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[54] **MODULAR CONCRETE FLOATATION UNIT**

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[52] **U.S. Cl.** ..... **114/0.5 F,** 61/48, 114/0.5 BD, 114/65 A

[51] **Int. Cl.** **B63b 35/00**

[58] **Field of Search** ..... 114/0.5 R, 0.5 BD, 114/0.5 F, 0.5 T, 45, 46, 230, 66 SF, 65 A, 26, 43.5; 9/8 R, 8 P; 61/46.5, 48, 46; 14/27, 75

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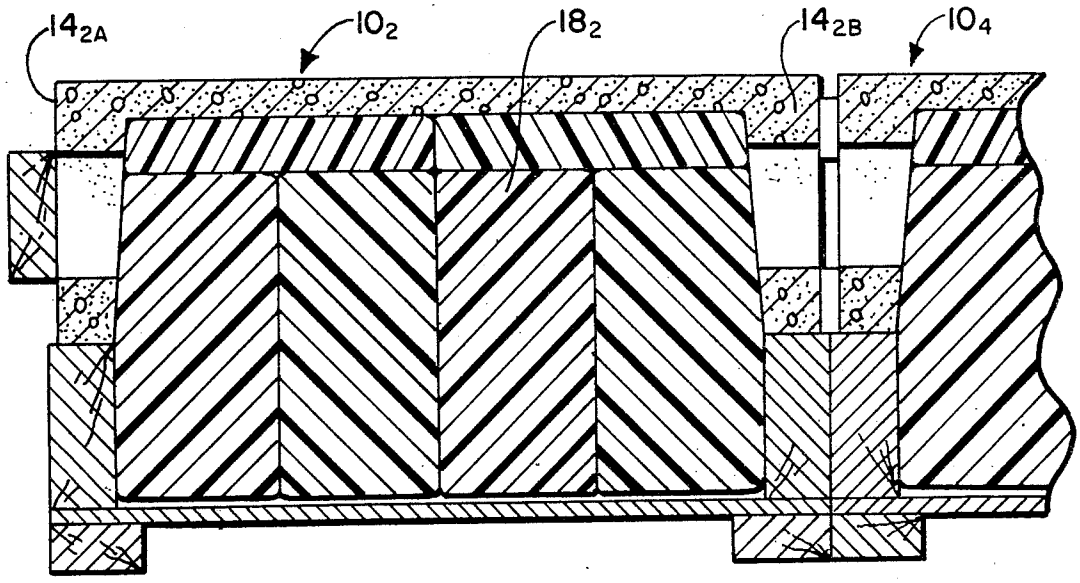
[57] **ABSTRACT**

A modular floatation unit useful in the construction of floating piers, boat houses, work platforms, docks, marinas, and the like, readily articulated and of particular utility in water bodies with frequent level changes. The modular floatation unit is comprised of the combination of a reinforced concrete channel slab having an upper flat side and a hollow or concave side, blocks of cellular foam or plastic wrapped in a protective covering or coated with a protective film packed within the hollow or concave side of the said slab, and an open wood frame secured to the underside of the concrete slab to hold the wrapped or coated blocks of cellular foam or plastic in place. The center of gravity of the modular floatation unit is located at a point wherein, in water, the upper flat side of the concrete slab will float above the surface, and provide a deck or walkway as well as protection for the wrapped blocks of cellular foam or plastic. The wood frame will be submerged where it will protect the blocks of cellular foam or plastic against impacts, and it is itself protected against deterioration.

