United States Patent [19]

Wudtke

[11] **3,842,776**

[45] **Oct. 22, 1974**

[54] **ANCHORING SYSTEM**

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[73] Assignee: **Skagit Corporation,** Sedro-Woolley, Wash.

[22] Filed: **Nov. 28, 1973**

[21] Appl. No.: **419,760**

[52] **U.S. Cl.** ..... **114/206 R,** 114/230

[51] **Int. Cl.** **B63b 21/50**

[58] **Field of Search** ..... 114/230, 206 R; 9/8 R, 9/8 P; 254/150 R, 175.7

[56] **References Cited**

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Attorney, Agent, or Firm—Robert C. Smith; William F. Thornton

[57] **ABSTRACT**

An anchoring system suitable for an offshore drilling platform is shown in which both wire rope and a length of anchor chain are used. Chain alone becomes too heavy in the lengths needed, and the wire rope used retains substantial residual forces which interfere with proper operation of the anchor unless a substantial weight of chain is interposed between the wire rope and the anchor. An end connector member which joins the chain and wire rope cooperates with a special fairlead sheave having three concentric grooves—one for wire rope, one for chain, and an outside groove designed to mate with a curved surface on the end connector to assure that the wire rope, end connector and chain may all pass smoothly over the failead sheave without imposing kinking forces on the wire rope or excessive bending forces on the chain links. The wire rope is stored on a drum driven by a winch. When the wire rope is essentially all on the drum and the chain is adjacent the drum, the load is transferred to a devil's claw or similar device, the chain is disconnected from the wire rope and end connector and is then connected to a lead chain extending from a windlass which transfers chain in and out of a chain locker. In this manner, both the wire rope and the chain are stored on the platform and are easily connected and separated for storage in separate facilities.

11 Claims, 5 Drawing Figures

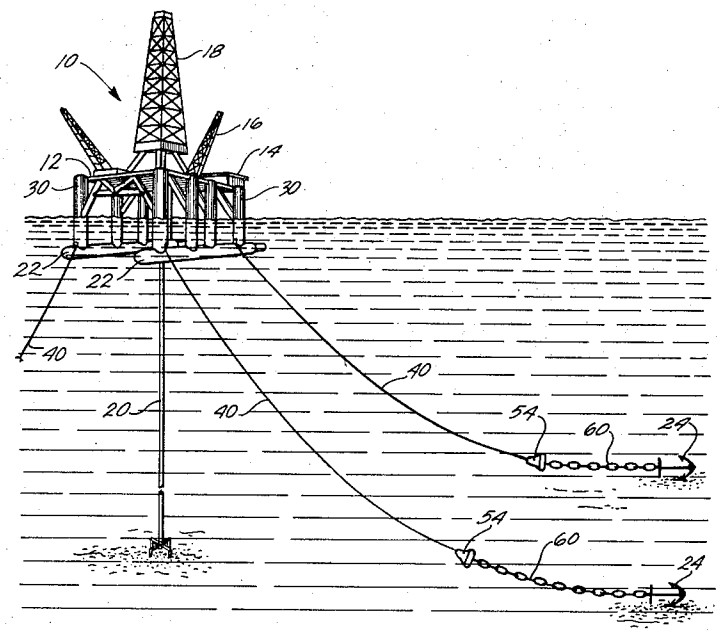
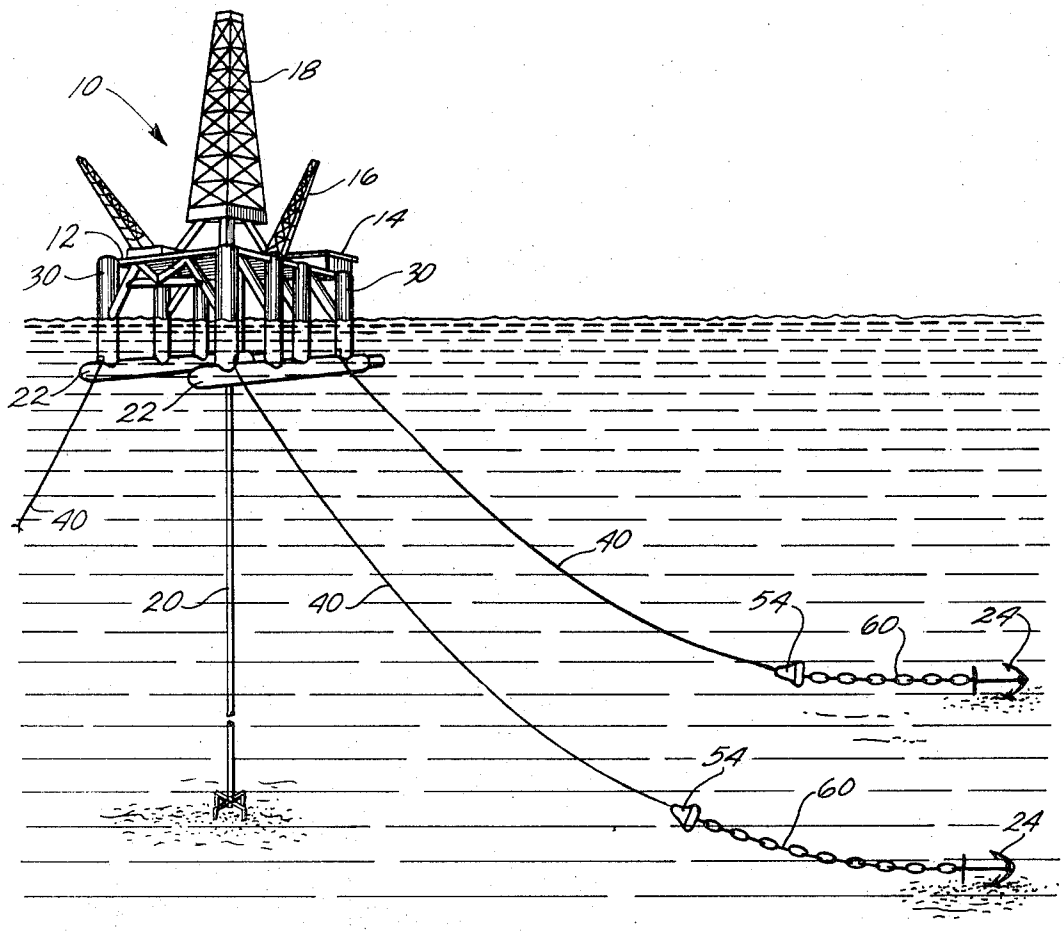


