FIP8407 XR 3,306,053

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 1

FIG.3a

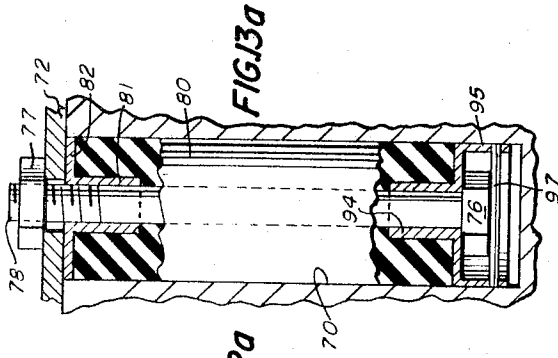


FIG.12a

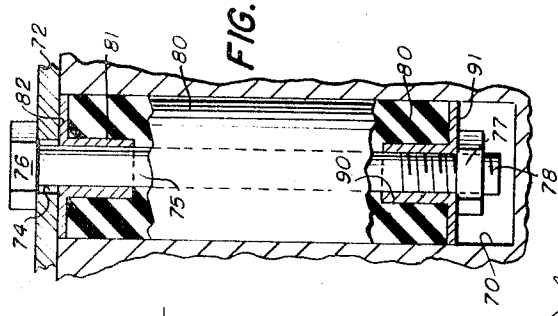


FIG. 1

INVENTOR
S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 2

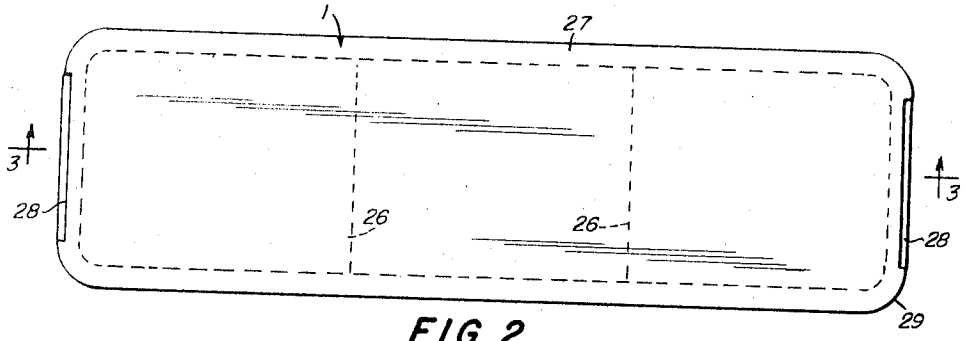


FIG. 2

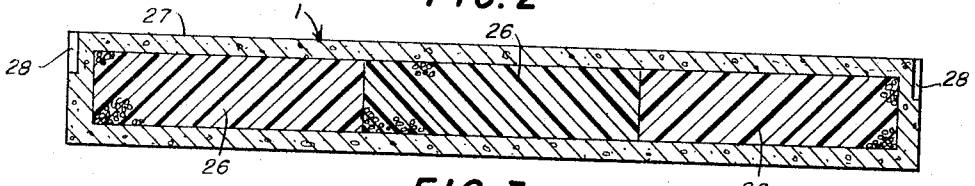


FIG. 3

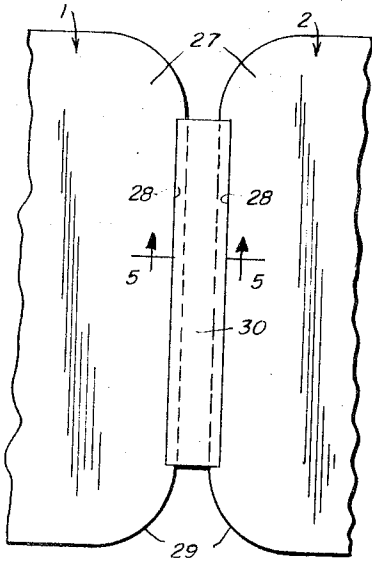


FIG. 4

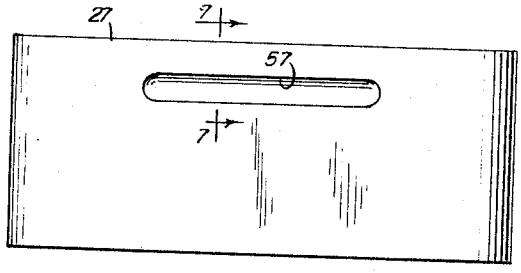


FIG. 6

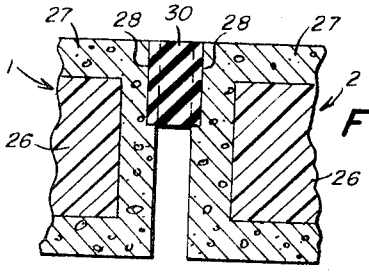


FIG. 5

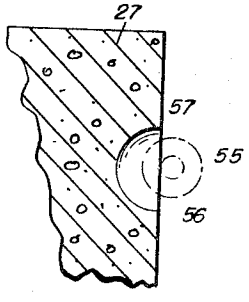


FIG. 7

INVENTOR

S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 3

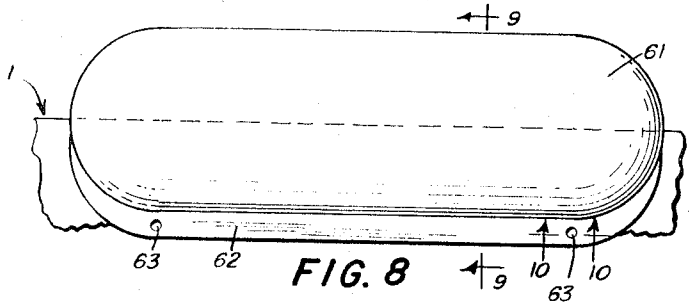


