Sept. 20, 1971 G. W. MORGAN 3,605,668

UNDERWATER RISER AND SHIP CONNECTION

Filed July 2, 1969 5 Sheets-Sheet 1

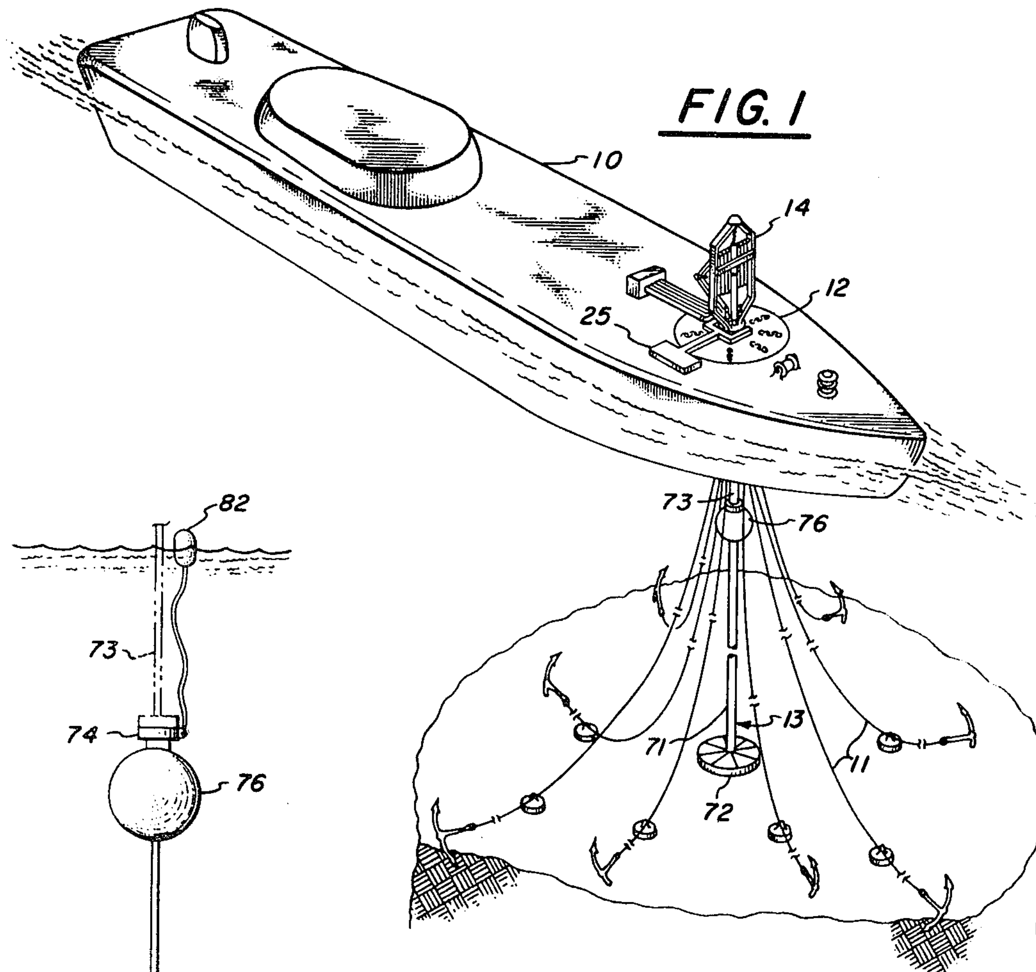

FIG. 1

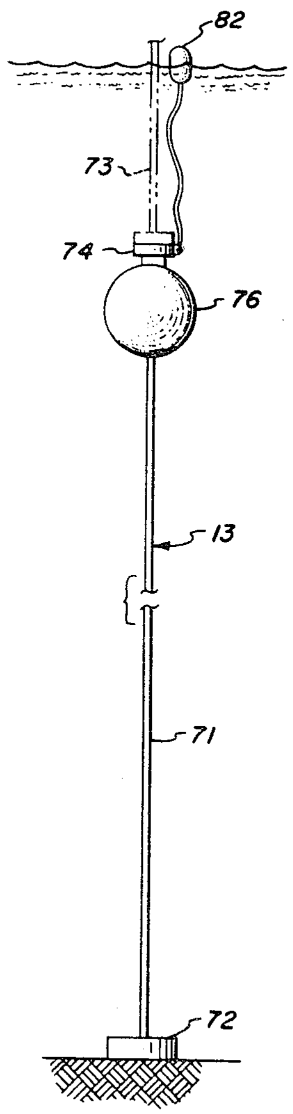

FIG. 7