Fig. 1



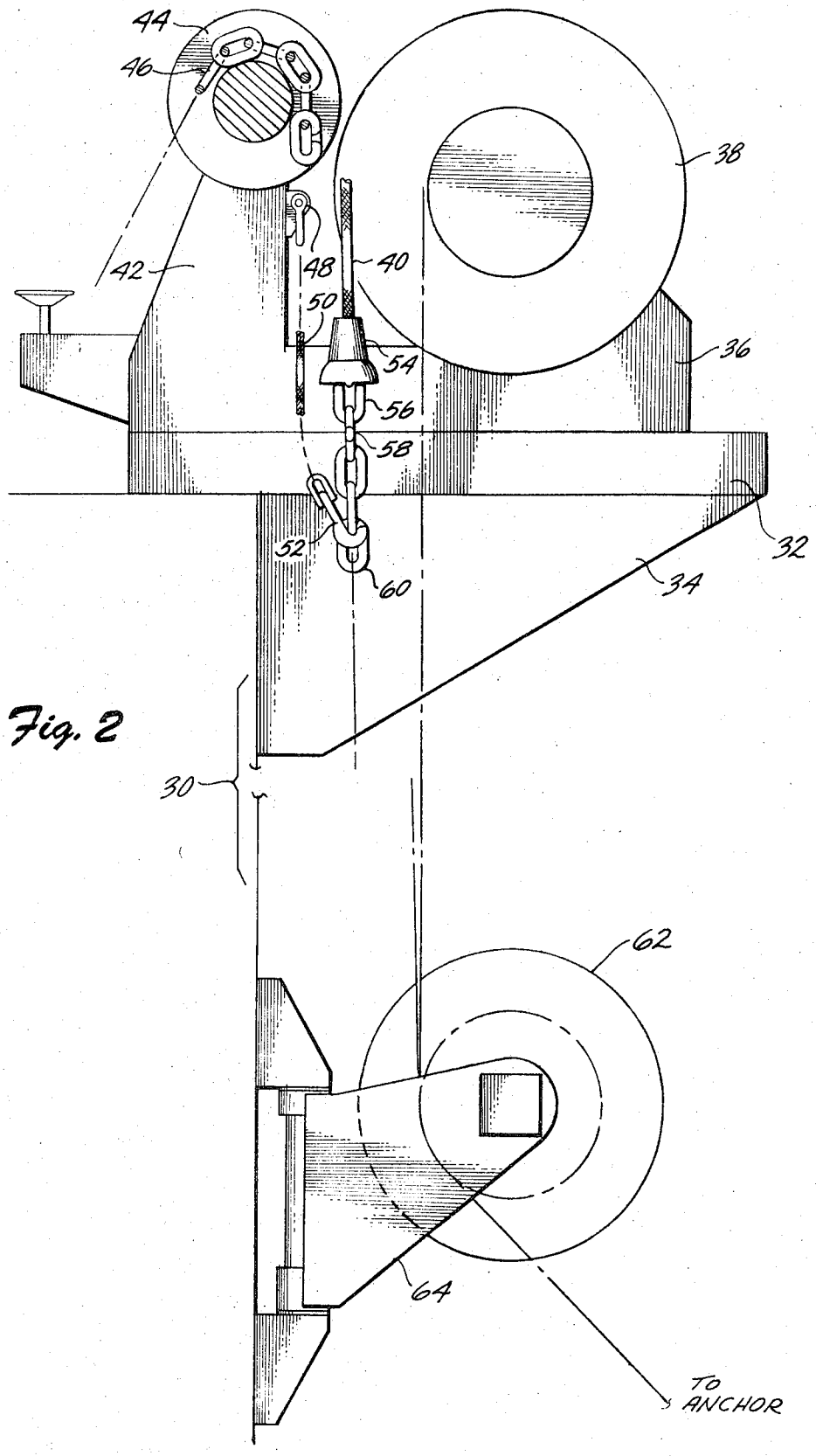


Fig. 2

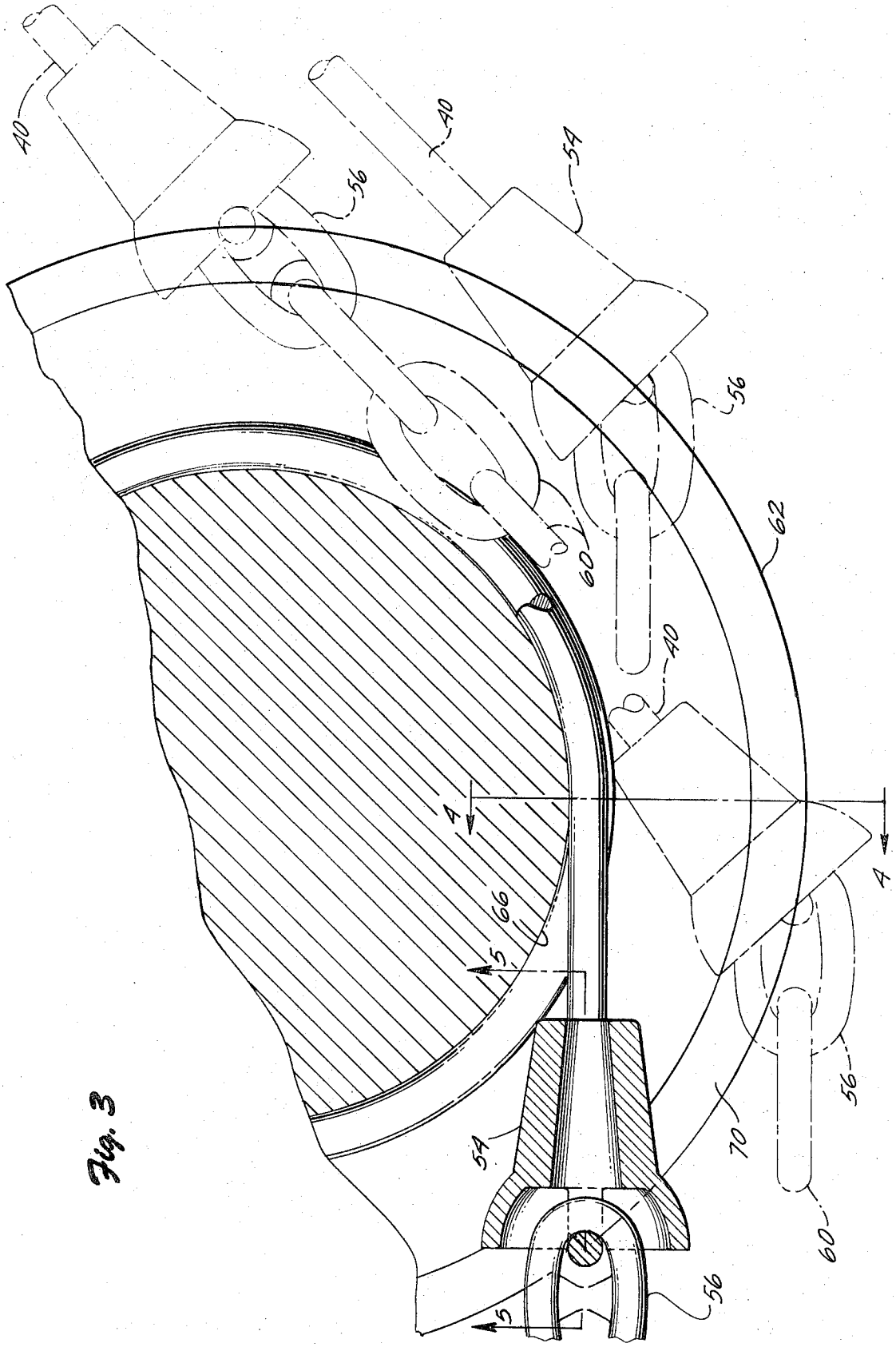


Fig. 3

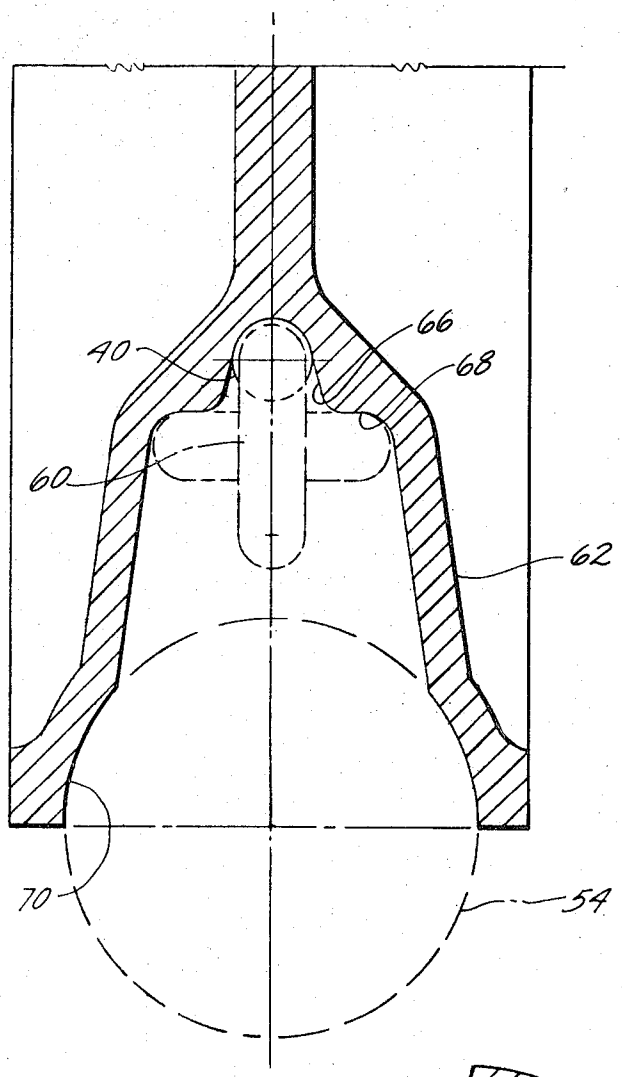


Fig. 4

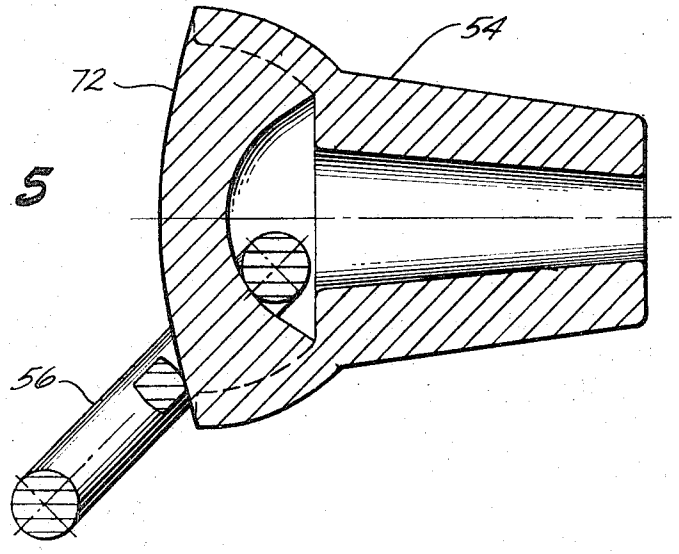


Fig. 5

ANCHORING SYSTEM

BACKGROUND OF THE INVENTION

Structures such as offshore drilling rigs or platforms are located at various locations in the ocean where they may be exposed to heavy seas. It is necessary for such structures to be very firmly anchored to avoid excessive lateral drift relative to the associated drilling structure. The anchoring structure used has consisted of a substantial number to conventional anchors having flukes which dig into the bottom attached by a length of chain. Because of the weight of the chain relative to its strength, this attachment means has limited the depth of such installation to about 500–600 feet. Wire rope has better characteristics with respect to strength per unit length, but does not, alone, form a good suspension emans for an anchor of the type referred to above because it tends to impose upward forces on the anchor when unloaded. Recent computer studies have indicated that an optimum suspension arrangement should include a length of chain attached to the anchor combined with a length of wire rope. This has been tried but has involved complications in retrieving the anchor and suspension means.

