

[54] MODULE CONNECTORS

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[56]

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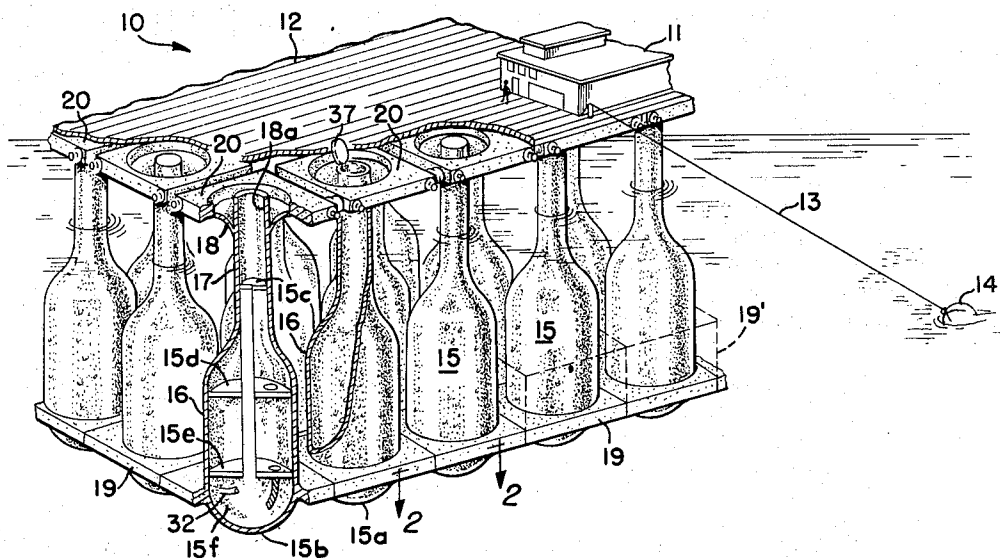
