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 compensation 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 counterweights 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 maintain 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 gusset differential which acts via one 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 damping pressure may be exerted in one of the chambers to dampen 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 damping 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 damping 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 damping chambers to accept fluid from the damping 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 damping 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 damping 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 motor may be provided to 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 higher than that required to pay out cable because the winch is well loaded, 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 movement 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 expedi-

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 facilitating 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 which is secured to upright flange 34 at its outer terminal end by nut 36. Shaft 36 extends into cylinder 22 for connection with a piston 40. Piston 40 drives 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 constant 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 54 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 to 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 56 and 58 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 routed 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 96 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 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 transatlational 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 the 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 112 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. Remember, FIGURE 3 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 and monitors 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 a failure. 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 the line 152 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 130b to communicate charging cylinder 148 with tension maintaining branch 111. The center position, chamber 130c, isolates lines 162 and 166 from each other. Chamber 130c is the 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 130b of valve 130 is positionable to provide communication between lines 126 and 162, as indicated by the flow arrow in chamber 130b, and, thus, to communicate charging cylinder 148 with accumulator 112. Valve chamber 130c 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 torque 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 hydraulic 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 dis- charge 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. The hydraulic operating value 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 181 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 194 permits 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 constant pressure in line 198 and at inlet 202 of motor 88. The accumulator also presents a back-pressure 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 off 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 is controlled 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 accordance with the opening of branch 114. Branch 112 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 dampening 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 tension is set on each of chambers 62 and 66. As object-base distance, tension will increase slightly. On the other hand, with a decrease in object-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 cylinder 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 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 building 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 build-up by providing a volume for dampening gas. The accumulator is precharged to a higher 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 the adjustable regulator 158. After repositioning valve 154, regulator 158 is set with valve 130 positioned such that chamber 130b 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 and accumulator 113. 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 130c 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 130b 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 to minimize 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 then operate 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 134 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 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 224 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 existing in line 192 passes through check valve 196 and into port 102 and is returned through port 206 to 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 throughout which is necessary to shut off flow of fluid to the cable in the case of an emergency. Valve 184 is normally open until a predetermined pressure is reached which is actuated by the pressure of the fluid acting on the base of the cable before and after relative movement between the object and the base.

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 spaced 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;
   (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 occa-
13. (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 irrespective 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
(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 rechargeable 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 attachment 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 cable 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 torque 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.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION


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, "dampening" 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, "atchmer should be --attachment--. Claim 21, column 14, line 61, "troque" should be --torque--.

SIGNED AND SEALED
OCT 13 1970

(SEAL)

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Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents