May 28, 1963 E. M. USAB 3,091,203

CONCRETE FLOATING WHARF STRUCTURES

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FIG. 1.

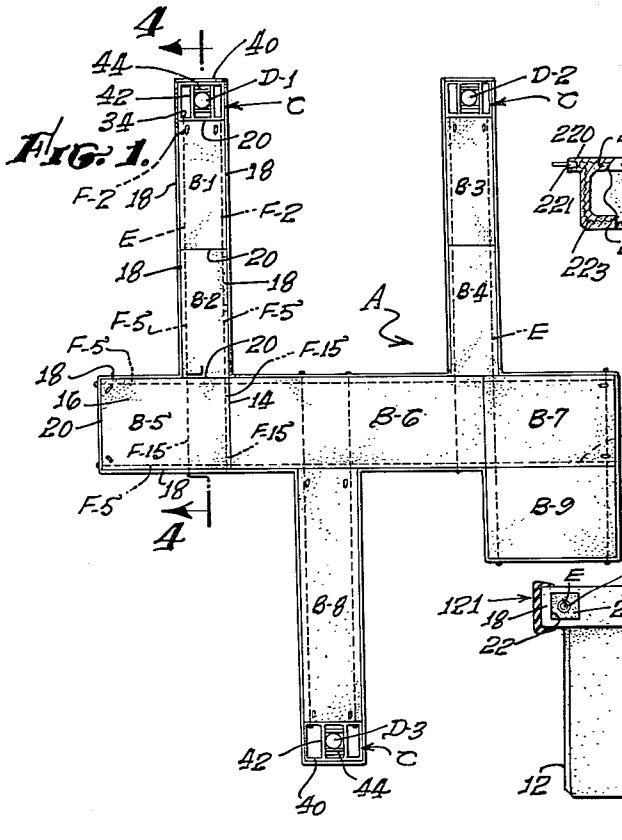


FIG. 14.

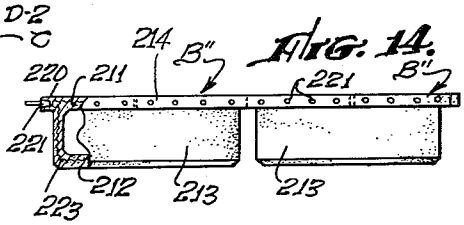


FIG. 3.

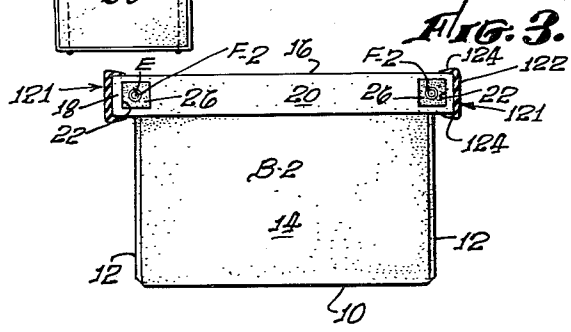
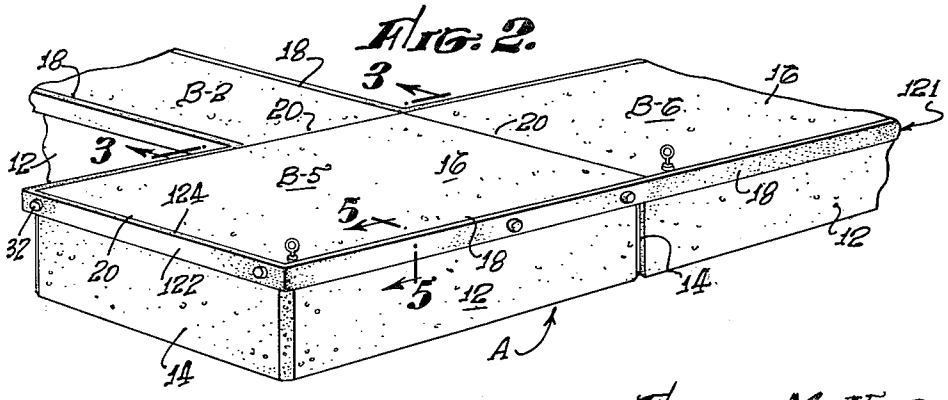


FIG. 2.



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CONCRETE FLOATING WHARF STRUCTURES

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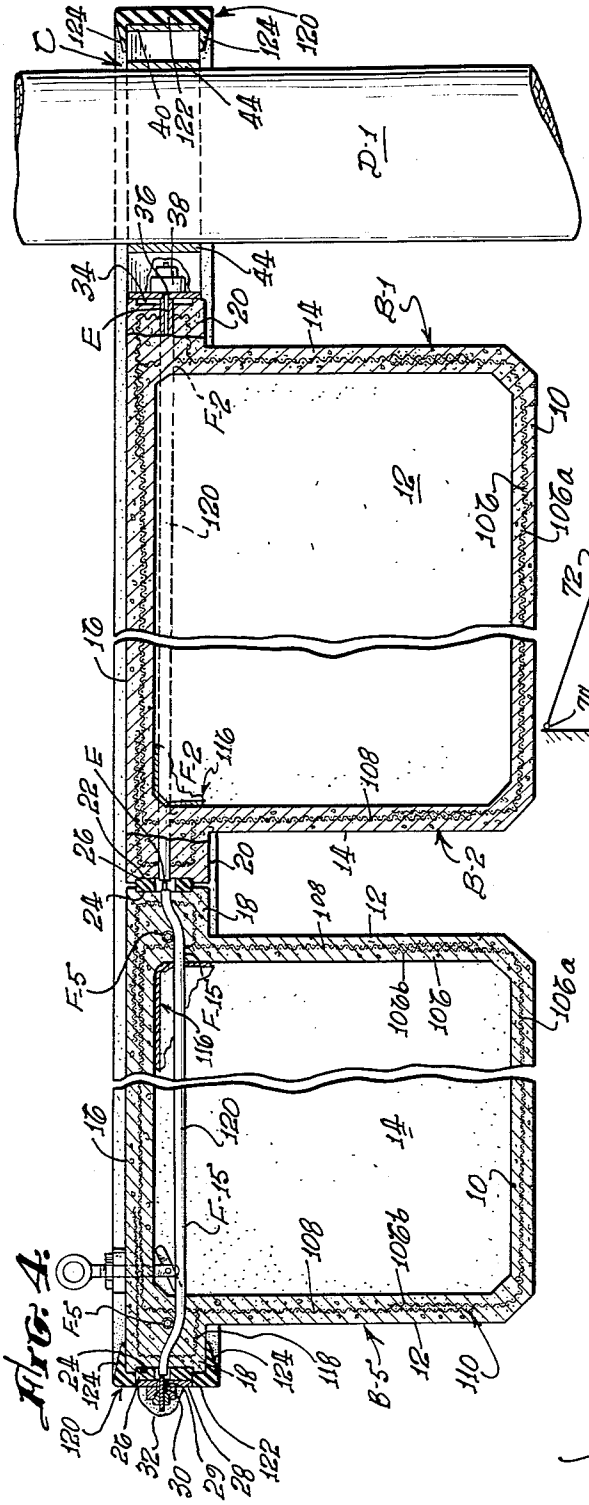


Fig. 4.

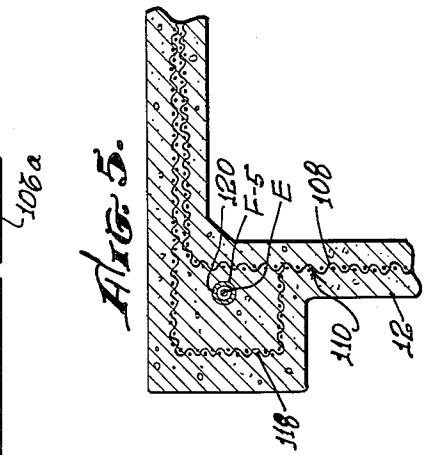


Fig. 5.

