March 10, 1970 E. E. HORTON 3,499,629

CONSTANT TENSION CHAIN JACK ASSEMBLY

Filed March 19, 1968

2 Sheets-Sheet 1

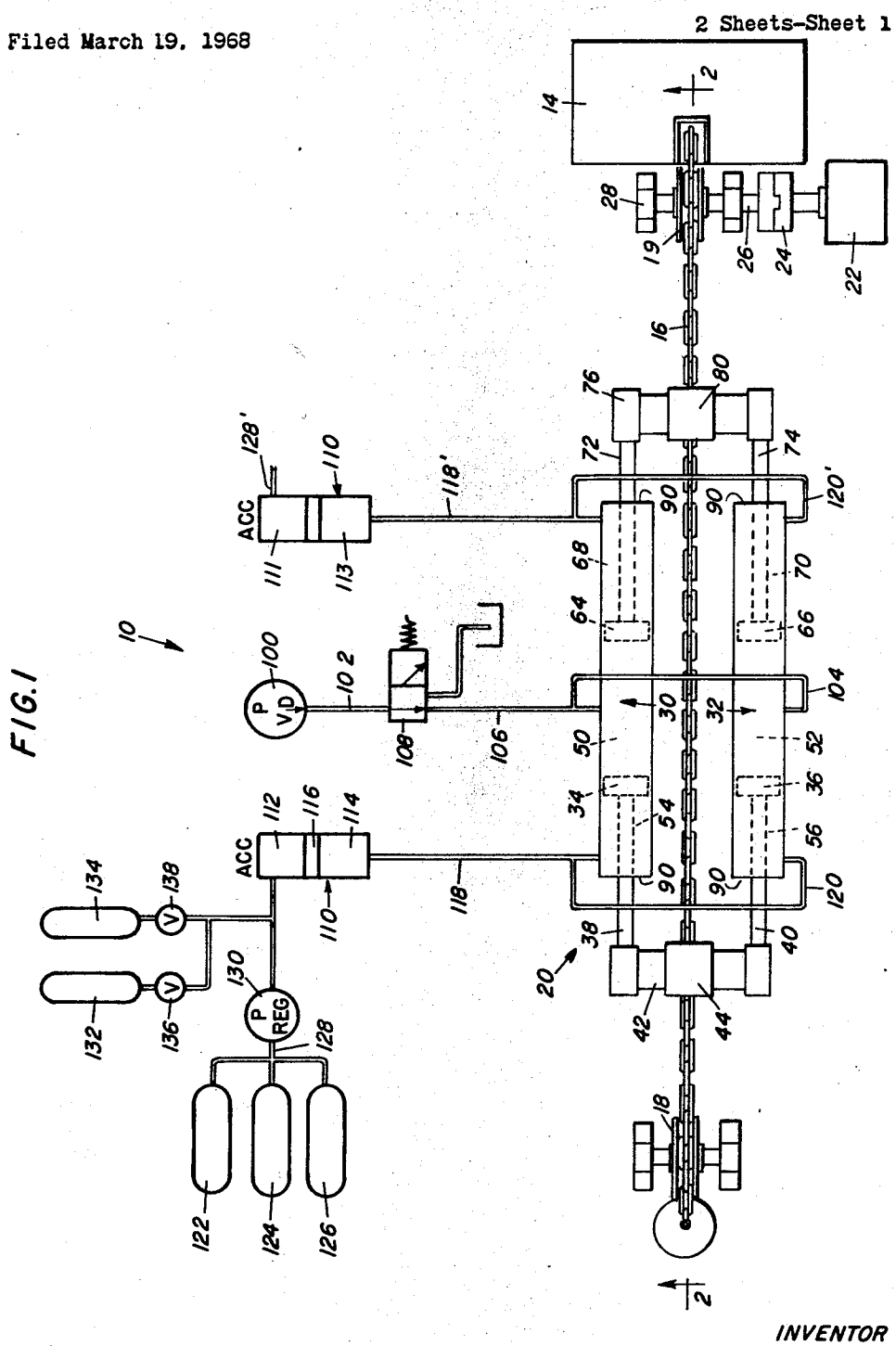


FIG. 1

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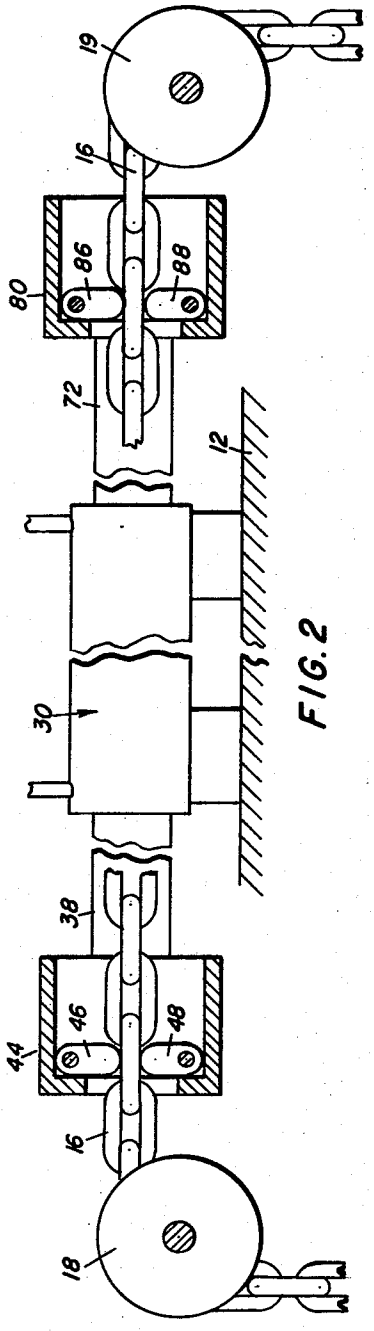


FIG. 2

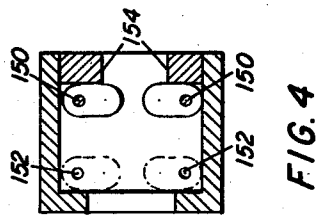


FIG. 4

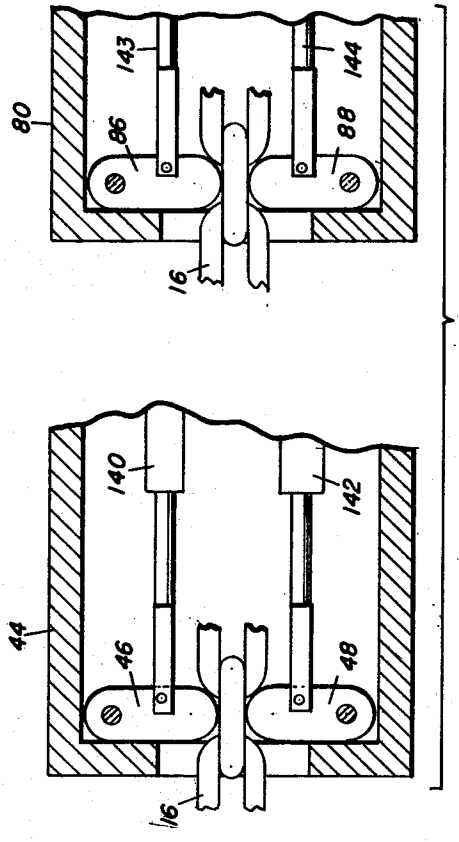


FIG. 3

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CONSTANT TENSION CHAIN JACK ASSEMBLY

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ABSTRACT OF THE DISCLOSURE

An apparatus for the step-by-step paying-out and hauling-in of a chain from a floating vessel wherein hydraulic cylinder means having a gas accumulator bias means working with the expansion chambers thereof permits limited movement of the chain for relieving tension and absorbing shock caused by vessel movements.