FIG. 8

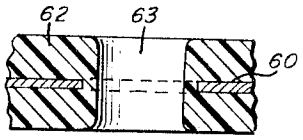


FIG. 10

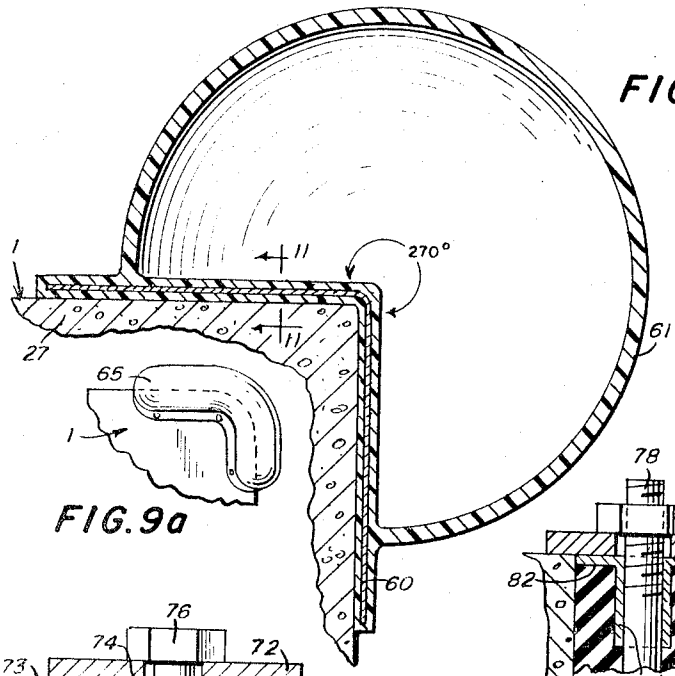


FIG. 9

FIG. 9a

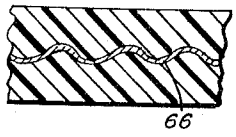


FIG. 11

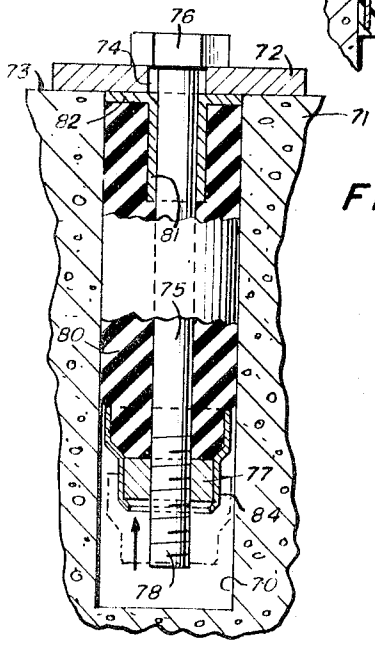


FIG. 12

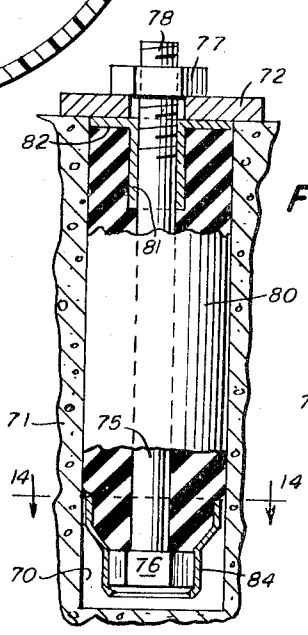


FIG. 13

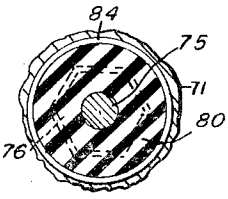


FIG. 14

INVENTOR

S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 4

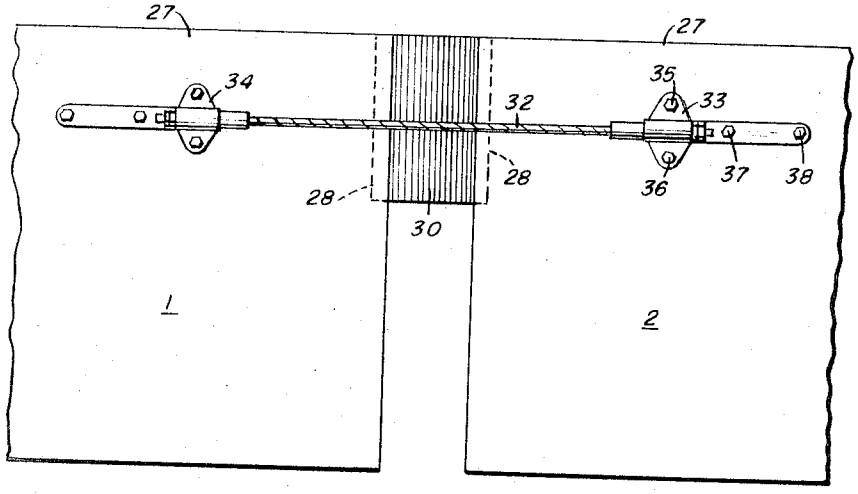


FIG. 15

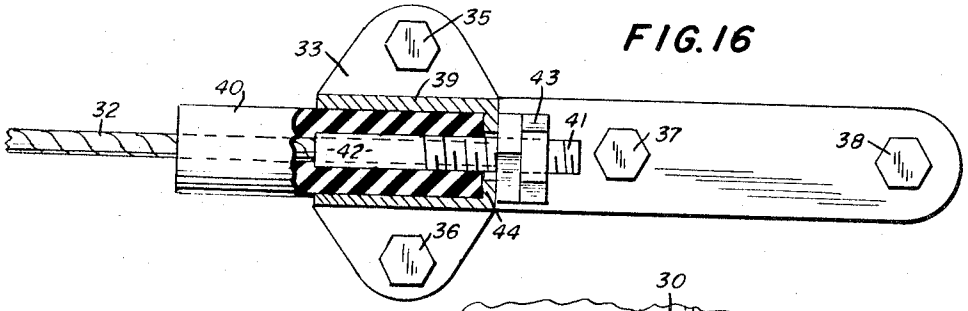


FIG. 16

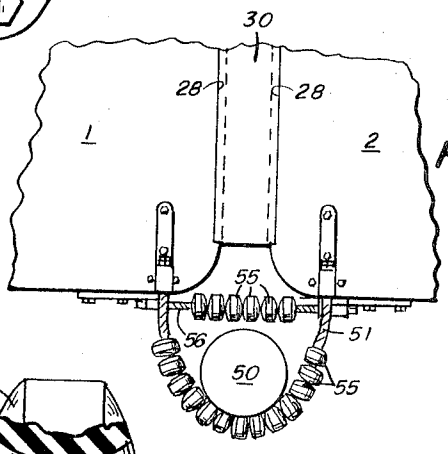


FIG. 18

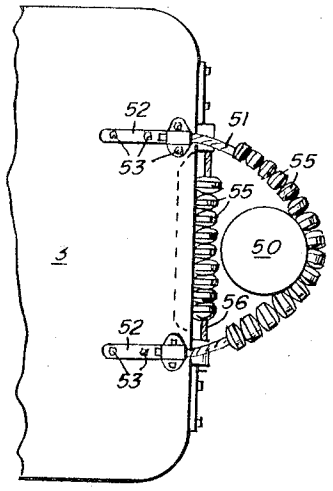


FIG. 17

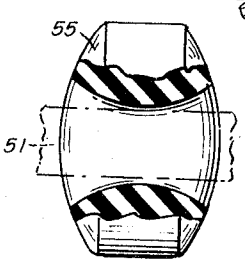