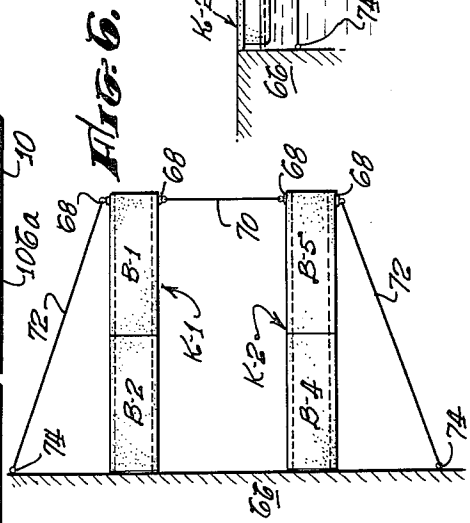


Fig. 6.

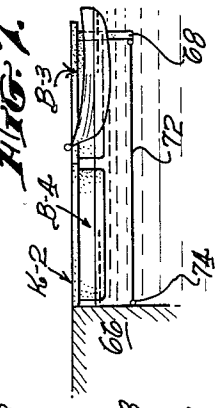


Fig. 7.

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CONCRETE FLOATING WHARF STRUCTURES

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FIG. 8.

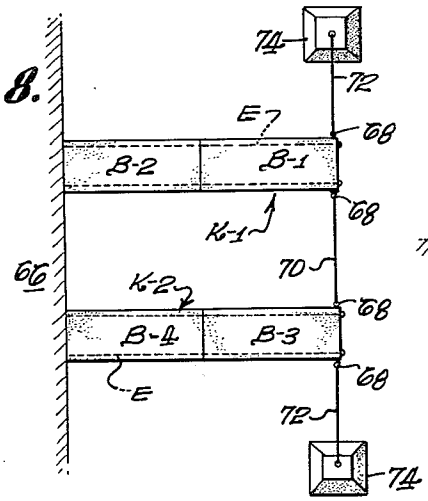


FIG. 9.

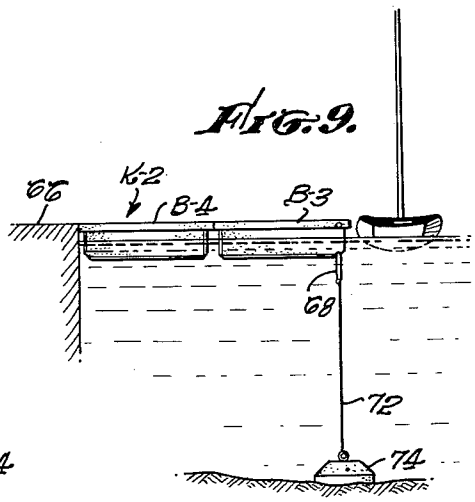


FIG. 11.

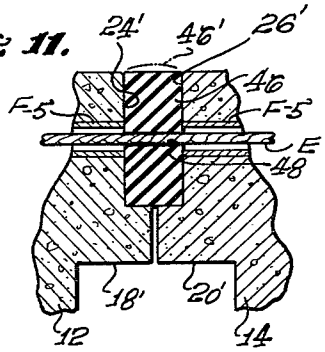


FIG. 13.

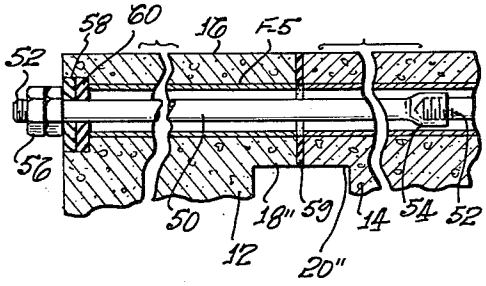
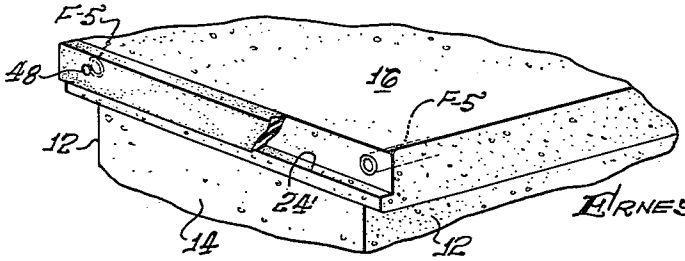


FIG. 12.



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CONCRETE FLOATING WHARF STRUCTURES

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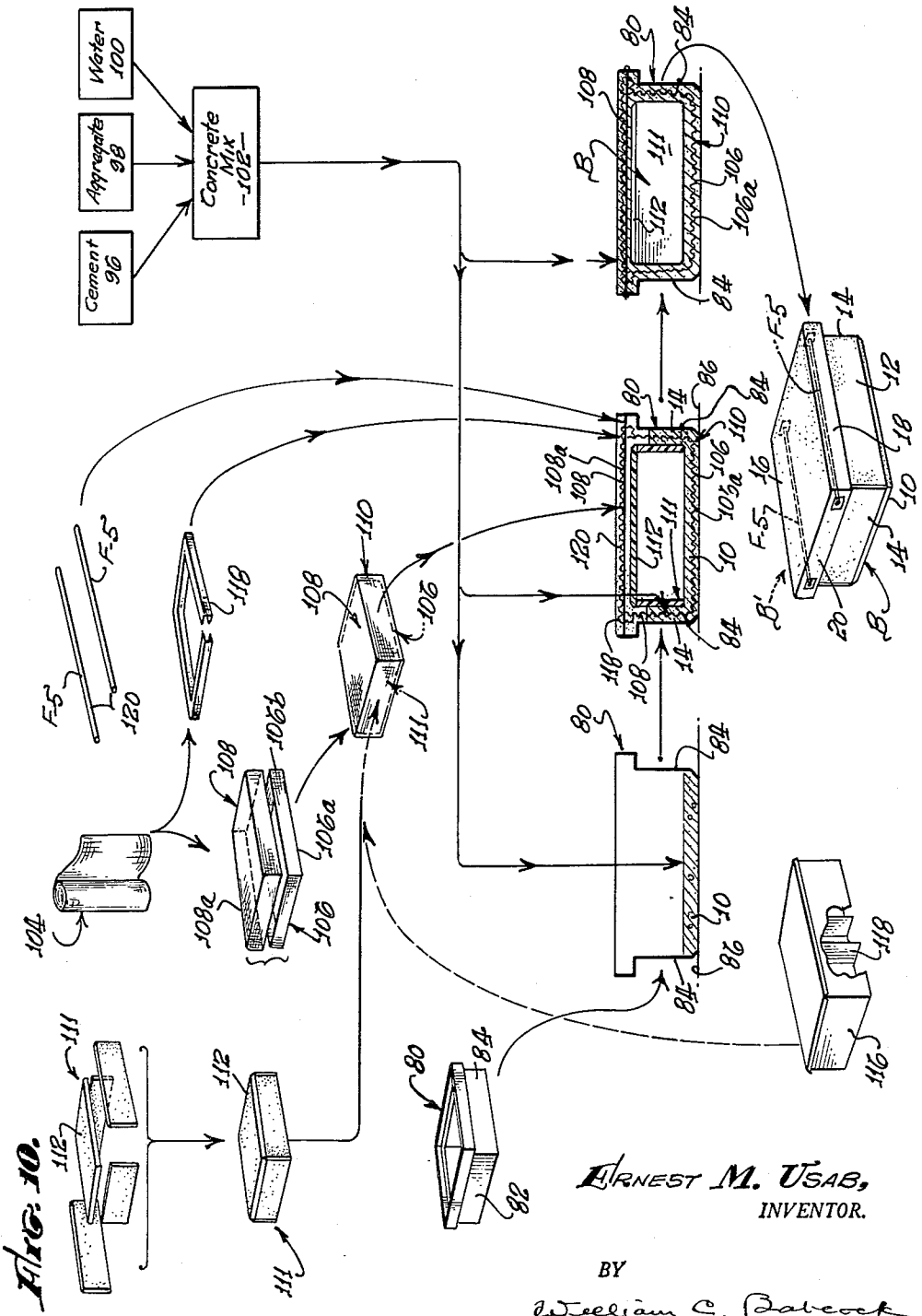


Fig. 10.

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United States Patent Office

3,091,203

Patented May 28, 1963

3,091,203

CONCRETE FLOATING WHARF STRUCTURES

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Filed Oct. 27, 1958, Ser. No. 769,801
22 Claims. (Cl. 114—.5)

The present invention relates generally to the field of concrete structures, and more particularly to an improved concrete float unit, a method of manufacturing same, and fastening means that may be used to maintain said float units in fixed relationship with one another to provide a horizontal load bearing surface above a body of water that is suitable for use as wharfage, walkways, roadways and the like.

The inventions disclosed in the present application provide various improvements over the concrete float structure described in my co-pending application Serial No. 674,901, filed July 29, 1957, and entitled "Floating Wharf Structure Made of Concrete Float Units," which issued as United States Letters Patent No. 2,857,872 on October 28, 1958, and in an application for reissue filed October 9, 1959 under Serial No. 845,581 which was granted on June 14, 1960 as Reissue Patent No. 24,837.

In constructing marinas or other boat harbors it is desirable to utilize floating wharf structures which are accessible from the land, and have one or more fingers extending outwardly into the body of water. In the past various types of pontoons have been used for this purpose, which pontoons are held in spaced relaitonship by a wood or metal superstructure disposed thereabove and supported between pontoons, and the superstructure serving as a support for a continuous substantially horizontal load bearing platform. However, irrespective of whether the superstructure is of wood or metal, it has been found to have a relatively short life due to the deteriorating effect thereon of the damp atmosphere normally present adjacent a body of water. This deteriorating effect is particularly acute when the pontoons and superstructure are disposed in a body of salt water.

According to the present invention, as well as the invention disclosed in my co-pending application, concrete float units are used to provide not only the buoyancy support necessary for the wharf structure but also the actual deck surface. Each float unt of the present invention is to a large extent an individual entity, having its own deck surface adapted for use as a walkway, roadway or for other load-bearing purposes as may be necessary, with the structure of the unit being hollow to provide the necessary buoyancy.

A fundamental concept of the present invention is that each individual unit includes at least one straight edge surface disposed above the water line of the unit, with the straight surface preferably defined by a projecting flange, which flange overhangs the side situated therebelow. This mode of construction makes it possible to dispose two of said float units together at the ends or sides thereof over which said flanges project, and with the flanges when so disposed maintaining such ends or sides of the box structures of the float units in spaced relaitonship where they cannot be damaged by physical contact with one another when subjected to substantial movement as may be occasioned by wave or wind action in a storm of substantial magnitude.

More specifically, the overhanging flange of each individual float unit makes it possible to dispose the deck surfaces of two adjacent float units together in a continuous manner so as to provide a walkway, roadway, or other desired load bearing surface. Another advantage of the overhanging deck feature, particularly when the flanges are extended along the sides of the float units, is

the great ease in mooring small boats to such units, and with the danger of damage to the units being completely eliminated by the overhanging side flanges which act as buffers to take any physical shock brought about by inadvertent contact of the boat with the float units.

One of the primary purposes in devising the inventions disclosed in the present application is to provide an improved method of forming the float units as monolithic concrete structures by a method that can be carried out with relatively simple and inexpensive molds, and the interior of the unit when so formed having a core that remains permanently within the confines thereof, but the core being of such density as to have no appreciable detrimental effects on the buoyancy of the unit, and in one method of forming the unit the core acutally increasing the buoyancy of the unit to the extent it is non sinkable.

Another object of the invention is to supply a float unit in which a number of spaced elongate passages are formed that may extend either longitudinally or transversely therethrought or both, depending upon the arrangement in which the floats are to be disposed, and with these passages of such transverse cross section as to be capable of receiving elongate resilient fastening members, which members after the floats are disposed in the desired arrangement are completely sealed within the confines thereof, and are accordingly protected from the corrosive action of damp air or damp salt air.

A further object of the invention is to provide float units of such construction that the resilient fastening members may be post tensioned after the floats are arranged in the desired configuration, with the magnitude of the post tensioning being determinable by the user or operator of the floating structure defined by the individual float units, and the magnitude being of such a degree as to hold the float units together with a desired degree of pressure contact therebetween.

Still another object of the invention is to provide float units in which substantially all but the projecting fastening ends of the elongate fasteners are disposed within the confines of the units and protected from the air, with the units when so fastened being adapted to be arranged in either end-to-end, side-to-side, end-to-side configuration or end of one unit adjacently disposed to portions of the sides of two adjacent units.

Another object of the invention is to provide float units of such structure that when connected together by the resilient fastening means above described that the fastening means can be connected to anchor points at desired fixed locations, which anchor points may actually be piles, deadmen embedded in or affixed to a portion of the terrain adjacent the position of the float units, or heavy bodies of concrete or other material that rest on the bottom of the body of water in which the units are disposed, with this last mentioned form of anchor point being particularly desirable in those installations in which the bottom of the water is realtively deep and the cost of installing piles therein would be excessive.

Still a further object of the invention is to provide float units which while connected by concealed resilient members disposed within the confines thereof, are still adapted to be provided with elongate buffers that extend along the longitudinal sides as well as the free ends thereof, which buffers serve to prevent damage to a boat inadvertently coming in contact with the float units, with the buffers preferably being formed of a resilient material that permits the buffers to be easily and removably affixed to the upper edge portions of the float units, and the buffers being not appreciably affected by the corrosive action of damp air including salt air even after being subjected to same for long periods of time.

A further object of the invention is to provide float units which while particularly adapted for use as wharfage for boats are not limited to this purpose, but when disposed side-by-side and end-to-end or combinations thereof may be used to provide walkways or roadways to offshore installations, such as islands or the like erected for the drilling and production of oil as is common in numerous localities along the Pacific and Gulf Coasts, and also for roadways across swampy land, or land that is periodically flooded.

A still further object of the invention is to supply float units that may be used to provide temporary wharf structures that may be easily erected and removed after the use therefor has ceased, such as may be occasioned in bringing equipment ashore for a particular purpose, as for example drilling oil wells in isolated areas, landing of provisions, equipment, personnel and the like from ships for either commercial or military purposes in such isolated areas.

Yet another object of the invention is to provide float units of a structure that can be used for the purposes above enumerated, and units that have the distinct advantage that they may be fabricated with a minimum of equipment at a location within close proximity to the body of water in which they are to be assembled to provide wharfage, walkway or roadway, with the cost of transporting the float units from the point of manufacture to the point of usage thus being substantially eliminated.

The above and other objects and advantages of the invention will become apparent from the following description thereof taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a plan view of a number of the individual float units held in a pre-determined configuration by resilient fastening means disposed within the confines thereof said fastening means being capable of holding float units together in end-to-end side-to-side, end-to-side and end-to-two sides relationship, with selected extremities of the float units being held at fixed positions by piles which serve as anchor points;

FIGURE 2 is a perspective view of a number of the float units disposed to form a portion of a wharf structure, roadway or walkway, and showing the manner in which the elongate fastening means projects from the upper portions of the units to hold them together in desired configuration;

FIGURE 3 is an end elevational view of one of the float units taken on the line 3—3 of FIGURE 2, and showing the position of the elongate resilient fastening means, the resilient pressure pads disposed in the upper end portion of the float, and resilient buffer strips extending along the sides of the float which tend to prevent damage to vessels or boats inadvertently contacting same.

