

Sept. 20, 1971

J. W. MOHLMAN

3,605,415

UNDERWATER RISER SUPPORT STRUCTURE

Filed June 30, 1969

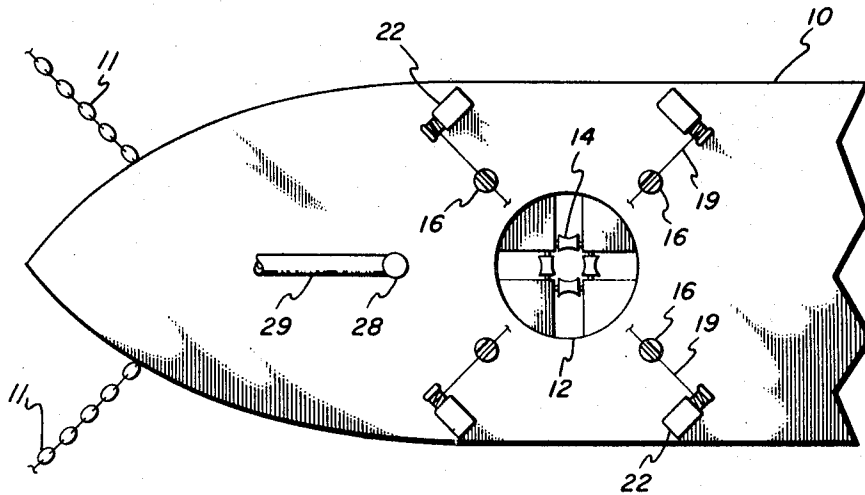


FIG. 1

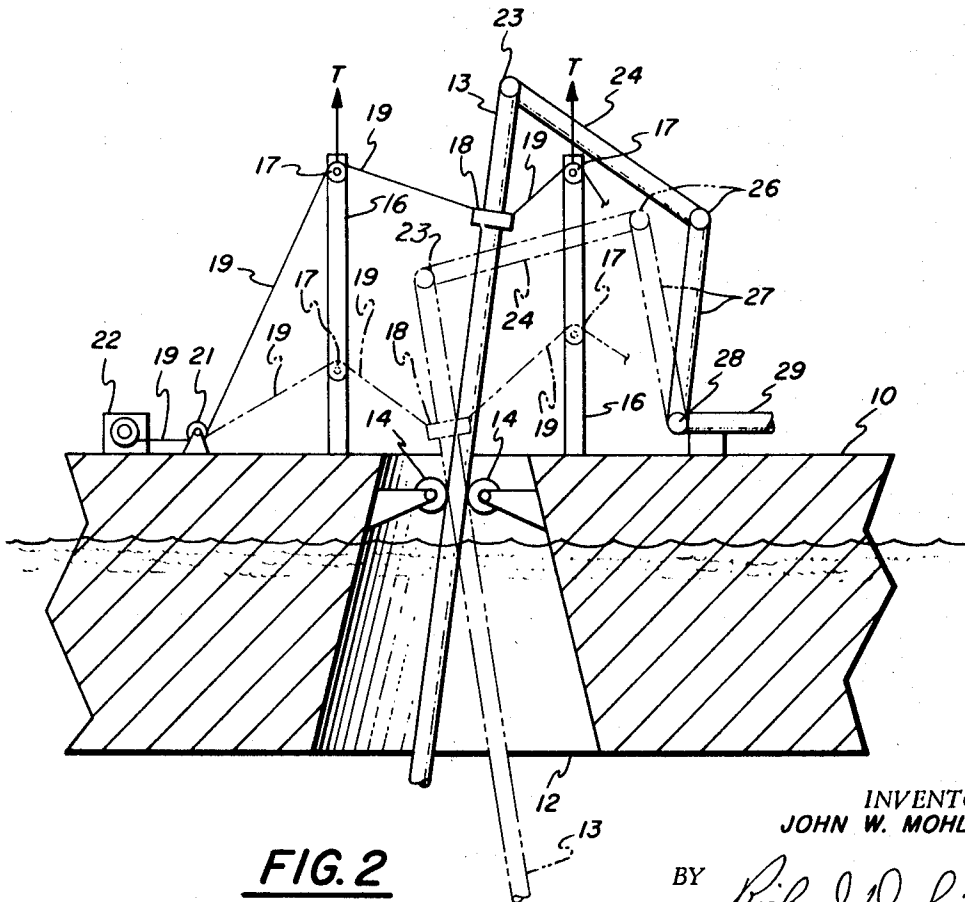


FIG. 2

INVENTOR.
JOHN W. MOHLMAN

BY

Richard D. Seibel

ATTORNEY

1

3,605,415

UNDERWATER RISER SUPPORT STRUCTURE

John W. Mohlman, Tarzana, Calif., assignor to

North American Rockwell Corporation

Filed June 30, 1969, Ser. No. 837,503

Int. Cl. E21b 17/00

U.S. Cl. 61-46

7 Claims

ABSTRACT OF THE DISCLOSURE

A ship mounted support for an underwater riser is described having a plurality of towers surrounding the upper end of the riser and connected thereto by constant tension winches. Cables from the winches pass over traveling idler pulleys which are urged upwardly on the towers to assist in maintaining a substantially constant upwardly directed force on the riser.

BACKGROUND

In the offshore production of oil and other subaqueous minerals there is a practical depth limitation for bottom mounted 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 towers to even shallower depths. An alternative to fixed towers is to provide a portion of the production facilities on the sea floor and provide a permanently moored, floating ship for the balance. When this is done a substantially vertically extending conduit or riser must be provided between the sea floor and the ship.

In relatively shallow depths and calm waters many of the problems of a riser permanently 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. Although such pipes have appreciable rigidity they are not self supporting and a force must be applied to the upper end to maintain them in a substantially vertical position. Some tilt of the upper end of the riser may also occur within elastic limits of the riser due to the ship drifting a short distance off the position directly above the base of the riser. Tilt of the riser relative to the ship may also occur due to pitch and roll of the ship floating on the sea surface. In addition the ship may heave due to wave action or tides and an interconnection must be provided between the ship and the relatively fixed rigid riser to minimize the stresses therebetween.

SUMMARY OF THE INVENTION