FIG. 19

INVENTOR

S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 5

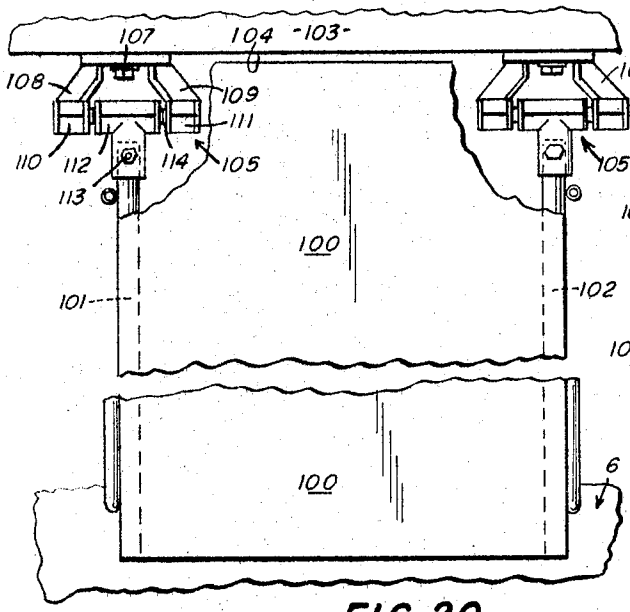


FIG. 20

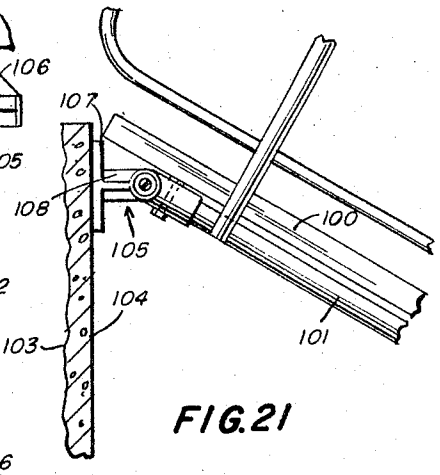


FIG. 21

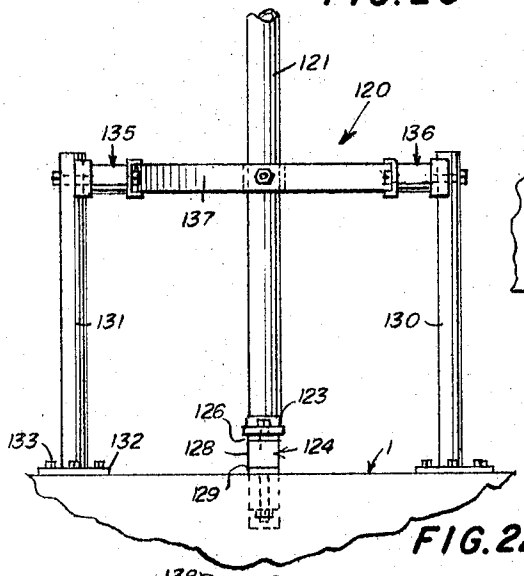


FIG. 22

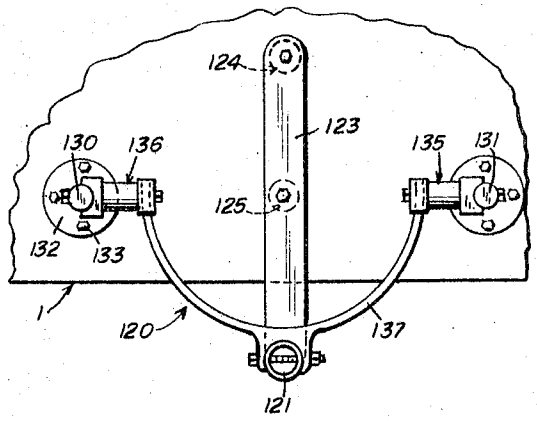


FIG. 23

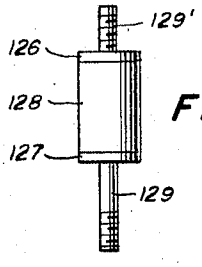


FIG. 22a

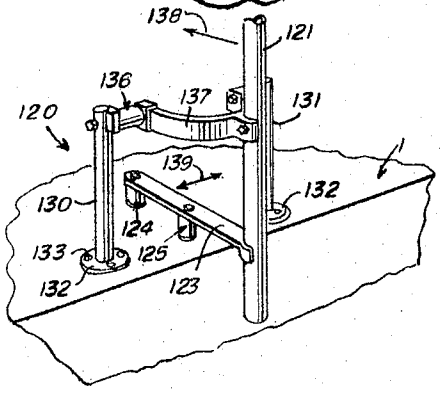


FIG. 24

INVENTOR

S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 6

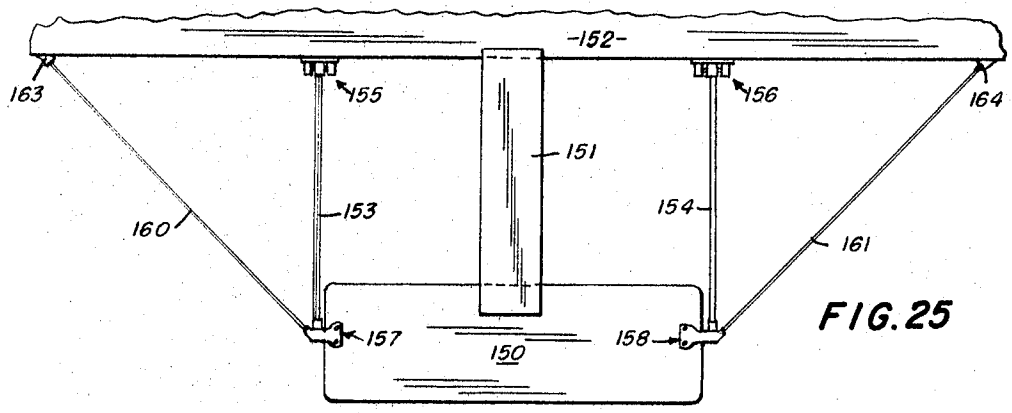


FIG. 25

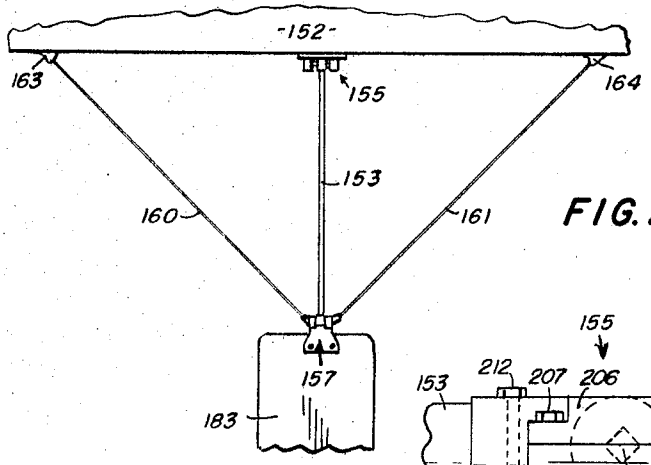


FIG. 26

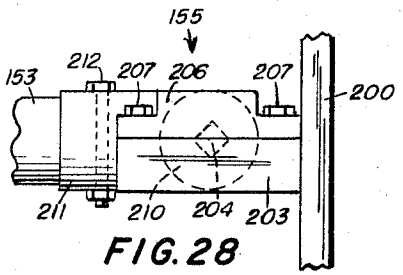
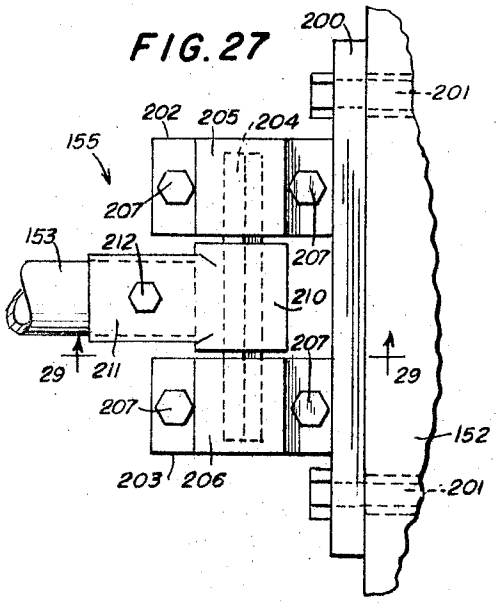


