Oct. 31, 1967 R. W. MOWELL ETAL 3,349,816

BOW MOORING

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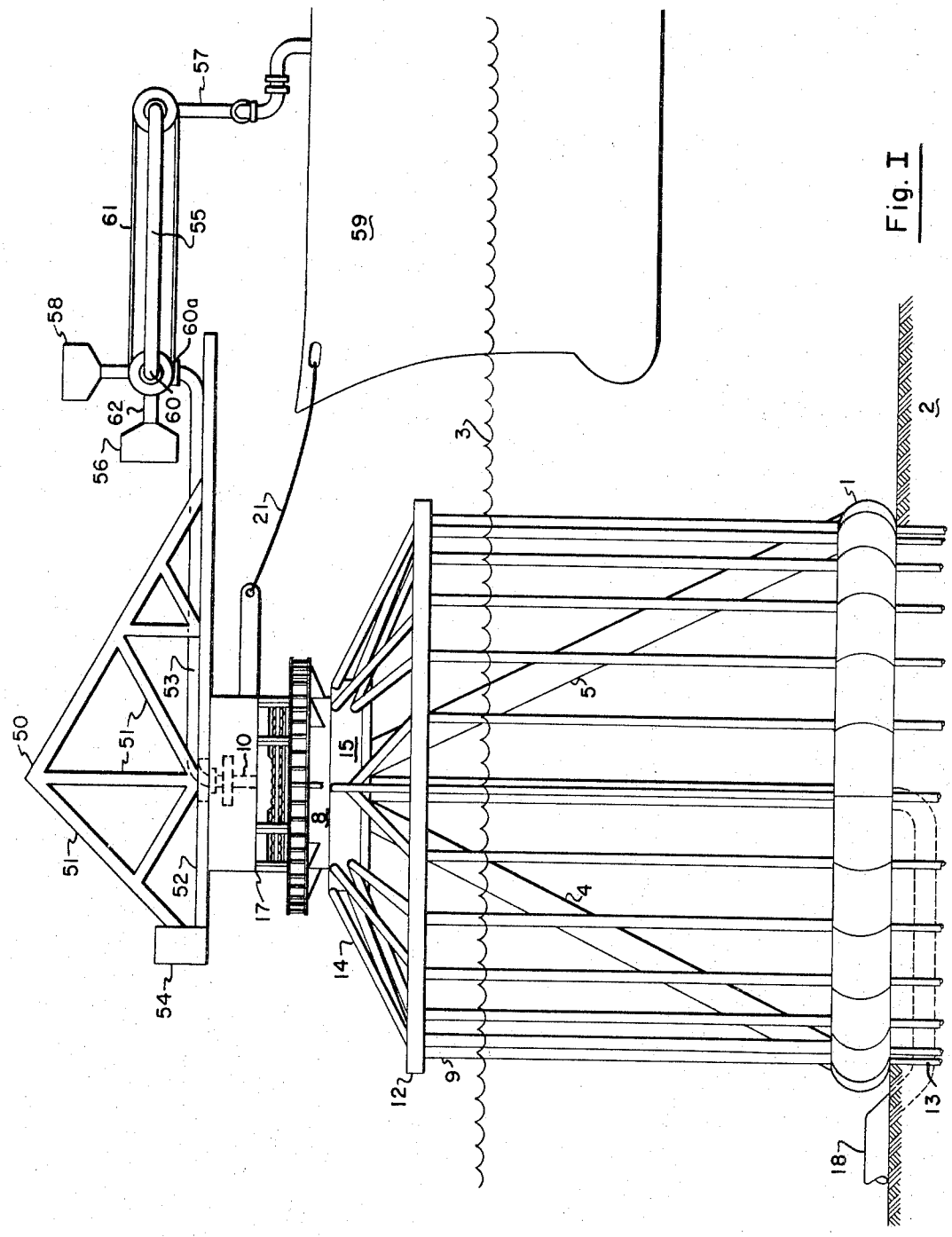


