Dec. 2, 1969 L. H. CONRY ET AL 3,481,584

CONSTANT TENSION WINCH

Original Filed June 7, 1967 3 Sheets-Sheet 1

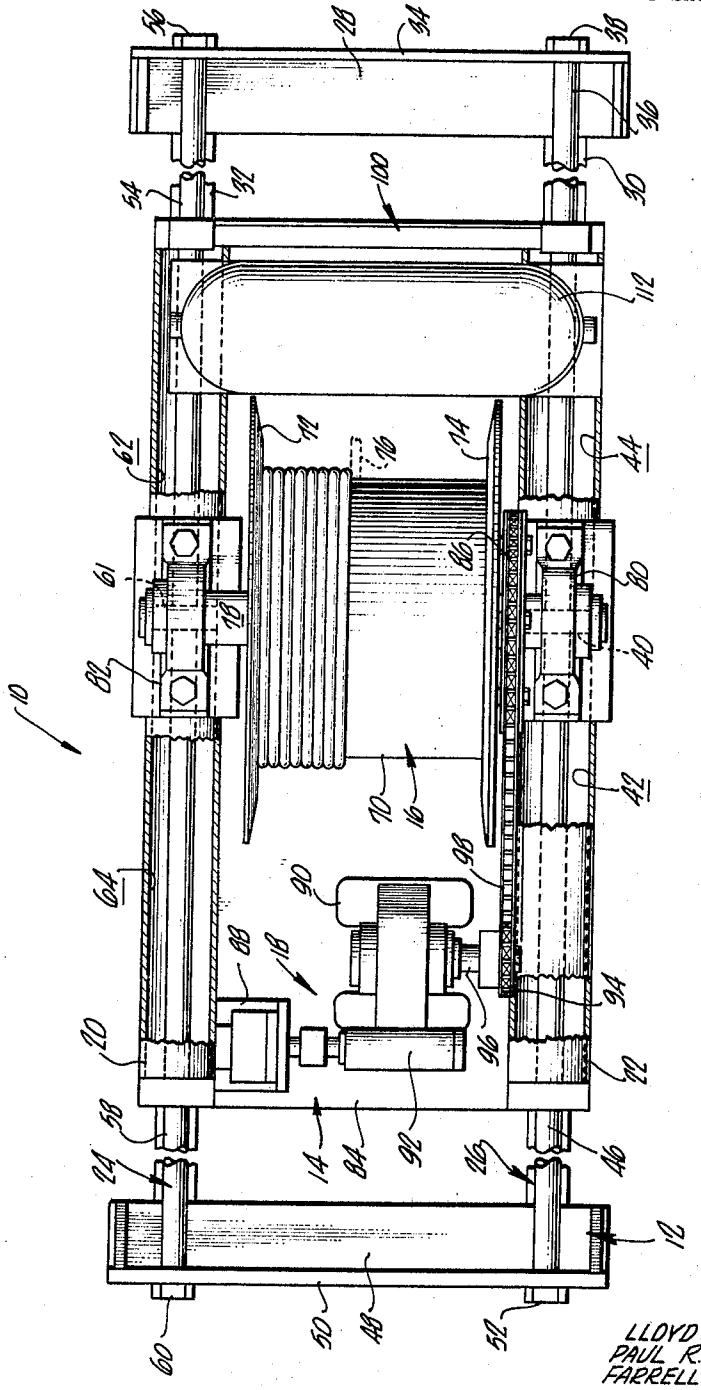


FIG. 1

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CONSTANT TENSION WINCH

Original Filed June 7, 1967 3 Sheets-Sheet 2

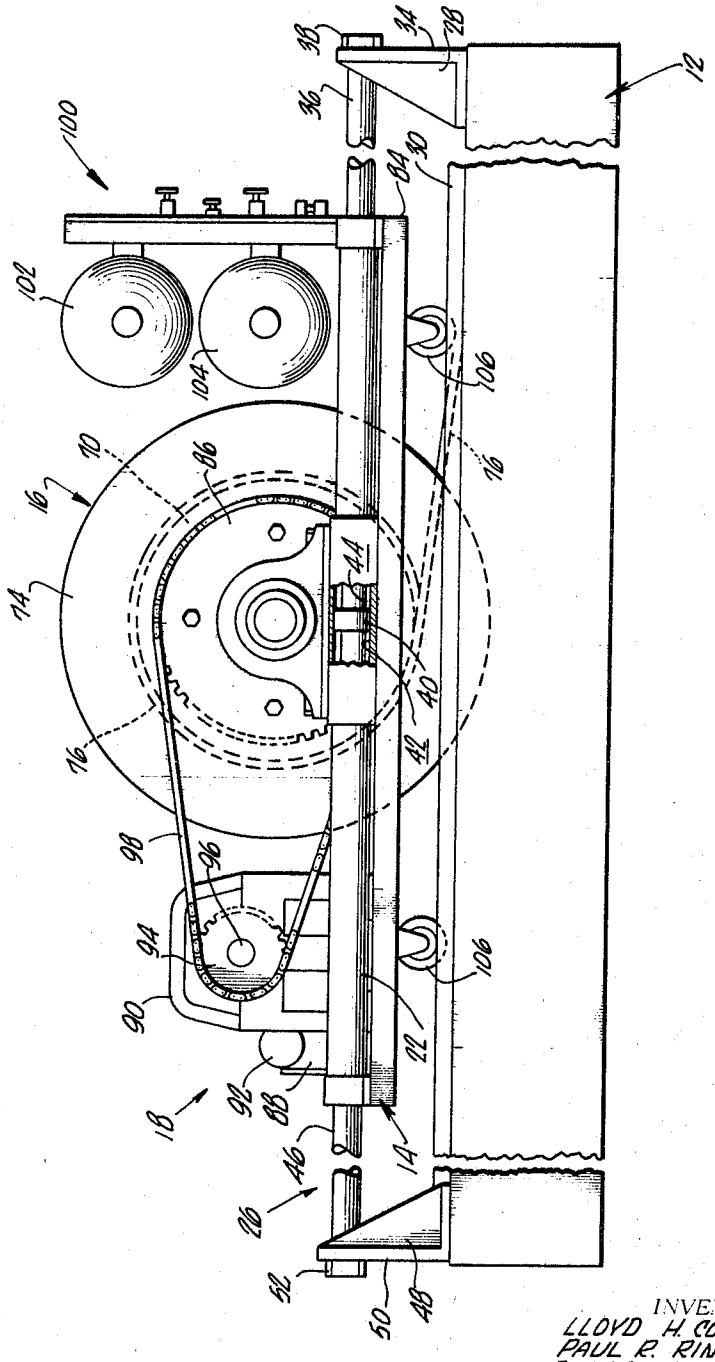


FIG. 2

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CONSTANT TENSION WINCH

Original Filed June 7, 1967 3 Sheets-Sheet 3

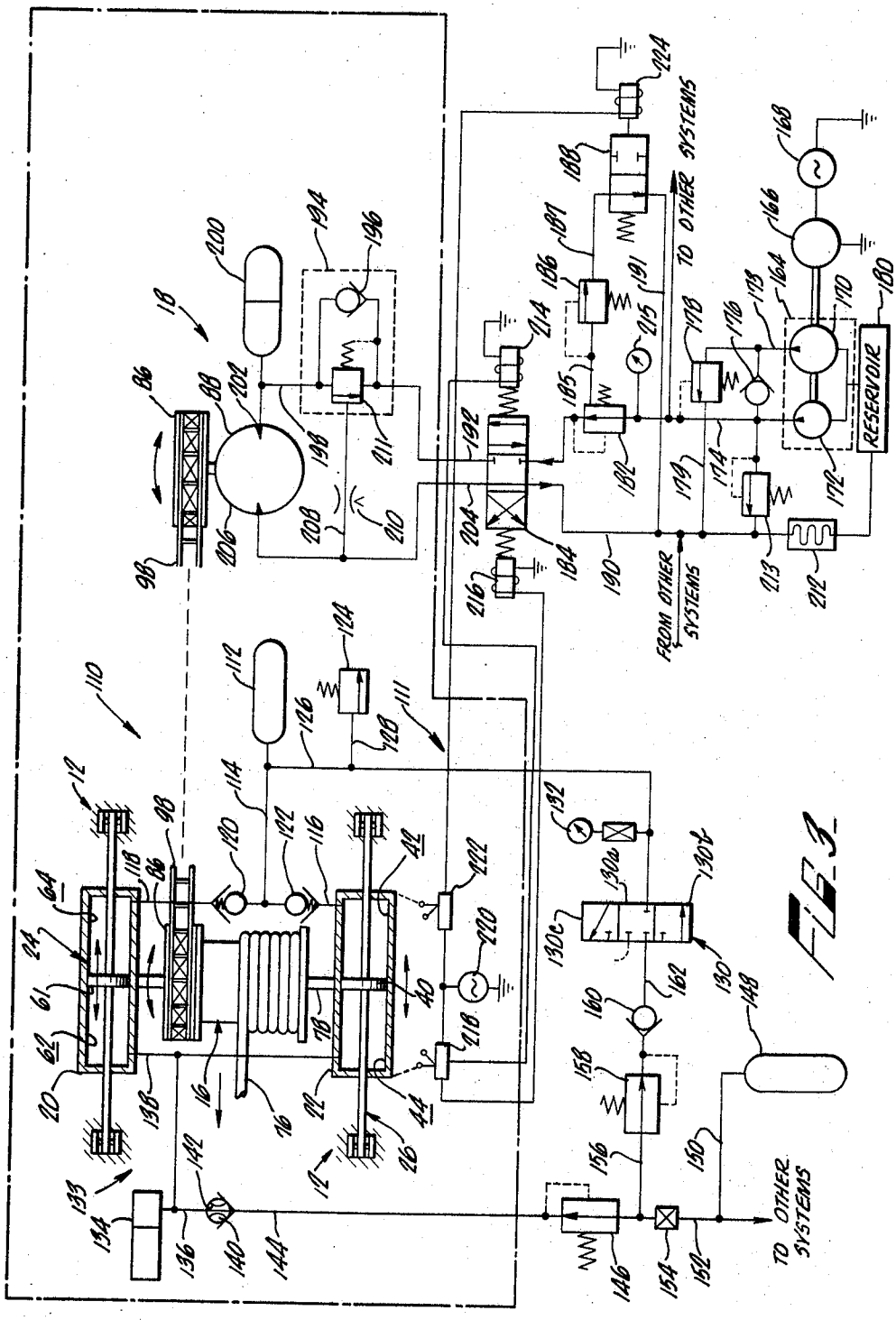


FIG. 3

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3,481,584

CONSTANT TENSION WINCH

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Continuation of application Ser. No. 644,135, June 7, 1967. This application Jan. 21, 1969, Ser. No. 796,286
Int. Cl. B66d 1/48; F01b 25/04
U.S. Cl. 254—172 25 Claims

ABSTRACT OF THE DISCLOSURE

A winch is mounted for translation on its base in response to relative displacement between the base and the point of attachment of the winch's cable. The tension on the winch's cable is maintained constant despite this relative displacement by coupling the winch drum to the base through a pair of movable cylinders in each of which a piston is disposed; the pistons are, in turn, secured to the base. A pressure differential exists across the piston of each cylinder which acts on the cylinders and maintains a predetermined, constant tension on the cable while the winch is stationary, yet allowing the winch to translate with respect to the base in response to the relative displacement of the base and cable attachment point. When displacement of the base with respect to the cable's point of attachment becomes relatively large, the winch's drive operates to haul in or pay out cable to reposition the winch intermediate its translational limits.

This is a continuation of Ser. No. 644,135, filed June 7, 1967, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to the art of winches and, more in particular, to a winch which maintains a predetermined tension on its cable despite relative movement between the winch's base and the point of cable attachment on an object.