FIG. 28

FIG. 27



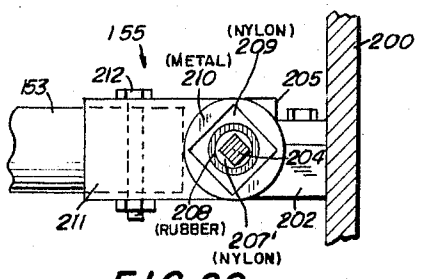


FIG. 29

INVENTOR

S. KING FULTON

BY Hurwitz & Case

ATTORNEY

Feb. 28, 1967 S. K. FULTON 3,306,053

MARINE FACILITIES

Original Filed Jan. 12, 1961 7 Sheets-Sheet 7

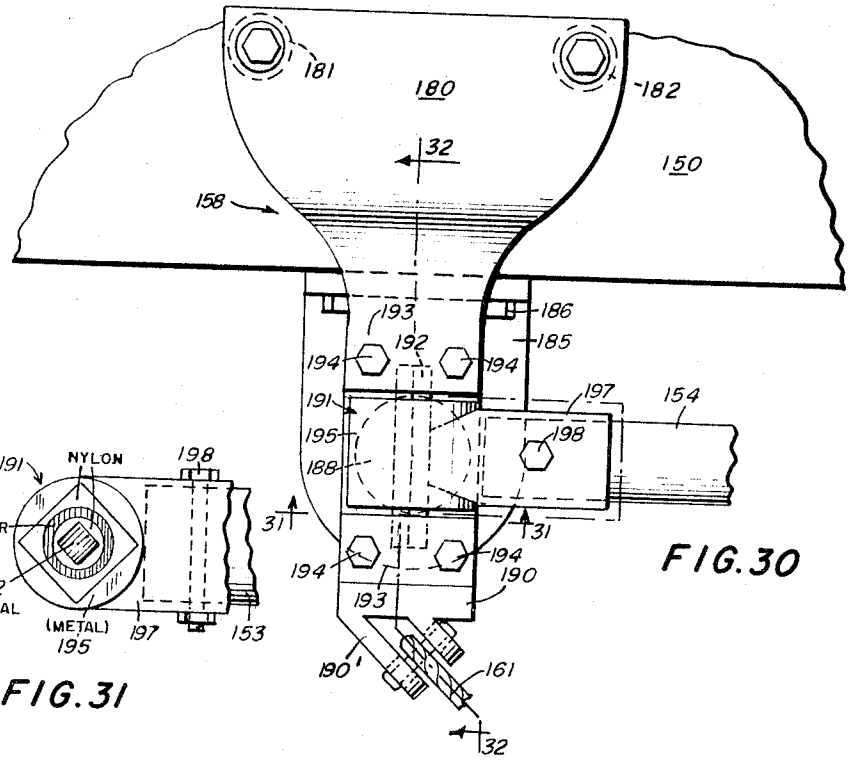


FIG. 30

FIG. 31

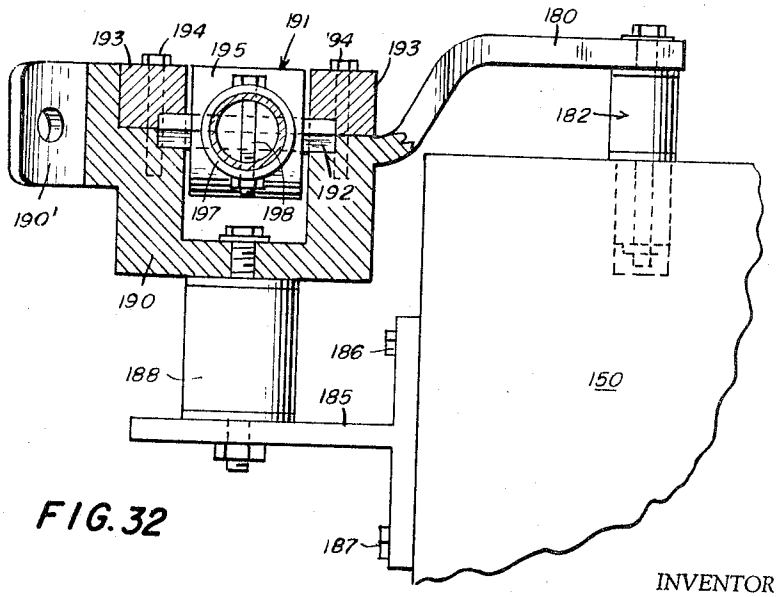


FIG. 32

INVENTOR

S. KING FULTON

BY Hurwitz and Rose

ATTORNEYS

United States Patent Office 3,306,053 Patented Feb. 28, 1967

3,306,053

MARINE FACILITIES

Samuel King Fulton, 1756 SE. 9th St.,
Fort Lauderdale, Fla. 33316

Original application Jan. 12, 1961, Ser. No. 82,298. Divided and this application Sept. 17, 1964, Ser. No. 403,680

2 Claims. (Cl. 61—48)

This application is a division of my application Serial No. 82,298, filed January 12, 1961, and entitled "Marine Facilities."

The present invention relates generally to marinas and more particularly to facilities for docking small boats, yachts and the like, these facilities including floating concrete docks, dock to piling assemblies, dock to dock coupling assemblies, dock to sea wall assemblies, gangplanks having devices for assembly to a sea wall, fenders, expansion bolts for assembling these to docks, sea walls and the like.

Briefly describing the invention, provision is made for a plurality of interconnected floating docks which may be coupled to piles, to each other, or to a sea wall, in various configurations. The individual floating docks are fabricated of cast concrete, having therein expanded polystyrene beads or other cellular plastic material, the proportion of concrete to cellular material being such that the docks float, and the exterior of the docks being entirely made of concrete, which is virtually ageless in any type of water, which requires substantially no maintenance, and which has extremely long life under operating conditions. Individual docks may be secured together and buffered from each other by means of rubber block elements which are held in compression by stainless steel cables extending between pairs of docks on a line extending through the blocks, the cables being under tension. The location and shape of the coupling or buffering element is such as to provide or permit only relative flexing of two adjacent docks about a fixed axis under the action of sea or waves, and no other relative motion. The material of which the coupling is fabricated is rubber, neoprene or the like tough resilient material. The coupling provides shock absorption and the location thereof provides a gangplank extending between docks, which is flush with the surfaces of the docks, enabling personnel readily to pass from dock to dock.

The problem of permitting the docks to rise and fall with the tide, and to move under wave action with respect to pilings, is solved by providing a cable extending about each pile and having ends secured to the docks. The cables are fabricated of stainless steel, and are provided with a large number of rubber or plastic beads which rotate freely in the cable and hence can roll on the pile and thus permit free motion of the cable vertically along the pile. In addition, steel cables having thereon rotatable rubber or plastic beads extend along an edge of a dock, or extend between two docks at their junction, and act as a fender or bumper in respect to the piles. Suitable piling assemblies may be provided for dock ends, dock sides or dock-to-dock locations.

A novel gangplink assembly is provided, which secures one end of a gangplank to a sea wall, or other rigid structure, while permitting the other end of the gangplank, resting on a dock, to rise and fall with the tide or under wave action. The end of the gangplank which is secured to the sea wall is provided with a resilient torsion mount.

In order to prevent impact of boats against the ends, corners or sides of the docks, suitable fenders are provided which are fabricated of molded plastic, and are air filled, and which extend outboard, above and below the dock's upper surface. These are secured along upper sides of the docks, or at corners, whereby impacts are absorbed which occur due to overhang of a boat moving downwardly, or from a boat moving transversely toward the dock. In addition, for boats having relatively high freeboard, vertical shock fender assemblies are provided, which are capable of absorbing impact and transferring same to the dock through shear mounts, regardless of the location of the point of impact of a boat against the shock fender assembly, or the angle of impact.

In addition, provision is made for securing dock assemblies to sea walls, bulkheads or fixed docks. These assemblies include salt water resistant fittings, stainless steel cables, torsion inserts and shear mounts invented to absorb shear in three dimensions, to eliminate stress and strain on both sea wall and dock, for every random motion of a dock under the action of the sea. In order to permit rapid and long lived assembly of elements to a concrete dock or the like, provision is made of a novel expansion bolt, the expansion element of which is a rubber or neoprene tube. Such bolts can be assembled to holes precast in the concrete dock.

It is well known that floating dock equipment undergoes great stress and strains in being constantly subjected to waves, surges, changing winds and tides, sudden impact by boats in docking or while moored at the docks, collisions, accidents, improper use of dock lines, and the like. It has been found that these factors play havoc with conventional equipment and that maintenance becomes a tremendous problem and a great expense.

It is a feature of the present invention to utilize floating concrete docks which are unsinkable, which have solid weight under foot, which utilize no moving parts, which contain no sharp corners, no overhang, no wood, no steel parts, no moving parts, and the like, so that they require no pumping, no maintenance, no painting and no rust removal.

It is a broad object of the invention to provide novel docking facilities which shall be capable of sustaining the stresses and strains of sea motions, wind, waves, changes of tide, collision and the like.

It is a further object of the invention to provide novel floating docks fabricated externally of solid concrete and rendered buoyant by means of internally located cellular plastic material.

It is still another object of the invention to provide devices for coupling two or more docks to a dock assembly, the latter being constituted of rubber blocks which are maintained under tension, and which are so dimensioned and positioned with respect to the docks as to permit buckling of an adjacent pairs of docks, about a line extending parallel to a dock end, but no other relatives motion. An assembly of docks thus acts as a unit, like a single waterlogged log, except for the possibility of buckling action.

It is still another object of the invention to provide novel facilities for securing floating docks to piling, while permitting free vertical motions of the docks and denying the possibility of impact of the docks against the piling.

A further object of the invention resides in the provision of devices for securing floating docks in seal walls, for securing gangplanks to sea walls, the latter including a combination of torsion and compression resistant fittings which minimizes strain on the wall and dock while permitting certain motions of the dock under the action of the sea.