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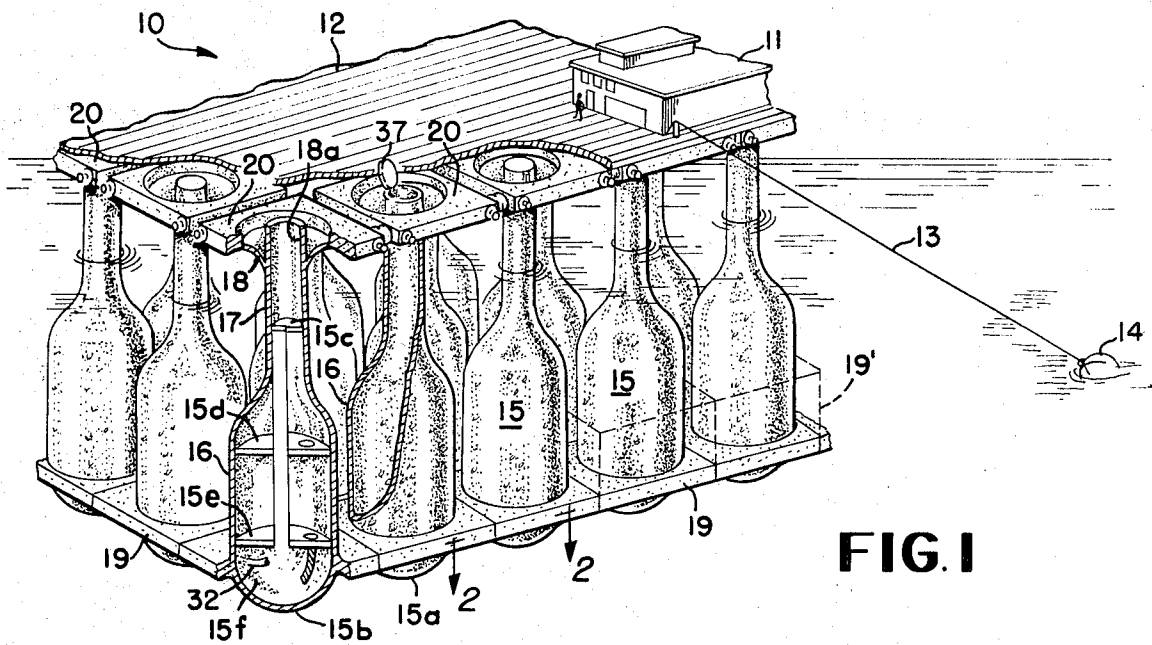
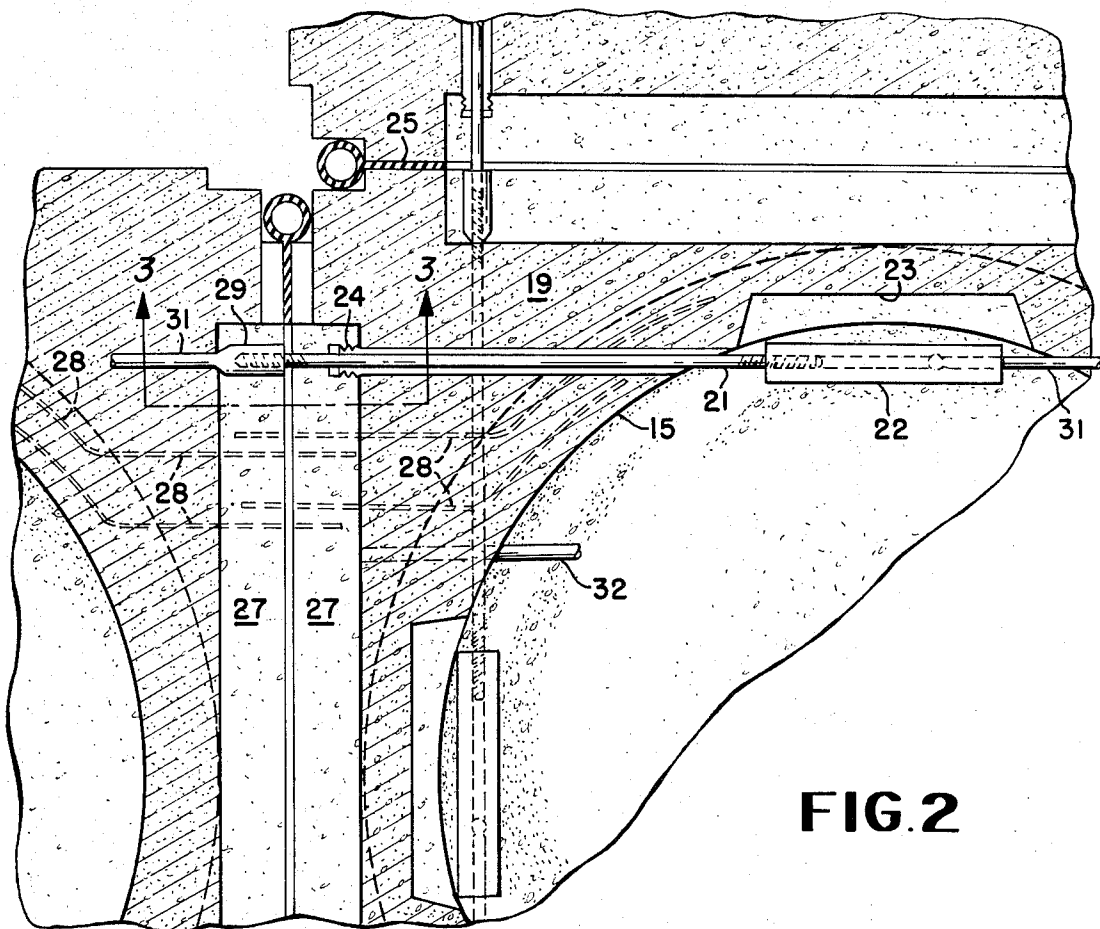
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ABSTRACT

