Feb. 17, 1970 J. R. SUTTON 3,495,806

APPARATUS FOR RAISING AND LOWERING AN OFF-SHORE PLATFORM

Filed Oct. 26, 1967 3 Sheets-Sheet 1

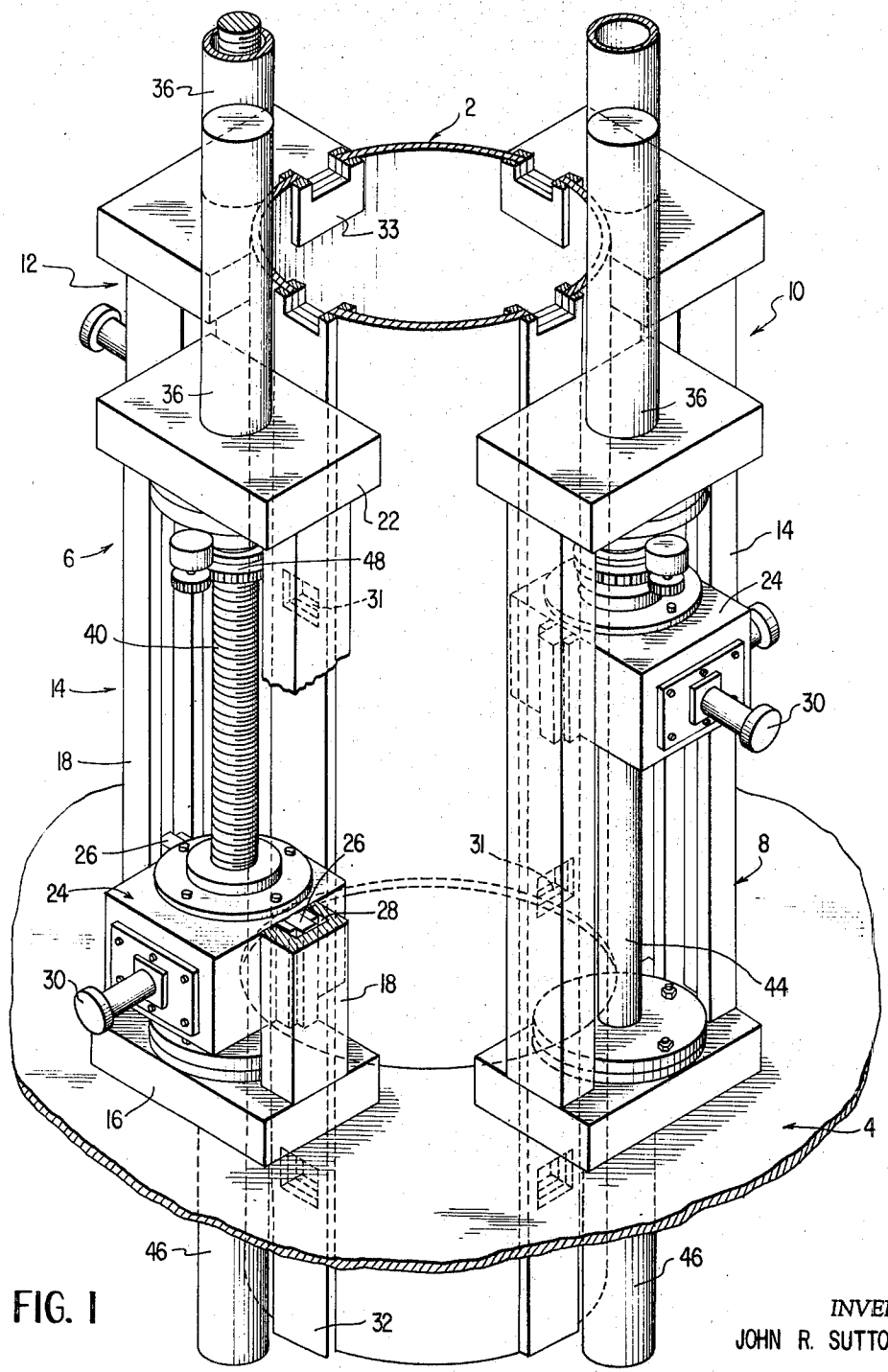


FIG. 1

INVENTOR
JOHN R. SUTTON

BY
Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS

Feb. 17, 1970 J. R. SUTTON 3,495,806

APPARATUS FOR RAISING AND LOWERING AN OFF-SHORE PLATFORM

Filed Oct. 26, 1967 3 Sheets-Sheet 2

FIG. 2

