United States Patent [19]

Malkiel

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[45] **Feb. 26, 1974**

[54] **FLOATING BREASTING PLATFORM**

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[21] Appl. No.: **289,116**

[52] **U.S. Cl.** **61/46**

[51] **Int. Cl.** **E02b 3/22,** B63b 21/00

[58] **Field of Search**. 61/46, 46.5, 48; 114/219, 220, 114/230, 1 F; 9/8

[56] **References Cited**

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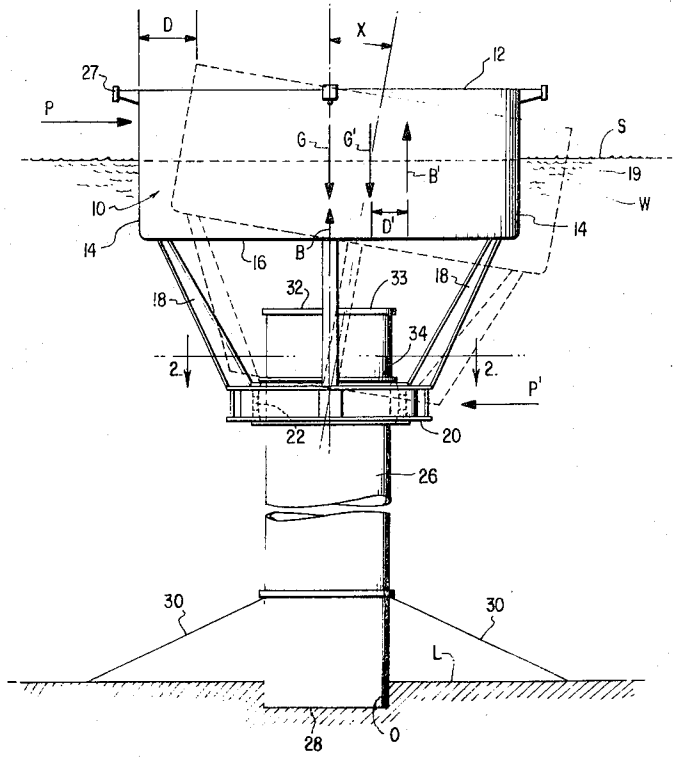
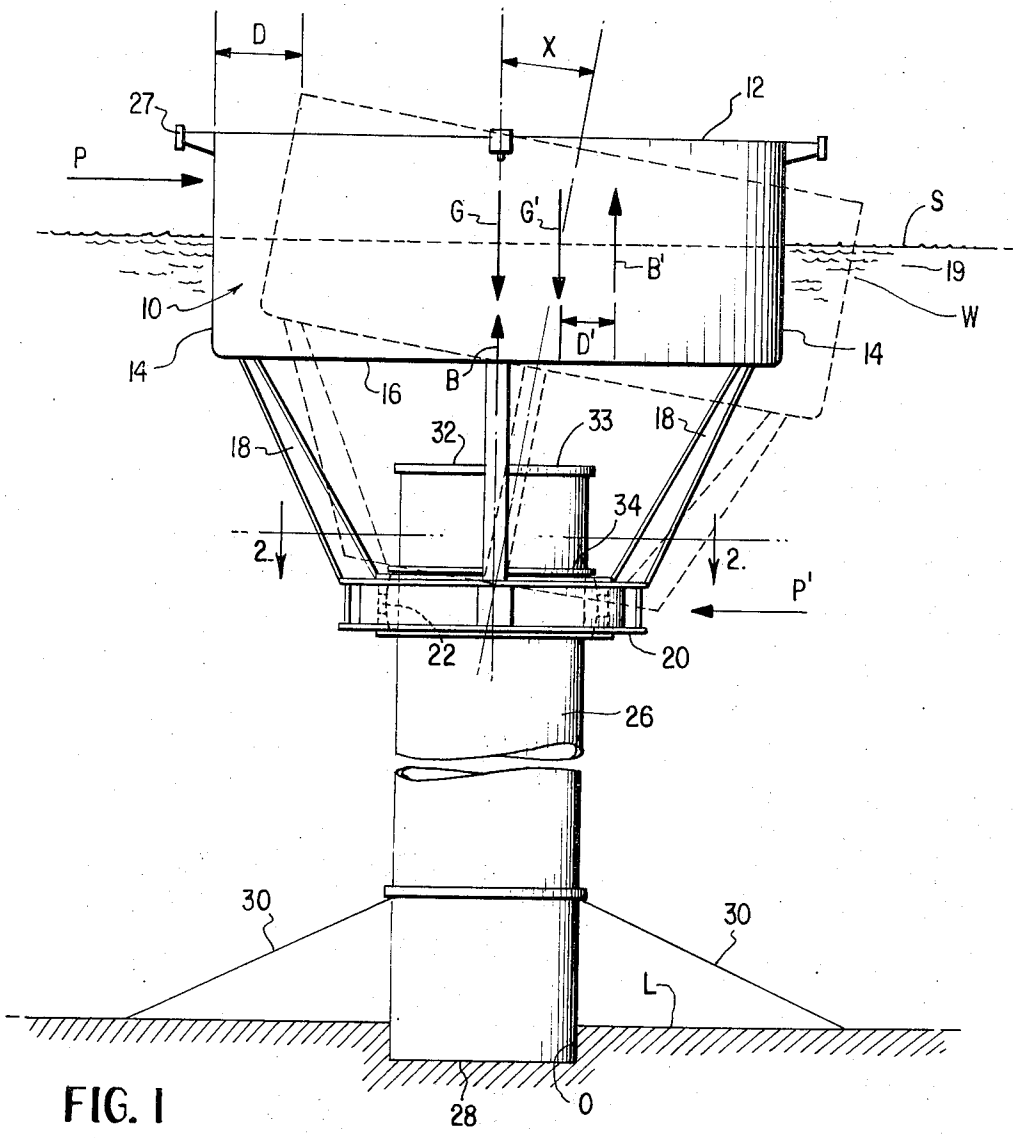
Attorney, Agent, or Firm—Hugo E. Weisberger

