Oct. 26, 1971 J. F. FLORY ET AL 3,614,869

PIVOTED TOWER SINGLE POINT MOORING SYSTEMS

Filed Sept. 9, 1969 2 Sheets-Sheet 1

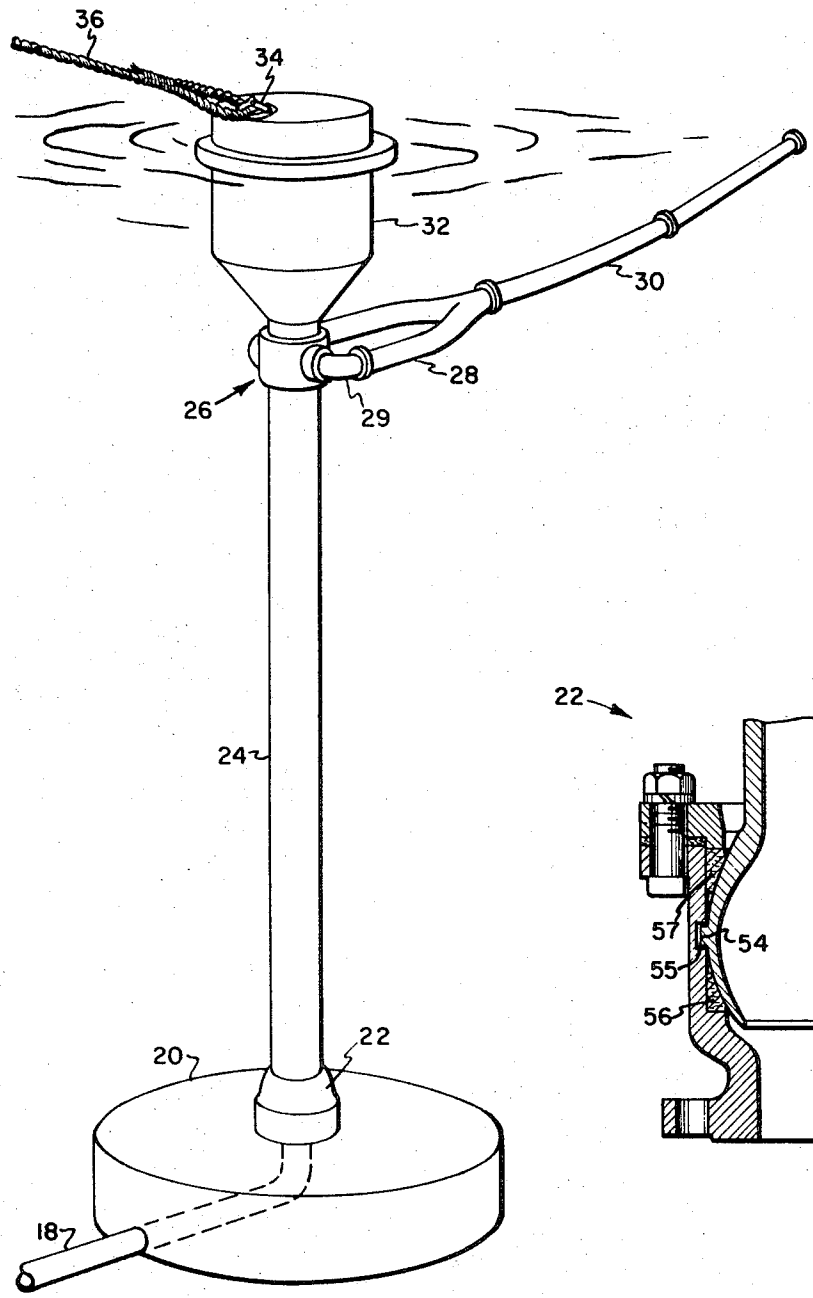


