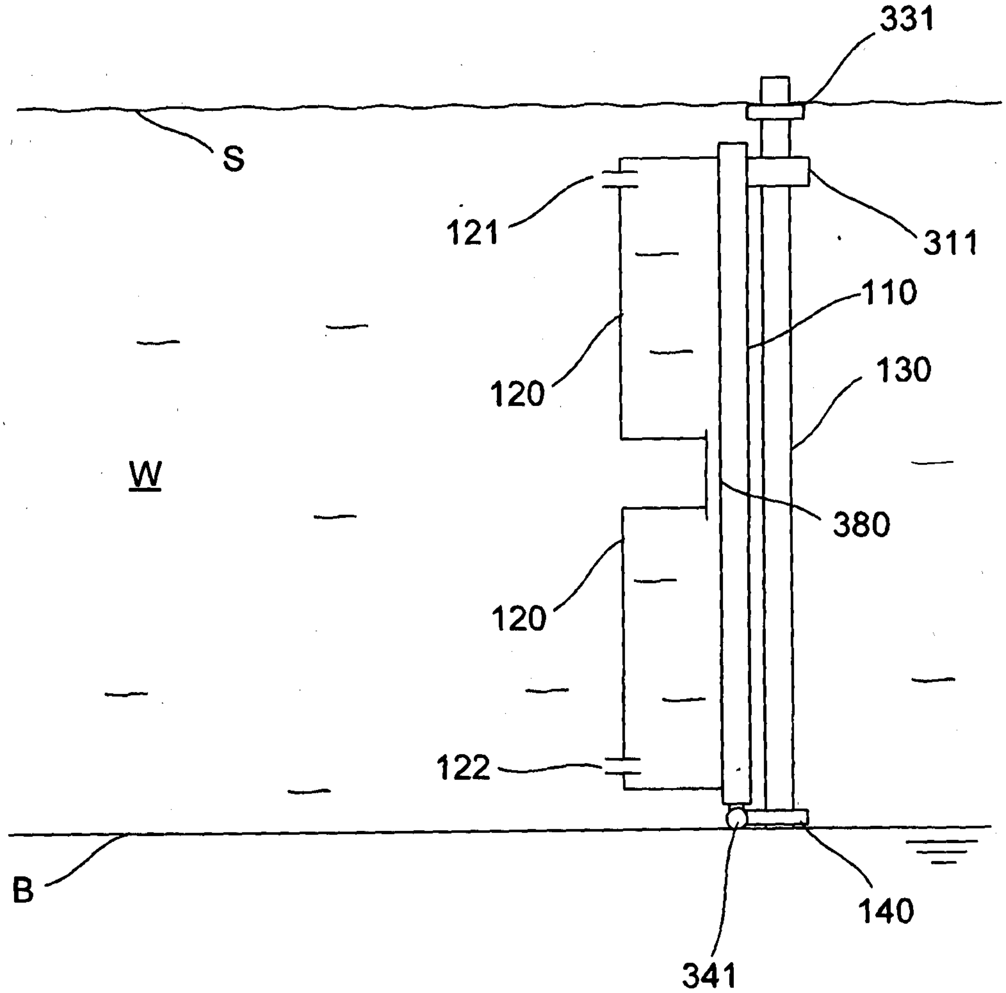

Fig. 3D

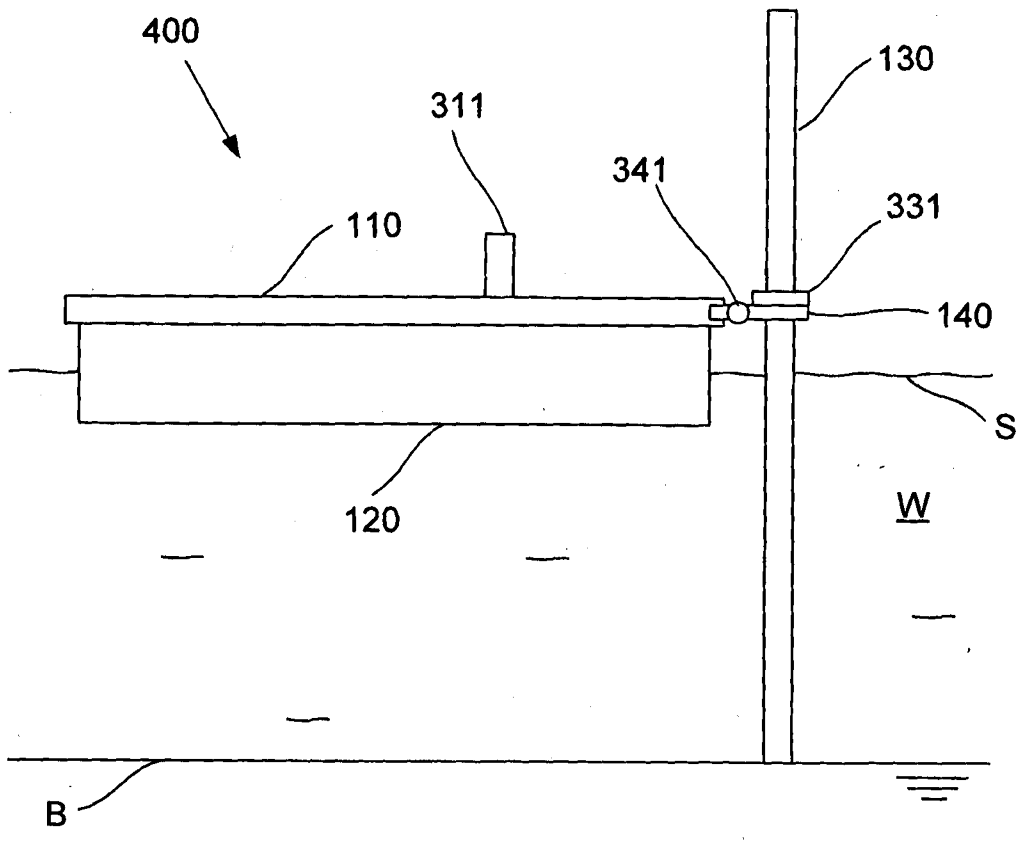

Fig. 4A

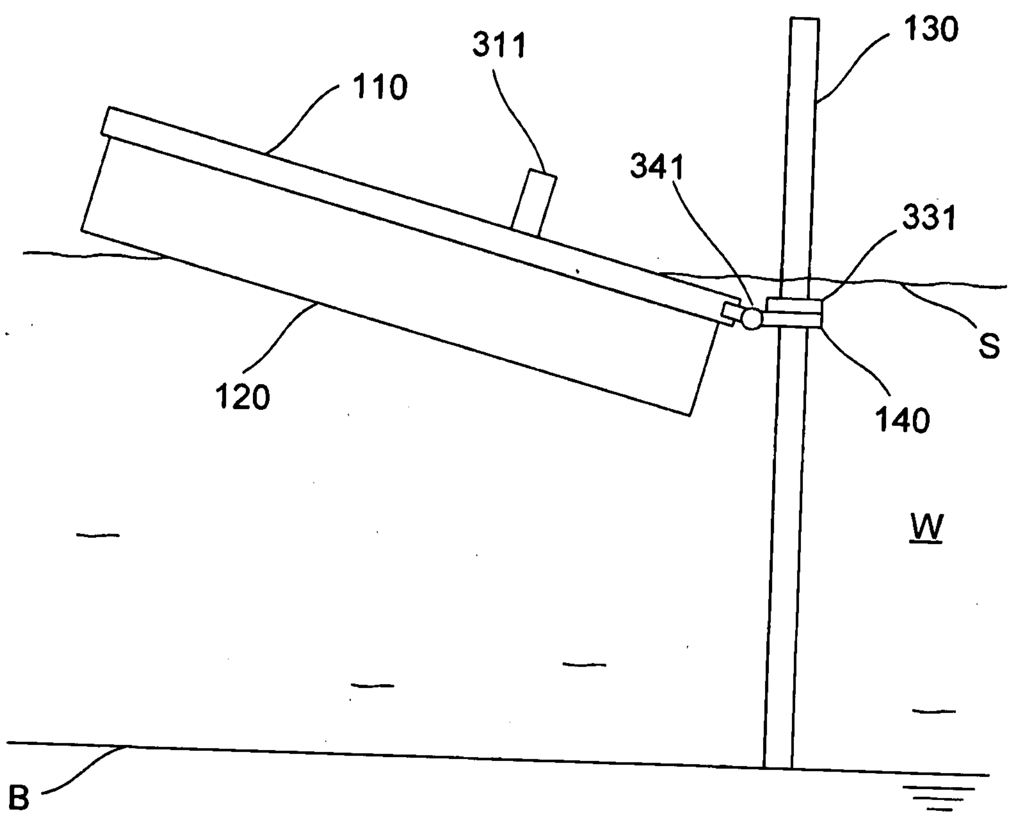

Fig. 4B

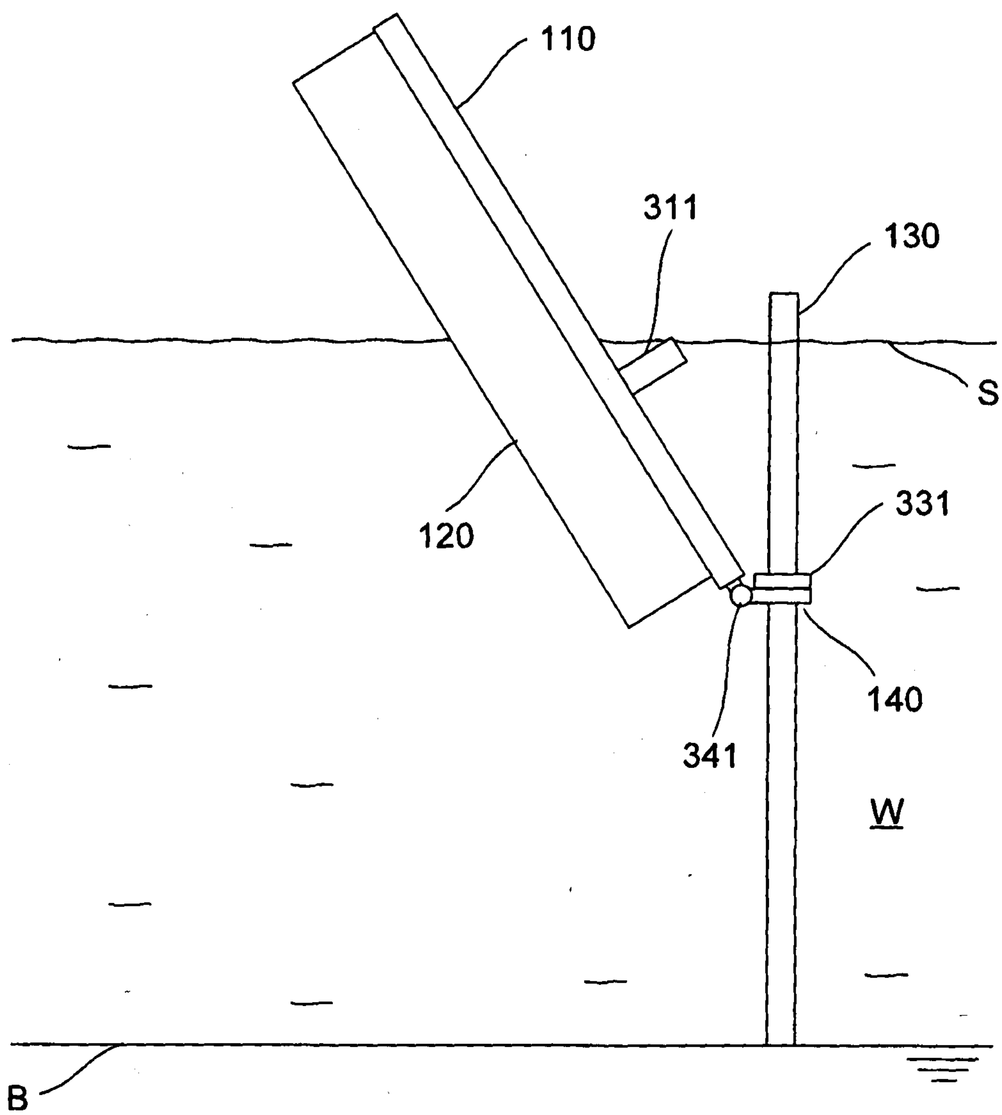

Fig. 4C

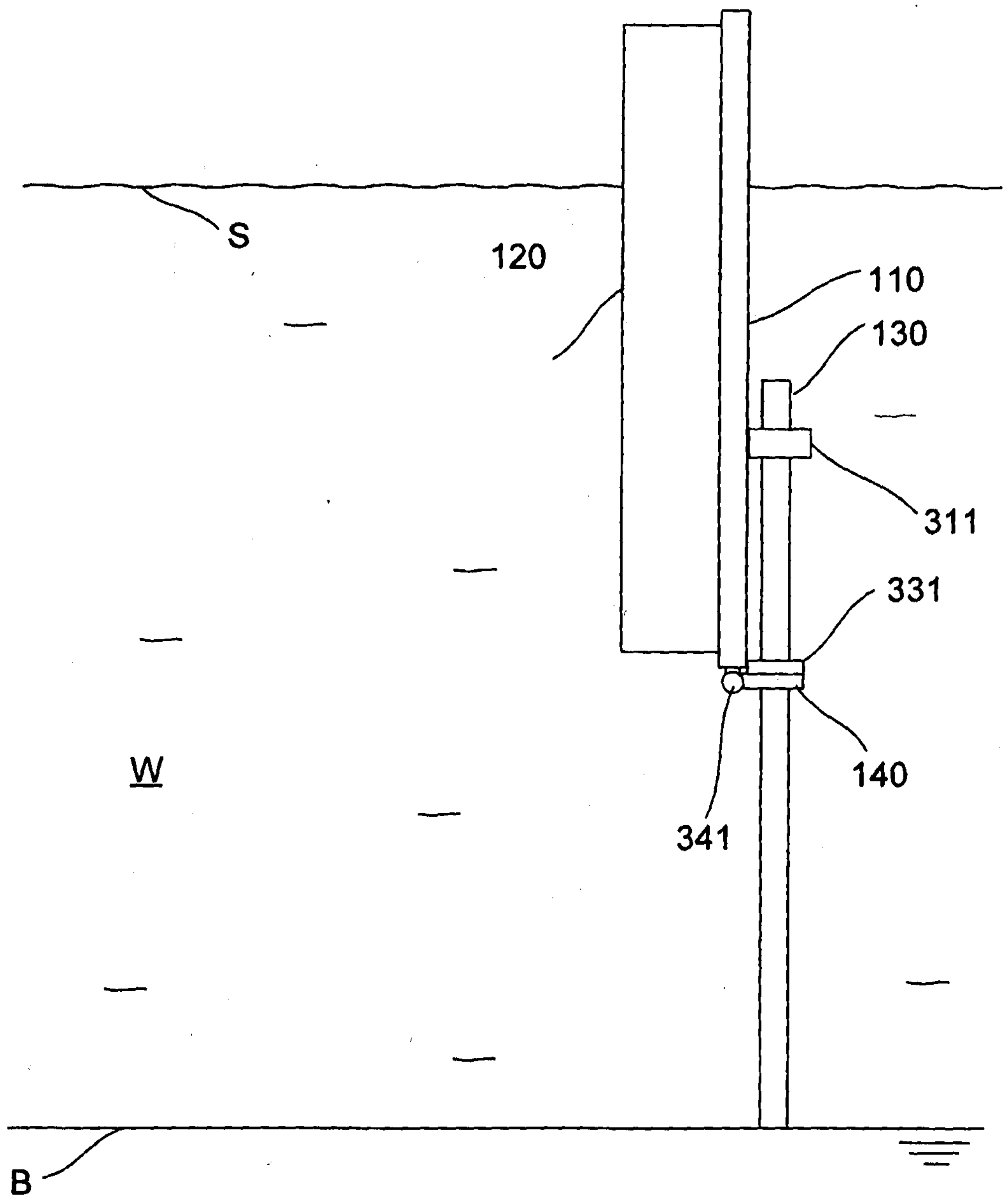

Fig. 4D

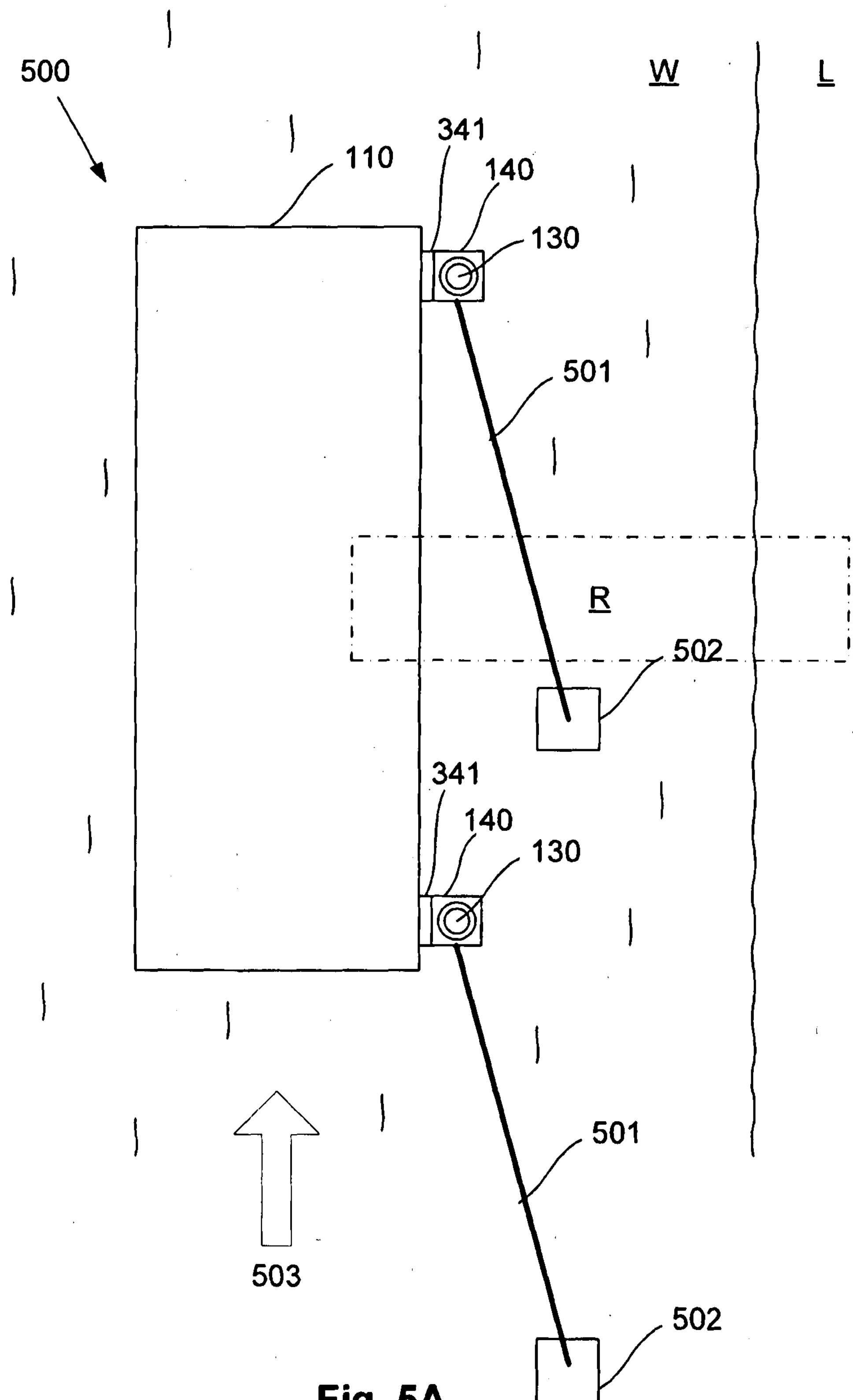

Fig. 5A

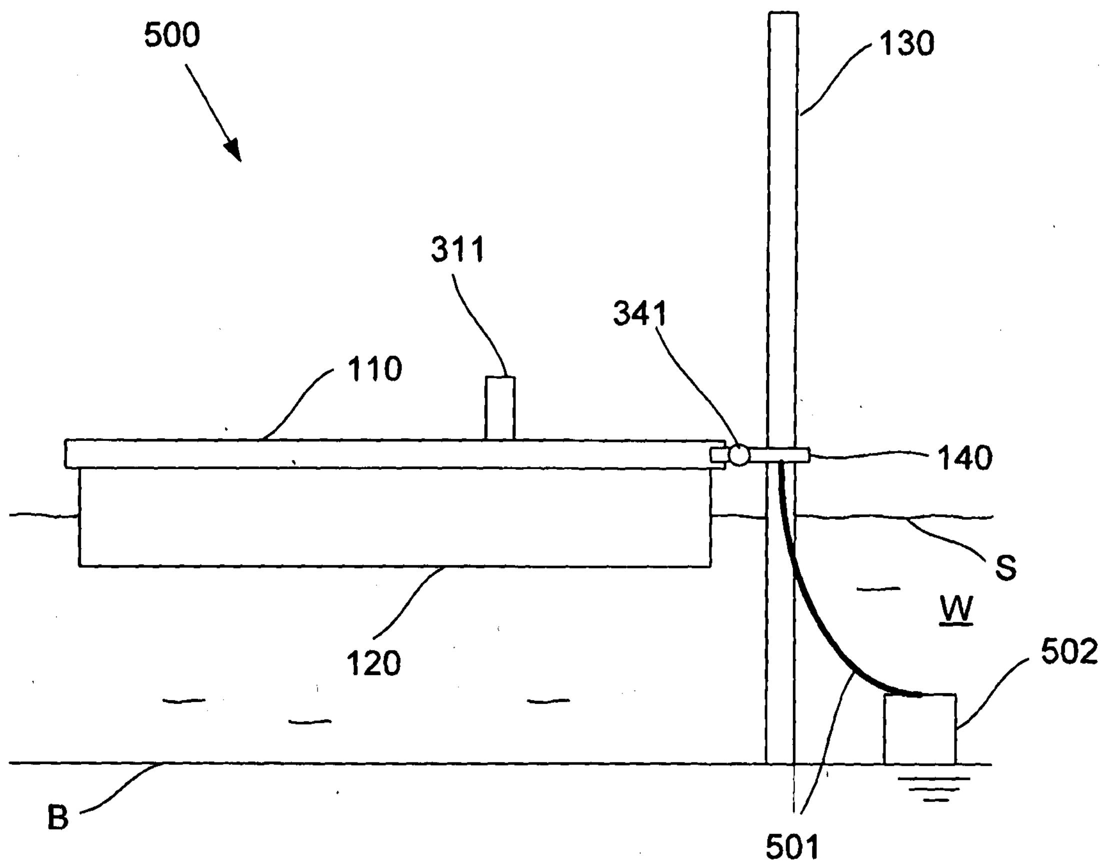

Fig. 5B

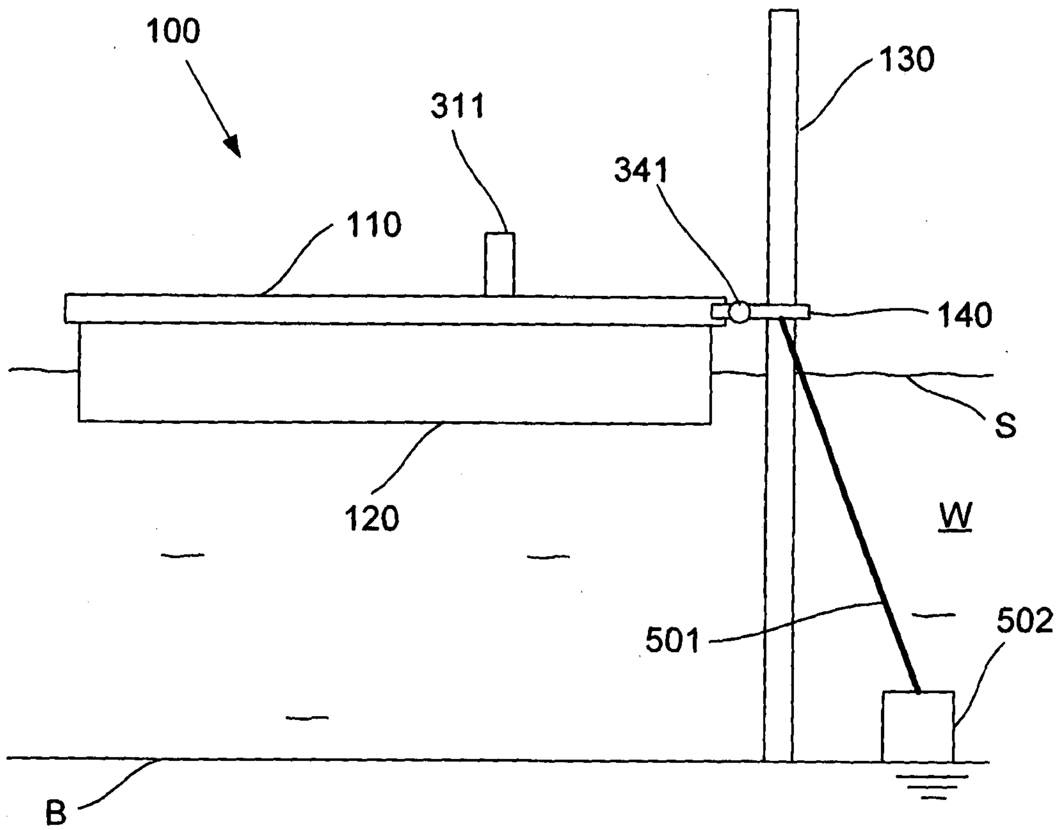

Fig. 5C

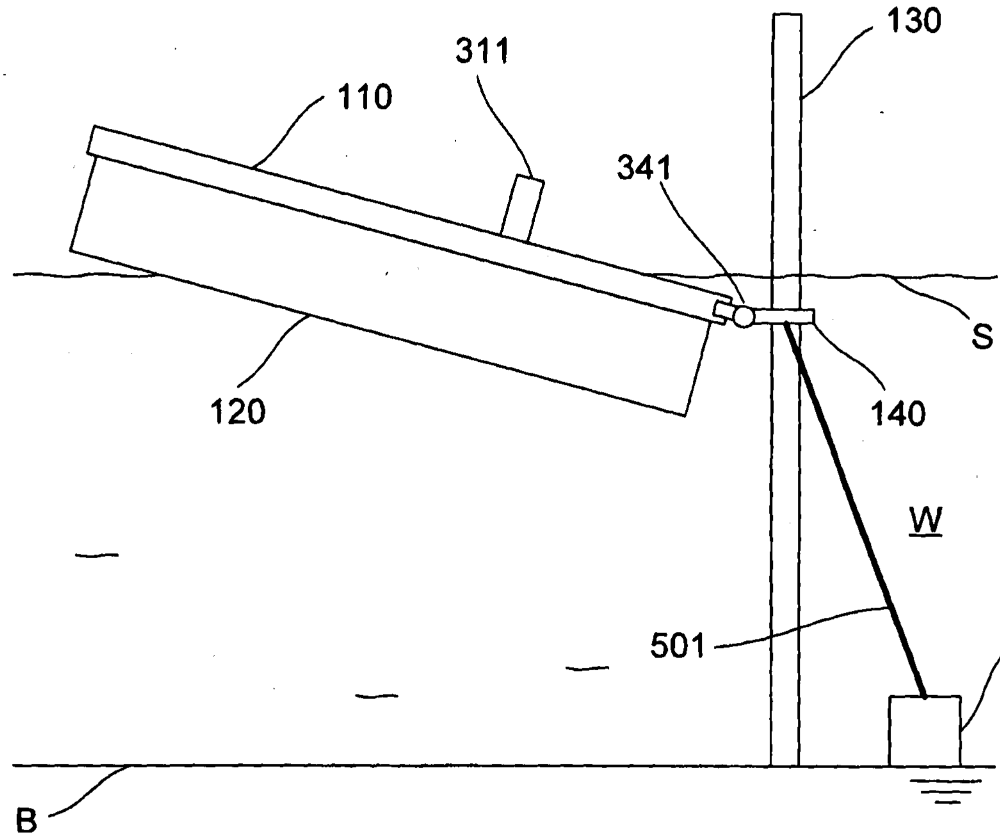

Fig. 5D

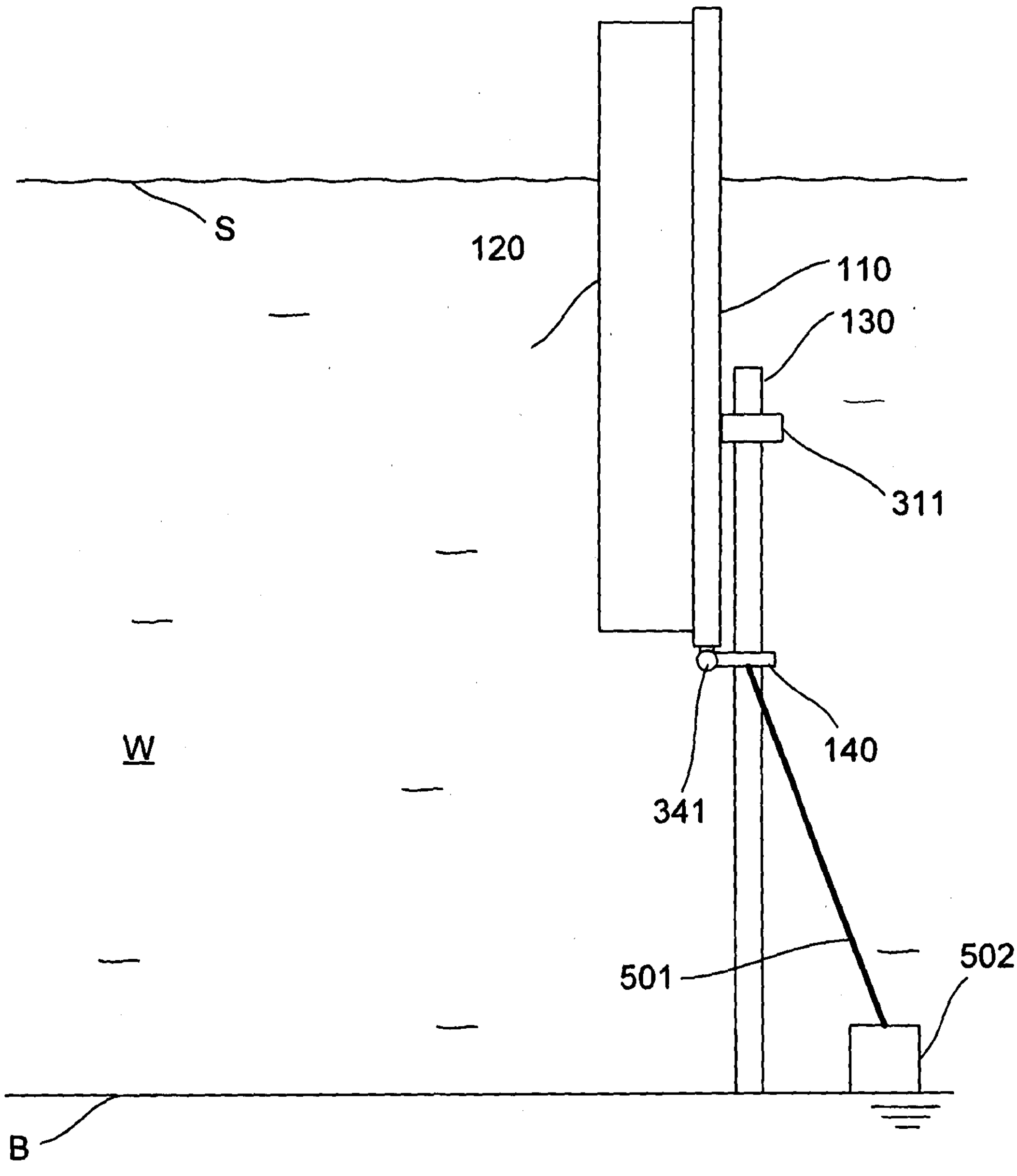