Still another object of the invention resides in the provision of a novel insertion bolt capable of being secured to a suitable opening in solid concrete, wood, steel, or other solid material.

A further object of the invention resides in the provision of novel air filled bumpers for floating docks.

Still a further object of the invention resides in the provision of fittings for securing docks to piling, while preventing impact of the docks against the piling or complete restraint of the dock when the latter are subjected to sea motions.

Still another object of the invention resides in the provision of a novel vertical shock mounted fender assembly capable of preventing impact directly against the docks of relatively large boats having high free board.

A further object of the invention resides in the provision of novel shock mount connectors for gangplanks which provide torsional resilience in coupling one end of the gangplank to a sea wall, a permanent dock, or the like and which permit free vertical motion of the dock under the action of tides, waves and the like while retaining the fixed positions of the docks in terms of spacing and orientation with respect to the sea wall.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a view in perspective of a dock assembly secured to a sea wall and anchored to piling. The assembly includes corner and vertical bumpers, dock to dock assemblies, dock to piling assemblies, and other features of the invention.

FIGURE 2 is a view in plan of a concreate dock according to the invention.

FIGURE 3 is a view in section taken on the line **3—3** of FIGURE 2.

FIGURE 4 is a view in plan showing a dock to dock connector assembly in place between two docks.

FIGURE 5 is a view in section taken on the line **5—5** of FIGURE 4.

FIGURE 6 is an end view of a dock.

FIGURE 7 shows in section a portion of a dock including a bead type piling fender.

FIGURE 8 is a view in elevation of a dock edge fender.

FIGURE 9 is a view in section taken on the line **9—9** of FIGURE 8.

FIGURE 9A is a view in plan of a modification of the fender of FIGURE 8 as applied to a corner of a dock.

FIGURE 10 is a view in section taken on the line **10—10** of FIGURE 8.

FIGURE 11 is a view in section taken on line **11—11** of FIGURE 9.

FIGURE 12 is a view in section of an expansible assembly bolt utilized for assembling parts to a concrete dock.

FIGURE 13 is a view in section of a modification of the bolt of FIGURE 12.

FIGURES 12A and 13A are views in section of modifications of the bolts of FIGURES 12 and 13, respectively.

FIGURE 14 is a view in transverse cross section taken on the line **14—14** of FIGURE 13.

FIGURE 15 is an end view corresponding with FIGURE 4.

FIGURE 16 is a view in longitudinal section of a table tensing element utilized in FIGURE 15.

FIGURE 17 is a view in plan of an end mooring unit for securing a dock to piling.

FIGURE 18 is a view in plan of a side mooring for securing two docks to piling, the mooring elements extending between the two docks.

FIGURE 19 is a view in section of a bead element utilized in the structures of FIGURES 17 and 18.

FIGURE 20 is a view in plan of a gangplank secured to a sea wall by means of torsion couplers.

FIGURE 21 is a side view of the gangplank assembly of FIG. 20.

FIGURE 22 is a view in rear elevation of a vertical bumper secured to a main dock.

FIGURE 22*a* is a view in front elevation of a shear mount, according to the invention.

FIG. 23 is a plan view of the bumper element of FIG. 22.

FIG. 24 is a view in perspective of the bumpers of FIGURES 22 and 23.

FIG. 25 is a view in plan of a dock to sea wall assembly wherein the dock extends longitudinally parallel to the sea wall.

FIGURE 26 is a view in plan of a variant of the arrangement of FIGURE 25 wherein the longitudinal dimension of the dock extends perpendicular to the sea wall.

FIGURE 27 is a view in plan of a torsion element for coupling a dock to a fixed structure such as a sea wall.

FIGURE 28 is an end view of the structure of FIGURE 27.

FIGURE 29 is a view in section taken on the line **29—29** of FIGURE 27.

FIGURE 30 is a view in plan of a shear mount according to the invention.

FIGURE 31 is a view in section taken on the line **31—31** of FIGURE 30.

FIGURE 32 is a view in section taken on the line **32—32** of FIGURE 30.

Referring now specifically to the accompanying drawings, and particularly to FIGURE 1 thereof, the reference numerals **1, 2, 3, 4, 5** and **6** denote docks of a dock assembly, which are coupled together by dock couplers **7, 8, 9, 10** and **11**. The dock **6** is secured to end pilings **12** and **13**, and a gangplank **14** extends from a sea wall **15** to the dock **6**. The docks **1** and **3** are secured to end pilings **16** and **17**, and further pilings **18** and **19** are provided at the junction of docks **1** and **2** and **2** and **3**. The several docks are provided with edge fenders as **20** and with vertical fenders as **21**. The dock couplers such as **7, 8**, are maintained in compression by tension cables **22, 23**, and dock to pile assemblies **23***a* are provided for securing the docks to the pilings while permitting vertical motion of the docks due to tide or due to the action of sea waves, surges and the like. The several components referred to are described in detail hereinafter.

FIGURE 1 illustrates one typical arrangement of an array of docks and their location with respect to a sea wall, but a wide variety of specific arrangements may be resorted to, limited only by the imagination of the architect.

The separate docks as **1, 2, 3, 4, 5, 6** are fabricated of concrete, being cast as a solid mass surrounding expanded polystyrene beads, as **26**, so that the concrete forms a shell **27** surrounding the polystyrene. The polystyrene beads form a cellular mass internally of the dock, when expanded, providing, however, only one convenient form of cellular plastic. Other forms may be utilized. Recesses such as **28** may be cast in the concrete, to permit installation of interdock couplers. Typical length for a dock is 20 feet, width 6 feet, and depth 29 inches, the corners being normally rounded as at **29**, and a one foot radius, and a free board of approximately 12 to 16 inches is provided, by utilizing suitable proportions of the polystyrene or other cellular plastic, which, being much lighter than water provides buoyancy for the concrete shell. Docks may be assembled in end to end relation or in end to side relation, but such assembly introduces the problem of providing simultaneous translational rigidity and torsional resilience between two docks, enabling buckling at the junction of the two docks, but preventing any other relative motion of the docks.

It has been found that these objectives can best be secured by providing rubber blocks intermediate adjacent docks, located in the recesses **28**. Such a rubber block is indicated at **30**, FIGURE 4, and may be constructed of solid rubber or of rubber with holes extending vertically therein or therethrough, in the form of a rectangular block fitting into the recesses **28** formed in the ends of the docks. The recesses **28** do not extend vertically

to the bottom of the docks nor laterally out to the sides, and accordingly the recesses 28 restrain the rubber block 30 against sidewise or downward motion. The weight of the blocks and friction against the concrete restrains the blocks against upward motion.

Each block is maintained in compression by means of cables 32, FIGURE 15, the cables being fabricated of stainless steel and being maintained in tension by means of fittings 33, 34, provided one on each dock. Each fitting is secured to the dock by means of four expansion bolts, as 35, 36, 37, 38, which extend into holes precast in the concrete of the docks.

The fitting 33 includes a hollow cylindrical section 39 which extends horizontally. Within the cylinder 39 and extending therethrough is a rubber tube 40, through which extends cable 32 in snug fitting relation. Welded to the end of the cable is a threaded element 41, the end of cable 32 extending into a suitable recess 42 in the element 41 and being welded thereto. A pair of nuts 43 threadedly engage the threaded end of the fitting 41, externally of cylinder 39, and bear against an end closure wall 44 of the cylinder 39. The fittings 33 and 34 may be duplicates, so that upon pulling up on the nuts 43 for each of the fittings, the cable 32 may be placed under tension, and thereby the rubber coupler 30 may be placed under compression.

The cable 32 is located vertically midway of the block 30, so that the docks can buckle with respect to a point midway vertically of the block 30, without placing additional stress on the cable 32, or relaxing the tension existing therein, i.e. the upper portion of the rubber block 30 may be further compressed while the lower portion is released, or, vice versa, the lower portion may be compressed while the upper portion is released, without materially changing the tension in the cable 32. At the same time the cable 32 prevents increased separation of two coupled docks, while the block 30 maintains substantially a minimum separation therebetween, since it is rigid in compression. The rubber tube 40 prevents friction between the cable or the cable end fitting 41 and the cylinder 39 or any other portion of the fitting 33.

Under the action of surges, waves and the like, it may be that one dock will tend to rise while the other is tending to fall, or it may be that one dock will tend to twist about its longitudinal axis while another is twisting in the opposite direction or sense, and in general a very wide variety of relative motions may tend to occur. It has been found that the simple device above described, i.e. the resilient block 30, maintained under tension by two cables properly located with respect to the block, is capable of preventing all these motions, except buckling on a transverse axis, without damage to any elements of the structure. No substantial relative lateral motion of two adjacent docks can take place, because of the block 30 is very hard laterally due to its considerable length laterally. Similarly, no vertical motion of one dock relative to another can take place because great frictional resistance exists between the rubber block and the dock. No twisting about a vertical axis can take place, of one dock with respect to another. The docks therefore, although they are coupled units, and not a unitary structure, move as if they constituted a unitary structure except for one freedom. This freedom is a freedom to move slightly in a buckling motion about a transverse line extending symmetrically through the block 30.

Since an entire dock assembly tends to lie dead in the water, due to the rigid coupling of the separate docks, waves or surges passing along the dock assemblage do not cause unsteadiness of the docks, but rather pass along the dock assemblage without moving any part of it, except in respect to the above described buckling motion or motion of all docks as a whole.

Docks or dock assemblages may be secured to piling, as 50. It is necessary to prevent impact of the docks against the piling, and also to permit the docks to ride up and down the piling freely, in response to rise and fall of the tide, or under action of the sea. To this end, an arcuate stainless steel cable 51 is secured at its ends to fittings 52, bolted by expansion bolts 53 to a dock, as 3. The cable 51 extends about the pile 50. A large number of freely rotatable beads 55 are mounted on the cable, the beads being fabricated of neoprene or suitable plastic. In addition a linear cable 56 extends between the pile 50 and the dock 1, or docks, as 1, 2. This cable, 56, as does the cable 51 has multiple beads 55 thereon. The latter cable acts as a buffer between the pile 50 and the dock, as 3. In the case of a dock end, a recess 57 is provided in the dock end, to provide space for the cable 56 and its beads, so that the latter may rotate freely. On the other hand, where a linear cable 56 extends between adjacent docks as 1, 2, the curvature of the dock corners provide the requisite space. The fittings 52 may duplicate the construction of FIG. 16.

It is a problem, in docking boats, that the boats impact the docks repeatedly, under the action of waves. It is therefore usual to provide fenders on boats or docks, or both. In the present system, two types of fenders are employed.

In one type of fender, illustrated in FIGURES 8, 9, 9*a*, 10, 11, an inflated flexible hollow structure is employed, which in cross section is circular, subtending 270°. The remaining 90° is occupied by an edge (FIG. 8) or corner (FIG. 9*a*) of a dock. The fender may be made of neoprene, rubber or the like and may be inflated in any convenient way to a small pressure, sufficient to maintain the shape of the fender, under the expected impacts.

On the upper edge of a dock, as 1, is provided a metallic right angled structure 60, moulded within a tube 61, subtending in arcular cross section an arc of 270° and completed by right angled structure 60, the arms of the latter constituting radii of the tube 61, and being covered with a coating of the same material as arcuate section 61, and being integral therewith. The arms of structure 60 extend beyond the confines of arcuate section 61, and in the extensions 62 so formed are provided holes 63, through which suitable expansion bolts extend, to secure the fender to the dock.

In FIGURE 9*a* is shown a fender 65 suitably shaped to conform to the corner of a dock. In FIG. 11 is shown a variant of metallic structure 60, identified as 66, which is corrugated to add strength, whereas structure 60 is flat.

In order to provide a docking facility on water, particularly salt water, it is essential that devices be provided for bolting components and fittings to the dock by bolts which are impervious to the action of the water, and which cannot be extracted from the docks even under extreme forces. In addition, it is desirable that the bolts be readily removable and insertable, when desired, since fittings may require replacement. In accordance with the present invention, expansion bolts are utilized for this purpose, which utilize rubber as an expansible element. A conventional nut and bolt is associated with a neoprene or rubber tube, through which the bolt extends. The tube fits loosely in a hole precast in the concrete dock structure, until the bolt is rotated with respect to the nut, or the nut with respect to the bolt, whereupon the tube is compressed longitudinally between the nut and the head of the bolt and expands laterally. The expansion is sufficient to effect a frictional union of the tube with the inside of the hole. The tube, on application of sufficient force to the bolt, fills the space between the bolt and the hole, so that water cannot leak into the hole, and deterioration of the bolt and of the rubber cannot occur.

In FIGURE 12 is illustrated one form of an expansion bolt according to the present invention. In FIGURE 12, the reference numeral 70 denotes a circular hole of uniform diameter extending into the body of a

mass of solid material, such as concrete, **71**, which in the present specific application of the invention is part of a concrete dock. The reference numeral **72** denotes an object such as a fitting or a plate, which may be fabricated of metal, and which is to be secured firmly against the surface **73** of the concrete dock. Plate **72** is provided with an opening **74**, through which extends into the hole **70**, a bolt **75** having a head **76** and a nut **77**, the latter engaging a threaded end **78** of the bolt **75**. Surrounding the bolt **75** is a rubber or neoprene tube **80** having an outer diameter slightly smaller than the outer diameter of the hole **70** and having an inner diameter slightly greater than the diameter of the bolt **75** before the bolt is expanded. A metallic insert **81** is provided within the tube **80**, which extends about twenty percent of the distance into the tube, and which is provided with a flange **82** covering the end of the tube **80**. The insert **81** is free within the tube **80**, so as to be movable with respect thereto, but fits snugly therein. At the lower end of the tube **80** is provided a metallic cylinder **84** which surrounds and is bonded to the lower end of the tube **80**, and which is shaped to include an extension extending below the end of the tube **80**, the latter being shaped to conform to the nut **77**, and constituting a device for preventing turning of the latter. The cylinder **84** is bonded to the exterior of the rubber tube **80**.

In operation the bolt **75** is run through the opening **74** and the plate **72** and the rubber tube **80** extended thereover, the head **76** of the bolt **75** being turned a few times to threadedly engage the nut **77**. Thereafter the assembly is placed within the hole **70**, and the head **76** of the bolt **75** is turned sufficiently that friction develops, to prevent turning of the tube **80** within the hole **70**. As the nut **77** is pulled up by rotation of the head **76** of the bolt **75** the rubber tube **80** is compressed longitudinally and therefore expanded laterally until it fills the hole completely for all positions intermediate the lower surface of the plate **72** and the upper limit of the cylinder **84**. The concrete has a certain roughness, and accordingly when sufficient pressure has been exerted an immovable bond is created between the rubber and the concrete.

When it is desired to remove the expansion bolt of FIGURE 12 the head **76** of the bolt **75** is rotated in reverse direction, which forces the nut **77** vertically downward, stretching the rubber tube **80**, and consequently causing it to contract laterally away from the wall of the hole **70**. It then may be removed readily by the fingers.

In FIGURE 13 of the accompanying drawings is shown a modification of the structure of FIGURE 12, wherein the head of the bolt **75** is located within the cylinder **84** of the nut **77** is located exteriorly of the hole and above the plate **72**. The mode of installation and the mode of operation of the structure of FIGURE 13 is obviously analogous to that of FIGURE 12 and accordingly is not further described.

In FIGURE 12*a* of the accompanying drawings is shown a modification of the structure of FIGURE 12 in which the external cylinder **84** is replaced by an internal cylinder **90**, which is bonded to the rubber cylinder **80** and which includes a flange **91** covering the lower edge of the rubber tube **80**. The nut **77** is bonded to the cylinder **90**, and is thus not free to turn. In the alternative, the nut **91** is unbonded, but becomes sufficiently held by friction when the bolt **75** is sufficiently turned up, as to be held immovable and irrotatable, so that the tube **80** may be compressed as in the system of FIGURE 12.