An improved method of joining elongate bottle members into a floatation structure is disclosed. A plurality of the elongate bottle members are joined together at a point beneath the water line of the body of water in which they are floating. This joint is accomplished by dewatering a volume between adjacent, specially-configured sections on the lower end of the elongate bottle members and filling the dewatered joint with a mixture of plastic concrete. After the concrete is cured, the joint is placed in a compressional loading to insure a rigid and mechanically stable union. If desired, a passageway may be structured between adjacent, elongate bottle members so as to provide a passageway therebetween.

11 Claims, 5 Drawing Figures





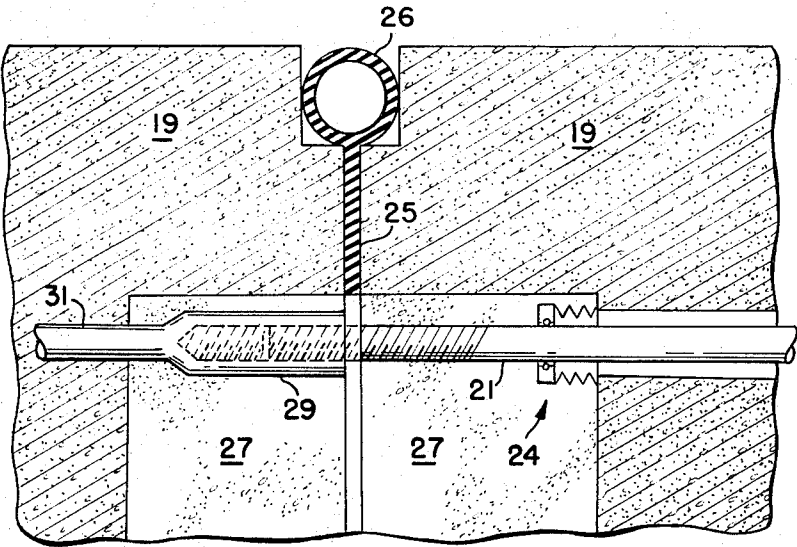


FIG. 3

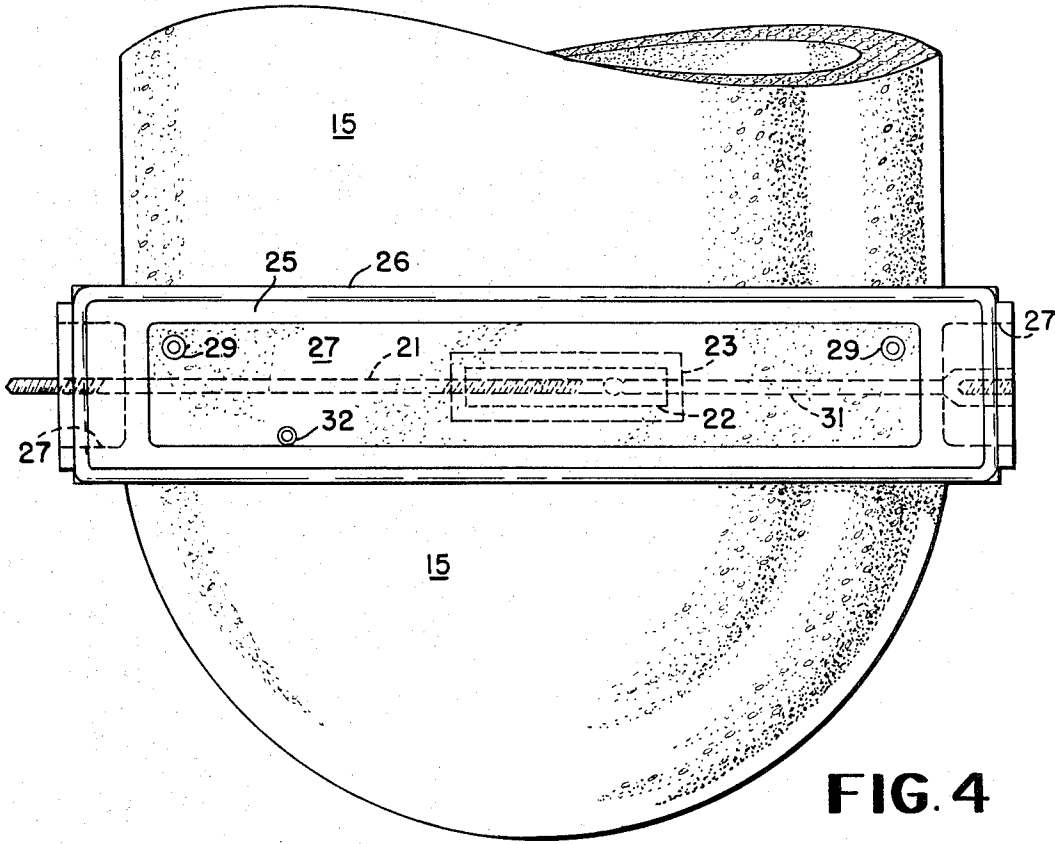


FIG. 4

MODULE CONNECTORS

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

1. Field of the Invention

This invention pertains to the field of naval architecture and marine engineering. Particularly, this invention pertains to the design and fabrication of buoyant marine structure using cement and ferrocement casting techniques. In still greater particularity, this invention pertains to the subsurface joining of a plurality of floating bottle-shaped modules to form a floating platform. By way of further particularization, the invention pertains to the connection of the subsurface ends of a plurality of bottle-shaped modules so as to form a unitary structure.

