United States Patent

Barron et al.

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[54] **STABILIZED LOAD HOIST APPARATUS**

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[52] **U.S. Cl.** **214/14,** 254/172

[51] **Int. Cl.** **B65g 67/58**

[58] **Field of Search** 214/13–15; 254/172, 173

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[57] **ABSTRACT**

Hoist apparatus for moving a load between relatively vertically movable locations, wherein the load is moved by a pair of load hoist cables, and a tension hoist cable is connected between the relatively vertically movable locations, the load hoist and the tension hoist being coupled together to cause movement of the load corresponding to the movement between the locations, the load hoist also being operable to move the load between such locations, the load being connected to the pair of load hoist cables and being guided on the tension hoist cable.

11 Claims, 7 Drawing Figures

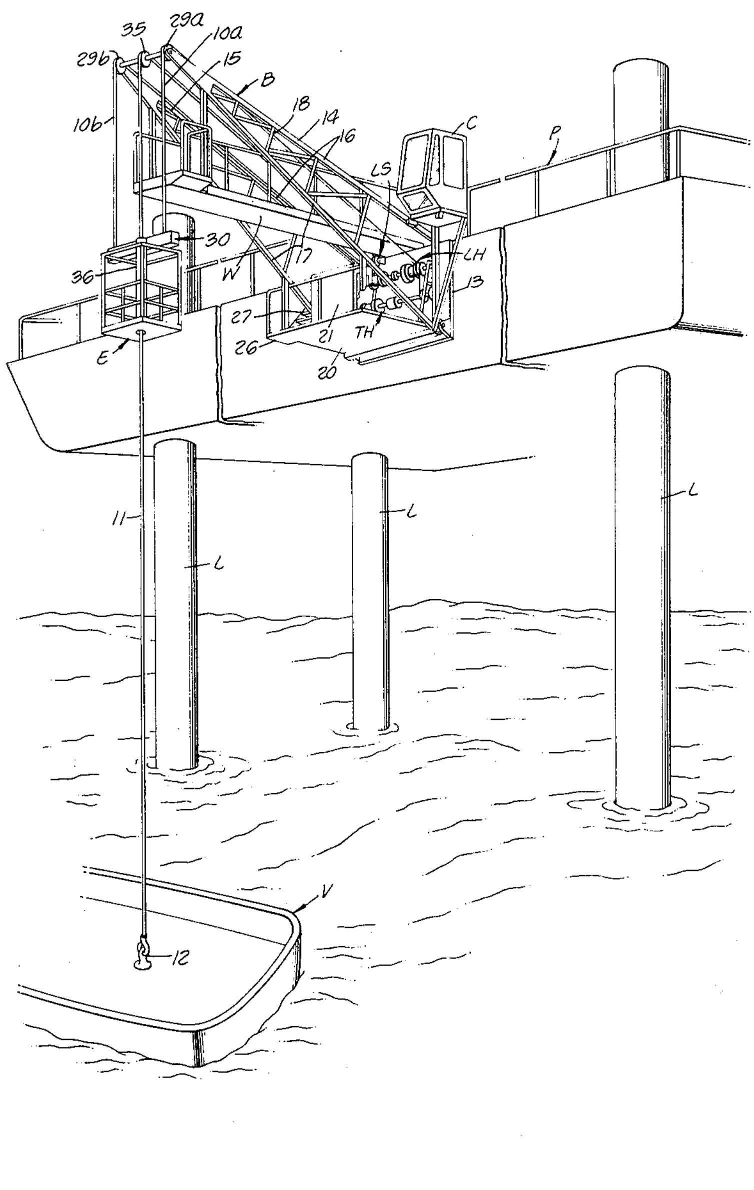
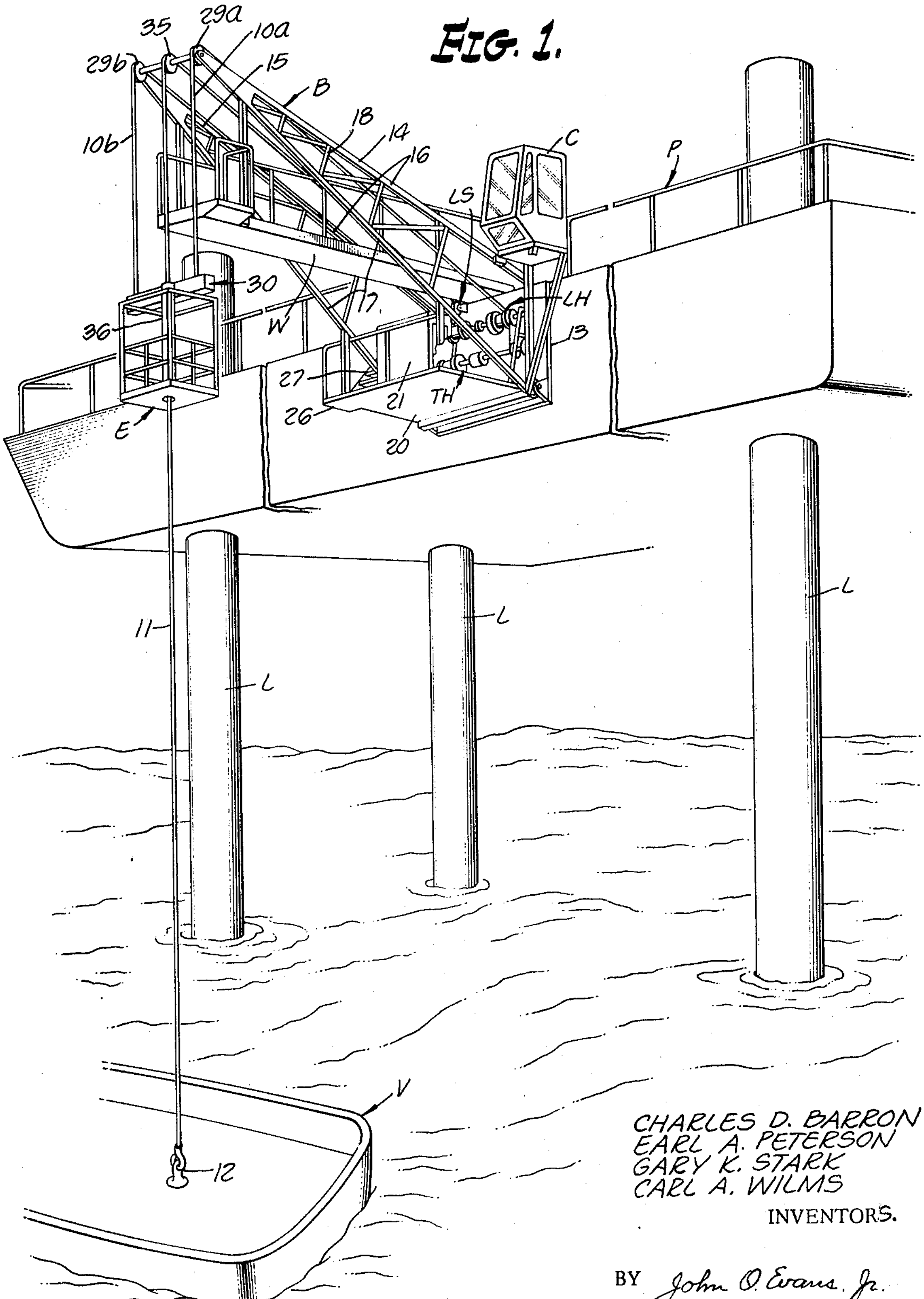


FIG. 1.



