United States Patent

[11] 3,556,170

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[45] Patented **Jan. 19, 1971**

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[54] **MOORING AND FLUID-TRANSFERRING METHOD**
6 Claims, 17 Drawing Figs.

[52] **U.S. Cl.** **141/1,** 114/230
[51] **Int. Cl.** **B63b 21/50**
[50] **Field of Search** ..... 9/80.P.; 114/230; 137/236, 236(OS), 615; 141/1, 279, 387, 388; 214/14, (Cursory)

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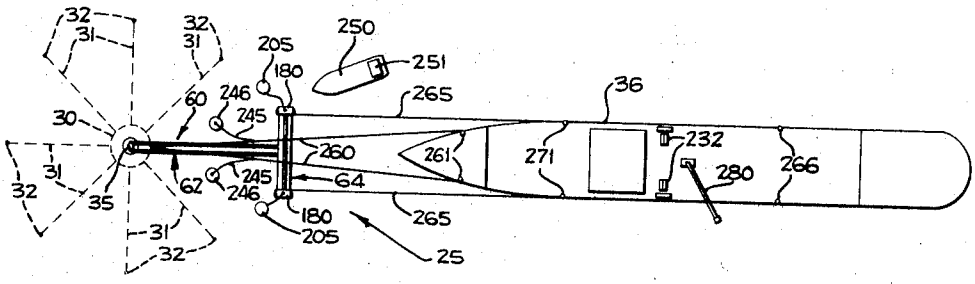
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ABSTRACT: An apparatus and method for mooring a floating marine vessel from a single offshore point, and for transferring fluid between the vessel and an onshore location. The apparatus includes an elongate rigid fluid-conducting conduit pivotally anchored at one end to the ocean floor, and connecting at the other end to a pallet that is raised and secured to the hull of the vessel, and articulated loading arms to conduct fluid from the pallet to the vessel's manifolds. The method includes aligning the vessel with the conduit, raising and securing the pallet to the vessel's hull, and connecting the loading arms to the manifolds.



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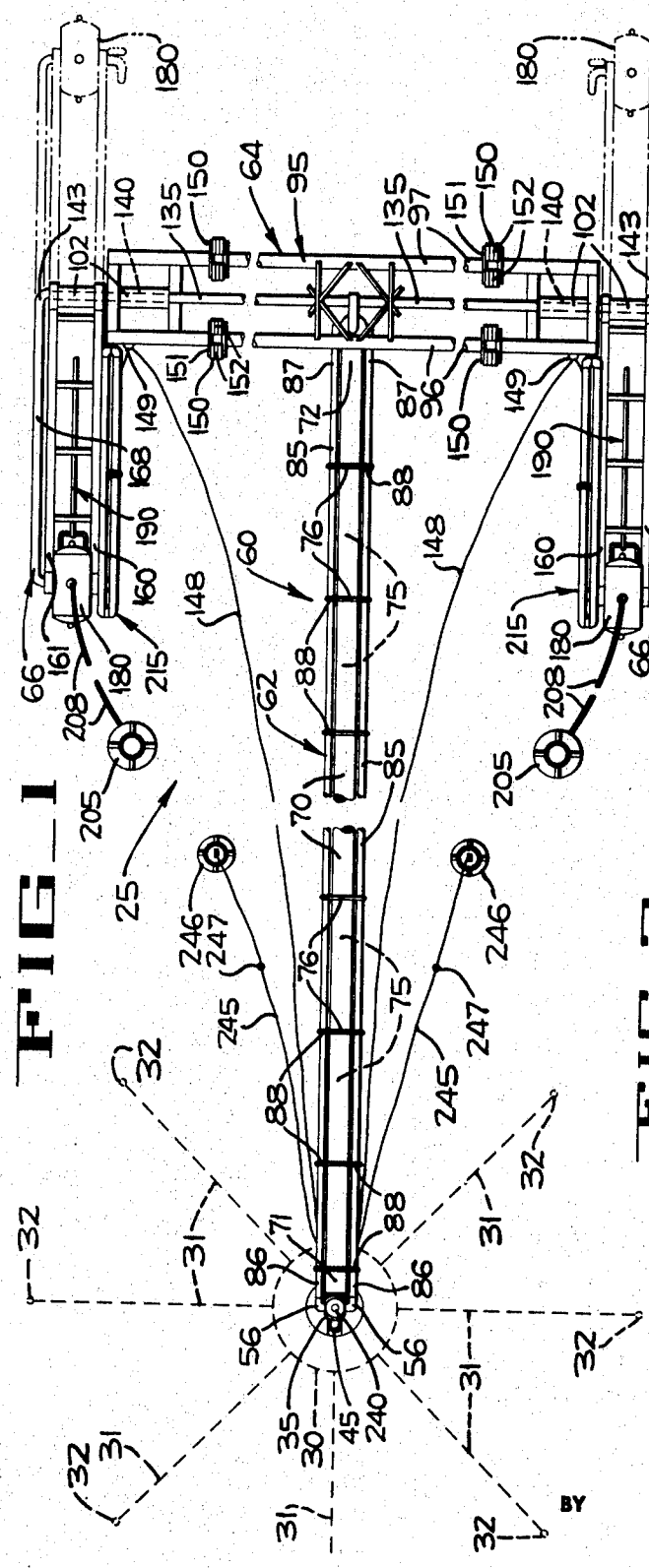