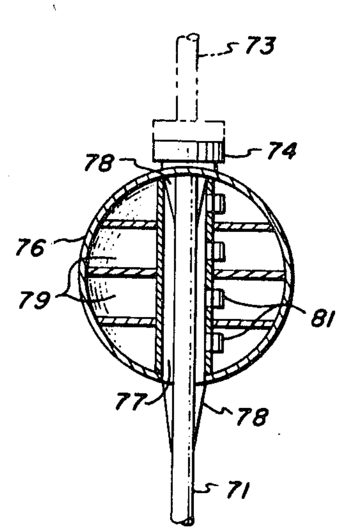

FIG. 8

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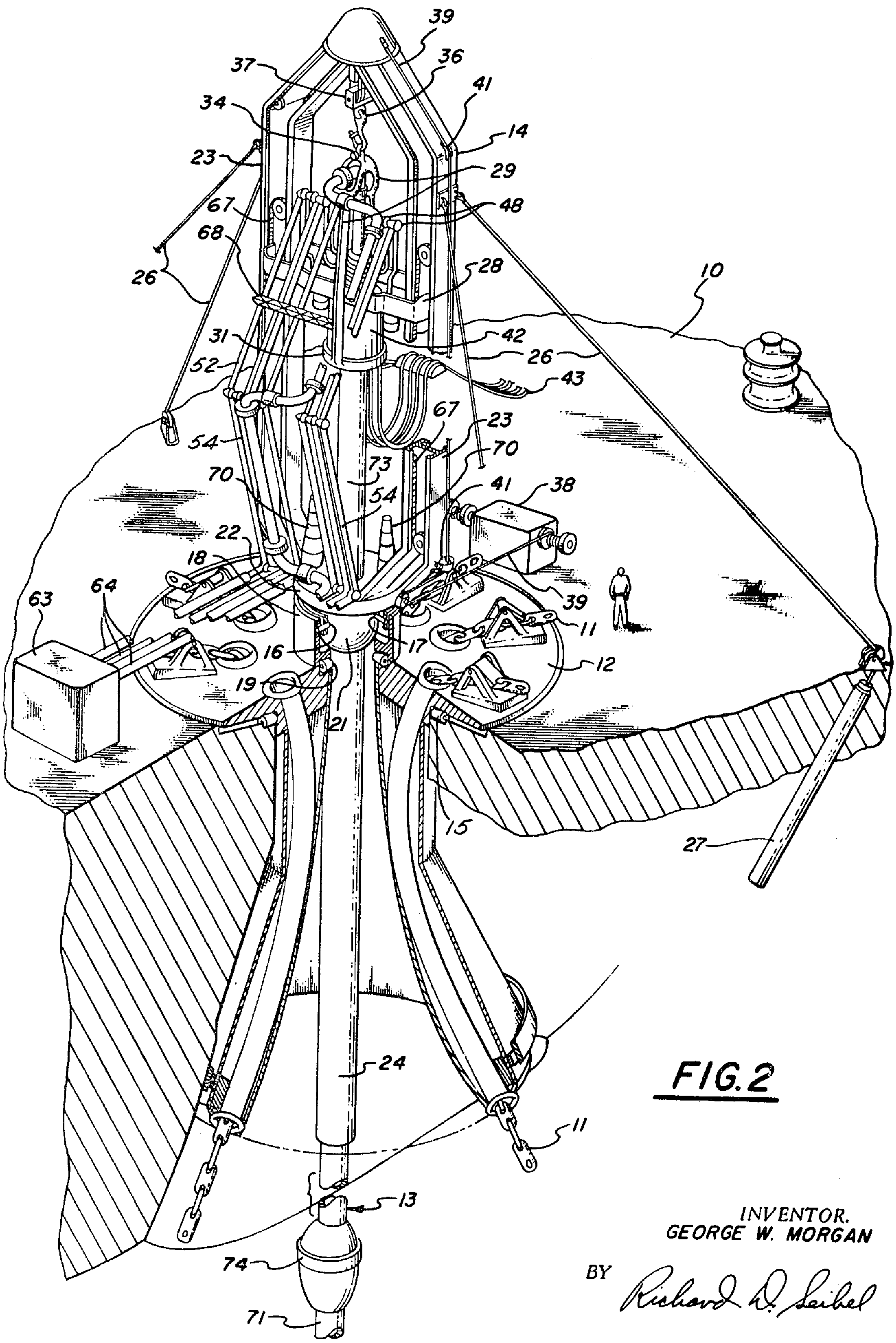

FIG. 2

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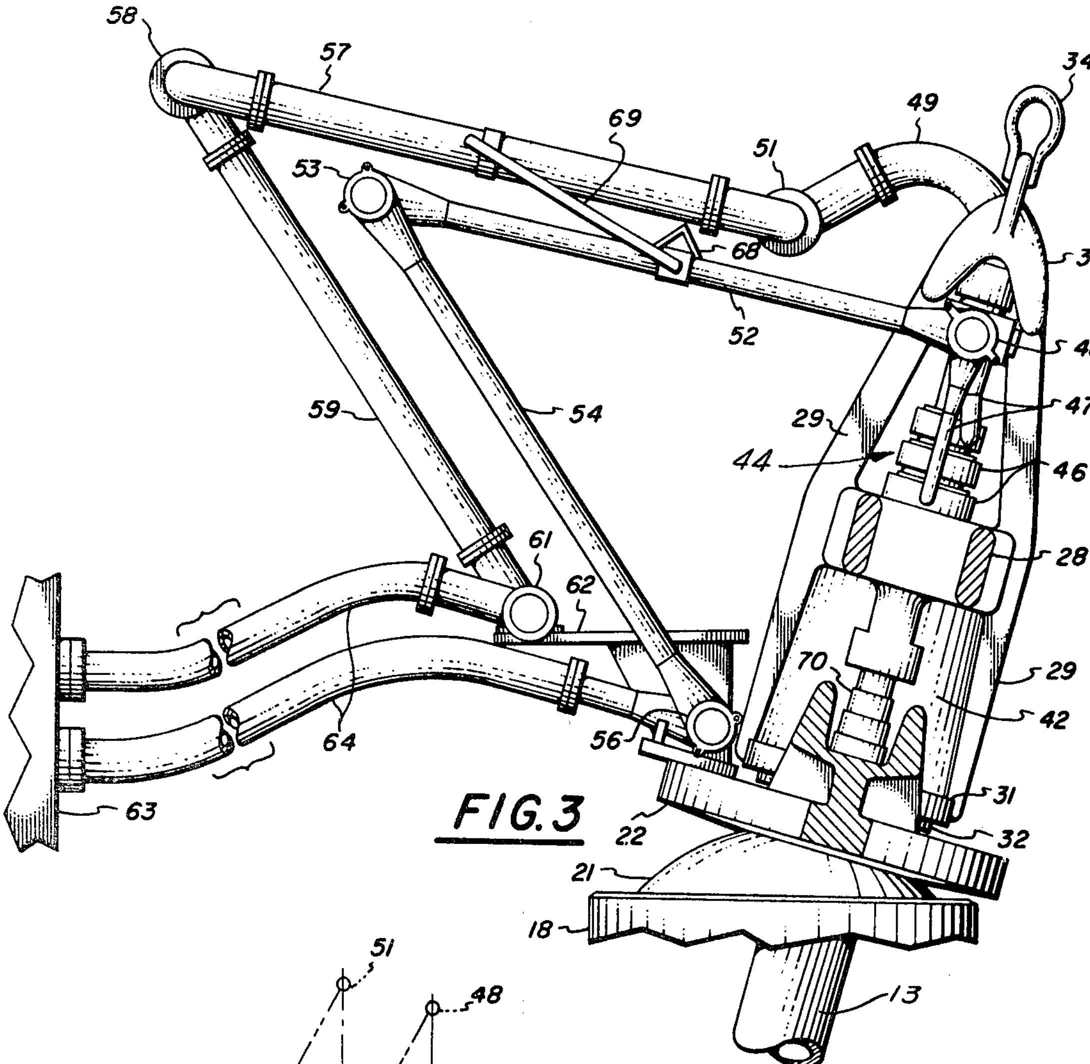