FIGURE 4 is an enlarged longitudinal cross sectional view of a plurality of the float units taken on the line 4—4 of FIGURE 1, and showing the manner in which the resilient fastening means holds the float units together, a fastening member in engagement with a pile, and the manner in which the projecting ends of the resilient fastening means are protected from deterioration due to contact with damp air, as well as the manner the pressure pad at the adjacently disposed faces of the overhanging flanges deforms inwardly as a result of a longitudinally applied force to seal the resilient fastening member from contact with the atmospheric air;

FIGURE 5 is a fragmentary vertical cross-sectional view of one of the float units taken on line 5—5 of FIGURE 2, showing the manner in which longitudinally and transversely extending passages are defined therein that house the resilient fastening members;

FIGURE 6 is a plan view of a wharf structure defined by said float units in which two elongate fingers are held at the desired spaced relationship with one another, and in extending positions from a fixed structure that may be a pier, land or the like, purely by the use of cables;

FIGURE 7 is a side elevational view of the assembled float unit structure shown in FIGURE 6, and the manner in which said cables maintain same in said fixed position;

FIGURE 8 is a plan view of a wharf structure defined by said float units held in a desired configuration by cables and anchor points which are heavy bodies that rest on the bottom of the body of water in which the assemblage of units is disposed and have said cables attached thereto;

FIGURE 9 is a side elevational view of the float unit structure and anchor point described in FIGURE 8;

FIGURE 10 is a diagrammatic view illustrating certain apparatus and the process by which two forms of the float units are manufactured;

FIGURE 11 is a fragmentary longitudinal cross-sectional view of a first alternate form of overhanging flange structure adapted for use on the adjacently disposed ends of two of said float units showing the manner in which a transversely extending resilient pad is disposed in recessed portions defined in each of said flanges, with said pad when longitudinally compressed deforming inwardly to completely seal the portion of said resilient member situated within said pad from contact with the atmosphere;

FIGURE 12 is a fragmentary perspective end view of one of the end overhanging flanges shown in FIGURE 11, showing the manner in which one of said flanges is recessed to receive a portion of the thickness of one of said pressure pads;

FIGURE 13 is a fragmentary longitudinal cross-sectional view of a second alternate form of flange structure and fastening members, for holding said flanges in a substantially fixed relationship with one another; and

FIGURE 14 is a perspective view of a plurality of said float units held in a predetermined relationship by the rails which extend along the flanges thereof.

Referring now to the drawings for the general arrangement of the invention, it will be seen that a wharf A or other floating structure can be provided by a number of float units referred to generally by the letter B, and specifically identified by the letter B having a numerical suffix added thereto as best seen in FIGURE 1.

Wharf structure A as shown in FIGURE 1 includes two identical outwardly extending fingers, with one finger being defined by two float units B–1, B–2 disposed in end-to-end relationship, and the outer extremity of unit B–1 supporting an engaging member C that engages a pile D–1 which serves as a first anchor point. Two float units B–3, B–4 that are identical in construction to units B–1, B–2 are also arranged in end-to-end relationship to provide a second finger. Float unit B–3 at the outer extremity thereof supports a second engaging member C that engages and holds float unit B–3 at a substantially fixed position relative to a second pile D–2.

Three float units B–5, B–6 and B–7 are disposed in end-to-end relationship in FIGURE 1, and have the floats B–1, B–2, and B–3, B–4 projecting outwardly therefrom and substantially normal thereto. It will be particularly noted that float unit B–2 is disposed normal to one side of float unit B–5, while float unit B–4 is perpendicularly positioned relative to side portions of both float units B–6 and B–7.

A float unit B–8 is shown in FIGURE 1 that is normally situated relative to a center longitudinal side portion of float unit B–6, with the opposite end portion of unit B–8 supporting an engaging member C that engages a pile D–3 that serves as a third anchor point. Side-by-side positioning of float units is illustrated in FIGURE 1 by float unit B–9 that is so situated relative to unit B–7. Thus, it will be seen from FIGURE 1, and the above description of the float units B, that a wharf structure A of any de-

sired size and configuration may be formed therefrom with the structure so formed providing a substantially continuous horizontal surface or deck that may be used as a walkway, roadway or for other load-bearing purposes.

The float units B are preferably held in the configuration shown in FIGURE 1, or any other desired configuration, by elongate resilient metallic fasteners E shown in phantom line. The fasteners E extend through elongate passages F formed in the float units B, as may best be seen in FIGURE 3. The structure of each of the float units B–1 to B–9 is substantially identical, except for the positioning of the passages F, which positioning is of course determined by the particular relationship a float unit will bear relative to other float units adjacently disposed thereto. Structural details of passages F, as well as their positioning in the float units B, will be later discussed in detail.

Structure common to each of the float units B–1 to B–9 inclusive, is best seen in FIGURES 2, 3, 4 and 5. As will be seen from these figures, each of the float units B–1 to B–9, inclusive is of a generally rectangular configuration and preferably cast as a monolithic unit from concrete, the process of which will later be explained in detail.

Taking the float unit B–5 as typical of the structure of the balance of the float units previously identified, unit B–5 will be seen to include a substantially rectangular bottom 10 from which two side walls 12 and two end walls 14 extend upwardly to define a box, and the upper edge portions of the end walls and side walls developing into a horizontal top surface defining member or deck 16. An outwardly projecting flange 18 is provided on at least one side of said unit B–5, which flange as can be seen in FIGURE 4 overhangs the exterior surface of said wall 12, and the upper surface of flange 18 being flush with the surface 16 and lying in the same horizontal plane.

Float unit B–2, as best seen in FIGURES 1 and 4, is disposed adjacent to float unit B–5, and has a flange 20 projecting therefrom that is structurally identical with the flange 18 projecting from float unit B–5, with both flanges 18 and 20 being adapted to be adjacently disposed to lie in the same horizontal plane. The upper surfaces of flanges 18 and 20 are merely extensions of the deck surfaces 16 of float units B–2 and B–5.

The chief structural difference between the float unit B–5 and float unit B–2 is that the float unit B–5 has both longitudinally extending passages and transversely extending passages that are spaced from one another. The longitudinally extending passages in float unit B–5 are identified in FIGURES 1 and 4 by the notation F–5, and transversely disposed passages in the float unit B–5 by the notation F–15. The passages F–15 are in alignment with longitudinally extending passages F–2 formed in float unit B–2 as can best be seen in FIGURES 1 and 4. It will be apparent from an inspection of FIGURE 3 that transversely disposed passages need not be formed in the float unit B–2, as no float units are positioned alongside thereof.

In FIGURES 3 and 4 it will be be seen that the flange 20 has two substantially rectangular recesses 22 formed therein that are centrally located relative to and in communication with the passages F–2. Complementary recesses 24 are formed in the exterior vertical face of flange 18, and are in communication with and centrally located relative to the end portions of the passages F–2 in float unit F–5. Two resilient compression pads 26 are provided, with each pad being of such thickness as to have a portion thereof situated within each of two of the aligned recesses 22 and 24, and when so disposed separating the adjacent faces of the flanges 18 and 20 by a distance of from one-eighth to three-eighths inch, depending upon the magnitude of the compressive force to which the pad will be subjected as later to be described.