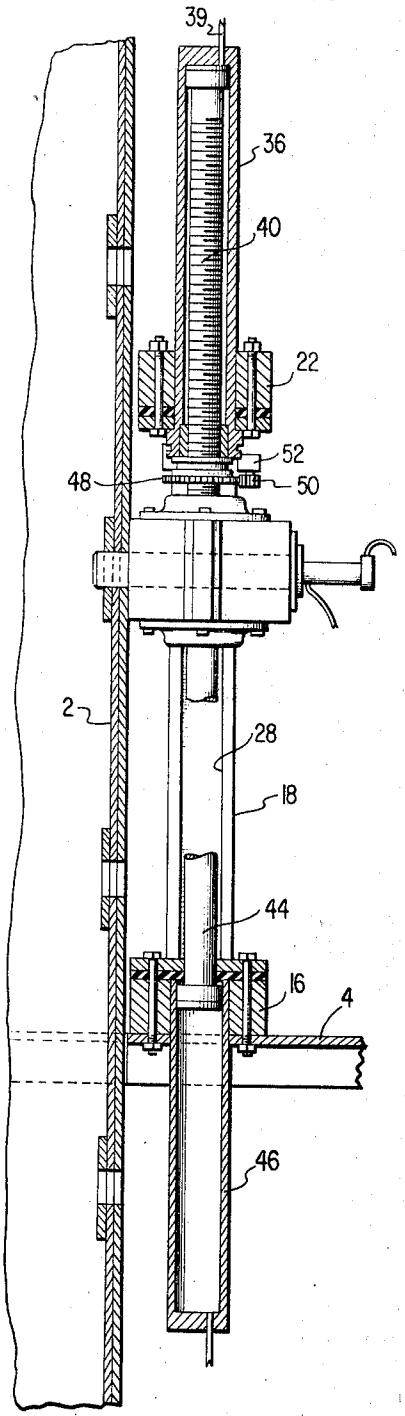
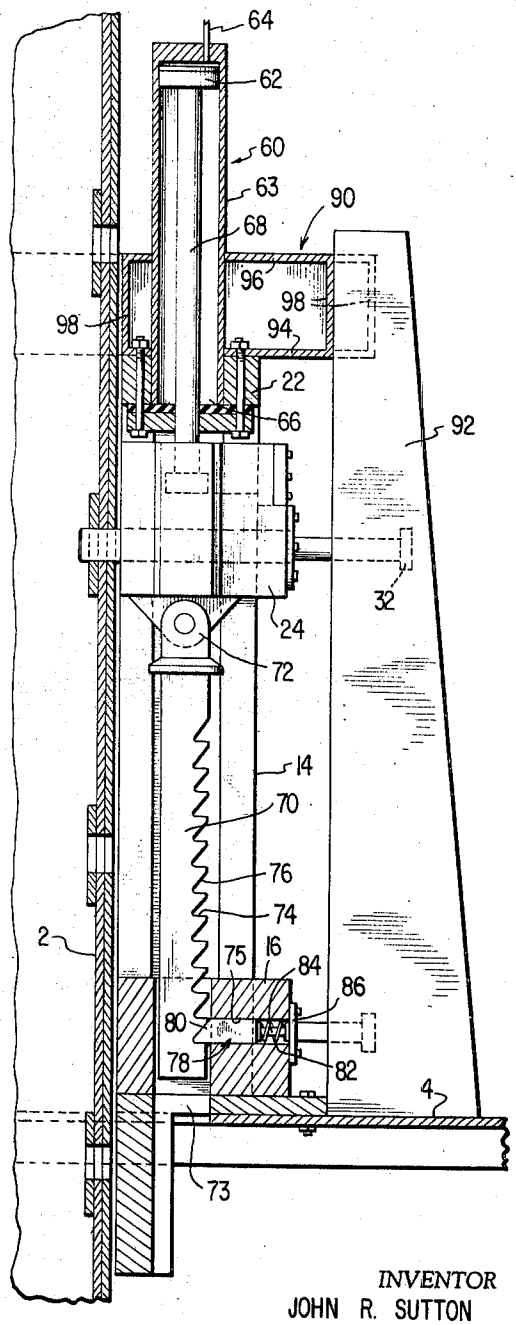


FIG. 3



INVENTOR
JOHN R. SUTTON

BY Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS.

Feb. 17, 1970 J. R. SUTTON 3,495,806

APPARATUS FOR RAISING AND LOWERING AN OFF-SHORE PLATFORM

Filed Oct. 26, 1967 3 Sheets-Sheet 3

FIG. 4

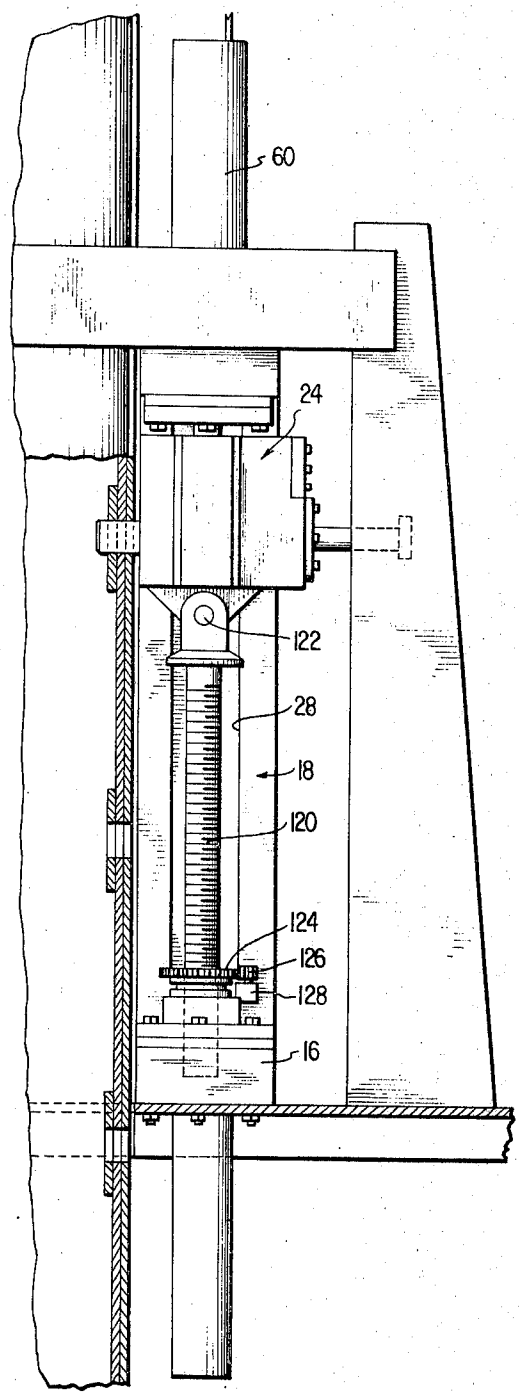
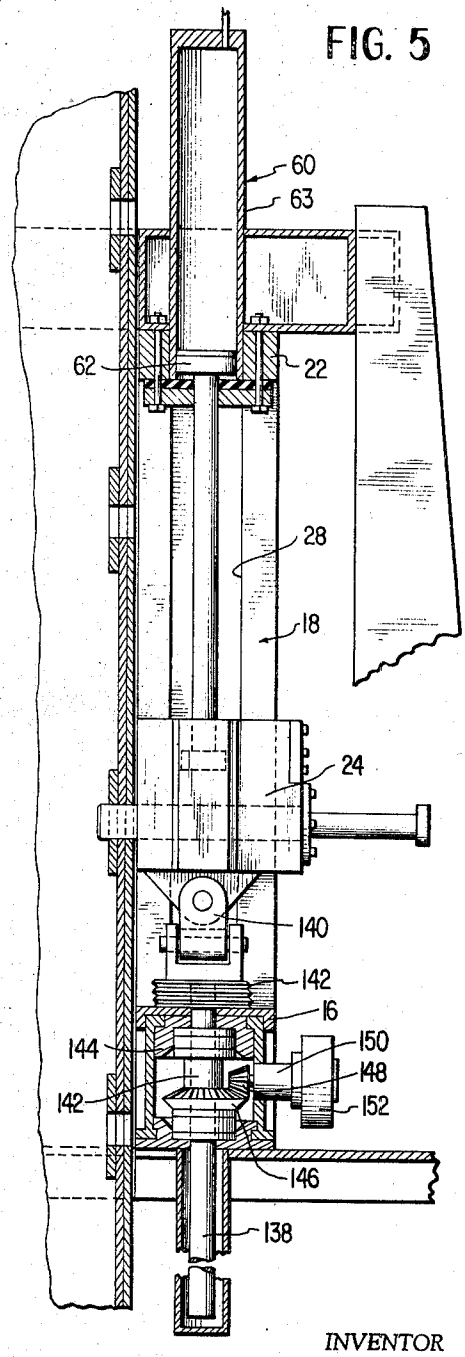