FIG. 3

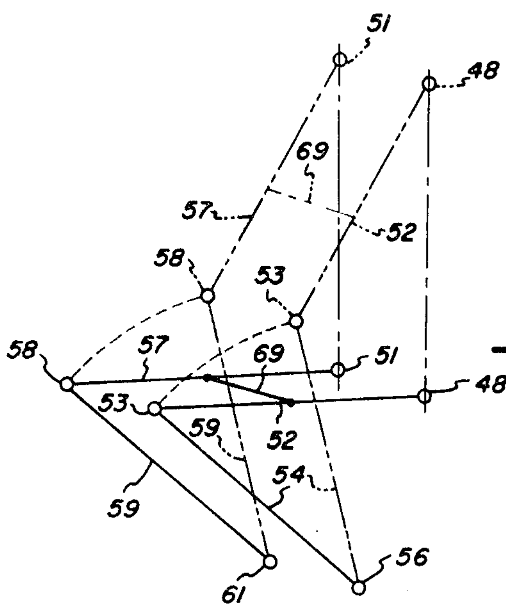

FIG. 6

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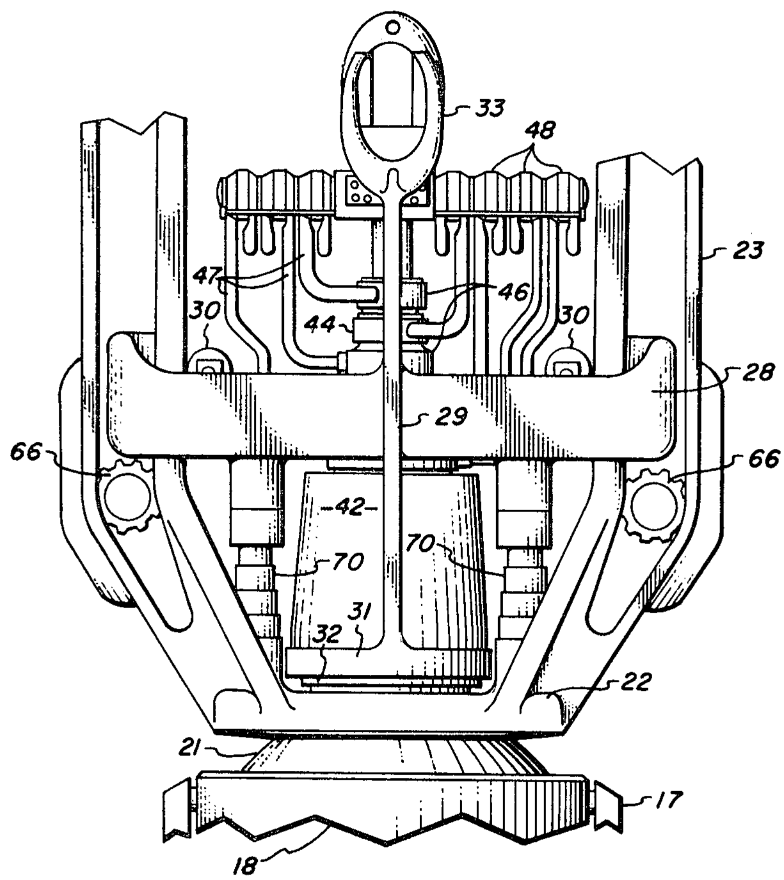