Similarly, in the system of FIGURE 13*b*, which constitutes a modification of the system of FIGURE 13, the head of the bolt is placed under and at the lower end of the cylinder **80**. In such case an internal insert **94** is provided which includes skirts **95** extending over and shaped to conform with the head **76** of the bolt. In addition a pin **97** is run through the skirts **95** below the head **76** of the bolt **75** to hold the bolt and prevent its falling through. When it is desired to move the expansion bolt of FIGURE 13*b* from a hole, the pin **97** serves as a reaction point against which the threaded end **78** of the bolt may be pressed to effect extension of the cylinder **80** and consequently its lateral contraction. When the cylinder **80** has been sufficiently contracted it loses contact with the inside of the hole **70** and can be readily removed.

Referring now to FIGURE 20 of the drawings, there is shown a gangplank **100**, which may be fabricated of any suitable material, such as wood or metal and which is secured to and supported on a pair of parallel pipes **101**, **102** located under the gangplank at the edges thereof. Pipes **101**, **102** may be secured at one end to a sea wall **103** and at its other end may rest on a floating dock. The sea wall **103** is merely typical of a stationary structure to which the gangplank **100** may be secured.

Bolted to the sea wall **103**, and specifically to a vertical wall **104** thereon, is a pair of fittings **105**. Bolting may be accomplished by means of expansion bolts **106** constructed in accordance with the teachings of FIGURES 12, 13, 12*a*, 13*a*, extending through a plate **107** which rests flush with the wall **104**. From plate **107** extend two arms **108**, **109**, which extends generally perpendicularly of the wall **104**, or at some convenient relatively small angle. The arms **108**, **109**, terminate in bearings **110**, **111** which are stationary. Intermediate the bearings **110**, **111** is a rotary bearing or member **112** which is secured to the pipe **101** as by a bolt **113** extending through a stub integral with the bearing **112** and having a cylindrical recess into which an end of the pipe **101** may extend.

A square shaft **114** may extend entirely through the bearings **110**, **111** and **112**, and may be separated from the latter by rubber torsion shock absorbing elements, which are bonded onto the shaft and/or which fit snugly about the shaft and are irrotatable with respect thereto, and which are also arranged to be irrotatable with respect to the bearings. Accordingly, any attempted rotation of the shaft due to vertical motion of the gangplank is counteracted or tends to be counteracted by torsion generated in the rubber sleeves. Any translational shocks imparted to the gangplank do not, however, tend to be isolated from the see wall **103** due to the incompressibility of the rubber inserts. Details of the torsion mount **105** are illustrated in FIGURES 26–29, inclusive.

The gangplank will obviously be subjected to sea motions, i.e. that end of the gangplank which rests on the dock will rise and fall and will be subjected to lateral and twisting motions forces. All these motions and forces, except those in torsion, are isolated from the fittings **105**, and therefore form the sea wall **103**, as will appear. There is consequently no tendency to rip the fittings away from the sea wall or to damage the fittings. In conventional practice, where rigid fittings are utilized, it has been found that fittings do not have a long life. By shock mounting the fittings torsionally, and by further procedures hereinafter described, it has been found that these have indefinite life even under the most difficult operating conditions.

In FIGURES 22, 23 and 24 is illustrated a vertical boat fender, arranged to be mounted on a dock, as **1**. The fender, identified by the reference numeral **120**, includes a vertical rod **121**, which is located outboard of the side of the dock **1**, and against which the bulkhead of a boat may impinge. The rod **121** extends below the upper surface of the dock **1** and upwardly to a height of perhaps six feet, so that it can serve as a fender for large or small boats. The rod **121** may be a hollow pipe made of polyvinyl chloride, but the material of which the rod **121** is made is not critical so long as the material can stand the required shocks. In one specific embodiment

which has been extensively tested in practice the rod **121** was a polyethylene pipe.

Welded or bolted to the rod **121** is a horizontal bracket **123**, which is secured to the surface of the dock **1** by means of a pair of sheer mounts **124, 125**. The bracket **123** extends back perpendicularly of the side of the dock and parallel to the surface of the dock. The shear mounts employed are constituted of two parallel plates **126, 127** (FIGURE 22*a*) between which is located a rubber or neoprene block **128**, which is bonded to the adjacent surfaces of the plates **126, 127**. From the exterior surfaces of the plates **126, 127** extends studs **129, 129'**, which may be threaded, and may serve to secure the shear mount to a hole internally of the dock **1** and to the bracket **123**. Associated with the stud **129** may be an expansion bolt, as in FIGURE 12, while the stud **129'** may be an ordinary threaded stud. Located on either side of the forward shear mount **125** are standards **130, 131**, which are bolted to the dock by means of flanges **132** and expansion bolts **133** extending therethrough into the dock. At the upper ends of the standards **130, 131**, are secured shear mounts **135** and **136**, having horizontally spaced plates, which in turn are secured to the vertical rod **121** by means of a metallic U-shaped bracket **137**. The ends of the arms of the latter are secured to the upper ends of standards **130, 131**, and the base or center to the rod or pipe **121**.

In operation the rod **121** may be impacted by a boat at any point along its length. If it is impacted above the location of the bracket **137** the shear mounts **135, 136** give rearwardly while the shear mounts **124, 125** are pulled forwardly. If the rod or pipe **121** is impacted intermediate the bracket **123** and the bracket **137** all the shear mounts are pressed backwardly as seen in FIGURE 24. If the rod or pipe **121** is impacted below the bracket **123** the shear mounts **124, 125** are pushed backwardly while the shear mounts **135, 136** are pulled forwardly. Accordingly, the connection of the rod **121** to the dock is shock mounted for any point of impact of the bolt against the rod **121**, assuming that the impact is directly backward, i.e. in the direction of the arrow **138**. However, the impact may occur at any angle. In such case the shear mounts **124, 125, 135** and **136** may each be moved in shear in a different way; for example, impact from the right may cause the shear mount **135** to move rearwardly while the shear mount **136** moves forwardly. Each of the shear mounts is free to move independently of the others, except insofar as it is mounted on a common bracket with one other shear mount. The shear mounts **124** and **125** may move in opposite directions parallel to the length of the dock, i.e. in the direction of the arrow **139**, while the shear mounts **135** and **136** may move in the direction of the arrows **138**, but either in the same or in opposite senses. In general shear mounts of the type described are hard or rigid in compression. Accordingly any tendency of the rod **121** to move vertically due to friction or impact of the boat, is translated into tilting of the rod **121** since the shear mounts **124, 125** in such case do not give, but the shock mounts **135, 136** can give in shear.

The great freedoms which exist in respect to the rod **121**, which can move or be moved in any direction in response to impact by a boat, becomes available because of the use of four shock mounts which are oriented in pairs at right angles to each other and which are linearly spaced from each other by a considerable distance.

Experience has taught that the fender **120** is capable of absorbing shocks due to large boats regardless of the peculiarities of the motions of the boats under the actions of a sea, of surges or of waves, or of the impact of such a boat in coming to the dock, and regardless of the character of the motion of the boat or of the concurrent motion of the dock, where that occurs.

In FIGURES 25 and 26 is illustrated a mode of securing a dock to a sea wall or other stationary object. The dock is shown at **150** and the gangplank **151** leads from the dock to the sea wall, the gangplank being mounted in accordance with the present invention. The dock **150** is spaced from the sea wall **152** by means of rigid poles **153, 154**, which are secured to the sea wall by means of torsion mounts **155** and **156** constructed in accordance with the teachings of FIGURES 27–29 inclusive, and are secured to the dock **150** by means of special shock mounts providing shear shock absorption in three dimensions and also providing torsion shock absorption.

