# United States Patent

**Mott**

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## [54] ANCHOR FOR BUOYANT MARINE STRUCTURES


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[51] **Int. Cl.** .....**B63b 35/44**, B63b 21/50

[58] **Field of Search**.....61/46, 46.5, 82; 114/.5 D, 114/206; 9/8 OP



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[57] **ABSTRACT**

The invention relates to a buoyant marine platform for positioning in a deep water offshore location. The platform includes buoyancy control means whereby to regulate the attitude of the unit at the water's surface as well as when submerged. The platform lower end is provided with an anchoring member adapted to seat, and be partially imbedded into a sloping or contoured ocean floor. Said anchor member comprises separate, yet cooperating components which permit adjustment of the anchor's disposition while at the ocean floor, to operably engage and fixedly position the buoyant platform.


**10 Claims, 6 Drawing Figures**

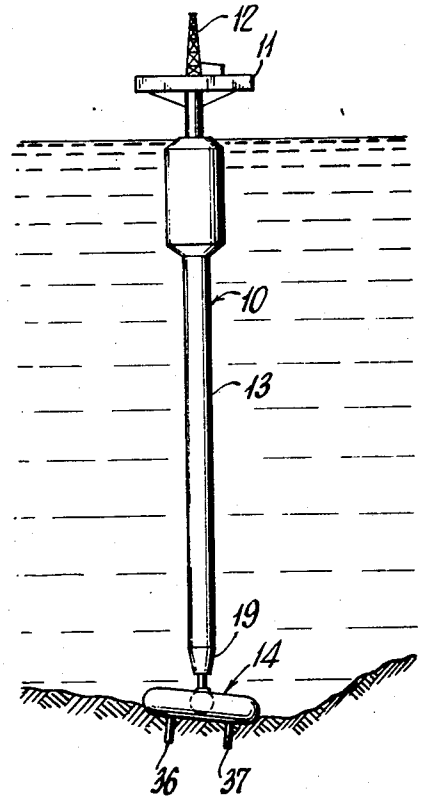


Fig.1

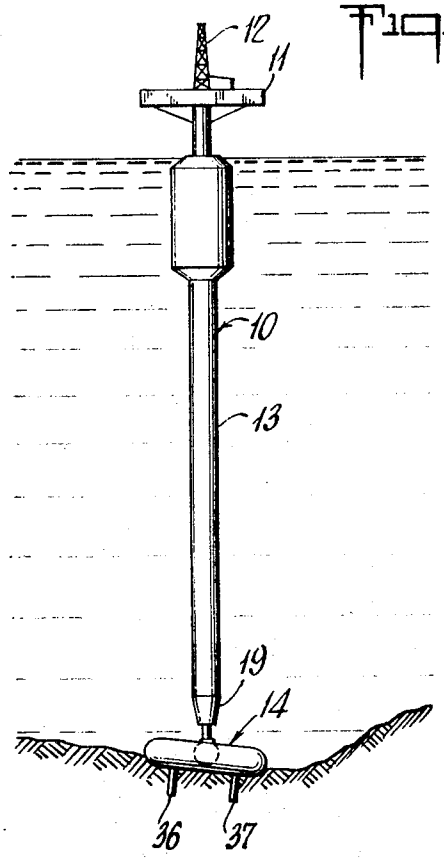



Fig.4

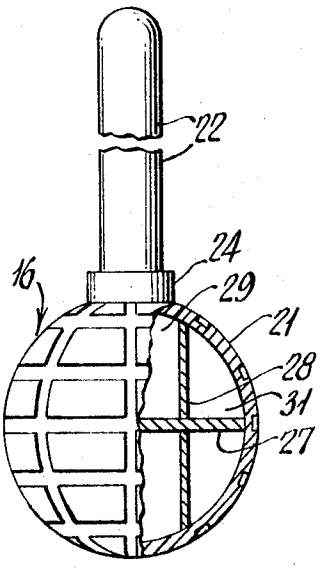



Fig.2.

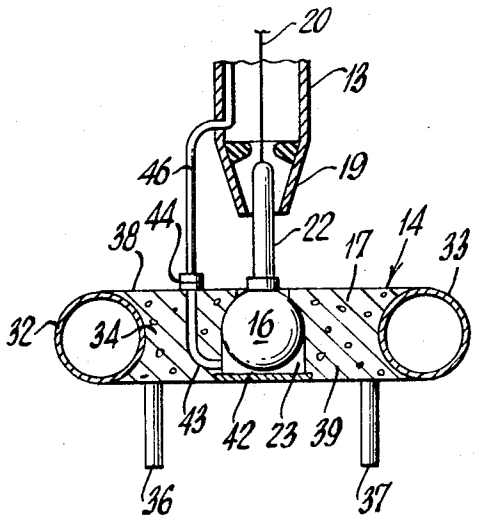



Fig.3.