2. Description of the Prior Art

The known oceanographic floating platforms of the prior art are, historically, one of two types, namely, platforms having an elongate cylindrical tanks extending a considerable distance into the water or platforms of the floating flat-bottom barge type. Experience has shown that the flat-bottom barge types, although inexpensive to manufacture, are most affected by the wave action of sea in which they are floating. This instability limits their usefulness to times when the sea state is relatively low. The elongate cylindrical floating platforms of the prior art, while having an improved stability over the barge type, still are difficult to stabilize in high sea states. Recently, great improvements have been effected by the incorporation of a bottle-shaped floatation unit which is positioned such that the enlarged end, providing the buoyancy, is below the wave action portion of the body of water and the relatively narrow neck portion extends through the air-water interface. These type platforms have the advantage of flexibility provided by assembling the bottle-like modules at the point where the platform will be used. The individual bottle-like modules are assembled at a point above the surface and a point below the surface to provide a stable base for the oceanographic platform. In the past, such assemblies relied entirely upon mechanical fasteners. While such fasteners are relatively satisfactory above the surface, the arduous conditions imposed by a constant emergence and the difficulty of periodic inspection and maintenance of mechanical fasteners below the water emphasize the need for improvement in this area.

SUMMARY OF THE INVENTION

A more permanent subsurface joint is made possible by a specific configuration of areas on adjacent bottle-shaped modules into hollow cavities and a waterproof gasket arrangement and connection therewith so as to permit the dewatering and filling of the interconnecting areas with a fluid concrete mixture which is allowed to cure so as to form a permanent bond therebetween. Additionally, the invention permits post-curing tensioning of the concrete bond in a compressional mode to strengthen the connecting joint. Further, the joint area may be configured to permit passage between the interior of adjacent bottle-shaped modules in the vicinity of the joint.

STATEMENT OF THE OBJECTS OF INVENTION

The object of the invention is to provide a unitized floatation module constructed at a relatively low expense and having improved strength.

Another object is to provide a method and structure for joining floatation modules below the surface of the water.

Yet another object of the present invention is to provide a joint between adjacent floating bottle-shaped modules.

Still another object of the invention is to provide a method and structure to join watertight modules below the surface of the water which is to establish a permanent joint therebetween and to provide module-to-module passage therebetween.

A still further object of the invention is to provide a structure and method for joining two cast bottle-shaped modules with a cement bond.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing a plurality of modules according to the invention joined to provide oceanographic platform.

FIG. 2 is a partial section and plan view taken along line 2—2 of FIG. 1 showing the structure of the underwater joint between adjacent individual modules.

FIG. 3 is a sectional view showing mechanical detail, of the joint between adjacent bottle-shaped modules taken along line 3—3 of FIG. 2;

FIG. 4 is a side elevation view of the structure according to the invention showing the area interconnecting adjacent modules; and

FIG. 5 is a side elevational view showing a modification of the joint between adjacent modules which permits a passageway to be formed therebetween.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, briefly described above, in which like numbers refer to the same or equivalent elements, the invention will be described. As shown in FIG. 1, an off-shore floating platform 10 has a structural habitat 11 constructed on a plainer deck section 12. Platform 10 may be a mobile, free-floating structure or may be secured in a fixed geographical location by means of lines 13 connected to suitable anchoring means, not shown, on the floor of the body of water. As is conventional in the marine arts, the intersection of line 13 with the water surface is marked by a buoy 14.

As illustrated, deck 12 is supported on a plurality of bottle-shaped floating modules. Each module comprises an enlarged center portion 15. Each module has a lower connecting collar 19 and an upper connecting collar 20. Lower collars 19 extend intrically into the walls of center portion 15 while upper collars 20 are connected with the neck portion 17 of the bottle-shaped modules by a flared support portion 18. The bulbous lower portion of the bottle-shaped module, indicated at 16, is quite spacious and may be used for storage, if desired.