There are many applications for a winch in environments where the winch and the subject attached to the winch's cable experience relative movement. It is often necessary, in this type of environment, to maintain constant tension on the cable of the winch. Cable tension can be maintained constant by paying out or hauling in cable to compensate for the relative movement; however, this type of compensatiton often requires the constant operation of the winch drive and is often not responsive enough to avoid unsatisfactory variations in desired cable tension.

One environment where relative displacement between the winch and its point of attachment on an object is constantly occurring is in marine winch applications. A winch used on a dock having its cable attached to a ship, for example, will experience relative displacement between the ship and the winch because of swell and wave action as well as tidal changes.

Offshore drilling is another application where constant cable tension is often required and relative movement between the point of cable attachment and the winch is experienced because of swell, wave and tidal action. Guide lines or risers are normally employed in marine drilling which run between a drilling ship and the ocean's floor for lowering and raising drilling equipment. These lines are maintained under tension to prevent lateral current displacement which would otherwise affect the efficient transport of drilling equipment and the like between the vessel and the drilling site.

Previously, guide line or riser tensioning in offshore drilling has been accomplished through the use of counter-

weights by running each guide line from the drilling site over a ship-supported shieve and attaching a counterweight at the free end of the line. The counterweight maintains guide line tension despite wave action, swells and tidal changes because it displaces vertically in response to these forces. However, the counterweight system is extremely cumbersome and, when a large cable tension is needed, requires an extremely heavy weight.