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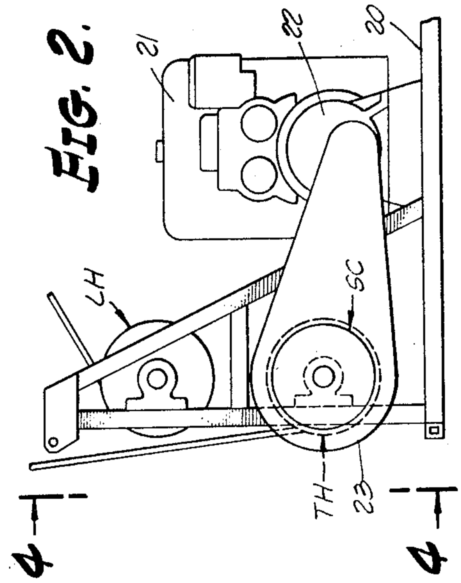

FIG. 2.

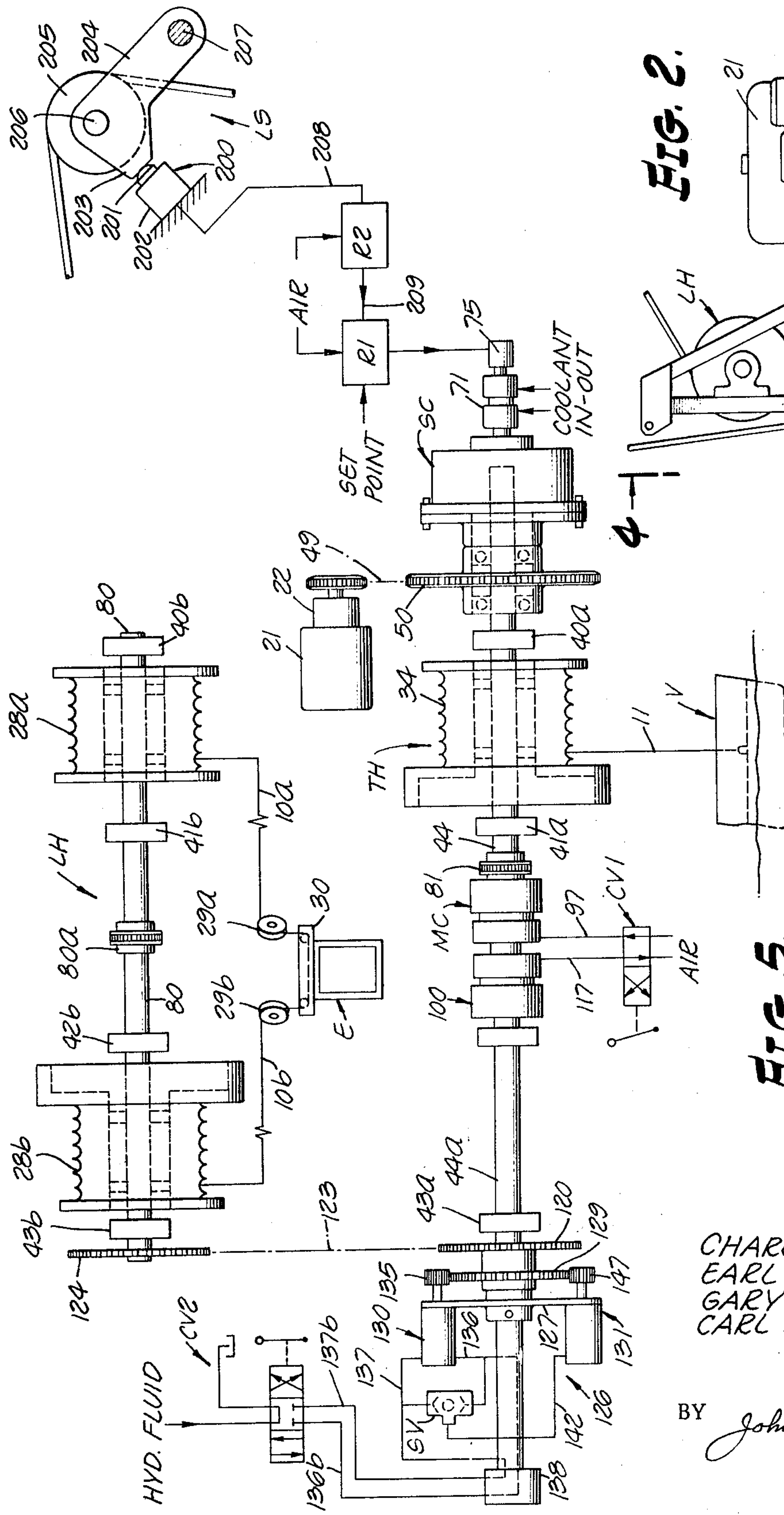

FIG. 5.

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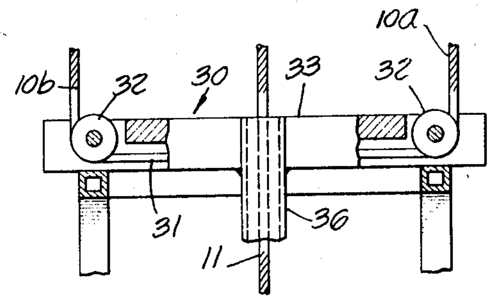

FIG. 3.

