United States Patent [19]

Flory

[11] **3,708,811**

[45] **Jan. 9, 1973**

[54] **SINGLE ANCHOR LEG SINGLE POINT MOORING SYSTEM**

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[73] Assignee: **Esso Research and Engineering Company**

[22] Filed: **Jan. 6, 1971**

[21] Appl. No.: **104,208**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 856,261, Sept. 9, 1969.

[52] **U.S. Cl.** ..... **9/8 P**

[51] **Int. Cl.** **D06p 3/00**

[58] **Field of Search** ..... 9/8 R, 8 P; 114/0.5; 137/236, 137/236 OS; 61/46.5; 166/0.5

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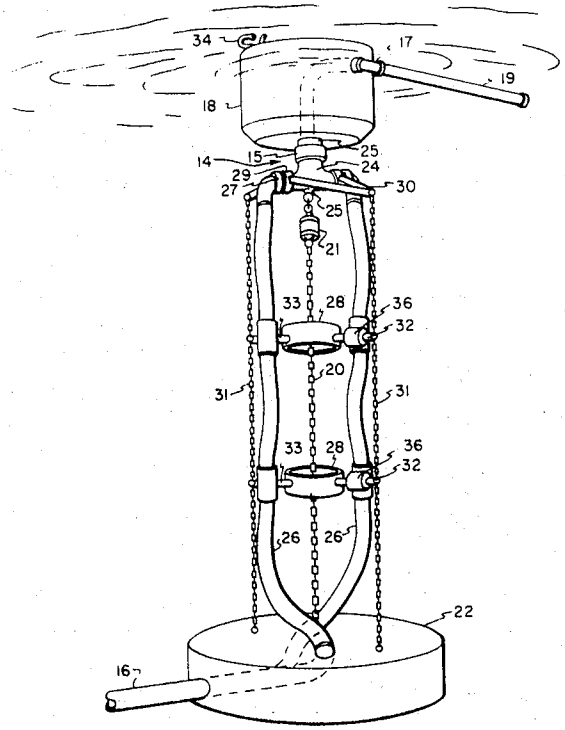
[57] **ABSTRACT**

A single anchor leg single point mooring and cargo handling system for seagoing ships is provided which comprises a mooring buoy anchored to a mooring foundation by anchor means such as a chain having little or no slack or an articulated rigid member (e.g. pipe, solid bar, etc.), cargo handling facilities extending between the mooring foundation and the mooring buoy, or alternatively directly between the mooring foundation and the ship to be loaded or unloaded, means for permitting the buoy to freely rotate, and restraint means for preventing entanglement of the cargo handling facilities and the anchor chain.