[57] **ABSTRACT**

A vessel-like floating platform, adapted for the breasting and berthing of transport vessels in a body of water at an offshore location and capable of resisting wave and impact forces and of adjusting to variations in water level, comprises a platform anchored or moored by a universal coupling to a vertical shaft embedded in the land surface underlying the body of water. The universal coupling comprises a downwardly extending outrigger structure which engages by means of a universal connection the surface of an annular member slidably mounted on the upper portion of the shaft, thereby enabling vertical, rotational, and angular movement of the platform and capability of adjusting to a position relative to prevailing wind, wave, and current forces for optimum in breasting the approaching vessels.

12 Claims, 10 Drawing Figures




D
X
27
12
P
G
G'
B'
S
19
W
10
14
D'
14
16
B
18
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33
18
34
2.
2.
P'
22
20
26
30
30
L
28
0

FIG. 1

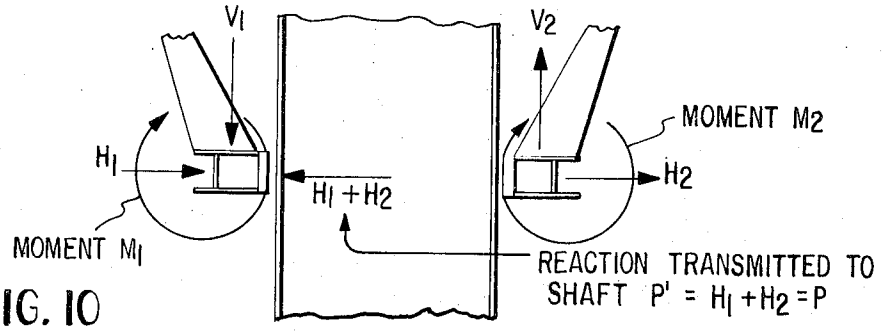
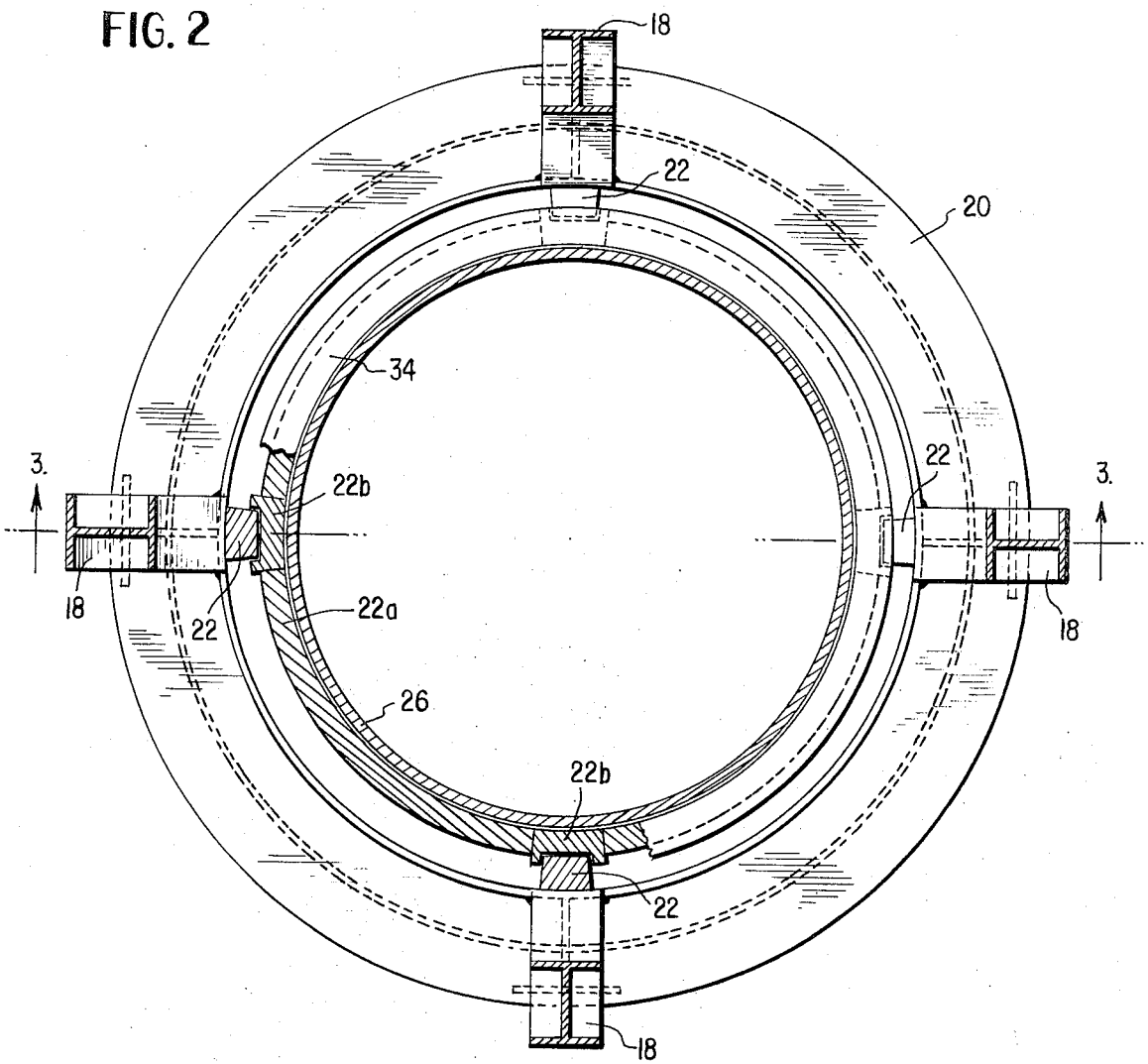

V1
V2
MOMENT M2
H1
H2
H1 + H2
MOMENT M1
REACTION TRANSMITTED TO
SHAFT P' = H1 + H2 = P

FIG. 10

FIG. 2


18
22
20
34
3.
22b
22
3.
18
22
22a
18
26
22b
22
18

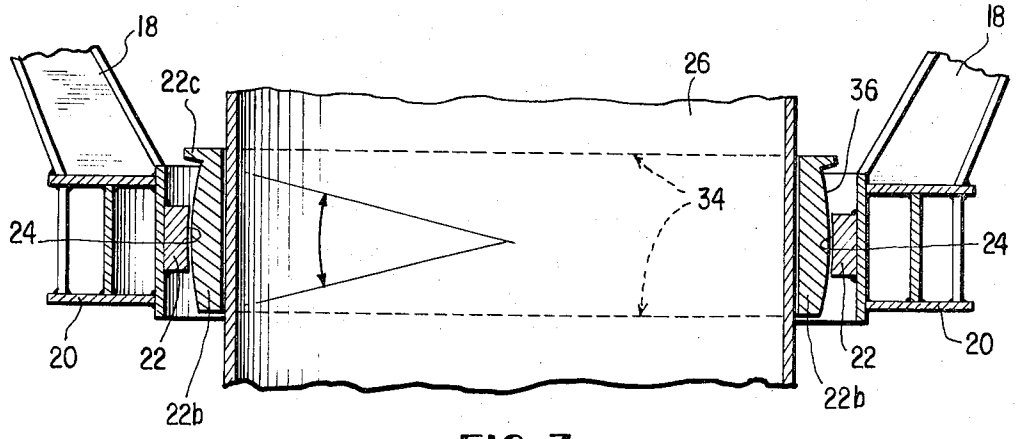

18
22c
26
36
18
34
24
24
20
22
22b
22
20
22b

FIG. 3

FIG. 4

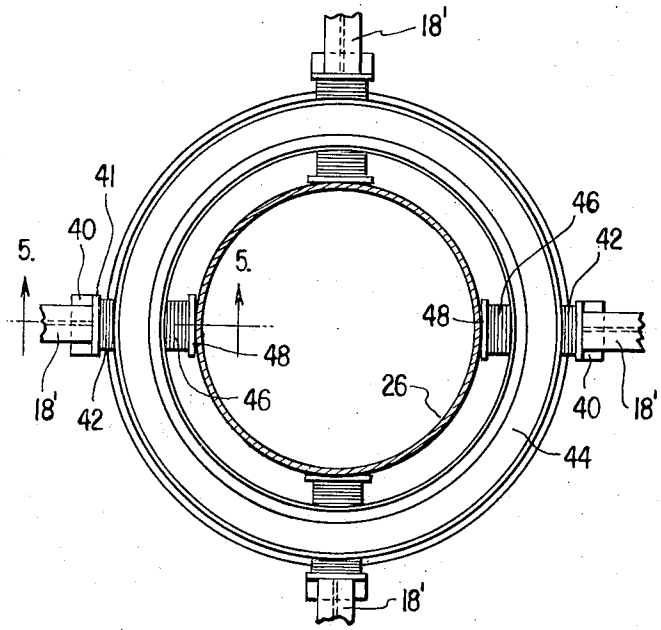
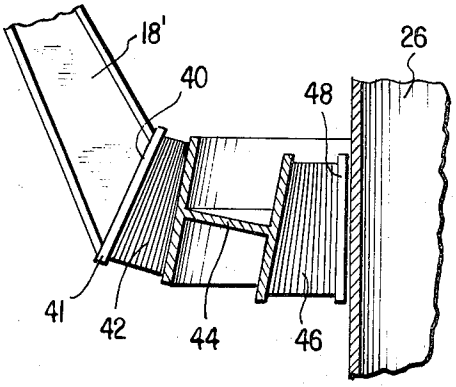


FIG. 5



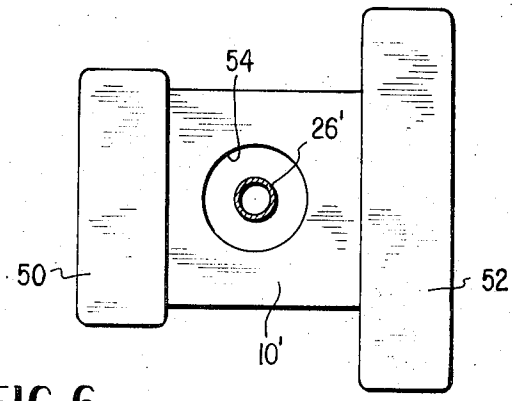


FIG. 6

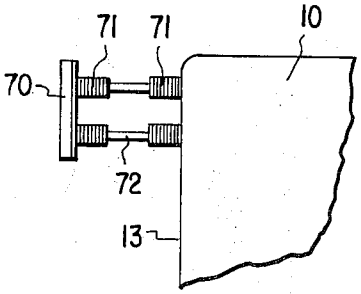


FIG. 8

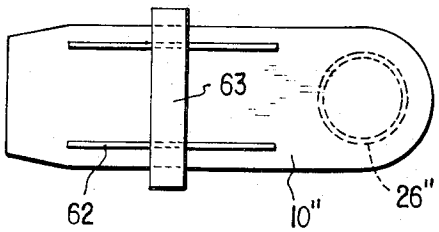


FIG. 7

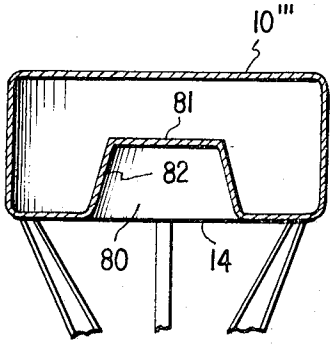


FIG. 9

FLOATING BREASTING PLATFORM

BACKGROUND OF THE INVENTION

The current efforts to achieve economies of scale in transocean shipping have been increasing in the direction of building ocean going vessels of increased deadweight tonnages as high as 500,000 dwt. Prominent among such vessels are the so-called supertankers, already in service or under construction for carrying oil from Middle East sources to ports in the Orient and Europe. Vessels of this size, holding from 2 to 3 million barrels of oil, may draw as much as 80 or 90 feet of water. Very few world ports, presently in existence, offer facilities capable of handling such supertankers. Existing ports on the East and Gulf coasts of the United States restrict vessels to a maximum of about 80,000 dwt, drawing not more than 45 feet of water.

In view of the prohibitive expense which would be involved in deepening the channels of most ports to accomodate the super-vessels, intensive studies are presently under way to find locations where offshore terminal facilities can be provided in semiprotected or sheltered waters which are deep enough to accomodate the super-tankers or other super-vessels. One approach to the problem has been to build artificial islands at close-in offshore locations, with approach channels provided by dredging to the site. Another approach has been to utilize natural deep-water harbors, having depths of 100 feet or more, but nearly all of these are in remote areas, necessitating trans-shipment of cargoes for long distances in smaller units which can be accomodated in existing coastal and inland waters.

A considerable body of technology has been developed which is concerned with the provision of floating vessels and platform structures adapted for supporting heavy equipment for off-shore petroleum exploration and recovery purposes, and having means for stabilizing the vessel or platform against the severe effects, such as rolling and pitching, induced by ocean waves and currents. However, most of these developments concern platforms and the like intended for operations such as oil drilling, on high seas where severe wave action is encountered permitting the stabilization of the platform in high seas but not suitable for breasting and berthing of vessels.

SUMMARY OF THE INVENTION

The present invention relates to a vessel-like floating platform to be maintained at an off-shore location, in water of sufficient depth to accomodate the breasting and berthing of transport vessels ,for transferring of cargo and the like, and which is capable of resisting moderate wave and impact forces arising from breasting of such vessels as well as from the sea natural conditions. The vessel-like floating platform is adapted for the breasting and berthing of other vessels at an off-shore location, particularly at locations in semi-protected or sheltered waters, and without the aid of tugs.

Such a vessel-like floating platform is suitable for operation in moderate seas such as may be encountered in offshore locations suitable for the transferring of petroleum products from supertanker vessels on-shore by a submarine pipeline or into smaller vessels or coastal barges, or for the transferring of bulk or containerized cargo from super-sized vessels to smaller

ocean going or coastal vessels. The floating platform is capable of supporting machinery and/or lifting equipment associated with such a transfer of cargo or petroleum products.

A facility according to the invention also may serve as a transfer and distribution center for crude oil or other petroleum products stored in submerged storage tanks or submarine pipelines. The floating platform includes apparatus and means for the breasting and mooring of vessels. The platform, in its make-up, also comprises an apparatus and means for resisting moderate wave and impact forces arising from the berthing and breasting of vessels.

In brief, the present invention is directed to an apparatus and method whereby a vessel-like floating platform is anchored or moored in a body of water having a moderate depth to a vertical pylon or shaft which is wholly or partially submerged and mounted on and restrained by the land formation underlying said body of water. The platform is mounted on the pylon or shaft by means of a unique downwardly and inwardly extending rigid structure which terminates in a concave bearing surface which engages an opposing bearing convex surface slidably mounted on the upper portion of the pylon or shaft. The arrangement is thus a type of universal coupling or connection. This arrangement permits both vertical and rotational movement of the platform, as well as a sufficient amount of angular movement away from the vertical position to allow the platform to adjust itself to variations in the sea level.

