Nov. 24, 1970 E. H. HARLOW 3,541,622

FLOATING PIER FOR LOADING AND UNLOADING VESSELS

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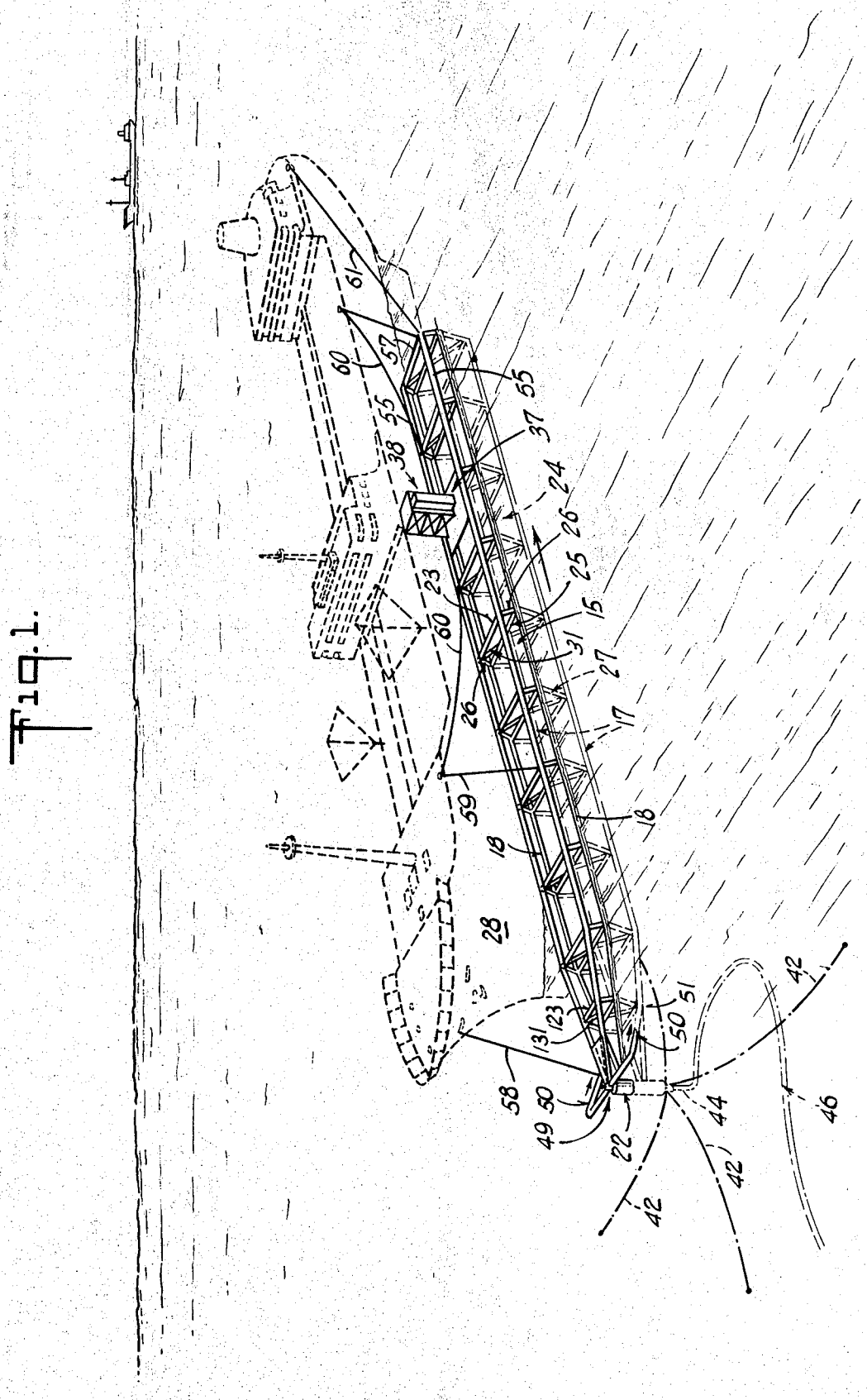
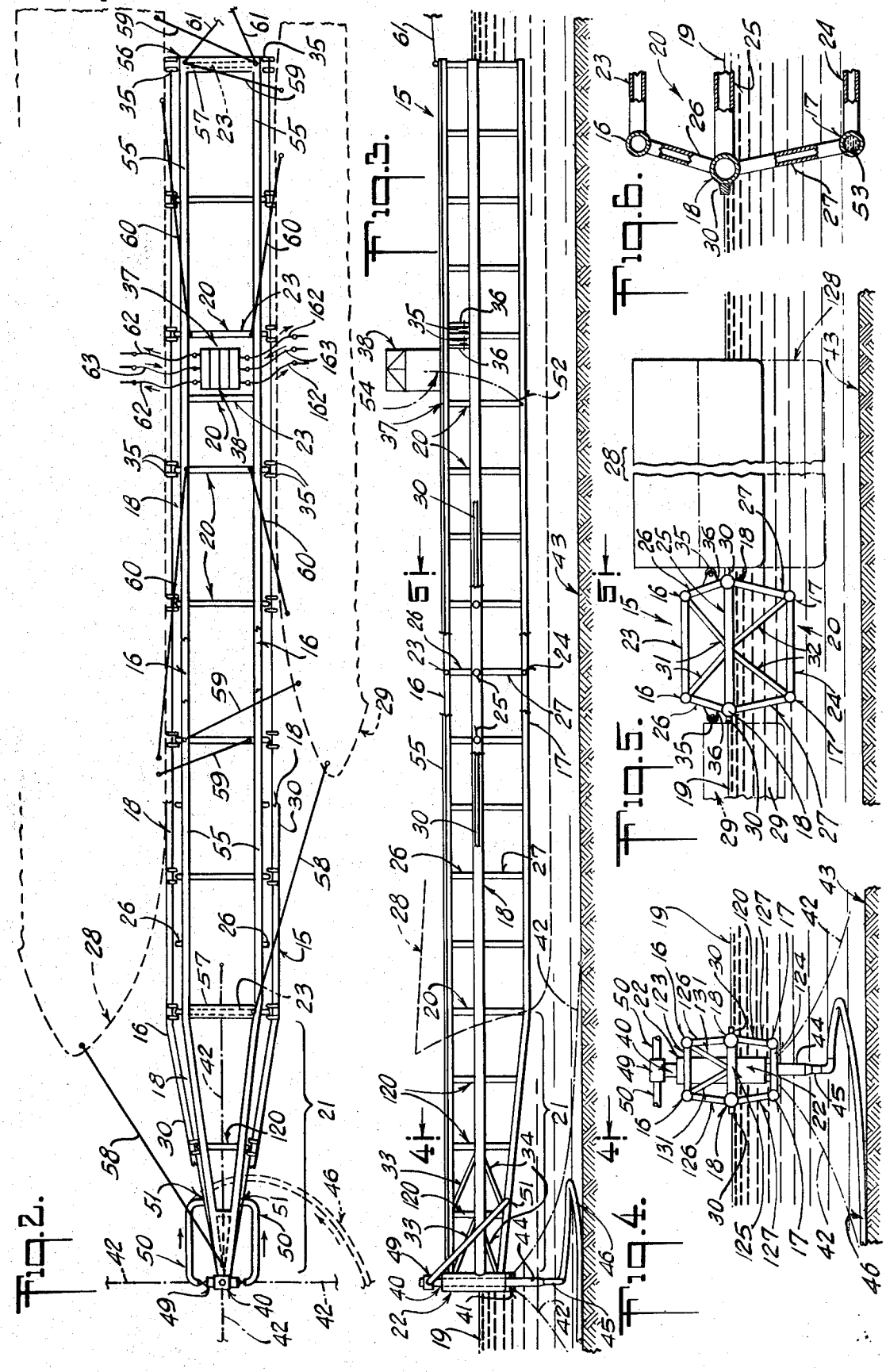


Fig. 1.

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Fig. 7.