FIG_1

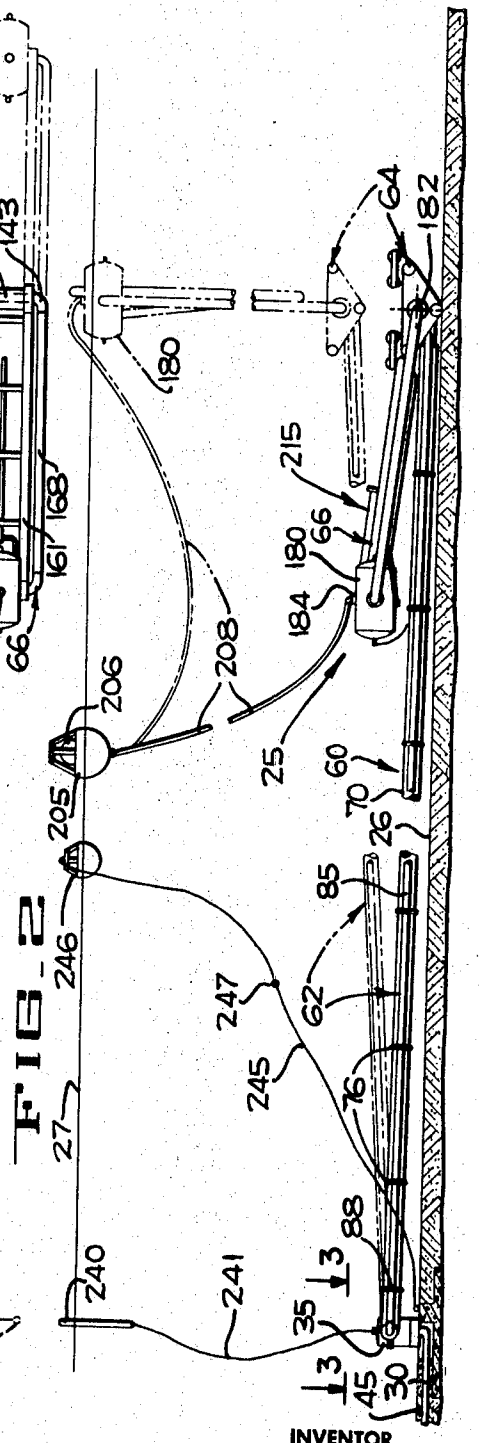


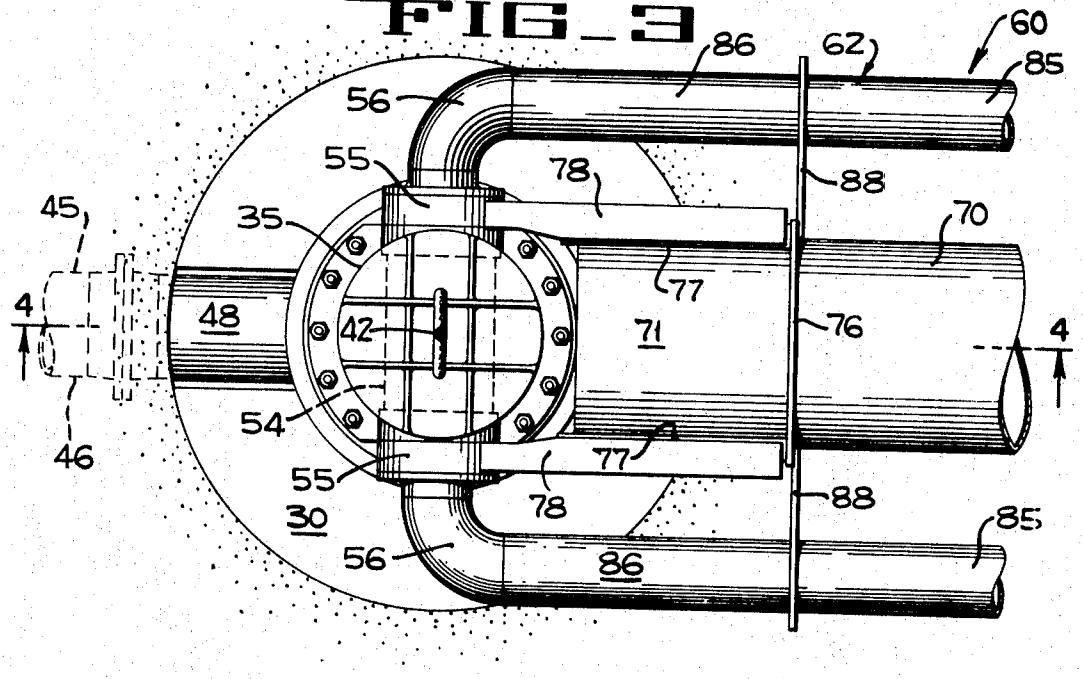
FIG_2

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FIG_3



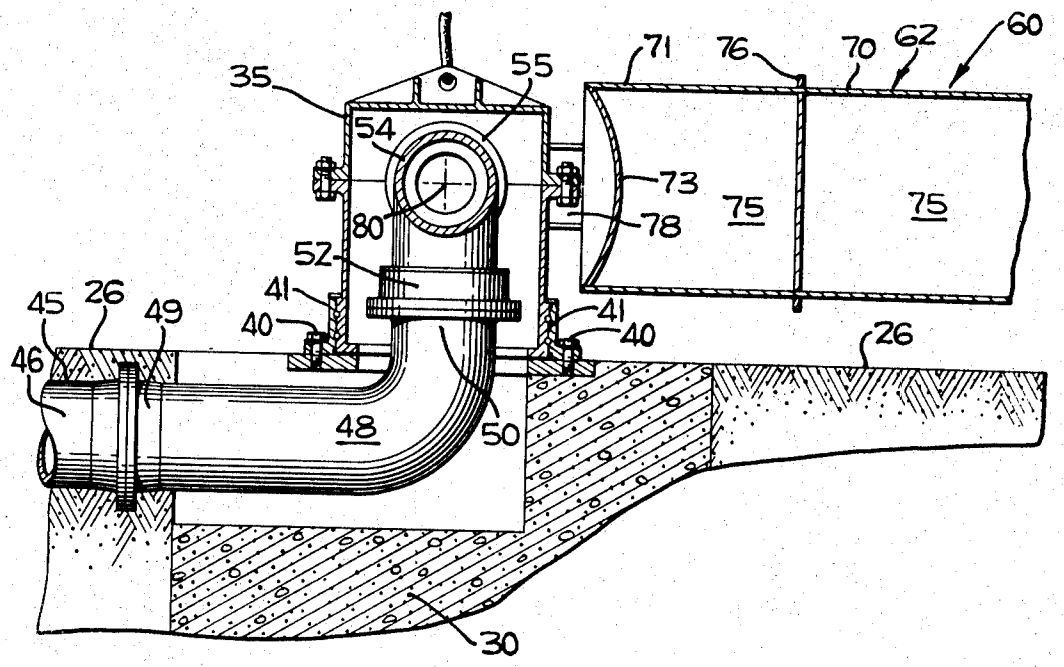


FIG_4

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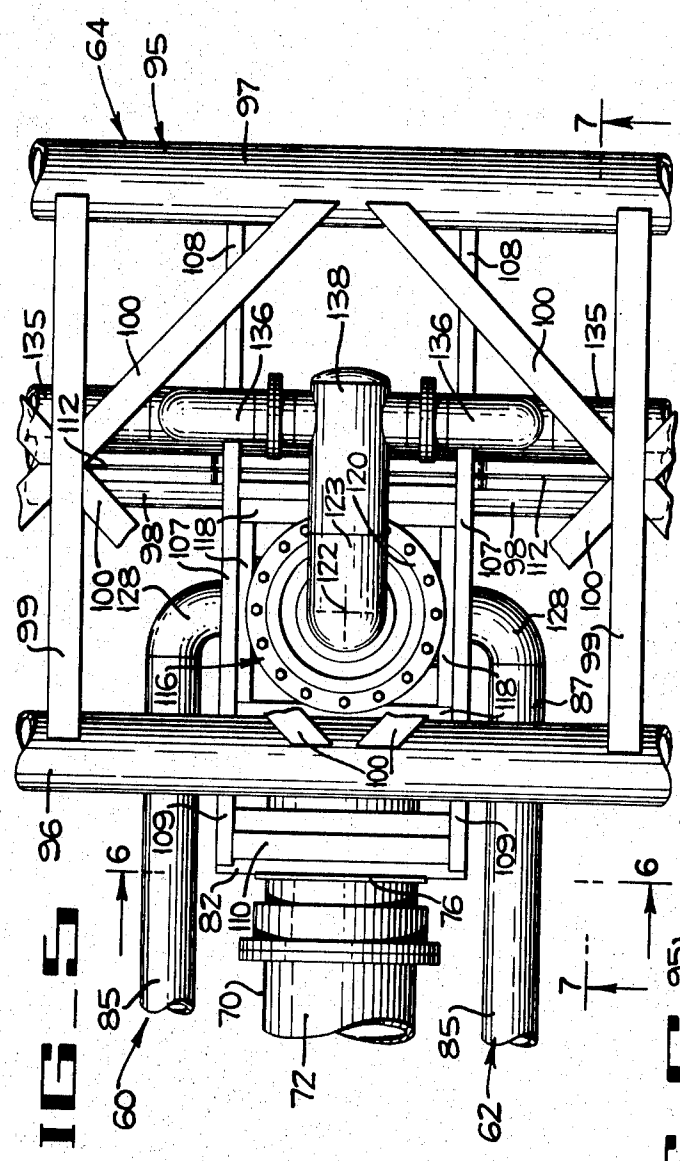


