United States Patent

Burrell

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[54] WAVE MOTION COMPENSATION SYSTEM FOR SUSPENDING WELL EQUIPMENT FROM A FLOATING VESSEL

[72] Inventor: **George R. Burrell,** Houston, Tex.

[73] Assignee: **Esso Production Research Company**

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[52] **U.S. Cl.** **254/173,** 175/5

[51] **Int. Cl.** **B66d 1/48**

[58] **Field of Search** 254/172, 173; 175/5, 6; 166/.5

[56] **References Cited**

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Primary Examiner—Joseph Wegbreit
Assistant Examiner—Merle F. Maffei
Attorney—Thomas B. McCulloch, Melvin F. Fincke, John S. Schneider, Sylvester W. Brock, Jr., Kurt S. Myers and Timothy L. Burgess

[57] **ABSTRACT**

A reversible hydraulic motor and a high pressure-low pressure hydraulic reservoir system are used to counterbalance the weight of a drill string or other well equipment suspended from a line wound on a draw works positioned on a floating vessel. A load cell controls the torque output and the direction of the output drive of the hydraulic motor and in turn torque on and the direction of rotation of the draw works. On downward movement of the floating vessel high pressure hydraulic fluid from an accumulator moves through the hydraulic motor into a low pressure hydraulic fluid reservoir to provide increased torque to the draw works as the draw works spools up line and upward movement of the floating vessel the hydraulic motor reverses and becomes a pump and moves low pressure fluid from the low pressure reservoir to the high pressure accumulator to provide decreased torque and reverse direction to the draw works as the draw works spools off line.