Fig. I

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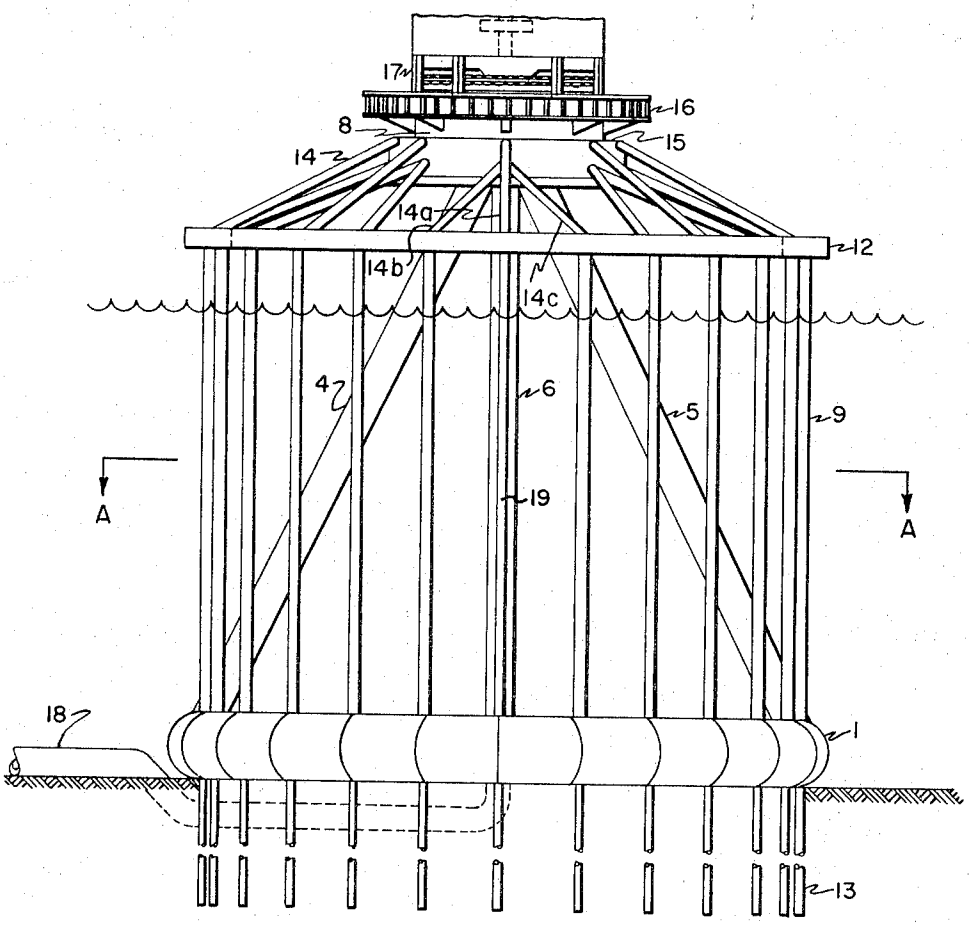
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BOW MOORING

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Fig. II



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BOW MOORING

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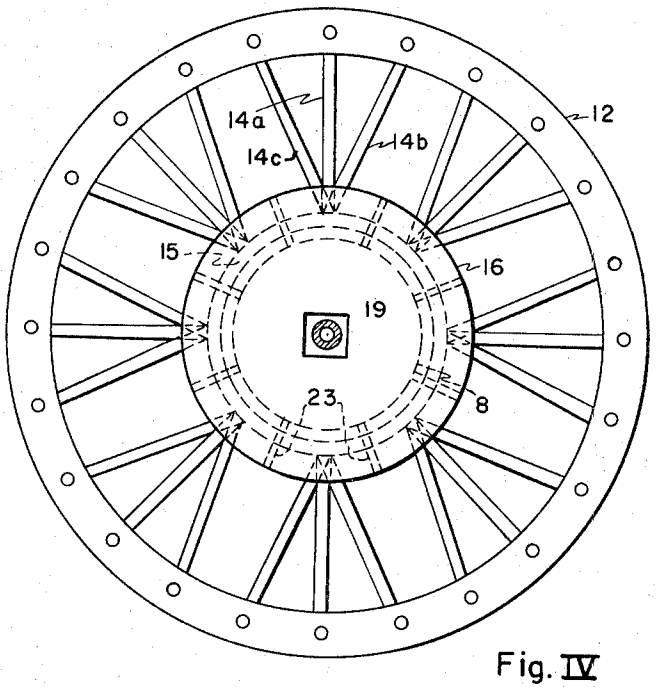