Fig. 1

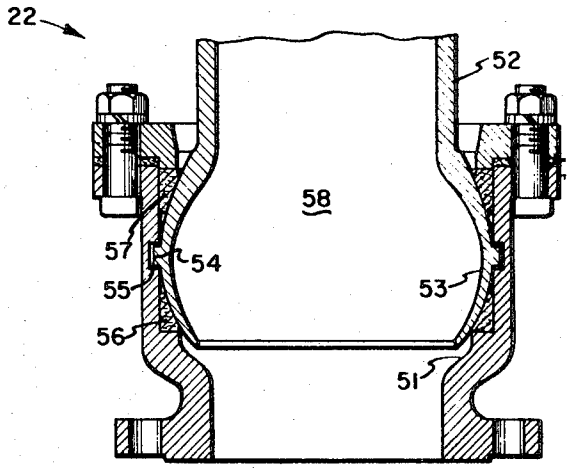


Fig. 4

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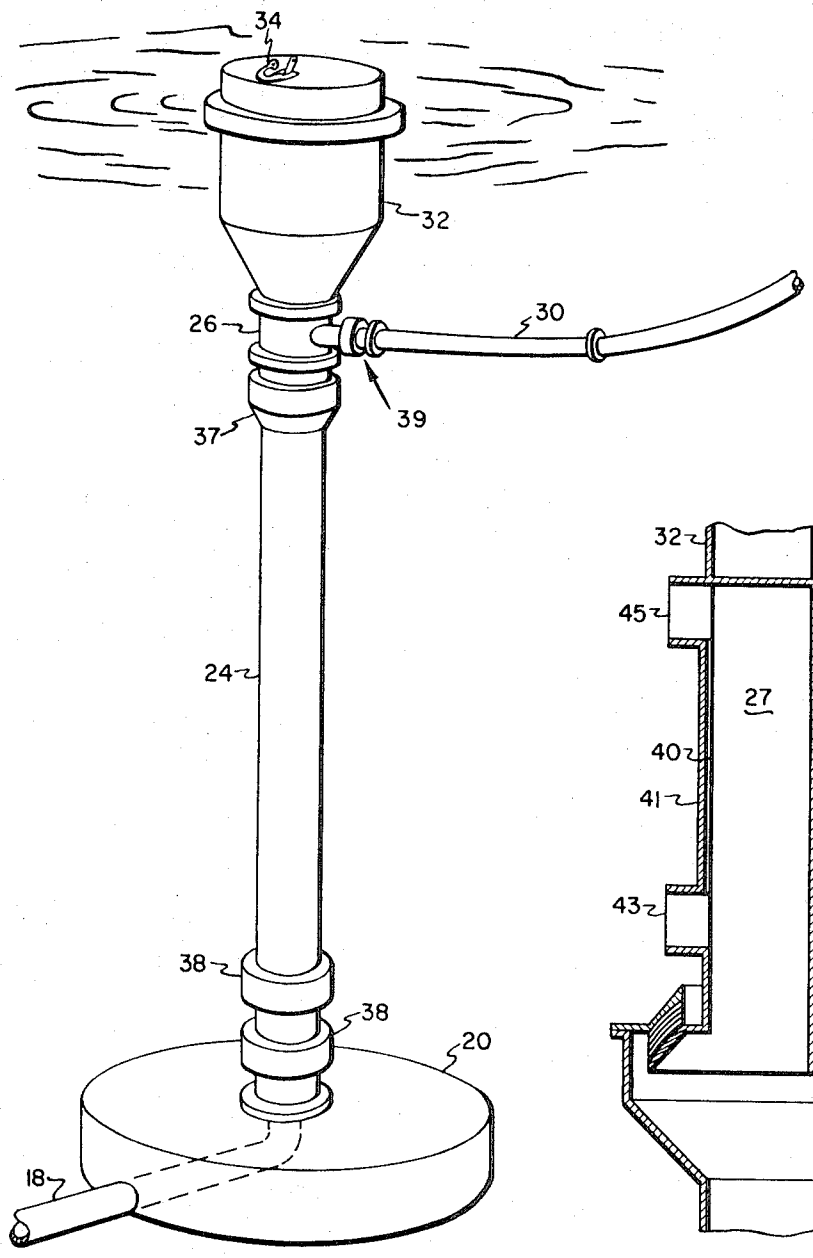