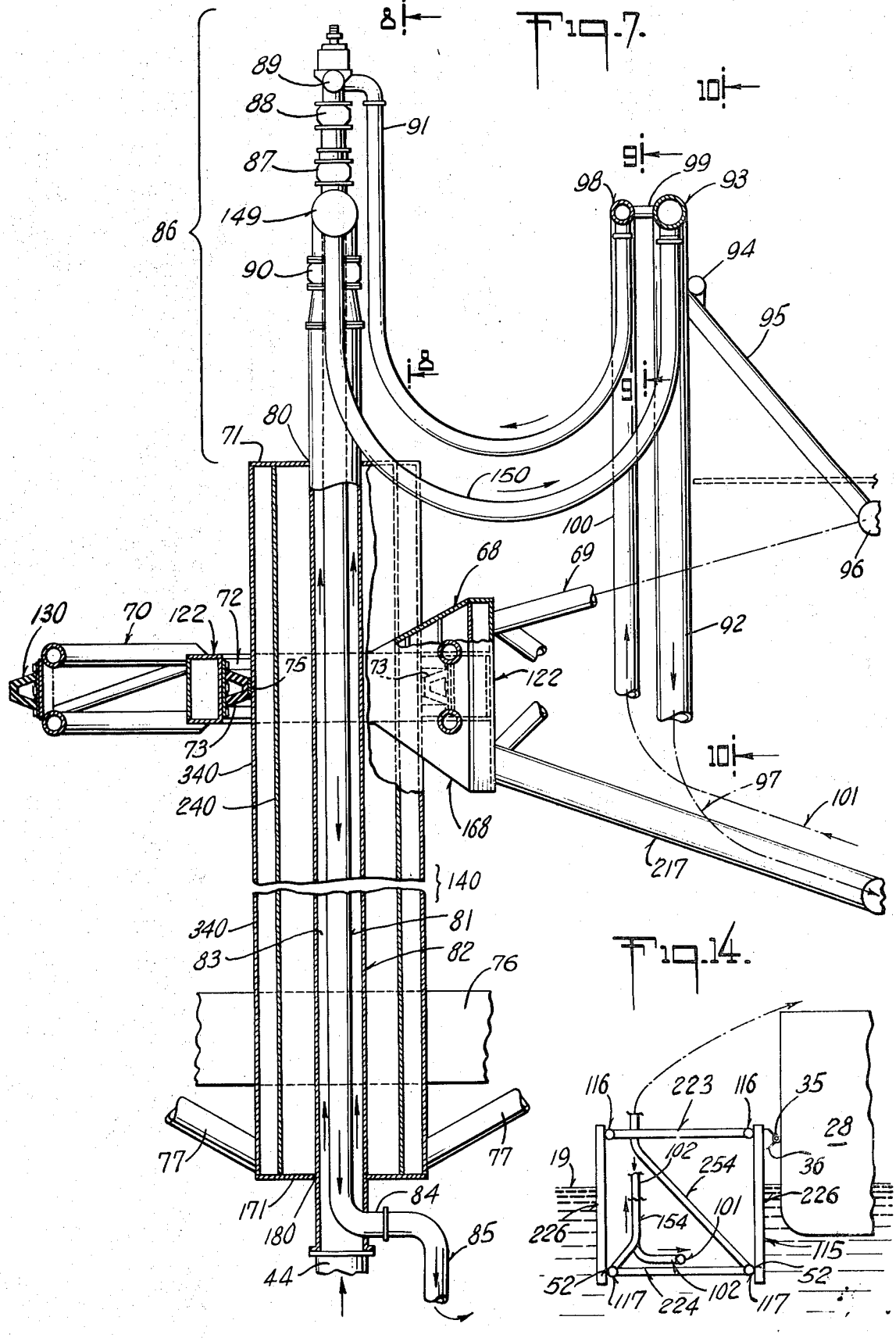


Fig. 14.

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Fig. 8.

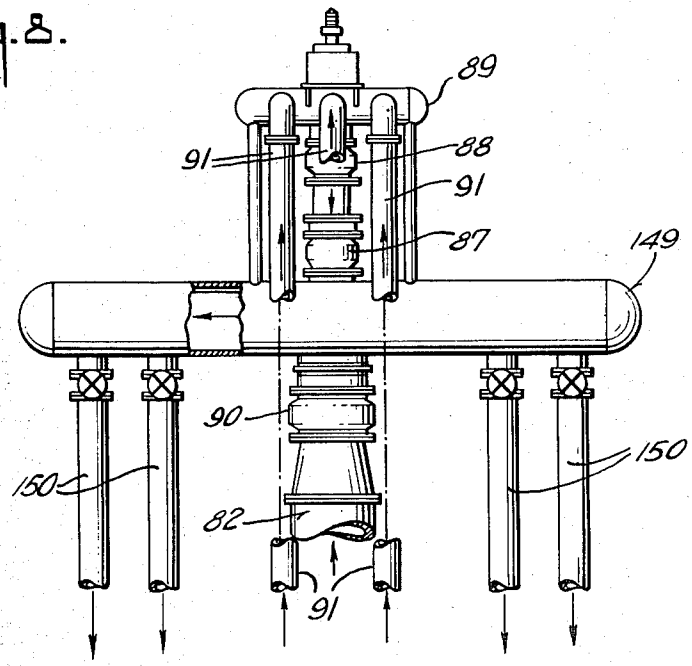


Fig. 9.

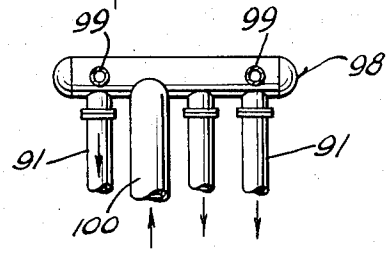
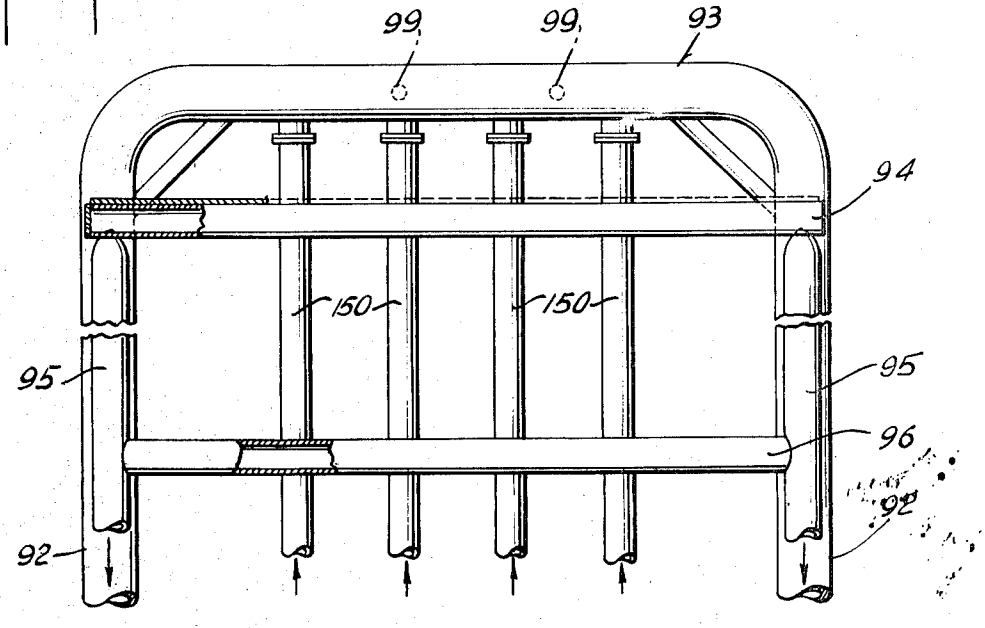


Fig. 10.



