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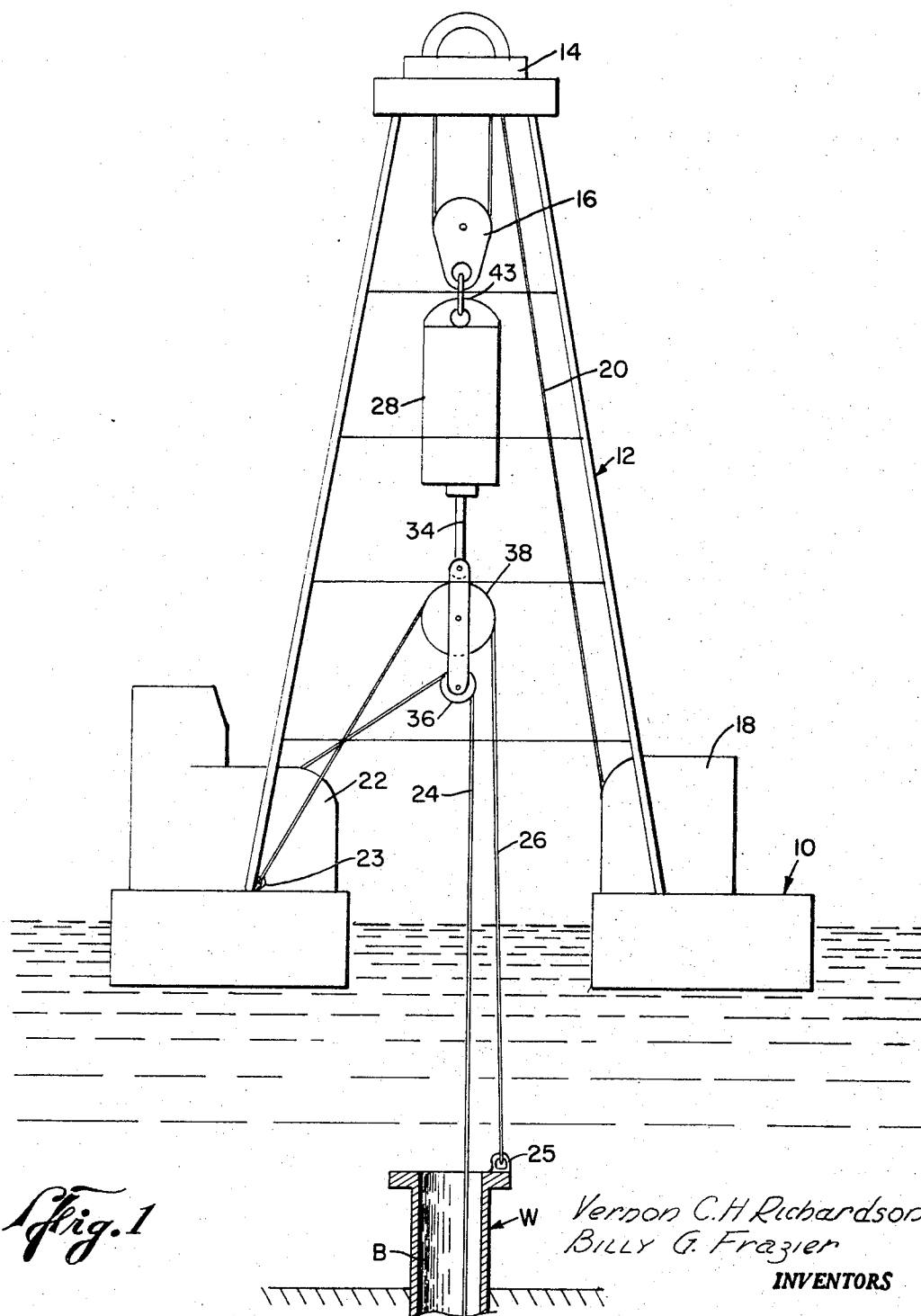
V. C. H. RICHARDSON ET AL

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APPARATUS FOR THE SUSPENSION OF WELL BORE DEVICES

Filed Dec. 17, 1965

2 Sheets-Sheet 1



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APPARATUS FOR THE SUSPENSION OF WELL BORE DEVICES

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4 Claims. (Cl. 166—5)

ABSTRACT OF THE DISCLOSURE

Apparatus for use on floating vessels for carrying out cable operations in well bores located beneath the water to maintain cable suspended equipment in the well at the same depth during movement of the vessel in response to wave action. The apparatus includes a suspension cable for the equipment in the well and a mooring cable anchored at its lower end to a fixed location beneath the water and yieldable pressure fluid means on the vessel having a movable connection with each of the cables to apply a constant tension to the cables during the paying out and taking in of the cables during movements of the vessel due to wave action.