4 Claims, 2 Drawing Figures

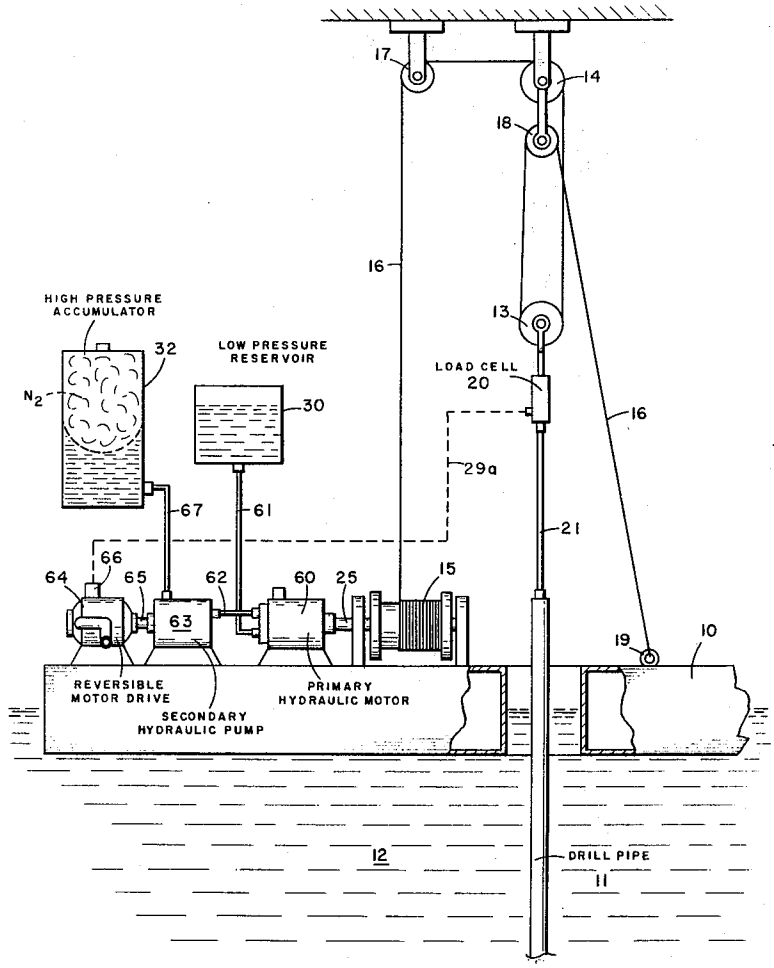