FIG. 5

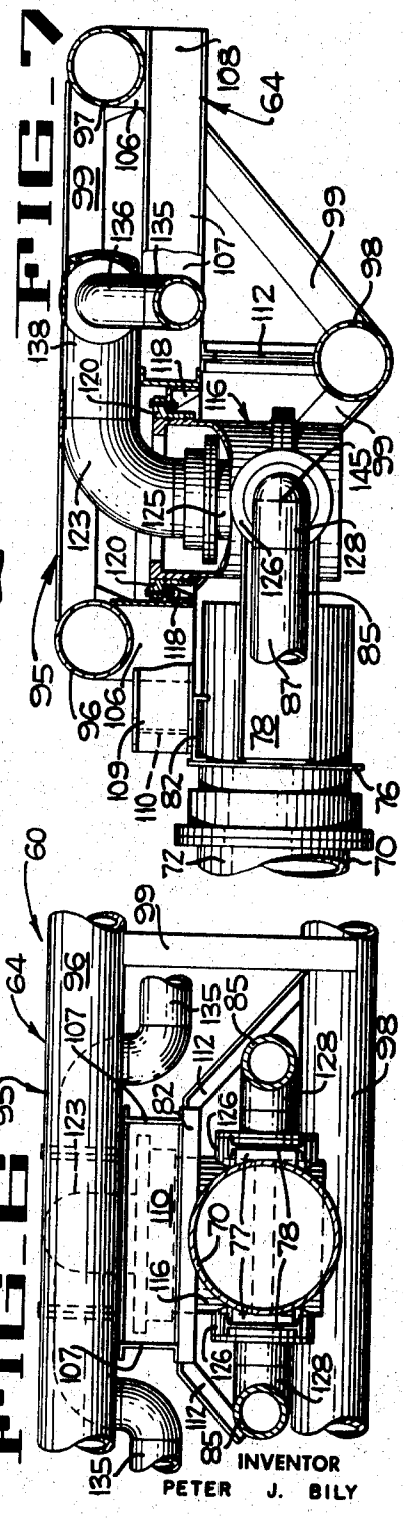


FIG. 7

FIG. 6

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FIG_8

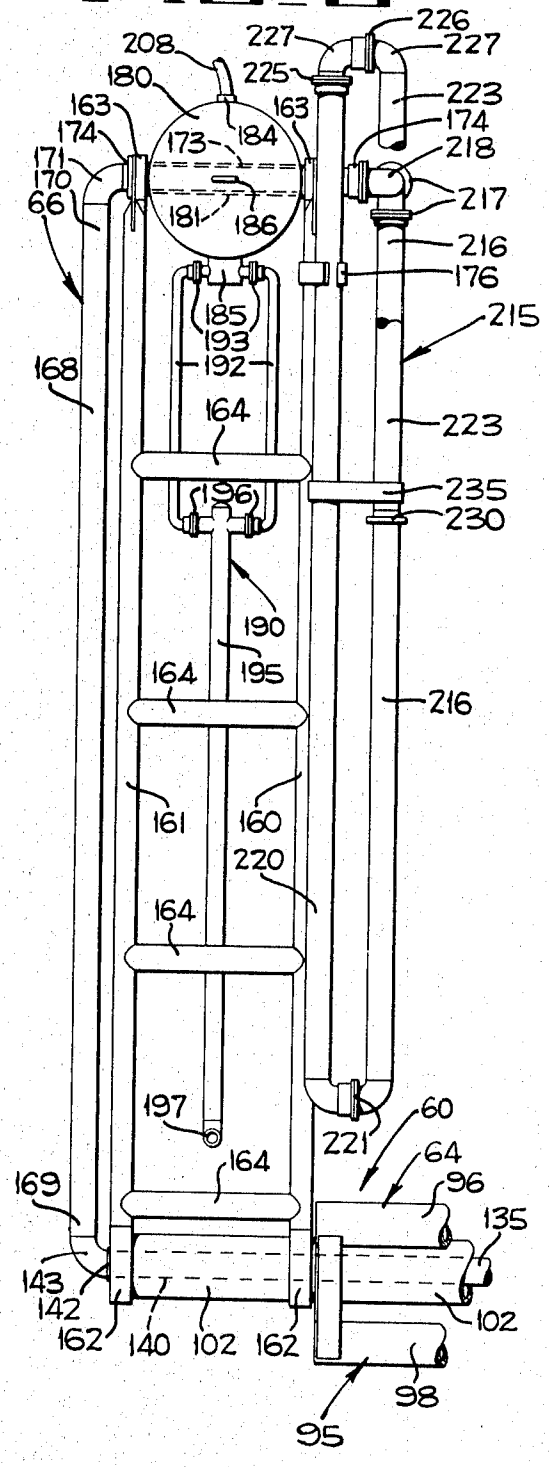


FIG_10

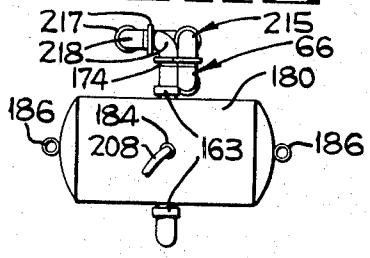
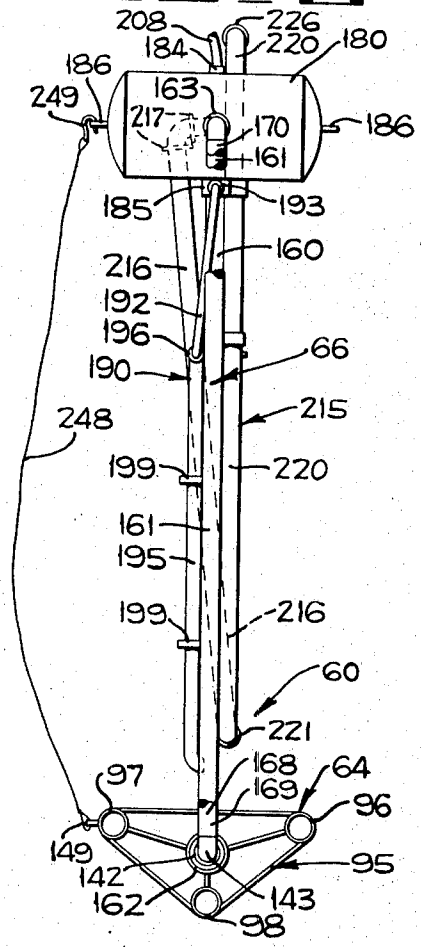