Fig. IV

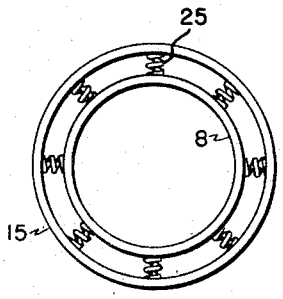


Fig. IV A

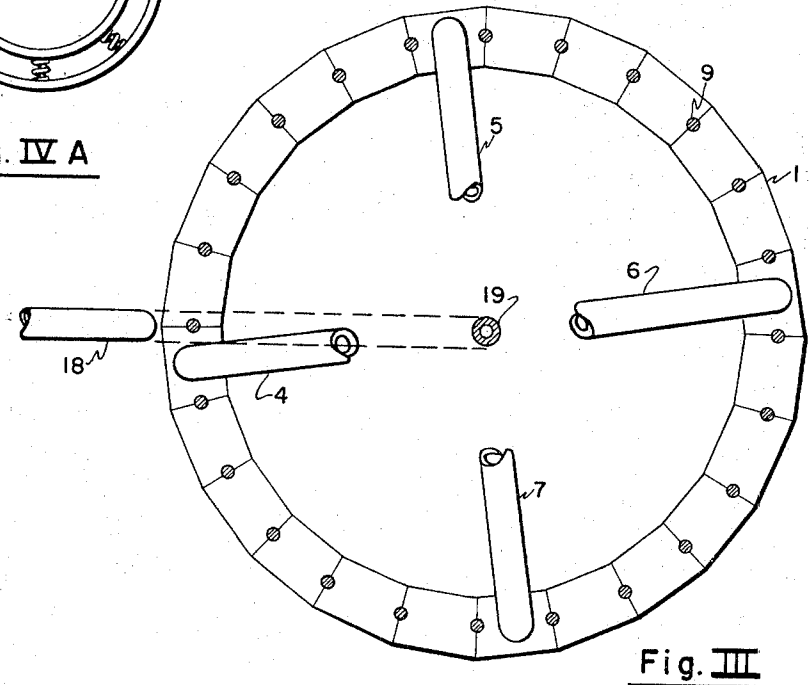


Fig. III

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BOW MOORING

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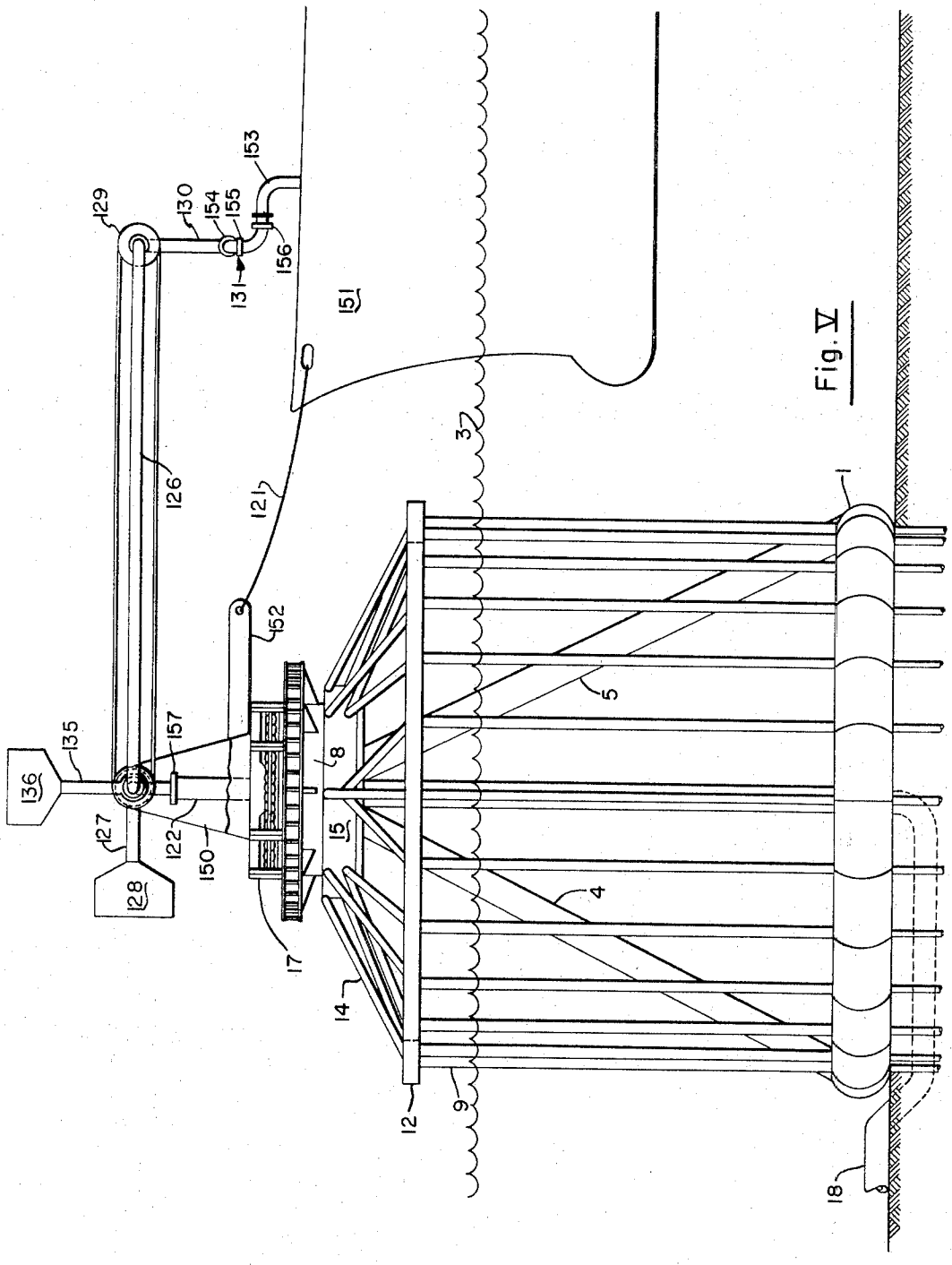