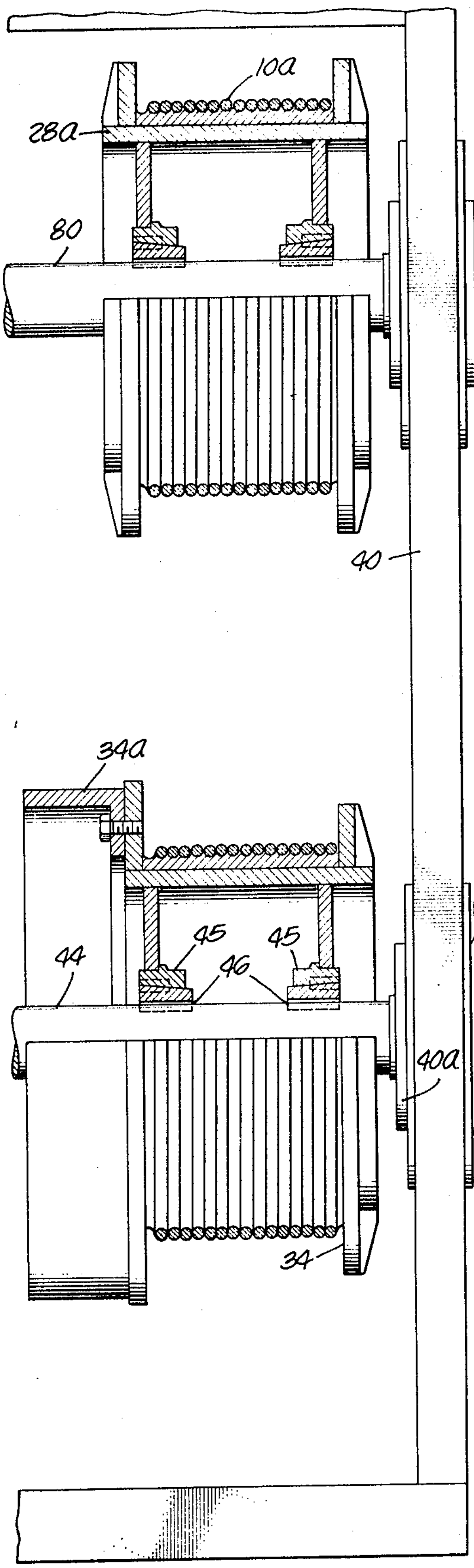
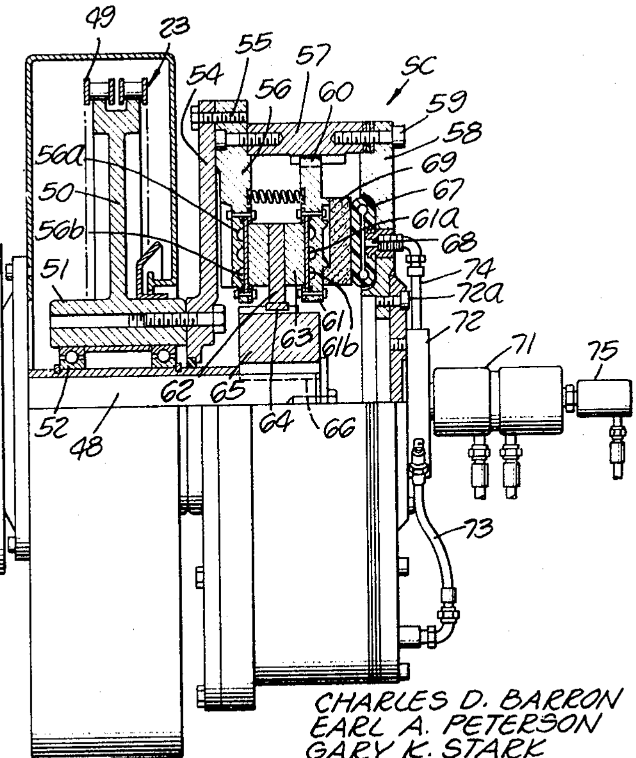

FIG. 4a.

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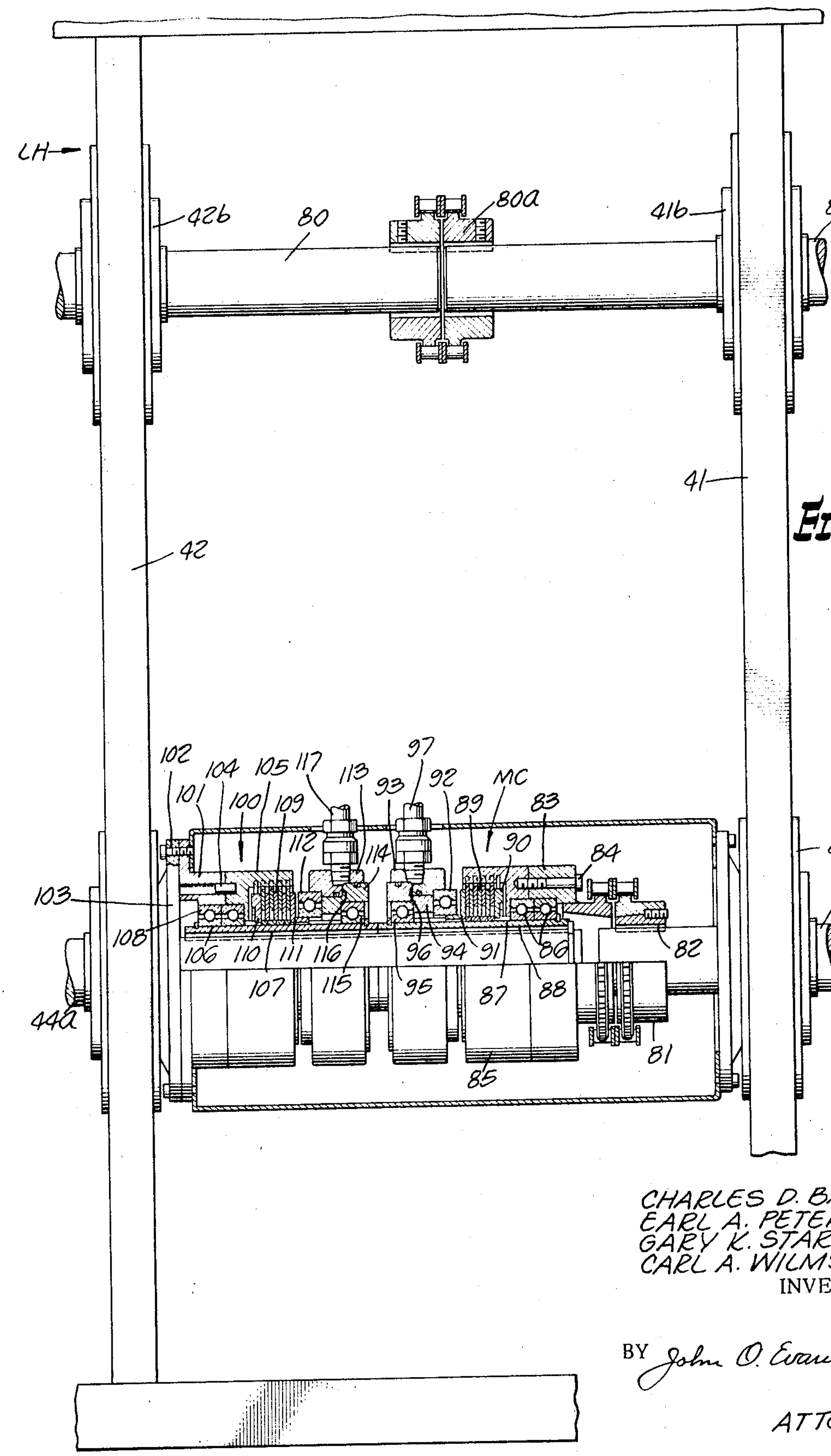

FIG. 4b.