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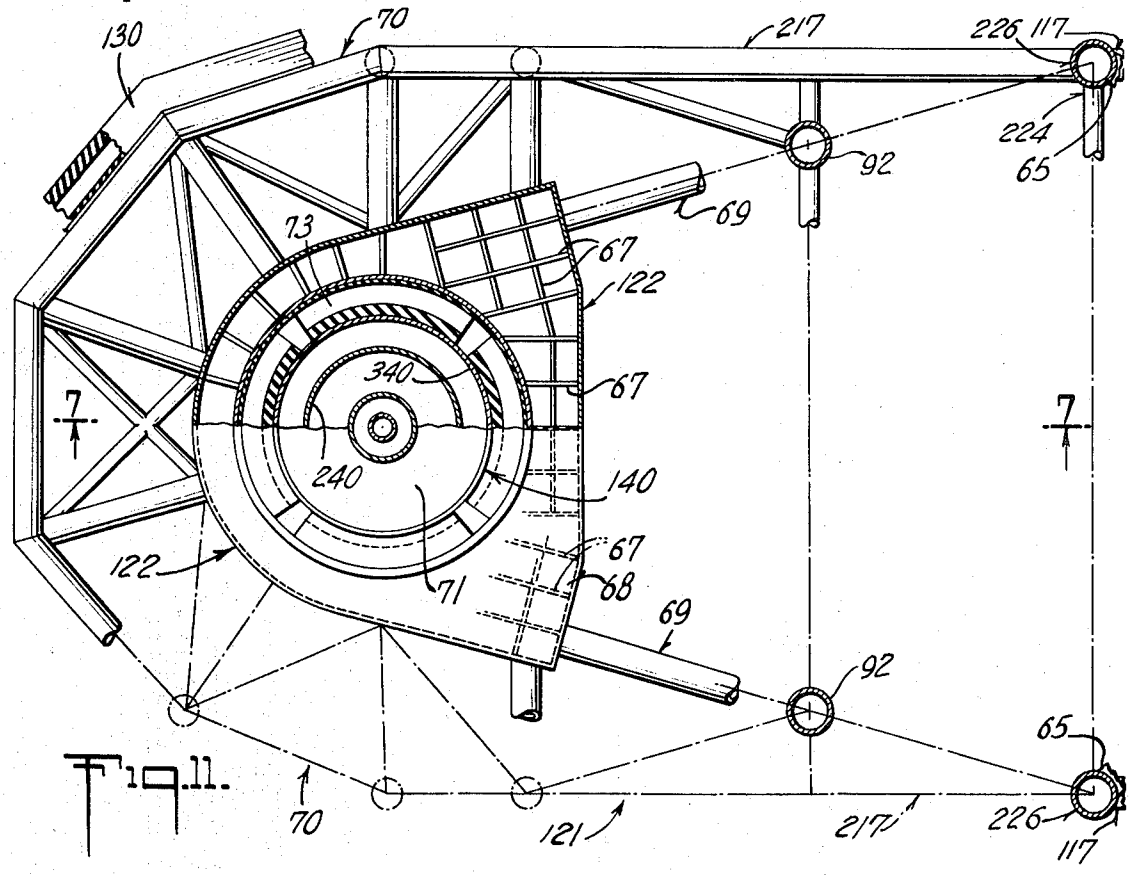


Fig. 11.

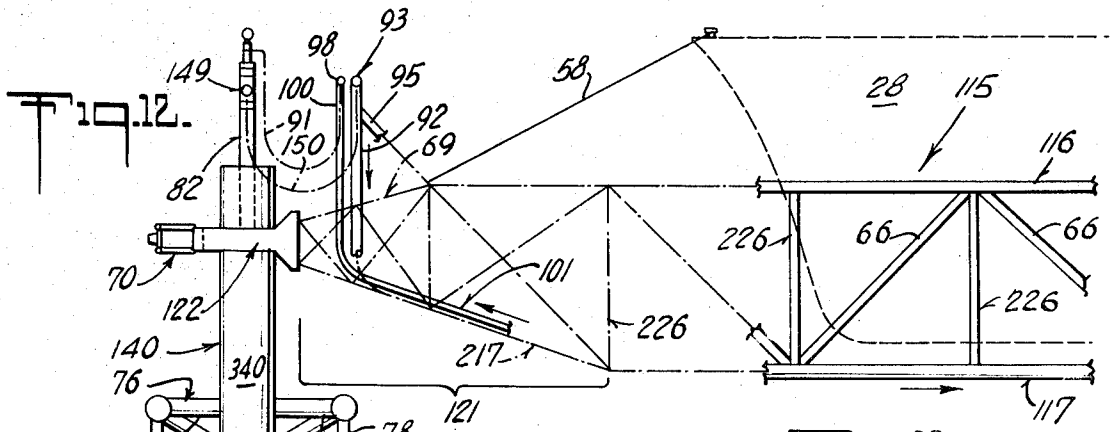
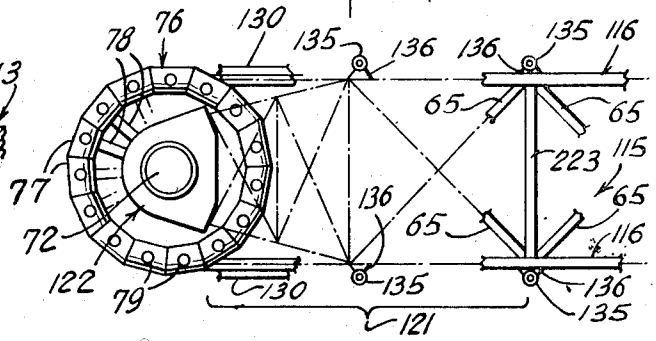


Fig. 12.

Fig. 13.



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3,541,622

FLOATING PIER FOR LOADING AND UNLOADING VESSELS

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Int. Cl. B63b 21/00
U.S. Cl. 9—8 8 Claims

ABSTRACT OF THE DISCLOSURE

This floating pier for mooring vessels and transferring bulk cargo liquids, such as crude oil, pumpable solids, slurries or other fluids that may contain solid particles, to or from vessels, in in the form of an elongated, open framework that is unsheathed by shell plating, and it has inherent floating buoyancy with appreciable draft. This open framework has a stem or head and a stern at opposite ends, and includes a plurality of longitudinally-extending tubular stringers with at least a transversely-spaced pair thereof embodied in the submergible lower portion thereof to flank the side margins of the latter and at least a transversely-spaced pair thereof embodied in the top portion above the waterline and flanking the side margins of the latter. These longitudinal hollow stringers are rigidly tied together by transversely-extending and upwardly-extending tubular struts at successive locations throughout. An appreciable number of the tubular stringers and struts have the interiors thereof sealed off against the entry of water for providing the inherent buoyancy. At least one of the stringers has a section adapted to conduct cargo liquid of the types described hereinbefore out along the framework to a point where it may be unloaded into tanker compartments. At this point is provided on the top of the open framework a lateral platform upon which may be mounted suitable vessel loading or unloading equipment. A substantially vertical tubular pivot structure adapted for flow of fluids therethrough is anchored to the sea bottom at a selected location with the top section of this pivot strcture projecting above the water surface and the bottom section connected to a submerged pipeline. The stem end of the floating pier fixedly carries a rotatable hub that is rotatably mounted about the pivot structure so as to permit free swing of the pier. Fluid transfer means is supported by the projecting top section of the pivot structure to transfer fluid to and from stringers or conduits of the open framework.

Other features of refinement include the particular constructions of unique embodiments of the pivot structure and the associated rotary hub, and selections as well as adaptions of the stringers to conduct cargo liquids and ballast liquids when desired details of which are illustrated by way of example in the drawings. Other features of the invention appear in the following specification and accompanying drawings.

The present invention relates to offshore constructions along side which oceangoing vessels may be anchored or moored for receiving therefrom or delivering thereto cargo liquids, such as crude oil or other pumpable products, supplied through such a structure to or from onshore tanks by suitable conduit means or submerged pipes or hoses.

Prior to the present invention it has been proposed to provide such a transfer structure either in the form of anchored floats or elaborate towers fixed to the sea bottom. Many of such structures ignore cost factors and are quite expensive. Others have failed to take into account the likelihood or possibility of a change in political climate

of the adjacent land areas which, when such equipment is permanently anchored in the seat bottom, may require costly abandonment thereof. These and other problems attendant upon practice of prior art proposals are effectively solved by the floating pier of the present invention.