23 Claims, 8 Drawing Figures



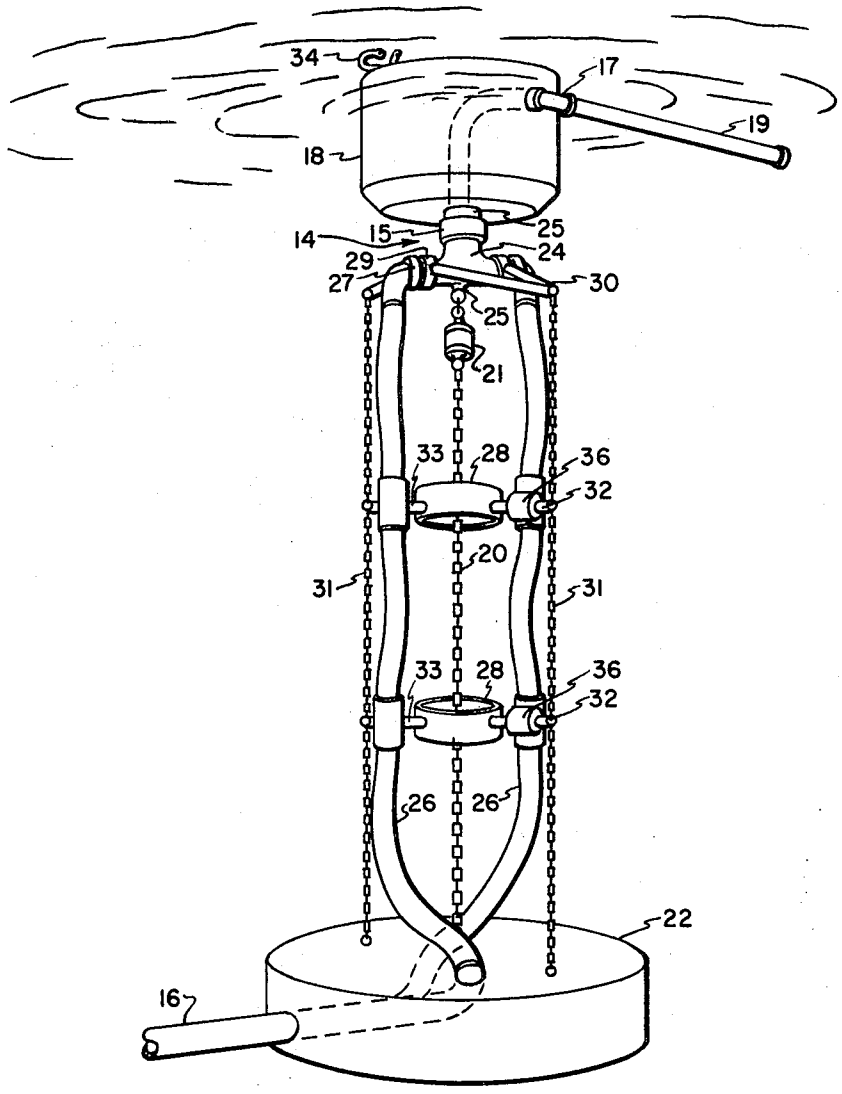


Fig. 1

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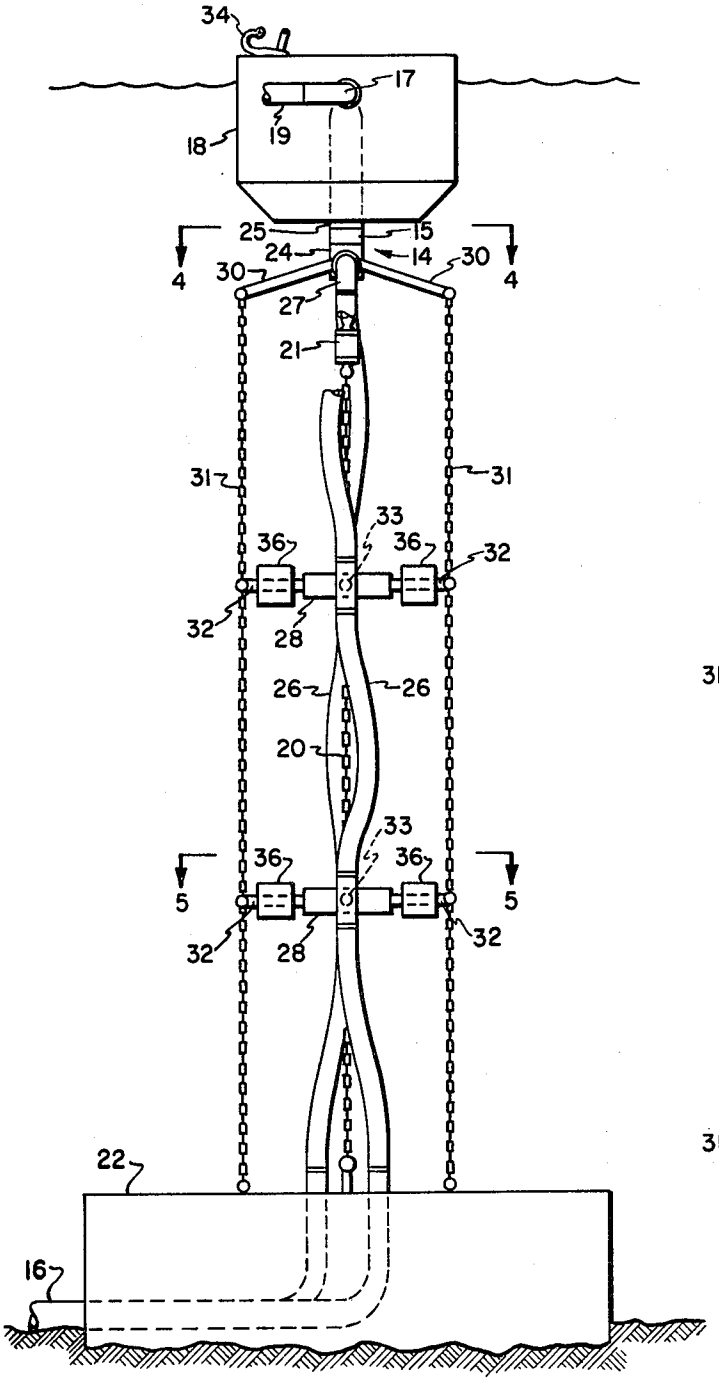