This invention relates generally to an apparatus for raising and lowering heavy submerged weights from the bottom of the sea by a chain jacking assembly mounted on a floating vessel. More specifically the invention relates to an apparatus which retrieves sunken objects with a chain and includes means for paying out and hauling in the chain while compensating for the rolls and heaves or other motions of the ship. The device is one particularly adapted for the retrieval of sunken vessels, the raising and lowering of heavy anchors, the pulling down of platforms or buoys and other requirements where heavy objects are manipulated from a floating ship. In addition, the invention is particularly well suited for raising and lowering drilling platforms whereby the sub-base can be lowered to the sea floor from a floating barge or other suitable vessel.

A principal objective of this invention is to provide a chain jacking assembly for lowering and raising the chain in a positive step-by-step procedure.

Another important object of the invention is to provide a means to compensate for vertical movement of the ship during the raising and lowering operations.

Another object of the invention is to maintain constant tension on the lifting chain by having hydropneumatic means compensating for the rolls and heaves of the floating vessel.

Another important objective of this invention is to provide a means for equally distributing the weight of the object which is to be raised or lowered over a number of chains. This is accomplished by the hydropneumatic accumulator system which can be adjusted such that all chain systems are operated at predetermined tensions.

Another important objective of this invention is to provide a hydropneumatic accumulator system wherein the stresses caused by the ship movements are substantially isolated from the lifting chain.

A still further objective of this invention is to provide an adjustable gas spring accumulator for developing a very low spring constant whereby the frequency of the spring response can be adjusted to a point much lower than the rolling frequency of the ship to thereby isolate the ship motion from the object retrieval chain.

These and other objects of the invention will become more apparent to those skilled in the art by reference to the following detailed description when viewed in light of the accompanying drawings, wherein:

FIGURE 1 is a schematic, diagrammatic view of the system;

FIGURE 2 is a partial enlarged diagrammatic elevation view of a portion of the system shown in FIGURE 1;

FIGURE 3 is an enlarged view of the chain stopper mechanism; and

FIGURE 4 is a view of the chain stopper pawls with actuators.

Referring now to the drawings wherein like elements indicate like parts, the numeral **10** generally indicates the chain jack assembly of this invention. The assembly is secured to the deck of a ship indicated by the numeral **12**. Also housed on the deck is a chain supply locker **14** in which a length of chain **16** is stored. The chain **16** is led from the chain supply locker over a sheave **18** through the assembly **10** and then outwardly to a sheave **19**. The outward sheave **19** is supported at the side of the vessel or is extended outwardly from the vessel by a boom construction not shown. From the outward sheave **19**, the chain extends downwardly to the object to be lifted.

Two separate but cooperating power means are provided for paying out and hauling in chain **16**. A hydraulic assembly indicated generally by the numeral **20** is the primary means for these purposes. With reference to FIGURE 1, it can be seen that a wildcat drive motor **22** is also provided to haul in or pay out the chain from its locker in those instances where relatively light or no loads are present. Additionally, as will be seen hereinafter, the wildcat maintains the chain taut during operation of the means **20**. The wildcat drive is powered through a slip clutch **24** and to sheave **18** by way of a drive shaft **26**. The drive shaft and sheave **18** are supported on the deck **12** via a trunnion assembly **28**.

The principal elements of the primary power means **20** are a pair of hydraulic cylinders **30** and **32**. Slidably received in these cylinders is a first pair of pistons **34** and **36** having piston arms **38** and **40** extending forwardly and having their outer ends interconnected by a bracket **42**. The bracket **42** carries a chain stopper apparatus **44** which is best seen in FIGURES 2 and 3. The chain stopper **44** includes a pair of pawls **46** and **48** which engage the chain **16** as it passes therethrough. As seen in FIGURE 2, the pawls will restrict movement (pay-out direction) of the chain to the left but will permit the chain to freely pass to the right (haul-in direction).

The pistons **34** and **36** respectively divide the hydraulic cylinders **30** and **32** into expansion chambers **54** and **56** and middle chambers **50** and **52**. A second set of pistons **64** and **66** are slidably received in cylinders **30** and **32** longitudinally rearwardly of the pistons **34** and **36**. The pistons **64** and **66** are slidable between the middle chambers **50** and **52** and rearward chambers **68** and **70**. Extending rearwardly from the pistons **64** and **66** are a pair of piston arms **72** and **74** joined at their outer ends by a bracket **76**. The bracket member **76** carries a second chain stopper device **80** having pawls **86** and **88** restrict pay-out movement of chain **16** but permit the haul-in movement thereof. In other words, they are operational in the same manner as the pawls of chain stopper **44**. The pistons **34** and **36** are sealed at either end by members **90**.