15 Claims, 6 Drawing Figures



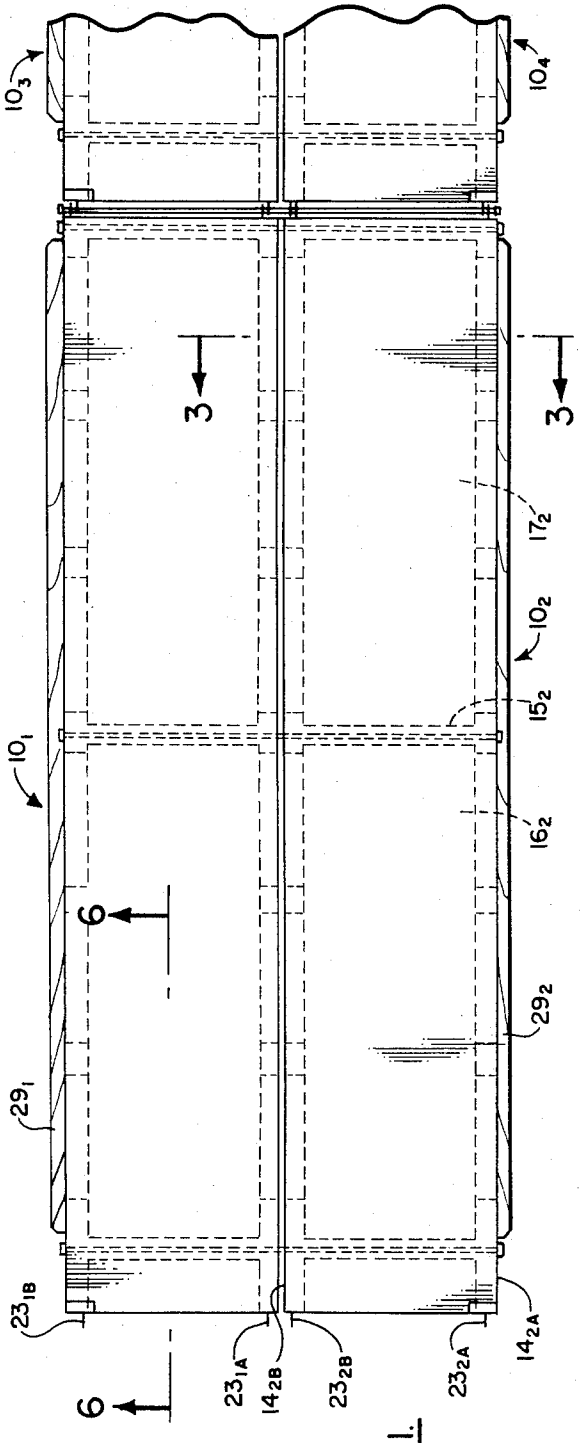


FIG. 1.

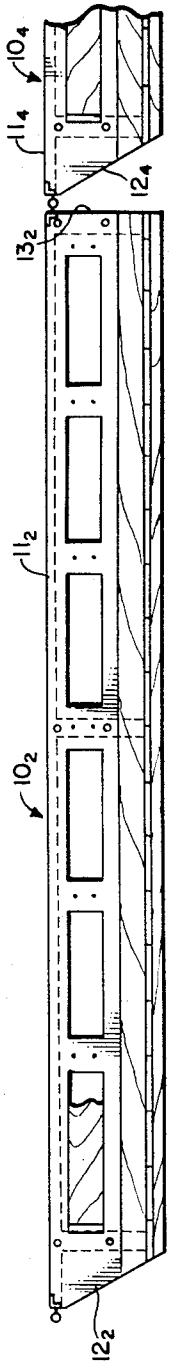


FIG. 2.

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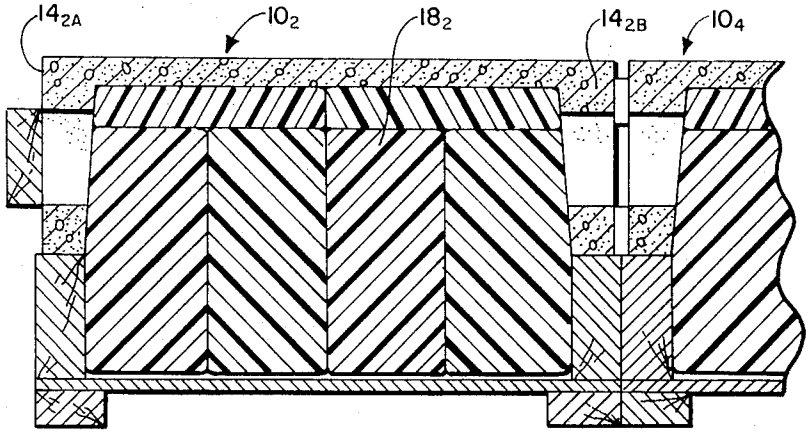
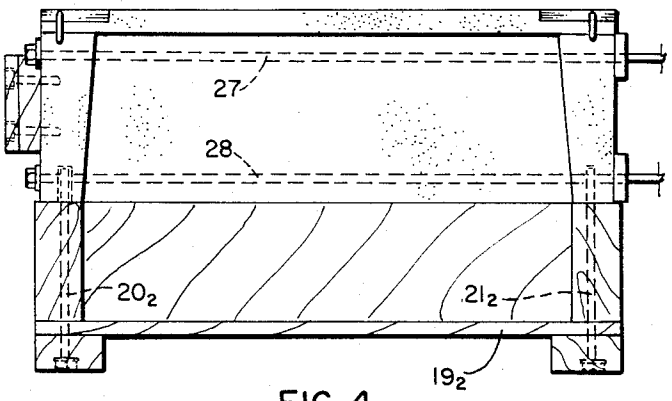


FIG. 3.



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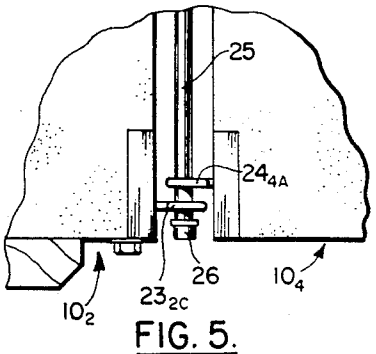

FIG. 5.

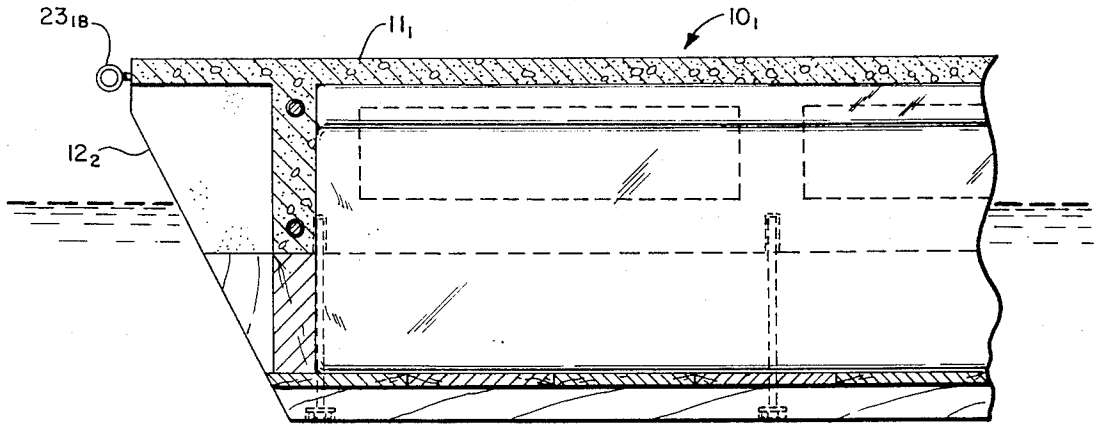

FIG. 6.

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MODULAR CONCRETE FLOATATION UNIT

Various floatation units, including buoyant structures of modular form, have long been known for use in the construction of floating piers, boat houses, work platforms, docks, small craft, yacht or boat marinas, and the like. Many of these units were constituted of hollow, box-like units which depended largely on the enclosed void to provide buoyancy. The materials of construction used in forming these units have been quite varied. A considerable number of floatation units were made of metal, but corrosion problems were burdensome and impacts sometimes damaged the units beyond repair. Early floatation units were also made of wood and the floatation unit, though initially heavy, further lost buoyancy by becoming water logged. Problems existed in sealing joints, and the wood deteriorated and was infested by marine organisms, borers, and fungi. Wooden planks forming the deck of such structures were subject to attack by moisture, boards loosened and nails rusted. Nails tended to pull out as the planks warped and twisted due to moisutre and weathering. Periodic scraping, sanding, painting and replacement of boards was necessitated. A high degree of maintenance was thus required to keep the wooden structures in serviceable condition.