Constant guide line or riser tension has also been accomplished by using a piston and cylinder system where fluid pressure acts on the piston which through pulleys is attached to the guide line. The fluid pressure maintains the tension and the piston moves with vertical ship movement to pay out or take in cable as required. This type system, while effective for wave and swell action, does not compensate for tidal changes because of the relatively large amount of displacement required and thus has limited value. Notwithstanding the effectiveness in any particular instance of the counterweight and fluid pressure systems just described in maintaining cable tension, these systems are not useful for any other purpose. When risers or guide lines are initially deployed to or subsequently removed from a drilling site, a winch must be used. Previous winches, however, do not have a responsive enough drive to compensate for ocean displacement forces and maintain cable tension constant because of the time required, whether hauling in or paying out cable, to actuate and turn off the winch's drive. Moreover, even if there is a sufficiently responsive drive, the constant operation of the drive would be wearing and require a large amount of power.

SUMMARY OF THE INVENTION

The present invention provides a winch which is operable to caintain constant tension on its cable despite displacement between the point of cable attachment and the winch.

In one form, the invention contemplates mounting a winch drum on a carriage and coupling the carriage to a base by means of which are operable in such a manner that a selected, predetermined tension is maintained on the cable despite relative movement between the base and the point of cable attachment on an object by maintaining the carriage-to-object distance substantially constant. Carriage-to-object distance is maintained constant by allowing the carriage to translate on the base an amount corresponding to but in the opposite direction from relative movement between the base and object. The coupling of the carriage to the base is such that a predetermined tension on the cable is balanced by a substantially constant force which is equal in magnitude to but opposite in direction from the predetermined tension and which constitutes to act despite translational position change of the carriage with respect to the base. The winch further includes means for rotating the winch drum to dispense or take in cable.

In preferred form, the winch drum together with its carriage are coupled to the base through at least one piston cylinder pair. Each piston and cylinder is capable of movement with respect to each other. Physical coupling is accomplished by attaching each piston to the base while the carriage is attached to the cylinder, or the converse. The predetermined tension is maintained and balanced by a pressure differential supplied by pressure means acting within the cylinders and in opposition to the predetermined tension, that is, the carriage and winch drum are maintained in position relative to the base by pressure acting in the cylinders. Upon relative movement of the base towards or away from the point of cable attachment, the carriage and winch drum move an equivalent distance because the cylinders move in response to

such displacement. Each piston may be disposed in its associated cylinder such that two chambers are defined which are separated from one another by the piston. With the two-chamber cylinder configuration, a dampening pressure may be exerted in one of the chambers to prevent rapid and catastrophic translation of the winch drum with respect to the base when cable tension is suddenly released as occurs, for example, when the cable breaks. The pressure differential between the two chambers is maintained such that the predetermined tension on the cable is balanced by the pressure acting in one of the chambers. The two-chamber cylinder configuration also admits to the ready adjustment of the desired predetermined tension by simply varying the pressure differential acting across the piston.

Preferably, the pressure is maintained within the cylinders by a pneumatic or a hydraulic fluid system which includes an accumulator in fluid communication with one of the chambers to exert a dominant pressure that balances the cable tension and the dampening pressure existing in the alternate chamber. The pressure in the two chambers may be adjusted for varying the desired cable tension by a valve. The valve is selectively operable to release or increase tension on the cable by venting or charging the accumulator. The accumulator may be charged from a charging cylinder through the valve. An isolating valve, such as a check valve, prevents pressure communication between the tensioning and dampening chambers. To facilitate adjustment of desired cable tension and maintain pressure in the dominant chambers, a regulator may be employed between the dominant pressure chambers and the charging cylinder which prevents a pressure differential exceeding that corresponding to the predetermined tension.

The invention preferably provides elements to prevent structural damage to the winch when cable tension fails. One of these elements is a prechargeable accumulator in fluid circuit with the dampening chambers to accept fluid from the dampening side of the circuit when the pressure becomes high and prevent an excessive pressure buildup, upon a sudden release of cable tension, which might otherwise rupture the system. The dominant pressure chambers are, in turn, coupled in fluid circuit with their accumulator through check valves which are operable to terminate pressure communication between these chambers and their accumulator when the pressure in the accumulator exceeds the pressure in the chamber by a prescribed amount. The check valves act as a safety measure to isolate the chambers from their pressure source when cable tension is suddenly released and thereby prevents, under these conditions, the accumulator's pressure from accelerating the rate of translation of the winch drum and carriage with respect to the base.

A gas, such as nitrogen, is the preferred fluid used in the first tensioning and second dampening chambers. Gas is used because the chambers are constantly undergoing volume changes at a rapid rate with the result that fluid flow is at a high velocity. If a liquid was used, friction loss in the attendant lines would be extremely high. Stated in a different manner, the preferred tension and dampening system operates by conserving energy. The conservation of energy requires a minimum loss of energy through friction and, thus, a gas is used as the working fluid.

Preferably, the winch drive includes a two-directional hydraulic motor, hydraulic pumps to supply the power to the motor and means to drive the pumps. The hydraulic motor is in hydraulic circuit with the pumps with hydraulic circuit elements included which effect a high-driving torque on the motor when cable haul-in is required and a relatively low-driving torque when cable payout is required. The hydraulic drive means are actuated to pay out or haul in cable when certain translational limits of the carriage with respect to the base have been reached as the result of relative displacement between the base and the object held by the cable. This hauling in or paying out of cable may be required, for example, to compensate for tidal variations. The means for actuating the hydraulic drive may include limit switches disposed at either end of the carriage which, upon sensing a displacement limit, actuate a valve to provide sufficient hydraulic pressure across the motor to effect the requisite amount of cable haul-in or payout. In addition, the hydraulic circuit includes elements which present a backpressure on the hydraulic motor that acts in opposition to the main hydraulic pressure when cable is being dispensed in order to control the rate of cable payout. Such circuit elements may include a prechargeable accumulator in hydraulic circuit with the motor. The hydraulic pump is preferably of the type which produces a low pressure, high capacity discharge and a high pressure, low capacity discharge. The low pressure, high capacity pump is used to effect a rapid pressure buildup to the motor and for high speed, low torque periods on the fluid motor. Means are preferably provided to take the high capacity pump out of hydraulic circuit when a predetermined pressure is reached.

Preferably, hydraulic pressure exists at all times on the fluid motor to effect a rapid application of power to the winch when cable haul-in is required. The power necessary to haul in cable is considerably higher than that required to pay out cable because the winch is required, in the former instance, to overcome the tension of the cable. The timely application of power to the winch to haul in cable and thereby center the winch drum with respect to the base is important if constant tension is to be maintained. The existence of hydraulic pressure across the fluid motor accomplishes this end because a modest increase of pressure causes the motor to respond rapidly. This feature takes advantage of the fact that fluid motors, under load, have a relatively broad stall range where no power is produced despite a relatively large pressure drop. Thus, the hydraulic circuit is preferably adapted to supply a pressure to the motor within the latter's stall range at all times and for increasing the pressure rapidly upon command. This may be accomplished by an appropriately placed reducing valve in circuit between the hydraulic pumps and motor for adjusting the pressure across the motor to within its stall range and means for effectively removing the reduced valve from the hydraulic circuit when the motor is called upon to haul in cable.

The winch of the present invention provides a convenient means for maintaining a predetermined cable tension despite relative movemet between the winch's base and the cable attachment point by allowing the winch drum to move in either direction in response to such relative movement. Cable tension is maintained constant by applying a restraining force to the winch drum which balances the tension, preferably through pressure acting in a piston-cylinder system. Thus, rapid and accurate response to relative movement between the winch and the point of cable attachment is achieved by allowing the winch drum to move with the displacement and restraining the drum in such a manner that the predetermined tension is always maintained.

The winch of the present invention is especially valuable in marine environments where small but rapid displacements occur due to wave and swell actions which are rapidly compensated for to prevent undesirable variations in cable tension by the unique winch-drum and the mounting of the invention. Long-term movement between the winch and the point of cable attachment is expeditiously compensated for by the hydraulic system which is operative to pay out or take in cable as required to readjust the position of the winch drum with respect to the base.

Relative to the previously described means to maintain constant cable or riser tension, the winch of the present invention provides a compact unit which affords compen-

sation for both tidal and wave motions while in the same unit providing the faciliting for cable dispensing and reeling.

These and other features, aspects and advantages of the present invention will become more apparent from the following description, appended claims and drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIGURE 1 is a plan view, partly in section, of a preferred embodiment of the winch of the present invention;

FIGURE 2 is a side elevational view, partly in section, of the embodiment shown in FIGURE 1; and

FIGURE 3 is a schematic depiction of the apparatus shown in the preceding figures with the preferred manner of maintaining predetermined tension on the winch's cable.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGURES 1 and 2 depict the general form of the constant tension winch of the present invention. Reference numeral **10** is used to denote the winch in general. Base **12** supports carriage assembly **14** which, in turn, carries winch drum assembly **16** and winch drum drive assembly **18**. Carriage **14** is coupled to base **12** for translation with respect to the base through a pair of cylinders **20** and **22** which, in turn, contain stationary piston assemblies **24** and **26**, respectively.

The stationary components of constant tension winch **10** include base **12** and piston assemblies **24** and **26**. Base **12** includes cross beam **28** which is rigidly secured to a pair of base rails **30** and **32**. A generally vertical, upright flange **34** forms a part of cross beam **28**. Piston assembly **26** includes a shaft **36** which is secured to upright flange **34** at its outer terminal end by nut **38**. Shaft **36** extends into cylinder **22** for connection with a piston **40**. Piston **40** divides cylinder **22** into a first chamber **42** and a second chamber **44**. As will subsequently become more apparent, cylinder **22** translates with respect to piston **40** to maintain constable cable tension. Piston assembly **26** further includes a second shaft **46** which extends from its connection with piston **40** through cylinder **22** for connection to base **12**. The connection of shaft **46** to base **12** is provided through a cross beam **48** which has an upright flange **50** cooperating with nut **52** to secure the shaft in place.

Piston assembly **24** includes a shaft **545** which extends to the right and out of cylinder **20** for connection through a nut **56** to upright flange **34**. A second shaft **58** of piston assembly **24** extends to the left and out of cylinder **20** for connection through a nut **60** in upright flange **50**. Shafts **54** and **58** are connected in cylinder **20** through a piston **61**. Piston **61** is disposed in like fashion to piston **40** of piston assembly **26** and therefore divides cylinder **20** into two chambers. The first chamber is shown by reference numeral **62** and the second chamber by reference numeral **64**. As with cylinder **20**, cylinder **22** translates with respect to base **12** to carry winch drum assembly **16** and carriage **14** a distance corresponding to the relative movement between base **12** and the point of cable attachment.

Cylinders **20** and **22** are coupled for translation with carriage **14** along piston assemblies **24** and **26**. The weight of the carriage and its associated structure are therefore carried by shafts **54** and **58** of assembly **24** and shafts **36** and **46** of assembly **26**. To minimize the size of these shafts while maintaining proper tracking, the shafts are preloaded in tension.

Winch drum assembly **16** includes drum **70** which has a pair of outwardly disposed cable flanges **72** and **74**. A cable **76** is wound about the cylindrical portion of drum **70** in a standard manner and is constrained laterally by the flanges in a well-known manner. An axle **78** supports winch drum assembly **16** and forms a part of carriage **14**. Axle **78** is mounted for rotation in journals **80** and **82** which in turn are secured to platform or skid **84** of carriage **14**. A sprocket **86** is fixed to drum **70** on flange **74** and forms a part of drum drive assembly **18**. Drum drive assembly **18** includes hydraulic motor **88** which is mounted on skid **84** of carriage **14**. Hydraulic motor **88** is operatively coupled to reduced **90** through drive **92**. Sprocket **94** is secured to an axle **96** which in turn is driven by reducer **90**. A chain **98** is engaged on sprockets **94** and **86** to complete the power train between hydraulic motor **88** and drum **70**. Chain **98** acts in opposition to cable **76** to minimize the load on axle **78**.

Control panel **100** rides with carriage **14** and forms a part of the carriage positioning and tension control apparatus to be described. This apparatus includes accumulators **102** and **104** which are mounted on panel **100**. Carriage **14** and its carried structure are supported above base **12** on rails **30** and **32** through rollers. These rollers include a pair of rollers **106**, shown in FIGURE 2, which track on rail **30**. A complementary pair of rollers, not shown, track on rail **32**. The weight of cariage **14** and its supported structure may be carried by base **12** through shoes or the like in order to adapt winch **10** for a vertical, slanted or an upside-down orientation, any of which may be required in a given application. In addition, the weight of carriage **14** may, if desired, be transmitted to base **12** through piston assemblies **24** and **26**.

Carriage **14**, winch drum assembly **16**, and winch drive **18** are capable of translating fore and aft with respect to base **12**. This translational facility allows the maintenance of a constant, predetermined tension cable **76** when base **12** moves with respect to the anchor point of cable **76**.

The translational facility of constant tension winch **10** and the manner in which a predetermined tension is maintained on its cable is best understood with reference to FIGURE 3. In general, cable tension is maintained by a pressure differential between the opposing chambers of cylinders **20** and **22** and varied by adjusting this pressure differential.