FIG. 4

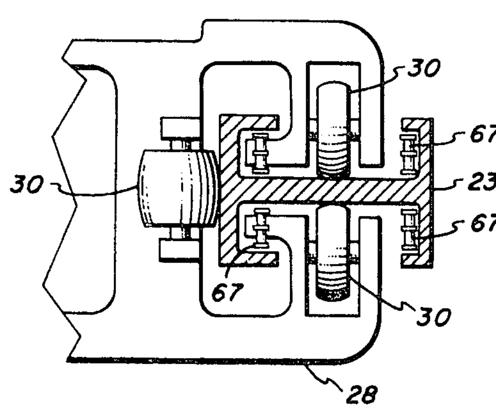

FIG. 5

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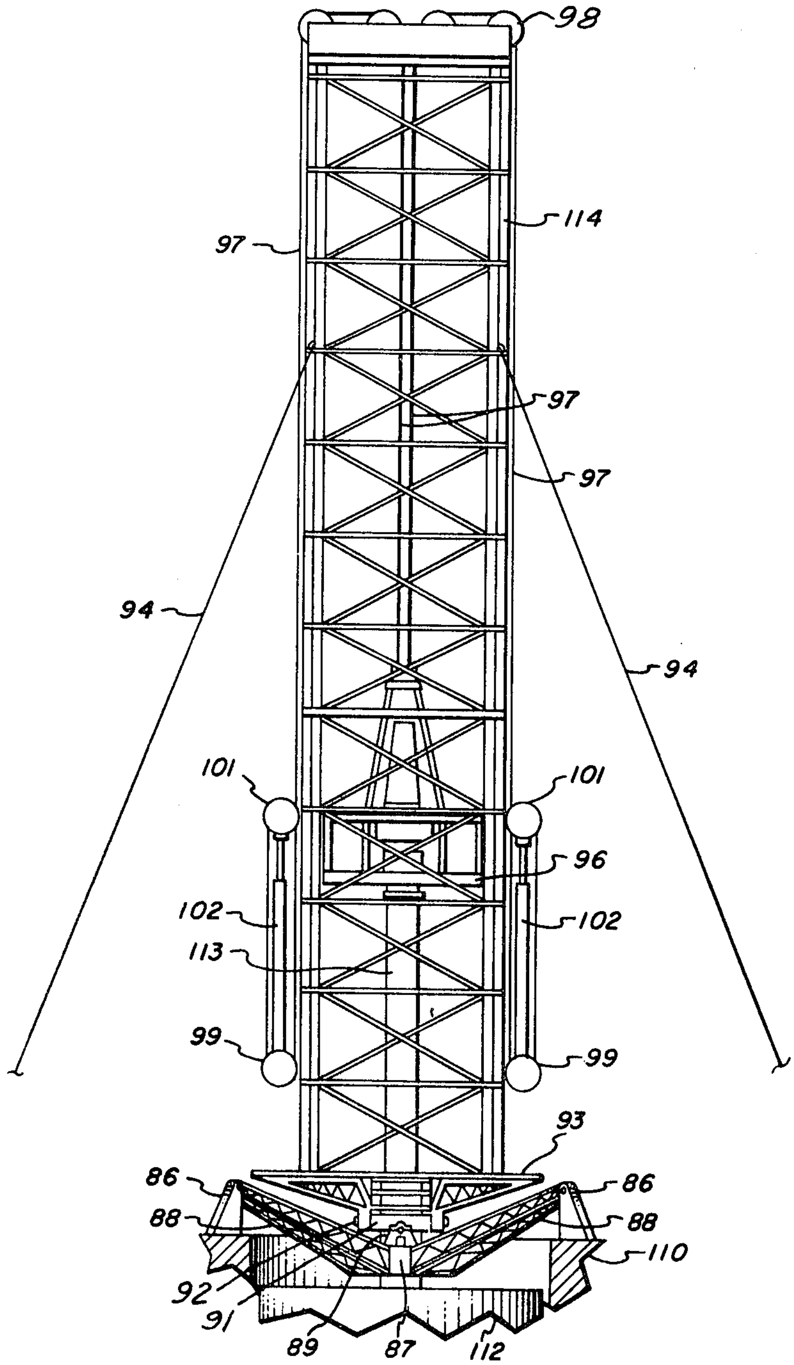

FIG. 9

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UNDERWATER RISER AND SHIP CONNECTION

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Filed July 2, 1969, Ser. No. 838,489
Int. Cl. B63b *35/00;* E21b *43/01*
U.S. Cl. 114—.5 14 Claims

ABSTRACT OF THE DISCLOSURE

A connection between a relatively rigid underwater riser and the deck of a ship is described. A tiltable tower on the ship accommodates ship motion while maintaining a tension in the riser. A buoyant body below the ship also applies tension to the riser. Articulated piping having rigid sections and swivel joints between the end of the riser and the lower base, accommodates heave of the ship relative to the riser and flexible piping between the tower base and the ship accommodates pitch and roll of the ship relative to the riser.

BACKGROUND

In the offshore production of oil and other subaqueous minerals there is a practical depth limitation for bottom mounted structures or towers that extend above the surface. This practical limit is in the order of about 600 feet and economic considerations may limit the utility of platforms to even shallower depths. An alternative to fixed platforms is to provide a portion of the production facilities on the sea floor and provide a moored floating facility for the balance. When this is done a substantially vertically extending conduit or riser must be provided between the sea floor and the floating facility. In relatively shallow depths and calm waters many of the problems of interconnecting a floating facility and the sea floor have been solved. Thus, for example, a flexible hose may be provided between the ship and the bottom. However, when the depths become great the stresses involved are too large for a conventional flexible hose and relatively rigid pipes are employed. In such a system the stresses between a moored ship and a relatively rigid riser become significant due to roll, pitch, heave and surge of the ship relative to the relatively fixed riser.

SUMMARY OF THE INVENTION

Thus there is provided in practice of this invention a fluid carrying riser having its upper end connected to the ship by way of a tiltable tower and articulated piping between the upper end of the riser and the deck of the ship.

DRAWINGS

Objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 illustrates a ship and riser system incorporating principles of this invention;

FIG. 2 illustrates in perspective cutaway a portion of the ship and underwater riser with a tower for accommodating pitch, roll, heave and surge of the ship;

FIG. 3 illustrates connections at the upper end of the riser and articulated piping;

FIG. 4 is a view of the upper end of the riser orthogonal to FIG. 3;

FIG. 5 illustrates a mounting of a riser drawbar on the tower;

FIG. 6 shows schematically the motions of the articulated piping;

FIG. 7 illustrates the riser;

FIG. 8 is a sectional view of a buoy in the riser; and

FIG. 9 illustrates an alternative tower and mounting therefor.

Throughout the drawings like reference numerals refer to like parts.

DESCRIPTION

This invention relates to aspects of an interconnection between an underwater riser and a floating ship. Other aspects of the interconnection between the riser and ship are described, illustrated and claimed in copending patent applications, Ser. No. 729,286 and now Pat. No. 3,496,898 entitled, "Marine Riser Structure" by George W. Morgan; Ser. No. 838,435 entitled, "Permanent Ship Mooring System" by Bruno R. Naczkowski; Ser. No. 838,513 entitled, "Riser Support Structure" by John M. Des Lierres; and Ser. No. 838,434 entitled "Oil Production Vessel" by George W. Morgan and Bruno R. Naczkowski, the contents of which are hereby incorporated by reference for full force and effect as if set forth in full herein.

The general relation of a ship and its parts and a riser incorporating the principles of this invention are illustrated in FIG. 1. As illustrated in this embodiment a ship **10** is moored to the ocean floor by a plurality of anchor chains **11** each of which is connected to a mooring plug **12** extending vertically through the ship. The mooring plug is mounted on bearings so that the ship may rotate relative to the mooring plug which is substantially fixed in position relative to the ocean floor. Additional detailed description of the mooring plug and anchoring system are contained in the aforementioned co-pending patent applications, particularly "Permanent Ship Mooring System." A vertically extending riser **13** passes upwardly from the ocean floor through a central aperture in the mooring plug **12** and is connected to a tower **14** above the deck of the ship.

As is seen in greater detail in FIG. 2, the tower **14** is mounted on a pair of orthogonal gimbals **16** and **17** so that the tower can tilt relative to the ship and remain aligned with the riser **13** during pitch and roll of the ship or displacement (surge) of the ship laterally from a position directly over the base of the riser. The size of the structures can be envisioned from the figure of a man on the deck of the ship.