Fig. V

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United States Patent Office 3,349,816 Patented Oct. 31, 1967

3,349,816

BOW MOORING

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Filed Aug. 18, 1965, Ser. No. 483,014
3 Claims. (Cl. 141—387)

This application is a continuation-in-part of applicants' prior copending application Ser. No. 418,646, filed Dec. 16, 1964 and now abandoned.

The present invention is concerned with an improved offshore ship mooring and ship loading structure whereby ships and other vessels can be more efficiently loaded and unloaded, particularly with fluids such as hydrocarbons, gasolines, crude oils, liquefied natural gas, liquefied petroleum gases, such as propane and the like. In accordance with the present invention, a unique structure comprising a caisson or equivalent structure is positioned offshore and utilized in conjunction with a unique type of boom to more effectively moor ships for the purpose of loading and unloading them. The mooring structure of the present invention is particularly adapted to be used in combination with a vessel having the loading manifold at the bow thereof. In accordance with a preferred adaptation, the boom is free to rotate about the structure or caisson as the vessel moves about the structure. A preferred application of the structure is its use for the loading and unloading of tankers, which vessels will be bow moored to the caisson. Thus, liquids such as crude oil, gasoline, liquefied natural gas, etc., are delivered to or unloaded from the ships' tanks by means of conduits, manifolds, etc., irrespective of wind, current and tide conditions. The preferred structure of the present invention comprises, in essence, a substructure used in conjunction with a revolving boom wherein said boom contains at its outboard end suitable means to convey fluids to and from the tanks of the vessel.

The rapid loading of marine equipment, particularly at offshore sites, with liquid products as, for example, hydrocarbons and the like, has always presented a problem due to the continuous shifting of the marine equipment being loaded. This shifting of marine equipment is due to factors such as tidal variations, changes in the ship's draft during the loading-unloading operations and also wave, current and wind action. Thus, there exists the problem of continually adjusting the position of the loading hoses and ancillary equipment to compensate for these continuing and unpredictable changes. Any appreciable change or variation in the relative position of the loading hoses, unless corrected, will cause a severe strain on the tanker connections and, in many instances, cause them or the hoses to break, thereby spewing inflammable oil, creating a hazardous condition and putting the tanker out of operation until repairs are effected. This is a very expensive operation.

Thus, whenever possible the vessels are loaded at onshore sites where the vessel may be more securely moored and protected. However, there are many instances where harbors are not available, particularly in areas of the world where it is desired to load and unload fluids, such as hydrocarbon fluids. Therefore, offshore loading facilities must be provided and attending difficulties overcome.

