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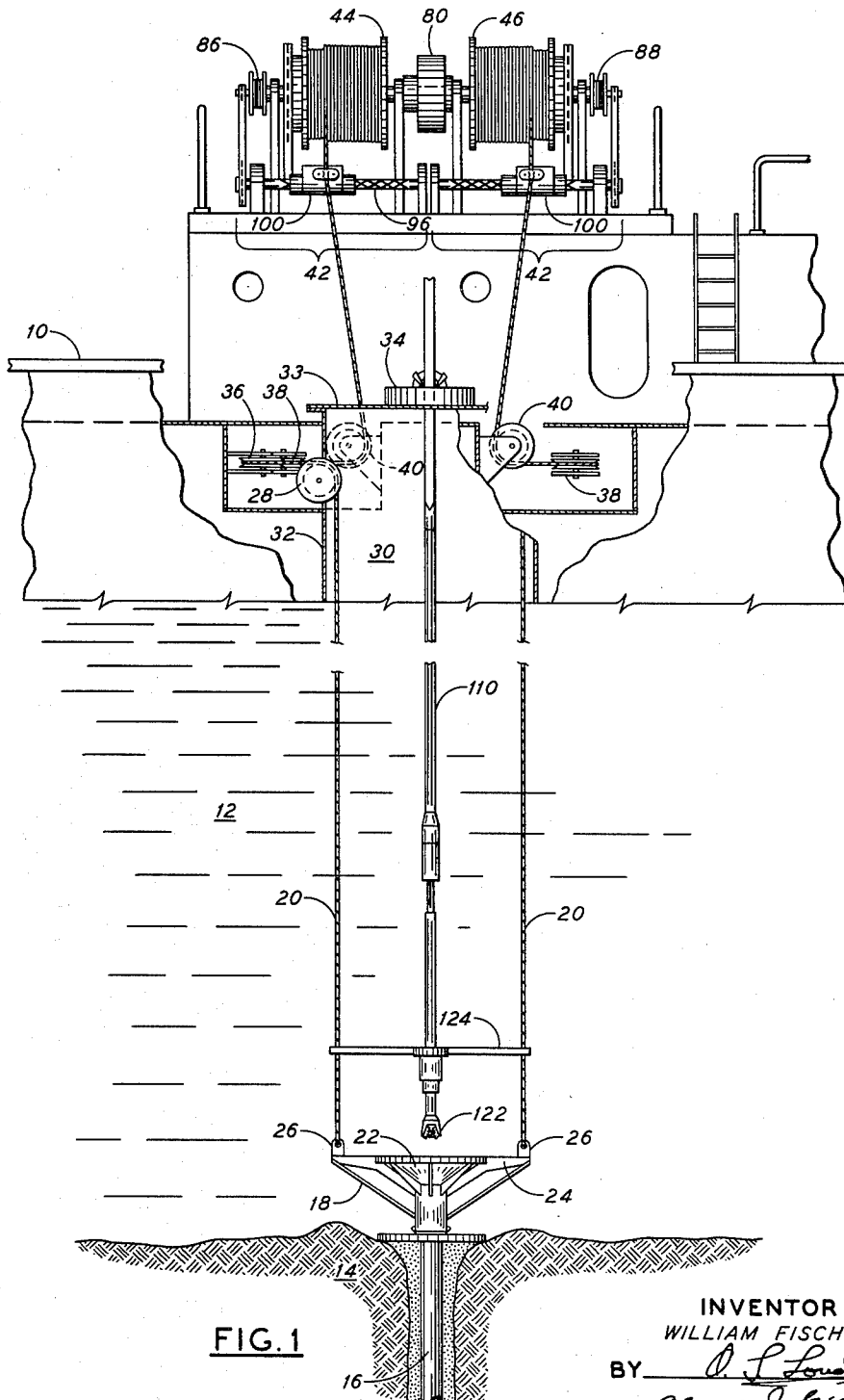
W. FISCHER