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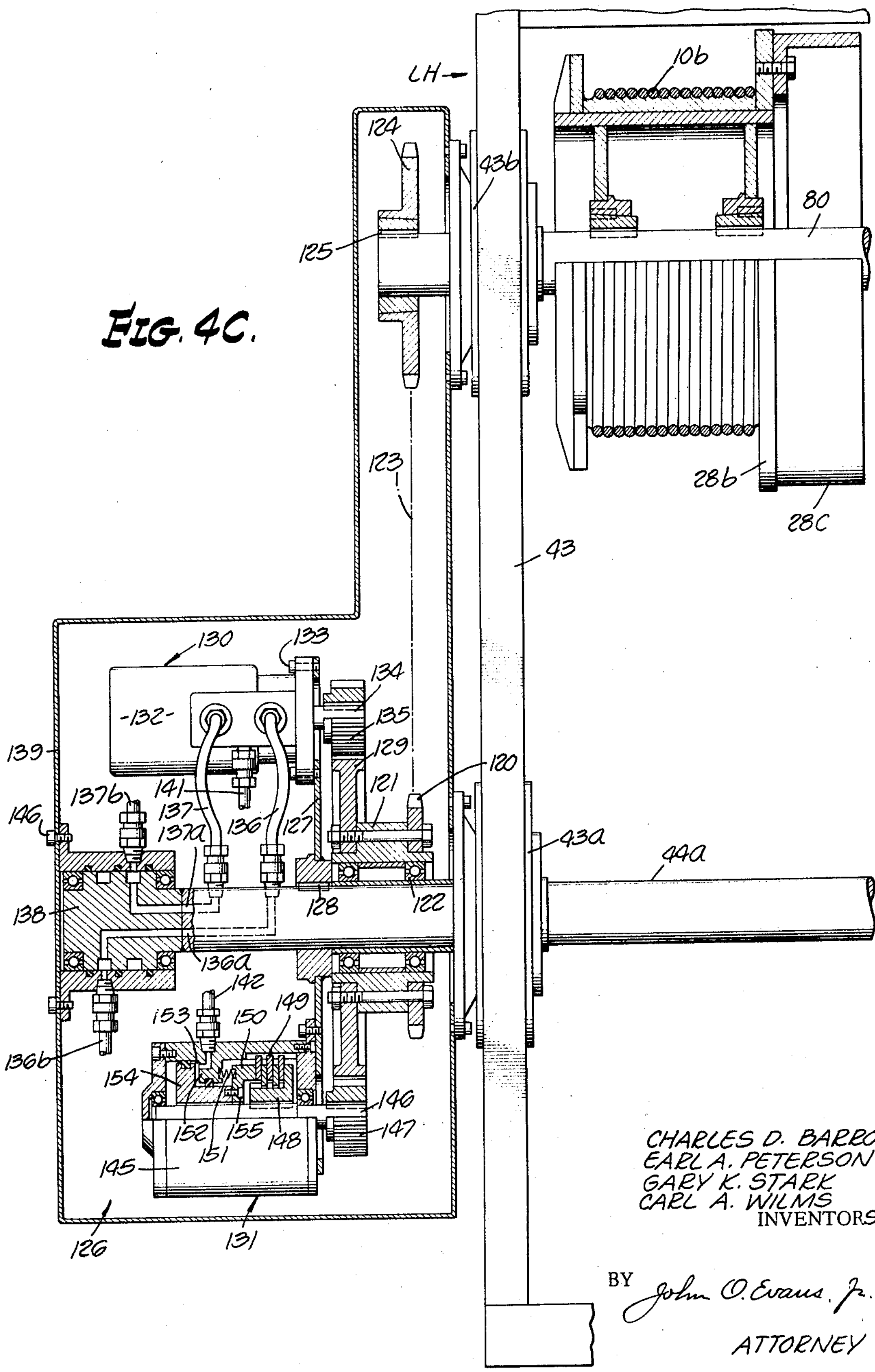

FIG. 4C.

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STABILIZED LOAD HOIST APPARATUS

BACKGROUND OF THE INVENTION

Problems are encountered in loading or unloading personnel or equipment on or from a floating transport vessel which is subjected to wave action causing upward and downward movements of the vessel relative to another larger vessel or barge or platform, such as, for example, at offshore well drilling or producing sites. Damage to the transport vessel or to the personnel or equipment may occur because of the difficulty encountered when the transport vessel is rapidly rising or falling.

THE PRIOR ART

Heretofore, as disclosed in the pending application for U.S. Pat., Ser. No. 19,582 filed Mar. 16, 1970, motion compensating hoist apparatus has been provided for moving the load between the two locations such as between a well drilling platform or barge at sea and a vessel used to transport men and equipment to and from the platform or barge, wherein the load is caused to move vertically in synchronism with the vessel, so that the load can be conveniently and also safely moved relative to the vessel. Such apparatus facilitates the movement of personnel or equipment onto or from the vessel notwithstanding the fact that the vessel may be caused to move vertically by the action of waves passing beneath the vessel.

More particularly, a load hoist and a tensioning hoist are provided and are adapted to be coupled together so that the motion of the transport vessel is imposed on the load, but the load may also be moved relative to the vessel by the load hoist. In such a hoist system the tension hoist has a tension line connected to the vessel and a fluid pressure actuated slip clutch drives the tension hoist to apply a substantially constant tension to the tension line and the load hoist is coupled to the tension hoist, the rise and fall of the vessel causing a variable control signal to be supplied to a fluid pressure controller to vary the pressure of actuator fluid supplied to the clutch. The load slidably engages the tension line so as to be guided to and from the deck of the transport vessel.

SUMMARY OF THE INVENTION

As the load, supported by the load hoist cable, is moved synchronously with the transport vessel under the influence of waves acting on the transport vessel, it is possible that the load may be caused to swing and possibly cause wrapping or snarling of the load line and the tension line.

Accordingly, the present invention provides a motion compensating hoist system, wherein the load is substantially stabilized by at least three lines which are connected to the load in spaced relation, certain of the lines supporting the load and other of the lines guiding the load, whereby the load is substantially stabilized against swinging about either line.

To accomplish this, one of the load and tension hoists has two drums and two cables or lines which are guided in axially spaced sheaves on the boom which projects from the platform or barge, and the other hoist has its cable or line guided in an intermediate sheave, whereby the three cables or lines can be connected to and slidably engaged with the load to stabilize the load. More particularly, the load hoist preferably has two drums and cables or lines, so that as a safety precaution the load is supported by two cables, and the load slidably engages the intermediate tension line. However, it will be apparent that equivalently a pair of tension hoist drums and cables or lines and a single load hoist drum and cable or line could be employed to accomplish the same results.

In either case, the load hoist and the tension hoist are adapted to be coupled so as to be driven together by the same power source, through a slip clutch which, on the one hand, allows downward movement of the vessel to pull cable or line from the tension hoist and correspondingly cause load cable or line to be played off of the load hoist, and which, on the other hand, causes the load hoist to reel in cable or line at a rate determined by the allowable reeling of tension cable or line onto the tension hoist as the vessel moves upwardly, and in addition, a load hoist drive is provided to separately move the load relative to the vessel when the load hoist and tension hoist are coupled or uncoupled.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective, fragmentary view, showing a platform or barge above the water and equipped with the invention for moving a load to or from a boat afloat in the water;

FIG. **2** is an end elevation of the power unit and the hoist and tension winches;

FIG. **3** is a fragmentary detail view, on an enlarged scale, with parts broken away and showing the connection of the load hoist lines and the sliding connection of the tension line to the elevator;

FIG. **4*a*** is a fragmentary view in side elevation, as taken on the line **4—4** of FIG. **2**, on an enlarged scale, and showing a portion of the hoist means with parts broken away to expose the drive for the tension winch;

FIG. **4*b*** is a fragmentary view, as taken on the line **4—4** of FIG. **2**, constituting a lateral continuation of FIG. **4*a***, and showing the selective drive connection of the tension winch to the load hoist;

FIG. **4*c*** is a fragmentary view, as taken on the line **4—4** of FIG. **2**, constituting a lateral continuation of FIG. **4*b***, and showing the motion compensating drive for the load hoist; and

FIG. **5** is a diagrammatic illustration of the combined winches and control means therefor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIGS. **1** and **2**, there is generally illustrated a barge or platform P adapted to be supported above the water on a number of suitably located legs L which extend to the bottom of the water, and on which the platform or barge P is mounted. In the case of certain barges, the platform is adapted to be elevated to a selected height above the water on the legs L, a distance of 80 feet more or less. On the barge or platform may be located the usual well drilling and/or completion or workover apparatus (not shown), as is well known in the art.