With the more recent advent of cellular forms and plastics, some floatation units were constructed of blocks of these materials, e.g., cellular polystyrene. These materials, however, had the disadvantage of friability which causes them to spall and the material can be easily rubbed away as when in contact with a shifting pier. Cellular forms can also become encrusted with barnacles, and the material is easily damaged when the barnacles are removed. Such materials are also readily attacked by acids, corrosives, detergents, and organic solvents, such as gasoline, which are often present around piers and docks due to spills. Attempts have been made to provide both the wooden and the cellular plastic materials with waterproof skins, but the problems were retained once punctured by impacts, e.g., from boats, as happened all too frequently.

Floatation units constructed of reinforced concrete have also been used in the art with some degree of success. Despite its excessive mass and relatively low tensile strength, concrete was recognized as a relatively inexpensive construction material. Moreover, it is very desirable and has the advantage of being highly resistant or impervious to attack by marine organisms, fungi, borers, corrosion and chemicals. Its weight has been overcome by the use of relatively light-weight aggregates, such as perlite, pumice, expanded shale and expanded clay. The use of wire mesh and reinforcing rods has alleviated the lack of tensile strength. Nonetheless, present concrete floatation units also suffer a number of serious disadvantages. An acute disadvantage is that great care must thus be exercised during shipment and in the positioning of the floats to assure against cracking or other structural damage. If any small holes are made in any of the concrete structures, water will fill the hollow center and cause the floats to sink. This hazard obviously remains even after the floats are shipped and positioned, due to potential impacts.

It is accordingly the primary objective of the present invention to provide a new, improved and highly durable floatation unit, or module, which will obviate the foregoing and other prior art disadvantages.

It is an object to provide such floatation unit, or module, of simple structure which can be used to support other structures or floated semi-free by use of standard anchor methods.

It is an object also to provide means for linking together a plurality of such floatation units, or modules, to form piers, boat houses, work platforms, and marinas for use by yachts, small craft, boats and the like.

A particular object is to provide floatation units, or modules, of simple and relatively inexpensive construction, particularly structures of such character which readily lend themselves to rapid mass production techniques.

These and other objects are achieved in accordance with this invention which embodies improvements in floating modules wherein reinforced concrete, cellular foams and plastics, and wood are each used in the construction to their best advantage. A modular floatation unit, particularly an articulated modular floatation unit, is comprised generally of a precast reinforced concrete channel slab, the hollow or concave side of which is packed with a cellular form or plastic, preferably coated or wrapped in a protective film or covering, the latter being secured in place by a wood frame, or frames, attached to the concrete slab.

In assembled position, the center of buoyancy is such that the precast reinforced concrete channel slab constitutes the upper portion of a modular floatation unit and the flat side thereof is floated out of the water, providing a floor surface or deck. The buoyancy for the modular floatation unit is provided by the cellular foam or plastic. Attack by acids, corrosives, detergents, organic solvents, and the like, is prevented in major part by the protective cover or film, and partly by the surrounding concrete. Immiscible solvents, such as gasoline, which float on the surface of the water often cannot contact even the protective film or cover of the cellular foam or plastic because of the surrounding layer of concrete. An open wood frame, or frames, is bolted or otherwise attached upon the bottom of the precast reinforced concrete channel slab to hold the wrapped cellular foam or plastic within the hollow or concave side of the slab while the module is out of the water, as during construction. Since the wood frame, or frames, constitutes the bottom of the modular floatation unit and lies totally submerged in the water, there is little or no deterioration as is common when wet wood is alternately wetted and dried. Further, the protective wood frame and concrete shields the cellular foam or plastic so that it cannot spall or rub away by contact with other objects as when the floatation unit comes into contact with stumps and similar objects due to fluctuating water levels.