The chain is normally stored in a chain locker and is reeled in by means of a windlass. The wire rope is wound on a reel or drum by means of a winch, and it does not appear practical to store both on the same drum or storage means. Also, efforts to guide through the same fairlead structure have frequently subjected the wire rope to kinking or sharp bends not conducive to long life.

One approach to recovery of the anchoring structure has involved operating a winch on the platform to reel in substantially all of the wire rope, hooking on to the anchor or anchor chain by means of a hook or grapple suspended from a work boat and pulling the end of the chain or anchor up to the work boat. The chain is then loaded into a chain locker on the work boat, and when the joint between the chain and wire rope is reached, this joint is disconnected and the remaining wire rope is reeled onto the drum on the platform and the remaining chain stored in the chain locker on the work boat. This arrangement is quite cumbersome since each of four corners of the drilling platform may be tied down with three such anchor structures, making a total of twelve to be so recovered before the platform can be moved.

SUMMARY OF THE INVENTION

From the foregoing it will be appreciated that a considerable saving in crew time and facilities expense could be effected if the platform contained means capable of reeling in and storing both the cable and chain structures smoothly and without requiring excessively complex gear. Applicant has devised a systen whereby this may be done. A key element in this system is a fairlead sheave which aligns the wire rope/chain assembly for loading onto he platform and which cooperates with a special end connector device to assure a smooth transition as the wire rope pulls through the sheave followed by the end connector and the chain, said transition being accomplished without subjecting the wire rope to bends sharper than that required to follow the sheave.

The sheave is also designed to provide good support for the chain links and specifically to avoid substantial bending forces on the links. This fairlead sheave has an inner groove which is of minimum diameter to limit the curvature of the wire rope to that which imposes acceptable stresses. The determination of such diameter is well within the skill of the art. A second or intermediate groove has a broad base such that it essentially supports the links which lie flat against it, alternate links being oriented in the plane of the sheave and extending into the inner groove. It is desirable for the vertical links to bear on the wire rope groove if the proportions of the diameter of the wire rope and the diameter of the chain link are such that they are compatible. In this case the forces carried in the vertical links become largely tension forces which are more easily accommocated than the bending forces carried by links lying flat against the sheave.

An outer groove has a larger cross-section and is curved to mate with a bell-shaped end connector to which the chain is attached at its large end and the wire rope at its smaller end. The large end has a surface in the form of a spherical segment which lies in the outer groove as it rotates around the sheave and prevents excessive bending of the wire rope at the point of contact with the end connector until the rope begins to wrap around the sheave.

The wire rope is reeled onto a drum by means of a winch mounted on the platform, thereby pulling the chain up adjacent the drum. A load-retaining device in the form of a devil's claw or similar device is then attached a few links below the end connector and the winch operated to unload these few links, one of which is detachable, and transfer the load to the devil's claw. The detachable link is then disconnected and remains with the end connector, and a second detachable link at the end of a lead chain is lowered by means of a chain hoist and is connected to the upper link of anchor chain. Alternatively, a single detachable link is disconnected from near the end connector and attached to the lead chain. The chain hoist is then operated to wind in the chain, storing it in a chain locker on the platform, except for the length extending from the hoist to the anchor which is normally stored on a fixture on the side of the column just below the fairlead sheave.