Periodically, the workers on the platform must be transported between the platform and the shore, and in addition, it becomes necessary from time to time to move various gear between the shore and the platform. Thus, a boat or vessel V is in part illustrated, and such boats or vessels range considerably in size from comparatively large work boats adapted to move heavy gear and supplies between the shore and the platform, and small personnel carrying boats. In either case, problems are experienced in transferring the gear or personnel between the vessel and the platform.

When the weather is fair and the water is calm the problem is less pronounced, but, when the water becomes rough and swells tend to cause the boat or vessel V to rise and fall relative to the platform the problem is more pronounced. The greater the frequency of the swells the worse the problem, so that under many commonly encountered conditions, the transfer of equipment or personnel between the platform and the boat or vessel V is very difficult, if not impossible to accomplish.

The present invention contemplates a motion compensating hoist system whereby an elevator E or other load support is adapted to be raised or lowered between the outer extremity of a boom B and the vessel V, the elevator E being suspended by a pair of load hoist cables or lines **10*a***, **10*b***. A tensioning line or cable **11** extends between the outer extremity of the boom B and a point of attachment **12** to the deck of the boat or vessel V. The lines or cables **10***a*, **10***b* and **11** respectively, are controlled by load hoist means LH and tensioning hoist means th, whereby during the initial stages of the lifting of the elevator E from the deck of the vessel V and during the final stages of movement of the elevator E onto the deck of the vessel V, the elevator is caused to move synchronously with the vertical movement of the vessel V, i.e., the elevator E moves in the same direction and at the same rate that the vessel V moves, as the vessel V is subjected to wave action. Superimposed on the synchronous movement of the elevator E with the vessel V is independent movement of the elevator E in a controlled manner whereby the elevator E is moved smoothly and gently to or from the deck of the vessel V by the load hoist means LH. The load hoist means LH is also operable, when the elevator E is moving through the portion of its travel safely above the deck of the vessel V to independently cause vertical traverse of the elevator E.

More particularly, the boom B is mounted on suitable support structure **13** which is affixed to a side of the platform P. The boom comprises in the illustrative embodiment a pair of laterally spaced outwardly convergent V-shaped arms **14** and **15**, which are preferably fabricated from upper and lower rails **16** and **17** reinforced by suitable struts **18** for rigidity, the arms **14** and **15** being suitably connected to the support structure **13**. Also supported on the support structure **13** is a power unit platform **20** on which is mounted a power source, such as an engine **21**, adapted through a suitable reduction gear box **22** and a chain drive **23**, by way of illustration, to drive the hoist means consisting of the tensioning hoist means TH and the load hoist means LH previously referred to. At a suitable elevated and laterally displaced position relative to the support structure **13** is mounted a control cab C in which an operator has good vision of the hoisting operations. Located between the boom arms **14** and **15** and extending from the support structure **13** horizontally to a location below the outer extremity of the boom B is a walkway W, having a laterally enlarged loading deck **26** at its outer extremity. The walkway W, the power unit platform **20**, as well as the barge or platform P are all provided with suitable guard rails thereabout, and a stairway **27** leads between the deck of the platform or barge P and the power unit platform **20**.

The load hoist lines or cables **10***a*, **10***b* extend from load hoist drums **28***a*, **28***b* outwardly of the boom B and over sheaves **29***a*, **29***b* which are rotatably supported at the outer extremity of the boom. The load hoist lines **10***a* and **10***b* are connected to the top of load supporting means shown as an elevator E, and more particularly, the elevator E has equalizing means **30**, best seen in FIG. 3, which allow the elevator to hang vertically, notwithstanding any tendency of one of the load lines **10***a* or **10***b* tending to wind on or unwind from its drum **28***a*, **28***b*, respectively, at a greater rate than the other load line. Preferably, the lines **10***a*, **10***b* are constituted by a single length of line or cable the ends of which are respectively wound on the load hoist drums **28***a*, **28***b*, and the bight **31** of which engages the equalizing means including a pair of spaced rollers **32**, **32** carried by a support member **33** which spans the elevator E and is welded or otherwise affixed to the elevator.

The tensioning line **11** leads from the tensioning hoist drum **34** along the boom B and over a sheave **35** which is suitably rotatably supported at the outer extremity of the boom. The tension line extends through a guide or tube **36** which is centrally disposed in the elevator. Thus, the elevator E is supported at spaced locations by the lines **10***a* and **10***b* and guided on the intermediate tension line **11**, so that the load elevator is effectively stabilized against swinging or spinning, and wrapping of the lines one about the other is precluded. In addition, the elevator or other load will be guided to and from the deck of the vessel V, even though the vessel may tend to move relative to the barge or platform P.

Referring to FIGS. **4***a*, **4***b* and **4***c*, it will be seen that the support structure for the hoist means includes four laterally spaced uprights or posts **40**, **41**, **42** and **43**. The uprights **40** and **41** have mounted thereon a pair of laterally spaced bearing blocks **40***a* and **41***a* in which is rotatably journaled a horizontally extended tensioning hoist shaft **44**. The tensioning hoist means TH includes the drum **34** on which the tensioning line or cable **11** is wound, the hub **45** of the drum **34** being keyed as at **46** to the shaft **44** for rotation therewith. The shaft **44** extends through the bearing block **40***a* to provide a driven shaft end **48** adapted to be driven by the drive means **23** under control of slip clutch means SC.

More particularly, the drive means **23** includes a drive chain **49** adapted to be driven by the output sprocket (not shown) of the reduction gear box **22** of the power source **21**. This chain **49** is engaged with a sprocket **50**, the hub **51** of which is rotatably mounted on the shaft end **48** by bearings **52**. Affixed to the sprocket **50**, is a disc **54** which is in turn affixed by fasteners **55** to the outer periphery of the backup plate **56** of the slip clutch means SC.

This slip clutch means SC includes an outer annular body **57** to which an annular flange **58** is connected by fasteners **59** in opposed relation to the plate **56**. Internally thereof, the body **57** has a splined connection **60** with the outer periphery of an axially shiftable clutch pressure plate **61**. Between the clutch plates **56** and **61** is a clutch friction disc **62** having friction facing **63** on opposite sides thereof and having, as at **64**, a splined connection with a hub **65** which is disposed upon the shaft end **48** and is keyed thereto by a key **66**. Thus, rotation from the sprocket **50** will be transmitted to the tensioning hoist shaft **44** when the slip clutch means SC is engaged to transmit rotation from the clutch body **57** and its plates **56** and **61** to the friction disc **62**.

Engagement of the slip clutch means SC is accomplished by an annular expansible actuator tube **67** having an air inlet **68**. The actuator tube **67** engages an annular body of insulating material **69** interposed between the tube **67** and the clutch pressure plate **61**. Each of the clutch plates **56** and **61** has a number of annular radially spaced and concentric coolant passages **56***a* and **61***a* to which a coolant is supplied to dissipate the heat of friction caused by slippage of the clutch SC. These passages **56***a* and **61***a* are defined respectively between the clutch plates and wear disc **56***b* carried by the plate **56** and wear disc **61***B* carried by the plate **61**, the friction material on the friction disc **62** being engaged with the wear discs **56***b*, **61***b*.