The outer gimbal ring **18** upon which the tower **14** is supported is mounted on the mooring plug on a bearing **19** so that the tower **14** can remain fixed in position relative to the ship as the ship rotates about the essentially fixed mooring swivel. That is, the tower rotates with the ship about an axis through the mooring swivel, but is free to pivot or tilt as hereinafter described. A spherical structural member **21** is mounted in the inner gimbal **17** and a tower base **22** is fixed to the spherical member **21**. A pair of side rails **23** forming the principal structural members of the tower are mounted on the tower base **22** and extend upwardly therefrom. A guide tube **24** extends downwardly from the spherical member **21** surrounding the periphery of the riser **13** to provide stiffening thereof and reduce stresses on the riser as the ship pitches and rolls relative to the riser. Additional details of a guide tube are found in aforementioned copending application entitled, "Riser Support Structure."

As the ship pitches and rolls with the riser remaining in a substantially vertical position, the tower **14** and guide tube **24**, which are both connected to the spherical member **21**, tilt relative to the ship about fifteen degrees about the gimbals **16** and **17**. The extent of tilt of the tower is limited by four guy cables **26** each of which is connected to a conventional damper **27** which has a limited travel, the dampers **27** being mounted in the ship near its edges for greatest stability. In normal operations the angular position of the tower relative to the deck of the ship follows that of the upper end of the riser and therefore the dampers **27** serve to limit the angular excursions that the tower can follow and also serve to inhibit rapid or oscillatory motions. Each of the dampers can be fixed in position if desired to prevent tilt of the tower. This is employed, for example, when the ship is carrying an upper section of riser, disconnected from the lower section, for example, when traveling to and from the production site.

If desired a two axis accelerometer (not shown) can be installed at the top of the tower to sense tilting motions. The signals from the accelerometer can then be used to drive servo-motors on the damping cables **26** to minimize bending stresses in the riser by limiting the maximum permissible acceleration. Stresses are imposed on the riser in tilting the tower against the restraining force of the dampers, friction of various joints, flexing of hoses hereinafter described, and in dynamic situations due to inertia of the heavy tower.

The guy cables **26** serve to restrain the tower in a substantially vertical position and to some extent prevent twisting of the tower relative to the ship. If desired, other structural connections may be provided between the tower base and the ship to prevent substantial twisting, such as rigid links or oppositely reacting cables interconnecting the tower and the ship. A particularly suitable technique is to provide a wishbone like or forked structure **25** (shown in FIG. 1 and deleted from the other drawings for purposes of clarity) having the open end pivotally connected to the outer gimbal ring **18** and the single leg pivotally connected to the ship. Such a structure readily accommodates the various degrees of tilt of the tower without permitting twist of the tower about a vertical axis relative to the ship. It will be apparent that cable connections can also be provided on the outer gimbal **18** to accommodate tower tilt without permitting tower rotation.

In addition to pitch and roll of the ship it may heave with wave action or the tides or it may drift or surge a short distance off the position directly over the base of the riser, either of which may cause the height of the end of the riser above the deck of the ship to change. Means are therefore provided for moving the upper end of the riser vertically along the side rails **23** of the tower to accommodate the heave of the ship. A cage-like drawbar **28** is mounted with end portions fitted within the opposite sides between the flanges of the I-beam shaped side rails **23** of the tower. The draw bar **28** and other aspects of the upper portion of the swivel are also illustrated in the sectional view of FIG. 3 wherein the side rail **23** of the tower is cut away to show the structure therebehind and the side view of FIG. 4 wherein piping is deleted for clarity. As illustrated in FIG. 3 the tower and hence, tower base **22**, are tilted relative to the outer gimbal ring **18**, and the draw bar **28** and structure connected thereto is at its lowermost extent on the tower to show flexing of the articulated fluid connections.

Bearing wheels **30**, seen in the partial section view of FIG. 5, on the ends of the drawbar **28** engage the web and flanges of side rails **23** of the tower to permit vertical motion of the draw bar along the length of the tower. The bearing wheels **30** prevent lateral motion of the drawbar relative to the sides of the tower and transfer lateral loads between the riser and the side rails of the tower. Roller chain sprockets **66** (FIGS. 2 and 4) are mounted within each open side of each of the I-beam shaped side rails **23** and an endless roller chain **67** is provided between each of the four sets of sprockets **66**. Each roller chain **67** is connected to the drawbar at a single point so that vertical motion of the drawbar along the side rails moves the chain which causes the sprocket **66** to rotate. The sprockets on opposite side rails of the tower are interlocked so that the drawbar is constrained to move along the length of the tower without cocking. In addition, the sprockets are connected to impellers (not shown) of a conventional hydraulic damping system which circulates hydraulic fluid to damp out small amplitude and oscillatory vertical motions of the drawbar relative to the tower. The drawbar **28** is rigidly connected to a pair of vertical structural bars **29** are each connected to a ring **31** the drawbar on each side thereof. At their lower ends the vertical structural bars **29** are each connected to a ring **31** which supports the upper end of the riser by means of a conventional swivel bearing **32**. The upper ends of the structural members **29** are connected by way of an open cage **33** to a clevis **34**. The clevis is in turn supported by a hook **36** supported by a cable block **37** (FIG. 2).

In operation a tension is applied to the upper end of the riser to support at least a portion of the weight thereof. The tension load on the upper end of the riser is maintained constant by a conventional constant tension winch **38** on the deck of the ship. A pair of cables **39** extend from the winch **38** to the tower base and thence up along the side rails **23** of the tower by way of a series of pulleys **41**. The tension cables **39** are led through the pulley block **37** as many times as desired, to obtain a given mechanical advantage. Thus by way of the constant tension winch **38**, cables **39**, block **37**, hook **36**, clevis **34**, cage **33**, vertical structural members **29**, ring **31**, and bearing **32**, seriatim, a constant tension load is applied to the upper end of the riser **13**. The nature of a constant tension winch is to apply a constant tension to the cable wound thereon irrespective of the cable position. Thus as the ship may rise or fall, for example, and the upper end of the riser remains in a substantially fixed position, the drawbar **28** will ride up and down the side rails of the tower and more or less cable **39** is paid out or withdrawn as required, by the constant tension winch **38**. With this arrangement a constant tension is applied to the upper end of the riser throughout the extent of any excursion of the riser end along the length of the tower. If desired, a conventional dynamic compensator (not shown) can be inserted in the cable **39** between the block **37** and winch **39** to accommodate shock loads.