The reverse process is used to deploy the anchor, chain and wire rope assembly. The chain hoist winds the chain out until the detachable link is just above the devil's claw, and the devil's claw is attached to the chain. The hoist is then operated to cause the load to be taken up by the devil's claw and removed from the detachable link. The detachable link is then opened and either remains with the lead chain or is attached to the end link of the few links extending from the end connector, if there is not a second detachable link attached thereto. The winch is then operated to remove the load from the devil's claw, the devil's claw is disconnected, and the wire rope/chain assembly then reeled out as needed to cause the anchor to reach the ocean bottom. As set forth above, there may be as many as 12 such anchor assemblies on a platform.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a typical offshore drilling platform and anchoring means;

FIG. 2 is a side view of a winch and chain hoist assembly mounted on one column of the above drilling

platform, including a wire rope, anchor chain and fairlead assembly;

FIG. 3 is a view, partly in section and partly in phantom, of a fairlead sheave according to my invention;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3; and

FIG. 5 is a sectional view taken along line 5—5 of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a perspective view of an offshore drilling platform 10 of the type for which anchoring systems incorporating my invention are designed. A deck 12 of substantial area, such as approximately 260 feet by 320 feet, supports one or more buildings 14 for housing men and machinery, a number of cranes 16, and a drilling tower 18. Drilling may take place in water up to 1500 feet deep or more with a drill shaft 20 extending vertically downwardly from the tower 18 to a location on the ocean bottom which should be essentially directly below the tower. Flotation for the platform is provided by a pair of large pontoons 22 which are ballasted such that they are submerged to a depth where the wave action is much less than at the surface. The deck is supported on the pontoons by means of a plurality of columns 30. The corner columns may be about 32 feet in diameter. Extending from the corner columns are shown a plurality of anchors 24 attached by means of wire ropes 40, end connectors 54, and a length of anchor chain 60 connected to anchors 24. Although only two such anchor assemblies are shown in detail, it will be appreciated that to maintain the position of platform 10 over the drilling location, at least two or three such anchor assemblies will usually extend from each corner column arranged to resist forces in all directions.

Referring now to FIG. 2, one of the columns for the offshore platform is shown at numeral 30. At the top of this platform is a radially extending annular shelf structure 32 which is supported at various places by means of a plurality of trusses 34 fastened to the side wall of column 30. Mounted on the top surface of the annular member 32 is a drum and chain hoist assembly built on a frame 36 which supports a large winchdriven drum 38 upon which is reeled a substantial length of wire rope 40. Also mounted on frame 36 is a chain hoist 42 including a wildcat 44 driven by suitable motor means and which carries a length of lead chain 46. Chain extending from the left side of sheave 46 extends down into s chain locker, not shown. Also attached to the frame 36 is a boss 48 supporting a short length of wire rope 50 which in turn is attached to a devil's claw 52.

Wire rope 40 is firmly secured through a zinc poured socket or by other suitable means to a bell-shaped end connector 54 having an opening at its larger end and a cross-member for supporting a chain link 56. Attached to link 56 is a detachable link 58 which is, in turn, attached to the anchor chain 60. As shown, the devil's claw 52 is affixed below one of the links of chain 60 such that any significant movement downwardly of the chain would cause the chain load to be transferred from the wire rope and the upper links of the chain to the devil's claw 52. The remaining length of chain 60 extends downwardly where it is directed around a fairlead sheave 62 and from there downwardly and outwardly to an anchor structure, not shown. Fairlead 62 is pivotally attached to column 30 by means of a bracket 64 attached to the side wall of column 30.