Such cooled, slip clutches are well known, and generally are provided with a coolant circulating system including a stationary coolant connector **71** through which coolant flows to and from a rotary connector **72** which is connected, as by fasteners **72***a*, to the clutch flange **58** and which has conduit means **73** for supplying coolant to the passages **56***a* and **61***a*, as well as conduit means for the return flow of coolant to the connector **71** and thence to a heat exchanger. In addition, the rotary connector **72** provides a connection for air conduit means **74** which leads to the air inlet **68** for the clutch actuator tube **67** from a stationary air inlet fitting **75**. As is well known, the torque transmitting capacity of such slip clutches varies with the pressure of air in the actuator tube **67**.

Preferably, the slip clutch means SC is made in accordance with the disclosure of U.S. Pat. application Ser. No. 19,601, filed Mar. 16, 1970, in the name of C. D. Barron, so that the clutch plates and discs are more effectively cooled.

Referring to FIGS. **4***b* and **4***c*, it will be seen that motion compensating drive means are adapted to selectively drivingly connect the shaft **44** of the tensioning hoist means TH to a shaft **44***a* which is in turn drivingly connected to a shaft **80** of the load hoist means LH. This shaft **80** is preferably in two parts connected by a chain or other coupling **80***a* mounted for rotation in bearings **40***b*, **41***b*, **42***b* and **43***b* which are mounted on the supports **40**, **41**, **42** and **43** so that the shaft **80** extends in parallel relation to the shaft **44** and the shaft **44***a* in laterally spaced relation. It will be understood that the relationship between the tensioning hoist means and the load hoist means is only illustrative of a preferred arrangement under given conditions, but that the shafts **44**, **44***a* and **80** may be otherwise arranged.

As seen in FIG. 4*b*, the shaft **44** has a chain or other coupling **81** connected thereto by a key **82**, the coupling also being connected to an adapter **83** which is in turn connected by fasteners **84** to an annular body **85** of the motion compensating drive clutch means MC. The adapter **83** and the clutch body **85** are revolvably mounted on bearings **86** on a sleeve **87** which is splined to the end of the shaft **44***a* as at **88** for rotation therewith. Typically, the clutch assembly MC. also includes a plurality of clutch discs **89**. Alternate discs **89** are splined to the adapter sleeve **87**, and the other discs **89** are splined to the annular clutch body **85**, whereby rotation is transmitted to the shaft **44***a* from the shaft **44** when the discs **89** are engaged between the usual backup plate **90** and the shiftable pressure plate **91**. In order to engage the clutch discs **89** between the plates **90** and **91**, actuator means responsive to fluid pressure are provided, including a thrust bearing **92** which is engaged with the pressure plate **91** to shift the latter towards the backup plate **90** in response to corresponding movement of an outer actuator sleeve **93** which also is engageable with the thrust bearing **92**. This actuator sleeve is slidable on a fixed actuator sleeve **94** within which the adapter sleeve is rotatable on a bearing **95**. These actuator sleeves **93** and **94** are suitably formed and sealed to provide a pressure chamber **96** to which fluid, such as air, may be admitted through a conduit **97** to effect engagement of the clutch MC, or to allow its release in the absence of pressure fluid.

As also seen in FIG. 4*b*, the shaft **44***a* has a brake **100** adapted to brake the shaft **44***a* when the clutch MC is disengaged. This brake **100**, in the illustrative embodiment, is like the clutch MC. More particularly, the brake **100** includes an adapter **101** which is fastened, as at **102**, to a stationary plate or flange **103** which is suitably affixed to the support **42**. A pin **104** connects the adapter **101** to an annular brake body **105**, and an adapter sleeve **106** which is splined to the shaft **44***a*, as at **107**, is revolvable in bearings **108** within the adapter **101** and the brake body **105**. A pack of discs **109** are disposed between a backup plate **110** and a pressure plate **111**, and alternate discs **109** are splined to the body **105** and the sleeve **106**, whereby to hold the shaft **44***a* against rotation when the brake **100** is engaged. To engage the brake **100**, a thrust bearing **112** is interposed between the pressure plate **111** and an annular actuator member **113** which is axially shiftable on an internal actuator member **114** within which the shaft **44***a* revolves in a bearing **115**. These actuator members **113** and **114** are formed and sealed to provide a chamber **116** into which pressure fluid is supplied through a conduit **117** to engage the brake **100**.

As will hereinafter be more fully described, the clutch MC and brake **100** are preferably supplied with actuating fluid pressure simultaneously, so that when the brake **100** is engaged, the clutch MC is released, and vice versa. When the clutch MC is engaged, rotary motion will be transmitted from the shaft **44***a* to the shaft **80**, in the direction and at the rate determined by operation of the tension hoist TH and the slip clutch means SC.

As seen in FIG. 4*c*, rotation o the shaft **44***a* is not only adapted to be transmitted to the shaft **80** of the load hoist, but, in addition, the load hoist shaft **80** may be further driven to superimpose a traverse movement of the elevator E on the compensating movement. In this connection, the shaft **44***a* extends through a bearing **43***a* carried by the support **43** and has a sprocket **120** carried by a hub **121** and revolvable about the shaft **44***a* on bearings **122**. A chain **123** is engaged with the sprocket **120** and with a similar sprocket **124** which is keyed, as at **125**, on the shaft **80**. Motor brake means **126** are provided to connect the sprocket **120** to the shaft **44***a* to drive shafts **44***a* and **80** in unison and to further, separately drive shaft **80**.

A plate **127** is keyed on the shaft **44***a* by a key **128**, and a gear **129** having external teeth thereon is fixed on the hub **121**. Motor means **130** and brake means **131** are carried by the plate **127** and are selectively operable to drive the gear **129**, and hence the drive sprocket **120**, simultaneously synchronously with and oppositely relative to the shaft **44***a*, or to lock the gear **129**, and hence the drive sprocket **120** and the plate **127** together for unitized rotation.

More particularly, the motor means **130** includes a housing **132** connected by fasteners **133** to the plate **127** and an output shaft **134** which extends through the plate **127**. On the output shaft **134** is a pinion **135** which is drivingly in mesh with the external gear teeth of the gear **129**. Fluid is supplied to the motor **130** in selected, reversible directions through conduits **136** and **137** to effect reverse operation of the motor, such fluid being supplied through passages **136***a* and **137***a* which extend longitudinally in the shaft **44***a* and are supplied from stationary source conduits **136***b* and **137***b*, respectively, which are connected to a rotary fluid connector **138** suitably mounted in a housing **139**, as by fasteners **146**. Such a rotary connector **138** is common and requires no further specific discussion. The motor **130** also has a fluid outlet **141** which, as will be more fully described hereinafter, supplies fluid to the inlet conduit **142** of the brake means **131** to release the latter when the motor **130** is operating, whereby the load hoist shaft **80** is revolvable whether or not the shaft **44***a* is revolving. When the motor means **130** is operating, the net rotary motion of the shaft **80**, is a function of the direction and extent of rotation of the shaft **44***a* modified by the direction and extent of rotation of the gear **129** about the shaft **44***a* in either direction. Therefore, the load hoist lines **10***a* and **10***b* and the elevator E may be raised or lowered by the motor **130**, while the lines **10***a* and **10***b* are also moving the elevator E in unison with movement of the boat or vessel V.