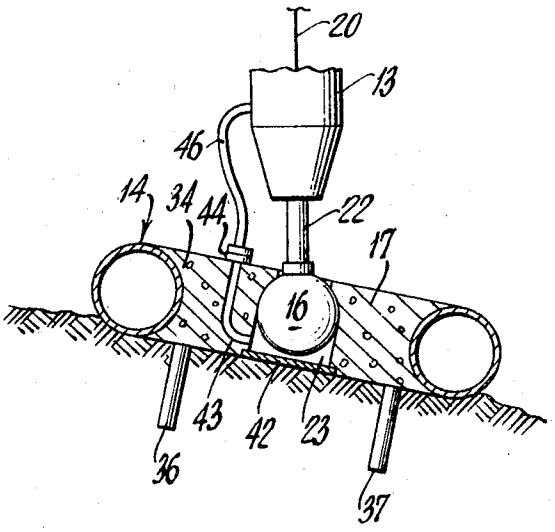


Fig. 5.

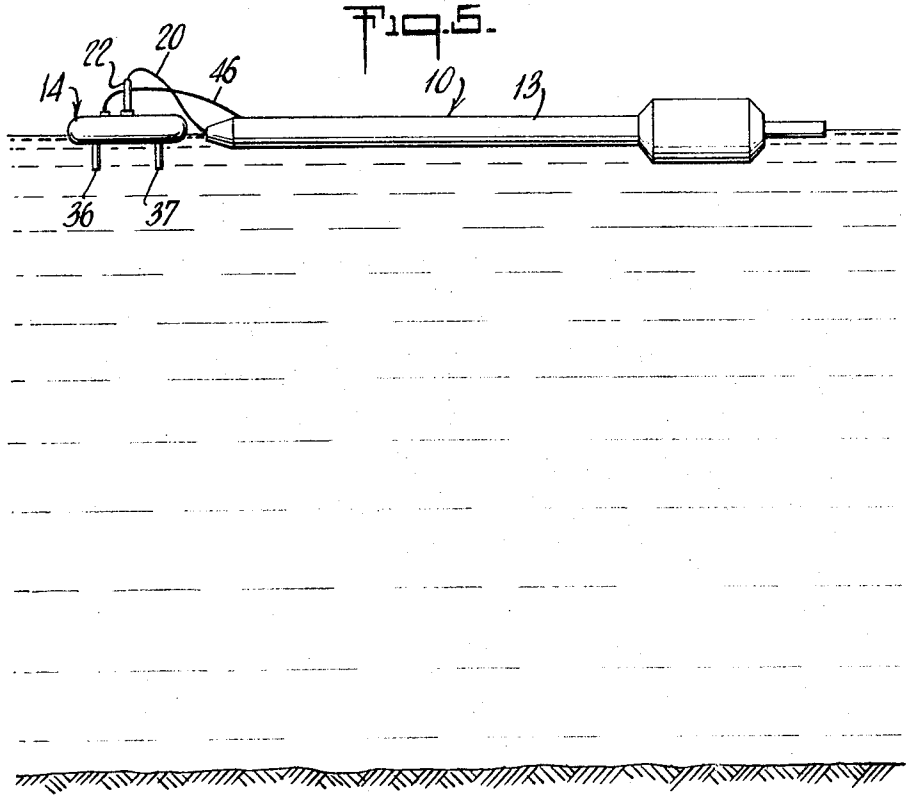
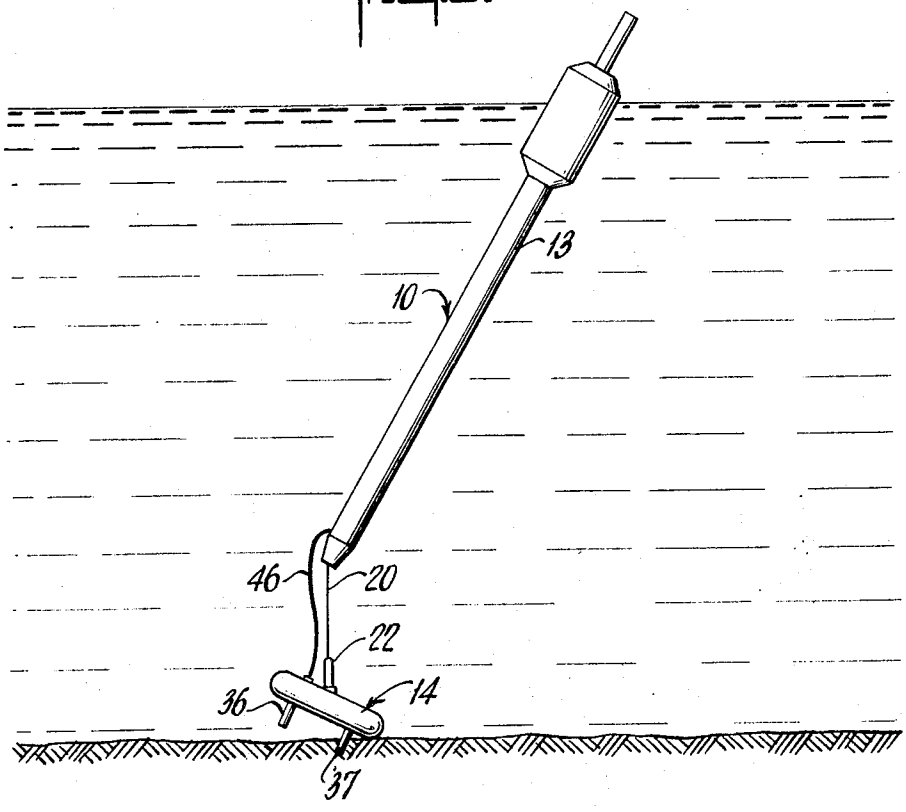