Each of the pads 26 has a centrally disposed opening formed therein, with the purpose of said opening being to permit one of the elongate fasteners E to pass therethrough, as well as to extend through the passages F–2 and F–15 previously described, and shown in FIGURE 1. The opening is slightly larger in transverse cross-sectional area than the transverse cross-sectional area of the elongate member E which extends therethrough. The elongate member E is preferably a flexible cable which, as can be seen in FIGURE 1, extends transversely through the float unit B–5 and longitudinally through float units B–2 and B–1. The end portions of member E project outwardly from the free flange 18 of float unit B–5 and the flange 20 of float unit B–1 that supports engaging member C adjacent pile D–1 as shown in FIGURE 1.

Float unit B–5 on the second flange 18 thereof also has recesses 24 formed therein. Each of these recesses 24 in the second flange 18 of float unit B–5 has a pressure pad 26 partially disposed therein, and pressure plates 28 being provided that abut against the exterior surfaces of the pads 26. A conventional cable gripping member 30 is provided that is affixed to the outer extremity of the cable E, and in abutting contact with the exterior face of pressure plate 28. The cable gripping member 30 is of larger transverse cross-sectional area than the centrally disposed bore 29 formed in pressure plate 28. To protect the cable gripping member 30, which acts as a stop to prevent movement of the fastener or cable E in the direction of float unit B–1 after tension has been applied to the fastener, the cable gripping member 30 is either enclosed in a suitable hollow plastic enclosure 32, or covered with a heavy mastic or other weather-protecting material, to minimize deterioration of the cable gripping member.

The float unit B–1, as can best be seen in FIGURE 4, is also formed with two end flanges 20. An elongate pressure plate 34 is provided that is of substantially the same size as the outermost flange 20 of float unit B–1 and abuts against the exterior vertical surface thereof. Pressure plate 34 has two transversely spaced openings 36 formed therein through which the fasteners project. The free end portions of the fasteners E adjacent plate 34 are engaged by conventional cable gripping members 38 that act as stops. The pressure plate 34 as can best be seen in FIGURE 1 supports engaging member C. The engaging member C is adapted to be fabricated in a number of different forms, so long as the structure selected is of sufficient strength to anchor float unit B–1 to pile D–1. Also, the engaging member should be of such structure as to be longitudinally movable relative to pile D–1, to allow vertical movement of float unit B–1 as will normally occur as the tide changes. Engaging unit C may be fabricated conveniently from a heavy, square U-shaped member that has the ends of the legs thereof welded or otherwise affixed in abutting contact to the exterior end portions of the pressure plate 34. The U-shaped member 40 and pressure plate have two parallel laterally spaced frame pieces 42 extending therebetween which are so spaced as to be slidably movable relative to the pile D–1 that is disposed therebetween. Frame pieces 42 have two parallel spaced cross pieces 44 extending therebetween that are also disposed on opposite sides of the pile D–1 and so spaced relative thereto that they can move vertically relative to the pile together with the balance of components forming the engaging member C as float unit B–1 moves vertically due to variations in the tide, or wave action to which the float unit is subjected.

The balance of float units B–3, B–4 and B–6 to B–9, inclusive, are tassembled into the wharf structure A in the same manner as above described in connection with units B–1, B–2 and B–5. After the float units have been assembled in the form shown in FIGURE 1, the elongate members E are post tensioned to draw the units together, as shown in FIGURE 4, with the pressure pads 26 being compressed, and serving to space the adjacent faces of the flanges 18 and 20 from one another, and to the extent that these faces, as well as the box portions of the floats, do not come into physical contact when the float units flex relative to one another under such conditions as they will

be subjected in actual use. The post tensioning of the fasteners E is accomplished by conventional hydraulic equipment used for this purpose, and from experience it has been found what hydraulic jacks of the type employed in post tensioning cables in concrete structures are ideally adapted for this purpose. Cable gripping member **30** or **38**, depending on which end of the fastener E has the tensioning force applied thereto, is mounted in a gripping position on this cable end after the post tensioning has been accomplished.

It will be apparent that the area of the compression pads **26** must be such that the compressing force applied thereto, when the fasteners are placed in post tension will not cause appreciable cold flow of the resilient material defining same from the confines of the recesses **22**, **24**.

In FIGURE 4 it will be noted that the transversely disposed passage conduits F–**15** are not straight, but curve upwardly at the ends thereof. The passage conduits F–**5** are straight and are disposed directly above the conduit passages F–**15** prior to their curving upwardly. In this manner the longitudinal axis of the conduits F–**5** may be maintained in the same horizontal plane as the center points of the openings in the ends of the conduit passages F–**15**.

Although the flange construction above described has been found to be quite satisfactory in use, flanges of a different design and structure may be used on the float units, with one such structure being illustrated in FIGURES 11 and 12. In these figures it will be seen that two flanges **18'** and **20'** are provided, each of which has a downwardly extending recess **24'** and **26'**, respectively, formed therein, with the recesses extending substantially the length of the flanges. The flanges **18'** and **20'** have passage-defining conduits F–**5** extending therethrough, which conduits terminate flush with the vertical faces of the recesses **24'** and **26'**. A relatively thick resilient rubber pad **46** is provided that is of greater thickness than the combined depths of the two recesses **24'** and **26'**, and this pad when disposed in the recesses separating the lower adjacent faces of the flanges **18'**, **20'**.

When the fasteners E extending through the passages F–**5** are post tensioned, the pad **46** is compressed, but with the adjacent faces of the flanges **18'** and **20'** still being separated by a sufficient distance that these faces will not contact one another when the float units of which the flanges **18'** and **20'** form a part are subjected to maximum flexing action. The pressure pad **46** has two bores **48** extending therethrough that are alignable with the passages F–**5**, and when the pressure pad **46** is compressed, the pad deforms inwardly to force the resilient portion thereof surrounding the bores **48** into sealing contact with the fastener E to seal the elongate passages from each other and from the atmosphere. Should a portion of the resilient pad **46** deform upwardly to any extent, as shown in phantom line in FIGURE 11, when the pad **46** is subjected to compression, this upwardly projecting portion **46'** may be shaved or cut therefrom after the post tensioning of the units has been completed.

From applicant's experience it has been found that the fastener E most convenient to use is a resilient cable, for the reasons that it is light in weight, may be coiled, and assumes a compact, portable configuration.

However, it is to be understood that the fasteners E capable of being used in the invention disclosed herein are not limited to cables, but that elongate rods may be used for this purpose such as shown in FIGURE 13. In this form of the invention lengths of sucker rod **50** such as are used in the oil fields are provided, with the threaded end **52** of one length of sucker rod being removably joined to the tapped socket **54** provided on an adjoining end portion of a length of sucker rod as shown in FIGURE 13. When sucker rod **50** is used for the fastener E, preferably in the passages F–**5**, the passages must be of greater transverse cross section than when cable is employed, for the passages must provide sufficient cross section to permit the sockets **54** to be disposed within the confines thereof. The projecting ends of the sucker rod **50** are threaded, and after being post tensioned lock nuts **56** are mounted on these threaded projecting end portions with the nuts bearing against pressure plate **58**, which in turn is in abutting contact with a resilient pad **60**.

When fasteners E of the rod type are employed, the adjacently disposed faces of the flanges **18'** and **20'** may be separated from one another by the construction shown in either FIGURES 4, 11 or by a resilient pressure pad **59** that abuts against the entire adjoining faces of the flanges, and is sufficiently resilient as to permit flexing of the flanges relative to one another the maximum amount that will occur when the float units are in actual use, without placing damaging forces or strains upon the concrete structure defining the flanges.

Although the wharf fingers composed of float units B–**1** to B–**4** inclusive may be held in fixed relationship in a body of water by the use of engaging members C and piles D–**1** and D–**2**, such a construction may be impractical or unduly expensive if the body of water is of considerable depth. A first alternate construction for holding a number of the float units in a desired spaced relationship, particularly when arranged to define two fingers K–**1** and K–**2**, is shown in FIGURES 6 and 7. In this first alternate construction the inwardly disposed ends of float units B–**2** and B–**4** are abutted against and affixed to a pier, other float units, or a portion of land, indicated generally in FIGURE 6 by the numeral **66**.