This type of construction is relatively inexpensive and readily lends itself to rapid mass production techniques. For example, the reinforced concrete channel slab is precast at a factory site in precisely the same manner as a slab built for roof constructions except for side openings. The slabs can be shipped, assembled into modules, and the modules then put together to form piers, docks, marinas, and the like, without major concern of cracking or creation of holes such as can produce catastrophic consequences with prior art type concrete floatation units. At the module assembly site the cellular or plastic foam can be wrapped in protec-

tive covers, placed within the hollow or concave side of the concrete slab and the wood frame, or frames, attached to the slab to hold the floatation material in place.

The invention, and its principle of operation, will be more fully understood by reference to the following detailed description of a specific embodiment, and to the attached drawings to which reference is made in the description. In the description, similar numbers are used to represent similar parts or components, and subscripts are used where there are a plurality of similar parts or components.

In the drawings:

FIG. 1 is a top plan view of improved floatation units or modules embodying the present invention, including a fragmentary view of similar floatation units or modules to which the former are attached;

FIG. 2 is a side elevation view of the preceding figure;

FIG. 3 is a section taken along lines 3—3 of FIG. 1 showing the interior construction of the floatation units or modules;

FIG. 4 is a front end view of one of the floatation units or modules, this figure also showing certain details of construction, and the manner in which modules can be fitted together in parallel or side-by-side relationship;

FIG. 5 depicts in enlarged fragmentary section the manner in which modules can be fitted together or attached in end-to-end relationship; and

FIG. 6 is an enlarged side elevation view of the forward end of a module taken along lines 6—6 of FIG. 1 showing certain details and the manner in which the module is floated.

Referring to the figures, particularly to FIGS. 1 and 2, there is shown a series of interconnected floatation units mo modules $10_1,10_2,10_3,10_4$ which can be linked or secured one to another in end-to-end and side-by-side or parallel relationship one to another to form a floating structure, e.g., a pier. Float modules $10_1,10_2$ and float modules $10_3,10_4$, respectively, are connected or bolted together in side-by-side relationship one to another to form a portion of the pier, and float modules $10_1,10_3$ are connected together in end-to-end relationship with float modules $10_2,10_4$. Virtually any number of the float modules can be linked together in end-to-end or side-by-side relationship to form shapes such as T's, L's, U's, rectangles and the like, consistent with practical considerations, and with the strength of the concrete and the structural requirements of the steel rods used to link the members together, particularly in side-by-side relationship. Suitably, 10 to 20, or more, of the float unit are linked together in end-to-end relationship and as many as 10 to 12, or more, in side-by-side relationship. The exact size and shape of the units can be readily varied to meet the plan of the construction, as can the relative location between the floatation units themselves whether staggered or in series.

It will be observed that the top portion of a floating module 10, or portion thereof, which floats above the water level is constructed of a precast reinforced concrete channel slab $11_2,11_4$, the flat side of which forms a walking surface or deck. Dock cleats or other such devices can be provided to which ropes or lines can be fastened so that yachts or small boats can be moored alongside the pier or floating structure. An inwardly sloped forward wall $12_2,12_4$ and vertically oriented end and side walls $13_2,14_2,14_{2B}$, respectively, of the concrete portion of a floatation module 10 join together in a parallelogram, each wall intersecting another at right angles, and each extending downwardly into the water. At the center of the module 10_2 the side walls $14_{2A},14_{2B}$ are perpendicularly joined through a vertically oriented inner wall 15_2 so that two compartments $16_2,17_2$ are formed within the hollow or concave side of a concrete channel slab 10_2. Galvanized steel reinforcement, e.g., steel reinforcing rods (not numbered), and wire mesh are located within the concrete channel slabs 10 for added strength, as required by structural considerations, and openings (not numbered) are cut within the side walls 14 to reduce the weight.

The compartments 16,17, e.g., compartment 17_2, of a module 10_2 are tightly packed with one or more blocks 18_2 of cellular foam or plastic, especially a monocellular foam such as Styrofoam, to provide buoyancy, and the blocks of Styrofoam are coated, wrapped or painted with a suitable protective film or thin cover which prevents attack by acids, corrosives, detergents, organic solvents, and the like.