2,984,455

MULTIPLE-CABLE TENSIONING DEVICE

Filed Aug. 6, 1957

2 Sheets-Sheet 1



INVENTOR
WILLIAM FISCHER
BY *Charles J. Gibson*
ATTORNEYS

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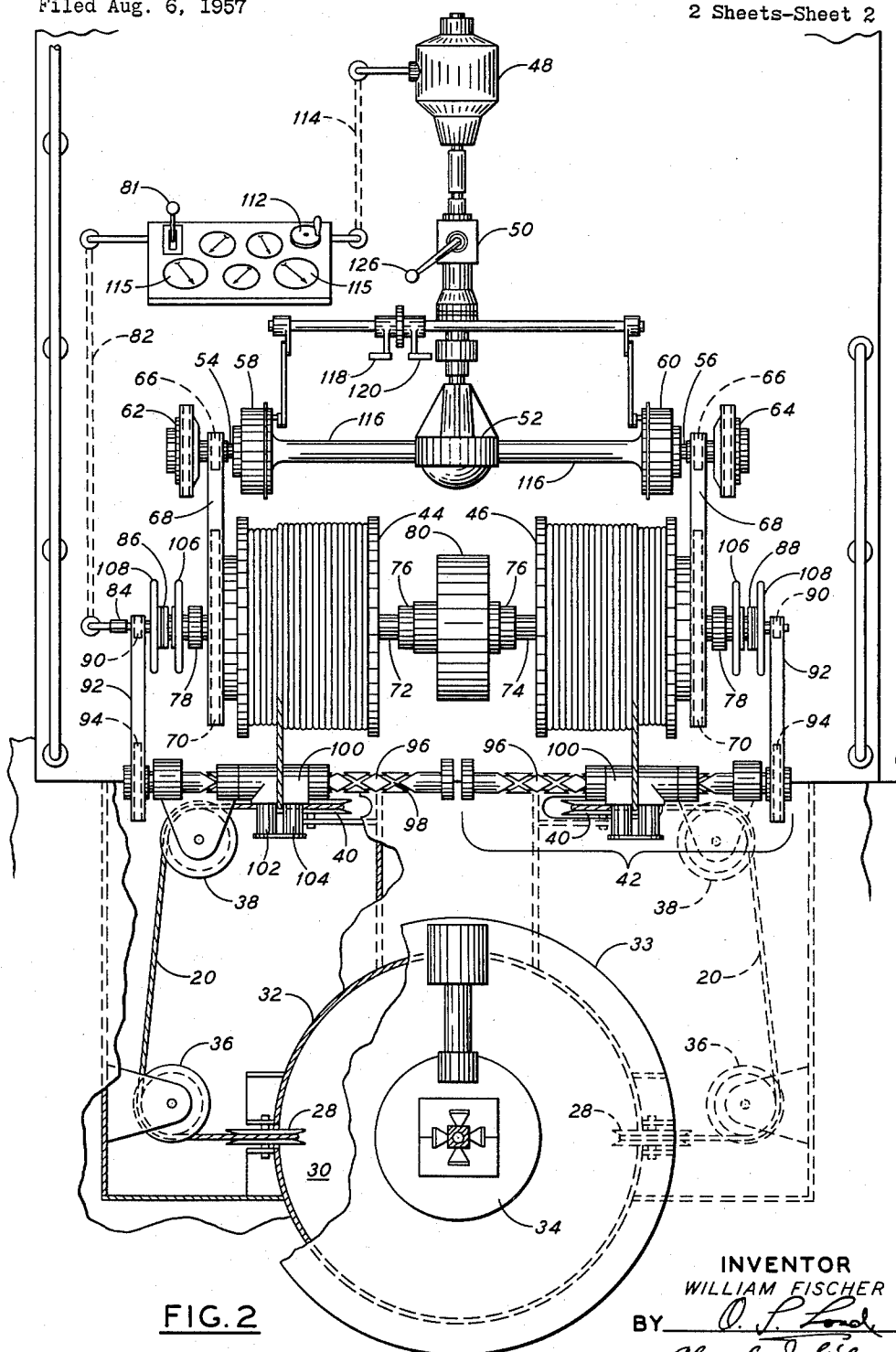


FIG. 2

INVENTOR
WILLIAM FISCHER
BY O. S. Lord
Charles J. Gibean
ATTORNEYS

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MULTIPLE-CABLE TENSIONING DEVICE