In the case of tankers at piers, wharves and the like, the manifolds of tankers are connected to the pier piping usually by multiple hoses or flexible arms. In the case of marine anchorages, the tanker manifolds are connected to hoses which are usually attached to submarine lines. The number of hoses is limited by the necessity of laying them out on the ocean bottom so that they are not tangled. The hoses must be long, usually 200 feet or more, and the weight, and hence the diameter is limited by the capacity of the ship's gear. Marine anchorages are generally limited to one or two hose connections of 12" diameter or smaller. Tankers are sometimes moored by the bow with hoses extending from the mooring to the bow. However, few tankers have bow connections. On most other tankers, it is necessary either to lay a hose from the bow to the amidship's manifold connections or use a floating hose alongside the vessel. The latter is subject to adverse wave, wind and current actions.

The present invention, as pointed out heretofore, covers an improved offshort ship mooring and offshore ship loading structure which is characterized in that the ship being loaded or unloaded, as well as the loading boom, will automatically adjust to the composite vector of tide, wind, sea and current as well as compensate for the changing buoyancy of the vessel during the loading or unloading operation. A feature of the present invention is that the arrangement is particularly suitable for the offshore loading of tanker vessels designed to transport liquefied natural gas (LNG) at cryogenic temperature. The cargoes in tankers of this general category are transported in insulated containers and are in the order of —259° F. Loading of such cargoes at cryogenic temperature presents serious structural difficulties as LNG at this temperature will embrittle and render inflexible any conventional form of rubber or flexible hose used for a conduit. Accordingly, mooring and loading devices such as shown in the McCammon U.S. Patent No. 3,093,167 may be unsuitable for the handling of such cargoes in view of the necessity of employing flexible hoses between the end of the loading boom and the moored ship.

In contrast, applicants' novel combination described herein employs a loading arm in combination with a fixed pylon structure to produce a novel combination of ship mooring and loading apparatus which is particularly suitable for, although not limited to, the loading of LNG cargoes at cryogenic temperature to a ship having a loading manifold located at its bow.

These and other objects and advantages of the invention will become apparent and the invention will be fully understood from the following description and drawings in which:

FIGURE I is a side elevation view of one form of the invention positioned on the ocean bottom showing the turntable and the loading boom;

FIGURE II is a fragmentary view of the arrangement of FIGURE I showing the fendering system in detail;

FIGURE III is a sectional view taken along line A—A of FIGURE I;

FIGURE IV shows a top view preferred adaptation of the fendering system;

FIGURE IVA is a detailed view showing an alternate form of fendering system employing dampening means; and

FIGURE V is a side elevation view of an alternate embodiment of the invention.

Referring specifically to FIGURE I, a lower base circular or donut ring 1 is shown positioned on the ocean floor 2 beneath the surface of the water 3. Extending upwardly and inwardly from lower base ring 1 are supporting legs 4 and 5 which extend above the surface of the water and are rigidly affixed at the upper ends thereof to a rigid top platform 8. Two other supporting legs are not illustrated in FIGURE I.

Extending upwardly from the bottom of lower base ring 1 are a plurality of fendering tubes 9. These tubes extend vertically upwardly and are positioned about the periphery of ring 1. These tubes are preferably hollow and are welded to ring 1 or otherwise suitably attached at the top of the ring and at the bottom of the ring.

These tubes extend to a predetermined point above the level of the water and are attached at the upper ends thereof to a circular member, preferably a box or equivalent girder **12**.

In positioning the structure into place, the donut base ring with the fendering rings is placed on the ocean floor. Piling members **13** are preferably driven through each or a selected number of the hollow tubes **9** into the ocean floor. The box girder fendering ring **12** is attached to the upper ends of these fendering tubes **9** and contains inwardly extending radial arms **14** which, in turn, are attached to a flexible or movable top ring **15**. The rigid platform **8** supports a turntable mechanism **17** which supports the loading boom. This turntable is of a conventional design. The turntable also supports mooring lines **21** and auxiliary mooring equipment (not shown) such as winches, power equipment and the like (not shown).

A rotating boom assembly **50** is rigidly affixed to turntable **17**, which assembly may be of a conventional design. The rotating boom **50** has supporting struts **51** designed to give it mechanical strength and a first arm **52** as well as an opposing second arm **53**, both extending horizontally from vertical element **10** which may comprise a supporting strut. A counterweight **54** is positioned at the end of arm **52** so as to stabilize and equalize the weight of the second opposing arm **53** and the equipment mounted thereon.