In a typical arrangement the underwater riser comprises a plurality of fluid conduits extending along the length of the riser for communicating fluids and a plurality of electrical conductors along the length for carrying power and electrical signals. A typical riser useful in practice of this invention is described in copending U.S. patent application Ser. No. 721,014 entitled, "Mmultiple Conduit Underwater Line" by George W. Morgan.

As pointed out hereinabove the tower **14** rotates with the ship about the mooring plug **12** and riser **13**, and the substantially fixed upper end of the riser is connected to the tower by way of a swivel bearing **32**. In addition to this mechanical connection, electrical and fluid connections need to be made to the upper end of the riser. Toward this end a conventional electrical swivel **42** having slip rings or the like is mounted on the riser supporting ring **31**. The electrical swivel is electrically connected to the conductors (not shown) of the riser. Flexible electrical cables **43** are also provided between the fixed portion of the electrical swivel and the deck of the ship for conducting power and electrical signals therebetween (FIG. 2).

A conventional fluid swivel **44** is mounted above the electrical swivel **42** and in fluid communication with the conduits (not shown) of the riser. A typical fluid swivel useful in practice of this invention is described in copending U.S. patent application Ser. No. 736,398, entitled "Multiple Pipeline Swivel Connector" by Eugene J. Camillo, which is hereby incorporated by reference for full force and effect as if set forth in full herein.

In a typical riser a plurality of fluid conduits are involved and several manifolds **46** are provided connected to the several conduits (not shown) of the riser. Pipes **47** are provided between the manifolds **46** and a plurality of conventional swivel joints **48**. In addition, if desired, a central conduit through the fluid swivel can be brought out through the top thereof as illustrated by the arching large diameter conduit **49**. The large conduit **49** is also connected to a conventional swivel joint **51**. The several swivel joints **48** and **51** on the several conduits are all arranged on parallel axes of rotation and fixed relative to the drawbar **28** so as to ride up and down the tower with the end of the riser.

The fluid swivel **48** are each connected to a rigid length of pipe **52**, a typical one of which is seen in FIG. 3. The opposite end of each of the rigid pipes **52** is connected to one of another set of conventional fluid swivels **53**, each of which is in turn connected to one of a second set of rigid pipes **54**. The opposite end of each rigid pipes **54** is connected to one of a third set of conventional fluid swivels **56** each which has its opposite leg secured to the tower base **22**. In a similar manner the larger diameter swivel **51** is connected by a rigid pipe **57**, fluid swivel **58** and rigid pipe **59**, to a conventional fluid swivel **61** secured on a platform **62** on the tower base **22**.

Referring specifically to FIG. 2, a truss-like strengthening beam or strut is provided on the rigid pieces of pipe **52** approximately midway between their ends for stabilizing the articulated piping and assuring that it moves as a unit. It will be apparent that other similar reinforcing structures can be employed at other places on the articulated piping such as adjacent the swivel joints **53** to enhance stability. In addition, as seen in FIG. 3 there is provided a link **69** interconnecting the truss-like reinforcing strut **68** and the larger pipe **57**. The link **69** is pivotally connected at its ends to the truss **68** and pipe **57** for movement therewith.

As the riser end travels up and down the length of the tower the various connections thereto including the fluid swivel **44** also travels up and down the length of the tower. The articulated piping **52, 54, 57** and **59** between the fluid swivel and the tower base maintains continuous fluid communication therebetween. As the riser head approaches the upper end of the tower, as illustrated in FIG. 2, the angle between the segments of articulated piping is relatively large or open and as the riser end and fluid swivel traverses to the lower end of the tower, as illustrated in FIG. 3, the angle between the rigid sections of articulated piping becomes more acute.

The articulation of the piping is further illustrated schematically in FIG. 6 wherein the arrangement of the pipes and swivel joints hereinabove described is shown with the riser in the lowermost position in solid, and with the riser in the uppermost position in phantom. It will be apparent from this schematic illustration that the several pipes **52, 54, 57** and **59** in this embodiment are each of the same length. The spatial orientation or position of the upper swivel joints **48** and **51** is also fixed relative to the orientation or position of the swivel joints **56** and **61** at the base of the tower. Specifically, a line drawn between the upper swivel joints **48** and **51**, is parallel to and of the same length as a line drawn between the lower swivel joints **56** and **61** at the base of the tower. It will be apparent that since the rigid links of pipe are all of the same length that a line drawn between the intermediate swivel joints **53** and **58** would also be parallel to and the same length as the other two lines between the upper and lower sets of swivel joints, respectively. Thus, as the articulated piping moves between its uppermost and lowermost extent, it moves as a pair of flexing parallelograms which at all times have parallel sides despite changes in the included angles of the parallelograms. Since the piping is arranged in the form of parallelograms, hinged links of fixed length such as the link **69** can readily be provided between the pipes on opposite sides of the parallelogram for stabilization and the link will move with, and provide stabilization in any position of the piping.

The truss-like structure **68** and link **69** afford some strengthening and buckling resistance to the articulated piping, however, this is a relatively minor effect and a principal reason for providing the interconnection between the several pipes is to modify the resonant frequency of vibration and prevent uncontrolled oscillations of the piping in dynamic situations. It will be apparent that a combination of trusses and links can be employed as required to "detune" the articulated piping and avoid resonant oscillations identified in the field.

In addition to travel of the riser end along the length of the tower it will be recalled, as illustrated in FIG. 3, that the tower may tilt about the gimbals **16** and **17** (FIG. 2). Upon so doing the tower base **22** to which the lowermost swivels **56** and **61** are connected also tilts and this tilt can be about either of two orthogonal directions. There are, therefore, a plurality of conventional flexible hoses **64** connected between the swivels **56** and **61** on the tower base and a pipe connection facility **63** on the deck of the ship. These hoses are sufficiently long that the maximum tilt of the tower in any direction can be accommodated by bending of the flexible hoses **64**. It will be apparent that the illustrated curvature in FIG. 3 is exaggerated for purposes of illustration. Tilt of the tower in a direction orthogonal to that shown in FIG. 3 is readily accommodated by a combination of twisting and bending of the flexible hoses **64**.