Fig. 2

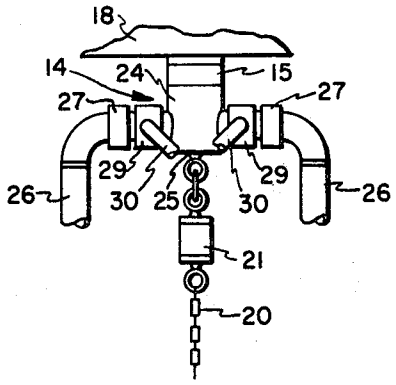

Fig. 3

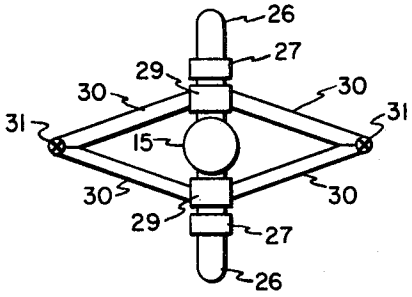

Fig. 4

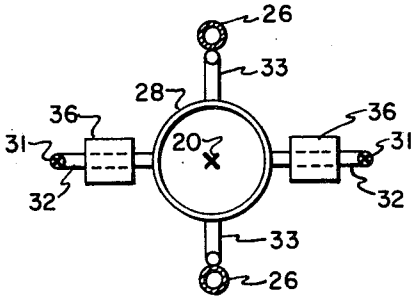

Fig. 5

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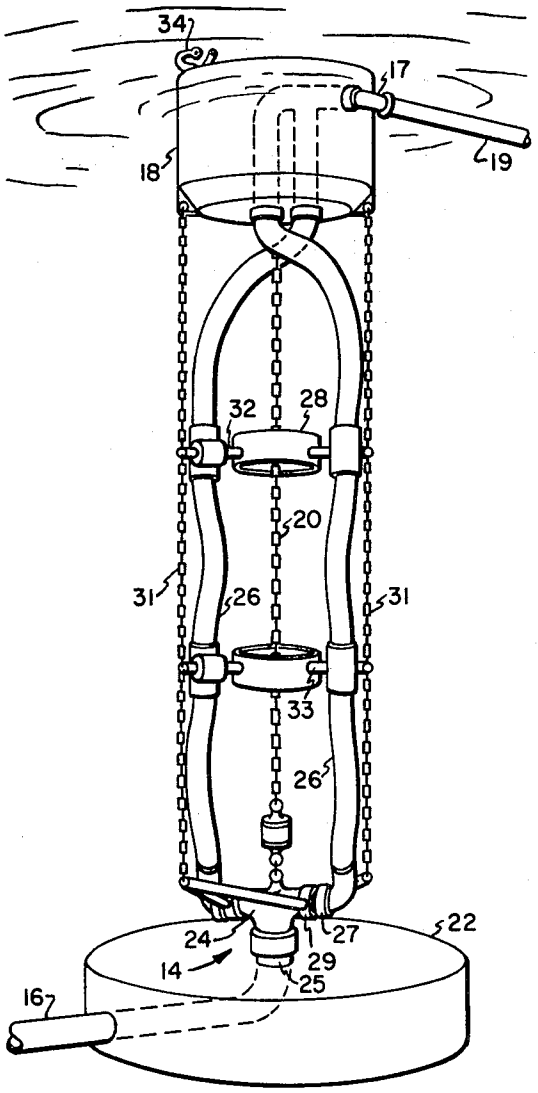