Thus there is provided in practice of this invention a ship and an underwater riser passing through an aperture in the ship. Means are provided in the aperture for restraining the riser from substantial lateral motion while permitting relative motion of the ship along the length of the riser and means are provided on the ship for applying a tension on the riser independent of pitch, roll and heave 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 is a top view of a portion of a ship incorporating the principles of this invention, and

FIG. 2 is a vertical cross-section through the ship showing means for applying tension to the riser.

2

Throughout the drawings like reference numerals refer to like parts.

DESCRIPTION

A portion of a ship incorporating the principles of this invention is illustrated in the top view of FIG. 1 and the vertical cross-section of FIG. 2. As illustrated in this preferred embodiment a ship 10 is moored to the sea floor by a plurality of anchor chains 11 so that the ship remains in a substantially fixed position relative to the ocean floor. An aperture 12 is provided vertically through the ship extending from the deck line through the bottom of the hull. A substantially rigid riser 13 as seen in FIG. 2 is connected to the sea floor (not shown) and extends upwardly through the aperture 12 in the ship 10, terminating at point above the deck of the ship. For clarity of illustration the riser 13 is omitted from the top view of FIG. 1.

A plurality of rollers 14 with concave riser engaging faces are mounted in the aperture 12. The rollers, a pair of which are seen in FIG. 2, engage the riser and prevent substantial lateral movement relative to the ship of a point along the length of the riser that is in engagement with the rollers. The rollers also permit motion of the riser along its length relative to the ship. It will be apparent, of course, that the point on the riser restrained from appreciable lateral motion will vary as the riser moves higher or lower relative to the ship. It will also be apparent that the motion of concern is the relative motion between the riser and the ship and that, in fact, the riser is substantially fixed and the ship moves relative thereto due to its roll, pitch and heave. As discussed herein the reference frame will normally be the ship and it will be considered that the riser moves relative to the ship.