Fig. 2

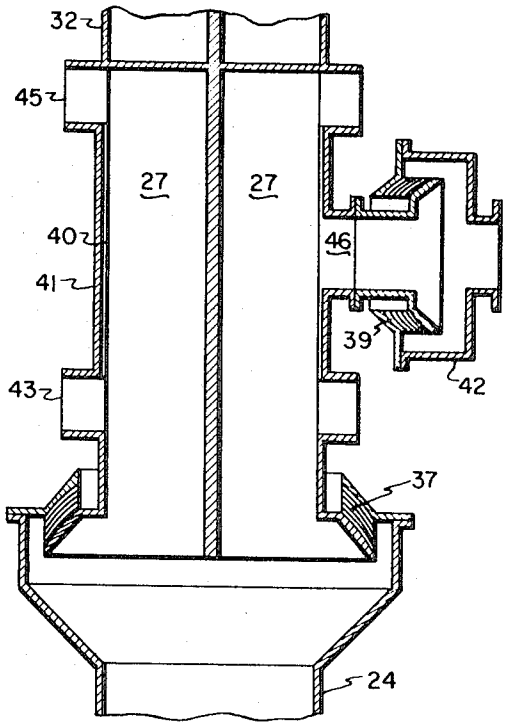


Fig. 3

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PIVOTED TOWER SINGLE POINT MOORING SYSTEMS

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Int. Cl. E02b 17/02; B63b 21/00
U.S. Cl. 61—46 7 Claims

ABSTRACT OF THE DISCLOSURE

A pivoted tower single point mooring and cargo handling system, primarily for tanker vessels, is provided which comprises a buoyancy chamber with attached rigid pipe which is pivotally connected to a mooring foundation, a flexible cargo conduit for conducting cargo from the base of the buoyancy chamber to the vessel, means for conducting cargo from the foundation through the pipe to the base of the buoyancy chamber and swiveling means at the base of the buoyancy chamber for permitting the flexible cargo conduit to rotate with respect to the buoyancy chamber.

FIELD OF THE INVENTION

This invention relates to a single point mooring system for sea going ships, particularly tanker vessels, wherein fluid cargo handling facilities are integrated with the mooring system. More particularly, this invention relates to an integrated mooring and cargo handling facility comprising a buoyancy chamber and anchor leg wherein the anchor leg is a rigid pipe capable of supporting the mooring load and of conducting fluid cargo to a fluid swivel rotatably mounted at the base of the buoyancy chamber.

PRIOR ART

With the advent of exceptionally large tanker ships, i.e., 200,000 d.w.t. and up, the loading and unloading of such ships has become increasingly complex. These ships generally have such deep drafts that natural harbors often cannot accommodates them, and their size is such that mooring forces are quite high. Rather than create new harbors at an exceedingly high cost, it has been suggested to moor such ships in deep water and to transfer the fluid cargo via underwater pipelines to shore based facilities.

When a ship is moored to a single buoy in such a manner that it is free to swing around the buoy, the system is referred to as single point mooring. The ship is usually moored to the buoy by bow hawsers and is free to rotate 360° about the buoy, thereby reducing mooring forces. Provisions must be made to transfer the fluid cargo between the ship and the underwater pipeline as the ship rotates. Previous single point mooring systems have been designed which have a multiplicity of anchor chains and underwater fluid conduits, and which require means for preventing fouling of the one with the other. Other prior art single point mooring systems have been designed which have massive turntables mounted on the deck of a buoy or tower to enable the tanker to swing around the mooring point. By the practice of this invention, however, an integrated single point mooring and cargo handling facility is provided whereby the anchor leg of the mooring system simultaneously serves as the underwater fluid conduit. Additionally, the fluid conduit is connected to a swivel positioned beneath the buoyancy chamber where it is protected from the severe environment at the sea surface.

SUMMARY OF THE INVENTION

In accordance with this invention, a pivoted tower single point mooring system having integrated cargo handling facilities is provided wherein a buoyancy chamber, located at or near the surface of the sea, is anchored to a foundation fixed to the sea bottom through a single anchor leg of predetermined length which holds the buoyancy chamber down against its natural buoyancy force. The anchor leg comprises a rigid conduit or pipe which is capable of conducting cargo, and is capable of carrying a mooring load, means for pivotally connecting the lower end of the rigid pipe to the mooring foundation, and optional means for pivotally connecting the buoyancy chamber to the upper end of the rigid pipe, each of the pivotally connecting means having internal fluid passages. A fluid swivel means surrounds the base of the buoyancy chamber and a flexible fluid conduit communicates between the fluid swivel means and the vessel thus comprising a cargo transfer path between the foundation and the vessel. Additionally, an elastic mooring line is connected through a load carrying swivel to the top of the buoyancy chamber and extends to the bow of the vessel, thus mooring the vessel while permitting it to rotate around the mooring system.

Since the flexible conduit between the vessel and the system is connected underwater, i.e., at the base of the buoy, several distinct advantages are obtained. Previous designs for single point mooring systems have utilized expensive floating loading hoses connected to the top of the buoy through turntable or swivel arrangements on the buoy. Such designs are objectionable in that hose connections near the surface of the sea are subjected to the full force of the waves and are apt to tangle with mooring lines. Furthermore, the splash zone environment at the surface of the sea, is especially severe on mechanical components due to the alternate salt water immersion and drying to which such components are subjected. The practice of this invention eliminates these problems.

DRAWING DESCRIPTION

This invention, in several of its embodiments, will be more easily understood by referring to the attached drawings where identical numerals depict identical components.

FIG. 1 shows a mooring tower comprising a buoyant chamber, an underwater pipe, a foundation, a ball socket joint and a fluid swivel means surrounding the base of the buoyant chamber.

FIG. 2 shows an alternate embodiment wherein spherical elastomer joints are utilized at the connection between the buoyant chamber and the pipe and at the connection between the pipe and the foundation.

FIG. 3 is a detail of the fluid swivel means and the spherical elastomer joint at the base of the buoyant chamber.

FIG. 4 is a detail of the ball socket joint at the base of the pipe.

Referring now to FIG. 1, mooring foundation **20** is anchored to the sea bottom, e.g., by piles, etc., and receives an underwater pipe **18** from shore based facilities. Buoyancy chamber **32** is located at the sea surface and

contains a mooring eye **34** connected to a mooring swivel capable of receiving bow hawsers **36** from a ship, not shown. Disposed between buoyancy chamber **32** and foundation **20** is a rigid pipe **24** capable of supporting a mooring load and of predetermined length such that the buoyancy chamber is generally at or near the surface of the sea.

The pipe **24** is connected to the foundation **20** by a ball socket joint **22** having an internal fluid passage. The ball socket joint, shown in detail in FIG. 4, allows pipe **24** to pivot about axes in the horizontal plane but resists any rotational movement of pipe **24** about a vertical axis much like a universal joint. The ball socket joint is similar (but larger in size) to those ball socket joints now readily available to industry. Essentially, and referring to FIG. 4, the joint consists of a spherical socket **51** into which a cylinder **52** having a ball shaped end **53** is secured. Keys **54** provided on the ball project into keyways **55** in the socket **51** to prevent rotation about a vertical axis. The outer diameter of the ball and the inner diameter of the socket are arranged in sealing relationship by sealing glands **56** and **57**. The underwater pipe **18** communicates with pipe **24** through the passage **58** in ball joint **22** by way of foundation piping shown in dotted lines. By virtue of this pivot connection, the buoyancy chamber **32** and pipe **24** may be pulled off the vertical line through the center of the foundation by the movement of the ship (due to wind, waves, and/or current) such that the buoy may, at certain times, be partially submerged.

At the base of buoyancy chamber **32**, a fluid swivel assembly **26** with an internal load carry member is mounted. This fluid swivel assembly is shown in greater detail in FIG. 3 and will be described later. Pipe yoke **28** is attached through fluid swivels **29** to outlets of the fluid swivel assembly **26** and is joined to loading hose **30**, which transfers cargo between the vessel and the mooring tower. The fluid swivel joints and hose connections are then below the water surface and protected from the wave and splash zone environments. The hose **30** is generally a floating hose which rises to the surface some distance from the mooring tower. As the vessel swings around the buoyancy chamber **32**, i.e. due to the action of wind, waves and/or current, the hose **30** will cause the fluid swivel assembly **26** to rotate with respect to pipe **24** and buoyancy chamber **32**.