This invention relates to the carrying out of operations in well bores from floating vessels, and more particularly to mechanism for the suspension of objects in well bores beneath the water and for maintaining the same at the same vertical location during movements of a vessel in response to wave action.

In carrying out operations in well bores located beneath the water and particularly such operations which require the maintenance of equipment in the well at a predetermined depth great difficulty is often encountered due to wave action on the barge or other supporting structure. Attempts have been made to overcome the effects of wave action by mooring or by the provision of compensating apparatus to maintain the vessel substantially stationary. Such equipment is, however, difficult to operate satisfactorily and requires constant attention and maintenance.

The present invention has for its primary object the provision of apparatus which is designed to support equipment in a well bore from a floating object and to maintain the equipment at the same depth in the bore during vertical movements of the vessel due to wave action.

Another object of the invention is to provide apparatus for use in connection with cable suspension mechanism for rapidly paying out and taking in cable in response to vertical movements of a supporting vessel to maintain the equipment suspended thereby at the same depth in a well bore during movements of the vessel in response to wave action.

A further object of the invention is the provision of cable suspension apparatus for use with well equipment supported on a floating vessel embodying cable winding mechanism by which the equipment is suspended in a well from a vertically movable suspension means and means for moving such suspension means vertically in response to vertical movements of the vessel to maintain the suspension point of the equipment at the same level.

A still further object of the invention is the provision in cable suspension apparatus of the kind mentioned of means whereby the equipment is maintained at the same vertical position in the well bore while allowing variations in the vertical position of the suspension point of the equipment without varying the length of cable which is unwound from the winding mechanism.

The above and other important objects and advantages of the invention will be apparent from the following de-

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tailed description of a preferred embodiment of the invention when considered in conjunction with the annexed drawings wherein:

FIGURE 1 is a front elevational view of a drilling barge or other vessel showing the suspension apparatus of the invention in position thereon and supporting well equipment in a well bore beneath the water;

FIGURE 2 is a fragmentary side elevational view, partly in cross-section of the suspension apparatus of FIGURE 1, showing details of structure of pressure fluid mechanism forming a part thereof;

FIGURE 3 is a fragmentary side elevational view, partly in cross-section illustrating a modified form of the pressure fluid mechanism of the invention; and

FIGURE 4 is a diagram illustrating the relative positions of the parts of the suspension apparatus assumed in response to changes in the vertical position of the supporting vessel due to wave action.

Referring now to the drawings in greater detail the suspension apparatus of the invention is illustrated herein in connection with its use on a barge or other floating vessel, generally designated 10, of a conventional type, having a derrick 12 thereon which is provided with the usual crown block 14 and travelling block mechanism 16 by which the well equipment is suspended for the carrying out of operations in a well bore indicated at B beneath the water.

Suitable cable winding mechanism 18 is provided on the vessel from which a cable 20 leads over the crown block 14 to the travelling block 16 by which the suspension mechanism may be raised and lowered, and other cable winding mechanism 22 is provided on the vessel from which a cable 24 leads to the well bore B and by which the equipment is suspended therein.

The suspension mechanism includes the suspension cable 24 with its winding mechanism 22 and a mooring cable 26 which is connected at one end at 23 to the vessel 10 and which is anchored at its other end 25 to some stationary point, such as the well head equipment W or other fixed location.

The suspension mechanism also has pressure fluid means, generally designated 28, including a pressure cylinder 30, in which a piston 32 is movably disposed, having a piston rod 34 to whose outer end sheave means is attached comprising rotatably mounted pulleys 36 and 38 over which the cables 24 and 26, respectively, are passed. The piston rod 34 is extended upwardly into an upper end tubular extension 40 of the cylinder 30 in which the rod is slidable to guide the same and prevent tilting of the rod and piston relative to the axis of the pressure cylinder.