Fig. 5E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2013/000234

A. CLASSIFICATION OF SUBJECT MATTER

B63C 1/02 (2006.01) B63C 1/00 (2006.01) E02B 3/20 (2006.01) B63B 35/34 (2006.01) B63B 35/44 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC; IPC, CPC; B63C1/-, B63B35/-, E02B3/-; keywords; platform, submerge, post, restrain, float, gas, tilt, sensor, actuate and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2013	11 June 2013

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au Facsimile No.: +61 2 6283 7999	Savio Albuquerque AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832913

INTERNATIONAL SEARCH REPORT

International application No. **PCT/AU2013/000234**

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	US 6409431 B1 (LYNCH) 25 June 2002	
X	Abstract, figures 1-4 and column 3, line 9 - column 6, line 52	1-10, 18-25
Y	Figure 1 and column 3, line 59 - column 4, line 55	11-17, 30-36
	US 4938629 A (BOUDRIAS) 03 July 1990	
X	Abstract, Figures 1-11 and column 1, line 65 - column 4, line 42	1, 2, 6-10, 18-27
Y	Figures 1, 2, 4	11-17, 30-36
	US 4838735 A (WARNER) 13 June 1989	
Y	Abstract, figures 1-11 and column 2, line 48 - column 5, line 63	11-17, 30-36

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **28 and 29**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
See Supplemental Box

3. ☐ Claims Nos:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of **Box II**