Identical rigid members **68** project downwardly from opposite sides of both the float units B–**1** and B–**3**, and may be either cast of concrete as an integral part thereof, or affixed to the units by means suitable for this purpose. A cable **70** that is at all times in tension extends between the inwardly disposed members **68** as shown in FIGURES 6 and 7. The cable **70** is situated a sufficient distance beneath the surface of the body of water in which fingers K–**1** and K–**2** are situated as to be cleared by any boat used in this body of water that would draw alongside float units B–**1**, B–**2**, B–**3** or B–**4**. Two cables **72** are also provided that are likewise at all times under tension and extend from the lower portions of the outwardly positioned members **68** to anchor points **74** on the body **66** against which float units B–**2** and B–**4** abut.

A second construction for holding a number of float units together in the form of two fingers K–**1** and K–**2** is shown in FIGURES 8 and 9, with this second construction being identical with the first construction except that the cables **72** extend to two heavy weights, concrete blocks or the like identified by the numerals **74** lying on the bottom of the water as best seen in FIGURE 9.

The methods of forming two species of the float units shown in detail in FIGURES 4 and 5 is disclosed in FIGURE 10. A mold **80** is provided that comprises two separate side walls **82** and two separate end walls **84** that may be removably clamped together at the vertically extending end portions thereof by means not shown. Side walls **82** and end walls **84** when so disposed provide interior surfaces that are complementary to the exterior side wall, end wall and flange surfaces of the float units B shown in FIGURES 1, 2, 3 and 4.

Cement **96**, aggregate and sand **98**, and water **100** are mixed in conventional power-operated cement mixing equipment (not shown) until a concrete mix **102** is obtained which, when it sets and solidifies after a curing period, is waterproof.

When the concrete float units B are to be used in salt water, it is highly desirable that the aggregate be one that has been subjected to a sufficiently high temperature that all metals present in the aggregate are volatilized, with the resulting aggregate being substantially free of any appreciable free metals. Even slight quantities of metals present in the aggregate of concrete exposed to salt water are detrimental, for they provide large numbers of tiny galvanic couples, with a resultant flow of elec-

tricity through the concrete when these couples are exposed to salt water. The path of the flow of electricity that results from such galvanic cells is completely unpredictable, and may result in the rapid disintegration of the concrete in which the cells are situated by electrolytic action. Therefore, it is highly desirable that all float units manufactured in accordance with the present process be free of aggregate carrying appreciable metal content.

The concrete mix **102** after it has attained the correct consistency is poured into one of the molds **80** to a depth sufficient to form the bottom **10** when the concrete solidifies as shown in FIGURES 4 and 10. It will be noted that the mold **80** has no bottom, and merely rests on a suitable smooth flat surface **86**. Rolls of metallic wire mesh or other metal webbing **104**, such as that suitable for reinforcing concrete, are formed to define upper and lower box portions **108** and **106**, respectively, as shown in FIGURE 10, with the upper box **108** being of slightly larger transverse cross-sectional area than the lower box **106** and adapted to be slid downwardly thereover to form a complete enclosure **110**.

One of the box portions **106** is now lowered downwardly in the mold **80** in which the first pour of concrete has been made, with the bottom **106***a* of the box being pressed downwardly into the still unset concrete defining the bottom **10** to be substantially centrally disposed therein. The upwardly extending walls **106***b* of box **106** are disposed inwardly from the interior surfaces of the mold side walls. At this point of the process it is necessary to decide whether the first or second species of the float unit B will be formed by the use of the process.

Should the first species of float unit B be elected to be manufactured, which species is unsinkable in water, relatively thick sheets of a suitable buoyant polymerized resin foam, such as Styrofoam manufactured by Dow Chemical Company of Midland, Michigan, are disposed in mold **80** to form an inverted box **111**. The outer surfaces of the vertical walls of box **111** serve to confine the concrete to define the inner vertical surfaces of the walls **12** and **14** of the float units B. The upper surface of horizontal wall **112** of box **111** defines the lower interior surface of top **16** of float units B.

A second pour of concrete is made into mold **80** between the interior vertical surfaces thereof and the exterior vertical surfaces of box **111**. The second pour of concrete into mold **80** substantially forms the walls **12** and **14** of float units B. One of the upper web box portions **108** is now disposed in mold **80**, and the vertical walls thereof are pressed downwardly in the concrete-defining walls **12** and **14** until the top **108***a* of the box portion is situated a substantial distance below the upper edges of the flange-defining portion of mold **80**. A number of lengths of metallic web in the form of channels **118** are disposed in the upper portion of the mold **80**, as are a number of rigid tubular members **120** that will provide the passages F–5 and F–15 when the float unit is completed. The third pour of concrete is now made to fill the mold, with the web channels **118**, tubular members **120** and box **108** being imbedded therein.

The process of forming the second species of the float unit, which is identified by the notation B′, is identical with the process of forming the first species with the exception that the box **111** which serves as the core in the above described forming operations has a heavy cardboard box **116** of the same exterior dimensions substituted in its stead. Box **116** is filled with interlocking sheets of heavy cardboard **118** arranged in the well-known egg crate like structure to form a reinforcing interior, and prevent collapse of the box **116** when supporting the freshly poured concrete in the second and third major steps of the process. Box **116** remains as a core in the units B′ after they are formed, but ceases to serve any useful function after the concrete defining the box has set.

An inexpensive buffer **121** that protects the paint surfaces of boats from damage due to contact with the flanges **18** and **20** is shown in transverse cross section in FIGURE 3. The buffer in transverse cross section is of a channel shape and defined by a web **122** from which two parallel legs **124** project outwardly at the ends thereof. Buffer **121** may be formed of rubber or a resilient polymerized resin. The spacing of the legs **124** is such that they frictionally grip the upper and lower surfaces of the flanges **16** to hold the buffers **120** in place thereon. Buffers **121** are supported on flanges **18** in end-to-end relationship.

The first, second and third pours of concrete above mentioned are made in as rapid succession as possible in order that the concrete in one pour will not have set at the time the following pour is made. In this manner each float unit B or B′ is of monolithic structure, and the possibility of cracks developing therein as a result of cold joints is eliminated.

Another form of the invention is shown in FIGURE 14, in which float units B″ are shown that are of the same general shape as the units B and B′ previously described, and can be manufactured in the same manner outlined hereinabove in conjunction therewith. The units B″ are disclosed in detail in the copending application Serial No. 674,901 previously mentioned. Each float unit B″ consists essentially of a hollow box whose length and width are substantially greater than its depth and whose top, bottom and walls are made of reinforced concrete. A top slap **211** and a bottom **212** are exactly parallel to each other since the box has a uniform depth throughout. End and side walls **213** interconnect the top and bottom portions of the box.

A reinforced concrete flange protrudes outwardly from the sides and ends of the box of each float unit B″ to provide an extension of the top surface thereof, the flange portions being identified by the numeral **220**. These flanges effectively form a buffer means to receive impacts and to space propellers on boats being directed away from adjacent vertical ends of a float unit as well as to prevent the hull of the boat from coming in contact with the box portions of the float units. The flanges have imbedded therein a plurality of protruding, spaced apart threaded bolts **221** or other fastening means. These bolts or other fastening means are adapted to removably engage longitudinally extending tie rods **214** that connect the float units B″ together, the tie rods also acting as buffers to prevent inadvertent damage to boats disposed adjacent the float units.