The pressure cylinder is carried in a closed outer casing 42 containing a suitable hydraulic fluid 44, above which the casing is pressurized with a suitable fluid, such as air, which may be introduced from any suitable pressure source through an inlet pipe 46 under the control of suitable valve mechanism 48. The casing 42 is attached to the travelling block 16, above, by any suitable means, such as that shown at 43, to support the suspension mechanism therefrom.

The cylinder 30 has ports 50 at its lower end through which hydraulic fluid 44 may flow into and out of the cylinder.

The casing 42 is provided with the usual safety valve 52 and pressure gauge 54.

In the operation of the suspension mechanism the well equipment is suspended at the desired location in the well on the cable 24, by operation of the winding mechanism 22, the cable 26 being anchored at some fixed location, as shown, and the pressure in the cylinder 30 being adjusted so that the equipment is supported by the piston 32.

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With the apparatus thus adjusted, the equipment in the well bore attached to the cable 24 will be maintained stationary during upward and downward movements of the vessel in response to wave action, the cable 24 being taken in over the pulley 36 during downward movement of the vessel and paid out thereover during upward movement of the vessel. Upon upward movement of the vessel, the cylinder 30 moves upwardly therewith, as does also the winding mechanism 22 of cable 24 and the point of connection 23 of the cable 26 with the vessel, so that the portion of the cable 24 between the pulley 36 and the equipment in the well becomes longer, while the portion of cable 24 between pulley 36 and the winding mechanism 22 becomes shorter. Similarly the portion of cable 26 between pulley 38 and the well head W becomes longer while the portion of cable 26 between pulley 38 and the point of connection 23 becomes shorter.

Moreover, as the vessel moves upwardly, carrying with it the cylinder 30, the hydraulic fluid beneath the piston 32 is forced out through ports 50 into the casing 42, compressing the pressure fluid therein above the hydraulic fluid to maintain the tension on the piston rod 34, whereby the tension on the cables 24 and 26 is maintained.

Upon downward movement of the vessel the connection point 23 and cable winding mechanism move downwardly therewith to lengthen the portion of cable 24 between the pulley 36 and winding mechanism 22 while shortening the portion of cable 24 between pulley 36 and the equipment in the well bore. The portion of cable 26 between pulley 38 and connection point 23 is also lengthened while the portion of cable 26 between pulley 38 and connection point 25 is shortened. Such downward movement of the vessel also results in downward movement of the cylinder 30, so that hydraulic fluid in casing 42 under the pressure of the pressure fluid thereabove is forced into cylinder 30 beneath the piston 32 to maintain the tension on the cables to prevent any slackening of the same.

FIGURE 4 illustrates diagrammatically the operation of the apparatus during upward and downward movements of the vessel. As seen at the left in FIGURE 4 the vessel is in a lower position L, and under these conditions the cylinder 30 is in a lowered position relative to the piston 32, the portions of cables 24 and 26 designated A-B being lengthened while portions thereof designated B-C are correspondingly shortened. Centrally in FIGURE 4 the vessel is seen in an intermediate vertical position M of its movement, in which the cylinder 30 is shown at a somewhat higher position relative to piston 30, the cable portions A-B being now somewhat shorter than in the lower position of the vessel while portions B-C are correspondingly lengthened. At the right of FIGURE 4 the conditions prevailing when the vessel is in an upper position are shown, the cylinder 30 being now in a higher position relative to piston 32 while portions A-B of cables 24 and 26 are more shortened and portions B-C thereof are more lengthened. It will be apparent however that in all positions of the apparatus and the vessel, the sum of the portions A-B and B-C of cable 24 is the same, as does also the portions A-B and B-C of cable 26, as shown in the lower diagram of FIGURE 4, and the position of the equipment in the well attached to cable 24 remains unchanged.