Each bottle-shaped module is made of a cast concrete material which, as will be understood by those fa-

miliar with the concrete working arts, may be reinforced to obtain additional structural strength. Each bottle-shaped module is cast as an integral structure in a conventional fashion. The precise technique employed is, therefore, considered to be a matter of choice to one versed in concrete working arts. However, for purposes of illustration, the technique disclosed in U.S. Pat. No. 3,598,357 issued Aug. 10, 1971 to William B. McLean et al, for "Apparatus for Constructing a Bottle-Shaped Module" may be used if desired.

The size and construction of the bottle-shaped modules permit a variety of internal constructions. For example, the module indicated as 15a is shown as having a single void occupying the entire interior. Such a module may be used for the storage of consumable fluids, for example oil, or may be left vacant strictly for buoyancy. On the other hand, a module, such as 15b, may be divided into a plurality of decks by appropriately spaced watertight dividers indicated at 15c, 15d, and 15e. These compartments may be used as habitable space or for storage of dry consumables as conditions and purpose may warrant. The multiple compartmented module may have its buoyancy regulated by filling its lower compartment 15f with a fluid such as sea water, for example. Also, the modules having separate compartments are more easily arranged and put in place as described in U.S. Pat. No. 3,592,155 issued on July 13, 1971 to Edgar N. Rosenberg for "Floating Platform."

The connection of the individual bottle-shaped modules forms a unitary buoyant support. The connection of upper collars 20 is facilitated by mechanical structure carried by connecting collars 20. The operation of this connecting structure is described in the patent to Rosenberg, cited above.

Referring now to FIGS. 2-4 the connection of the bottle-shaped modules at their subsurface end will now be described. As shown, collars 19 have threaded rods 21 which extend from the outer portions thereof to the interior of the enlarged section 15 bottle-shaped members. Threaded rods 21 are connected to turn buckles 22 for tensioning purposes as will be presently described. If desired, recesses 23 may be provided in the wall of enlarged section 15 of the bottle-shaped module to facilitate the turning movement of turn buckles 22. Of course, recesses 23 are provided during the molding process of the bottle-shaped modules at a great saving in time and effort when compared to the provision of such recesses after a casting operation has been completed.

Threaded rod 21 passes through a wall of the bottle-shaped module in a precast passageway and therefor requires a suitable water seal indicated at 24. The sealing of shafting where it passes through the external wall of a buoyant vessel is well understood in the marine engineering art and any suitable type of shaft packing which permits axial movement and has a small degree of lateral flexibility may be employed for this purpose. However, for purposes of completeness and clarity of illustration it should be noted that that seal described in the Rosenberg patent cited above, may be employed if desired.

The end of threaded rod 21 is received in a socket structure, to be described, effectively attached to the opposite module.

As may be best seen in FIGS. 3 and 4, the outer surface of collar 19 is provided with a watertight gasket 25 which has an inflatable seal 26 about the marginal edge thereof. The technique of manufacture and the use of such seals are well understood in the marine engineering arts and any suitable known construction may be used. Likewise, conventional material, such as synthetic rubber, may be used in the construction of gaskets 25 and inflatable seal 26. The apparatus and the construction of inflatable seal 26 to permit inflation and deflation also may be that commonly employed in such structures of the prior art such as, for example, that shown by U.S. Pat. No. 3,640,078 issued on Feb. 8, 1972 to Francisco M. Serrano for "Devices and Methods of Connecting Two Inhabitable Enclosures Underwater."

The butting faces of collars 19 are formed to have a cavity 27. Cavity 27 is, of course, surrounded by gasket 25 and seal 26 such that when the adjacent collars 19 of bottle-shaped modules are placed in a contiguous and aligned relationship a watertight chamber is defined by corresponding cavities 27 in the adjacent bottle-shaped module as may be best seen in FIG. 3.

Threaded rod 21 is received in a socket 29. Socket 29 is carried at the distal end of a rod 31 which passes through the wall to the interior of large section 15 of the bottle-shaped module. However, it is not necessary that rod 31 be moved during union of the two bottle-shaped modules. Accordingly, rod 31 may be cast in place during construction of the modules.