Fig. 6

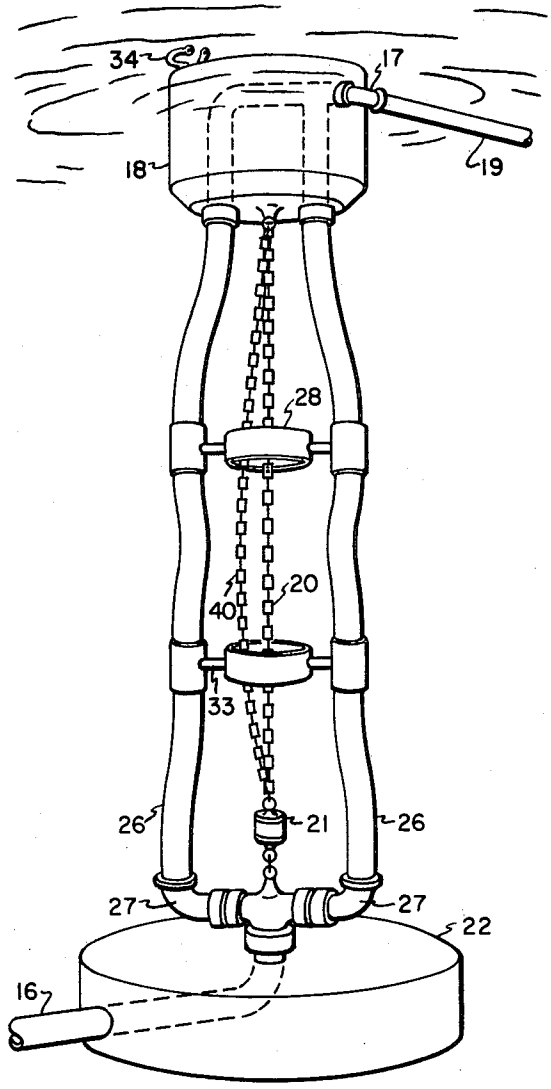

Fig. 7

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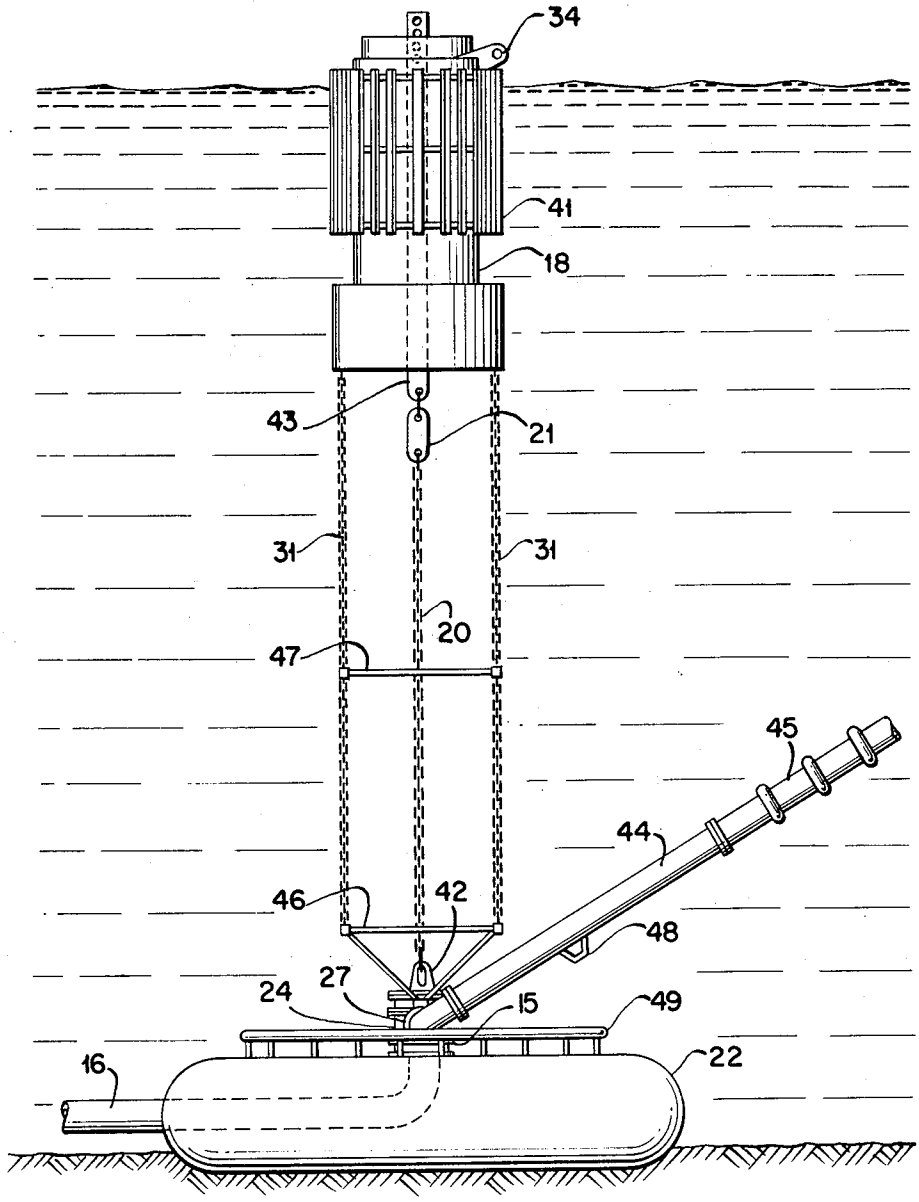
Fig.8.



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SINGLE ANCHOR LEG SINGLE POINT MOORING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of applicant's prior filed copending application, U.S. Ser. No. 856,261, filed Sept. 9, 1969.

FIELD OF THE INVENTION

This invention relates to a single anchor leg single point mooring system for seagoing ships, especially tankers wherein fluid cargo handling facilities are integrated with the mooring system. In a particular embodiment hereof, a single anchor leg connects a mooring buoy and a mooring foundation and a fluid conduit or conduits are provided for transferring fluid cargo between the foundation and the buoy. Means are provided to prevent the fluid conduits from becoming tangled with the anchor leg and other means are provided to permit the mooring buoy to rotate freely in response to the movements of the moored ship. A further embodiment contemplates connecting the fluid transfer conduit or conduits directly between the mooring foundation and the ship.

BACKGROUND OF THE INVENTION

The increasing uses of petroleum and petroleum products throughout the world have brought about a surge in the demand for petroleum. Since there are only a relatively few producing areas relative to the number of areas where petroleum and petroleum products are used, the transportation of petroleum has become increasingly complex as the need for greater amounts of petroleum increases. In order to transport large amounts of petroleum, the so-called supertankers have been developed and built, i.e., tankers of 200,000 to 300,000 dwt with tankers of 500,000 dwt being contemplated. While such tankers are capable of transporting large amounts of petroleum, serious problems have arisen due to the exceptional size of these tankers. For example, these tankers have rather deep drafts and many harbors cannot accommodate them with normal facilities. This is particularly true in producing areas which are located in remote parts of the world. In order to solve this problem, the concept of single point moorings has been developed to moor and load such tankers in deep water outside harbors or relatively far from shore based facilities. In single point mooring systems, the ship is moored, usually by its bow, to a single point, such as a buoy or tower. This mooring method permits the ship to move freely about the mooring point under the influence of wind, waves, and current. At such moorings, it is necessary to provide means for the relief of torsional stresses transmitted to the mooring system by the movement of the ship. It is also necessary to provide means for transferring cargo between the ship and the shore. This invention provides an integrated single point mooring and cargo handling system that obviates the problems of such systems.