FIG. 5



INVENTOR
JOHN R. SUTTON

BY Burns, Doane, Benedict, Swecker & Mathis
ATTORNEYS.

United States Patent Office 3,495,806
Patented Feb. 17, 1970

3,495,806

APPARATUS FOR RAISING AND LOWERING AN OFF-SHORE PLATFORM

John R. Sutton, 1189 Calder Ave.,
Beaumont, Tex. 77701

Filed Oct. 26, 1967, Ser. No. 678,397
Int. Cl. B66f 3/08
U.S. Cl. 254—107 14 Claims

ABSTRACT OF THE DISCLOSURE

An off-shore platform includes a horizontal deck supported on a plurality of legs extending vertically and slidably through the deck. At least one elevating assembly is associated with at least one of the legs for raising and lowering the deck relative to the leg. The elevating assembly comprises first and second elevating units. Each elevating unit includes a vertically extending structure fixedly secured to the deck and provided with guiding members. Connecting means adapted for selective connection to the legs are guided for vertical motion relative to the structure by the guiding members between one position adjacent the deck and another position adjacent an end portion of the structure remote from the deck. Each elevating unit further includes main moving means for selectively causing reltaive vertical motion between the structure and the associated connecting means in one vertical direction, and a return moving means for causing relative vertical motion in an opposite direction. The moving means of the first and second elevating units are operatively interconnected so that the main moving means of the one elevating unit operates concurrently with the return moving means of the other elevating unit. In operation, one only of the elevating units is engaged with the leg and the asosciated main moving means is operated to cause vertical movement of the deck along the leg with the return moving means of the other elevating unit operating concurrently to return the associated connecting means to position for commencement of the next succeeding vertical movement of the deck along the leg by the other of the elevating units.

The elevating assembly also includes locking means connected with the first and second elevating units for automatically locking each connecting means to its associated structure uopn failure of the asosciated main moving means, to provide a fail-safe capability.

Background of the invention

This invention relates to apparatus for raising and lowering a platform of the type used for supporting equipment at variable heights above ground level such as, for example, a tower for supporting geophysical, radio, radar, or nuclear equipment. In particular, but not exclusively, the invention relates to an off-shore platform for performing off-shore marine operations such as underwater drilling operations.

In performing off-shore marine operations in continental shelf areas or the like, it is sometimes advantageous to use an off-shore platform of the so-called "jackup" type for supporting oil drilling and like equipment. Such "jackup" platforms usually comprise a horizontal deck supported on a plurality of legs which rest on the sea bed at their lower ends and which extend vertically and slidably through the deck. Extensible jacks may be secured to one side of the deck. The remote end of each jack is provided with means for selective locking engagement with at least one leg. Similarly, the deck is also provided with means for selective locking engagement to the legs. By engaging the remote ends of the jacks with the legs

and disengaging the deck and then causing linear extension or extraction of the jacks, the deck may be moved vertically along the leg. Representative examples of such offshore platforms are disclosed in U.S. Patents Nos. 3,082,607, 3,245,658 and 3,282,565, issued to the present applicant.

Although elevating platforms of the type described are generally satisfactory, certain operational disadvantages may be encountered. For example, in performing the elevating sequence described, it is usually necessary, once the deck has been elevated and resecured to the leg, to undergo a period of dwell while the jack is retracted to place it in condition for the next subsequent lifting operation. Such periods of dwell, however, may involve an unacceptable loss of time, particularly in conditions where frequent adjustment of height of the platform is necessary.

Another serious problem is posed by the possibility of jack failure which may occur from time to time due to weakness of the jack or the fluid line connections or similar causes. Jack failure may permit the deck to commence slipping down the leg and such motion once started is difficult to check immediately in view of the enormous loads involved. In this event, local buckling of the leg and the platform, or other even more serious consequences, both in terms of capital lost and possible injury to life and limb of those working on the platform may be incurred.

Summary of the invention

It is therefore a general object of the invention to provide apparatus for raising and lowering an off-shore platform intended to obviate or minimize problems of the type previously described.

It is a particular object of the invention to provide apparatus for raising and lowering an off-shore platform wherein the amount of dwell time required between successive steps of vertical movement is effectively minimized.

It is yet another object of the invention to provide apparatus for raising and lowering an off-shore platform designed to have fail-safe capabilities so that alternative fixed support for the platform is provided at any time that one of the elevating jacks should fail under load.