The Busking U.S. Pat. No. 3,335,690 proposes a floating storage barge of expensive construction with the interior of its hull subdivided into storage compartments and its head end equipped with a hub which rotatably receives a pivot unit supported thereby above the water surface and which in turn is to be flexibly anchored to the sea bottom at a chosen location. Cargo liquid, such as crude oil, is to be supplied to this anchored pivot construction through a submerged conduit or submarine hose leading from an onshore supply so as to transfer through this pivot structure such cargo liquid to the various storage compartments of the barge. The barge is designed to serve also as a floating pier to which a tanker may be mored so that the cargo liquid stored in the barge compartments may be transferred to the tanker. In possible realization of the fact that undesirable motion of the barge may be induced by wind and attendant waves, and by water currents that may be caused by tides and flowing river water when such a barge is anchored in an area, e.g., a river mouth, where such currents are prevalent, the Busking patent proposes equipping the stern of the barge with side propellers, driven from an on-board motive source, entailing considerable additional expense to swing the stern thereof back against motion-inducing influences.

The floating pier of the present invention is of relatively economical construction featuring a long, narrow and self-buoyed open framework which is unsheathed by shell plating so as to present minimum resistance to wind, waves and water currents. The buoyancy of this open framework is such that it is only partially submerged and is of a construction permitting ready attainment and maintenance of trim. This open framework essentially includes a plurality of longitudinally-extending tubular stringers extending from the stem to the stern with at least a transversely-spaced pair thereof embodied in the submergible bottom portion and flanking the side margins of the latter, and also at least a transversely-spaced pair thereof embodied in the top portion above the waterline and flanking its side margins. These longitudinal tubular stringers are rigidly tied together by transversely-extending and upwardly-extending tubular struts. An appreciable number of these tubular stringers and struts have the interiors thereof sealed off against the entry of water for providing the desired floating buoyancy. At least one of the bottom stringers has a section adapted to conduct cargo liquid of the types described hereinbefore along the open framework to or from a location on the top of the latter of suitable vessel loading or unloading equipment for transfer of such liquids to or from a vessel suitably moored to the side of this floating pier.

Embodiments of the present invention provide partially submerged vertical tubular pivot means adapted for flow therethrough of cargo fluids and a submarine conduit leading from a supply or to an unloading point onshore, and such pivot means is independently anchored to the sea bottom at a selected location with the top section thereof projecting above the water surface and the bottom section connected to a submerged pipeline. The stem of the pier open framework has fixedly mounted thereon means which define a rotary hub through which is freely received this tubular pivot structure for free relative rotary movement and, preferably, axial movement of the hub on the pivot structure. Cargo transfer equipment is supported on the top section of the tubular pivot structure to flow-connect the submarine conduit and flow passages extending longitudinally of the floating pier, such as

through one or more longitudinal stringer members of the latter.

A relatively small platform is supported upon the top of this open framework at a selected distance from its stem upon which are mounted suitable vessel loading or unloading equipment and to the vicinity of which fluid-conducting sections of certain of the bottom stringers extend. Preferably, suitable narrow walkways are supported on the top of the framework above selected ones of the top longitudinal stringers and transversely-extending struts for ready access to mooring fittings, and to the platform and cargo transfer equipment mounted on the latter. Thus, such a localized platform, the cargo transfer equipment mounted thereon and such walkways minimize resistance to wind, as does the exposed top portion of the open framework, so as to reduce effectively any tendency to be unduly swung under such influence.

In order to maintain the trim of the floating pier open framework during passage of cargo fluid through sections of one or more stringers thereof, so as to minimize tendency of heel-over during cargo transfer, the transversely-spaced stringers selected for this service are arranged substantially symmetrically about the vertical centroidal plane of the pier.

If it is desired to draw from the vessel ballast water through this floating pier structure at the same time as cargo liquid is supplied thereto, an embodiment of the present floating pier may be so designed that one of these stringers is used for conducting the cargo fluid toward the vessel, and the other may be employed for counter-flowing away therefrom the ballast liquid. In this case maintenance of trim may require that the sections of the stringers which conduct the cargo liquid and the ballast water in opposite directions have their conducting sections provided in different diameters to take into account the differences in the specific gravities of these liquids. As an alternative, the pair of stringers which are located to opposite sides of the centroidal plane at equal distances may be simultaneously employed for forward delivery of the cargo liquid with a longitudinal conduit located in the centroidal plane being used for the counter-flow conduction of the ballast away from the vessel. The same principles apply when it is desired to draw cargo from the vessel and at the same time supply ballast thereto, it only being necessary to supply means for the reversal of the flows.

In any event, when such different liquids are to be counter-flowed forward and back along the floating pier open framework, the tubular pivot means which determines the point of anchorage of the stem or head section thereof will be in a form to include at least a pair of telescopically arranged tubes, with one constituting a core tube in which the hollow interior provides a liquid passage, the other tube being concentrically arranged about the core tube so that the intervening annular space constitutes a passage for counter-flowing the other liquid therethrough. Suitable conduit means are provided for separately communicating this pair of concentrically arranged passages to different conduits, with one serving as the cargo liquid conductor and the other serving as the counter-flowing ballast liquid conductor. When the pivot means is of such a construction the rotary hub of the pier may be mounted for free swing about and axial motion along the outer tube thereof.

It is desirable that embodiments of the floating pier of the present invention provide the open framework along one or more of its sides with suitable fender means. This may include a rubbing strip and/or fender rollers. Some of the fender rollers may be disposed in vertical planes with their axes extending horizontally and others thereof may be arranged in lateral planes with their axes extending vertically.

It will thus be seen that as the stem end of the floating pier is constrained to remain relatively stationary in a lateral plane the stern end thereof may swing to assume

a most favorable aspect with respect to prevailing wind, current and wave conditions. When a vessel is moored to one side of this floating pier by suitable mooring lines the vessel hull will be brought to bear against the fenders so that the pier and vessel may have some relative up and down motion for accommodating their different responses to waves and currents as well as that which may be caused by shift in draft of the vessel as it is progressively loaded, while causing them to move together laterally to assume the most favorable aspect with regard to wind, current and wave conditions and changes therein.

It is an object of the present invention to provide such a floating pier construction that is economical in cost as to construction and assembly of parts as well as with respect to maintenance while assuring the previously indicated advantages of assumption of the most favorable aspect with regard to conditions prevailing at the installation site as well as changes therein.

Another object of the present invention is to permit the loading or unloading of fluid cargoes to and from vessels with effective facility at location outside of harbors, such as near the fields producing the crude oil that may constitute the cargo liquid, while allowing the practice of some docking procedures similar to those employed at conventional fixed piers and wharves, but eliminating the necessity of using tug systems, with achievement of the docking and undocking in substantially less time than that required at conventional spread mooring type facilities.

A further object of the invention is to permit the advantageous use of usch a floating pier in combination with underwater storage tanks, if this is desired, and to eliminate oil spill hazards and maintenance costs inherent in floating supply hoses.

A still further object of the invention is to provide embodiments of such a floating pier in structural forms that allow the parts to be easily and economically prefabricated and then readily transported or towed and assembled in simple fashion at the site.

Other objects of the invention will in part be obvious and will in part appear from reference to the following detailed description taken in connection with the accompanying drawings, wherein like numerals identify similar parts throughout, and in which:

FIG. 1 is a perspective view to greatly reduced scale of a suitably anchored embodiment of the present invention showing it afloat in a body of water and illustrating its anchorage by the pivot structure thereof at a certain site, the pictorial representation of a vessel being suitably moored to one side thereof being depicted in broken lines;

FIG. 2 is a top plan view, with parts broken away and omitted, of the embodiment of the floating pier illustrated in FIG. 1 and depicting in broken lines portions of the outlines of the hulls of vessels moored to opposite sides thereof;

FIG. 3 is a side elevational view, with parts broken away, of the embodiment of the floating pier depicted in FIGS. 1 and 2 while it is in use in loading a vessel, partially depicted in broken lines, at a time when the loading is near completion;

FIG. 4 is a transverse sectional view taken substantially on line 4—4 of FIG. 3;

FIG. 5 is a transverse sectional view taken substantially on line 5—5 of FIG. 3, and illustrating the use of the embodiment of the pier depicted in FIGS. 1, 2 and 3 for loading vessels moored to opposite sides thereof as in FIG. 2;