In essence, the weight of **54** is adjusted so that the moment on one side of the swivel or point of rotation **10** is substantially equivalent to the moment on the diametric other side. It is preferred that arm **52** not overextend ring **12** and that the length of arm **53** substantially overextend ring **12** so as to put the mechanism at the end of arm **53**, preferably over the bow of the vessel being handled. Thus the weight of **54** is generally very substantial in order to secure substantially equivalent moments on both sides of the point **10**.

A double counterweighted loading assembly **61** is positioned at the end of arm **53**. In essence, the loading assembly comprises a loading arm **55** which is substantially counterbalanced by weight **56** and an outer arm **57** which is counterbalanced by counterweight **58**. It is evident that the counterweight **56** also counterbalances arm **57** and the ancillary equipment such as hoses, couplings and the like needed to attach the same to the tanker **59**, when the outer arm **57** is in the vertical position.

Thus the sum of the moments about the swivel assembly **60** is substantially zero, so that the length of arm **62** and the weight of **56** will substantially counterbalance the weight of arm **55** in any position and the weight of arm **57** and ancillary equipment when arm **57** is in a vertical position. A loading arm assembly which is satisfactory for positioning at the end of arm **53** is described in U.S. Patent No. 3,073,343, issued Jan. 15, 1963 entitled "Cargo Loading Apparatus." Inventors: R. W. Mowell et al. As in the case in the aforementioned patent, it will be understood that the loading arm assembly is capable of horizontal rotation about a vertical axis about a lower swivel bearing **60***a*.

Thus, in operation, if a ship to be moored nudges against box girder **12** thereby exerting a forward thrust on the girder, this thrust is resisted by bending fendering tubes **9** and the piling contained therein so as to cause ring **15** to move backwardly until the same makes contact with the rigid platform **8**. While this distance may vary appreciably, it is preferred that the same be from about 1 to 30 feet.

This method of attaching the radial arms from top ring **15** to box girder **12** is more clearly illustrated in FIGURE II wherein similar elements described in FIGURE I are similarly numbered. Referring specifically to FIGURE II, fendering tubes **9** are shown attached to box girder **12**. Box girder **12** is securely attached to top ring **15** by means of radial arms **14***a*, **14***b* and **14***c*, both top

ring **15** and the rigid top platform **8** are positioned below working platform **16**. Working platform **16** is attached to rigid top platform **8**. The working platform **16** is supported by suitable means. A vertical feed line **19** is shown extending from shore line **18**. While only one shore feeding line **18** and one vertical feed line **19** are illustrated, it is to be understood that a plurality of lines may be utilized carrying different fluids, utilizing a special swivel arrangement to allow passage of the separate fluids through the turntable section **17**.

FIGURE III is a vertical view through A—A of FIGURE II. The inclined supporting legs **4**, **5**, **6** and **7** are shown rigidly attached to the lower base ring **1** and the shore feeding line **18** is shown in communication with the vertical feed line **19**. The fendering tubes **9** are shown extending vertically upwardly from the lower base ring **1**.

FIGURE IV illustrates a preferred method of connecting movable ring **15** to girder **12** in order to secure maximum mechanical strength. Strut **14***a* is substantially perpendicular to the respective rings while struts **14***b* and **14***c* are connected diagonally. A plurality of support struts **23** are also employed to brace platform **8** to platform **16**. Referring specifically to FIGURE IVA, a desired modification is shown wherein springs **25** are shown positioned between rigid platform **8** and flexible ring **15**. Thus as girder **14** is pushed inwardly by a vessel, this movement will be resisted by the springs resisting the movement of flexible ring **15**. Thus, as the vessel is being loaded or unloaded it will swing about the periphery of the structure, depending upon wind and wave conditions. As the vessel swings around the substructure, the turntable will rotate along with the structure, thereby eliminating any tension or undesirable thrust on the loading conduits and lines.