FIG. 3 is a view, partly in section, of the fairlead sheave 62 showing the arrangement whereby the chain 60, the end connector 54 and the wire rope 40 may all smoothly and conveniently pass across the fairlead sheave 62 without danger of either kinking the wire rope 40 or imposing substantial bending stress on the links of chain 60. In this view, the wire rope 40, the end connector 54, and the chain 60 are shown in various positions typical of those which they assume as the assembly passes the fairlead sheave 62. As the cable/-chain assembly is retrieved, the wire rope 40 will first reach the sheave 62 where it falls naturally and smoothly into the inside groove 66 of said sheave. Member 54, as shown in section, has just made contact with the larger diameter groove 70 of the sheave, and the chain, including link 56, is shown pulling straight to the right as viewed in this figure. In the sectional view, FIG. 4, it will be appreciated that the sheave 62 actually incorporates three separate grooves, on of which is the inside groove 66 designed to accommodate the wire rope 40, an intermediate groove 68 having a broad base for supporting links of chain 60 which are oriented perpendicularly to the plane of the sheave and a third groove 70 which is larger in diameter and has a curved configuration to mate with the spherical segment portion at the large diameter end of end connector 54.

Referring again to FIG. 3, as end connector 54 makes contact with the internal surface of groove 70, it will be carried by said groove around the periphery of the sheave 62 as shown in the successive phantom views. There is essentially a line contact between the spherical surface of member 54 and each side of the groove 70 until the end connector approaches the position shown in the upper right of the drawing where it is about to separate from the sheave. Just before member 54 separates itself from sheave 62, the line contact becomes shorter and diminishes to a point on each side of the groove 70.

It will be observed that in the first of the several positions, the wire rope 40 is pulled directly toward the right from the smaller end of member 54 and is not caused to bend until it begins to wrap around the groove 66. In the next position, the connector member 54 has been carried a substantial distance around the periphery of the sheave 62 and assumes a quite different angle with respect to the sheave; however, the wire rope 40 still pulls directly outwardly from the small diameter end of member 54 and suffers no bending effect until it reaches the edge of groove 66. In the third position of member 54 as it is rotated farther to the right, member 54 is now at a postion and oriented at an angle such that wire rope 40 is completely outside the periphery of sheave 62, and yet the force on it is such that it pulls straight away from the small diameter end of member 54. In the fourth position of member 54, this connector member is just at the point of being separated from contact with sheave 62 and wire rope 40 is still pulling directly outwardly from the small diameter end of member 54. Thus, member 54 always assumes a position which permits the wire rope 40 to pull directly outwardly from the small diameter end thereof and never permits rope 40 to be subjected to a sharp bend or kink adjacent its point of entry into the member 54.

The large diameter end of member **54** includes an open chamber for receiving one end of link **56** which is secured to member **54** by means of a cross bar **72** whose center is even with the end of member **54.** FIG. **5** shows a sectional view of member **54** taken along line 5—5 of FIG. **3** such that the section shown in FIG. **5** is perpendicular to that shown in FIG. **3.** In this section, cross bar **72** is shown as extending across the center of the opening in the large diameter end of member **54** and shows the manner in which end link **56** is captured by bar **72.** This arrangement limits, to some extent, the angle at which link **56** can pull against member **54** without imparting bending forces to the link **56.** This angle is normally in the order of 45° and provides adequate flexibility for the system. Should this not be the case in any particular installation, those skilled in the art can modify the dimensions of the parts to provide the necessary clearance. The location of the cross bar **72** is of some importance, since the point of contact with link **56** against said cross bar should be very close to the point at which the large diameter portion of member **54** tends to rotate in groove **70.** If cross bar **72** were to be moved substantially outwardly or to the left as shown in FIG. **3,** a moment would be created causing member **54** to rotate around a pair of contact points in the groove **70,** thereby tending to swing the small diameter end of member **54** outwardly with resultant risk of kinking the wire rope **40.**

While only a single embodiment is shown and described herein, modifications may be made within the scope of the present invention. Thus, while the large diameter segment of end connector **54** is a spherical segment, other convex curvilinear shapes will be operable. A conical shape is not recommended because of a tendency to wedge in the groove. The arrangement of detachable links may vary as discussed above, or a disconnecting device may be combined with end connector **54.**

I claim:

1. An anchoring system for anchoring a structure comprising

an anchor,

a chain attached to said anchor,

an end connector attached to said chain of generally frusto-conical configuration with a convex curvilinear surface at its larger end and means in said larger end for receiving and retaining a link of said chain,

a wire rope having one end secured within the smaller diameter end of said end connector, and

a fairlead shave supported on said structure, said sheave including an inner groove for receiving said wire rope, an intermediate groove, and an outer groove having inner surfaces substantially mating with said convex curvilinear surface, said grooves being concentric along radii of said sheave.