FIG_9



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FIG_11

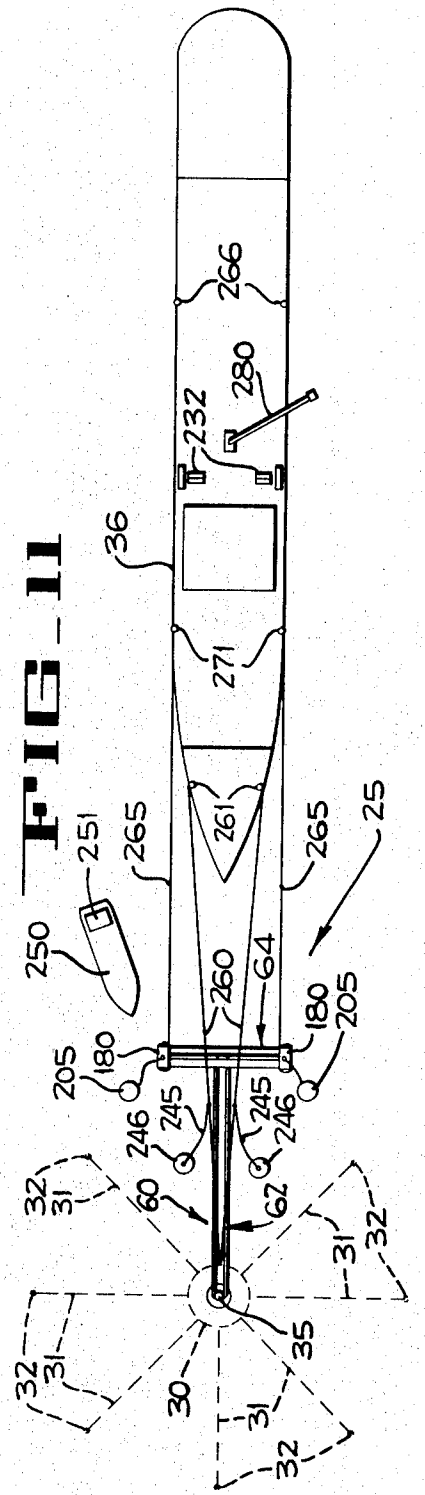
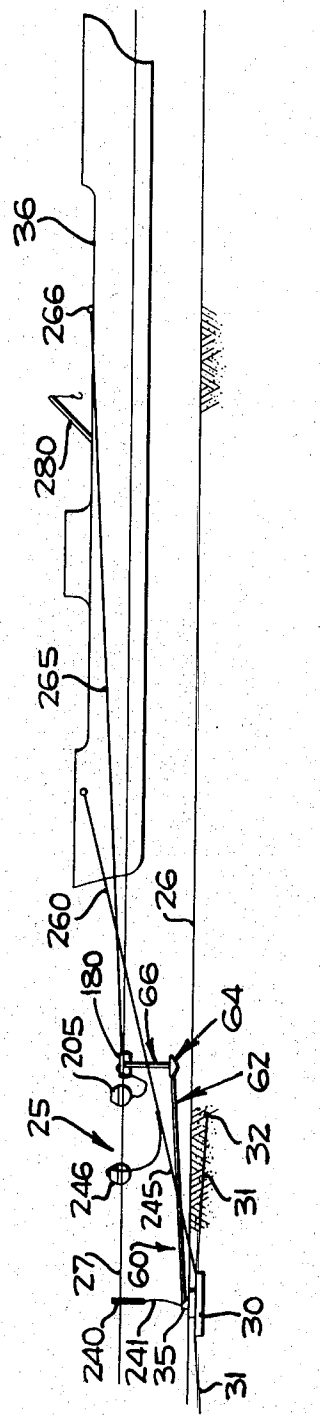


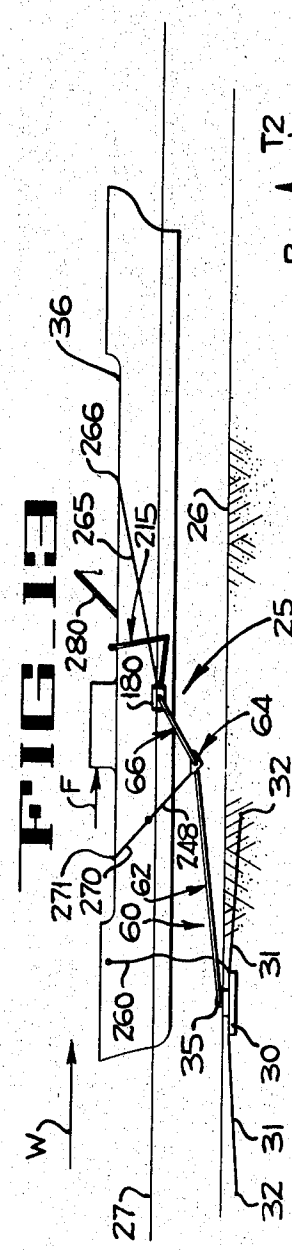
FIG_12

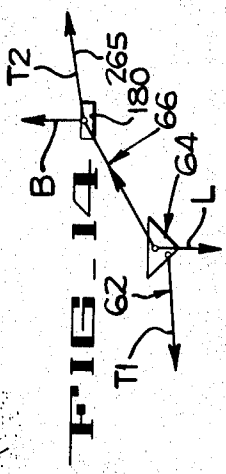


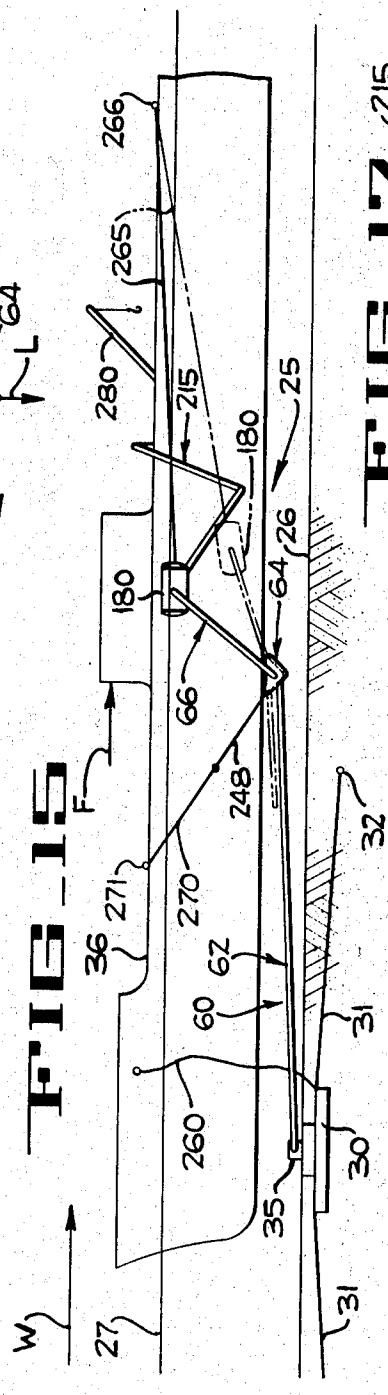
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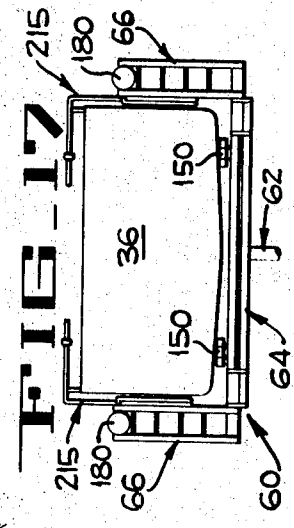
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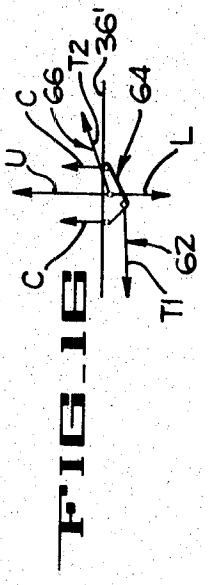
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MOORING AND FLUID-TRANSFERRING METHOD

CROSS-REFERENCE TO RELATED APPLICATION This application is a division of applicant's copending application Ser. No. 336,906, filed Jan. 10, 1964, and entitled "Mooring and Fluid Transferring Method and Apparatus" now U.S. Pat. No. 3,472,293

BACKGROUND OF THE INVENTION

The field of art to which the present invention pertains includes methods for mooring floating marine vessels to a single offshore anchor facility that is also capable of transferring fluid, such as a petroleum cargo, between the vessel and an onshore storage terminal.