SUMMARY OF THE INVENTION

In accordance with this invention, a single anchor leg single point mooring system having integrated cargo handling facilities is provided for seagoing ships, particularly tankers, which comprises a mooring buoy located at or near the surface of the sea, the mooring buoy being held down against its buoyancy by an anchor leg which is maintained in tension and anchored to a mooring foundation fixed at the sea bottom. Means are provided to permit the buoy to rotate freely with respect to the mooring foundation and about a vertical axis passing through the center of the mooring foundation. As an integral part of this single point mooring system, cargo handling facilities for transferring cargo to and from the ship are provided. The cargo handling facilities generally comprise one or more conduits for transferring cargo between the shore and the mooring foundation, one or more conduits for transferring cargo between the mooring foundation and the mooring buoy, and one or more conduits for transferring cargo between the mooring buoy and the ship or alternatively, one or more conduits for directly transferring cargo between the mooring foundation and the ship. Essential to the integration of the cargo handling facilities and the single anchor leg mooring system is a restraint means for preventing the cargo conduits disposed between the mooring foundation and the mooring buoy from twisting around the anchor leg with consequent fouling of the elements of the system.

DRAWING DESCRIPTION

This invention will be more readily understood by reference to the several drawings attached herewith, wherein identical numerals are used to designate identical parts.

FIG. 1 represents a preferred embodiment of this invention and shows an integrated single point mooring and cargo handling system in which the fluid swivel assembly is placed beneath the mooring buoy.

FIG. 2 is an elevation view of this system showing the relation of the various elements.

FIG. 3 is a side view, in greater detail, of the fluid swivel assembly and the connection between anchor leg and mooring buoy.

FIG. 4 is a section looking down upon the detail of FIG. 3.

FIG. 5 is a section looking down upon the restraint means for preventing twisting of the anchor chain and the cargo conduits.

FIG. 6 shows an alternate integrated single point mooring and cargo handling system in which the fluid swivel assembly is placed on the mooring foundation.

FIG. 7 shows another alternate integrated single point mooring and cargo handling system in which the restraining chains are not employed.

FIG. 8 shows a further alternate integrated single point mooring and cargo handling system wherein the cargo transfer conduit(s) is connected between the fluid swivel located on the mooring foundation and the ship.

Turning now to FIG. 1 (and where necessary to its associated drawings FIGS. 2–5), 22 represents a mooring foundation which is anchored to the sea bottom and 16 represents a submerged cargo conduit, either rigid pipe or flexible hose, leading from shore based facilities to the mooring foundation. One end of a flexible anchor chain or cable 20 is attached to the mooring foundation 22 and the other end is connected through a chain swivel 21 to a rigid force transmitting member, or

shaft, 25, firmly attached to the base of mooring buoy 18. Thus, the rotation of the buoy will result in rotation of the shaft in unison therewith. The entire mooring load is thus taken by force transmitting member 25, swivel 21, and anchor chain 20. Ships are moored to mooring buoy 18, generally by attaching bow hawsers to mooring hook 34. The mooring of the ship by bow hawsers to a single mooring buoy 18 permits the ship to swing 360° around a vertical axis through the center of the mooring foundation, thereby minimizing forces on the ship that may be caused by wind, waves, and/or current. In order to prevent twisting of the anchor leg and possible breakage thereof as the ship and mooring buoy rotate, chain swivel 21 is provided which permits rotation of the upper portion of the anchor leg relative to the lower portion of the anchor leg. In this embodiment, the upper portion of the anchor leg is comprised of the rigid force transmitting member 25 which rotates with the buoy, and the lower portion of the anchor leg comprising anchor chain 20, remains fixed, i.e., does not rotate. FIG. 6 discussed hereinbelow, shows an alternate embodiment wherein the force transmitting member 25 is stationary and the anchor chain 20 rotates in unison with the buoy. An alternate arrangement to the use of the anchor chain or cable 20 comprises an articulated pipe loading system. Thus, a solid bar or pipe articulated at one end or both ends thereof if necessary by means of suitable universal joints can be connected between the mooring buoy and the mooring foundation. This arrangement would be desirable in situations where excessive wear in the chain is experienced. The universal joints can be lubricated to reduce wearing effects.

The submerged conduit 16 is connected through conduits in the mooring foundation, shown by dotted lines, to cargo hoses 26. Two cargo hoses are shown but one, or more than two, may be employed as is necessary or desirable in each installation of the system. The hoses 26 extend upwardly to pipe elbows on fluid swivel joints 27. The fluid swivel joints 27 are attached to a fluid swivel housing 24 rotatably mounted on a fluid swivel joint 15 and concentric with force transmitting member 25. The fluid swivel housing 24, the fluid swivel joint 15 and the force transmitting member 25 comprise a fluid swivel assembly 14. This fluid swivel assembly is further detailed in copending U.S. Pat. application Ser. No. 856,259, filed Sept. 9, 1969, which is hereby incorporated herein by reference as it regards a fluid swivel assembly having a concentric force transmitting member through the center of the swivel assembly. Thus, for example, when fluid cargo is being transferred from shore to the ship, it will flow upwardly through hoses 26 through swivel joints 27 and into fluid swivel assembly 14, then through mooring buoy piping, shown as dotted lines in buoy 18, through swivel joint 17 and floating loading hose 19 to the moored tanker.