The shock mounts **157, 158** are secured to the dock by their upper surface along a longitudinal axis thereof, i.e. midway between the sides of the dock. Secured to the mounts **157, 158** are cables **160, 161** which extend to the sea wall **152** and which are there secured by means of any suitable fastenings **163** and **164**. The latter fastenings may be rigid, but the point of attachment of the cable **160** and the cable **161** to the shock mount fittings **157** and **158** are provided via shock mountings. The cable **160** and the cable **161** may make an angle with the longitudinal axis of the dock, or with respect to the poles **153** and **154**. The latter may extend perpendicularly of the longitudinal axis of the dock **150** whereas the cables **160** and **161** may occupy an angle of approximately 45°, although the precise angle utilized is not essential to the invention, and other angles may be suitably employed.

The fact that shock mounts **157** and **158** are mounted on the longitudinal axis of the dock **150** implies that the dock is permitted by the shock mount to oscillate about its longitudinal axis. The fact that the dock **150** is spaced from the sea wall **152** by rigid poles **153** and **154** implies that the dock cannot recede from or approach the sea wall **152**, but the presence of torsion mounts **155, 156** implies that the dock can rise and fall as a whole. Were the dock restrained solely by the poles **153** and **154**, longitudinal motion of the dock would be feasible, which would rip the poles **153, 154** from their mountings. To prevent this the cables **160, 161** are provided. These assure that the dock cannot move longitudinally in gross. The extent to which the dock can, in fact, move is solely that permitted by the shock mounts.

Reference is made to FIGURES 30, 31 and 32 for details of the latter. In FIGURES 30, 31 and 32 is illustrated a shock mounting **158**, which is a mirror image of the shock mounting **157** so that exposition of one of these will serve for both. The shock mounting **158** includes a horizontal plate **180**, which is shock mounted by means of shear mounts **181** and **182** at two separated points to a dock **150**. The latter is viewed in plan in FIGURE 30, and accordingly the shock mounts extend vertically, but provide shock absorption in shear, i.e. horizontally. Specifically, the plate **180** can move as a whole backwardly or forwardly as seen in FIGURE 30, or can move about a vertical axis, in which case one of the shock mounts may move rearwardly while the other is moving forwardly. A bracket **185** is provided which is secured by means of expansion bolts **186** and **187** to a vertical face of the dock **150**, and includes a shelf which extends horizontally. To the latter is secured a shock mount **188** operative in shear and extending vertically upward from the shelf. To the shock mount **188** is secured a U-shaped casting **190** having its open element facing vertically upward, the casting **190** being rigidly secured to the bracket or plate **180**. In the open element of the U is secured a torsion mount **191**, including a hexagonal shaft **192** which is secured to the casting **190** by cover plates **193** and bolts **194**. Mounted on the square shaft **192** between the arms of the U-shape casting **190** is a metallic cylinder **195** having a torsion element internally thereof which grips the square shaft **192**, and the cylinder **195**, so that the cylindrical element **191** can rotate with respect to square shaft **192** only to an extent permitted by the resilience of the torsion element. The torsion mount provided by the torsion element, the square shaft, the mounting for the shaft and the outer metallic

cylinder **195**, includes a stub extension **197** to which is rigidly secured, by means of a bolt **198**, the pipe **154** (FIG. 25). Accordingly, the vertical position of the U-shaped casting **190** is fixed with respect to the dock, as is also the vertical position of the plate or bracket **180**. However, motion in the horizontal plane of the casting **190** is permitted in any direction since the shear mounts **181**, **182** and **188** permit horizontal motion in all directions. The pipe **151** is further permitted to oscillate about the center line of the square shaft **192**. This oscillation permits oscillation of the dock **150** about its longitudinal axis, whereas the shear mounts permit movement of the dock **150** toward and away from the sea wall, or laterally of the sea wall, i.e. the shear mounts permit play of the dock **150** with respect to the poles **154**. The cable **160**, which is secured at one end to a fitting **163** secured rigidly to the sea wall, is secured at its other end to a fitting **190'** secured to the U-shaped casting **190**. The U-shaped casting **190** can move with respect to the dock **150** by virtue of the shear mountings **181**, **182** and **188**, so that the end of the cable **161** has some play, on a shock mounted basis, with respect to the dock.

Rise and fall of the dock as a whole is permitted by the torsion shock mounts **155** and **157** on one side of the dock and sea wall **152**, and by torsion shock mounts **156** and **158** on the other side, while oscillation about a longitudinal six is permitted by the torsion shock mounts **157** and **158** alone. These latter are mounted on a longitudinal center line of dock **150** to freely permit such oscillation. Lateral and backward and forward motion of the docks is permitted by the shear mounts **181**, **182**, **188**, and similarly any combination of forward, rearward and lateral motion is permitted by these same shear mounts. Oscillation about a vertical axis is also permitted, since the shear mounts **157**, **158** can shear in opposite senses simultaneously, being in this respect independent of one other. So far as gross movement is concerned, on the other hand, the dock **150** is held rigidly by the pipes **153**, **154** and by the cable **160**, **161**, against movement either laterally or backwardly and forwardly.

In FIGURE 26 is indicated a mode of securing the end of a dock, as **183**, to a sea wall, as **152**. In such case only a single pole **153** is utilized to effect lateral spacing, and a pair of cables **160** and **161** to anchor the dock laterally. A torsion mount **155** is employed on the sea wall, and a shear-torsion mount, **157**, at the dock end of pole **153**.

In FIGURES 26, 27 and 28 of the drawings is illustrated a sea-wall torsion mount **155** appropriate to securing a dock, as **150**, to a sea wall **152**. The problem is then presented that the dock has been completed previously and includes poles **153**, **154** mounted thereto so that the sea wall end of poles **153**, **154** must be secured to the sea wall, while the dock **150** is floating free.

The sea wall torsion mount **155** (or **156**) includes a face plate **200**, secured against the side of the sea wall **152** by means of a plurality of expansion bolts **201**. Extending horizontally from the face plate **200** as a pair of separated but parallel brackets **202**, **203**. The ends of a square metallic shaft **204** are clamped against the brackets **202**, **203** by cover plates **205**, **206**, which are bolted to the brackets **202**, **203**, as by bolts **207** extending through the cover plates **205**, **206** and the brackets **202**, **203**.

Extending about the square shaft **204**, but not bonded thereto, is a nylon sleeve, **207'**, conforming to the shape of the shaft **204** internally, but circular externally.

A rubber torsion sleeve **208** having a cylindrical outer surface and inner surface, is bonded to the outer surface of the nylon sleeve, **207**, and also to the inner surface of a nylon fitting **209** having a square external shape, and which in turn fits snugly, but in unbonded relation, within a conforming metallic fitting **210**. From the latter, in a direction perpendicularly of square shaft **204**, extends a hollow stub, **211**, within which is secured, as by bolt **212**, an end of the pole **153**.

The square metallic shaft then bears directly entirely on nylon, which is tough. The outer metallic fitting **210** also bears entirely on nylon. The rubber torsion element **208** is cylindrical, interiorly and exteriorly, is resilient in torsion but not in compression, and is held between the nylon elements **207'**, **209**, being bonded thereto.

It will be appreciated that the construction of the torsion element can be utilized at **105** (FIGURE 20) or **191**, FIGURES 30, 31, 32, and also that torsion elements can be included between brackets **202**, **203** and cover plates **205**, **206**, in securing the ends of shaft **204** thereto. The shape of the shafts, as **204**, **192**, etc. can be shaped other than square, for example hexagonal. It is only essential that the shaft be irrotatable with respect to its nylon bushing.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A boat fender for an edge of a dock consisting of an inflated elongated tubular member of a single integral sheet of resilient material having a shape in cross-section compounded of approximately 270° of a circle completed by planar members of said material forming walls extending generally toward the center of said circle and meeting at an angle with respect to each other, a metal plate disposed entirely within each of said planar members, said metal plates serving as mounting plates for securing said fender to a dock.

2. The combination according to claim **1** wherein said metal plates are integral with one another.

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CHARLES E. O'CONNELL, *Primary Examiner.*

J. SHAPIRO, *Examiner.*