As is reflected by the prior art, it has been proposed to moor a floating marine vessel to an offshore, above-water terminal by flexible lines that run between the vessel and the terminal, and also between the vessel and anchors at strategically placed positions. Establishing fluid communication between the vessel and the terminal by a flexible hose system also has been proposed, there being fluid lines on the ocean floor which extend from the terminal to a storage facility, usually on an adjacent shore.

These systems, however, have several disadvantages. For example, the terminal is subject to storm damage and is a navigational hazard since it permanently projects above the water. Another disadvantage is that the flexible hoses are difficult to handle and are subject to the corrosive action of salt water, which can render them unusable in a relatively short period of time. Still another disadvantage is that the mooring lines do not allow sufficient movement of the vessel nor do they satisfactorily accommodate normal mooring forces. Additional disadvantages of the previous systems include the difficulty involved in positioning the marine vessel properly in order to connect up to the mooring and fluid-transferring equipment, the problems that are incident to maintenance of this proper position during the fluid transfer operation, especially during inclement weather, and the not infrequent difficulty of casting off from these systems with safety as well as speed.

The present invention solves these problems and difficulties by providing a quick, safe, and uncomplex procedure for mooring the vessel, and for transferring the fluid to or from it.

SUMMARY OF THE INVENTION

This invention comprises a method for mooring a floating marine vessel to a submerged offshore terminal by orienting the terminal with the prevailing wind, aligning the vessel with an imaginary path over the terminal, moving the vessel along the path toward the terminal, and maintaining the vessel in the proper position for subsequent fluid transfer operations. The method involves pivoting a submerged mooring structure about its anchor at the ocean floor until it is oriented properly, guiding the vessel into the desired alignment with the structure, moving the vessel along a designated path toward the anchor of the submerged mooring structure until it is in a desired berthing area, and holding it in this berthing area by connecting it to strategically placed mooring members.

Accordingly, an object of the invention is to provide a method for mooring a floating marine vessel so that it can move about a given point with freedom, yet securely maintaining it in the required fluid transfer position. Another object of this invention is to provide a method for mooring a floating marine vessel to an offshore single point terminal with a minimum of trouble, even under bad weather conditions, and then to cast off from its mooring quickly and safely.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan of a mooring and fluid transferring apparatus for use in carrying out the subject invention, with portions of the apparatus being broken away, with the full lines showing the apparatus in its rest position on the seabed, and with the phantom lines indicating how part of the apparatus looks in a mooring position when it is connected to a vessel.

FIG. 2 is a side elevation of the apparatus shown in FIG. 1 with the full lines showing the apparatus in its rest position and the phantom lines showing the apparatus in a transitory position between rest and mooring positions.

FIG. 3 is an enlarged fragmentary plan as viewed from a position indicated by line 3–3 in FIG. 2.

FIG. 4 is a vertical section taken on line 4–4 in FIG. 3.

FIG. 5 is an enlarged fragmentary plan of another portion of the apparatus shown in FIG. 1 and with parts being broken away.

FIG. 6 is a transverse vertical section taken on line 6–6 in FIG. 5.

FIG. 7 is a longitudinal vertical section taken on line 7–7 in FIG. 5 and with portions being broken away.

FIG. 8 is an enlarged front elevation of still another portion of the apparatus shown in FIG. 1 and with portions being broken away, it being noted that this portion of the apparatus is shown in said transitory position.

FIG. 9 is a side elevation, reduced in scale, of the apparatus shown in FIG. 8 as viewed from a position on the left of FIG. 8, it being noted that parts are broken away.

FIG. 10 is a plan of the apparatus shown in FIG. 9.

FIGS. 11, 12 and 13 and 15 are diagrams which illustrate the operation of the subject apparatus as used in transferring fluid to or from a vessel at an offshore location.

FIGS. 14 and 16 are diagrams showing certain forces which exist as a result of the use of the subject apparatus.

FIG. 17 is a schematic transverse section through a vessel, showing the relationship of the subject apparatus to the vessel when the apparatus is connected thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIGS. 1 and 2, a mooring and fluid-transferring apparatus 25 for use in carrying out the present invention is shown in a rest position, in full lines, lying on the bed 26 of the ocean 27. Although the subject apparatus is described herein as being located in the ocean, it is equally as useful in other bodies of water. The apparatus includes an anchor 30 partially embedded in and fixed on the seabed by anchor lines 31 and deadman anchors 32 connected to the outer ends of the lines; other types of anchors could be employed.

The subject apparatus 25 also includes a vertical forward coupling housing 35 (FIG. 1—4). It is to be noted that the terms "forward" and "rearward" are used with reference to the orientation of a vessel 36 (FIG. 13) above the apparatus during operation of the latter. The coupling housing (FIG. 4) is secured to the anchor 30 by bolts 40 and includes a lower outer swivel joint enabling rotation of the housing about a forward vertical axis 42 (FIG. 3).

A supply pipe 45 (FIGS. 2—4) lies in the seabed 26 and has an offshore end 46 in the anchor 30. The supply pipe also has an opposite end, not shown, which leads to a storage facility, also not shown, but usually located on an adjacent shore; this storage facility may also be located offshore as, for example, adjacent to an offshore well. The subject apparatus includes a forward coupling elbow 48 within the anchor, which elbow has a lower end 49 connected to the offshore end 46 of the supply pipe and an upper end 50 projecting upward within the coupling housing 35. An upright inner swivel joint 52 is connected to the upper end of the elbow, and a horizontal pipe coupling 54 (FIGS. 3 and 4) is connected to this inner swivel joint. Lateral swivel joints 55 (FIG. 3) are individually connected to opposite ends of the pipe coupling, and lateral elbows 56 are respectively connected to the lateral swivel joints.

Also included in the subject apparatus 25 is a metallic, preferably steel, conduit structure 60 (FIGS. 1 and 2) that has a rigid longitudinal lower section 62 connected to the forward coupling housing 35 and projecting rearward therefrom, a rigid transverse intermediate section 64 pivotally connected to the lower section, and rigid longitudinal upper sections 66

pivotally connected to opposite ends of the intermediate section. The intermediate and upper sections are also referred to herein as a U-shaped pallet.

The lower section **62** of the conduit structure **60** includes a rigid reinforcing tube **70** (FIGS. **1**, **3**, **4** and **5**) having a mounting end portion **71** and an opposite coupling end portion **72** provided with outwardly facing concave end walls, as **73**. The reinforcing tube is divided into a plurality of compartments **75** (FIG. **1**) some or all of which are flooded or partially flooded with water in order to regulate the weight of the lower section; normally, in any given installation of the apparatus, the weight desired is predetermined and selected compartments are filled with water and sealed. Rims **76** are secured to the tube in longitudinally spaced relation therealong, and lateral blocks **77** are secured on opposite sides of the tube and project endwardly from the mounting and coupling end portions thereof. Forward and rear I-beam elements **78** are secured to the blocks and likewise project from the end portions of the tube. The forward I-beam elements are connected to the lateral swivel joints **55** on the coupling housing **35** so that the reinforcing tube is mounted for elevational adjustable movement about a horizontal axis **80** (FIG. **4**). A lower stop **82** (FIGS. **5**—**7**) is secured to the upper surface of the reinforcing tube at its coupling end portion immediately rearward of the rearwardmost rim **76**; the purpose of this stop will be subsequently described.