Thus, by means of a fluid swivel **44** and articulated piping, plus a length of flexible hose, it is possible to accommodate all manners of relative motion between the ship and riser. Heave of the ship is accommodated by articulation of the piping between the fluid swivel and the tower base and pitch and roll of the ship are accommodated by flexing of the hoses between the tower base and the deck of the ship.

Shock absorbers **70** are provided at the tower base so that the drawbar **28** seats thereon when the riser is at its lowest extent in the tower. This prevents sudden tension overloads on the riser and with suitable load or drawbar position sensors, actuation of the riser disconnect **74** can be initiated to prevent riser damage.

Referring again to FIG. 1 and to FIGS. 7 and 8 the riser **13** is made in the form of a lower section **71** connected to the ocean floor by a conventional bottom structure **72** shown schematically and an upper segment **73** extending downwardly from the ship **10**. The lower portion of the riser **71** and the upper portion **73** are interconnected by a conventional disconnect **74** for separating the electrical and fluid lines of the riser and maintaining some tension load.

A large buoy **76** is provided at the upper end of the lower segment **71** of the riser and this buoy **76** has sufficient buoyancy to apply a tensile force at the top of the riser **71** for supporting its weight and maintaining it in a near vertical position. As seen more clearly in FIG. 8 the buoy **76** is preferably a hollow steel sphere or other surface of revolution having a vertically extending cylindrical passage **77** through which the lower riser section **71** passes. The riser **71** is connected to the buoyant sphere **76** by tension couplers **78** as required. The interior of the sphere is divided into a plurality of water tight compartments **79**, each of which can be reached by a hatch **81** from the central passage **77** so that divers can enter and inspect the compartments while the buoy is submerged. The central passage **77** is sealed at the top and is filled with air to force water out of the lower end so that the hatches **81** can be opened without flooding the compartments.

The lower portion of the riser **71** has a length such that the buoy **76** floats at a depth sufficient to minimize any action thereon by waves in the heaviest storms anticipated in the area normally about 100 feet below the surface. In the course of normal operations the upper section **73** of the riser is connected to the lower section **71** while the ship is moored over the riser base **72**. The underwater disconnect **74** is provided, however, so that the principal lower portion **71** of the riser can be installed in connection with the riser base **72** without the ship **10** being present. This also permits disconnect of the ship from the riser in the course of routine maintenance and the like. When the ship is removed from the site or otherwise disconnected from the riser, the break is made at the disconnect **74** at the top of the riser buoy **76**. The upper segment **73** of the riser is drawn up into the ship by drawing the block **37** (FIG. 2) to the top of its travel in the tower. With the tower locked in position by the dampers **27** the upper section of the riser is held in a firm position for transport or more significantly during weathering of a storm.

In case of a storm of sufficient magnitude to cause the ship to heave or drift by an excessive amount for the tower to accommodate and still maintain connection with the riser, the disconnect **74** is opened and the upper section of the riser **73** is taken to the top extent in the tower so that the ship can rise and fall on the waves without interference between the two ends of the riser which could cause significant damage. This permits the ship to weather the severest storms on site in the oil field without damage to the riser and without removing the riser from its bottom connection. A float **82** is connected to the lower portion of the disconnect **74** so that the buoy **76** can be reacquired after the storm is passed and the two segments of the riser reconnected at the disconnect for continued operation.

An alternate tower and mounting therefore are illustrated in FIG. 9. As illustrated in this embodiment a ship **110** has a mooring swivel **112** mounted therein in substantially the same manner hereinabove described. In this embodiment, however, the tower **114** is supported on the ship **110** rather than applying its weight and the tension force of the riser directly on the mooring swivel **112**.

Thus there are provided a plurality of stanchions **86** on the deck of the ship. A spider-like tower supporting member **87** is located below the stanchions and supported therefrom by a plurality of truss legs **88** radiating from the tower support member **87**. An outer trunnion **89** on the tower support member supports a gimbal ring **91** and an inner trunnion **92** on the gimbal ring **91** supports a flat tower base. The trunnions **89** and **92** are orthogonal for providing tower tilt as hereinabove described and sufficient clearance is provided between the tower base **93** and the spider legs **88** to accommodate the maximum permissible tower tilt.

A commercially available truss-like tower **114** is mounted on a tower base **93** and its upper portion is connected to the deck of the ship by guy cables **94** in substantially the same manner as hereinabove described. The upper end of a riser **113** is supported by a drawbar **96** for motion along the length of the tower. Swivels, fluid connections, and other paraphernalia associated with the drawbar **96** and upper riser end are illustrated only schematically in FIG. 9 and can readily be of the same form hereinabove described or of other forms that may be apparent to one skilled in the art.

The drawbar **96** and riser are supported by a pair of cables **97** reeved over pulleys **98** at the top of the tower.

The cables then pass downwardly along the length of the tower and around pulleys **99** and **101** which form a portion of a constant tension device. A pneumatic or hydraulic cylinder **102** between the pulleys **99** and **101** urges them apart and thereby provides a uniform tension on the cables **97** to support the riser. The cylinders **102** have a substantial stroke so that cable **97** can be retracted or payed out as required as the riser travels along the length of the tower. The cable **97** can be wrapped several times around the pulleys **99** and **101** to provide a sufficient length without an undue stroke in the hydraulic cylinder **102**, and to obtain a desired mechanical advantage.

Obviously many other modifications and variations of the present invention are possible in light of the above teachings. One skilled in the art can readily provide modifications of the structural arrangements to accommodate variations in operating conditions.