Translation and tension control of winch assembly **16** and its cable **76** is accomplished through pneumatic circuit **110**. Branch **111** of circuit **110** is responsible for maintaining cable tension. Branch **111** includes an accumulator **112**, corresponding to accumulator **102** of FIGURES 1 and 2, which supplies gas under pressure to chambers **64** and **42** of cylinders **20** and **22**, respectively. This accumulator may be a gas bottle or the like. Pressure communication between accumulator **112** and chambers **64** and **42** is provided through line **114** which emanates from the accumulator and branches into lines **116** and **118**. Line **118** is in fluid and pressure communication with chamber **64** while line **116** is in fluid and pressure communication with chamber **42**. Spring-loaded check valve **120** in line **118** allows pressure and fluid communication between accumulator **112** and chamber **64** under normal operating conditions. Therefore, the orientation of the check valve is such that its spring urges it open until a predetermined pressure differential exists between accumulator **112** and chamber **64** which is in excess of that experienced under normal operating pressure. In like manner, check valve **122** is interposed in line **116** between accumulator **112** and chamber **42**. Valve **122** normally permits fluid and pressure communication between chamber **42** and accumulator **112** but terminates such communication when the pressure differential between the accumulator and chamber **42** exceeds the predetermined value mentioned above. Relief valve **124** is in pneumatic circuit with accumulator **112** through lines **126** and **128**. The relief valve is set to open to prevent the pressure in tension maintaining branch **111** from increasing beyond a prescribed value. Line **126** continues past relief valve **124** to balance valve **130**. Gauge **132** is connected through a valve to line **126** to monitor pneumatic pressure in the line and, therefore, to indicate the tension of cable **76**.

Circuit **110** includes a system for supplying a dampening pressure in chambers **44** and **62** of cylinders **22** and **20**, respectively. This dampening branch of the circuit is

indicated generally by reference numeral **133**. The dampening system includes precharged accumulator **134** which is in communication with chambers **44** and **62** through lines **136** and **138**. Precharged accumulator **134** is in circuit with chambers **44** and **62** to prevent an excessive pressure increase in branch **111** in the event of cable failure. The accumulator accepts fluid from these chambers when a predetermined pressure is reached while allowing the pressure to act in dampening cylinder travel. The predetermined pressure may be, by way of example, 600 p.s.i. while the normal operating pressure within chambers **44** and **62** is 40 to 50 p.s.i. Normal accumulator action to compensate for changes in the volumes of chambers **44** and **62** is provided by the dampening circuit's lines.

Dampening branch **133** is connected to a gas charging cylinder through check valve **140**. Check valve **140** is interposed in line **136** and contains a bleed orifice **142** which pressure-communicates line **136** with line **144**. Check valve **140** is disposed to open when the pressure in line **136** exceeds the pressure in line **144** to allow charging of the dampening branch. Regulator and relief valve **146** is also in line **144** and serves to prevent overcharging of system **133** by establishing a predetermined pressure within the line during charging.

Charging cylinder **148** is connected through lines **150** and **152** through shutoff valve **154** to branches **111** and **133**. Line **152**, in turn, may go to other constant tension winch systems which may be required in a given operation. A regulator **158** is coupled in circuit in the line **156** and together with regulator **146** maintains pressure in branches **111** and **133** to compensate for leakage once pneumatic circuit **110** is charged with gas. Regulator **158** is adjusted to balance the pressures between chambers **42** and **64** of cylinders **22** and **20** to that value corresponding to the desired predetermined tension during the tensioning process. Check valve **160** is interposed between regulator **158** and balance valve **130** to prevent fluid flow in a direction away from the valve.

Valve **130** is employed to establish the desired predetermined tension in cable **76**. After the predetermined tension is set, the valve is oriented in position **130*b*** to communicate charging cylinder **148** with tension maintaining branch **111**. The center position, chamber **130*a***, isolates lines **162** and **126** from each other. Chamber **130*c*** is employed to release tension. In operating condition, the opposing chambers of cylinders **20** and **22** are out of fluid and pressure communication because of check valve **160**. Tensioning chamber **130*b*** of valve **130** is positionable to provide communication between lines **126** and **162**, as indicated by the flow arrow in chamber **130*b***, and, thus, to communicate charging cylinder **148** with accumulator **112**. Valve chamber **130*c*** isolates line **162** and opens line **126** to atmosphere to release or reduce tension.

Normal operation is effected through drum drive assembly **18**. However, the drive assembly also serves in repositioning winch assembly **16** and carriage **14** when cylinders **20** and **22** are close to the limits of their travel in either direction. Drive assembly **18** effects a high torque on winch drum **70** when cable is being reeled in and a relatively low toque when cable is being dispensed. In addition, a hydraulic brake is provided to prevent cable runaway when cable is being paid out.

Drum drive assembly **18** includes a two-directional hydraulic motor **88** which receives its power through hydrauplic pumps **164**. Pumps **164** are in turn driven by an electric motor **166** which is energized through a power source **168**. Pump **164** includes a high volume, low pressure pump **170** and a low volume, high pressure pump **172**. The outlet of pump **170** is in communication with a discharge line **173** and with a main hydraulic line **174** through a check valve **176** between the two lines. Valve **176** is positioned to allow flow only from pump **170** into line **174** to prevent fluid from line **174** from entering discharge line **173** of pump **170**. Pump **170** is connected through an unloading valve **178** to reservoir **180**. When the pressure in main hydraulic line **174** exceeds a given value, for example 700 p.s.i., the pilot line of valve **178** senses this pressure and opens valve **178** to communicate the discharge of pump **170** with unloading line **179** which leads to reservoir **180**. Thus, the opening of valve **178** effectively takes the low pressure pump out of hydraulic circuit. Pump **170** accelerates the rate of pressure increase in the hydraulic circuit of drive assembly **18** but is not required after a predetermined pressure has been reached.

Pump **172** is directly in communication with main hydraulic line **174** and through a pressure reducing valve **182** to a control valve **184**. The setting of control valve **184** determines whether motor **88** will haul in or pay out cable. The chamber of pressure reducing valve **182** is in communication through a line **185** with a relief valve **186** which in turn is connected in hydraulic circuit through a line **187** to a two-way valve **188**. Two-way valve **188** is in turn connected to return line **190** through line **191**. As will subsequently become apparent, valve **188** closes when a high torque is required on motor **88**. Valve **186** is normally closed but opens when its pilot line sees the requisite pressure in line **185**, a condition which occurs in normal operation to allow motor **88** to be maintained in a stall condition.

A line **192** communicates control valve **184** with a counterbalance valve **194** which contains a check valve **196** to allow hydraulic communication between line **192** and a line **198**. The counterbalance valve allows hydraulic fluid flow from lines **174** and **192** to reach motor **88** in its high torque and stall mode while allowing return of fluid from the motor to reservoir **180** in the low torque mode. Accumulator **200**, which may be of the bladder type, supplies a constant pressure in line **198** and at inlet **202** of motor **88**. The accumulator also presents a backpressure to fluid entering the left side of the motor. Check valve **196** thus prevents loss of accumulator pressure through line **192**.

A line **204** passes from control valve **184** to motor inlet **206**. A pilot line **208** extends between line **204** and valve **194**. A needle valve **210** is interposed in line **208** to prevent excessive hydraulic fluid flow in the pilot line. Balance valve **194** includes valve **211** which normally closes line **198** to line **192**. The pressure existing in pilot line **208**, upon reaching a given value will, however, open valve **211** to allow hydraulic fluid return through line **192** to line **190** when motor **88** is operated in its low torque, cable payout mode.