The provision of means for resisting such angular movement is based upon the principle that, under horizontal impact forces, delivered during berthing operations of another vessel at the platform edge, or by the impact of unrushing waves, the vessel-like platform will be laterally displaced at sea level with accompanying displacement of its centers of buoyancy; the displacement will take place along a nearly circular arc, with the center of rotation being the instantaneous intersection of the axis through contact area of the extending members with the center of the shaft. The displacement by impact forces will cause the vessel-like platform to tilt, thereby shifting the center of buoyancy relative to the center of gravity and thus will induce a torque of a force couple reacting to restore the unbalanced equilibrium of the platform.

The displacement of the buoyancy force relative to the equal but oppositely acting gravitational force of the platform represents a mechanism to store potential energy in the platform to offset the input of the kinetic energy of the impact forces. This conversion of the delivered kinetic energy into stored potential energy may be considered as comparable to the action of a pendulum which, at rest, if subjected to a lateral impact force, will swing outward, and will be forced back to its original position by the potential energy stored in the pendulum.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in elevation of an illustrative embodiment of the present invention showing the floating platform mounted on the supporting shaft;

FIG. 2 is a cross-sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a fragmentary cross-sectional view taken on line 3—3 of FIG. 2;

FIG. 4 is a cross-sectional view similar to FIG. 2 but showing a modification;

FIG. 5 is a fragmentary cross-sectional view taken on line 5—5 of FIG. 4;

FIG. 6 is a plan view of an alternative embodiment in which the floating platform is provided with central opening through which the shaft extends upward, and

FIG. 7 is a plan view of still another embodiment in which the shaft is in off-set position with respect to an elongated platform;

FIG. 8 is an elevational view, partly in cross-section showing means for fendering vessels against the platform, and

FIG. 9 is an elevational view, partly in cross-section, of an alternate form of the floating platform in which the lower portion is provided with a recess to accomodate the upper end of the shaft, and

FIG. 10 shows diagrammatically the various forces acting upon the bearing portion.

DETAILED DESCRIPTION OF THE INVENTION

Referring now in detail to the drawings, specifically to FIG. 1, a buoyant floating platform **10**, shown partly submerged below surface S of a body of water W, is vessel-like in character, may have any suitable shape, and be made of any suitable material, advantageously a steel hollow hull ballasted as necessary to effect suitable draft. The platform **10** is provided with an upper deck **12**, which may serve as a stage for handling cargo, or for supporting cargo handling machinery and equipment, oil products, pipes, and the like. The platform also comprises sidewalls **14** and a bottom wall **16**. Secured to the submerged bottom wall **16** or adjacent portion, is a plurality of downwardly extending strut members **18**, terminating into a rigid circular ring girder **20** having a concave bearing surface **24** (as shown in FIGS. **2** and **3**). The downwardly extending members **18** will induce strains which will be equalized by the rigidity of the ring girder.

Positioned beneath the floating platform is a vertical pylon or shaft **26** which is suitable anchored to the bottom or land L underlying the body of water W in which the platform floats. This anchoring may be by sand or gravel ballast, or by means of an excavated opening O in the underwater bottom L into which the lower end **28** of the shaft is inserted. The length of the shaft typically will be about 70 to 80 feet, for the type of service contemplated by the invention.

The shaft may be hollow to accommodate a submarine oil pipe or pipes, or else it may advantageously be filled with concrete to provide greater weight to the shaft. The shaft may be supported in vertical position by additional guys **30** anchored in the sea bottom L.

The top **32** of the shaft will usually be at a substantial distance below the water surface, allowing for an appropriate tidal difference. It is sealed by a suitable closure **33**. The diameter of the shaft may range from about 2 to about 30 feet, depending upon requirements and upon whether it is employed in relative close-in coastal service, or at some distance offshore, say as much as 2 to 3 miles offshore. In any event, there is provided a distance between the top **32** of the shaft and the bottom **16** of the floating platform, to permit of clearance when at low tide the platform is tilted by reason of forces produced by the berthing of a vessel or by wave action, or both.