The main motivating force of the hydraulic cylinder means **30** and **32** is a variable volume, reversible hydraulic pump **100** having an output line **102**. The output line **102** is communicated with the middle expansion chambers **50** and **52** by a pair of hydraulic lines **104** and **106**. Disposed across line **102** is a solenoid control valve **108**. The valve **108** is of a type which causes a selected amount of fluid to enter or leave chambers **50** and **52** upon each actuation thereof.

The main load of any outward pull on chain **16** is principally supported by the fluid in chambers **54** and **56**. An accumulator **110**, divided into an air chamber **112** and a hydraulic chamber **114** by a sliding piston member **116**,

has its hydraulic chamber **114** communicated with the forward chambers **54** and **56** via conduits **118** and **120**.

The gas chamber **112** is maintained at a selected gas bias pressure by a plurality of pneumatic storage back-up accumulators **122**, **124** and **126** via the air pressure hose line **128**. Disposed between the gas chamber **112** and the the back-up accumulators is a conventional pressure regulator control **130**. Additional gas storage members **132** and **134** are connected to hose line **128** between the pressure regulator **130** and the chamber **112**. The additional gas storage members are under the separate control of individual pressure regulators **136** and **138**.

As will be seen more clearly hereinafter, the accumulators provide a gas spring with a very low spring constant. Because of the very high volume ratio between the chamber **112** and the accumulators, the gas spring response can be adjusted to a very slow frequency. This permits the user to tune the response of the gas spring to a frequency much lower than that of the ship itself. Thus, energy is not transferred upon every roll of the ship. An accumulator system partially shown at **110'** is provided for the spring bias in chambers **68** and **70**. In this system, elements corresponding to the elements of the previously described accumulator system are indicated by the same numerals with the addition of prime marks.

In operation, chain **16** is first extended over the sheave **18** through the chain stopper devices **80** and **44** and from there over forward sheave **19** which is normally disposed over the load to be lifted or lowered. The end of chain **16** is adapted to be affixed to a load of substantial weight. In order to lift this weight, the chambers **50** and **52** are pressurized by pump **100**. As the chambers **50** and **52** expand, the pistons are moved outwardly toward their respective ends. Since pawls **86** and **88** are in gripping engagement, the chain **16** is drawn inboard (to the right in the drawings). During this movement, the pawls **46** and **48** are riding over the chain. At the end of this expansion stroke, the stroke distance being controlled by the volumetric characteristics of valve **108**, the pump **100** is reversed and fluid is removed from chambers **50** and **52** causing these chambers to contract. During this portion of the stroke, the pawls of stopper **44** are in engagement with chain **16** and thus carry the chain to the right while the pawls of stopper **80** are riding over the chain. When the pistons reach their neutral position, the pump is again reversed and the cycle is repeated. The wildcat drive maintains a minimum tension on the chain during the entire cycle.

With the pawl arrangements as described above, the apparatus is particularly useful for the hauling in of heavy loads. The pawl placement of FIGURE 3 does not permit pay-out movement of the chain. Of course, it is simple enough to manually move the pawls out of engagement when the chain is not under load to permit pay out.

However, there are circumstances when it is necessary to lower a heavy object. The unit can be connected for such use by merely extracting the pins **150** from apertures **152** and displacing the pins and their respective pawls to the positions shown in FIGURE 3. Stop bosses **154** are provided on the interior surface of stoppers **44** and **80** to position the pawls in their engagement positions.

In FIGURE 3 the chain stopper mechanisms **44** and **80** are shown in enlarged detail showing a further embodiment of the invention. In this embodiment the pawl units **46**, **48**, **86** and **88** are connected respectively to hydraulic actuators **140**, **142**, **143** and **144**. The actuators are utilized to move the pawls independently of the particular forces to which the pawls are subjected by chain tension. Thus, the lifting and lowering capacities described above can be accomplished without a requirement of removing pins or otherwise changing the pawl pivot positions.