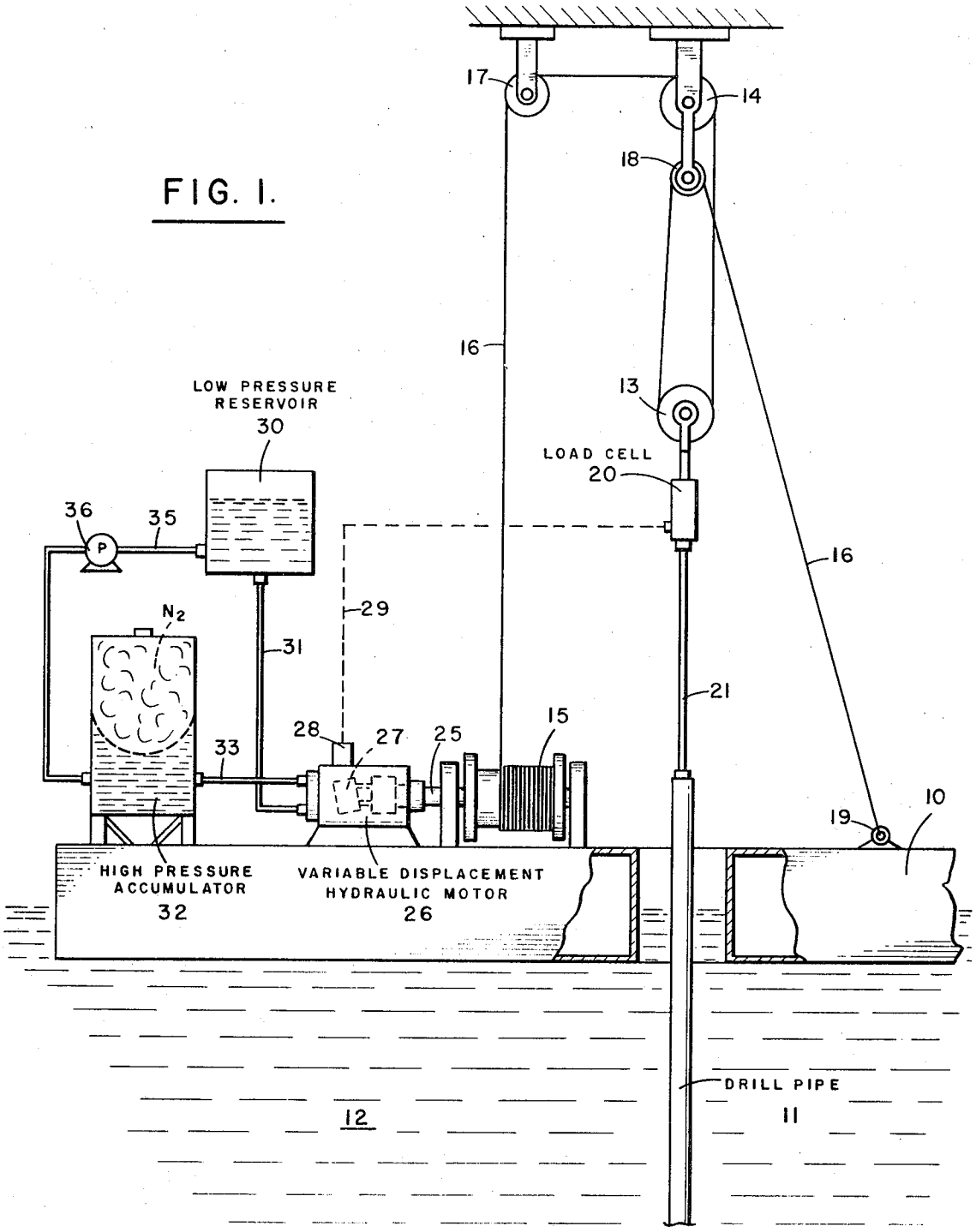
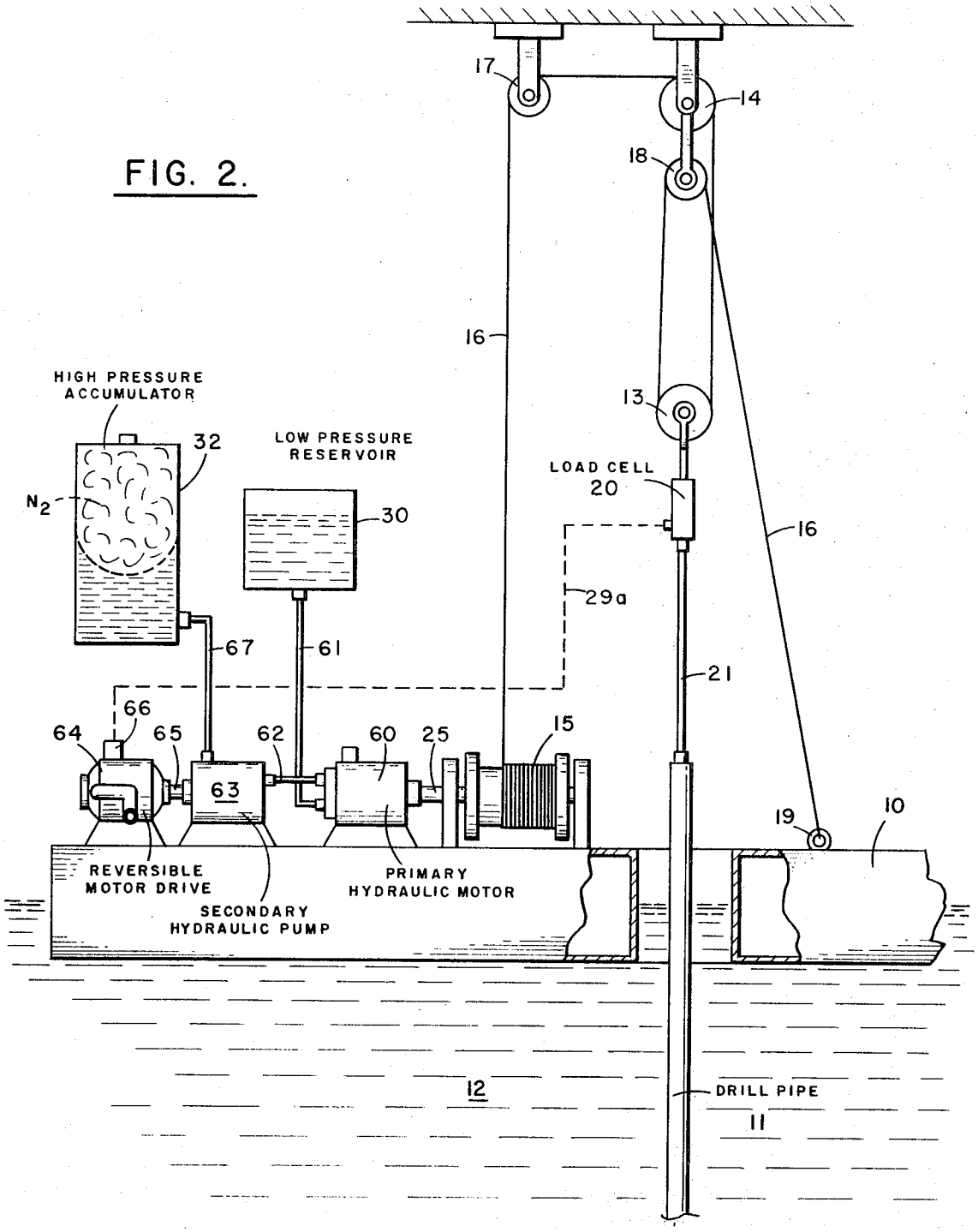