In each portion of the box structure of the float unit B″, the concrete is reinforced at approximately the center portion thereof by a galvanized wire mesh screen **223**, or other suitable reinforcing material. As shown in FIGURE 14 the reinforcing screen **223** in top slab **211** is curled over at the outer edges thereof to provide reinforcement for the adjoining flange portion. As also shown in FIGURE 14 the reinforcing screen, although arranged in a number of separate pieces, has sufficient interweaving, overlapping or other interconnection of adjoining screen portions so as to assure a firm structural support for the entire float unit.

There are several reasons for supplying the float unit of the present invention with a flange surrounding its top surface. First the flange is approximately twice as thick as the top slab, or main deck, and being thoroughly reinforced provides a heavy beam which protects the top slab from bending or cracking. This construction is also common to both the float units B and B′ previously described in the present application. In this connection it may be noted that the reinforcing material is arranged in the form of a hollow rectangular enclosure whose sides in either a longitudinal or transverse direction lie near the respective surfaces of the flanges. A second reason for the flange is to provide a point of strength or buffer means to receive impacts, as from a boat when it is being docked. A third reason is to protect the main body of the float from being damaged from any projecting object as, for

example, the propeller of a boat. A fourth reason is to support the bolts or other fastening means, and to distribute forces received from the tie rails throughout the structure of the top portion of the float units. It will be particularly noted that any forces developing as a result of flexing of the float units relative to one another may result in tensional forces in the tie rails, the tie rails transmit such forces to the flanges and top portions of the float units as compressive forces. A still further reason for providing the flanges on the unit B'' as well as the units B and B' previously described is to provide a space between adjacent float units at the water surface, so that tides or currents readily pass therebetween, and as a result laterally applied forces to the float units are held to a minimum, and there is a minimum tendency of the aligned float units to deviate from this position due to extraneous lateral forces of the type just mentioned. Spacing of adjoining float units below the flange portions thereof eliminates the possibility of damage to the units by contact therebetween as the units are moved relative to one another by wave action, currents or the like.

Although the inventions above described are fully capable of achieving the results and providing the advantages hereinbefore mentioned it is to be understood that they are merely illustrative of the presently preferred embodiments of the inventions and that there is no intention to be limited to the details of construction herein shown and described other than as defined in the appended claims.

I claim:

1. A first concrete float unit adapted to be attached and held in a substantially fixed position relative to a second float unit by resilient elongate metallic fastening members to provide a horizontal load bearing surface comprising: a hollow concrete box having a bottom surface adapted to be normally submerged in a body of water and a normally upwardly facing horizontal top surface connected by a straight side surface extending upwardly from said bottom to said top surface; a concrete flange of substantial width projecting outwardly from said top surface on at least said one straight side of said box and providing an extension of said top surface; and a plurality of spaced passage-defining means extending through said concrete flange and alignable with passage-defining means formed in said second of said float units, with said passage-defining means when said straight sides of said first and second float units are adjacently disposed being capable of having said fastening members disposed therein to hold said first and second float units together separated by a distance slightly greater than the combined width of both of said flanges.

2. A float unit as defined in claim 1 in which a core is disposed that is formed of non-metallic sheet material of an egg crate structure.

3. A float unit as defined in claim 1 in which a core of material is disposed within the confines thereof, said core material being in the shape of an inverted open box and said material being a polymerized resin foam.

4. A float unit as defined in claim 1, in which a core of polymerized resin foam is disposed, said resin being of such density and present in such quantity within the confines of said float that said float will remain in a floating position should the water in which it floats be admitted to the interior thereof.

5. A float unit as defined in claim 1 in which each of said passage-defining means is a rigid elongate conduit having an interior transverse cross-sectional area greater than the transverse cross-sectional area of one of said fastening members, and each of said conduits being held in a fixed position within the confines of one of said units above the water line thereof when said unit is subjected to the maximum load it is designed to receive in use.

6. A first concrete float unit adapted to be removably attached and held in a substantially fixed position relative to a second of said units by resilient elongate members to provide a horizontal load-bearing surface comprising: a hollow concrete box having surface adapted to be normally submerged in a body of water and a normally upwardly facing horizontal top surface connected by a straight side surface extending upwardly from said bottom surface to said top surface; a concrete flange of substantial width projecting outwardly from said top surface on at least said one straight side of each of said first and second float units and providing extensions of said top surfaces thereof with at least one elongate passage extending through said concrete of each of said float units, and each of said float units having a recess formed in said flange thereon, with said passage in each of said units in communication with said recess formed in said flange thereof, and said first and second units capable of being disposed in a floating position with said flanges adjacently disposed and said passages and recesses aligned with one another; and a resilient compression pad of substantially greater thickness than the combined depth of said recesses in said flanges, said pad of such dimensions as to be insertable within the confines of said recesses, and said pad formed with a bore of slightly greater transverse cross-sectional area than the transverse cross-sectional area of one of said elongate members, and each of said elongate members when extended through two of said aligned passages and through said bore in said compression pad disposed in said recesses in communication with said aligned passages and subjected to a predetermined tension, longitudinally compressing said pad to deform same inwardly into sealing contact with said elongate member to protect that contacted portion of said elongate member from contact with the atmosphere, with said compression pad separating the adjoining end surfaces of said flanges in which said recesses are formed to the extent that said first and second units may flex relative to one another the maximum amount to which they will be subjected when in use, and without any portions of said flanges coming into physical contact as a result of said flexing movement.

7. A float unit as defined in claim 6 in which a plurality of said passages are formed in each of said float units and a corresponding plurality of said recesses are formed in said flange in spaced apart relationship, said passages spaced from one another and terminating in said spaced recesses formed in said flange of said unit, and a plurality of said resilient pads are provided, each of said pads being of such size as to snugly fit within the confines of one of said recesses to have one of said elongate fastening members extend therethrough.

8. A float unit as defined in claim 7 in which said elongate passages are defined by a plurality of elongate rigid tubular members with each of said tubular members having an interior transverse cross-sectional area greater than the transverse cross-sectional area of one of said elongate fastening members, said tubular member being embedded within said concrete defining one of said float units.

9. A floatable structure that defines a horizontal load bearing surface of desired configuration comprising: a plurality of float units, with each of said units comprising a hollow concrete box having a bottom surface adapted to be normally submerged in a body of water and a normally upwardly facing horizontal top surface, with each of said float units having concrete flanges extending from those sides thereof that will be disposed adjacently to another of said units, said flanges projecting outwardly from said top surfaces to provide extensions thereof, and each of said flanges defining a straight flat face on the outer extremity thereof that is substantially normal to said horizontal top surface, and each of said float units having at least one passage extending therethrough, with said passage disposed above the water line of said unit when said unit is subjected to the maximum load it will encounter in actual service, with each of said passages

terminating in an opening in one of said flanges; a plurality of elongate resilient members extending through said passages for connecting said units together to provide said surface of said desired configuration; means for holding the free end portions of said elongate members at fixed positions relative to those flanges from which said members project; and a plurality of resilient compression members disposed between the adjacently disposed faces of said flanges and in abutting contact therewith, with said resilient compression members separating said adjacently disposed faces of said flanges to the extent that no portion of said float units contacts adjacent float units when said float units are subjected to the maximum flexing relative to one another that they will encounter in the body of water in which they are installed.

10. A floatable structure as defined in claim 9 in which each of said passages is defined by an elongate conduit having an interior transverse cross-sectional area that is greater than the transverse cross-sectional area of said elongate member that will be disposed therein.

11. A floatable structure as defined in claim 10 in which said flat straight face of each of said flanges has a recess formed therein that is in communication with at least one of said conduits.

12. A floatable structure as defined in claim 11 in which each of said resilient compression members is of such shape as to fit within the confines of one of said recesses, each of said compression members being of such thickness that when said compression member is longitudinally compressed by said elongate member extending therethrough being loaded said flat adjoining faces of said flanges are separated to the extent that no portion of adjacently disposed flanges will contact one another when said floatable structure is subjected to the maximum flexing action said structure will encounter in actual use.

13. A floatable structure as defined in claim 12 in which said elongate resilient members are resilient cables.

14. A floatable structure as defined in claim 12 in which said elongate resilient members are a plurality of resilient rods, with each of said rods having male and female threaded means disposed on opposite ends thereof, and said rods capable of being assembled into the necessary lengths to hold said floats together by the male threads at one end of each of said rods engaging the female threads on the end of an adjacently disposed one of said rods.

15. A floating load supporting structure comprising: a plurality of hollow float units disposed in end to end relation with their axes in alignment, each of said units including spaced apart top and bottom walls of concrete and a plurality of upright concrete side walls connecting said top and bottom walls to define a chamber, said chamber being of sufficient size to provide buoyancy to said unit sufficient to float said unit with the top thereof above the surface of a body of water, said float units each having wall sections formed with tension element-receiving passage means of small cross-sectional area isolated from the hollow interior of the float unit having ends opening respectively on opposite ends of the float unit, the ends of corresponding passage means of adjacent float units being in alignment; and means for flexibly connecting said plurality of hollow float units in end to end relation with the ends of adjacent float units spaced from each other and with said float units being capable of yielding to wave action, said last-named means including at least one flexible elongated tension element extending through said passage means of said plurality of float units to interconnect same with the ends of adjacent float units spaced from each other, the cross-section of each tension element being only slightly smaller than the cross-sectional area of the corresponding passage means, and resilient means positioned between each pair of adjacent float units in sealing relationship with the aligned ends of the passage means thereof, said tension member traversing said resilient means.

16. A floating load supporting structure as defined in claim 15 in which each resilient means comprises a resilient pad between the ends of the aligned passages of adjacent float units, said pad having an opening through which the corresponding tension element extends, said opening being only slightly larger than said tension element whereby tensioning of said tension element compresses said resilient pad around the tension element in sealing relationship therewith.

17. A floating wharf structure comprising: a plurality of hollow float units, each of said units including spaced apart top and bottom walls of concrete and a plurality of side walls connecting said top and bottom walls to define a chamber, said chamber being of sufficient size to provide buoyancy to said unit sufficient to float said unit with the top thereof above the surface of a body of water, said float units each having wall sections formed with tension element-receiving passage means isolated from the hollow interior of said float units; elongated tension elements extending through said passage means to interconnect said float units in adjacent relationship; and resilient abutment means interposed between said units to cooperate with said tension elements to render said float units capable of yielding to wave action and the tension of said tension elements to be transferred to said wall sections for distribution to said float units as compressional forces.

18. A floating load supporting structure comprising: a plurality of hollow float units disposed in end to end relation with their axes in alignment, each of said units including spaced apart top and bottom walls of concrete and a plurality of upright concrete side walls connecting said top and bottom walls to define a chamber, said chamber being of sufficient size to provide buoyancy to said units sufficient to float said unit with the top thereof above the surface of a body of water; a conduit means embedded in the concrete of each float unit at a position adjacent the top wall reinforcing same and providing a tension element-receiving passage means isolated from the hollow interior of the float unit, the ends of the conduit means opening respectively on opposed ends of such float unit at a level below the top surface of said top wall but above said surface of said body of water, the ends of corresponding conduit means of adjacent float units being aligned; and means for flexibly connecting said plurality of float units in end to end relation with the ends of adjacent float units spaced from each other and with said float units being capable of yielding to wave action, said last-named means including an elongated tension element extending through the passage means of said float units to interconnect same, and a resilient member around said tension member in the space between the ends of adjacent float units and compressed between such ends in sealing relation with said aligned ends of said conduit means by tension in said tension element.

19. A floating load supporting structure comprising: a plurality of hollow float units disposed in end to end relation with their axes in alignment, each of said units including spaced apart top and bottom walls of concrete and a plurality of upright concrete walls comprising two opposed side walls and two opposed end walls connecting said top and bottom walls to define a chamber of sufficient size to provide buoyancy to said unit sufficient to float said unit with the top thereof above the surface of a body of water; two longitudinal conduits embedded in the concrete of each float unit respectively near the junction of the two side walls and said top wall, said conduits providing two longitudinal tension element-receiving passages having ends opening respectively on the ends of the corresponding float unit, the ends of corresponding conduits of adjacent float units being aligned; means for flexibly connecting said plurality of float units, said last-named means including two flexible elongated tension elements extending respectively through said conduits of said float units to interconnect same in end to end

relation; and resilient abutment means interposed between the ends of adjacent float units at a level adjacent the level of said conduits and compressed between such ends of adjacent float units by the tension loads of said tension elements.

20. A floating load supporting structure as defined in claim 19 in which at least one of said float units includes also at least one transverse conduit crossing said longitudinal conduits at a level offset from the level of the latter, said transverse conduit providing a transverse passage having ends opening on the opposed sides of such one float unit, and including another float unit disposed alongside said one float unit, said other float unit having concrete top, bottom, side and end walls defining a chamber of sufficient size to provide buoyancy to said other float unit with the top thereof above said water surface and substantially laterally aligned with the top of said one float unit, said other float unit having a through conduit having its ends opening respectively on the sides of such other float unit with one such end in alignment with one end of said transverse passage of said one float unit, means for flexibly connecting said one float unit and said other float unit in alongside relation comprising a transverse flexible elongated tension element extending through said transverse conduit of said one unit and said through conduit of said other unit to interconnect such float units, and resilient abutment means interposed between the adjacent sides of said one unit and said other unit compressed between such adjacent sides by the tension load of said transverse tension element.

21. A floating wharf structure comprising: a plurality of hollow float units, each of said units including spaced apart top and bottom walls of concrete and a plurality of side walls connecting said top and bottom walls to define a chamber of sufficient size to provide buoyancy to said unit sufficient to float said unit with the top thereof above the surface of a body of water, the top wall of each float unit having a straight flange portion overhanging an adjacent side wall and being formed with reinforced wall sections provided with at least two longitudinal tension element-receiving through openings isolated from the hollow interior of said float units; elongated flexible tension elements extending through said openings to interconnect said float units to retain said flange portions in adjacent relationship, and resilient abutting members interposed between said flange portions to cooperate with said tension elements to render said float units capable of yielding to wave action and the tension of said tension elements to be transferred to said reinforced wall sections for distribution to said float units as compressional forces.

22. A floatable structure providing a float load bearing surface, said structure comprising: a plurality of hollow concrete float units disposed end to end with their axes in alignment, each of said float units including spaced apart top and bottom walls of concrete and paired side and end walls of concrete connecting said top and bottom walls, said top walls providing flat top surfaces compositely forming substantially the entire flat load bearing surface of said structure, said top, bottom, side and end walls defining a chamber of sufficient size to provide buoyancy to such float units sufficient to float same with said top surfaces a substantial distance above the surface of a body of water whereby a substantial portion of each end wall of each float unit is exposed above said water surface; and means for flexibly connecting said float units exclusively in a horizontal plane close to the top of said float units and substantially above said water surface to permit said float units to yield to wave action, said last-named means including resilient spacer means comprising spacer members exclusively in said horizontal plane, at least one of said spacer members being disposed between each pair of adjacent float units holding the end walls thereof apart to provide a space therebetween both in said horizontal plane and therebelow, the spaces between the ends of adjacent float units below said spacer means providing passages for water currents transverse to said plurality of floats, said spacer members being formed of a material substantially more resilient than said concrete, and flexible elements exclusively in said horizontal plane and on opposite sides of the aligned axes of said float units, said flexible elements extending between adjacent float units and transverse to said spacer means for holding the adjacent float units together with at least one of said resilient spacer members therebetween.

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