Restraint means are provided to prevent relative rotation of the cargo hoses 26 with respect to anchor chain 20, thus preventing tangling. As seen in FIGS. 3 and 4, spreader arm 30 is pivotally mounted at pivot points 29 attached to the fluid swivel housing 24. The spreader arm 30 extends outwardly from the pivots and away from the anchor leg. Affixed at the ends of the spreader arm 30 are torsion chains or cables 31 which are connected at their other ends to the mooring foundation 22, the torsion chains being of predetermined length so as to be slack while anchor chain 20 is pretensioned by the mooring load. When spreader arm 30 is rotated about a vertical axis, the torsion chains 31 become tensioned, thus preventing the spreader arm and the fluid swivel housing from rotating excessively with respect to the mooring foundation 22, i.e., while some rotation is allowed the fluid swivel assembly is maintained in a substantially unrotated position with respect to the foundation.

As seen in FIG. 5, additional spreader arms 32 are located at one or more points along the length of the torsion chains between the foundation and the fluid swivel housing, as may be required by the water depth or as may be desirable. These spreader arms 32 extend radially from collars 28 which encircle, but do not in any way restrain the anchor chain 20. The outer end of said spreader arms 32 are connected to the torsion chains 31. The torsion chains 31 are then maintained at these points at a finite distance from the anchor chain 20. Since the installation will be made with the torsion chains having little slack, the intermediately located spreader arms 32 and collar 28 will maintain the torsion chains 31 substantially parallel, i.e., in a substantially fixed spaced relationship, to anchor chain 20. Emanating radially from collars 28 and rigidly attached thereto are other spreader arms 33 which pivotally joint, at their outer ends, with flanges on the loading hoses 26. The pivoted ends of spreader arms 33 allow the hoses to move freely but also maintain a finite distance, i.e., spaced relationship between the hoses 26 and the anchor chain 20. Since both spreader arms 32 and spreader arms 33 are rigidly attached to collars 28 and restrain the rotational movement of chains 31 and hoses 26, there will not be excessive relative rotation between anchor chain 20 and hoses 26. Flotation chambers 36 may be mounted on collar 28, spreader arms 32 or spreader arms 33 to support the weight of these parts and torsion chain 31 and hose 26.

FIG. 6 shows an alternate installation of the single point mooring system described herein. As distinguished from FIG. 1, wherein the buoy 18 and the force transmitting member 25 rotate in unison with respect to the stationary foundation 22 and the remaining substructure, FIG. 6 shows an inverted installation wherein the buoy and substructure rotate in unison with respect to the stationary foundation 22, and the force transmitting member 25 which is rigidly attached to the foundation. Thus, in FIG. 6, the fluid swivel housing 24 is fully rotatable around the force transmitting member 25 rigidly mounted to the foundation 22. As the buoy 18 rotates due to the motion of the ship, the rotational motion will be transmitted through torsion chains 32 and spreader arms 31 to fluid swivel housing 24. Moreover, the upper portion of the anchor leg, i.e., anchor chain 21, will be flexible and will rotate relative to the lower and rigid portion of the anchor leg, i.e., force transmitting member 25.

FIG. 7 shows another alternate installation of the single point mooring system described herein. In this alternate, the torsion chains have been omitted thus providing a simpler but less preferred installation. The fluid swivel housing 24 is fully rotatable about the force transmitting member 25 rigidly mounted to the founda-

tion 22. The buoy 18 is moored to the force transmitting member 25 through anchor chain 20 and chain swivel 21. Flexible fluid conduits 26 connect fluid swivels 27 on the fluid swivel housing 24 rotatably surrounding the force transmitting member 25 with piping in the buoy 18. Spreader arms 33, extending from chain collars 28 surrounding the chain 20, connect at their outer ends to flanges on the flexible fluid conduits 26. These spreader arms maintain the flexible fluid conduits at some distance away from the chain 20 thus preventing the chain from abraiding the conduits.

As the buoy 18 rotates, the flexible fluid conduits 26 will begin to revolve around the chain 20. The conduits are held away from the chain by the spreader arms 33, however, and when the conduits become taut, they will begin to rotate the fluid swivel housing 24. In this alternate system, the flexible fluid conduits 26 thus serve the same function as the torsion chains 31 served in the previously described systems.

In FIG. 7 an auxiliary anchor chain 40 is provided in parallel with the principal anchor chain 20. This chain 40 is attached to the base of the buoy 18 in the same manner as the anchor chain 20 and is attached to the upper eye of chain swivel 21. The auxiliary chain 36 is slightly longer than the principal chain 20 so that in the event the principal chain breaks the load is transferred to the auxiliary chain and the failure is indicated by a change in buoy freeboard. The moored vessel is thus warned and may abandon the mooring.