As shown in FIGS. **1** and **3**, an annular journal member **34** is slidably mounted on the column **26** to permit of vertical movement of said member. The journal member **34** has a convex outer surface **36** engaged by the opposing concave surfaces **24** of the bearing members **22**, with sufficient clearance to permit universal movement therebetween, while at the same time remaining anchored to the column. The bearing members **22** are mounted at suitable intervals on the inner portion of the rigid circular ring **20**, being spaced apart as shown in FIG. **2** to maintain relationship between the bearing parts **22** and portions **22*b*** of journal **34**. In this respect the ring and bearing assembly function in a manner similar to a ball-and-socket joint. This arrangement permits angular, vertical, and rotational movement of the platform with respect to the shaft, in response to external lateral and vertical forces previously described. The details of this arrangement are shown more clearly in FIG. **3**, which depicts an embodiment in which bearing members **22** at their outer end are seated in a recess set into the face of portions **22*b*** of journal **34** which provides the actual bearing surfaces. The bearing surfaces **22*b*** are spaced laterally by arcuate portions **22*a*** of journal **34**, and each has a detent **22*c*** at its upper end to prevent disengagement of bearing members **22** from the surface of members **22*b***, due to variations in clearance between members **22** and **22*b***.

As shown in FIG. **2**, four outrigger strut members advantageously constitute a set, but the invention is not to be regarded as limited thereto.

Thus, referring to FIG. **1**, if the platform **10** is subjected to a lateral impact force P it will be displaced by the distance D. Such displacement will affect the center of buoyance B, causing it to shift to position B′, and the gravitational force G to shift to position G′. The forces B′ and G′ will remain equal and opposite, acting at a distance D′ to create a reacting torque to restore the platform to its original equilibrium, which will also induce a reaction force P′ at the point of contact of the outrigger arms with the annular bearing surface, equal and opposite to impact force P.

The effect of the various forces acting upon the bearing portion, and particularly upon ring girder **20**, is illustrated in FIG. **10**. Three sets of forces are involved: (a) transitory couple V_1 and V_2 which induce rotational motion along bearing surface **24**; $V_1 = V_2$; (b) Moments M_1 and M_2 which are equal and acting oppostie will strain the rigid ring girder **20**; and (c) H_2 will constitute a pulling force transmitted through the ring girder to opposite side where $H_1 + H_2 = P'$ will be transmitted to the shaft **26**.

As shown in FIG. **3** the assembly of ring girder **20**, and bearing components **22** and journal **34** are free to slide and to rotate on the shaft **26**, and may be made of metal or of an elastomeric material, such as synthetic rubber. Clearance between the shaft **26** and ring may be, for example, about 1/16 inch. The convex surface **36** of the journal member **34** is adapted freely to engage corresponding concave surfaces **24** of bearing components **22** positioned at intervals on ring girder **20**, which may also be made of metal or rubber, and having a similar clearance distance.

A modification of the universal connection between the struts **18** and the shaft **26** is shown schematically in FIGS. **4** and **5** utilizing four elastomeric bearing members **40**. Each member comprising a bearing plate **41**,

fixed to the inner end of each strut, which plate **41** has bonded thereto an elastomeric bearing **42** that in turn, is bonded to the outer circumferential surface of a rigid ring **44** surrounding, in spaced relation, the shaft **26.** Similar elastomeric bearings **46** are bonded to the inner circumferential surface of the ring **44** and have wear plates **48** bonded to their surfaces opposite the ring **44** for sliding engagement with the shaft **26.** The elastomeric bearings **42, 46,** may comprise blocks of elastomeric material laminated with or having embedded therein reinforcing sheets or plates. As the blocks are elastic in nature they accommodate a universal flexing between the struts and the shaft while the plates **48** enable rotary and vertical movement according to environmental conditions.

Elastomer bearings are well known in the art, and are described, for example, in the article by C. Rejcha, entitled "Design of Elastomer Bearings", in J. of the Prestressed Concrete Institute, Vol. 9. No. 5, pages 62–78 (Oct., 1964). A plain elastomer bearing is provided by a single homogeneous neoprene or rubber bearing pad. A laminated elastomer bearing is composed of a multiplicity of neoprene or other synthetic rubber layers, approximately ⅜ to ¾ inch thick, bonded to metal plates.

Obviously, the platform **10** may comprise many variations to accommodate particular functions. For example, as shown in FIG. **6,** the platform **10** may be provided with berthing stations **50, 52** of different sizes or configurations, and/or it may have a well or opening **54** freely surrounding the shaft **26** which may extend above the water surface S of the water and support various equipment. This permits the shaft itself to be utilized as a support for cargo-handling machinery. Another modification is shown in FIG. **7** wherein the platform **10''** is elongated and the shaft **26''** is disposed adjacent one end thereof.