The lower section **62** of the conduit structure **60** also includes lower conduits **85** (FIGS. **1**—**3**) having mounting end portions **86** individually connected to the lateral elbows **56** and opposite coupling end portions **87** adjacent to the coupling end portion **72** of the reinforcing tube **70**. The conduits extend along opposite sides of the tube and are rigidly connected thereto by braces **88** which are connected to the rims **76** as well as to the conduits. Thus, the lower section of the conduit structure is mounted for swiveling movement about the axes **42** and **80**. Also, the lower conduits are in fluid communication with the supply pipe **45** through the forward coupling elbow **48**, the swivel joint **52**, the pipe coupling **54** and swivel joints **55**, and this fluid communication is maintained notwithstanding swiveling movement of the section.

The intermediate section **64** of the conduit structure **60** (FIGS. **1**, **5**—**7**) includes a main frame **95** having forward and rearward upper tubes **96** and **97** and a lower tube **98**, which tubes, as viewed in FIG. **7**, are in triangular relation with each other. These tubes are connected in this relation by main upper and lower struts **99** and by diagonal struts **100**. Furthermore, the main frame includes tubular end portions **102** (FIGS. **1** and **8**) which project from opposite ends of the tubes **96**, **97** and **98**. Since one of the functions of the intermediate section is to provide a predetermined amount of weight, the tubes may be compartmented like the reinforcing tube **70**, and water may be placed in these tubes to add weight if needed.

The main frame **95** of the intermediate section **64** also includes vertical support plates **106** (FIG. **7**) depending from the forward and rear tubes **96** and **97**. Laterally spaced mounting channels **107** (FIG. **5**) are secured to the support plates and have rear ends **108** under the rearward tube **97** and forward ends **109** projecting forward from the forward tube **96**. An upper stop **110** interconnects the forward ends of the mounting channels and is in overlying relation to the lower stop **82**. In addition, the main frame **95** includes central webs **112** which extend between and are connected to the lower tube **98** and to the mounting channels.

With particular reference to FIGS. **5** and **7**, an upstanding rear coupling housing **116** is supported by and bolted on a plurality of brackets **118** which are fixed to the mounting channels **107** and which define a rectangular opening that receives the rear housing. This rear coupling housing includes an upper outer swivel joint **120** that enables relative rotation between the rear housing and the main frame **95** about a rear upright axis **122**. A rear coupling elbow **123** projects downward within the rear housing and is connected to a T-coupling **125** within the housing. Rear lateral swivel joints **126** are connected to this T-coupling and lateral elbows **128** (FIGS. **5** and **6**) individually interconnect the rear lateral swivel joints and the coupling end portions **87** of the lower conduits **85**. Furthermore, the rear I-beam elements **78** are individually secured to the outer portions of the rear lateral swivel joints so that the intermediate section **64** is connected to the lower section **62** and so that the rear housing and therefore, the entire frame **95** can tilt down and back, that is clockwise, from the position illustrated in FIG. **7**.

The intermediate section **64** of the conduit structure **60** also includes intermediate conduits **135** (FIGS. **1** and **5**—**7**) extending lengthwise of the main frame **95** and having inner ends **136** connected to the rear coupling elbow **123** by a T-coupling **138**. The intermediate conduits also have outer ends **140** (FIGS. **1** and **8**) that project through the tubular end portions **102**. Outer swivel joints **142** are individually connected to the outer ends of the intermediate conduits, and elbows **143** are respectively connected to these outer swivel joints.

It will be understood from the foregoing description that the intermediate section **64** of the conduit structure **60** is mounted on the lower section **62** thereof for pivotal movement about the upright axis **122** and about a substantially horizontal axis **145** (FIG. **7**). Counterclockwise pivoting of the intermediate section about the axis **145** is limited by engagement of the upper stop **110** with the lower stop **82**, this limiting position being the position wherein a plane containing the forward and rearward upper tubes **96** and **97** is substantially parallel to a plane containing the lower reinforcing tube **70**.

Pivoting movement of the intermediate section **64** about the axis **122** is limited by guy lines **148** (FIG. **1**) which have rear ends connected to eyelets **149** at opposite ends of the forward upper tube **96** and forward ends connected to the anchor **30**. Preferably the guy lines permit pivotal movement of the intermediate section about axis **122** within an angle of about 15° both forward and rearward of a neutral position wherein the intermediate section is perpendicular to the lower section **62** or, in other words, a 30° total range of pivoting movement; this angle is given by way of example only since the invention is not limited to any particular angle of pivoting movement of the intermediate section.

Cushions **150** (FIG. **1**) are mounted on the forward and rearward upper tubes **96** and **97** on opposite sides of the centerline of the lower section **62** of the conduit structure **60**. Each of these cushions includes a bracket **151** secured to its respective tube and a plurality of annular resiliently compressible pads **152**, such as rubber tires, mounted on the brackets. The pads are rotatable on the brackets and project upward therefrom as shown in FIG. **2**.

Each of the upper section **66** (FIGS. **1** and **8**) of the conduit structure **60** includes inboard and outboard support tubes **160** and **161** having lower bushings **162** rotatably fitted on the adjacent tubular end portion **102** of the intermediate section and opposite upper bushings **163**. Tubular ribs **164** rigidly interconnect the support tubes in parallel relation with each other.

Each upper section **66** also includes an upper conduit **168** having a lower end **169** connected to its associated lateral elbow **143** and an upper end **170** connected to an upper elbow **171**. A cross duct **173** extends through the upper bushings **163** of each upper section, and an outer swivel joint **174** interconnects an outer end of this cross duct with the associated upper elbow **171**. Furthermore, an inner swivel joint **174** is connected to an inner end of the cross duct. A spring clamp **176** is mounted on the inboard support tube **160** adjacent to the cross duct.

Each upper section **66** of the conduit structure **60** includes a buoyancy tank **180** (FIGS. **8**—**10**) of generally cylindrical shape and which has an internal sleeve bearing **181** concentric with the minor axis of the tank and journaled in the upper bearings **163**. The cross duct **173** of the associated upper section projects through this sleeve bearing. The buoyancy tank is mounted between the inboard and outboard support tubes **160** and **161** for swinging movement about an axis substantially parallel with the axes **80** and **145** and the axis **182** (FIG.

2) of pivotal movement of the upper sections with respect to the intermediate section **64**. Each tank has an upper air fitting **184** and a lower water fitting **185** both of which communicate with the otherwise fluid-tight interior of the tank. In addition, each tank has forward and rear eyelets **186**.

Associated with each buoyancy tank **180** is a buoyancy control pipe **190** having a dual upper portion **192** connected in fluid communication with the water fitting **185** by upper swivel joints **193** and having a single lower portion **195** connected to the upper portion by lower swivel joints **196** and terminating in an open lower end **197**. U-shaped straps **199** are connected to a pair of the ribs **164** and loosely extend about the lower portion **195** of each buoyancy control pipe; these straps support the buoyancy control pipe on the ribs during pivoting of each upper section into its rest position, as illustrated in full lines in FIG. **2**, and yet accommodate longitudinal movement of the lower portion **195** of the pipe during swinging movement of the buoyancy tank between a position with its major axis substantially normal to the plane of the support tubes **160**, **161** (FIG. **9**) and a position with this major axis in substantially the same plane as the plane of the support tubes (full lines in FIG. **2**).