Fig. 6.



# ANCHOR FOR BUOYANT MARINE STRUCTURES

## BACKGROUND OF THE INVENTION

In the drilling for and producing of oil, gas, and other petroleum based fluids from offshore sites, it has been found feasible under certain conditions to utilize a floatable rather than a fixed platform. Such a platform is usually tethered by an elongated rigid structure as to be buoyant while being connected at its lower end to an anchoring or foundation member. Operations such as drilling and producing of oil and gas wells can then be readily achieved from a work deck supported atop the buoyant structure.

Because of its great size and weight particularly in deep water, positioning of the foundation member constitutes a substantial engineering problem. Toward at least partially overcoming this problem it has been determined that the anchor or foundation member, can be economically floated into place and thereafter submerged to a desired site. With the anchor thus partially imbedded into the ocean substratum, the platform or rigid connecting member is guided to and operably engaged at its lower end to the anchor. The connection means joining the platform and foundation member must be pivotable to absorb displacing forces such as wind, water currents, waves and the like. Further, said connection must be versatile as well as being readily adapted to encounter adverse weather conditions at the water's surface.

Additional problems inherent to the use of such an anchoring arrangement, particularly in deep water, are topographical irregularities which characterize the ocean floor. Such irregularities comprise not only a generally uneven surface, but may be in essence a gradual or steep grade. For example, certain sections of the Continental Shelf or the Outer Shelf are at such a grade as to prohibit an ordinary foundation base from assuming a level attitude.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical elevation illustrating a marine platform of the type contemplated buoyantly anchored in a body of water.

FIG. 2 is a segmentary view on an enlarged scale and in cross-section of the anchor member shown in FIG. 1.

FIG. 3 is similar to FIG. 2 illustrating the anchor member partially imbedded in the substratum.

FIG. 4 is an enlarged view in partial cross-section of the anchor coupling shown in FIGS. 2 and 3.

FIG. 5 is a side view of the marine platform shown in FIG. 1 as the platform and anchor are floatably positioned on the water's surface, and

FIG. 6 is similar to FIG. 5 illustrating the platform during the step of being uprightly positioned in a body of water.

The invention provides a novel, controllably buoyant marine platform for an offshore location. The platform includes an elongated support structure that extends from a distance above the water's surface, to the ocean floor. The structure is normally buoyantly positioned in the water and fixed at its lower end to a single anchor. The latter includes a substantially upstanding connecting member, and a base that firmly rests on the ocean floor while maintaining the connecting member in its normal upright disposition. The connecting member is adapted to operably engage the lower end of the buoyed structure whereby the latter can oscillate in the water, through a limited radius about the anchor. When properly positioned, the connector member and base member are firmly unitized to prevent relative movement therebetween.