FIG. 6 is a sectional detail to larger scale, with parts broken away and omitted an others in side elevation, showing associated framework members of the floating pier as arranged in a group in one of the transverse panels of the construction;

FIG. 7 is a side elevational view, to small scale with parts broken away and in section, of an embodiment of the pivot and rotary hub means, and the transfer means for flow connecting this pivot means to an embodiment

of the floating pier, differing from those illustrated in FIGS. 1 to 4 incl.;

FIG. 8 is an enlarged elevational view, taken substantially on line 8—8 of FIG. 7, with parts broken away and in section, of the top section of the pivot tower illustrated in FIG. 7;

FIG. 9 is an enlarged elevational view taken substantially on line 9—9 of FIG. 7, of the liquid transfer manifold shown in FIG. 7 that is mounted on the stem or head of the floating pier for transfer of ballast liquid delivered by the latter to the pivot tower;

FIG. 10 is an elevational view, taken substantially on line 10—10 of FIG. 7, with parts broken away and in section, of the cargo liquid manifold mounted on the head or stem of the floating pier, which is illustrated in FIG. 7 as serving to transfer the cargo liquid from the pivot tower to the floating pier;

FIG. 11 is a top plan view to enlarged scale, with parts in section and broken away, of the structure shown in FIG. 7;

FIG. 12 is a side elevational view to reduced scale, with parts broken away, showing in somewhat diagrammatic form the stem end section and other parts of an embodiment of the floating pier of the present invention, portions of which are depicted in FIGS. 7 to 10 incl., with the pivot structure shown supported upon a pile ring fixed to the sea bottom by a plurality of piles driven down into the latter;

FIG. 13 is a top plan view to substantially the same scale of FIG. 12, of parts of the stem or head end section of the embodiment of the floating pier illustrated in FIGS. 11 and 12, with parts broken away and omitted, showing a top view in full lines of the pile ring, the outer tube of the pivot assembly and the main portion of the rotary hub rotatably mounted thereabout as are illustrated in FIGS. 11 and 12; and

FIG. 14 is a transverse sectional view of the embodiment of the floating pier of which parts are illustrated in FIGS. 7 and 10 to 13 incl., taken at the location of the connections of the longitudinal conduits to the transfer equipment on the platform, substantially to the same scale as are FIGS. 12 and 13, and illustrating a portion of a vessel moored along one side thereof.

As will be seen from FIGS. 1 to 6 incl., an embodiment of the floating pier of the present invention, indicated as **15**, may be substantially of the following construction. This floating pier **15** includes, as essential elements, a plurality of longitudinally-extending tubular stringers, of which there may be several groups. One group of these stringers comprises a pair of transversely-spaced top stringers **16** located substantially in a common horizontal plane (FIGS. 3–6). Another pair of longitudinally-extending and transversely-spaced pair of stringers **17** are located in the bottom of this open framework and are also substantially positioned in a common horizontal plane. A third pair of such transversely-spaced, longitudinal stringers **18** which may be provided, in some applications of the design, likewise are located in a substantially horizontal plane intervening the top and bottom planes in which the stringers **16** and **17** are respectively located. Other embodiments of this invention may include fewer or additional stringers, singly or in pairs, in any arrangement which will minimize the motions of the pier under the most adverse conditions of waves and wind at any selected location, notwithstanding the accompanying drawings which only serve to illustrate the basic concepts, and, if desired, a pair thereof may be located in the vicinity of the waterline **19**.

These sets of longitudinal stringers **16**, **17** and, as the case may be, **18** are rigidly tied together by a plurality of tubular struts at least a large quantity thereof preferably being arranged in groups that are longitudinally spaced apart, and constituting with the longitudinal stringers a plurality of transversely arranged and longitudinally-spaced panels **20** and **120** (substantially all of which are indicated in FIG. 3, but every other one thereof being omitted from FIG. 2 to avoid confusion in the showing in the latter). Desirably the transversely-extending struts of the longitudinally-spaced groups may have a certain pattern of arrangement in such transversely-extending panels in the stem or head section **21** (FIG. 2) differing from those in the groups in the remaining section of the open framework **15**, as will be understood from FIGS. 3 to 5 incl. Such tubular stringers and struts preferably are of steel so that they may be welded together. It will also be seen from FIGS. 2 and 3 that in the stem section **21** the longitudinal stringers **16**, **17** and **18** preferably are bent so that those of each transversely-spaced pair gradually approach each other for cluster thereof at a vertically-extending, tubular hub **22**, to which they are fixedly tied, such as by welding.

As will be seen in FIG. 5 the struts which rigidly tie the longitudinal stringers **16**, **17** and **18** together in each of the transverse panels **20** may, but do not necessarily, include the following: a horizontal strut **23** extending transversely across, in the top of the open framework **15**, to tie together the transversely-spaced top stringers **16**; a similar transversely-extending bottom strut **24** rigidly tying together the bottom stringers **17**; and an intermediate, transversely-extending strut **25** rigidly tying together the transversely-spaced stringers **18**. In each such group of struts **20** a pair of oblique or vertical struts **26**, depending on the selected optimum configuration of stringers, extend upwardly in the transverse plane from the intermediate stringers **18** to the top stringers **16** for rigidly tying together stringers **16** and **18** on each side of the open framework, and likewise a pair of oblique or vertical struts **27** respectively tie together the intermediate stringers **18** and bottom stringers **17** on each side.

Longitudinally-extending fender elements may be affixed to certain stringers or to certain struts so that the pier may be closely approached by the sides of ship hulls (illustrated in broken lines at **28** and at **29** in FIG. 2). This fendering function preferably is enhanced on opposite sides by fixing to the outside surface of certain of the longitudinal stringers a suitable rubbing strip **30** which desirably may be formed of elastic material, such as rubber or rubber-like composition, with each such fender strip being solid or of hollow core construction as may be desired (such rubbing or fender strips being indicated in FIG. 2 as being carried by stringers **18**, but omitted from FIG. 3 to avoid confusion in the showing of the latter).

As will be understood from FIG. 5 each of the transverse panels **20** may embody therein to advantage additional pairs **31** and **32** of obliquely arranged, interior struts for the purpose of bracing the longitudinal stringers in the transverse plane. The struts **23** to **27** incl. in each transverse panel **20** may have their ends rigidly anchored to the appropriate stringers by certain welding that seals off the hollow interiors thereof against the entry of water. Likewise, the oblique struts **31** and **32** may be anchored by similar welding to the appropriate stringers and, as the case may be, to intermediate struts, sealing off the hollow interiors thereof for like purpose. Also, the ends of the top and bottom stringers **16** and **17** may have their hollow interiors sealed off by similar welding in fixing the various parts of the open framework **15** together to provide watertight spaces. Such watertight spaces in the tubular members of the open framework **15** provide the required buoyancy of this floating pier.

With regard to the smaller transverse panels **120** in the stem section **21**, as is illustrated in FIG. 4 a pattern of the struts in each group or transverse panel thereof may be provided that is somewhat similar to that in the larger transverse panels **20**, illustrated in FIG. 5. Thus, tubular strut **123** cross-connects the top stringers **16**, tubular strut **125** may cross-connect the tubular stringers **18** in the event that such intermediate stringers are deemed advantageous, and tubular strut **124** cross-connects the tubular stringers **17**. Oblique tubular struts **131** may connect the tubular stringers **16** to the midsection of the

transverse strut **125**, and other oblique struts (not shown) which may be similar to those at **32** in FIG. 5 may connect the stringers **17** to this midsection. In the event that intermediate strut **25** is not used, a single strut **131** may connect stringer **16** to the diagonally opposite stringer **17**, or a pair of oblique struts **131** may be provided for cross-bracing of the transverse frame. As is indicated in FIG. 3 the various transverse panels **120** may be further connected to gether successively by pairs **33** and **34** of tubular struts for increasing the rigidity of the open framework **15**, and this may be repeated with respect to the larger transverse panels **20** in the main section of the open framework, if desired.