One preferred embodiment of the invention intended to accomplish at least some of the foregoing objects includes an elevating assembly intended to be utilized in conjunction with an off-shore platform of the type including a generally horizontal deck supported on a plurality of ground-engaging, generally vertical, legs extending slidably through the deck. The elevating assembly is associated with one of the legs for raising and lowering the deck relative to the leg and includes first and second elevating units. Each of the elevating units includes a vertically extending structure adapted to be fixedly secured to the deck extending generally perpendicular therefrom, with an end portion of the structure spaced fixedly and remotely from the deck. Each elevating unit also includes connecting means adapted for selective connection to the leg at any of various points spaced vertically along the leg. Each connecting means is guided for vertical motion relative to its associated one of the structures between one position adjacent the remote end thereof and another position adjacent the deck, by guiding members forming a part of each structure. Each elevating unit further includes a main moving means connected with the structure and the associated connecting means for selectively causing relative vertical movement between the structure and the connecting means in one direction, and a return moving means for causing relative vertical motion therebetween in an opposite vertical direction. The moving means of the first and

second elevating units are operatively interconnected to cause operation of one of the main moving means of one of the elevating units to occur concurrently with operation of the return moving means of the other of the elevating units. In operation, one only of the elevating units is engaged with the leg and the associated main moving means operated to cause vertical movement of the deck along the leg. Concurrently, the returning moving means of the other elevating unit is returning the associated connecting means to position for commencement of a succeeding vertical movement of the deck along the leg by the other of the elevating units.

The main and return moving means of each elevating unit includes shaft means fixedly connected with the associated connecting means extending vertically therefrom. Hydraulic jack means is fixedly connected with the associated structure and with the associated shaft means for moving the shaft means vertically relative to the structure.

In order to provide a fail-safe capability, first and second locking means are connected with the structures of said first and second elevating units respectively, and with the respective shaft means of the elevating units. Each of the locking means is automatically operable to fixedly engage the associated shaft means with the structure upon failure of the associated one of the hydraulic jack means. This automatically prevents further relative motion between the associated connecting means and the deck. In this manner, runaway downward motion of the deck along the leg which might occur upon failure of a lifting jack under load is automatically prevented.

In one embodiment of the invention each shaft means includes a first rod fixedly connected with the associated connecting means extending vertically toward the end portion of the adjacent structure and a second rod fixedly connected with the connecting means extending vertically toward the deck. The hydraulic jack means include a single-acting main hydraulic jack fixedly connected with the remote end of the structure and connected with the first rod for selective extension thereof outwardly of the first jack, to move the associated connecting means towards the deck, and a single-acting return hydraulic jack fixedly connected with the structure adjacent the deck and connected with the second rod for selective extension thereof outwardly of the return hydraulic jack to return the connecting means vertically. The first and second locking means each include an axially extending threaded portion upon one of the associated first and second rods. Each locking means further includes a nut threadedly engaging the threaded portion of the one rod with the nut rotatively mounted upon and fixedly connected with the adjacent structure. Each nut is rotated by a nut motor connected with the nut for rotating the nuts synchronously with axial motion of the associated rod to permit axial motion thereof relative to the associated jack. The nut motor is operatively connected with the associated main hydraulic jack to automatically prevent further rotation of the nut upon failure of the main hydraulic jack, thus fixedly engaging the connecting means with the structure to prevent further motion of the deck.

In a first alternative embodiment of the invention, a double-acting hydraulic jack is connected with one of the first and second rods for selective extension and retraction thereof with the second rod provided with vertically spaced notched portions engaged by a spring-loaded ratchet plunger fixedly secured to the structure. The ratchet plunger prevents relative vertical motion between the structure and the connecting means in one vertical direction corresponding to downward vertical motion of the deck relative to the leg, but permits relative vertical motion in an opposite vertical direction.

In a second alternative embodiment, otherwise similar to the first alternative embodiment, the ratchet plunger locking arrangement is replaced by a threaded peripheral portion on the other of the first and second rods threadedly engaging a power-driven nut connected with the structure, with rotation of the nut being automatically terminated upon failure of the hydraulic jack.

In a third alternative embodiment of the invention, otherwise similar to the first alternative embodiment, the ratchet and plunger arrangement is replaced by a threaded portion on the other of the first and second rods engaging a ball nut fixedly and rotatively mounted on the structure. The ball nut is of such high efficiency as to be rotated relative to the structure by axial motion of the rod. However, rotation of the nut may be terminated by action of a power-operated brake connected with the nut, the brake being actuated automatically upon failure of the hydraulic jack.

The drawing

Certain preferred embodiments of the invention are illustrated in the accompanying drawings in which:

FIGURE 1 is a partially sectioned, partially broken away, perspective view of a preferred embodiment of an apparatus for raising and lowering an off-shore platform according to the present invention;

FIGURE 2 is a side view, partially in cross-section, of an elevating unit forming a part of the apparatus shown in FIGURE 1;

FIGURE 3 is a side view, partially in cross-section, of a first alternative embodiment of the elevating unit forming a part of the present invention;

FIGURE 4 is a side view, partially in cross-section, of a second alternative embodiment of the elevating unit forming a part of the present invention; and

FIGURE 5 is a side view, partially in cross-section, of a third alternative embodiment of the elevating unit forming a part of the present invention.

Detailed description

Referring to FIGURE 1 of the drawings, a portion of a conventional, "jackup" type off-shore platform suitable for elevation by an apparatus according to the present invention, is there shown. The portion of the off-shore platform illustrated includes a vertically extending, hollow, cylindrical leg projecting slidably and snugly through a portion of a generally horizontal deck **4**.

An elevating assembly according to the present invention for moving the deck **4** vertically along the leg **2** includes a plurality of separate elevating units **6**, **8**, **10** and **12** spaced at right angles about the leg **2**. Each of the elevating units **6–12** includes a vertically extending structure **14**. Each structure **14** includes a horizontal base **16** secured to the deck, two spaced, opposed, vertically extending, side members **18** and an upper end member **22** secured to the upper ends of the two side members **18** in fixed spaced relation above the base **16**. Each of the elevating units **6–12** further includes a connection block **24** mounted for vertical motion within and relative to the associated structure **14**. The block **24** is guided between the base **16** and the upper end member **22** by sidewardly directed, vertically extending projections **26** on the connection block **24**, which snugly and slidably travel within opposed, inwardly facing, vertically extending guide channels **28** provided in each of the side members **18**. Each connection block **24** includes a conventional, selectively actuated, motor operated plunger **30** of a type described in more detail in applicant's co-pending application Ser. No. 663,330, filed Aug. 25, 1967. Each plunger **30** is movable radially towards the leg **2** upon selective actuation to selectively engage the plunger **30** with an adjacent one of a plurality of vertically spaced apertures **31** provided in the leg, to fixedly engage the block **24** with the leg **2** against vertical or radial motion. Local stiffening for the leg **2** in the region of the apertures is provided by a vertically extending continuous strip **32** fixedly connected to the exterior of the leg **2** and by local reinforcing plates

33 fixedly connected to the interior of the leg 2 about each of the apparatus 31.