A heat exchanger **212** in interposed in return line **190** to cool hydraulic fluid before it enters reservoir **180**. Relief valve **213** is in hydraulic circuit with the outlets of pumps **170** and **172** to prevent excessive pressure in line **174**. Gauge **215** monitors the pressure in line **174**.

Control valve **184** is selectively operable to communicate hydraulic line **174** with hydraulic line **192** by a solenoid **214**. In normal and preferred operation, solenoid **214** is always energized and lines **174** and **192** in communication until cable payout is required. Line **174** is communicated with line **204** by the energization of solenoid **216** when it is desired to pay out cable from drum **70**. When solenoid **216** is energized, line **192** is communicated with return line **190** for the discharge of fluid into reservoir **180**. Solenoid **216** is in circuit through single throw, double pole limit switch **218** with power source **220**. When limit switch **218** closes, solenoid **216** is energized and solenoid **214** de-energized. Limit switch **222** is in circuit with power source **220** and controls solenoid **224** of valve **188** to close the valve and prevent loss of hydraulic pressure from line **174**.

Operation

The operation of constant tension winch **10** in maintaining a constant tension on cable **76**, despite displacement between base **12** and the point of cable attachment

on an object, is best understood with reference to FIGURE 3. This description of the operation will also illustrate the manner in which a predetermined tension on cable **76** may be adjusted to a desired value and the establishment of a stall condition in motor **88**.

Pneumatic circuit **110** is charged with its working fluid by charging cylinder **148**. Branch **111** is charged by opening valve **154**, adjusting valve **130** to communicate lines **162** and **126** and allowing pressure to increase in accumulator **112**. Dampening circuit **133** is charged simultaneously through valves **154**, **146** and **140**.

In general, once a predetermined tension has been set on cable **76**, a certain pressure differential exists between chambers **62** and **64** of cylinder **20** and chambers **44** and **42** of cylinder **22**. Piston assemblies **24** and **26** are anchored to base **12** while cylinders **20** and **22** are able to translate to vary the volume of their chambers. The force which maintains winch drum assembly **16** in position will then be the pressure acting on the right-hand walls of cylinders **20** and **22** within chambers **64** and **42**, respectively. The force produced by this pressure balances the dampensing force produced on the other end of cylinders **20** and **22** by the pressure existing in chambers **62** and **44** as well as the tension on cable **76**. When relative displacement occurs between the object anchored to the end of cable **76** and base **12**, a variation in the tension in cable **76** will occur. With an increase of object-to-base distance, tension will increase slightly. On the other hand, with a decrease in object-to-base distance, tension will diminish somewhat. These variations in tension produce a force imbalance between the tension in cable **76** and the pressures in the chambers of cylinders **20** and **22** which will equalize by translation of the cylinders in the appropriate direction. Thus, when relative displacement increases the tension in cable **76**, drum assembly **16**, carriage **14** and cylinders **20** and **22** will translate a distance to the left until equilibrium is re-established at which point the predetermined tension existing before displacement once again appears in cable **76**. When relative displacement causes a slight slackening in cable **76**, cylinders **20** and **22** will translate to the right until equilibrium is once again established between the pressures acting within their chambers and the predetermined tension on cable **76**. The relative movement compensation just described would typically be used in marine applications for compensating for swells and wave action. Slow but larger movements between the object attached to cable **76** and base **12** are compensated for by hauling in or paying out cable through the appropriate actuation of drum assembly drive **18**. This portion of the operation will be subsequently described.

Accumulator **112** supplies the restraining pressure in chambers **42** and **64** which maintains a predetermined tension on cable **76**. This accumulator, however, will augment any damage which would occur to the constant tension winch **10** in the event that cable **76** should break. To offset this hazard, spring-loaded check valves **120** and **122** are provided which seat when the pressure downstream of these valves, that is, the pressure in accumulator **112**, is sufficient to offset the bias force of their springs. Thus, when cable tension is suddenly released, cylinders **20** and **22** will begin to translate to the right increasing the volume and lowering the pressures in chambers **42** and **64**. When this pressure is sufficiently low, check valves **120** and **122** close to prevent the admission of pressurized gas from accumulator **112** and thus prevent accumulator pressure from driving the cylinders with a great force to the limits of their travel.

Upon a sudden release of tension in cable **76** the pressure in dampening branch **133** and chambers **62** and **44** will increase as the cylinders translate to the right and thus provide a dampening action against translation. However, the pressure buildup in these two chambers may become sufficiently high to damage the dampening branch of pneumatic circuit **110**. To prevent the possibility of damage, accumulator **134** is provided. The accumulator acts to prevent excessive pressure buildup by providing a volume for dampening gas. The accumulator is precharged to a high pressure to prevent its action until the pressure in the dampening branch exceeds the precharge pressure. Another safety feature provided in pneumatic circuit **110** is dumping valve **124** which relieves pressure in branch **111** in the event that it becomes too high.

Orifice **142** in check valve **140** allows the pilot line of valve **146** to sense the pressure existing in chambers **44** and **62**. When the pressure in these chambers reaches a certain value, the valve will open to vent the dampening portion of the circuit. Orifice **142** and valve **146**, then, provide a means for maintaining desired dampening pressure despite leakage from tensioning chambers **42** and **64** across pistons **40** and **61** to the dampening circuit. Regulator **146** also serves to prevent the relatively high charging pressure of tank **148** from being admitted directly to accumulator **134** and the dampening chambers of cylinders **20** and **22**.

The tension in cable **76** is readily adjusted by altering the pressure differential between chambers **62** and **64** of cylinder **20** and chambers **44** and **42** of cylinder **22**. When it is desired to increase cable tension, the pressure differential which corresponds to a desired cable tension is set on adjustable regulator **158**. After opening valve **154**, regulator **158** is set with valve **130** positioned such that chamber **130***b* communicates tank **148** with tank **112**. The requisite pressure will then appear in tank **112** by virtue of regulator **158** and the communication through valve **130** between tank **148** with accumulator **112**. In short, tank **148** is allowed to charge accumulator **112**. When it is desired to release tension on the cable, it is necessary to relieve the pressure within chambers **64** and **42**. To accomplish this, valve **130** is set such that chamber **130***c* communicates line **126** with the venting port in the valve and the pressure is reduced. When the desired cable tension has been set, valve **130** is positioned with chamber **130***b* between lines **162** and **126** to communicate tank **148** with tensioning branch **111** through relief valve **158**. This communication compensates for leakage in the tensioning branch.

As was previously mentioned, relative movement between base **12** and the point of attachment of cable **76** may become too large for constant tension winch **10** to handle without spooling out or hauling in cable. When this condition is reached, hydraulic drive assembly **18** is actuated to pay out or haul in enough cable to reposition winch assembly **16** intermediate the limits of travel of cylinders **20** and **22**.