As seen in FIG. 2, prior to being unitized at the ocean floor, the anchor includes a central coupling member having means depending from the upper end to engage and operably hold the lower end of a floatable marine structure. The coupling element, comprising a spherical or hemispheric unit, is movably held within a cavity formed within the anchor member. When ultimately positioned to most conveniently engage a floating or buoyant structure, the cavity formed within the anchor is filled with a hardenable material to fixedly imbed the coupling member, and to establish its position for best accommodating said structure.



As shown in FIG. 1, in a typical offshore installation utilizing the present anchor or foundation member, a buoyant marine platform 10 is utilized for drilling one or more subterranean wells into the ocean stratum. The surface of the latter as shown, is unevenly disposed at an exaggerated slope or grade. Platform 10 includes a working deck 11 holding a derrick 12, draw-works, and other equipment peculiar to an oil drilling and/or producing operation. Deck 11 is normally supported 50 or 60 feet above the water's surface to maintain equipment and men beyond the reach of high waves during severe weather conditions.

Deck 11 is supported at its desired height by an elongated deck supporting structure 13 which includes one or more legs that extend downwardly from above the water's surface, to the ocean floor. Said structure 13 is made controllably buoyant by the use of a ballasting system incorporated into the structure. The system includes primarily, longitudinally spaced buoyancy tanks which are readily controlled to regulate the attitude of structure 13 either uprightly as shown in FIG. 1, or at the water's surface as shown in FIG. 5.

Under normal operating conditions, by altering the buoyancy of the floor supported anchor member 14, and by adjusting the buoyancy of support structure 13, the latter is caused to slowly submerge and assume a generally vertical disposition at the offshore site from the horizontal towing position shown in FIG. 5. Thereafter, the structure's lower end is engaged with the imbedded anchor 14 and retained by one or more flexible lines 20. Thus, the platform including deck 11 and support structure 13, can oscillate in the body of water over a predetermined degree of lateral displacement while still maintaining sufficient stability to carry on operations at the deck level.

In the shown arrangement, platform 10 is anchored in place. However it is appreciated that the entire structure 13 is subjected to continuous tidal movement within the range of at least several feet, up to approximately 30 feet of height depending on the location of the offshore site and the weather circumstances. It is therefore necessary, in order to achieve the desired degree of stability in the platform's vertical disposition, that the lower end of support structure 13 be operably retained rather than merely connected firmly to anchor 14.

Referring to FIG. 2, the floor positioned anchor 14 comprises a plurality of discrete, though cooperatively arranged elements. Said elements include basically a coupling 16 and a ballastable retainer 17. The latter embodies controllable flotation tanks which can be flooded to provide the necessary weight to anchor 14 whereby to submerge and hold the entire unit at the ocean floor.

Referring again to FIG. 2, an embodiment of coupling 16 includes an enlarged body 21, adapted by virtue of its discontinuous outer surface to be movably confined within the floating ballast or base section 17. Body 21 is initially slidably confined within cavity 23 to permit connecting post 22 to assume a desired disposition. Preferably, such disposition is finalized with connector post 22 aligned in a generally vertical disposition. When so positioned, connector post 22 will slidably engage a corresponding sleeve 19 at the lower end of the support structure 13.

Body 21 of coupling member 16, can include a variety of geometric configurations which, in the instance of the present device, are spherical, hemispherical or similarly contoured. The function of curved body 21 within the scope of the invention is to afford coupling member 16 a degree of universal movement within the confines of cavity 23 prior to being cemented or otherwise unitized into place. It is appreciated that although body 21 as illustrated bears a generally spherical configuration, such a geometric shape is primarily to foster sliding movement between the body upper surface, and the adjacent surrounding cavity walls 23. Such movement could be achieved in a manner of fashion by the mating of non-

spherical, although similarly contoured adjacent rubbing surfaces.

Connecting posts 22 depending upwardly from the surface of body 21, are firmly imbedded in the latter. A hub 24 at the lower end of the connector post defines an intermediate collar between the post lower end and the surface of said body 21. Connector post 22 comprises a generally elongated, uniform diameter cylindrical element shaped to register within sleeve 19 of support structure 13.

Prior to being cemented at the ocean floor, body 21 is upwardly supported in slidable engagement with the walls of cavity 23. Thus, by exerting upward tension along support cable 20 and post 22, ballast member 17 can adjust its attitude upon encountering a contoured ocean floor, regardless of the topography of the latter. Further this adjustment will be achieved independently of the position of body 21 which supports ballast member 17.