In FIG. 8, there is shown an alternate arrangement of an integrated single anchor leg single point mooring system having a bottom-mounted loading hose arm. The system includes the mooring foundation 22 anchored at the sea bottom and centrally mounted thereon is the fluid swivel housing 24 with the force transmitting member or load-carrying central shaft 25. The mooring buoy 18, which typically may include conventional fenders 41, is connected through the anchor chain or cable 20 and the chain swivel 21 to an eye 42 formed at the top of the load-carrying shaft 25. During installation, the anchor chain 20 is pretensioned by means of a manually adjustable tension shaft 43 secured to the buoy 18, such that the buoy will be pulled downward, and thus has only a small freeboard in still water. The tanker is moored to the buoy by means of suitable mooring lines (not shown) attached preferably, between the bow of the tanker and the buoy by means of the mooring eye 34 located thereon.

The underwater pipeline or cargo conduit 16 transfers the cargo between shore and the buoy and is connected to the fluid swivel housing 24 in the mooring foundation 22, as shown by the dotted lines in FIG. 8. As in the previously-described embodiments, the fluid swivel housing 24 is mounted on swivel joints 15 to permit continuous rotational movement about the center shaft 25. A cargo transfer hose arm 44 pivotally is mounted to the fluid swivel housing 24 by means of the swivel joints 27. Preferably, two strings of loading hose 45 are connected at the end of the hose arm 44 and rise to the water surface with a gradual slope so that they will float on the water surface at the side of the tanker. The foregoing system also includes a suitable torsion or chain spreader 46 (similar to that disclosed heretofore) pivotally mounted on the fluid swivel housing 24, which is attached to the mooring foundation of the buoy and assures that the fluid swivel housing 24 and the hose arm 44 will rotate with the buoy 18. A further torsion chain spreader 47 which may be like those previously disclosed herein, is provided substantially midway between the extremities of the torsion chains 31 to maintain the torsion chains in continuous spaced relation from the centrally located anchor chain 20. A bumper 48 is provided on the underside of the hose arm 44 to prevent the hose arm from being pivoted downward beyond a certain limit. An annular bumper rail 49 secured to the mooring foundation 22 is disposed such that if the hose arm pivots downward for any reason the bumper 48 will contact the rail 49, thus, preventing the hose arm from contacting the foundation and causing possible hose damage.

From the foregoing description, it can be seen that the anchor leg and tension cables permit the substructure of the system to be pulled away from the vertical axis by the action of the ship pulling away from the buoy. Thus, the principal mooring load in the anchor leg will be axial.

Having now described the invention, of which modifications and variations will be obvious to those skilled in the art, the following claims will point out that which is believed to be the invention herein.

What is claimed is:

1. A single point mooring and cargo handling system for tanker vessels which comprises, in combination:

a mooring foundation anchored to the sea bottom,

a mooring buoy for operably receiving a mooring load and located at or near the surface of the sea, said buoy anchored to said foundation through a single anchor leg and including means for mooring the vessel directly thereto, said mooring buoy coaxially arranged with said mooring foundation;

said single anchor leg axially receiving the entire mooring load and being of a predetermined length such that said buoy is held down against its buoyancy, said single anchor leg comprising a relatively rotatable load-bearing rigid shaft and anchor chain, and an anchor swivel for permitting said relative rotation,

cargo swivel means coaxial with, rotatably mounted around, and in sealed relation with said rigid shaft,

flexible cargo handling means cooperatively associated with said cargo swivel means for transferring cargo between said buoy and said foundation, and

restraint means for preventing excessive rotation of said cargo handling means relative to said single anchor leg.

2. The system of claim 1 wherein said anchor chain is attached to said foundation and said rigid shaft is fixedly secured to said buoy, said anchor swivel operably connected between said rigid shaft and said anchor chain.

3. The system of claim 1 wherein said rigid shaft is fixedly secured to said foundation and said anchor chain is attached to said buoy, said anchor swivel operably connected between said rigid shaft and said anchor chain.

4. A single point mooring and cargo handling system which comprises, in combination:

a mooring foundation anchored to the sea bottom,

a mooring buoy for rotatably receiving a mooring load and located at or near the surface of the sea, said buoy anchored to said foundation through a single anchor leg and including means for mooring the vessel directly thereto, said mooring buoy coaxially arranged with said mooring foundation,

said single anchor leg comprising a load-bearing rigid shaft and anchor chain means,

said load-bearing shaft rigidly attached to said buoy for movement therewith and extending downwardly therefrom,

cargo swivel means rotatably surrounding said shaft in sealed relation therewith and capable of transferring cargo to and from said buoy,

said anchor chain means capable of carrying a mooring load and connecting said shaft and said foundation and comprising means for permitting movement of said shaft with respect to said foundation,

at least one flexible cargo-carrying conduit operably disposed directly between said cargo swivel means and said foundation, and

restraint means for preventing excessive rotation of said flexible conduit relative to said anchor chain means.

5. The system of claim 4 including at least two flexible cargo-carrying conduits arranged on opposite sides of said single anchor leg and disposed directly between said cargo swivel means and said foundation, and of a predetermined length such that said cargo swivel is prevented from excessive rotation with respect to said foundation.