The wrapped blocks of Styrofoam 18_2 are held in place within compartment 17_2 of module 10_2 by a wood frame 19_2 which is bolted or otherwise secured to the underside of the said module 10_2, e.g., by bolts $20_2,21_2$. Preferably, the wood frame 19_2 is pretreated with a preservative under pressure, e.g., as when pretreated under pressure with creosote in conventional manner. Creosote treated wood frame 19 will last almost indefinitely under water out of contact with air. The location, in the modular structure, of the concrete, the wrapped cellular plastic foam, and the wood is ideally suited to maximize the advantage of each of the individual units for the good of the whole. The total module has the advantage of reinforced concrete in the location where it is most needed, viz., to shield against impacts, to provide optimum mass for shock absorption, and also to provide maximum durability against the action of the elements and normal environmental conditions. The plastic foam is an integral part of the modular unit and provides optimum buoyancy. It is protected by the surrounding layer of concrete but yet it offsets the major disadvantage of concrete, viz., its excessive mass. The open wood frame, on the other hand, is also highly durable when below water. It protects the cellular plastic from impacts from below, where some impacts can be expected, particularly at the time the structure is first placed in water. The structure is open to ingress and egress of water, differing basically from prior art floatation units which were destroyed by holes or cracks sufficient to permit ingress of water such as would destroy the buoyancy of the structure.

The forward wall of a module 10, including both the wall of precast reinforced concrete channel 12 and the forward wall of wood frame 19, is sloped inwardly and both the sloped forward end of a module 10 and the opposite end are provided with a plurality of aligned eye bolts 22,23 through which a rod 24 can be passed to secure modules 10 in end-to-end relationship.

Reference to FIG. 5 there is illustrated a preferred method in which float modules $10_2,10_4$ can be secured together in end-to-end relationship while yet permitting some relative motion between the modules as can be expected from ordinary wave action. A rod 25 is thus passed through eye bolts $23_{2C},24_{4A}$ which are affixed upon float modules 10_2, 10_4, respectively and paired with other similar eye bolts. The end or head of the rod

25 is threaded and an enlarged screw cap **26**, threadably engaged therewith, prevents accidental removal of the rod **25**. In the series, a forward sloped wall is paired with a vertical wall to permit free upward and downward motion by the modules, as when they are influenced by waves, so that they do not come into contact one wall with the other.

In a pier construction it is also generally necessary to secure a number of the modules **10** together in side-by-side relationship, thus providing a wide surface or deck area, and a platform which is highly stable against wave action. Typically, the modules are fastened together via bolts **27,28** and the outside faces of the modules of a series is normally provided with wood rails $29_1,29_2$ which serve as bumpers.

It is apparent that various modifications and changes can be made in the structure without departing from the spirit and scope of the present invention. Changes can thus be made in the absolute or relative dimensions of the parts, materials used, and the like, as well as in the suggested mode of securing the component parts of the individual module together, or in attaching the individual modules themselves together to form a floating pier, boat house, work platform, dock, marina, or the like.

The concrete slabs can be precast in conventional manner, and reinforced with ordinary welded wire mesh or concrete reinforcing rods, or both. Ordinary concrete or lightweight concrete aggregates which include, e.g., perlite, pumice, expanded clay, expanded shale, and the like, can be used in the formation of the precast concrete slabs. The lightweight concrete aggregates are preferred.

Cellular or plastic foam of various types is widely known in the art, these being characterized by their very low weight per unit volume and closed cell structure. In this invention, monocellular foam is used, and it is preferably used in the form of rigid blocks. Exemplary of such foam materials are polyurethane, polystyrene, and the like. Styrofoam, a polystyrene foam of monocellular structure manufactured and sold under the Dow Tradename, is a particularly suitable material because it is highly impervious to penetration by water, even after extremely long periods of exposure. The blocks of cellular or plastic foam are coated, wrapped, or painted by a protective film or cover which is waterproof and impervious to most corrosives, acids, detergents and organic solvents. Illustrative of such materials are polyethylene, polypropylene, polyvinylidene chloride, and polyvinyl chloride. Polyvinyl chloride sold under the Ethyl Tradename Visqueen is particularly useful in this capacity.