Preferably, the rubbing fender strips **30** which are shown extending along and mounted on the outer side of each of the intermediate tubular stringers **18**, but which, in other embodiments of this floating pier, may be mounted on other stringers, e.g., the top stringers **16**, are supplemented by a plurality of pairs of rubber fender rollers **35** at each transverse panel **20** (FIGS. 2, 3 and 5) suitably supported in any desired manner, such as by yoke arms **36** mounted upon the side struts **26**, with the axes of these rollers extending horizontally for rotation in vertical planes, so that when the side of the hull **28** or **29** of a vessel engages there-against it will be permitted ready relative fall of the vessel hull as vessel loading progresses without imposing undue pier upsetting force on the floating pier. If desired, similar fendering rollers may be mounted at the sides of the transverse panels **120** (not shown) in the stem section **21**, and it may be desirable to dispose the axes of the paired rollers here vertically so as to facilitate relative longitudinal movement between the tanker hull and either side of the floating pier as the tanker approaches in the docking procedure. Such rollers **35** may have solid rubber tires, but preferably these are tubular or of the hollow core type which entrap air therein, so that they are pneumatic rollers.

At any selected or desired distance from the stem end of the floating pier **15** the open framework thereof preferably is provided with a relatively small platform **37** suitably supported on the top thereof such as by the top transverse struts **23** of succeeding transverse panels **20** (FIG. 2). This platform **37** is located at a convenient distance from the stem end of the floating pier so as to be opposite the manifolds of the vessel when the latter is moored to the pier and has mounted thereon suitable liquid transfer or loading equipment, indicated generally at **38** in FIGS. 1, 2 and 3 that may include suitable piping valves, pumping units, and masts, booms or cranes for handling the transfer hoses, rigid swiveled loading arms, etc.

The stem or head of the floating pier **15** is to be anchored at a relatively fixed point offshore in the water and, for this purpose, a substantially vertical tubular pivot means **40** is provided, through which the cargo liquid may flow and, if desired, ballast from the vessel may counter-flow down therethrough. Accordingly, such tubular pivot means **40** may, if desired, be equipped with an anchoring collar **41** (FIG. 3) from which extends radially a plurality of anchor chains **42** suitably anchored to the sea bottom **43** (FIGS. 3 and 4). As will appear hereinafter, if desired, such anchorage of the vertical tubular pivot structure **40** may be accomplished by other means, such as a plurality of piles driven into the sea bottom to fix it thereto. The rotary hub **22** which is fixedly supported on the stem end of the floating pier **15** with its axes extending substantially vertical, is telescoped down over the tubular pivot structure **40** with the bottom end of this pivot structure **44** extending therebelow to swivel connection with a hose or pipe fitting **45** in turn connected to a spiraled or looped end of a submarine supply hose **46** that extends out from the onshore supply point and may rest upon or be buried in the sea bottom **43**, as desired.

Any such anchorage of the vertical tubular pivot means **40** should allow vertical rise and fall of the stem end of the floating pier **15** for accommodating the rise and fall of the waterline which may result from normal tide action or winds, etc. Anchorage by the anchor chains **42** may permit rise and fall of the vertical tubular pivot structure **40** with the rotary hub **22**, but preferably the latter is permitted free axial motion as well as swinging motion thereabout.

The top end of the vertical tubular pivot structure **40** projects upwardly an appreciable distance above the top end of the rotary hub **22** and it supports by suitable swivel connection a laterally-extending manifold **49** and having its interior communicating with a plurality of conduits **50**, such as a pair thereof, each in turn being connected at **51** (FIGS. 1–3) to the hollow interior of one of the bottom stringers **17**. Thus each of the bottom stringers **17** has a section extending between the point **51** and a point **52** (FIG. 3) in the vicinity of the liquid transfer or loading equipment **38** mounted on the platform **37** through which the cargo fluid, e.g., crude oil, may be pumped from the onshore point of supply, as is indicated at **53** in FIG. 6. Between point **52** on each of the bottom stringers **17** and the transfer equipment **38** mounted on the platform **37** extends suitable conduit structure, e.g., that indicated in broken lines at **54** in FIG. 3, for supply of the cargo fluid through the hollow stringer section. It is to be understood that other of the hollow tubular stringers may serve for other utility purposes, such as for conducting other fluids, and if they are liquid in nature it is preferable that they be provided in the bottom portion of the pier open framework **15** while if gaseous in nature stringers such as **16** or **18**, or sections thereof, may be employed for such service.

It will be seen from FIGS. 2 and 3 that desirably narnow walkways may be mounted on the top of the pier open framework **15** and may extend along, for superposed support, the longitudinal top stringers **16** and transversely over selected ones of the transverse top struts **23**. For example, longitudinally-extending walkways **55** may extend from the stem area of the pier open framework **15** to the stern **56** thereof, past and adjacent to opposite sides of the platform **37**. Crosswalks, such as those indicated at **57**, may be provided to be supported on cross struts **23** located therebeneath at any selected transverse points. Such longitudinal walkways **55** may be suitably flanked by hand rails and curbs, as may also be the crosswalks **57**.

The top of the pier open framework **15** is also to be provided with desirable ship mooring equipment such as bollards, cleats, winches and quick release hooks, and for this purpose they may be mounted on or adjacent the margins of the walkway structures. For the purpose of mooring a ship to one side of the pier open framework **15** or two ships, one to each side thereof, suitable mooring lines will be tied to such ship mooring equipment on the top of the floating structure. For example, it is indicated in FIG. 2 that the ship hull **28** may be moored to one side of the floating pier **15** by a bow line **58**, breast lines **59**, spring lines **60** and a stern line **61**. Similar mooring lines are employed to moor the hull of the vessel **29** to the opposite side of the floating pier **15** if it is desired to load these vessels simultaneously or immediately successively.

It will also be seen from FIG. 2 that the loading equipment at **38** may include supply hoses **62** to deliver the cargo fluid to the manifold of the vessel **28** and that an additional hose **63** may be provided for pumping out liquid ballast from the tanker compartments as they are being filled with cargo fluid. In lieu of hoses, rigid pipe arms may be provided, mounted on swivels so that they can adjust to the differential motions of the vessel and the floating pier. If it is desired to use both of the bottom tubular stringers **17** for the purpose of delivering cargo liquid, e.g., crude oil, to a single vessel, such as that indicated at **28**, hoses **62** may be connected between them and the ship manifold for this purpose while the ballast may

be spilled overboard possibly by a conduit having its outlet located farther out to sea to avoid shoreline fouling. Also, it may be desired to use one of the bottom tubular stringers **17** for the supply line and the other for counter-flowing the ballast liquid forward and down through the tubular pivot structure, or an additional longitudinally-extending conduit or stringer in the bottom portion of the floating pier may be employed for this purpose with the use of hose **63** employed to effect such ballast delivery or counter-flowing. In a second embodiment of the invention which is illustrated in other figures of the drawings, a tubular pivot structure is disclosed which may serve this purpose, as is explained in detail later. With respect to the second vessel **29** similar hoses **162** and **163** may be employed for like purposes. Increased draft of the ship hull **28**, as it is progressively loaded, is indicated in broken lines at **128** in FIG. 5.

As will be seen from FIGS. 7 to 14 incl. other embodiments of the present invention may be characterized by variations in certain features thereof. For example, such a different embodiment may provide the main section of the floating pier open framework **115** in the form of a structure which is also polygonal in cross-sectional shape, and more specifically substantially rectangular, at each transverse panel of a group of the strut members (see FIGS. 12, 13 and 14). In this main section the top chord or longitudinal panel is made up of a pair of transversely-spaced, longitudinally-extending tubular stringers **116** and a plurality of transverse tubular struts **223** tying them together. Additionally, this top chord includes a plurality of obliquely arranged and conceivably crossing struts **65** which cross-tie together the transversely-spaced top stringers **116** as well as the successive transverse struts **223** (FIG. 13). Each of the pair of side chords includes one top tubular stringer **116** and one bottom stringer **117** as well as a plurality of longitudinally-spaced vertical tubular struts **226** and oblique and conceivably crossing struts **66** extending between the top stringers **116** and the bottom stringers **117** (FIG. 12). The bottom chord includes the pair of transversely-spaced and longitudinally-extending stringers **117** and the longitudinally-spaced transverse struts **224** which rigidly tie them together, as well as supplemental struts arranged to obliquely in this bottom chord as in the top chord to tie successive transverse panels thereof together.