William Fischer, Fullerton, Calif., assignor, by direct and mesne assignments, to California Research Corporation, San Francisco, Calif., a corporation of Delaware

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This invention pertains to an apparatus for effecting automatically a controlled, comparable tension in a plurality of cables which are connected between a structure and a winch mechanism mounted on a foundation having a nonuniform, variable motion relative to the structure and, more particularly, to an apparatus for maintaining automatically by a single motor a controlled, substantially equal tension in a plurality of spaced-apart cables which are connected between a vessel floating in the water and the earth at the bottom of the water. The invention has specific pertinence to apparatus used in drilling offshore wells from a floating vessel, and will be exemplified as applied to this procedure.

In one method of offshore drilling from a floating vessel, the vessel is anchored over the well site, and a conductor casing is jetted or drilled into the ocean bottom by drilling apparatus aboard the vessel and is cemented in place. The conductor casing is used as an anchoring fixture for a pair of guidelines which extend downwardly from the vessel and are employed during the drilling operation to guide tools and equipment into the opening of the well bore.

The guide cables are run over respective sheaves mounted on the vessel and are loaded with counterweights. The counterweights hold the guidelines under a constant tension as the vessel moves with the surface of the water and relative to the fixed anchor at the bottom. The counterweight system performs well and has an advantage of simplicity of structure and operation. However, it is limited in several capacities.

The selection of the counterweights and the number of lines used over traveling blocks supporting them in the system predetermines the fixed tension imposed on the guide cables during the drilling operation, and this tension cannot easily be changed unless the counterweight mass or the number of lines is changed. Thus, the system is not practicably flexible to afford variable control of the guideline tension to establish conveniently the optimum tension for a particular condition which may occur during a drilling operation.

Another limitation of the counterweight system lies in its limited capacity for boat motion. If the vessel moves relative to the ocean bottom more than the designed capacity of the system permits, as may occur, for instance, if the vessel should drag its anchors while drilling, or suddenly be forced upwardly by waves of unusual height, the system will exceed its line capacity and be damaged or torn out.

These are some of the several limitations field use has shown to be inherent in the counterweight system. They illustrate also difficulties it is desirable to eliminate from a multiple-cable tensioning system for offshore drilling use.

It is an object of this invention to provide a novel multiple-cable tensioning system, and further to provide an apparatus which solves the aforementioned difficulties encountered in offshore drilling procedures. Other ob-

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jects will become apparent as the description of the invention proceeds.

The apparatus of this invention uses as a principal power source a single motor in which the torque output can be controllably limited, and which will operate continuously at the controlled output. The motor drives through a multispeed transmission and a differential mechanism to a plurality of cable drums. The drums can rotate relative to each other through the differential action or be locked together by an interlocking clutch means to rotate as a unit. A guide cable is wound on each drum. A respective brake for each drum is operatively connected to the drive to the drum from the differential mechanism, and torque-limiting clutches are connected in the drive between the brake and the drum. By this arrangement, the drums can be braked individually, or locked in position independent of the motor drive. The torque-limiting clutches will prevent a back drive from the guide cables from overstraining the apparatus when the brakes are set. Synchronized, individual level winders are used for each drum.

During a drilling operation the apparatus may be set so that the drive through the differential will rotate the drums relatively independently to compensate automatically for changes in individual guide-cable tension caused by the motion of the drilling vessel with the water. The driving motor is set to hold the tension at a predetermined value, and any overload in the guide cables above the preset tension, as may occur when the vessel rises with the wave action at the surface of the water, will cause the mechanism to drive backwards to place an opposing torque on the motor. When the torque imposed on the motor through the backward drive exceeds that which was preset as the maximum torque output, the motor will be overpowered and turned in the reverse direction, and thus relieve the tension in the cables in excess of that placed on them by the preset torque output.

When the guide cables and the apparatus connected to the lower ends of them are being lowered into the water, or when they are being retrieved, the drums may be locked together to rotate as a unit and perform the function of paying out or taking up the cable simultaneously.

The accompanying drawings, which are a part of this specification, illustrate an exemplary embodiment of this invention as applied to apparatus used in an offshore drilling operation.

In the drawings:

Figure 1 represents in front elevation and partly in section an embodiment of the present invention as used on a floating offshore drilling vessel.

Figure 2 is a schematic representation illustrating in greater detail the embodiment of this invention employed in the arrangement of Figure 1.

Referring to the drawings, and particularly to Figure 1, there is illustrated an offshore drilling vessel 10 which has been anchored in a body of water 12 at a site where a well is to be drilled into the ocean bottom 14. A string of conductor casing 16 has been established in the ocean bottom by the drilling vessel and cemented in place. A guide assembly 18 is latched to the top of the conductor casing, and to it the guide lines 20 are connected.

The guide assembly has a centrally located funnel 22 which serves to centralize tools and equipment guided downwardly from the drilling vessel with the opening of the conductor casing. Integral arms 24 extend outwardly from the guide assembly, and the guide cables are attached to their radially outer ends by connections 26 to hold them in spaced-apart relationship. The guide cables extend upwardly from the guide assembly to the floating vessel where they are passed over sheaves 28 and thence through other sheaves to the guideline tensioning apparatus. The spread of the arms 24 and the positions of

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the sheaves 28 are selected to keep the guide cables substantially parallel throughout their length in the water.

The drilling vessel illustrated in the drawings has a centrally located opening 30, formed with a cylindrical wall 32, which extends from its deck through the bottom of the hull and through which the principal drilling operations are accomplished. A removable system of beams and plates forms a platform 33 over the deck opening and supports a rotary table 34 which performs the same functions as a rotary table used in drilling operations on land. The guide cables 20 also extend upwardly through the opening 30, and the sheaves 28 are mounted to partially protrude into the opening to clear the cables from contact with the wall 32. In the particular arrangement illustrated, the cables each continue through a series of sheaves 36, 38 and 40 and thence through a respective level-winder device 42 to a respective winch drum 44 and 46. The winch drums are mounted to rotate relative to each other through a differential action or to be connected together to rotate in a unitary manner as will be described hereinafter.

The single power source for driving the winch drums of this apparatus is preferably a motor which can be variably adjusted to maintain a preselected torque output and which may be rotated in the reverse direction by a back drive from the cables without becoming inactive if a torque is imposed on it which exceeds the preset torque. Although various types of motors will satisfy these conditions, a piston-type compressed-air motor has been found to be well suited for this purpose.

A illustrated in Figure 2, the motor 48 is connected through a multispeed transmission 50 to a differential mechanism 52. The driven shafts 54 and 56 from the differential have brakes 58 and 60, respectively, operatively connected to them. The shafts continue outwardly from the brakes to respective torque-limiting clutches 62 and 64. The drive through each clutch rotates a corresponding sprocket 66 which drives a chain 68 engaging a complementary sprocket 70 on each drum. It will be appreciated that there are various types of torque-limiting clutches available which can be used as the clutches 62 and 64 of this apparatus, and the manner of mounting such clutches on a drive shaft is well known. Therefore, it is not believed necessary to show the specific details of the torque-limiting clutch mechanism.

The winch drums 44 and 46 are mounted on axles 72 and 74, respectively. Each axle is supported by a set of bearings 76 and 78, and they are positioned in alignment with their inwardly extending ends adjacent each other. An interlocking clutch 80 is placed between the inner ends of the axles to selectively lock them together to eliminate the differential action and cause them to rotate as a unit, or to disconnect them and permit them to rotate relative to each other. Preferably the clutch is remotely controlled and may be a pneumatically operated clutch having its controls at the driller's console. In the apparatus illustrated, pressurized air for operating the clutch is controlled by valve 81 and is led by the conduit 82 through a rotary coupling 84 mounted on the end of axle 72 and thence through a central bore in the axle to the interior of the clutch mechanism.