What is claimed is:

1. A riser system comprising:

an elongated tension member having a lower end connected to the sea floor;

a buoyant body connected to the end of the elongated tension member opposite from the end connected to the sea floor; said buoyant body having sufficient buoyancy to support the weight of said elongated member in the water and apply a substantial tension to the upper end thereof, said elongated tension member being only of a sufficient length that said buoyant body is restrained below the surface of the body of water a distance greater than the depth of water subjected to substantial turbulence due to transient surface conditions;

a surface structure floating at the water surface;

a second tension member interconnecting said buoyant body and said surface structure;

means for maintaining substantially constant tension on said second tension member irrespective of relative motion between said surface structure and said buoyant body, said means including;

a tower tiltably and gimbally mounted on said floating structure and having at least a pair of side rails,

support means connected to said second tension member and having a carriage movable along said side rails,

cable means for applying a constant tension on said second tension means by way of said carriage; and

a thrust bearing between said carriage and said second tension member for permitting relative rotation therebetween about an axis along said tension member.

2. An underwater riser structure comprising:

a floating structure at the surface of the sea;

an elongated multiple conduit riser having a lower end connected to the sea floor;

means interconnecting the floating structure and the upper end of said riser, said means comprising means connected to the upper end of said riser for maintaining a substantially constant, axially directed, tension on said riser while maintaining six degrees of relative motion between said floating structure and the sea floor so that the floating structure moves up-and-down and nutates back-and-forth and rotates relative to the riser; and

a plurality of means at the upper end of said riser for conveying fluids between the interior of each of the multiple conduits and said floating structure while maintaining the six degrees of relative motion between said floating structure and the sea floor.

3. A riser structure as defined in claim **2** wherein said means for conveying fluids comprises:

a fluid manifold surrounding a portion of the length of said riser and in fluid communication with a conduit thereof; and

means for accommodating relative rotation between said manifold and said riser about an axis substantially coincident with the axis of said riser so that said floating structure may rotate about said riser.

4. A riser structure as defined in claim **3** further comprising a tower mounted on said floating structure and fixed thereto so as to prevent relative rotations therebetween about an approximately vertical axis;

means for mounting said tower on said structure for permitting limited rotation therebetween about at least a pair of axes in a substantially horizontal plane;

said tower supporting at least a portion of said means for applying constant tension to said riser including a portion movable along the length of said tower; and

means on said tower for interconnecting the manifold and a point adjacent the base of said tower for fluid flow.

5. A riser structure as defined in claim **4** wherein said means for interconnecting comprises a plurality of articulating fluid conduits, each of said conduits comprising:

a first fluid swivel connected to the upper end of the riser to travel along the length of the tower therewith;

a second fluid swivel connected to the other end of said first length of pipe from said first swivel;

a second length of rigid pipe connected to said second swivel; and

a third fluid swivel connected to the other end of said second length of pipe from said second swivel and mounted on said tower base; and wherein

the first, second, and third swivels on at least a pair of said conduits are all rotatable about parallel axes; and

the first and second pipes on one of the pair of conduits are parallel to the first and second pipes respectively of the other one of the pair of conduits in all positions of the upper end of the riser along the length of the tower so that said first pipes and said second pipes of the pair respectively can be mechanically interconnected.

6. A riser structure as defined in claim **5** wherein a line interconnecting the axes of rotation of said first swivels on the pair of conduits is parallel to a line interconnecting the axes of rotation of said third swivels on the pair of conduits whereby said first pipes are sides of a first parallelogram and said second pipes are sides of a second parallelogram; and further comprising:

a link pivotally connected at one end to one of the first pipes of the pair intermediate the ends and at the other end to the other of the first pipes of the pair with the length of the link extending parallel to the line interconnecting the axes of rotation of the first swivels.

7. An interconnection between a ship and a fluid carrying riser connected to the sea floor comprising:

a tower pivotally mounted on the ship for limited rotation therebetween about at least a pair of axes in a substantially horizontal plane;

a drawbar connected to the upper end of the riser and mounted for motion along the length of said tower;

constant tension means connected to said drawbar for applying a uniform tension to the upper end of the riser as said drawbar assumes various positions on the length of said tower; and

movable means for conveying fluids between said riser and the ship, said movable means including means for accommodating motion of the drawbar along the length of the tower and means for accommodating tilt of the tower relative to the ship.

8. An interconnection as defined in claim **7** wherein said means for accommodating motion of the drawbar comprises:

a first fluid swivel connected to the base of the tower;

a second fluid swivel connected to the drawbar;

a first pipe connected to said first swivel;

a second pipe connected to said second swivel; and

a third fluid swivel interconnecting said first and second pipes and free to move as said drawbar moves.

9. An interconnection as defined in claim **8** wherein said means for accommodating tilt of the tower comprises

a flexible hose interconnecting said second fluid swivel and the ship.

10. An interconnection as defined in claim **9** further comprising:

a thrust bearing between said drawbar and the upper end of the riser for permitting relative rotation therebetween about an axis along the length of the riser.

11. An interconnection as defined in claim **10** further comprising:

a fluid swivel connected to the upper end of said riser with an axis of rotation along the length of the riser.

12. In a combination with a ship, riser between the sea floor and the ship, and a riser support tower, an improved tower comprising:

a tower base;

a gimbal mounting for said tower base for permitting limited tilting of the tower relative to the ship;

a pair of tower side rails on the tower base;

a drawbar engaging said side rails for motion along the length of the tower;

a thrust bearing on said drawbar for at least partly supporting the riser;

constant tension means interconnecting said drawbar and the tower for supplying a constant tension on the riser;

a fluid swivel on the drawbar and connected to the riser for providing fluid communication during relative rotation of the drawbar and riser;

articulated fluid conduits between the fluid swivel and the tower base for conducting fluids therebetween; and

flexible hose between the tower base and the ship for conducting fluids therebetween.

13. In an improved tower as defined in claim **12** further improvements comprising:

said constant tension means including a constant tension winch on said ship and a cable interconnection between said winch and said drawbar for applying tension thereto during motion of the drawbar along the length of the tower; and

damping means for inhibiting rapid motion of said tower and said drawbar.

14. In an improved tower as defined in claim **12** further improvements comprising:

a plurality of articulated fluid conduits between the fluid swivel and the tower base, said conduits including parallel lengths of rigid pipe and fluid swivels all pivoting about parallel axes, at least a pair of said lengths of pipe moving by changing including angles of a parallelogram.

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