FIG. 2 shows an alternate embodiment wherein elastomeric bearings are utilized. Pipe **24** is connected to foundation **20** through one or more elastomeric bearings **38** in place of the ball socket joint. One or more elastomeric bearings **37** are placed at the junction between the buoyancy tank **32** and the pipe **24**. The use of the elastomeric bearings acts as a flexible joint at this point and greatly reduces bending moments on the pipe **24**.

FIG. 3 shows a detail cross section through the base of the buoyancy chamber, the fluid swivel assembly, the elastomeric bearing and the top of the pipe in the system of FIG. 2. A rigid cross shaped load carrying member **40** is disposed between pipe **24** and buoyancy chamber **32** and may be considered as forming part of the base of the buoyancy chamber **32** and is securely mounted to the top of pipe **24**. Thus, the pipe **24** and buoyancy chamber **32** will pivot about the foundation **20** as a single unit. The load carrying member is designed to take both axial and lateral loads and bending moments due to mooring loads applied to the buoyancy chamber. A housing **41** is rotatably mounted around the load carrying member **40** on sealed bearings **43** and **45**. Fluid passages **27** in the load carrying member **40** communicate with port **46** in the side of the housing **41**. Thus, as the loading hose (connected via port **46** to housing **41**) moves with the movement of the vessel, housing **41** will rotate about load carrying member **40**. This fluid swivel assembly is described in greater detail in copending application Ser. No. 856,259, filed Sept. 9, 1969, assigned to the same assignee as that of the present application.

Hose connection flange **42** is coupled with port **38** by elastomeric bearing **39**. The elastomeric bearing **39** provides flexibility at the hose connection point thus relieving stress in the floating loading hose. Load carrying member **40** is connected with the top of the pipe **24** by elastomeric bearing **37**. The elastomeric bearing **37** provides flexibility at the junction between the buoyancy chamber **32** and the pipe **24** thus reducing greatly the moment loads in the pipe and load bearing member. The elastomer bearing **37** could alternately be located between load carrying member **40** and buoyancy chamber **32** or elastomeric bearings could be provided both above and below the load carrying member.

The elastomeric bearings are constructed of alternate hemispherical layers of elastomer, e.g., silicone rubbers, neoprene, or other water resistant rubber, and metal, e.g. steel. The elastomeric layers are either molded or secondarily bonded to the metal spacers to provide an integral structure. When the bearing is deflected to the side the elastomeric material deforms in shear. The joint does not rotate about its axis under torsional load but does bend under moment loads much as a universal joint. A cavity is provided in the joint through which fluid may be conveyed and the joint can withstand relatively high internal and external pressures. Such joints are sold under the trade name Lockseal by the Lockheed Propulsion Co.

Having now described the invention, various modifications of which will be obvious to those skilled in the art, the following claims are made.

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 buoyancy chamber located at or near the surface of the sea,

a rigid pipe, capable of supporting a mooring load and of conducting cargo, disposed between said foundation and said buoyancy chamber,

pivot means connecting said pipe to said foundation and containing a fluid passage in communication with said pipe,

conduit means for conducting fluid between said vessel and said system, and

fluid swivel means disposed between said pipe and said buoyancy chamber and rotatably mounted around the base of said buoyancy chamber, said fluid swivel means being capable of rotating with respect to said buoyancy chamber and being in fluid communication with said pipe and said conduit means.

2. The system of claim **1** wherein flexible pivoting means are provided between said buoyancy chamber and said pipe, said flexible pivot means containing a fluid passage in communication with said pipe.

3. The system of claim **1** wherein flexible pivoting means are provided between said conduit means and said pipe, said flexible pivot means containing a fluid passage in communication with said pipe and said conduit means.

4. The system of claim **1** wherein flexible pivot means are provided between said buoyancy chamber and said fluid swivel means.

5. The system of claim **1** wherein said pivot means connecting said pipe and said foundation is a ball socket joint having an internal fluid passage.

6. The system of claim **1** wherein said pivot means connecting said pipe and said foundation is a flexible spherical bearing comprising alternating layers of elastomeric and metallic materials and having an internal fluid passage.

7. The system of claim **1** wherein undersea conduits are provided for conducting fluid to and from said foundation and means are provided for fluid communication

between said undersea conduits and said fluid passage contained in said pivot means.

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J. KARL BELL, Primary Examiner

U.S. Cl. X.R.

9—8; 114—230