It is to be observed that any platform of a rectangular or elongated shape, or of any symmetrical shape in which the shaft is eccentrically located, will tend to rotate under the influence of current and wind forces, positioning itself in the direction of the least resistance, meaning in the direction of the prevailing forces, which would be the optimum position for the berthing of vessels. It is a fact that for optimum conditions in berthing and removal, vessels should be positioned against prevailing current and wind forces. The ease of rotation of the platform will always facilitate a positioning of the platform and the berthed ships in line with the prevailing wind and tidal forces, thus eliminating the difficulty experienced in stationary berthing facilities during removal of vessels, or docking of vessels in the direction of prevailing forces, without appropriate assistance of tugs.

In FIG. **7, 63** represents a gantry crane, and **62** represents a set of rails therefor.

In FIG. **8** there is illustrated a form of a fendering or bumper arrangement shown generally at **27** in FIG. **1,** for assisting in the berthing of vessels alongside the platform and to protect both platform and vessel. In the embodiment of FIG. **8,** this comprises a pair of struts **72** having elastomer blocks **71** at each end. The struts are mounted on the upper portion of the platform sidewall **13,** and carry a fendering member **70** at the outer ends.

FIG. **9** illustrates another form of floating platform **10,** in which the bottom of the platform **14** has in its central portion a hollow upwardly extending section **80,** having a top **81** and walls **82,** into which the top of the vertical column can extend so as to permit closer coordination of platform and column.

The mode of operation of the apparatus of the invention comprises anchoring the vertical column at a preselected location to the land surface underlying the body of water and then connecting the platform thereto via the outrigger and bearing structures.

What is claimed is:

1. In an apparatus for the berthing or breasting of other vessels in a body of water at an offshore location and capable of resisting wave and impact forces, and of adjusting to variations in water level, and maintaining approximately a uniform vertical relation with such vessels, the combination of:

a. a buoyant platform to float in a body of water;

b. a support column for said platform set substantially vertically in the body of water; and

c. means anchoring said platform on said column at a position adjacent the top of the column to enable vertical, rotational, and angular movement of said platform according to environmental conditions, said means comprising an outrigger structure extending downwardly from said platform and secured by a universal connection slidably mounted on and vertically movable about the outer surface of said column.

2. The apparatus of claim **1** in which said universal connection comprises a vertically slidable annular member having a convex outer surface and said outrigger structure has a concave surface engaging said annular member, permitting free movement of the outrigger structure and its associated platform.

3. The apparatus of claim **2** in which said annular member is segmented, with at least two of its segments having a convex outer surface.

4. The apparatus of claim **2** in which said outrigger structure comprises at least one pair of downwardly and inwardly extending rigid members which terminate in a concave bearing surface to engage said annular member.

5. The apparatus of claim **1** in which said universal connection comprises at least one pair of opposing outrigger members, an annular member slidably mounted on said column, said outrigger members being connected to said annular member by elastomeric bearings.

6. The apparatus of claim **2** in which said annular member comprises a rigid ring member adapted to support on the outer surface thereof an elastomeric bearing assembly connecting said outrigger structure thereto, and on the inner surface thereof an elastomeric bearing between said ring and said shaft.

7. The apparatus of claim **1** in which said vertical column is embedded in the land surface underlying said body of water.

8. The apparatus of claim **1** in which the top of said vertical column is below the water surface.

9. The apparatus of claim **1** in which the top of said vertical column extends above the water surface and said platform includes a central opening adapted to receive said column and through which the column extends.

10. The apparatus of claim **1** in which the lower portion of said platform is provided with a recess to accommodate the upper end of said vertical column.

11. The apparatus of claim 1 in which the outrigger structure is mounted on said platform in an offset position with respect to the vertical axis through the center of gravity of the platform.

12. The apparatus of claim 1 in which said universal connection comprises an annular member slidably mounted on said column, a plurality of bearing members on said annular member and each having a convex outer surface, and a corresponding plurality of bearing blocks on said outrigger structure and each slidably engaging the convex surface of a bearing member.

* * * * *