Mounted on the deck of the ship are four towers 16 radially spaced about the aperture 12 and extending a substantial distance above the deck of the ship. On each of the towers 16 there is a traveling idler pulley 17 mounted for motion along the height of the tower. In addition each of the towers includes conventional means for urging the traveling pulleys 17 toward the top of the tower. This means for urging the pulleys toward the top of the tower is represented schematically in FIG. 2 by the arrow T pointing upwardly from the top of the tower. It will be apparent that many such means may be provided such as for example, a winch and cable arrangement for pulling the traveling pulley toward the top of the tower or a hydraulic or pneumatic ram for pushing the pulley toward the top of the tower.

A connector 18 is provided on the riser near its upper end and tension cables 19 are connected thereto. The tension cables each pass over traveling pulley 17 on one of the towers and thence outwardly and downwardly to an idler pulley 21 mounted on the deck of the ship. After passing over the pulley 21 the cable 19 is connected to a conventional constant tension winch 22 on the deck of the ship. It will be apparent, of course, that the winches 22 and pulleys 21 may be mounted below the deck of the ship if desired.

Since the riser 13 is a fluid carrying conduit, means are provided for conducting fluid from the upper end of the riser to the deck of the ship. Thus, a swivel joint 23 is connected to the upper end of the riser and to a rigid length of pipe 24. The other end of the pipe 24 is connected to a second or intermediate swivel joint 26 which is in turn connected to a second rigid length of pipe 27. The other end of the second pipe 27 is connected to a conventional ball joint 28 which is connected to piping 29 fixed to the deck of the ship. This connection by articulated piping permits fluid transfer between the riser end and the deck of the ship in any riser position as it rises, falls and tilts as seen in the solid and phantom views respectively shown in FIG. 2.

As the upper end of the riser moves relative to the ship, the swivel joint 23 moves or flexes so that the angle between the riser and the pipe 24 changes. This in turn causes the intermediate swivel joint 26 to flex. At the same time the ball joint 28 moves to allow the lower pipe 27 to assume a new position. A ball joint (or pair of orthogonal swivel joints) is employed between the lower pipe and piping 29 on the deck of the ship to accommodate tilt of the riser in a direction normal to the direction illustrated in FIG. 2. (The pipes interconnecting the pipe 29 and the riser are deleted from FIG. 1 for purposes of clarity).

Referring to FIG. 2 there is illustrated in solid lines the riser 13 near the top of its travel and tilted to one side and in phantom the riser near the lower extent of its travel and tilted to the opposite side to show motion of the cables and traveling pulleys. When the riser 13 and connector 18 are relatively high the traveling pulleys 17 are urged to the top of the tower 16 by the forces T as seen in solid in FIG. 1. On the other hand, when the riser 13 is relatively low in the aperture the traveling idler pulleys 17 are pulled relatively lower on the towers as seen in phantom in FIG. 2. The traveling pulleys 17 are forced downward on the towers against the constant urging force T by the cable 19. Since the cable is flexible it can exert only a tension and this force can be considered as a vector along the length of the cable. The vector sum of the forces exerted by the cable 19 in a direction along the height of the tower will exactly balance the constant upwardly urging force T. The magnitude of the downward force exerted by the constant tension cable is dependent on the angle between the cable and the tower. Since the angle between the tower and segment of cable between the pulley and connector 18 will vary as the riser moves vertically or tilts from side to side and the angle between the tower and segment of cable between the pulley and the winch varies as the traveling pulley moves up and down the tower, magnitude of downward force exerted by the cable 19 on the traveling pulley 17 will vary. The pulley 17 is thereby caused to move against the urging force T until the angles made by the cable on the traveling pulley are adjusted to reach equilibrium.

The result of the coaction between the downward pulling constant tension cables 19 and the traveling pulleys 17 as urged upward by constant forces T is a reasonably constant upwardly directed force along the length of the riser exerted by the several cables 19 extending upwardly and radiating outwardly from the connector 18. It will be apparent that, by adjusting the angles between the cables, tower and riser and the magnitude of the urging forces T and constant tension on the cables 19, any desired range of upwardly directed force on the riser 13 can be provided.

The cooperation between the constant tension cables 19 and the traveling pulleys 17 is emphasized by considering the effects if either were eliminated. Thus, for example, if the constant tension winches 22 were omitted and the cables 19 were of substantially fixed length from points capable of traveling along the tower length, it is apparent that substantial bending forces would be induced in the riser as it tilts relative to the ship.