The outwardly disposed ends of the drum axles are connected through respective, manually operable clutches 86 and 88 to corresponding sprockets 90 which mesh with and drive chains 92. These chains in turn drive complementary sprockets 94 fixed on the level-wind shafts 96. The level-wind shafts have continuous, helical grooves 98 cut in their outer circumferential surfaces which engage a follower on the corresponding carriage 100 to cause the carriage to travel back and forth along the shaft in an axial direction as the shaft rotates. Each carriage has rollers 102 and 104 to confine the guide cable 20 and cause it to follow the axial motion of the carriage. Hence, as the apparatus rotates, the level winder will traverse the guide cable across the winch drum so that it will be wound thereon in even layers. It will be ap-

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preciated that the position of the level winders relative to their respective winch drums as shown in Figure 2 is somewhat schematic, in order to illustrate the details of the apparatus more clearly. Preferably the level winders will be located below the drums to decrease the number and degree of bends in the lines as they are wound on them. The sheave 40 may be placed in vertical alignment with the level winder and mounted on a hinged axis to adjust to the varying angle of the line as it is traversed across the face of the drum.

The clutches 86 and 88 can be manually disengaged by the hand wheel 106 to disconnect the drive from the winch-drum axle to the level-winder sprockets. When the clutch has been thus disengaged, the handwheels 108 may be used to operate the level winders independently to place either guide cable in proper alignment or in a particular position on its respective winch drum, after which the clutches can again be engaged to make the level-winding operation automatic.

In accordance with one method for establishing a submarine well, a string of conductor casing is attached to the guide assembly prior to the time it is lowered through the water. The guide assembly and attached conductor casing string are hung in the water from the boat, and a drill string is inserted through the conductor casing to the bottom of the water where a hole is drilled into the submarine earth formations large enough and deep enough to accept the string of conductor casing. The guide assembly has the guide cables attached to it and, together with the conductor casing, is lowered along the drill string 110, which remains in the hole, until the guide assembly is at the bottom of the water. During this operation the winch drums are clutched together so that both guide cables are paid out uniformly. If the conductor casing hangs up in the hole before it is inserted to its full depth, the apparatus of this invention may be operated to alternately raise and lower the guide assembly and conductor casing string to work it up and down in the drilled hole until it is properly seated.

When the conductor casing string is properly seated in the hole, it is cemented to the subterranean formations in a manner analogous to oil field operations on land. The apparatus of this invention permits the guide cables to be slacked off conveniently while the cement is setting. It will be appreciated that tension in the guide cables during this operation will dislodge the conductor casing and may cause it to be protruding above the bottom an undesired amount after the cement has fixed it in place.

When the conductor casing, and hence the assembly, has been secured to the ocean bottom, the interlocking clutch between the winch drums is disconnected so that as the vessel rolls and heaves with the water motion the guide cables will be acted upon individually to maintain them each at the optimum preset tension. For example, if the sheaves 28 are not located on the center line of the vessel in the manner illustrated, as is the case in some installations, normal roll imposes unequal tension on each guideline. Likewise, if wave motion raises the forward portion of the vessel relative to the aft portion, the guide cable disposed toward the forward portion will be placed under increased tension, and that toward the aft portion will be slacked off. In either circumstance, the drive through the differential immediately will rotate the winch drum on the line which is under the greatest tension in a direction to pay out guide cable and at the same time will relatively rotate the winch drum on the line which is under lesser tension to take up guide cable, and this will continue until each of the guide cables again achieves its preset tension and the system is in balance.

The amount of tension imposed on a guide cable during normal operation will be controlled primarily by the output torque of the air motor 48 as modified by the gear ratios selected in the transmission 50. The air motor is a very flexible unit, and its output torque can be set from substantially zero up to the full-rated motor output by manipulating the control valve 112 on the com-

pressed-air line 114 to it. The tensions in the respective cables may be determined by appropriate tensiometers which preferably have their indicators 115 at the driller's console.

The output torque of the motor will, of course, subsequently be imposed on the winch drums to hold the guide cables at a tension related to the output torque. If the tension in the guide cables exceeds this amount, as may happen when a wave lifts the vessel relative to the bottom of the ocean, the cables will cause the mechanism to drive backwards, and a torque will be placed on the air motor in excess of that for which it was preset. In such circumstances, the air motor will slip, that is, the pistons will operate in a reverse direction and against the air pressure imposed upon them by the motivating pressurized air. Hence, the torque at the motor will remain substantially constant, and the guide cables will unreel from their respective drums at substantially the desired preset tension. When the vessel again falls with the surface of the water and decreases its elevation relative to the bottom of the ocean, the guide cables will slack off, and the backward drive through the apparatus will cease. When the back torque imposed on the air motors by the guide cables falls below that derived from the motivating pressurized air, the motor immediately will operate to rotate the winch drums and take up the guide cables to hold the tension in them at the preselected value.