A somewhat modified form of the pressure cylinder mechanism of the invention is illustrated in FIGURE 3, wherein the casing 42' is surrounded by a closed annular chamber 58 upon which suitable compressor mechanism generally designated 60 of a conventional type is mounted. The compressor 60 has a discharge line 62 which leads into the chamber 58 through which the chamber may be pressurized to the desired pressure. A supply pipe 64 leads from the chamber 58 into the interior of the casing 42' near the top of the casing to pressurize the casing above the hydraulic fluid therein. The chamber 58 thus forms a pressure accumulator from which fluid under

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pressure is supplied to the casing 42' to replenish the pressure therein and to vary the pressure applied to the cylinder 30'. The chamber 58 has a relief valve 52'', which is set to open at a higher pressure than the relief valve 52' of the casing 42', so that a higher pressure will be built up in the accumulator chamber 58 than in the casing 42'.

A supply pipe 64 leads from the chamber 58 into the casing 42' under the control of an adjustable regulator, which may be set to maintain the pressure in the casing 42' at a desired pressure. In other respects the pressure cylinder mechanism of FIGURE 3 is like that of FIGURE 2, and operates in a similar manner.

By this arrangement, upon a downward movement of the piston 32' in cylinder 30' pressure will be applied to the pressure fluid in casing 42' above the hydraulic fluid therein, to open valve 52' whereby the pressure in casing 42' will be maintained constant. Upon upward movement of the piston 32' in cylinder 30' the pressure on the pressure fluid in casing 42' above the hydraulic fluid will be reduced whereupon fluid from accumulator chamber 58 will flow into casing 42' through pipe 64 to maintain a constant pressure in the casing, whereby the forces acting upon the piston 32' are maintained substantially constant at all times.

It will thus be seen that the invention constructed as disclosed herein provides suspension mechanism for use in supporting equipment in a well bore beneath the water from a floating vessel and by which the position of the equipment in the well can be held at the desired depth regardless of the movements of the vessel in response to wave action or fluctuations in tide.

The invention is disclosed herein in connection with certain specific embodiments of the same, which it will be understood are intended by way of illustration only, it being apparent that various changes in the construction and arrangement of the parts may be made within the spirit of the invention and the scope of the appended claims.

The invention, briefly described, comprises a suspension cable and winding mechanism therefor supported on a floating vessel so that the suspension cable may be used to support equipment in the bore of a well located beneath the water, and a mooring cable whose upper end is fixedly attached to the vessel and whose lower end is fixedly anchored at a location beneath the water. Both of the cables pass over pulleys yieldably supported on the vessel to allow the cables to be paid out over the pulleys upon upward movement of the vessel due to wave action and taken in upon downward movement of the vessel due to such action. The yieldable means by which the pulleys are suspended includes a hollow casing suspended from above on the vessel and a cylinder in the casing whose upper end is closed and whose lower end is closed by the bottom wall of the casing, the cylinder having openings adjacent its lower end through which liquid in the casing may flow into and out of the cylinder. A piston is movably disposed in the cylinder and has a piston rod slidably extended through the bottom wall of the casing which rod is connected to the pulleys and means is provided for applying pressure to the liquid in the casing to apply a yieldable tension to the cables in response to vertical movements of the vessel.

Having thus clearly shown and described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for suspending equipment in a well bore beneath the water from a floating vessel comprising:
 - a suspension cable connected to the vessel and extending into the well bore;
 - a mooring cable connected to the vessel and to a fixed location;
 - tensioning means comprising an elongated hollow casing, means for suspending the casing at one end above the vessel, a cylinder in the casing extending

axially thereof whose upper end is closed and whose lower end is closed by the lower end wall of the casing and formed adjacent its lower end with openings through which fluid in the casing may flow into and out of the cylinder, a piston slidably disposed in the cylinder, a liquid in the casing and in the cylinder beneath said piston, and means slidably extended through the lower end wall of the casing into the cylinder and means forming a movable connection between the piston and each of said cables to apply a tension to the cables in response to vertical movement of the vessel.

2. The apparatus as set forth in claim 1 wherein said connecting means includes rotably mounted pulley means over which said cables pass.

3. The apparatus as claimed in claim 1, wherein said casing is movably supported on the vessel for movement to a position to move the piston to a predetermined loca-

tion in the cylinder when a predetermined tension is applied to the cables.

4. The apparatus of claim 1 wherein said tensioning means includes means for applying pressure to the liquid in said casing to maintain a constant pressure of fluid in the cylinder.

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