FIG. 1.



INVENTOR.
GEORGE R. BURRELL,
BY John D. Schneider
ATTORNEY.

FIG. 2.



INVENTOR.
GEORGE R. BURRELL,
BY John J. Schneider
ATTORNEY.

WAVE MOTION COMPENSATION SYSTEM FOR SUSPENDING WELL EQUIPMENT FROM A FLOATING VESSEL

BACKGROUND OF THE INVENTION

In one known system used to compensate for wave action when well equipment is suspended from a floating vessel a conventional draw works and traveling block hoisting arrangement is powered by a hydraulic motor which works in conjunction with a high pressure fluid accumulator for counterbalance effect. The accumulator provides hydraulic fluid to the motor to raise the traveling block when the floating vessel is dropping because of wave motion. When the floating vessel starts to rise with the next wave, the hydraulic motor acts as a pump and pumps low pressure hydraulic fluid back into the accumulator. This action tends to provide a constant pull on the suspended well equipment except for the change in pressure of the accumulator and the hysteresis effect caused by frictional losses in the system. Since the hysteresis effect may be in the range of 15 to 20 percent, the actual tension on the drill string may vary plus or minus 15 percent of the static pull over a wave period. The present invention reduces or eliminates such hysteresis effect in systems of this type.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, a reversible hydraulic drive means is coupled to a draw works for driving the draw works to spool up line on which well equipment is suspended when rotated in one direction and to spool off line when the draw works is rotated in a reverse direction. A load cell transmits signals proportional to changes in weight of the well equipment to a controller which is connected to the hydraulic drive means to control torque output to the draw works and the direction of rotation of the hydraulic drive means. The hydraulic drive means is connected to a high pressure hydraulic fluid accumulator and a low pressure hydraulic fluid reservoir. When the load cell weight decreases below a preselected weight (as the floating vessel falls from the crest of a wave) more torque is supplied to the draw works causing the draw works drum to spool up line to return the load cell weight to its preselected weight. In such operation high pressure accumulator fluid moves through the hydraulic drive means to the low pressure fluid reservoir. As the floating vessel rises with the next wave the load cell weight increases to above the preselected weight resulting in a decrease in torque output to the draw works and a reversal of the direction of the hydraulic drive means to spool off line from the draw works. In such operation low pressure reservoir fluid is pumped back into the high pressure fluid accumulator.

In one embodiment of the invention the hydraulic drive means comprises a variable displacement reversible hydraulic motor connected by conduits to the fluid accumulator and fluid reservoir.

The controller is connected to the variable displacement hydraulic motor. An auxiliary pump maintains pressure in the accumulator at a prescribed high level to compensate for frictional losses in the system.

In another embodiment of the invention the hydraulic drive means comprises a reversible fixed displacement hydraulic motor connected by conduits to the fluid reservoir and to a hydraulic pump which in turn is connected by a conduit to the fluid accumulator. A reversible motor, to which the controller is connected, is coupled to the hydraulic pump to boost the fluid pressure output of the hydraulic pump.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates a hoisting system in accordance with one embodiment of the present invention; and

FIG. 2 schematically illustrates such a system in accordance with another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, there is shown a vessel **10**, from which is suspended drill pipe **11**, floating in a body of water **12**. The drill pipe is suspended on a traveling hoist arrangement which includes a traveling block **13**, a crown block **14**, and a draw works drum **15**. A line or cable **16**, wound about drum **15**, traverses a pulley **17**, crown block **14**, traveling block **13**, and another pulley **18**, and is secured to vessel **10** at **19**. A load cell **20**, sensitive to weight of the drill string, is suspended below traveling block **13** on a kelly **21** connecting the traveling block and drill string. Draw works drum **15** is connected by a drive shaft **25** to a variable displacement hydraulic motor **26** provided with a moveable swash plate, not shown, the angle of which is controlled by a controller **28** which in turn is controlled by signals from load cell **20**, as indicated by the dotted line **29**. A low pressure reservoir **30** is connected by a conduit **31** to motor **26** and a high pressure fluid accumulator **32** is connected by a conduit **33** to motor **26**. Reservoir **30** and accumulator **32** are connected to each other by a conduit **35** in which is arranged a pump **36**.