When the drum is required to pay out cable, cylinders **20** and **22** will be positioned relatively far to the left, that is, close to the object held by cable **76**. The volume of chambers **44** and **62** will be relatively large in this position while the volume in chambers **42** and **64** will be relatively small. However, the predetermined tension is still being maintained on the cable.

At the payout terminal position, limit switch **218** will close the circuit to solenoid **216** and interrupt the circuit to solenoid **214** which will actuate valve **184** to communicate line **174** with line **204** and line **192** with line **190**.

The hydraulic pressure provided by pump **172** will cause hydraulic fluid to pass through main hydraulic line **174**, through control valve **184** and into motor inlet **206**. However, the discharge of motor **88**, port **202**, feels the pressure provided by accumulator **200** and thus a relatively small pressure drop will exist across the motor. This relatively small pressure drop is to prevent cable runaway and provide more control to the winch's operator. Returning hydraulic fluid reaches return line **190** for passage through heat exchanger **212** to re-

servoir **180** through valve **194** in the following manner. When a predetermined pressure differential exists, for example 200 p.s.i,. between the chamber of valve **211** and pilot line **208**, the valve will open allowing discharge from line **198** into line **192** and ultimately to reservoir **180**. Check valve **196** and valve **211** in its closed position prevent loss of pressure from accumulator **200**. The chamber of valve **211** is vented through the line shown in phantom to line **192**.

When it is required to haul in cable, cylinders **20** and **22** will be located relatively far to the right with chamber volumes **42** and **64** relatively large and chamber volumes **44** and **62** relatively small.

In the haul-in orientation, limit switch **222** is closed to energize solenoid **224**. Solenoid **214** maintains valve **184** in position to communicate main hydraulic line **174** with line **192** and line **204** with return line **190**. Solenoid **224** closes valve **188** to allow maximum hydraulic pressure to exist in hydraulic line **174** by preventing discharge through valve **186**. The main hydraulic pressure existnig in line **192** passes through check valve **196** and nto port **202** and is returned through port **206** and line **204** through heat exchanger **212** to reservoir **180**. In this mode, there is no effective backpressure provided by accumulator **200**.

Valve **186** cooperates with valve **188** to maintain a stall condition in motor **88** when it is not called upon to provide power. Solenoid **224** is normally out of circuit resulting in valve **188** being open to return line **190**. The pressure existing in the pilot line of valve **186** upon reaching a sufficient value will open the valve allowing fluid to flow from the chamber of valve **182** through valve **188** to return line **190**. While solenoid **214** is energized, a condition which exists until pay out is required pump **172** is in communication with port **202** of motor **88** through line **174**, valve **184**, line **192**, valve **211** and line **198**. Thus, the setting of valve **186** determines how much pressure exists in line **192** and across motor **88** during the time that the motor is not called upon to pay out or haul in cable.

The setting of valve **186** which determines the stall condition is accomplished in the following manner. After the desired cable tension is set as indicated on gauge **132**, valve **186** is adjusted until drum assembly **16** just begins to haul in cable. The valve is then backed off, in the opposite direction, until cable travel stops. Valve **186** is then set and motor **88** is in its stall range.

Normal operation of drum assembly **16** in paying out or hauling in cable as may be required to reel in or dispense cable is merely accomplished by an appropriate override circuit which is not shown in the figure. This circuit would control valve **184** and electric motor **166** to allow motor **88** to haul in or pay out cable.

The present invention has been described with reference to a certain preferred embodiment.

What is claimed is:

1. A constant tension winch comprising:

(a) a base;

(b) a carriage;

(c) means coupling the carriage to the base for straight line translation of the carriage between first and second space apart limit positions on the base;

(d) a winch drum rotatably mounted on the carriage for storing, dispensing and taking in cable;

(e) motor means selectively operable to rotate the winch drum to dispense or take in cable;

(f) means for preventing winch drum rotation until the motor means is operated; and

(g) means associated with the coupling means and operable without winch drum rotation to maintain a predetermined tension in the cable at any position of the carriage on the base by applying a force on the carriage in opposition to the predetermined tension, the tension maintaining means being sensitive to variations in the predetermined tension occasioned by relative movement occurring between the base and an object attached by the cable to allow the carriage to translate on the base an amount corresponding to but in the opposite direction from the relative movement to thereby restore the predetermined tension.

2. The constant tension winch claimed in claim **1** wherein:

(a) the means for maintaining a predetermined tension includes

(i) at least one cylinder,

(ii) at least one piston for each cylinder, each piston dividing its associated cylinder into first and second chambers, and

(iii) first pressure means in fluid pressure communication with the first chamber and operable to maintain a substantially constant pressure therein regardless of the relative position of the cylinder to the piston; and

(b) the carriage is coupled to the base through the piston and cylinder such that the predetermined tension is opposed and substantially maintained by the pressure of the fluid acting in the first chamber before and after relative movement between the object and the base.

3. The constant tension winch claimed in claim **2** including pressure damping means operable to exert a pressure in the second chamber which acts in opposition to the pressure in the first chamber such that the predetermined tension and pressure in the second chamber oppose the pressure in the first chamber.

4. The constant tension winch claimed in claim **3** wherein the means for maintaining a predetermined tension on the cable is adjustable to vary the predetermined tension, and the first pressure means and pressure dampening means employ gas as a working fluid.

5. The constant tension winch claimed in claim **4** wherein:

the first pressure means includes an accumulator in pressure communication with the first chamber.

6. The constant tension winch claimed in claim **5** wherein the predetermined tension adjusting means includes:

means operably coupled in fluid circuit with the first and second chambers to adjust the predetermined tension by adjusting the pressure differential between the first and second chambers.

7. The constant tension winch claimed in claim **6** wherein the adjusting means includes valve means selectively operable to:

(a) decrease the pressure differential between the first and second chambers to release tension on the cable;

(b) increase the pressure differential between the first and second chambers to increase tension; and

(c) prevent pressure communication between the first and second chambers to hold the cable tension at the predetermined tension.

8. The constant tension winch claimed in claim **7** wherein the predetermined tension adjusting means includes:

(a) a source of pressurized gas; and

(b) adjustable regulator means operably coupled in fluid circuit with the first chamber and the source of pressurized gas to prevent the pressure differential between the first and second chambers from exceeding the value corresponding to the predetermined tension, such means being adjustable to vary the predetermined tension by varying the pressure differential between the first and second chambers.

9. The constant tension winch claimed in claim **10** including means for preventing rapid translation of the carriage with respect to the base upon a sudden release of cable tension including:

(a) check valve means between the first chamber and the first pressure means operative to terminate pressure communication therebetween upon a sudden release of pressure in the first chamber; and

(b) accumulator means in circuit with the second chamber operable to admit gas from the second chamber when the pressure therein exceeds a predetermined value in excess of the normal dampening pressure.