To move the connecting block 24 of each of the elevating units 6–12 downwardly within the associated structure 14, each elevating unit is provided with a single acting main hydraulic jack 36 secured to the upper side of the upper end member 22 of the structure 14. Each jack 36 (FIGURE 2) includes a cylinder 37 having a closed upper end with a piston 38 slidably mounted in the cylinder. Fluid applied from a conventional source (not shown) through a connection 39 to the cylinder moves the piston 38 downwardly. The piston 38 is connected by a ram or rod 40 to the upper side of the adjacent connecting block 24 and application of fluid pressure to the hydraulic jack forces the rod 40 downwardly to move the connection block 24 downwardly relative to the structure 14.

To return the connecting block 24 from a final position adjacent the base to a starting position adjacent the end member 22, a second rod or ram 44 connected to the underside of the block 24 is moved upwardly relative to the structure 14 by another, generally similar, single-acting, return hydraulic jack 26 fixedly secured to the base 16 and extending downwardly through the deck 4.

Suitable conventional hydraulic power and control equipment (not shown) connected with the plungers and the various jacks is provided for effecting selectively controlled operation of the elevating units in the manner about to be described.

In operation, the elevating units are operated in pairs with the units 8 and 12 constituting a first pair and the units 6 and 10 constituting a second pair. Commencing an operating cycle with the units in the positions shown in FIGURE 1, the plunger 30 of the first pair of elevating units 8 and 12 are selectively engaged with the adjacent apertures 31 in the legs to fixedly connect the first pair of elevating units 8 and 10 with the leg 2. At the same time, the plungers 30 of the second pair of elevating units 6 and 10 are selectively withdrawn from the leg. The main jacks 36 of the first pair of elevating units 8 and 10 are then operated to extend the rams 40 thereby raising the structures 14 relative to the associated connecting blocks 24 fixedly engaged with the leg 2, thus raising the deck 4 along the leg 2. At the same time, the connecting blocks 24 of the second pair of elevating units 6 and 10 are being returned to their starting position by concurrent operation of the associated return jacks 46 which are operatively interconnected with the main jacks 36 of the first pair of elevating units and with the source of fluid pressure by conventional hydraulic control circuitry extending the rams 44 to their upper position adjacent the end members 22 of the associated structures 14.

As the bases 16 of the first pair of elevating units 8 and 12 approach their associated connection blocks 24, the connection blocks 24 of the second pair of elevating units 6 and 10 are concurrently approaching the end members 22 of their associated structures 14. Operation of the various jacks 36 and 46 is then terminated with the plungers 30 of the second pair of jacks 6 and 10 aligned with the now adjacent ones of the apertures 31 and the plungers are operated to engage to fixedly secure the second pair of elevating units 6 and 10 to the leg. A second cycle of operation similar to that just described is then performed but with the second pair of elevating units 6 and 10 functioning to elevate the deck while the connecting blocks 24 of the first pair of elevating units 8 and 12 are returned to their starting position for the next elevating cycle by the first pair of elevating units.

Lowering of the deck is performed in a similar manner but with the directions of travel reversed.

It will be appreciated that by operating the elevating units in tandem in this manner with one pair of elevating units being returned to its starting position while the other pair of elevating units is concurrently raising the deck, the amount of dwell time between the successive lifting cycles is substantially reduced and may in fact be almost eliminated. In this manner, particularly rapid elevating rates may be achieved, thus rendering the platform particularly suitable for operations requiring frequent raising and lowering operations.

In a particular safety aspect of the invention intended to prevent run-away motion of the deck down the leg in the event that one of the main jacks 36 should fail while engaged in moving the deck under load, the ram 40 of the failed jack automatically becomes immediately locked against further motion relative to the associated one of the structures 14 upon failure. This function is effected in the preferred embodiment by providing the ram 40 with a threaded portion extending along its external periphery and passing through a nut 48 in threaded engagement therewith. The nut 48 is fixedly and rotatably mounted on the lower end of the main ram 36 and is provided with gear teeth on its periphery meshingly engaging a second gear wheel 50 drivingly connected with a motor 52 fixedly connected with the structure 14. In normal operation, the motor 52 is power driven by conventional means (not shown) to permit the ram 40 to move axially in and out of the jack 36. However, the fluid supply to the ram 36 and the power connection to the nut motor 52 are operatively interconnected so that a sudden drop in fluid pressure (such as would be caused by failure of the hydraulic jack 36) terminates power drive to the motor 52 so that further motion of the nut 48 is automatically prevented, thereby locking the ram 40 in its particular position of extension. Such operative interconnection may be provided in a number of ways; for example, the nut motor 52 may be driven by electrical or fluid power through a power circuit including a pressure sensitive switch responsive to fluid pressure in the main jack and opened by a spring upon fall in fluid pressure below operating level to break the power circuit to the nut motor. However, such a mode of operative interconnection is exemplary and other conventional forms of operative interconnection may be employed as desired. Thus, with the particular connecting block 24 engaged with the leg 2 and with the ram 40 locked against further movement relative to the jack 36 and the structure 14 by the nut 48, further relative motion between the deck 4 and the leg 2 is automatically prevented to provide a "fail-safe" capability.

In the preferred embodiment, a commercially available threaded ram jack manufactured by William S. Pine Company, Los Angeles, Calif., which includes the hydraulic jack 36, the threaded ram 40, the threaded nut 48, and nut motor 52, is utilized. However, it will be appreciated that other forms of jack having the construction described including a threaded ram, a nut engaging the ram and a motor for turning the nut with the motor automatically rendered inoperative upon failure of the jack may be utilized.