In the embodiment of the invention shown in FIGURE V, a vessel such as an LNG tanker **151** is moored to a pylon structure similar to that of FIGURE I by means of a mooring line **121**. Each of the elements of the pylon structure is similar to that of FIGURE I and have been designated with like reference numerals. A preferred adaptation of the embodiment of FIGURE V is to have the outwardly extending arm **152** terminate at a point radially shorter than the periphery of the fendering ring **12**. Unlike the previous embodiment described, the embodiment of FIGURE V has its counterweighted loading arm mounted directly on top of the platform **17** with the axis of rotation of the loading arm coincident with the axis of rotation of the turntable **17**. The loading arm includes an inner boom **126** connected through swivel **129** to the upper end of an outer arm **130**. The outer boom **130** is shown in a substantially vertical position and is connected at its lower end to a fixed bow manifold **153** mounted on the vessel **151**. The lower elbow structure shown generally at **131** includes swivel flanges **154**, **155** and **156** to allow respectively for pitching, yawing and rolling movement of the vessel.

A counterweight **128**, acting through a boom arm **127** along with a second counterweight **136** and its associated arm **135** act in the aforesaid described fashion to keep the inner boom **126** and outer boom **130** in substantially static equilibrium irrespective of their relative orientations with respect to gravity. An upstanding portion **122** of the shore line **18** and vertical feed line **19** is connected to the boom **126** conduit through a suitable swivel connection **157**. In this embodiment of the invention, it should be noted that by virtue of the mounting of the loading arm assembly with its pivotal axis coincident with the axis of rotation of the turntable **17** that it is free to swing with the vessel **151** in simplified fashion as the ship weathervanes about the pylon structure.

While in the preferred application of the present invention the cargo conduits **18**, **19** and those running through the inner-outer booms of the loading arm will preferably be insulated to maintain the LNG at a low temperature,

those skilled in the art will readily appreciate that the invention may be used to equal advantage in the bow loading of cargos of more conventional character. However, an important feature of applicants' novel combination is that it permits the loading of LNG cargos at cryogenic temperature to a fixed manifold located at the bow of a vessel directly from an offshore mooring without the need for passing any of the LNG cargo through a flexible hose connection. This is accomplished by the fact that all of the movable connections of applicants' arrangement are of metallic construction not relying upon the flexibility of a length of hose for providing pivotal freedom.

While specific embodiments of the invention have been shown and described in detail, to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In combination, a ship and mooring structure for transferring a liquid cargo at cryogenic temperature to and from said ship; said ship having a rigid manifold connection attached to its foredeck and being free to rotate about said mooring structure without the passage of the liquid through flexible hoses; and a mooring structure, said mooring structure including a lower base donut ring adapted to be positioned on the ocean floor, supporting legs affixed to said donut ring and extending upwardly and inwardly from said donut ring to a point above the surface of the water, a top rigid platform supported above the water by said supporting legs, fendering tubes extending upwardly from said donut ring and positioned about the periphery of said donut ring to a point above the surface of the water, a fendering ring rigidly attached at the upper ends of said fendering tubes, a top ring positioned within and above said fendering ring and rigidly attached to said fendering ring by means of structural members, said top ring being positioned about said rigid top platform, a turntable mechanism positioned on said rigid top platform and adapted to rotate with respect thereto, a first arm extending horizontally outwardly from said turntable mechanism, a second arm extending outwardly from said turntable mechanism and diametrically mounted with respect to said first arm, a loading mechanism positioned on the outboard end of said second arm and pivotally supported for horizontal rotation with respect thereto, a first counterweight positioned on the outboard end of said first

arm, the weight of which is to produce substantially equivalent moments of said first arm and of said second arm and loading mechanism; said loading mechanisms including an inner rigid conduit pivotally connected through a swivel coupling to a support base, an outer rigid conduit pivotally connected through a swived coupling at one end to the inner conduit and at its opposite end arranged to be directly fastened to the rigid manifold on said ship, insulating means about said inner rigid conduit, and said outer rigid conduit, a second counterbalancing means to substantially counterbalance the inner conduit and, a third counterbalancing means being mounted for rotation relative to the outer conduit and rotatable in response to the movement of the outer conduit from a vertical position to change its movement arm in a direction and an amount to substantially counterbalance the outer conduit as it moves from said vertical position whereby said cryogenic liquid cargo may be transferred to and from said ship exclusively through insulated rigid conduits.

2. Structure as defined by claim 1 wherein said first arm terminates inwardly of said fendering ring and wherein the length of said second arm overextends said fendering ring.

3. Structure as defined by claim 2 wherein said turntable contains means terminating inwardly of said fendering ring and adapted to receive a mooring line from the bow of said vessel.

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