10. The constant tension winch claimed in claim **1** wherein:

(a) the carriage has a first and a second terminal position corresponding respectively to a limit of relative movement of the base towards the object and a limit of such movement away from the object; and including

(b) first winch drum actuating means to actuate the motor means to dispense a selected amount of cable when the carriage reaches the first terminal position and thereby move the carriage closer to the second terminal position; and

(c) second winch drum actuating means to actuate the motor means to take in a selected amount of cable when the carriage reaches the second terminal position and thereby move the carriage closer to the first terminal position.

11. The constant tension winch claimed in claim **10** wherein the winch drum motor means includes:

(a) a two-directional hydraulic motor operatively coupled to the winch drum to rotate the drum in either direction;

(b) hydraulic pump means operatively coupled to the hydraulic motor to drive the motor; and

(c) means for driving the hydraulic pump means.

12. The constant tension winch claimed in claim **11** wherein:

the winch drum power means includes means for supplying a relatively greater amount of torque from the hydraulic motor when cable is being taken in with respect to the torque supplied by the motor when cable is being dispensed.

13. The constant tension winch claimed in claim **12** including:

(a) means for presenting a back pressure on the hydraulic motor's outlet when cable is being dispensed to control the rate of cable dispensing; and

(b) means for maintaining the hydraulic motor in a stall condition before cable is taken in, such means being operable to supply hydraulic fluid under pressure to the hydraulic motor within the motor's stall range.

14. The constant tension winch claimed in claim **13** wherein:

(a) the back pressure means includes prechargeable accumulator means in hydraulic circuit with the motor; and

(b) the winch drum power means includes valve means in hydraulic circuit with the motor and pump means operable:

(i) by the first winch drum actuating means to communicate the hydraulic motor with the hydraulic pump means to supply hydraulic pressure across the motor in opposition to accumulator pressure; and

(ii) by the second winch drum actuating means to communicate the hydraulic motor with the hydraulic pump means such that a supply of hydraulic pressure across the motor in excess of the pressure existing in the motor's stall condition is provided without opposition by accumulator pressure.

15. The constant tension winch claimed in claim **14** wherein the hydraulic pump means includes a low pressure, high capacity pump and a high pressure, low capacity pump, the low pressure, high capacity pump being in hydraulic circuit with the motor until a predetermined pressure is reached.

16. A winch for maintaining cable tension constant despite movement between the point of cable atachment and the winch's mounting, comprising:

(a) a base;

(b) a carriage;

(c) a winch drum rotatably mounted on the carriage for storing, hauling in and paying out cable;

(d) motor means operable to rotate the winch drum to haul in and pay out cable;

(e) means to prevent winch drum rotation until the motor means is operated;

(f) at least one piston and cylinder pair coupling the carriage to the base such that translation of the carriage on the base is possible without winch drum rotation in response to movement between the point of cable attachment and the winch's mounting:

(g) means for maintaining a pressure in the cylinder which acts through the carriage to maintain a predetermined tension on the cable before and after movement between the point of cable attachment and the winch's mounting, such means being sensitive to variations in the predetermined tension occasioned by the movement to allow the carriage to translate on the base an amount corresponding to but in the opposite direction from the movement to thereby restore the predetermined tension; and

(h) means operatively coupled to the motor means to:

(i) pay out a given amount of cable when the carriage reaches a first terminal position located towards the object to translate the carriage away from the object; and

(ii) take in a given amount of cable when the carriage reaches a second terminal position located away from the object to translate the carriage towards the object.

17. The winch claimed in claim **16** wherein:

(a) each cylinder is divided into first and second chambers by its associated piston;

(b) the pressure maintaining means is operable to establish a pressure differential between the two chambers with a dominant pressure in the first chamber which maintains the predetermined tension; and

(c) means is provided to alter the pressure differential between the two chambers and adjust the value of the predetermined tension.

18. The winch claimed in claim **17** wherein the motor means is operable to supply a relatively high torque on the winch drum when hauling in cable with respect to the torque on the winch drum when paying out cable.

19. The winch claimed in claim **18** including dampening means operable upon a sudden release of cable tension to slow the rate of translation of the carriage on the base which occurs upon such release of cable tension, the dampening means including means for maintaining a dampening pressure in the second chamber.

20. The winch claimed in claim **19** wherein the motor means includes a hydraulic motor and hydraulic pump means to supply power to the hydraulic motor.

21. The winch claimed in claim **16** wherein the motor means includes:

(a) hydraulic means including a hydraulic motor operable to apply a relatively large amount of torque on the winch drum when it is hauling in cable, a relatively small amount of troque on the winch drum when it is paying out cable and to maintain the motor in a stall condition before it hauls in cable; and

(b) braking means for exerting a back pressure on the hydraulic motor when cable is being paid out.

22. The winch claimed in claim **21** wherein the motor means includes at least one pump operatively coupled to the hydraulic motor to supply hydraulic fluid under pressure thereto and which is capable of relatively high displacement at least until a predetermined hydraulic pressure is reached.

23. The winch claimed in claim **16** including means for applying a dampening pressure in the cylinder acting in opposition to the first-mentioned pressure.

24. The winch claimed in claim 23 wherein the winch drum driving means includes hydraulic means operable to supply a relatively high torque on the winch drum when hauling in cable with respect to the torque on the winch drum when paying out cable.

25. The winch claimed in claim 24 wherein the hydraulic means includes:

(a) a hydraulic motor operatively coupled to the winch drum to haul in and pay out cable;

(b) back pressure means in hydraulic circuit with the hydraulic motor to apply a restraining pressure therein when cable is being paid out; and

(c) means for maintaining a pressure in the motor to keep the motor in a stall condition before cable is hauled in.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,481,584 Dated Dec. 2, 1969

Inventor(s) L. H. Conry et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the specification: Column 1, line 44, "subject" should be --object--. Column 2, line 35, "caintain" should be --maintain--; line 53, "constitutes" should be --continues--. Column 4, line 46, "reduced" should be --reducing--; line 66, delete "and the" at end of line. Column 5, line 2, "facilitir should be --facility--; line 39, "constable" should be --constant--; line 45, "545" should be --54--. Column 6, line 4, "reduced" should be --reducer--; line 28, before "cable" insert --on--. Column 7, line 56, after "normal" insert --winch--; line 67, "hydrauplic" should be --hydraulic- Column 8, line 50, "in" should be --is--. Column 9, line 22, "dampensing" should be --dampening--. Column 11, line 21, "existnig" should be --existing--; line 22, "nto" should be --into--.

In the claims: Claim 1, column 11, line 62, "space" should be --spaced--. Claim 16, column 13, line 74, "atachmer should be --attachment--. Claim 21, column 14, line 61, "troque" should be --torque--.

SIGNED AND
SEALED
OCT 13 1970

(SEAL)
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