In a first alternative embodiment of the invention shown in FIGURE 3, each of the previous described elevating units 6–12 is provided with a double acting hydraulic jack 60 in place of the single acting hydraulic jack 36 provided in the preferred embodiment. Each double acting jack 60 is of conventional form having a piston 62 movably mounted within a cylinder 63 with fluid connections 64 and 66 to the cylinder 63 at opposite ends thereof for selective application of fluid under pressure selectively moving the piston 62 in one axial direction or the other in the jack. The piston 62 is connected by a plain rod or ram 68 to the upper side of the previously mentioned connecting block 24 which may be moved upwardly or downwardly relative to the associated structure 14 from the starting position adjacent the end member 22 to the final position adjacent the base 16.

To provide a fail-safe capability for the first alternative embodiment, a second rod 70 fixed to the underside of the connecting block 24 by a pivotal connection 72 and extending downwardly is provided. The rod 70 extends slidably into a vertically extending passage 73 passing through

the previously mentioned base **16** and the deck **14**. On its external periphery facing away from the leg **2**, the rod **70** is provided with a plurality of vertically spaced ratchet notches **72** each of which is defined by a horizontal, radially extending lower edge **74** and an upwardly and radially outwardly inclined upper edge **76**. Slidably mounted in a bore **74** provided in the base **16** is a horizontal ratchet plunger **78** provided with a forward end **80** configured to matingly engage the slots **72** of the rod **70** one at a time. The ratchet plunger **78** is biased into engagement with the rod **70** by a compression spring **82** surrounding a portion of the plunger **78** and extending between an abutment **84** on the plunger **78** and a fixed plate **86** secured to the base **16**. In operation, with the associated connecting block **24** engaged with the leg, as shown in FIGURE 3, and with the hydraulic jack **60** having fluid applied thereto through the port **64** to extend the ram **68** downwardly to elevate the deck **4** along the leg, the inclined faces **76** of the notches **72** will be moving downwardly relative to the plunger **78** which is successively depressed to permit downward movement of the rod **70**. If, however, the hydraulic jack **60** should fail, downward movement of the deck **4** relative to the leg **2** would be prevented by engagement of the horizontal lower face of the forward end **80** of the plunger **78** with the horizontal lower edge **74** of the particular notch **72** currently engaged by the plunger, to provide fail-safe capabilities.

In order to enable the jack **60** to return the connecting block **24** to the starting position when necessary, conventional means such as an electrical solenoid (not shown) attached to the plunger **78** are actuated to withdraw the plunger completely from contact with any of the notches **72** in the rod **70**.

It will further be noted that in order to provide additional rigidity for the various elevating units **6–12** an annular box member **90** extending about the leg **2** and connected with each of the end members **22** of the separate elevating units **6–12** is provided. The box member **90** is fixedly connected with the deck by four, rigid, similar, vertically extending support members **92** each of which is positioned adjacent one of the elevating units **6–12**. The box member **90** includes two opposed annular, horizontally extending, upper and lower plates **94** and **96** with the lower plate **94** fixedly secured to the upper sides of the previously mentioned end members **22** of the elevating units **6–12**. The plates **94** and **96** are connected together at their inner ends by a peripherally extending vertical web **98** extending about and spaced from the leg **2** and at their outer ends by portions of the various supports **92**.

It will be appreciated that this additional structure comprising the box member **90** and the supports **92** provide substantial extra rigidity and bracing for the various elevating units and may also be provided for the preferred embodiment previously described and for each of the other embodiments shortly to be described.

In a second alternative embodiment of the invention wherein each elevating unit is provided with a double acting hydraulic jack **60** in a manner similar to that of the first alternative embodiment, depending threaded rods **120** are secured one each to the undersides of the various connecting blocks **24** by a pivotal connection **122**. Each rod **120** extends vertically downwardly and is provided in the place of the ratchet rod **70** of the first alternative embodiment. The threaded rod **120** threadedly engages a threaded nut **124** rotatably and fixedly connected with the adjacent base **16** of the associated structure **14**. The nut **124** is provided with a tooth periphery meshingly engaging a gear wheel **126** driven by a motor **128** fixedly connected with the structure **14**. The rod **120** extends downwardly of the nut **124** into suitably located vertically extending passages provided in the base **16** and deck **4** in order to permit the passage therethrough of the rod **120** as the rod moves downwardly. The nut motor **128** drives the nut in the manner previously described for the first embodiment to permit vertical motion of the rod **120** relative to the nut. However, the power supply (not shown) to the motor **128** is operatively interconnected (as previously described for the preferred embodiment) with the fluid supply to the hydraulic ram **60** in such a manner that upon failure of the ram the nut becomes automatically locked against rotation to prevent further vertical motion of the rod **120**, thus preventing motion of the deck down the leg.

The threaded rod **120**, nut **124** and nut motor **128** form part of another hydraulic threaded ram unit of the type previously described for the preferred embodiment but with the hydraulic connections to the ram placed in a disconnected or inoperative condition. However, it will be appreciated that any power driven nut with the motor driving the nut and operativey connected with the source of fluid to the main hydraulic ram **60**, may be provided.

A third alternative embodiment of the invention illustrated in FIGURE 5 is similar to the first and second alternative embodiments in that the various connection blocks **24** are each moved by separate double acting hydraulic jacks **60** connected to the associated upper end members **22** of the structure of the various elevating units **6–12**. However, one of a plurality of depending threaded rods **138** is connected to the underside of each connecting block **24** by a gimbal connection **140** permitting pivotal movement of the rod **138** relative to the associated connecting block **24** about two mutually perpendicular horizontal axes. A flexible, bellows type, protective sleeve **142** is provided between each gimbal connection **140** and the base end **16** of the associated structure **14** to prevent corrosion of the threaded rod **138** by sea spray and the like.

Each of the rods **138** passes through and threadedly engages an associated ball nut **142** rotatably and fixedly mounted within conventional thrust bearings, generally designated **144**, mounted in the adjacent base **16**. As the advantages of ball nuts and their construction and operation are generally well known, further description of the details of the ball nut **142** will not be given except to say that it may be of the type disclosed, for example, in U.S. Patent No. 2,932,209.