Buoyancy control buoys **205** (FIGS. **1** and **2**) float in the water **27** above the conduit structure **60** and include valves **206**. The valves are individually connected to the air fittings **184** of the buoyancy tanks **180** by flexible buoyancy control hoses **208**. If the tanks are above the lower ends **197** of the buoyancy pipes **190** and the valves are open, the air fittings **184** of the buoyancy tanks are open to the atmosphere and water is hydrostatically forced into the tanks through the buoyancy control pipes **190**, causing the tanks and thus the upper sections **66** of the conduit structure to submerge into their rest positions, as shown in full lines in FIG. **2**. The tanks will stabilize at a submerged position just above the open lower ends **197** of their respective pipes so that the greater pressure at these lower open ends maintains water in the tanks. When it is desired to raise the upper sections, air is forced into the tanks through the valves and hoses, expelling water from the tanks, and rendering the tanks buoyant so that they raise the upper sections into positions extending upward from the intermediate section **64**. Vertical upwardly extending positions of the upper sections, as shown in phantom in FIG. **2**, are merely transitory, however, since when the upper sections are connected to a vessel **36**, the upper sections project rearward from the intermediate section, as illustrated in phantom in FIG. **1**. The valves **206** are closed to capture air in the tanks so that the tanks remain buoyant and in upper positions until the valves are opened and the air is forced out by water rushing in through the buoyancy control pipes **190**.

The subject-mooring and fluid-transferring apparatus **25** also includes articulated metallic loading arms **215** (FIG. **2** and **8—10**). Each loading arm has an inner conduit **216** connected by inner swivel joints **217** and elbows **218** to the inner swivel joint **174** on its associated upper section **66**. Each inner conduit is connected to an intermediate conduit **220** by an intermediate swivel joint **221**, and an outer conduit **223** is connected to the intermediate conduit by outer swivel joints **225** and **226** and elbows **227**. The outer conduit **223** has a coupling **230** adapted for connection to one of the manifolds (FIG. **11**) **232** on the vessel **36**.

The loading arms **215** have folded positions (FIG. **8**) wherein their intermediate conduits **220** are releasably held within the clamps **176**. In addition to the clamps **176**, clamps **235** releasably connect the intermediate conduits to their respective outer conduits **223** adjacent to the couplings **230**. The loading arms are movable from their folded positions into projected positions (FIG. **13**, **15** and **17**) wherein they can be connected to the manifolds **232**. In the folded positions of the loading arm (FIG. **8**), the intermediate conduits overlap the inboard support tubes **160** and the intermediate swivel joints **221** are above the intermediate section **64** of the conduits structure **60**. Therefore, when the upper sections **66** pivot between their rest positions (FIG. **2** in full lines) and their fluid-transferring positions (FIG. **13**), the loading arms remain folded against the upper sections (that is, do not swing relative to the upper sections) and the joints **221** do not contact the intermediate section of the conduit structure.

The present apparatus **25** also includes an anchor marker buoy **240** (FIG. **2**) that is connected to the forward coupling housing **35** by a line **241**. This marker buoy projects out of the water at all times and, of course, indicates the position of the anchor **30**. Furthermore, bow connecting lines **245** have lower ends secured to the anchor **30** and upper ends connected to bow line buoys **246**. Shackles **247** are fastened to the bow-connecting lines. Also, auxiliary lines **248** are connected to the eyelets **149** on the main frame **95** and are releasably fastened by shackles **249** to the front eyelets **186** on the tanks **180**.

OPERATION

When not being used in a fluid-transferring operation, the conduit structure **60** and loading arms **215** lie submerged on the seabed **26** as in full lines in FIGS. **1** and **2**. Insofar as the apparatus **25** is concerned, only the buoys **205**, **240** and **246** are visible from the surface of the water. Since the buoyancy tanks **180** are filled with water, this fully submerged rest position is maintained so that the apparatus does not constitute a navigational hazard, is not subject to wind damage, and yet can readily be spotted since the buoys are visible.

When it is desired to moor a tanker or other vessel **36** for purposes of transferring fluid to or from the vessel, a launch **250**, on which is provided an air compressor **251**, motors out to one of the buoyancy control buoys **205**, and the crew connects the air compressor to the valve **206** on the buoy. Air is forced into the associated buoyancy tank **180** thereby expelling water from the tank and causing the tank and its associated upper section **66** of the conduit structure **60** to rise into the transitory vertical position illustrated in phantom lines in FIG. **2**. The valve **206** is then closed in order to capture the air in the tank and cause it to remain buoyant. The air compressor is disconnected from this valve, and the launch motors to the other control buoy whereupon, by repeating the described operation, the other buoyancy tank and upper section are made to rise into vertical position. Such upward movement of the buoyancy tanks and upper sections lifts the intermediate section **64** off the seabed **26** into the position illustrated in FIG. **12**. In this position of the apparatus, the tanks are of course visible on the surface of the water.

Next, tow lines, not shown, on the launch **250** are connected to the rear eyelets **186** on the tanks **180** and the conduit structure **60** is swung about the axis **42** until the lower section **62** is in alignment with the direction W of the prevailing wind and projects rearward from the anchor **30** in the same direction as the direction of the prevailing wind.

With the tanker **36** (FIG. **11**) headed into the prevailing wind, the tanker is maneuvered toward the anchor marker buoy **240** and on a path which extends between the now visible buoyancy tanks **180**. Before the bow of the tanker is between the tanks, the ship's bow lines **260**, which are connected to bow line winches **261**, are individually connected to the anchor bow lines **245**, and the tanker is pulled toward the anchor **30** by operation of the bow line winches.

When the tanker's bow is between the tanks **180**, ship's mooring lines **265**, which are connected to aft winches **266**, are individually connected to the aft eyelets **186** on the buoyancy tanks on their respective sides of the ship. By operating the aft winches, the ship's mooring lines are tensioned, which in turn pivots the upper sections **66** rearward and lifts the intermediate section **64** (FIG. **13**) thereby tensioning the conduit structure, in order to pull the ship forward until it is spotted over the conduit structure **60** (FIG. **13**), that is, until the ship's manifolds **232** are just aft of the tanks. It will be noted that as the tanker moves into this fluid transferring position, the bow lines **260** become slack. Next, ship's auxiliary lines **270**, which are connected to auxiliary winches **271**

between the bow and aft winches **261** and **266**, are connected to the auxiliary lines **248**, the latter being disconnected from the tanks **180** at this time. These auxiliary lines are provided to restrict forward movement of the ship in the event of a sudden reversal of the wind direction, W.

A hoist **280** on the tanker **36** is then employed to lift the loading arms **215** on board the ship, and the arms are connected to the manifolds **232**. A signal is communicated to the storage facility, not shown, and the transferring operation begins, either loading fluid into the ship or unloading the fluid from it. If fluid is being loaded onto the ship, it travels from the supply pipe **45** (FIG. **1**) through the forward coupling housing **35** (FIG. **4**) into the lower conduits **85** (FIG. **5**), through the rear coupling housing **116** into the intermediate conduits **135**, thence into the upper conduits **168** (FIG. **8**), and finally through the loading arms **215** (FIG. **17**) into the manifolds **232** of the tanker; if fluid is being unloaded, the flow is reversed as will be understood.