The brake means **131** comprises a housing **145** secured to the plate **127** so as to revolve with the shaft **44***a*. Carried by and disposed in the housing **145** is a rotatable stub shaft **146**. This shaft **146** extends through the plate **127** and has a pinion gear **147** keyed thereon and engaged with the gear **129**. A brake rotor **148** is keyed on the shaft **146**, and friction discs **149** are interposed between the brake rotor **148** and an actuator member **150**, alternate discs being splined to the rotor **148** and to the housing **145**, so that when the discs are engaged, the rotor **148** will be held stationary, thereby holding the pinion **147** against rotation, to brake the gear **129**, and hence the load hoist shaft **80**. The brake **131** is normally engaged by a number of coiled compression springs **151** spaced circumferentially of the actuator member **150** and acting on the same and on an internal flange **152** in the housing **145** to bias the member **150** in a brake-engaging direction. To disengage the brake means **131**, fluid under pressure is supplied from the conduit **142**, previously referred to, to a sealed piston chamber **153** in which is a piston **154** connected to the actuator member **150**, as by screws **155**, to move the actuator member **150** to a brake-release position. When the brake means **131** is engaged, the hoist shaft **80** is effectively connected to the shaft **44***a* for rotation therewith, but when the brake means **131** is released, the motor means **130** is effective to not only connect the shaft **44***a* to the shaft **80**, but also to effect relative rotation thereof, as previously described.

OPERATION

It will now be apparent that when the slip clutch means SC is engaged to apply tension to the line **11**, the tension hoist drum **34** will be caused to rotate to play out line when the vessel V descends, and the drum **34** will be rotated in the other direction to take up line when the vessel rises, such rotation of the drum **34** in either direction being at a rate determined by the rate of vessel movement. When the motion compensating clutch means MC is engaged, corresponding rotation will be transmitted through the shaft **44***a* to the motor-brake means **126** and thence through the sprockets **120** and **124** to the load hoist shaft **80** and its load hoist drums **28***a* and **28***b*, whereby the load or elevator E will move synchronously with the vessel V. When the motor **130** is also operated, further movement of the elevator will be effected to move the elevator during that portion of its travel close to the vessel. The other portion of movement of the elevator is accomplished with the motion compensating clutch MC released and the brake **100** engaged to hold shaft **44***a* stationary, as the motor **130** is operated to raise or lower the load or elevator E.

The operation of the load compensating hoist system will be further understood with reference to FIG. 5, wherein the apparatus is schematically illustrated together with operating and control means therefor. For convenience of illustration, the tension line is not shown as slidably engaged with the elevator E, but in practice would be so engaged, as previously described.

In this view, it will be noted that air under pressure is supplied to the inlet connector **75** os the slip clutch means SC through a controller or pressure regulator R1, so that the slip clutch means may be adjusted to transmit sufficient torque to the drum shaft **44** as to maintain a predetermined tension on the tension line **11** of the tension hoist means TH which is connected to the vessel V. The controller R1 needs no specific illustration, but is preferably of the type that will cause an outlet pressure which is a function of a "SET POINT" signal and a signal derived from tension on the tension line **11**. The line tension of the tension hoist TH is selected so as to be proportionate to load, represented by the elevator E, namely, the weight of the elevator E together with the weight of the load to be carried in the elevator, and inertia forces to be overcome in accelerating and decelerating the load when the system is compensating for movement of the vessel V.

In order to cause motion compensating motion of the load lines **10***a* and **10***b*, whether or not they are connected to a load or to the elevator, the motion compensating clutch means MC is engaged and the brake means **100** is released. This is accomplished by suitable valve means, herein illustrated as including a control valve CV1 which is interposed between a suitable source of air under pressure and the pressure conduits **97** and **117**, the valve CV1 being operable in one position to connect the air supply to both the clutch means MC to engage the same and the brake means **100** to release the same, and conversely, in the other position, to exhaust the clutch and brake to allow release and engagement thereof, respectively. Thus, with the clutch means MC engaged, the load hoist shaft **80** will be driven synchronously with the shaft **44** through chain **123**, and rotation of the load hoist shaft **80**, which is locked to the shaft **44***a* by the motor-brake means **126**, will be in the same direction and at the same rate as rotation of the tension hoist shaft **44**, as the latter is caused, alternately, to turn in one direction by the pull on the line **11** by the vessel V, as the vessel moves downward, and in the other direction, as the vessel rises on a wave, the tension on line **11** remaining substantially constant at the value established by the slip clutch means SC.

With the load hoist lines **10***a* and **10***b* thus moving with the vessel V, the lines **10***a* and **10***b* may be raised or lowered, whether or not connected to the elevator E, by the operation of the reversible hydraulic motor **130**, when the brake means **131** is released, whereby the load hoist drums **28***a* and **28***b* are subjected to a motion which is superimposed on the motion of shafts **44** and **80** caused by the rise and fall of the vessel V.

To accomplish this, suitable valve means are provided, herein illustrated as a control valve CV2, adapted to control the flow of hydraulic motor fluid to the motor means **130** and to the brake means **131**, and from the motor means to a reservoir. The valve means CV2 has a position for directing fluid from a suitable pressure source through conduits **136***b* and **136** and to an exhaust to cause motor rotation in on direction, and another position for directing fluid through the conduits **137***b* and **137** to cause motor rotation in the other direction. In either event, pressure fluid is also supplied to the brake inlet conduit **142** from a shuttle valve SV interposed between the conduits **136** and **137**.

For moving the load hoist lines **10***a* and **10***b* independently of the tension line **11**, the control valve CV1 is operated to relieve operating air pressure from the clutch means MC and the brake means **100**, so that the drums **28***a* and **28***b* may be driven independently of the tension hoist means, to raise or lower the load lines **10***a* and **10***b* when the load is safely above the vessel V, whether the lines **10***a* and **10***b* are loaded or unloaded.

With the foregoing in mind, it will now be understood that the tension on the tension line **11** caused by the application of preset air pressure to the slip clutch means SC is preferably maintained at a constant value whether or not the load hoist lines **10***a* and **10***b* are supporting a load. Accordingly, load sensing means LS are provided to cause the application of a variable air pressure to the slip clutch means SC to adjust the torque capacity of the slip clutch means SC so that the pressure supply to the slip clutch means is decreased, if the tension on line **11** tends to increase, or the pressure supply to the slip clutch means is increased, if the tension on the line tends to decrease.

Such load sensing means may be any typical devices adapted to sense load on a line to produce a related signal, such as a load cell of the hydraulic type, as indicated at **200** in FIG. 5. This load cell **200** has a piston **201** which projects from the cylinder **202** and is engaged by a portion **203** of a lever **204** which supports a tension line sheave **205** on the axle **206**, the lever being pivotally mounted on a pin **207** carried by the support structure, as is obvious. Leading from the load cell cylinder **202** is a conduit **208** which is connected to a pressure regulator or transmitter R2 of any suitable type which, as is well known, is operative to regulate the drop in air pressure supplied from a source and establish an outlet air signal pressure pressure in a conduit **209** which is a function of the applied hydraulic pressure from the load sensor means LS. The air pressure from the regulator R2 is conducted by the conduit **209** to the controller R1 to modify the net output pressure from the controller R1 to the slip clutch means SC.