Toward achieving a more firm connection between coupling 16 and retainer cavity 23, the outer surface of body 21 is provided with a series of surface depressions 26. Said depressions can achieve the same effect by assuming the form of a series of projections extending outwardly of the surface whereby affording the cement binder a greater holding area.

In one embodiment of body 21, the latter is formed of steel plate so contoured and welded together to permit the upper surface to be slidably received as noted above, within a corresponding surface of cavity 23. Further, the body interior is compartmented by transversely positioned gussets or panels 27 and 28 respectively placed to define individual chambers 29 and 31. Said panels are appropriately placed to brace and strengthen the walls of the body.

Although not illustrated in detail, internal compartments 29 and 31 of body 21 are mutually communicated through wall openings with cavity 23. Thus, as the latter is filled with fluidized cement, the overflow will enter said compartments 29 and 31 to harden into a firm mass. This will not only add weight to the anchor, but will provide a greater degree of binding to secure body 21 within cavity 23.

The major portion of anchor 14 includes the foundation or retainer 17 that partially encloses body 21. Said retainer 17 comprises a peripheral frame formed of interconnected buoyancy tanks 32 and 33. The latter are communicated with a buoyancy system extending to and actuated at the water's surface whereby said tanks 32 and 33 can be flooded or evacuated if required.

A central foundation pad 34 is disposed within the peripheral rim defined by tanks 32 and 33. Said pad is fabricated of reinforced concrete and designed with a sufficient volume to afford anchor 14 the necessary weight to achieve its anchoring function. Pad 34 includes one or more cylindrical stub piles 36 and 37 which depend from the pad's undersurface. Thus as the anchor retainer is lowered to the ocean floor, the stub piles will be urged by the weight of pad 34 into the substratum whereby to prevent lateral displacement of the anchor.

Pad 34 is generally planar, and formed of cast concrete having an outer edge that conforms to and engages the peripheral tanks 32 and 33. The pad is provided with centrally disposed cavity 23. The latter extends intermediate the pad's upper and lower surfaces 38 and 39 respectively. Said cavity 23 is formed with a constricted opening 41 at the pad upper face 38, which opening is sufficiently large to register post 22 and hub 24, while permitting sliding movement of coupling member 16 within cavity 23.

Cavity 23 is formed in concrete pad 34, having an upper bearing surface that substantially conforms in contour to the corresponding upper surface of body 21. Thus, when said body 21 assumes a spherical disposition the contour of cavity 23 will similarly comprise a spherical segment. However, said cavity will be sufficiently greater than the diameter of body 21 to permit the latter to slidably adjust within the cavity.

From a spherically contoured upper surface, cavity 23 opens into a cylindrical segment which extends to the lower surface 39 of pad 34. A bottom plate 42 is received in the walls of said cavity lower end forming a closure to the latter. When anchor 14 is at the water's surface, coupling 16 is supportably confined within cavity 23 by said bottom plate 42.

Pad 34 is provided with a conduit 43 which extends through the pad and opens at the discharge end into cavity 23. The upper, external end of the conduit 43 is provided with a flange 44 adapted to removably engage a mating flange of cement conductor 46. The latter depends from support structure 13 and is communicated with a cement source at the water's surface whereby a pressurized flow of fluidized cement can be directed to cavity 23.

Functionally, when connector 16 is properly aligned at the ocean floor to dispose post 22 in a generally upright position a flow of cement is introduced to the lower end of cavity 23. Cement will thus fill the cavity, both beneath body 21 and in the interspace formed between said body and the walls of cavity 23. As the cement sets, body 21 will be rigidized with pad 34 whereby the post 22 will be firmly held in said upright disposition. When so aligned, sleeve 19 of structure 13 can be slidably engaged with the post as the entire structure 13 is controllably lowered into the water.

In the procedure for installing the subject platform at an offshore body of water, normally the platform as well as the anchor is fabricated and assembled onshore or close to shore in relatively shallow water. The unit is then buoyed to a desired attitude by selective flooding and evacuating of buoyancy tanks placed discretely about and within the structure. While the platform is completely buoyant, it is understood that it can also be transported to a desired offshore location by barging if the latter system proves to be more feasible.

Anchor 14 and platform 10 are flexibly connected by line 20 which is attached to post 22 and passes through the entire length of structure 13, to the upper end of the latter. When so positioned, both the floating anchor and the floating structure 13 are towed at the water's surface, to a desired offshore location where the unit is to be submerged.