Virtually any wood is found useful in the formation of frames for use in such constructions, notable amont which is pine.

Having described the invention, what is claimed is:

1. A modular floatation unit useful in the construction over water of floating piers, boat houses, work platforms, docks, marinas, and the like, comprising the combination of:

a reinforced concrete channel slab having an upper flat side, a maximum of two parallel aligned side walls secured to the edges of said upper flat side, enclosing end walls and up to one intermediate wall providing a box-like member with a hollow underside, said side and end walls extending below the surface of said water when said floatation unit is floated, and an open bottom,

cellular plastic foam packed within and completely filling the hollow underside of said reinforced concrete channel slab, and

an open wood frame secured to the under-side of the concrete channel slab which holds the cellular plastic foam in place within the hollow under-side of the concrete channel slab,

the center of gravity of the aggregate structure which is located at such point that the flat upper surface of the concrete channel can be floated above the surface of the water, while the wood frame lies totally submerged in the water.

2. The apparatus of claim **1** wherein the wood frame is pretreated with a preservative to suppress deterioration due to fungi or other living organisms.

3. The apparatus of claim **1** wherein the cellular plastic foam is comprised of blocks, and the blocks are wrapped with a protective film substantially unreactive to acids, corrosives, detergents, organic solvents, gasoline and the like.

4. The apparatus of claim **3** wherein the blocks of cellular plastic foam are of monocellular structure.

5. The apparatus of claim **3** wherein the protective film is polyvinyl chloride.

6. The apparatus of claim **1** wherein the reinforced concrete channel slab constituting a portion of the modular floatation unit is precast, and provided with end walls and side walls, the latter containing openings which lessen the mass of the said slab.

7. The apparatus of claim **6** wherein a plurality of the modular floatation units are secured together in parallel relationship by bolts which are passed through the side walls of adjacent units.

8. The apparatus of claim **6** wherein each of the end walls of the modular floatation unit is provided with a plurality of spaced-apart eye bolts through which a bar can be passed to secure a plurality of modular floatation units together in series.

9. The apparatus of claim **8** wherein an end wall of the modular floatation unit is sloped inwardly and the opposite end wall is vertically oriented.

10. The apparatus of claim **9** wherein a plurality of the modular floatation units are secured together in end-to-end relationship via passage of a bar through the said spaced-apart eye bolts.

11. A modular floatation unit useful in the construction over water of floating piers, boat houses, work platforms, docks, marinas, and the like, comprising the combination of

a reinforced concrete channel slab which includes an uppe flat side, a maximum of two parallel aligned side walls secured to the edges of said upper flat side, enclosing end walls, and an intermediate inner wall in parallel relationship to said end walls which divides the underside of the channel into two compartments in tandem relationship one with regard to the other, said side and end walls extending below the surface of said water when said floatation unit is floated,

blocks of cellular plastic foam packed within and completely filling the two com-partments on the under-side of the said reinforced concrete channel slab, and

open wood frames secured to the under-side of the concrete channel slab over each of the compart-

ments to hold the blocks of cellular plastic foam in place within said compartments within the concrete channel slab,

the center of buoyancy of the modular floatation unit being located such that the flat upper surface of the concrete channel can be floated above the water to provide a deck surface, while the frames are totally submerged within the water.

12. The apparatus of claim **11** wherein the reinforced concrete channel slab is precast, and the side walls thereof are provided with openings which lessen the mass of the said slab.

13. The apparatus of claim **11** wherein the blocks of cellular plastic foam are wrapped with a protective plastic film substantially unreactive to acids, corrosives, detergents, organic solvents, gasoline, and the like.

14. The apparatus of claim **11** wherein the outside face of each end wall of the modular floatation unit is provided with a plurality of spaced-apart eye bolts through which a bar can be passed to secure a plurality of the modular floatation units together in series, one end wall of the modular floatation unit is sloped inwardly and the opposite end wall is vertically oriented.

15. The apparatus of claim **11** wherein a plurality of the modular floatation units are bolted together in parallel via bolts which pass completely through the width of the said units.

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