For instance, when lowering a weight, the pump **100** pressurizes chambers **50** and **52** to extend the arms **38**, **40**, **72** and **74**. During this expansion stroke, the arms of the actuators **142** and **143** are withdrawn so that pawls **86** and **88** are disengaged and the pawls **46** and **48** are moved to engagement with the chain to carry the chain inboard. When pump **100** is reversed to withdraw fluid from chambers **50** and **52**, the pawls are moved to their opposite position. The pawls are similarly controlled for lifting a weight.

There has been described an apparatus which can haul in, pay out or hold fast a loaded chain extending from a vessel while maintaining constant tension on the chain while performing any of these functions. For instance, presume the apparatus in neither paying out nor hauling in and the deck **12** heaves upwardly away from the load to which the chain is attached. The stopper units will not permit movement in this direction but all of the pistons **34**, **36**, **64** and **66** will move to the left permitting a relaxing pay out of the cable. Since the volumes in chambers **50** and **52** are fixed (when pump **100** is neither supplying nor extracting) the movement is against the spring bias in chamber **112**. There is a consequent reduction in pressure in pneumatic chamber **111** of accumulator **110**. The accumulators will then work to stabilize the system until the equilibrium position of FIGURE 1 is realized.

As the deck **12** dips toward the load, the opposite occurs. That is, the equilibrium pressure will be upset and the pistons will move to the right in opposition to the pneumatic bias created in chamber **111**. Again the gas bias systems will act until the equilibrium position is realized. Since the solenoid valve **108** meters a particular amount of fluid during the expansion and contracting stroke of a lifting or lowering operation, the accumulator balance system is just as effective during these operations.

In a general manner, while there has been disclosed effective and efficient embodiments of the invention, it should be well understood that the invention is not limited to such embodiments, as there might be changes made in the arrangement, disposition, and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What is claimed is:

1. An assembly for raising, lowering and suspending a heavy object by a chain from a floating vessel disposed over said object, the improvement for maintaining said chain under substantially uniform tension comprising a hydraulic cylinder means affixed to the deck of said vessel along an intermediate length of said chain, a piston means slidable within said cylinder means and dividing said cylinder means into first and second chambers, chain engaging means connected to said piston means, a first hydropneumatic spring means in communication with said first chamber, a second hydropneumatic spring means in communication with said second chamber, an accumulator means forming a part of said first hydropneumatic spring means and means for adjusting the volumetric ratio between said first chamber and said accumulator means.

2. The improvement of claim **1** wherein said first and second hydropneumatic spring means exert pressures on said piston means to normally center said piston means longitudinally of said cylinder means.

3. The improvement of claim **1** wherein said piston means comprises first and second members having a middle chamber therebetween.

4. The improvement of claim **3** wherein a variable power reversible pump delivers fluid and extracts fluid from said middle chamber.

5. The improvement of claim **4** wherein said first piston member has an arm extending outwardly from first chamber end of said cylinder means and said second piston member has an arm extending outwardly from the second chamber end of said cylinder means and said chain engaging means comprised of one-way pawl means are mounted on each of said arms in engagement with said chain.

6. The improvement of claim **5** wherein said pawl means restrict movement of said chain toward said object

but permit said chain to freely pass in the opposing direction.

7. The improvement of claim 5 wherein actuators for selectively positioning said pawls are mounted on said assembly.

8. The invention of claim 2 wherein said cylinder means includes first and second cylinders and said first piston means includes first and second piston arms extending beyond the end of said cylinders and said chain engaging means comprised of cooperating pawls are mounted at their outer ends in engagement with said chain.

9. The invention of claim 8 wherein said second piston means includes third and fourth piston arms extending beyond the outer ends of said cylinders and second cooperating pawls are pivotally secured to the outer ends thereof.

10. The invention of claim 1 wherein a drive motor having a slip clutch is disposed on said deck in driving relationship with said chain.

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