As is indicated in FIG. 11, which shows the stem section **121** of the open framework floating pier **115**, the top chord includes a rotary hub or collar structure **122** in the form of a yoke embodying web plates **67** arranged in grid pattern covered over by plating **68**. Similar cover plating **168** is provided on the bottom face of the yoke **122** (see FIG. 7). This yoke **122** is tied to the transversely-spaced top stringers **116** by a pair of converging tubular members **69**. The bottom stringers **117** are tied to the yoke **122** by a pair of tubular members **217** which are aligned with stringers **117** in the vertical plane, but extend obliquely upward to the yoke (see FIGS. 7, 11 and 12). Sections of tubular members are tied together, end to end, and are suitably cross-braced to provide an open framework **70** extending about and beyond the rotary hub defined by the yoke **122** to serve as a generally arcuate or semi-circular, rigid fender structure **70** (FIGS. 7, 11 and 12). Fender structure **70** is supplemented by a rubbing or bumper strip **130** mounted on the outer edge thereof and preferably it is continued to extend along the outer sides of the top tubular stringer members **116**.

The tubular pivot structure **140** includes a pair of tubular sleeves **240** and **340** with the former coaxially nested in the latter (FIGS. 7 and 11), and the intervening space may be utilized to advantage to provide a recessed vertical ladder (not shown). These nested tubular sleeves **240** and **340** may be decked over by circular plating to provide a workman's platform **71** which may be circumscribed by a protective hand rail (not shown). The yoke **122** has a cylindrical hole **72** extending vertically therethrough which is desirably lined with a shock-absorbing torus **73** that may be in the form of a hollow core, pneumatic rubber ring preferably equipped on its inner circular wall with a sleeve bushing **75**, preferably bonded thereto, that is rotatable about and slidable axially up and down along the outer tubular sleeve **340** for free relative rotatable and axial movement.

The outer sleeve **340** is fixed coaxially within a polygonal pile cap ring **76**, which may be made up of a plurality of contiguous and connected sections **77**, and this ring is suitably braced in this position by a plurality of radially-extending struts **78** and **178** (FIGS. 7 and 12). The pile cap ring **76** is designed to be supported on and to serve as a guide for the driving of an annular series of vertical piles **79** with the bottom ends thereof driven down into the sea bed **43** for fixed location of the tubular pivot structure **140**.

The nested tubes **240** and **340** have their bottom ends secured together by transverse circular plating **171** as are their top ends by the circular plating **71** so as to provide a rigid sleeve construction, serving as the tubular pivot structure **140**. The closed spaces therein may provide a desired degree of buoyancy. The end platings **71** and **171** are provided coaxially with aligned circular holes **80** and **180** through which extend a pair of coaxially arranged nested tubes **81** and **82**. The core tube **81** provides a through conduit and the annular space **83** intervening the core tube and the outer tube **82** provides another fluid conducting passage. The core tube is provided with an elbow fitting **84** to divert its passage through the wall of the tube **82** for connection thereto of flexible tubing or hose **85** to conduct ballast liquid out along the sea bed **43** to a desirably remote point of discharge (FIGS. 7 and 12). The top section of the core tube **81** and the surrounding tube **82** project an appreciable distance above the platform **71** to define a tower **86**. In the tower **86** the core tube **81** is connected through suitable fittings and swivel connections **87** and **88** to a tower transverse manifold **89** (FIGS. 7 and 8). The top end of the surrounding tube **82** is superposed by a swivel connection **90** for support thereon of a tower, cargo liquid supply manifold **149**. The tower ballast manifold **89** has connected thereto a plurality of flexible conduits or hoses **91**. The cargo fluid supply manifold **149** has connected thereto through suitable valves a plurality of flexible hoses **150**.

As will be understood from FIGS. 7, 9, 10, 11 and 12, the stem section **121** of the floating pier **115** supports by suitable bracing members, including diverging tubular members **69**, tubular legs **92**, a transverse, pier manifold **93** to which the cargo fluid supply hoses **150** are communicated. Such bracing structure includes transverse tubular member **94**, oblique braces **95**, and transverse brace **96** which tie these oblique braces rigidly together (FIGS. 7, 10 and 12) for secure support thereof. The tubular vertical legs **92** serve as conduits for flow connection respectively to the pair of bottom stringer sections **217**, one such connection being indicated in broken lines at **97** in FIG. 7.

It will be seen in FIGS. 7, 9, 10 and 12 that another transverse, pier manifold **98**, which is in the counterflow path of ballast, is supported by suitable means fixed to the pier cargo fluid manifold **93**, such as by a plurality of intervening rigid brackets **99** which may be in the form of sections of tubing welded to these manifolds. Suitable fittings communicate the interior of the pier ballast manifold **98** to the flexible hoses **91** for delivery through the latter to the discharging tower ballast manifold **89** for flow of the ballast liquid down through the core tube **81**.

It is indicated in FIGS. 7, 9, 12 and 14 that the manifold **98** receives ballast liquir through a vertical tube **100** which is provided as a terminal section of a tubular conduit **101** that is supported longitudinally in the central or keel area of the bottom portion of the pier open framework **115** (FIG. 14). The supply conduit **101** is

flow-connected by any suitable means, in the vicinity of or by the liquid transfer equipment **38** to one, or alternately to both, of the ballast supply conduits **63** and **163** (FIGS. 14 and 2). When two vessels such as **28** and **29**, moored to opposite sides of the floating pier are being simultaneously loaded the ballast pumped therefrom out through the conduits **63** and **163** may be combined in the equipment supported on the loading platform **37** commonly to flow out through transfer conduit **102**, delivery conduit **101** in the centroidal plane of the pier and section **100** to the delivery pier manifold **98** or, if desired, an additional longitudinally-extending conduit, similar to that at **101**, may be provided in the floating pier adjacent the latter to serve the second ship while ballast from the first ship is being pumped out through conduit **101**. In this transfer vicinity of FIG. 14 the cargo fluid for the two ships is transferred respectively from the flow sections of stringers **117** to the ship loading equipment **38** by transfer conduits **154** and **254**, for delivery to the ships respectively by hoses **62** and **162**.

It will thus be seen that embodiments of the elongated, open framework which is unsheathed by shell plating, that characterize the floating piers of the present invention, have inherent floating buoyancy with appreciable draft; and that each includes essentially a plurality of longitudinally-extending, tubular stringers extending from stem to stern of the floating pier and a plurality of transversely-extending and upwardly-extending tubular struts rigidly tying these tubular stringers together in open box formation. The longitudinally-extending tubular stringers essentially include at least a transversely-spaced pair thereof embodied in the submergible bottom portion of the framework and flanking the side margins of this portion, and also at least a transversely-spaced pair thereof embodied in the top portion thereof above the waterline and flanking the side margins of this top portion. At least one and preferably a plurality of the longitudinally-extending tubular stringers in the bottom portion of the floating pier framework provide by their hollow interiors flow passages for transfer of fluids, such as cargo liquid, or cargo liquid and ballast liquids, or such liquids and additionally to provide for other utility service. Sufficient numbers of the tubular stringers and struts in such floating pier framework are made watertight to assure the inherent floating buoyancy for the framework and equipment supported on the top thereof. The transverse panels of such pier open framework are polygonally shaped in outline, such as square, hexagonal, etc., as may be desired.

An appreciation of the relative sizes of the parts of embodiments of the floating pier of the present invention may be had from the facts that an embodiment of the elongated, unsheathed, open framework may be about 1,000 feet long and about 50 feet deep, with the bottom stringers being about 3 feet in diameter and the top stringers being about 2 feet in diameter. Further, it is to be understood that while embodiments of this floating pier may be designed primarily for loading cargo fluids into ships they are equally useful for unloading fluids from the latter to points onshore.