Claims 28 and 29 do not comply with Rule 6.2(a) because they rely on references to the description and/or drawings.

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-27 are directed to a docking apparatus for positioning in a water body having a water level, the docking apparatus including a floatation chamber containing gas. The feature of "when the at least one floatation chamber ... platform to be submerged in the water body" (page 36, lines 6-11 of claim 1) is specific to this group of claims.

- Claims 30-36 are directed to a docking apparatus for positioning in a water body having a water level, the docking apparatus including hinges to allow the platform to tilt and at least one restraint for restraining the platform from moving axially relative to the posts. The feature of "only one side ... angle from the hinges" (page 39, lines 5-7 of claim 30) and "at least one restraint for restraining ... submerged in the water body" (page 39, lines 9-13 of claim 30) is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is *a docking apparatus for positioning in a water body having a water level, the docking apparatus including platform, the platform being connected to posts anchored to a water body bed such that the platform is substantially restrained from moving laterally relative to the posts and the platform is allowed to move axially relative to the posts; and, at least one flotation chamber for buoyantly supporting the platform.*

However this feature does not make a contribution over the prior art because it is disclosed in:
US 6409431 B1 (LYNCH) 25 June 2002

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/000234**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 6409431 B1	25 Jun 2002	US 6409431 B1	25 Jun 2002
US 4938629 A	03 Jul 1990	CA 1270655 A1	26 Jun 1990
		US 4938629 A	03 Jul 1990
US 4838735 A	13 Jun 1989	US 4838735 A	13 Jun 1989

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.