Assuming that the vessel V, with a load thereon, such as certain equipment or personnel to be elevated to the platform P is situated at a location below the boom B, the tension line **11** is lowered, either first or with the load lines **10***a* and **10***b*, and the tension line **11** is connected to the vessel V, with the line extending through the guide **36** of the elevator E. Air is supplied at a preset value to the slip clutch means SC to apply a tension to the line **11** proportionate to the weight of the elevator E and any load which it is to lift. At this time, the rise and fall of the vessel V will cause the tension drum **34** to oscillate. The motion compensating clutch means MC is engaged, and the drum shaft brake means **100** correspondingly released, so that the load hoist drums **28***a* and **28***b* will oscillate in unison with the tension hoist drum **34**, causing synchronous movement of the load lines with the tension line, corresponding to movement of the vessel. While such synchronous motion occurs, the load hoist drum motor **130** may be supplied with fluid, and the brake means **131** is released, to enable controlled downward movement of the elevator E, or other load support, to the deck of the vessel for loading.

Thereafter, the motor **130** is reversed, causing upward movement of the load relative to the vessel, while the load continues to rise and fall synchronously with the rise and fall of the vessel. As the load is lifted from the deck of the vessel, the load will require substantially the full output of the slip clutch means SC which has been preset for the known load value. Thus, there is a tendency to reduce the tension on the tension line **11**, which tendency is sensed by the load sensor means LS. The reduced hydraulic signal from the load cell **200** causes an increase in the air pressure supplied from regulator R2 to controller R1 and a resultant increase in the air pressure supplied from the regulator R1 to the slip clutch means until the torque capacity of the slip clutch SC is sufficient to not only maintain the initial tension on the line **11**, but also to elevate the load, while the motion compensation continues. When the load is at a safe distance above the vessel, and motion compensation is no longer necessary, the brake means **100** for the load hoist means are engaged and the motion compensating clutch means MC are released. At this time, since the slip clutch means SC no longer is subjected to the load, the entire torque for the slip clutch is applied to the tension drum **34** tending to increase the tension, resulting in an increased hydraulic signal to the regulator R2 and a reduction in the net air pressure supplied to the slip clutch means to the original preset value, whereby the tension on line **11** will be held substantially at the constant predetermined value.

The lowering of a load onto the vessel will simply involve reversal of the operations described above in elevating a load.

During all of the travel of the elevator E between a location adjacent to the loading platform **26** of the boom B and a location on the deck of the vessel V, the sliding connection between the elevator E and the tension line **11** provided by the tube **36** and the spaced connection of the load lines **10***a* and **10***b* to the elevator E will prevent the elevator or the other load from spinning or wrapping a load line and the tension line. In addition, the load is guided to a precise location on the deck of the vessel, notwithstanding movement of the vessel beneath the end of the boom.

For the sake of safety, it will be understood that fail safe means (not shown) may be provided. In this connection, it is customary that hoists or winches have normally engaged or spring-set band brakes associated with the drum, and more particularly with the flange **28***c* (FIG. 4c) of the hoist drum **28***b*, for example, and with the corresponding flange **34***a* (FIG. 4a) of tensioning hoist drum **34**. Such brakes may be also employed in the present apparatus and released responsive to the fluid pressure in the operating system, so that the band brakes would automatically set in the event of loss of pressure in the system or any portion thereof. In addition, the brake means **100** and **131** may be employed as a fail safe means for holding the load hoist against movement upon loss of operating fluid pressure. Any such fail safe brake for the tension hoist TH should allow the line **11** to be played off of the drum **34** under tension applied by fall of the vessel, so as to avoid any tendency to overload the tension line.

I claim:

1. In motion compensating hoist mechanism including a support structure adapted to be mounted at a location over a vessel floating in the water for raising or lowering a load from or to said vessel, hoist means on said support structure including a load hoist and a tension hoist, drive means for releasably coupling said hoists for unitized operation, a source of power, slip clutch means for connecting said hoist means to said source of power for driving said hoist means, said tension hoist having cable means connectable to said vessel and slidably engaging said load, and said load hoist having cable means connectable to said load, fluid pressure operated means for varying the torque transmitting capacity of said slip clutch means, pressure controller means for varying the actuating fluid pressure to said fluid pressure operated means, and load responsive means for operating said controller means to vary the pressure of actuating fluid to increase the torque transmitting capacity of said slip clutch means when the tension on said tension hoist cable means decreases and to decrease the torque transmitting capacity of said slip clutch means when the tension on said tension hoist cable means increases, the improvement wherein the cable means of one of said hoists includes a pair of cables, the cable means of the other of said hoist comprises a single cable disposed between said pair of cables.

2. In motion compensating hoist mechanism as defined in claim **1**, said cable means of said load hoist comprising said pair of cables.

3. In motion compensating hoist mechanism as defined in claim **2**, said pair of cables being connectable to said load, and including equalizer means associated with said pair of cables and said load for allowing said load to hang vertically between said pair of cables when said load hoist raises and lowers said pair of cables.

4. In motion compensating hoist mechanism as defined in claim **1**, said cable means of said load hoist comprising said pair of cables, a pair of drums disposed in axially spaced relation, said pair of cables respectively being wound on said spaced drums.

5. In motion compensating hoist mechanism as defined in claim **1**, said load including a load support having guide means thereon, said cable means of said tension hoist slidably extending through said guide means.

6. In motion compensating hoist mechanism as defined in claim **5**, said load support comprising an elevator cage.

7. In motion compensating hoist mechanism as defined in claim **1**, said cable means of said load hoist comprising said pair of cables, and said load including a load support slidably engaging said cable of said tension hoist.

8. In motion compensating hoist mechanism as defined in claim **7**, said load support comprising an elevator cage having a central cable guide, said tension hoist cable extending slidably through said guide, and said pair of load hoist cables being connected to said cage in spaced relation at opposite sides of said tension hoist cable.

9. In motion compensating hoist mechanism as defined in claim **1**, said support structure having a boom projecting therefrom, said hoist means being adjacent to said support structure, said boom having an outer end provided with spaced cable guides for laterally spacing said cables, said pair of cables extending over a pair of said guides and said single cable extending over one said guide located between said pair of guides.

10. In motion compensating hoist mechanism including a support structure adapted to be mounted at a location over a vessel floating in the water for raising or lowering a load from or to said vessel, hoist means on said support structure including a load hoist and a tension hoist, drive means for releasably coupling said hoists for unitized operation, a source of power, slip clutch means for connecting said hoist means to said source of power for driving said hoist means, said tension hoist having cable means connectable to said vessel and slidably engaging said load, and said load hoist having cable means connectable to said load, said tension hoist comprising a drum shaft, tension hoist drum means rotatable with said shaft, said slip clutch means connecting said shaft to said source of power, said load hoist comprising a drum shaft, load hoist drum means rotatable with said latter drum shaft, said drive means comprising clutch means for connecting said shafts for unitized rotation, and means for selectively separately rotating said load hoist shaft, the improvement wherein the cable means of one of said hoists includes a pair of cables, the cable means of the other of said hoist comprises a single cable disposed between said pair of cables.

11. In motion compensating hoist mechanism including a support structure adapted to be mounted at a location over a vessel floating in the water for raising or lowering a load from or to said vessel, hoist means on said support structure including a load hoist and a tension hoist, drive means for releasably coupling said hoists for unitized operation, a source of power, slip clutch means for connecting said hoist means to said source of power for driving said hoist means, said tension hoist having cable means connectable to said vessel and slidably engaging said load, and said load hoist having cable means connectable to said load, clutch means for selectively driving said tension hoist and said load hoist in unison, and separate drive means for driving said load hoist, the improvement wherein the cable means of one of said hoists includes a pair of cables, the cable means of the other of said hoist comprises a single cable disposed between said pair of cables.

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