Referring to Figure 2, it will be observed that the brakes 58 and 60 are placed between their respective differential shafts and the stationary housing 116. This arrangement permits braking action to be placed on either winch drum independently of the other by manipulating the respective brake handles 118 and 120. The brakes can be made to hold either or both winch drums locked in position and block the back drive of the system to the air motor. If the drums are locked in position and the boat rises with the surface of the water while the guide cables are fastened to the bottom, the backward drive imposed on the apparatus through increased tension in the guide cables is released at the torque-limiting clutches 62 and 64, thereby preventing damage to the apparatus. The torque at which these clutches are set to slip is, of course, selected to be above that imposed on the system by the operation of the air motor or by the back drive induced by the increased guide-cable tension during normal operation.

The flexibility of the system enables the optimum tension to be set in the guide cables for particular conditions of operation. For example, when a bit 122 on the end of drill string 110 is to be guided from the floating vessel into the submerged well, the air motor control and multispeed transmission 50 may be set to hold the cables taut so that the retractable bit guide 124 will slide downwardly along them as the drill string is lowered to center the tool with the submerged guide assembly, through which it will enter the well opening. During drilling, however, it is desirable to relieve the tension in the guide cables and hold them under only sufficient tension to prevent them from becoming tangled with each other or the submerged drilling mechanism. In the latter circumstance the transmission 50 preferably is set in high gear by lever 126 to provide a direct drive from the motor to the winch drums to give maximum sensitivity to the system.

When a well is completed, the guide assembly 18 is detached from the top of the conductor casing and retrieved. During this operation the winch drums are interconnected by the interlocking clutch, and the winch apparatus is operated to raise the guide assembly up

into the opening 30 of the vessel where it can be attached to a hoist and lifted aboard.

The apparatus of this invention permits great flexibility for use in various water depths and for inadvertent movement of the floating drilling vessel relative to the submerged well site. The winch drums provided sufficient cable storage over and above that needed for a specific drilling location to permit the vessel to move to a new location of greater water depth and start operation immediately without requiring new guide cables to be rigged on the boat to accommodate the greater depth. Furthermore, if the floating vessel should be subjected to larger vertical movement than normally expected or to excessive wave forces which cause it to drag anchor and be displaced from its vertical position above the drilling site, the apparatus of this invention will readily accommodate itself to such unusual circumstances without overstraining or otherwise damaging the equipment.

Although the multiple-cable tensioning system of this invention has been described as applied to a guide-cable tensioning device for offshore drilling use as an exemplary embodiment thereof, it will be apparent that the invention is not limited to this specific use. Furthermore, specific elements of the apparatus which have been described have been described by way of example only. Therefore, it is not intended that the invention be limited to the specific exemplary embodiment described and illustrated herein, but that the concept include all equivalents within the scope of the appended claims.

I claim:

1. A winch apparatus for controlling the tension in a plurality of cables comprising a separate winch drum for each of said cables, a separate driving connection for each of said drums, a differential mechanism connecting said separate driving connections, a separate brake means operatively connected to each of said driving connections and located between the respective said driving connections and said differential mechanism, a torque-limiting means operatively connected in each of the said driving connections and located between the said separate brake means and the respective said driving connections, a motor means to drive said winch drums through said differential means to rotate said winch drums relative to each other to maintain a comparable substantially constant tension in all of said cables as the tension in individual ones of said cables tends to vary, and means to interlock said winch drums to be rotated as a unit by the said motor drive through said differential means to reel and unreel all of the said plurality of cables at a substantially constant rate.

2. Apparatus in accordance with claim 1 wherein said motor means is a pneumatically operated motor which is constructed to slip when the torque imposed on it through increased tension in said cables exceeds the preset maximum torque, and which automatically will operate to rotate said winch drums when the tension in said cables is less than the tension the preset maximum torque of said motor can maintain.

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