In the operation of this embodiment of the invention, assume floating vessel **10** is at the top point of heave due to wave action. At this point draw works drum **15** is stopped with, for example, hydraulic motor **26** stalled at a swash plate angle of 10°, high pressure fluid accumulator **30** at a pressure of 2,000 psi and the weight on load cell **20** at 50,000 lbs. As vessel **10** begins to fall, the load cell weight decreases causing swash plate control **28** to increase the swash plate angle to more than 10°. This increased angle increases the torque output of motor **26** to provide more torque to draw works drum **15** and cause the drum to spool up line **16** to bring the load cell weight back to 50,000 lbs. High pressure accumulator fluid from accumulator **32** moves through conduit **33** to power motor **26**. Thereafter the fluid is discharged to conduit **31** and low pressure fluid reservoir **30**. When the vessel stops at the bottom point, the load cell weight increases and causes the swash plate angle to decrease to the 10° stall point. As the vessel starts to rise with the next wave, the load cell weight further increases causing the swash plate control **28** to decrease the swash plate angle to less than 10°. This reduces the torque output of motor **26** below the stall torque and causes the hydraulic motor **26** to rotate in the reverse direction as drum **15** spools off line **16**. Low pressure fluid from reservoir **30** is then pumped by motor **26** acting as a pump back into high pressure accumulator **32** through conduits **31** and **33**. At the high point of vessel travel, the load cell weight decreases and causes the swash plate to shift back to the 10° stall point. Pump **36** in **35** **36** pumps fluid from reservoir **30** to accumulator **32** to make up losses of the counterbalance system by maintaining pressure in the accumulator at 2,000 psi, for example. The above cycle of operation is repeated for each new wave action.

Variable displacement hydraulic motors such as illustrated by motor **26** are conventional and well known to the art. The swash plate angle determines the length of the piston stroke. When operating as a power means to drive draw works shaft **25**, the length of the piston stroke determines torque output and when operating as a pump driven by shaft **25** the length of the piston stroke determines the fluid output. In this manner a constant tension is maintained on the drill pipe by varying the angle of the swash plate through the controller **28** which receives control signals from load cell **20**.

The assembly of apparatus shown in FIG. 2 which will now be described is similar to that of FIG. 1 and the same elements are identified with the same numerals. A fixed displacement hydraulic motor **60** is connected to draw works **15** by drive shaft **25**. The swash plate, not shown, is fixed at a predetermined angle. Hydraulic drive fluid under pressure is transmitted from accumulator **32** to motor **60** through conduit **67**, hydraulic pump **63**, and conduit **62**. Motor **60** is connected to low pressure fluid reservoir **30** by a conduit **61**. Pump **63** is driven by a reversible motor drive **64** through a drive shaft **65**. The torque output of motor drive **64** and its reversibility are

controlled by signals from load cell **20** transmitted to a controller **66** as indicated by dotted line **29***a*.

In the operation of this embodiment of the invention assume loading vessel **10** to be at the top point of heave to the wave action as before. At this point draw works drum **15** is stopped, high pressure accumulator **32** has a pressure of 2,000 psi and the weight on load cell **20** is 50,000 lbs. as before.

As vessel **10** begins to fall the load cell weight decreases causing the torque output of motor **64** to increase and drive hydraulic pump **63** to boost the fluid pressure output of that pump to some pressure above the fluid pressure output provided by the accumulator alone. The amount of pressure boost depends upon the frictional losses to be compensated for in any particular system. The increased fluid pressure supplied to motor **60** through conduit **62** increases the torque output to draw works drum **15** to cause the drum to spool up line **16** to bring the load cell weight back to 50,000 lbs. Hydraulic fluid from motor **60** passes through conduit **61** to low pressure reservoir **30**. When the vessel **10** stops at the bottom point and starts to rise with the next wave, the load cell weight increases and causes hydraulic motor **64** to rotate in the reverse direction as the drum **15** spools off line **16**. Low pressure fluid from reservoir **30** is then pumped back into the high pressure accumulator **32** through conduits **61**, **62**, motor **60** (acting as a pump), pump **63**, and conduit **67**. At the high point of vessel travel the load cell weight decreases and causes hydraulic motor **64** to reverse its direction. In most systems total power for hydraulic pump **63** is in the range of 15 to 20 percent of the power for hydraulic motor **60**. The above cycle of operation is repeated for each new wave action.

Load cell **20** may be any commercial type load cell such as the Martin Decker Model WS-8-1 shown on page 3,246, 1966–67 of the Composite Catalog of Oil Field Equipment and Services. The controller **28** may be a Foxboro, Model 40 apparatus shown on page 1,815 of such Composite Catalog. The swash plate controls may be electric, hydraulic, or pneumatic in operation.

The systems described above will provide compensation for wave action in addition to furnishing a method of varying the bit weight by simple surface control.

Having fully described the apparatus, operation and objects of my invention, I claim

1. Apparatus for maintaining substantially constant tension on well equipment, such as drill pipe, suspended from a traveling block mounted on a floating offshore structure comprising:

a rotatable draw works for spooling up or spooling off line from which said well equipment is suspended;

reversible hydraulic drive means coupled to said draw works for driving said draw works to spool up said line when rotated in one direction and to spool off said line when rotated in a reverse direction and including means for increasing torque for driving said draw works when spooling up said line;

a load cell suspended directly from and movable with said traveling block for transmitting signals proportional to changes in weight of said well equipment;

a controller connected to said hydraulic drive means and to said load cell to control torque output to said draw works and direction of rotation of said hydraulic drive means and said draw works in response to said signals transmitted by said load cell;

a low pressure hydraulic fluid reservoir connected to said reversible hydraulic drive means by a conduit; and

a high pressure hydraulic fluid accumulator connected to said reversible hydraulic drive means by a conduit;

said high pressure hydraulic fluid moving to said low pressure hydraulic fluid reservoir when said load cell decreases below a preselected weight to provide increased torque output to said draw works to spool up line to return said load cell to said preselected weight and low pressure hydraulic fluid moving from said low pressure reservoir to said high pressure accumulator when said load cell weight increases above said preselected weight to provide decreased torque output to said draw works and reverse direction of said hydraulic drive means as said draw works spool off line.

2. Apparatus as recited in claim **1** in which said hydraulic drive means comprises a variable displacement reversible hydraulic motor connected directly to said accumulator and said reservoir, said controller varying the displacement of said motor and thereby the torque output of said motor as well as the fluid output of said motor when said motor functions as a pump.

3. Apparatus as recited in claim **2** including a conduit directly connecting said reservoir and said accumulator to each other; and

a pump in said conduit for pumping fluid from said reservoir to said accumulator to maintain said accumulator pressure at a preselected level.

4. Apparatus for maintaining substantially constant tension on well equipment, such as drill pipe, suspended from a traveling block mounted on a floating offshore structure comprising:

a rotatable draw works for spooling up or spooling off line from which said well equipment is suspended;

reversible hydraulic drive means coupled to said draw works for driving said draw works to spool up said line when rotated in one direction and to spool off said line when rotated in a reverse direction and including means for increasing torque for driving said draw works when spooling up said line;

a load cell suspended directly from and movable with said traveling block for transmitting signals proportional to changes in weight of said well equipment;

a controller connected to said hydraulic drive means and to said load cell to control torque output to said draw works and direction of rotation of said hydraulic drive means and said draw works in response to said signals transmitted by said load cell;

a low pressure hydraulic fluid reservoir connected to said reversible hydraulic drive means by a conduit; and

a high pressure hydraulic fluid accumulator connected to said reversible hydraulic drive means by a conduit;

said hydraulic drive means comprising a reversible fixed displacement hydraulic motor coupled to said draw works and connected to said reservoir;

a hydraulic pump connected to said hydraulic motor and to said accumulator; and

a reversible motor drive coupled to said hydraulic pump, said controller being connected to said reversible hydraulic motor drive to control torque output and direction of said hydraulic motor drive and thereby fluid pressure output of said hydraulic pump;

said high pressure hydraulic fluid moving to said low pressure hydraulic fluid reservoir when said load cell decreases below a preselected weight to provide increased torque output to said draw works to spool up line to return said load cell to said preselected weight and low pressure hydraulic fluid moving from said low pressure reservoir to said high pressure accumulator when said load cell weight increases above said preselected weight to provide decreased torque output to said draw works and reverse direction of said hydraulic drive means as said draw works spool off line.

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