6. The system of claim 5 wherein at least one spreader assembly is disposed about said anchor chain means between said buoy and said foundation, said spreader assembly containing a collar and at least one spreader arm extending outwardly from said collar and attached to said flexible conduits.

7. The system of claim 4 wherein said restraint means comprises at least one spreader arm attached to said cargo swivel means, flexible tension means connecting said spreader arm and said foundation and of a predetermined length such that said cargo swivel means is prevented from excessive rotation with respect to said foundation.

8. The system of claim 7 wherein said spreader arm is pivotally mounted on said cargo swivel means.

9. The system of claim 7 wherein said flexible tension means is interconnected by at least one spreader assembly disposed about said anchor chain means between said buoy and said foundation, said spreader assembly containing a collar, at least one spreader arm extending outwardly from said collar and attached to said flexible tension means, and at least one spreader arm extending outwardly from said collar and attached to said flexible conduit, said spreader assembly providing a spaced relationship between said anchor chain means, said flexible conduit, and said flexible tension means.

10. The system of claim 9 wherein said spreader assembly contains at least one flotation chamber.

11. A single point mooring and cargo handling system which comprises, in combination:

a mooring foundation anchored to the sea bottom,

a mooring buoy for rotatably receiving a mooring load and located at or near the surface of the sea, said buoy anchored to said foundation through a single anchor leg and including means for mooring the vessel directly thereto, said mooring buoy coaxially arranged with said mooring foundation,

said single anchor leg comprising a load-bearing shaft and anchor chain means,

said load-bearing shaft rigidly attached to said foundation and extending upwardly therefrom,

cargo swivel means rotatably surrounding said shaft in sealed relation therewith and capable of transferring cargo to and from said foundation,

said anchor chain means capable of carrying a mooring load and connecting said shaft and said buoy and comprising means for permitting movement of said buoy with respect to said foundation,

at least one flexible cargo-carrying conduit operably disposed directly between said buoy and said cargo swivel means, and

restraint means for preventing excessive rotation of said flexible conduit relative to said anchor chain means.

12. The system of claim 11 including at least two flexible cargo-carrying conduits arranged on opposite sides of said single anchor leg and disposed directly between said cargo swivel means and said foundation, and of a predetermined length such that said cargo swivel is prevented from excessive rotation with respect to said foundation.

13. The system of claim 12 wherein at least one spreader assembly is disposed about said anchor chain means between said buoy and said foundation, said spreader assembly containing a collar and at least one spreader arm extending outwardly from said collar and attached to said flexible conduits.

14. The system of claim 11 wherein said restraint means comprises at least one spreader arm attached to said cargo swivel means, flexible tension means connecting said spreader arm and said buoy and of a predetermined length such that said buoy and said cargo swivel means rotate in unison with respect to said foundation.

15. The system of claim 14 wherein said spreader arm is pivotally mounted on said cargo swivel means.

16. The system of claim 14 wherein said flexible tension means is interconnected by at least one spreader assembly disposed about said anchor chain means between said buoy and said foundation, said spreader assembly containing a collar and at least one spreader arm extending outwardly from said collar and attached to said flexible tension means, and at least one spreader arm extending outwardly from said collar and attached to said flexible conduit.

17. The system of claim 16 wherein said spreader assembly contains at least one flotation chamber.

18. A single point mooring and cargo handling system for a tanker vessel which comprises, in combination:

a mooring foundation anchored to the sea bottom,

a mooring buoy for rotatably receiving a mooring load from a vessel directly moored thereto and located at or near the surface of the sea, said buoy coaxially connected to said foundation through a single anchor leg,

said single anchor leg axially receiving the entire mooring load and being of a predetermined length

such that said buoy is held down against its buoyancy, said single anchor leg comprising a load-bearing rigid shaft, an anchor chain, and an anchor swivel, said shaft fixedly secured to one of said buoy and said foundation,

cargo swivel means coaxial with, rotatably mounted around, and in sealed relation with said rigid shaft, and

cargo handling means operatively associated with said cargo swivel means for transferring cargo to and from said tanker vessel via said foundation and said cargo swivel.

19. The system of claim **18** wherein said rigid shaft is secured to said foundation and said anchor chain is attached to said buoy, said anchor chain swivel operatively connected for permitting relative rotation between said buoy and said rigid shaft.

20. The system of claim **19** wherein said cargo handling means extends directly from said cargo swivel means for connection to said tanker vessel.

21. The system of claim **20** wherein said cargo handling means comprises a lower substantially rigid portion secured to said fluid swivel means and an upper flexible portion secured to the free end of said rigid portion of said cargo handling means.

22. The system of claim **18** further including restraint means comprising at least one spreader arm attached to said cargo swivel means, and flexible tension means connecting said spreader arm and said buoy and of predetermined length such that said buoy and said cargo swivel means rotate in unison relative to said foundation.

23. The system of claim **18** wherein said anchor chain swivel is located adjacent said buoy.

* * * * *