The ball nut **142** is of such high screw efficiency that in normal operation axial motion of the threaded rod **138** relative to the ball nut **142** is not prevented by the ball nut **142** but instead causes rotation thereof in the bearings **144** about the vertical axis of the rod **138**. Fixedly secured to the exterior of the ball nut **142** is a horizontally disposed peripherally extending bevel gear **146** meshingly engaging a second bevel gear **148** connected to one end of a horizontally disposed shaft **150** mounted for rotation about a horizontal axis in the base **16**. Secured to the other end of the shaft **150** is a power operated brake **152** fixedly connected with the structure **14** and in a disengaged position from the shaft **150**, permitting free rotation thereof. However, the power supply to the brake **152** is operatively interconnected with the fluid supply to the double acting hydraulic ram **60** (by conventional means such as those previously discussed for the preferred embodiment) so that upon failure of the ram **60** the brake **152** is automatically applied to the shaft **150** to prevent rotation thereof relative to the adjacent structure **14**. Braking of the shaft **150** prevents rotation of the ball nut **142** so that further vertical motion of the rod **138** is arrested thus preventing further vertical motion of the deck relative to the leg.

It will be appreciated that in constructing an apparatus for raising and lowering an off-shore platform according to the present invention, certain important advantages are provided.

Particularly significant is the use of elevating units operating in tandem so that first one elevating unit is engaged with the leg and operated to elevate the deck while the other of the elevating units is disengaged from the leg and is concurrently placed in condition ready for the commencement of the next succeeding elevating step. In

this manner, dwell time between successive elevations of the deck relative to the platform is minimized, thereby providing for enhanced rates of deck travel.

Further, important advantages are provided by the fail-safe capability included in each of the several embodiments of the invention. For example, the provision of a threaded ram and power driven nut provided in the preferred embodiment ensures that the deck becomes automatically locked to the engaged connecting block if at any time one of the main jacks moving the deck should fail.

A similar function is provided by the ratchet plunger of the second embodiment, by the threaded ram of the third embodiment and by the ball nut and power brake of the fourth embodiment.

Although the invention is described with reference to certain preferred embodiments, it will be apparent to those skilled in the art that additions, deletions, modifications, substitutions, and other changes not specifically described or illustrated in the embodiments described may be made within the purview of the appended claims.

I claim:

1. In an off-shore platform including a generally horizontal deck supported on a plurality of ground-engaging generally vertical legs extending slidably through the deck, at least one elevating assembly associated with at least one of the legs for raising and lowering the deck relative to the leg, said elevating assembly comprising:

first and second elevating units, each of said first and second elevating units including,

connecting means adapted for selective connection to the leg at any of various points spaced vertically along the leg,

a vertically extending structure adapted to be fixedly secured to the deck extending generally perpendicularly therefrom, said structure including,

an end member remote from the deck,

guiding members for contacting and guiding said connecting means for vertical motion thereof relative to said structure between one position adjacent said end member and another position adjacent the deck;

main moving means connected with said structure and with said connecting means for selectively causing relative vertical movement between said structure and said connecting means in one vertical direction;

return moving means connected with said structure and with said connecting means for selectively causing relative vertical movement between said structure and said connecting means in an opposite vertical direction to said one direction;

said moving means of said first and second elevating units being operatively interconnected to cause operation of said main moving means of one of said elevating units to occur concurrently with operation of said return moving means of the other of said elevating units,

whereby during vertical movement of the deck along the leg with one only of said elevating units engaged with the leg, said connecting means of the other of said elevating units is concurrently returned to position for commencement of a succeeding vertical movement of the deck along the leg by the other of said elevating units.

2. An elevating assembly as defined in claim 1 wherein, said main and return moving means of each of said elevating units include,

shaft means fixedly connected with the associated said connecting means extending vertically therefrom, and

hydraulic jack means fixedly connected with said structure and connected with said shaft means for moving said shaft means vertically relative to said structure.

3. An elevating assembly as defined in claim 2 further including,

first and second locking means connected with said structures of said first and second elevating units respectively and with the respective said shaft means of said elevating units, each of said locking means automatically operable to fixedly engage the associated said shaft means and said structure upon failure of the associated one of said hydraulic jack means,

whereby further relative motion between the leg and the deck is automatically prevented.

4. An elevating assembly as defined in claim 2 wherein, each said shaft means includes,

a first rod fixedly connected with the associated one of said connecting means extending vertically toward said end member of the adjacent said structure,

a second rod fixedly connected with the associated one of said connecting means extending vertically toward the deck;

each said hydraulic jack means including,

a single acting, main hydraulic jack fixedly connected with said end member of the associated said structure and connected with the associated said first vertical rod for selective extension thereof outwardly of said first jack,

a single acting, return hydraulic jack fixedly connected with the associated said structure adjacent the deck and connected with the associated said second rod for selective extension thereof outwardly of said second hydraulic jack;

first and second locking means connected with said first and second elevating units respectively, each said locking means including,

an axially extending threaded peripheral portion on at least one of the associated said first and second rods,

a nut, threadedly engaging said threaded portion of said one rod, said nut being rotatively mounted upon and fixedly connected with the adjacent said structure, and

a nut motor connected with said nut and with the adjacent said structure for rotating said nut to permit axial motion of said one rod relative to said structure, said nut motor operatively connected with the associated said main hydraulic jack to automatically prevent further rotation of said nut upon failure of said main hydraulic jack.

5. An elevating assembly as defined in claim 2 wherein each said shaft means includes,

a first rod fixedly connected with the associated one of said connecting means extending vertically towards said end member of the adjacent said structure,

a second rod fixedly connected with the associated one of said connecting means extending vertically towards said deck;

each said hydraulic jack means including,

a double acting hydraulic jack fixedly connected with said structure and with one of said first and second rods for selectively extending and retracting said one of said rods outwardly and inwardly of said jack; and

first and second locking means connected with said first and second elevating units respectively, each said locking means including,

engaging means fixedly connected with each of said structures for automatically fixedly engaging therewith the associated other of said first and second rods upon failure of the associated said hydraulic jack to prevent further relative motion between the associated said connecting means and the deck.

6. An elevating assembly as defined in claim 5 wherein, each said engaging means includes,

vertically spaced, notched portions in said other rod of said first and second rods,

a spring-loaded, ratchet plunger fixedly secured to said structure, said plunger engaging one of said notched portions at a time, said plunger in an engaged position with an adjacent notched portion preventing relative movement between said structure and said connecting means in said opposite direction, but permitting relative motion in said one direction; and

means for selectively moving said plunger to an inoperative position out of contact with said notched portions.