During transfer of fluid, the tanker **36** remains moored to the anchor **30** but can move about while fluid-tight integrity of the connections between the loading arms **215** and the manifolds **232** and between the various conduits **45**, **85**, **135** and **168** is maintained. That is fore and aft movement of the ship due to varying intensity of the wind force W are accommodated by the conduit structure **60** and the articulated loading arms. Rocking of the ship is accommodated by the inner and outer swivel joints **225** and **226** of the loading arms **215**, and skewing of the ship from side to side is accommodated by pivotal movement of the intermediate section **64** about the axis **122**. Furthermore, pitching of the ship is accommodated by the swivel joints **174** and **221** as well as the pivotal connections between the sections **62**, **64** and **66** of the conduit structure. In addition, the ship can range full-circle about the axis **42** (through the anchor **30**) so as always to remain headed into the prevailing wind.

Since the prevailing wind will, therefore, almost always act on the tanker in a direction from the bow to the stern, as indicated by arrow W, the lower and upper sections **62** and **66** of the conduit structure **60** and the mooring lines **265** are maintained constantly under tension between the aft winches **266** and the anchor **30**. As the total rear wind force F (FIGS. **13** and **15**) on the ship increases, the lower section and the upper section and mooring line on each side of the ship move toward a colinear relation (phantom lines in FIG. **15**), and as this force decreases, they move into a more angulated relation (full lines in FIG. **15**).

The reason whey the associated upper and lower sections **66** and **62** and the mooring lines **265**, on their respective sides of the tanker **36**, do not assume a straight line relationship at all times while under tension should be noted. With reference to FIG. **14**, the load L, which is primarily the weight of the lower and intermediate sections **62** and **64**, tending to submerge the apparatus **25**, may be regarded as being concentrated at and directed downward through the axis **122** (FIG. **5**). The tanks **180** (FIG. **14**) have a capacity sufficient to buoy up the upper ends of the upper sections **66** at positions above the lower ends thereof with a total force B equal to the load L. Therefore, the upper sections are urged toward straight-up positions by the tanks but are held in rearwardly upwardly projecting positions by the mooring lines. Tension forces in the lower and upper sections and mooring lines are indicated by T1 and T2. As a specific example, if T2 is 100,000 pounds on each mooring line **265**, the total tension T1 on the lower section is 200,000 pounds. Furthermore, if the load L is 20,000 pounds, the buoyancy force B is also 20,000 pounds.

Assuming a constant wind force W, the tension forces T2 (and thus T1) vary as the draft of the ship **36** changes. As the draft increases, that is as the ship goes down under an increasing cargo load, T2 decreases because the force F decreases; the force F decreases under these conditions because as the ship goes down in the water, there is less area of the ship exposed to the wind force W and, therefore, less total force F imposed on the ship. These changes are illustrated by observing the changed positions of the apparatus **25** from FIG. **13** to FIG. **15** wherein it will be noted that since T2 decreases, the buoyancy tanks **180** (full lines) move forward and upward and the intermediate section **64** moves downward. When the draft decreases on rising of the ship as a cargo is removed therefrom, the reverse action takes place.

An important advantage of this apparatus is that the intermediate section **64**, or rather the cushions **150** thereon, does not come into contact with the bottom of the ship **36**, except perhaps in a storm wind of great force. This is true even though the buoyancy tanks **180** and the intermediate section move up and down in the water in the manner described above. If such contact does occur, as illustrated in phantom lines in FIG. **15**, the contact occurs gradually and gently and with a force considerably less than the forces T2 on the mooring lines **265**. FIG. **16** is a force diagram showing various forces in effect when contact with the bottom **36'** of the ship does occur. The force U is the vertical component of the force T2 acting at the illustrated angle on the intermediate section so that the force U may be approximately one third of the force T2. Furthermore, the total resultant upward force acting on the bottom of the ship is the difference between the force U and the load L, and this total force is distributed over the bottom of the ship among the several cushions **150**, the force exerted at each cushion being identified by the letter C. Therefore, if contact with the bottom of the ship does occur, the force C acting upward at any of the cushions is only a small fraction of the force T2 and one which can easily be withstood by the hull without any adverse effect.

Another important advantage of the apparatus **25** is its ability to absorb or cushion-mooring forces or, stated otherwise, to avoid abrupt imposition of stress on the conduit structure **60** (FIG. **13**), the mooring lines **265**, the anchor **30**, and the ship **36** as it surges back and forth. In understanding this advantage, it is helpful to regard the lower section **62**, the upper sections **66**, and the mooring lines **265** as an articulated linkage which interconnects a fixed point (the anchor **30**) on the seabed **26** and movable points (the tanker's winches **266**) and which includes upper pivot points (where the mooring lines connect to the buoyancy tanks **180**) and lower pivot points (where the upper sections connect to the intermediate and thus to the lower section). It is believed that this linkage is readily apparent by observation of FIGS. **13—15**. This linkage yieldably resists elongation into a colinear condition with a resistance which progressively increases as the tanker **36** moves rearwardly away from the fixed anchor point. Therefore, an abruptly increasing force F is gradually, rather than abruptly, imposed on the anchor, the conduit structure **60**, the mooring lines **265**, and the ship. Furthermore, this linkage is maintained under constant tension by the oppositely acting forces L and B imposed on the linkage so that the ship remains dependably moored in its fluid-transferring position.

After the transfer of fluid has been completed, the loading arms **215** are disconnected from the manifolds **232**, lowered by the hoist **280**, and clamped in their folded positions. The ship's auxiliary lines **270** are disconnected, and the apparatus' auxiliary lines **248** are again connected to the buoyancy tanks **180**. Still further, the bow lines **260** are detached from the anchor bow lines **245**, and the mooring lines **265** are disconnected from the buoyancy tanks **180**. The launch **250** moors alongside of the ship **36** so that the crew can open the valves **206** on the buoyancy control buoys **205**, allowing air to bleed out of the buoyancy tanks whereupon water rushes into the tanks causing the same to submerge. It is to be noted that the tanks are manually directed to swing downward in a forward direction so that they return to the illustrated rest positions adjacent to the seabed **26**. The ship **36** then leaves under its own power.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention.

I claim:

1. A method of mooring and transferring fluid to or from a floating marine vessel, having a bow and a stern, in a berthing area which includes an anchor and a mooring structure connected to the anchor, the mooring structure including a first member pivoted to the anchor, a second member connected to the first member and extending transversely thereof, third members individually pivoted to and projecting upward from the second member and spaced on opposite sides of the first member, and a pair of buoyant marker members individually connected to the third members and visible from the surface of the water and spaced on opposite sides of a path passing over the anchor, said method comprising:

a. pivoting the first member about the anchor until the path is aligned in a preselected direction;

b. aligning the vessel with the path;

c. moving the vessel along the path toward the anchor and between the marker members until the members are located between the bow and the stern of the vessel; and

d. maintaining the vessel in the berthing area by connecting it to the mooring structure.

2. The method of claim 1 wherein the vessel is first moved between the marker members and then over the anchor in positioning the vessel in the berthing area with the marker members disposed between the bow and stern.

3. The method of claim 1 wherein the vessel is moved between the marker members by connecting a line between the anchor and the vessel and then applying tension to the line.

4. The method of claim 1 wherein the vessel is maintained against movement out of the berthing area in the preselected direction by connecting it to the marker members.

5. The method of claim 4 wherein the vessel also is maintained against movement out of the berthing area in a direction generally opposite to the preselected direction by connecting it to the second member.

6. The method of claim 1 including the additional step of e. establishing a fluid-transferring connection between the vessel and the marker members for conduction of fluid between the vessel and a remote storage facility.