Prior to being submerged, cement conduit 46 is communicated with the corresponding conduit 43. By adjusting coupling 16, retainer 17 to negative buoyancy, and altering the buoyancy of structure 13, the entire unit will sink toward the ocean floor such that the platform as a result of its upper end positive buoyancy, will assume a substantially vertical disposition in the water. The buoyancy of the platform is thereafter maintained such that anchor 14 is suspended by flexible line 20.

With the platform so floatably positioned, anchor 14 is lowered to the ocean floor which, as previously noted is presumed to be of irregular topography such that ordinarily the anchor would not assume a planar disposition. The weight of the anchor will exert a sufficient downward pressure on piles 36 and 37 such that the latter are urged into the relatively soft substratum, the consistency of which has been predetermined by coring or similar means.

With retainer 17 at least partially imbedded in the substratum, aligning of post 22 in an upright position is achieved by exerting an upward tension on line 20. Such action forces the entire coupling into a vertical disposition by virtue of its sliding relationship within the cavity 23.

When a point of stability between the anchor and coupling is reached, cement is forced from the water's surface, through conductor 46 and conduit 43. The cement will fill the entire cavity 23 from bottom plate 42 upward between the adjacent coupling and cavity walls, excess cement overflowing through opening 41. With the cement eventually hardened, and the post 22 positioned vertically, buoyancy of structure 13 can be adjusted such that the sleeve 19 at the structure lower end slidably engages post 22.

Subsequent movement of the platform due to lateral forces exerted by wind and water currents will allow the platform a limited degree of movement about the lower joint as well as horizontal movement due to wave variations.

Obviously many modifications and variations of the invention, as hereinafter set forth, may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. The combination with a marine platform adapted to be buoyantly positioned at an offshore body of water, and including a submerged lower portion having a detachable connector means of;

a mooring anchor depending from said platform lower portion and comprising an upstanding coupling adapted to operably engage said detachable connector means, and a weighted retainer initially operably engaging said coupling member to stabilize the disposition of said coupling in an upright alignment when submerged to the floor of said body of water and

means for introducing a solidifiable material to said retainer whereby to solidify intermediate said coupling and retainer respectively to form said members into a unified anchor.

2. In the combination as defined in claim 1 wherein said retainer includes; buoyancy means, controllable to regulate the buoyant condition of said mooring anchor.

3. In the combination as defined in claim 1 wherein said retainer includes; a base member having opposed upper and lower faces, at least one buoyant tank connected to said base to controllably alter the buoyant force acting thereon whereby to control the attitude of said anchor.

4. In the combination as defined in claim 3 wherein; said at least one buoyancy tank is disposed peripherally of said base member.

5. In the combination as defined in claim 3 wherein; said base member includes means forming a cavity therein, said coupling being initially slidably received in said means forming said cavity to permit adjustment of the connector to an upstanding disposition prior to introduction of said solidifiable material to said base member.

6. In the combination as defined in claim 3 wherein, said base member includes; means forming a cavity therein, and an opening communicating said means forming said cavity with said upper retainer surfaces, said connector including a body contained in said cavity, and a post depending from the body in registry with said opening and extending upwardly from said anchor.

7. In the combination as defined in claim 6 wherein; said means forming said cavity and said body are provided with similarly contoured surfaces adjacently disposed to define a sliding relationship therebetween prior to introduction of said solidifiable material to the retainer.

8. A mooring anchor for a marine structure having a submerged portion extending toward the ocean floor including connector means at the structure's lower end, which mooring includes; a coupling member having an upstanding connector adapted to operably engage said structure connector means, and a retainer slidably engaging said coupling member to maintain the same at an ocean floor characterized by an uneven contour, and means for introducing a solidifiable material to said retainer, whereby to fixedly position said upstanding connector with respect to said retainer.

9. Method for installing a floatable marine structure in an offshore body of water characterized by an uneven floor, said structure including; a buoyant platform having a multi-component anchor comprising operably connected coupling and base members, positioned at the lower end thereof, which method includes the steps of; controllably submerging said structure into said body of water to position said multi-component anchor at said ocean floor, exerting an upward tension on said coupling member of said anchor to dispose said member in a substantially upright disposition independently of the attitude of said base member, and introducing a fluidized hardenable material to said anchor for contacting the respective base and upright members whereby to harden and unify said members.

10. In the combination as defined in claim 9 including the steps of; maintaining said upward tension on said upright member and permitting said hardenable material to solidify.

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