The stem of such elongated, unsheathed, open framework is anchored by pivot and rotary hub means which allow free swing of the floating pier to the most favorable aspect in response to prevailing wind, current and wave conditions with or without one or more vessels moored thereto. Further, such pivot and rotary hub anchorage allows the floating pier to rise and fall with tide and wave conditions as well as conditions imposed by transfer of fluids through tubular members thereof. While such up and down movement may be permitted by flexible anchorage of the pivot means, preferably it is attained by so fixing the pivot means to the sea bottom as to assure provision under all anticipated conditions of a top section thereof that extends appreciably above the surface of the water with the rotary hub being freely slidable axially up and down thereabout. When the pivot means is anchored in a predetermined location to the sea bottom by a plurality of disengageable anchors and flexible anchoring ties, e.g., anchor chains or cables, such an anchorage system permits salvage of the entire pivot means assembly for removal and transfer with the floating pier to another location. However, even should the pivot means be permanently anchored to the sea bottom, such as by a plurality of piles, either portions thereof may be removable for transportation or due to the relatively low cost of the structure thereof it may be abandoned for replacement when the floating pier is moved to another location.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is the novel subject matter defined in the following claims.

What is claimed is:

1. A floating pier for loading into or unloading from ships moored thereto fluids such as bulk cargo liquids, for example liquid petroleum materials, pumpable solids, slurries, or other fluids, comprising

(1) an elongated, open framework unsheathed by shell plating and having inherent floating buoyancy with appreciable draft that embodies a continuous top portion adapted to be buoyed above the waterline which has in contiguous succession a stem, a midsection and a stern, with the midsection intervening said stem and stern, the junctions of said stem and said midsection and of said midsection and said stern being co-linear, and which essentially includes

(a) a plurality of longitudinally-extending tubular stringers extending from the stem to the stern through said midsection with at least a transversely-spaced pair thereof embodied in the submergible bottom portion of said framework and flanking the side margins of this portion, and at least a transversely-spaced pair thereof embodied in the top portion thereof above the water-line and flanking the side margins of this top portion; and

(b) a plurality of transversely-extending and upwardly-extending tubular struts rigidly tying together said tubular stringers;

(c) an appreciable number of said tubular stringers and struts having the interiors thereof made watertight with areas of these watertight interiors being substantially free of liquid and carrying gaseous medium and with the combined capactity of these gaseous medium carrying areas providing said open framework with all of its floating boyancy, at least one of said bottom stringers having a section adapted to conduct fluid along said framework;

(2) means supported upon the top of said framework at a selected distance from its stem, that defines a platform upon which is mounted suitable fluid transfer equipment and to the vicinity of which said stringer conducting section extends;

(3) substantially vertical, relatively rigid, tubular pivot means adapted for flow of fluid therethrough and anchored to the sea bottom at a selected location with a top section thereof projecting above the water surface;

(4) means fixedly mounted on the stem of said framework defining a rotary hub rotatably mounted about said pivot means for anchorage of the pier thereto and swing of the latter thereabout; and

(5) fluid transfer means supported by said tubular pivot means and connected between the projecting

top section of the latter and said stringer conducting section.

2. The floating pier of claim 1 in which are provided means defining walkways extending longitudinally and transversely of the top of said open framework at chosen locations supported over sections of the stringers and selected ones of the transversely-extending struts that are in the top of said framework.

3. A floating pier for loading into or unloading from ships moored thereto fluids such as bulk cargo liquids, for example liquid petroleum materials, pumpable solids, slurries or other fluids, comprising

(1) an elongated, open framework unsheathed by shell plating and having inherent floating buoyancy with appreciable draft that embodies a stem, a stern and an intevening midsection, and which essentially includes

(a) a plurality of longitudinally-extending tubular stringers extending from the stem to the stern through said midsection with at least a transversely-spaced pair thereof embodied in the submergible bottom portion of said framework and flanking the side margins of this portion, and at least a transversely-spaced pair thereof embodied in the top portion thereof above the waterline and flanking the side margins of this top portion; and

(b) a plurality of transversely-extending and upwardly-extending tubular struts rigidly tying together said tubular stringers;

(c) an appreciable number of said tubular stringers and struts having the interiors thereof made watertight for providing said open framework with its floating buoyancy, at least one of said bottom stringers having a section adapted to conduct fluid along said framework;

(2) means supported upon the top of said framework at a selected distance from its stem, that defines a platform upon which is mounted suitable fluid transfer equipment and to the vicinity of which said stringer conducting section extends;

(3) substantially vertical tubular pivot means adapted for flow of fluid therethrough and anchored to the sea bottom at a selected location with a top section thereof projecting above the water surface;

(4) means fixedly mounted on the stem of said framework defining a rotary hub rotatably mounted about said pivot means to permit swing of the pier about the latter; and

(5) fluid transfer means supported by said tubular pivot means and connected between the projecting top section of the latter and said stringer conducting section;

(6) said transversely-spaced pair of bottom stringers having such fluid conducting sections for maintaining the trim of said pier framework during passage of fluid through sections thereof to minimize tendency of heel-over of said framework.

4. A floating pier for loading into or unloading from ships moored thereto fluids such as bulk cargo liquids, for example liquid petroleum materials, pumpable solids, slurries or other fluids, comprising

(1) an elongated, open framework unsheathed by shell plating and having inherent floating buoyancy with appreciable draft that embodies a stem, a stern and an intervening midsection, and which essentially includes

(a) a plurality of longitudinally-extending tubular stringers extending from the stem to the stern through said midsection with at least a transversely-spaced pair thereof embodied in the submergible bottom portion of said framework and flanking the side margins of this portion, and at least a transversely-spaced pair thereof embodied in the top portion thereof above the waterline and flanking the side margins of this top portion; and

(b) a plurality of transversely-extending and upwardly-extending tubular struts rigidly tying together said tubular stringers;

(c) an appreciable number of said tubular stringers and struts having the interiors thereof made watertight for providing said open framework with its floating buoyancy, at least one of said bottom stringers having a section adapted to conduct fluid along said framework;

(2) means supported upon the top of said framework at a selected distance from its stem, that defines a platform upon which is mounted suitable fluid transfer equipment and to the vicinity of which said stringer conducting section extends;

(3) substantially vertical tubular pivot means adapted for flow of fluid therethrough and anchored to the sea bottom at a selected location with a top section thereof projecting above the water surface;

(4) means fixedly mounted on the stem of said framework defining a rotary hub rotatably mounted about said pivot means to permit swing of the pier about the latter; and

(5) fluid transfer means supported by said tubular pivot means and connected between the projecting top section of the latter and said stringer conducting section;

(6) said tubular pivot means being in the form of at least a pair of telescopically arranged tubes with one constituting a core tube in which the hollow interior provides a fluid passage, said core tube being concentrically arranged within and spaced inwardly from the other to constitute a surrounding tube and together defining an intervening annular fluid conducting passage, the interior of the projecting section of one of said tubes being flow-connected by said transfer means to such fluid conducting section of one of said transversely-spaced pair of bottom stringers and the interior of the projecting section of the other of said tubes being flow-connected to the interior of longitudinally-extending tubular fluid conducting means extending from the framework stem to the vicinity of said platform.

5. The floating pier of claim 4 in which the longitudinally-extending fluid conducting means is a section of the other of the pair of transversely-spaced bottom stringers whereby fluid flow simultaneously through both of the latter substantially maintains the trim of said pier framework to minimize tendency of heel-over.

6. The floating pier of claim 4 in which the longitudinally-extending fluid conducting means is another bottom tubular conduit extending longitudinally of said framework to the vicinity of said platform in the centroidal plane of the framework for counter-flow out of the ship of ballast liquid as cargo liquid is loaded thereinto, both of said flanking transversely-spaced stringers having such fluid conducting sections with these sections commonly connected to the passage through one of said pivot means tubes which supplies cargo liquid to the ship.

7. The floating pier of claim 1 in which said rotary hub is unconstrainedly mounted about said pivot pivot means to permit relative axial motion of said hub on the latter as the floating pier may rise and fall.

8. The floating pier of claim 2 in which a major portion of said struts are arranged in longitudinally-spaced groups in each of which they define with said stringers that they there rigidly connect together a polygonal, transversely-extending framing sub-assembly of said pier framework with the transverse struts at the tops and bottoms thereof extending substantially horizontal whereby the top of said framework has substantially horizontal orientation for support in such orientation of said walkways

and platform and said transversely-spaced stringers in the bottom thereof are at substantially the same elevation for balanced attitude of said framework.

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