If, on the other hand, constant tension winches were employed with the traveling pulleys 17 fixed at the upper ends of the towers instead of traveling, the angle between the cables 19 and the riser 13 would change substantially as the riser moved along its length relative to the ship. With the riser at its lowest extent a relatively large tension would be applied thereto and at its upper extent only a relatively small tension would be applied thereto due to the decreased angle of applied force.

In practice of this invention by providing both constant tension cables 19 and traveling blocks 17 the range of variation of tensile forces on the riser is greatly minimized as are the bending forces thereon as the ship pitches, rolls and heaves.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. Thus, for example, additional pulleys may be provided between the traveling pulleys 17 and the pulley 21 on the deck of the ship for varying the angles involved. Likewise, the riser may be connected to the ship at the side or an end instead of through an aperture. In lieu of a ship a spar buoy, floating platform or the like may be employed. The principles of this invention may also be employed in drilling or other subsea operations in addition to oil production. Many other variations in the present invention will be apparent to one skilled in the art.

What is claimed is:

1. An underwater riser support structure on a floating structure comprising:

a plurality of guide towers fixed on the floating structure;

a plurality of idler pulleys, one pulley mounted on each of said guide towers;

a plurality of constant tension winch means;

a plurality of tension cables, one cable over each idler pulley, said cables each interconnecting one of said constant tension winch means and a point on a riser for applying a tension thereto; and

means on said floating structure for restraining a point on a riser against substantial lateral motion and for permitting relative longitudinal motion of the riser.

2. A structure as defined in claim 1 wherein said idler pulleys are each mounted for motion along the height of the guide towers; and further comprising:

means for urging said idler pulleys toward the top of the guide towers.

3. A combination comprising:

a ship having an aperture therethrough;

an appreciably rigid underwater riser connected to the ocean floor and passing through the aperture in the ship;

means in the aperture for restraining the riser from substantial lateral motion relative to the ship and for permitting relative motion between the riser and the ship along the length of the riser;

means on the ship for applying force directed substantially along the length of the riser independent of pitch, roll and heave of the ship;

said means for applying force including:

a plurality of towers around said aperture;

a connector on said riser;

a plurality of tension cables, one cable from each of said towers to said connector;

idler pulleys on said towers, said cables passing over said idler pulleys;

constant tension winch means on said ship for applying tension on said cables;

said idler pulleys mounted for motion along the height of said towers; and

means for urging said idler pulleys toward the top of said towers.

4. A combination comprising:

a ship having an aperture therethrough;

a substantially rigid riser connected to the sea floor and passing through the aperture in the ship;

a plurality of tension cables extending upwardly and radiating outwardly from a point on said riser to support points on said ship;

said cables collectively providing an upwardly directed force for supporting said riser in the aperture;

a plurality of towers arrayed around the aperture and disposed at said support points respectively;

means for applying a substantially constant tension on said cables;

said towers each including an idler pulley mounted for motion along the height of the tower, one of said cables passing over each of said pulleys; and

means for urging said idler pulley toward the top of said tower.

5

5. A combination as defined in claim 4 further comprising:

means in said aperture for restraining a point on said riser against substantial lateral motion relative to said ship and for permitting relative longitudinal motion of the riser. 5

6. A combination as defined in claim 5 further comprising:

articulated rigid piping interconnecting the end of the riser with the ship for accommodating relative motion therebetween. 10

7. A combination as defined in claim 6 wherein said piping comprises:

a first fluid swivel connected to said riser;
a first length of rigid pipe connected to said first swivel;
a second fluid swivel connected to said first length of pipe; 15

6

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

a third fluid swivel connected to said second length of pipe and to a fluid conduit on said ship, one of said first and third fluid swivels having pivotal freedom about at least two axes.

References Cited

UNITED STATES PATENTS

3,315,741	4/1967	Triplett	166—.5
3,426,843	2/1969	Visser	166—.5
3,465,817	9/1969	Vincent	166—.5
3,489,212	1/1970	Rininger et al,	166—.5

J. KARL BELL, Primary Examiner

U.S. Cl. X.R.

114—.5D; 166—.5