Concrete reinforcing rods may be cast into the bottle-shaped module during construction such as to extend from the surface thereof into and slightly beyond cavities 27. This placement of rods is indicated by the broken line showing at 28 in FIG. 2. Mere placement of rods 28 within cavities 27, without casting them in place, has also proved satisfactory. These placements are conventional as will be recognized by those familiar with concrete fabrication arts.

The individual bottle-shaped modules are aligned and connected by engagement of the aforescribed mechanical fasteners in a method such as described in the Rosenberg patent, cited above.

Briefly, the flexibility provided by seal 24 permits rods 21 to be threadly engaged in sockets 29. This engagement may be performed from within the bottle-shaped modules or, alternatively, may be made with the assistance of a diver operating outside the modules. Operation of turn buckle 22 draws the bottle-shaped modules together to complete the mechanical connection.

Once the modules are in alignment and have been mechanically connected, inflatable seals 26 are inflated to cooperate with gasket 25 and make volume enclosed by cavities 27 watertight. At this time, the enclosure formed by cavities 27 is dewatered. The dewatering requires that the water encapsulated during the mechanical connection be pumped out, and, in the cases where the bottle-shaped modules are connected in sea water, the cavity is required to be rinsed with fresh water to remove all residue of salt water still remaining in the enclosed volume. This pumping and refilling of the volume enclosed by cavities 27 is accomplished by means of conventional conduit cast within the walls of bottle-shaped module. One such conduit is indicated at 32 for purposes of illustration. However, it should be recognized that other conduits may be provided if desired.

As is common in the fluid handling arts, one conduit may be positioned at the lower surface of cavity 27, as illustrated, and another adjacent to the upper surface.

After the enclosed chamber formed by cavities 27 has been dewatered, the volume is filled with plastic concrete which is then allowed to cure or set. Because the bottle-shaped modules are themselves made of cast concrete this unitary concrete bond forms a lasting structural joint and distributes any load tending to cause the individual bottle-shaped modules to part over a larger surface area and thereby minimizes stress and fractures.

A further improvement in the bonding technique is provided by tensioning rods 21 into the cylindrical loading after the concrete in the enclosure formed by cavity 27 has cured. This tensioning action is facilitated by rotating turnbuckle 22 which, naturally, tends to draw rods 21 and 31 together. This action, of course, forces the two adjacent connecting collars 19 into a tighter bond thereby compressionally loading the concrete filled cavity.

Referring to FIG. 5, a modification of the collar structure is shown. As will be observed, this modification increases the vertical extend of the connecting collars 19 to form an enlarged connecting surface 19'. These collars cooperate in the same fashion as the inner collar 19 and are integrated at FIG. 1 by broken lines. The primary difference is the provision of a watertight door 33 buried in a protruding collar 34. Collar 34 is extended so as to be coplanar with the outer surface of connecting collar 19' and is provided with a gasket 35 and inflatable seal 36 which function is the same fashion as gasket 25 and inflatable seal 26. Once the concrete joint has been joined, set and compressionally loaded, watertight door 33 may be removed from its frame and cast into other modules thereby affecting a considerable savings in the cost of fabrication of these structures. If desired for damage control, door 33 may be left in place as a closure between adjacent bottle-shaped modules.

Of course, the purpose of watertight door 33 is to provide access from the interior of one enlarged portion 15 to an adjacent portion such that communications between the two floatation modules may be made without returning to the surface of deck 12. As may be readily visualized this is of particular importance in segmented bottle-shaped modules such as shown in 15b in FIG. 1. Thus, the single hatch 37 could provide access to five bottle-shaped modules and thereby minimize the number of openings in the working deck surface 12. Further, the advantages and weather integrity are too obvious to require additional comment.

It should be apparent that a variety of arrangements of connectors and seals are possible. That is, some bottle-shaped modules may have threaded rods 21 extending from both ends of turnbuckle 22 while others have only sockets 29 held rigidly in place rather than being in pairs, as shown. Similarly, arrangements could be devised to have "universal" arrangements. That is, arrangements permitting the joining of any two bottle-shaped modules into a unitary assemblage. Similarly, the arrangement of gasket 25 and inflatable seal 26 may be altered from that shown so as to be carried on either of the two mating coupling planges 19. Such minor variations in arrangement of parts are deemed to be within the exercise of ordinary design skill of the proficient artisan.