7. An elevating assembly as defined in claim 5 wherein, each said engaging means further includes,

an axially extending, threaded peripheral portion on said other rod of said first and second rods,

a nut rotatively and fixedly connected with adjacent said structure, said nut threadedly engaging said threaded peripheral portion of said other rod, and

a nut motor connected with said nut with adjacent said structure for rotating said nut to permit verical motion of said other rod relative to said structure, and nut motor operatively connected with the associated said hydraulic jack to automatically prevent rotation of said nut upon failure of said hydraulic jack.

8. An elevating assembly as defined in claim 5 wherein, each said engaging means further includes,

an axially extending threaded peripheral portion on said other rod of said first and second rods,

a ball nut rotatively mounted and fixedly connected with said structure, said ball nut threadedly engaging said threaded peripheral portion of said other rod, said ball nut being of such high efficiency as to be rotated by axial motion of said other rod through said ball nut,

a shaft fixedly connected with and rotatively mounted on said structure,

gear means drivingly connecting said ball nut and said shaft, and

a power operated brake connected with said structure and with said shaft, said power operated brake operatively connected with the associated said hydraulic jack to automatically prevent rotation of said shaft upon failure of said jack.

9. In an off-shore platform including a generally horizontal deck supported on a plurality of ground-engaging, generally vertical legs etxending slidably through the deck, at least one elevating unit associated with at least one of the legs for raising and lowering the deck relative to the leg, said elevating assembly comprising:

connecting means adapted for selective connection to the leg at any of various points spaced vertically along the leg,

a vertically extending structure adapted to be fixedly secured to the deck extending generally perpendicularly therefrom, said structure including,

an end member remote from the deck,

guiding members for contacting and guiding said connecting means for vertical motion thereof relative to said structure between one position adjacent said end member and another position adjacent the deck;

shaft means fixedly connected with said connecting means extending vertically therefrom,

hydraulic jack means fixedly connected with said structure and connected with said shaft means for moving said shaft means vertically relative to said structure; and

locking means connected with said structure and with said shaft means, said locking means automatically operable to fixedly engage said shaft means and said structure upon failure of said hydraulic jack means to prevent further relative motion between said connecting means and the deck.

10. An elevating assembly as defined in claim 9 wherein,

said shaft means further includes,

a first rod fixedly connected with said connected means extending vertically towards said end portion of said structure,

a second rod fixedly connected with said connecting means extending vertically toward the deck;

said hydraulic jack means including,

a single acting, main hydraulic jack fixedly connected with said end member of said structure and connected with said first vertical rod for selective extension thereof outwardly of said first jack,

a single acting, return hydraulic jack fixedly connected with said structure adjacent the deck and connected with said second rod for selective extension thereof outwardly of said second hydraulic jack; and

locking means connected with said structure, said locking means including,

an axially extending, threaded peripheral portion upon at least one of said first and second rods,

a nut, threadly engaging said threaded peripheral portion of said one rod, said nut being rotatively mounted upon and fixedly connected with said structure, and

a nut motor connected with said nut sand said structure for rotating said nut synchronously with axial motion of said rod to permit movement thereof relative to said jacks, said nut motor operatively connected with the associated said main hydraulic jack to automatically prevent further rotation of said nut upon failure of said hydraulic jack.

11. An elevating assembly as defined in claim 9 wherein,

said shaft means includes,

a first rod fixedly connected with said connecting means extending vertically towards the end portion of said structure,

a second rod fixedly connected with said connecting means extending vertically towards the deck;

said hydraulic jack means including,

a double acting hydraulic jack fully connected with said structure and with one of said first and second rods for selectively extending and retracting said one of said rods outwardly and inwardly of said jack; and

engaging means fixedly connected with said structure for automatically fixedly engaging therewith the other of said first and second rods upon failure of the associated one of said hydraulic jacks to prevent further relative motion between said connecting means and the deck.

12. An elevating assembly as defined in claim 11 wherein,

said engaging means includes,

vertically spaced notched portions in said other rod of said first and second rods,

a spring-loaded, ratchet plunger fixedly secured to said structure, said plunger engaging one of said notched portions at a time, said plunger in an engaged position with an adjacent notched portion preventing relative vertical motion between said structure and said connecting means in one vertical direction corresponding to downward motion of the deck relative to the leg and permitting relative vertical motion in a vertical direction opposite to said one vertical direction, and

means for selectively moving said plunger to an inoperative position out of contact with said notched portions.

13. An elevating assembly as defined in claim 11 wherein

said engaging means includes,

an axially extending threaded peripheral portion on said other rod of said first and second rods,

a nut rotatively and fixedly connected with said structure, said nut threadedly engaging said threaded peripheral portion of said other rods; and

a nut motor connected with said nut and with said structure for rotating said nut to permit vertical motion of said other rod relative to said structure, said nut motor operatively connected with said hydraulic jack to automatically prevent further rotation of said nut upon failure of said hydraulic jack.

14. An elevating assembly as defined in claim 11 wherein

said engaging means includes,

an axially extending, threaded peripheral portion on said other rod of said first and second rods,

a ball nut rotatively mounted and fixedly connected with said structure, said ball nut threadedly engaging said threaded peripheral portion of said

other rod, said ball nut being of such high efficiency as to be rotated by axial motion of said other rod through said ball nut,

a shaft fixedly connected with and rotatively mounted upon said structure,

gear means drivingly connecting said ball nut and said shaft; and

a power operated brake connected with said shaft, said power operated brake operatively connected with said hydraulic jack to automatically prevent rotation of said shaft upon failure of said jack.

References Cited

UNITED STATES PATENTS

2,875,980	3/1959	Grace	92—17
2,992,812	7/1961	Rasmussen	254—107
3,083,592	5/1963	Carlstedt	92—17
3,090,360	5/1963	Bennett	254—106
3,259,368	7/1966	Warnke	254—110

ROBERT C. RIORDON, Primary Examiner

D. R. MELTON, Assistant Examiner

U.S. Cl. X.R.

60—6; 61—46.5; 92—17