The foregoing description taken together with the appended claims constitute a disclosure such as to enable a person proficient in the marine engineering and naval architecture arts and having the benefit of the teachings contained therein to make and use the invention. Further, the structure and method of application herein described meets the aforesaid objects of the invention, and generally constitutes a meritorious advance in the art unobvious to such an artisan befit of the benefit of these teachings.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than specifically described.

What is claimed is:

1. A method of connecting a plurality of vertically floating hollow structures at a point below the water line comprising the steps of:

connecting threaded rods passing through the walls of the hollow structures to correspondingly threaded sockets in the adjacent walls of adjacent structures;

making watertight a compartment surrounding the threaded rods;

dewatering the compartment;

filling the compartment with fluid concrete;

curing the fluid concrete to form a solid cast-in-place joint between the concrete structures; and

tensioning the threaded rods to post-tension the concrete joint in a compressionally loaded joint.

2. A method according to claim 1 additionally comprising the step of placing reinforcing rods in the compartment prior to filling said compartment with fluid concrete in such a fashion as to strengthen the joint between the hollow structures to resist separating forces that might be generated between the structures.

3. A method according to claim 2 in which the aforesaid step of making watertight a compartment surrounding the threaded rods includes the inflation of a hollow o-ring-like seal surrounding the perimeter of the compartment.

4. A method according to claim 2 in which the aforesaid step of dewatering the compartment includes pumping seawater from the compartment; filling the compartment with fresh water and pumping it dry until no residue of seawater remains.

5. A method according to claim 2 in which the aforesaid step of tensioning the threaded rod comprises turning a turn buckle means located within the hollow floating structure and threadably fastened to the threaded rods.

6. In a flotation structure for diminishing the effects of wave action including an elongate bottle-shaped chamber cast of concrete and having, a first portion shaped with a cross sectional area disposed and sized for defining a center buoyancy below said wave action, a second portion defining a neck of said bottle-shaped chamber integrally extending therefrom through and above the area of said wave action having an area which is a fraction of said cross-sectional area and, an upper connecting means carried adjacent said second portion including a plurality of prestressed members mounting coupling means attached on their opposite ends, an improved means for connecting adjacent said first portions is provided comprising:

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a seal for establishing a watertight union between adjacent lower connecting means similarly formed with adjacent elongate bottle chamber means; threaded rod means extending from within said first portion to threadably engage sockets on said adjacent lower connecting means of adjacent elongate bottle-shaped chambers for pulling said lower connecting means into an abutting relationship; recesses in the abutting faces of each lower connecting means defining an adjoining cavity therebetween; means for filling the adjoining cavity with plastic concrete to cure into a solid joint; and tensioning means to place said threaded rods in tensional loading from within said first portion of said elongate bottle-shaped chambers.

7. A flotation structure according to claim 6 in which said seal includes a synthetic rubber gasket which extends over the face of said lower connecting means.

8. A flotation structure according to claim 7 in which said synthetic rubber gasket includes an inflatable seal extending around the marginal portion thereof.

9. A flotation structure according to claim 6 further including reinforcing rods cast integrally into the lower connecting means and extending outwardly therefrom within the recesses in the abutting faces thereof to aid in strengthening a joint produced by filling the recesses with plastic concrete.

10. A flotation structure according to claim 6 fur-

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ther including:

shoulder means formed in said recess and extending outwardly to be coplanar with the abutting faces of said lower connecting means;

second seal means extending about the periphery of said shoulder means for making a watertight union between the shoulder means and a similar shoulder means in the adjoining flotation structure; and

a watertight door carried by said shoulder means in the surface thereof surrounded by said second seal means and communicating with the interior of the flotation structure for providing a passageway between the interior of the flotation structures.

11. A flotation structure according to claim 9 further including:

shoulder means formed in said recess and extending outwardly to be coplanar with the abutting faces of said lower connecting means;

second seal means extending about the periphery of said shoulder means for making a watertight union between the shoulder means and a similar shoulder means in the adjoining flotation structure; and

a watertight door carried by said shoulder means in the surface thereof surrounded by said second seal means and communicating with the interior of the flotation structure for providing a passageway between the interior of the flotation structures.

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