2. An anchoring system as set forth in claim **1** wherein said structure includes a drum and drum means for storing said wire rope,

a chain locker for storing said chain and a chain hoist with a length of lead chain,

means for transferring the anchor load from said wire rope to a chain link, and

means including a detachable link for enabling said anchor chain to be detached from a link near said end connector and attached to said lead chain.

3. An anchoring system as set forth in claim **1** including a detachable link in said lead chain and a detachable link in said anchor chain, and wherein alternate links of said chain are at least partially supported in said inner groove.

4. A system for anchoring a structure in the sea including an anchor, an anchor chain, a wire rope and means connecting said wire rope to said anchor chain, drum and winch means for storing, retrieving and paying out said wire rope, a chain locker and a windlass for retrieving and paying out chain from said chain locker including a length of lead chain, and a fairlead sheave for guiding said wire rope and said chain toward said drum, characterized in that said connecting means comprises an end connector of generally frusto-conical configuration with a convex curvilinear surface at its larger end and means in said larger end for receiving and retaining a link of said chain and with one end of said wire rope fastened to its smaller end,

said sheave including an inner groove for receiving said wire rope, an intermediate groove to at least partially support links of said chain, and an outer groove having inner surfaces substantially mating with said convex curvilinear surface, said grooves being concentric along radii of said sheave.

5. A system for anchoring a structure as set forth in claim **4** wherein a load-engaging member is suspended from said structure,

and at least one detachable link is incorparated into said chain near said end connector whereby said anchor load may be transferred from said wire rope to said load-engaging member, said detachable link may be transferred to said lead chain, said windless may be actuated to take up the load from said load-engaging member allowing said member to be disconnected from said chain, and said chain may then be drawn into said chain locker.

6. A system for anchoring a structure as set forth in claim **4** wherein said curvilinear surface is substantially spherical.

7. A system for anchoring a structure as set forth in claim **4** wherein a load-retaining member is fastened to said structure for attachment to said anchor chain and a detachable link is placed is said anchor chain near said end connector such that the load of said anchor chain may be transferred to said load-retaining member and said detachable link may thereby be unloaded and opened to permit said anchor chain to be connected to said lead chain.

8. An anchoring system for anchoring a structure in deep water comprising

an anchor;

a substantial length of chain attached to said anchor;

an end connector member having a generally frusto-conical configuration with a convex curvilinear surface at its larger end and a socket in said larger end, said socket including means for retaining a link of said chain;

a substantial length of wire rope fastened at one end of the smaller diameter end of said end connector, and

a fairlead sheave supported on said structure, said sheave including a large diameter groove having inner surfaces of configuration substantially mating with said convex curvilinear surface of said end connector member, an inner diameter groove of

cross-section sufficient to support said wire rope and to provide at least partial support for alternate links of said chain and of diameter at least sufficient to avoid excessive bending stress in said wire rope, and an intermediate diameter groove at least partially supporting other alternate links of said chain, said groove being concentric such that said chain, end connector and wire rope are retained in alignment in a single plane as they pass over said sheave.

9. An anchoring system as set forth in claim **7** wherein said cirvilinear surface is essentially a spherical segment.

10. In an anchoring system for anchoring a structure including an anchor, an anchor chain, a wire rope, an end connector connecting said wire rope to said anchor chain, a drum and drum drive means for storing said wire rope, a chain locker and chain hoist means including a length of lead chain for storing said anchor chain,

a method for retrieving and storing said anchoring system on said structure comprising the steps of

1. winding said wire rope on said drum,
2. attaching a link of said anchor chain to a load-retaining member fastened to said structure,
3. unwinding said wire rope slightly to remove the load from a few links adjacent said end connector, one of said links being detachable,
4. detaching said anchor chain from said end connector and attaching it to said lead chain,
5. operating said chain hoist means to unload said retaining member,
6. detaching said retaining member, and
7. operating said chain hoist means to load said chain into said chain locker.

11. A method of retrieving and storing an anchoring system as set forth in claim **9** wherein first and second detachable links are used on said anchor chain near said end connector and on said lead chain, respectively, so that said anchor chain is removed from said first detachable link leaving said link with said end connector and said anchor chain is connected to said second detachable link on said lead chain.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,842,776 Dated October 22, 1974

Inventor(s) DONALD J. WUDTKE

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

Column 7, line 11, change "cirvilinear" to --curvilinear--.

Column 8, line 15, change "9" to --10--.

Signed and Sealed this

Twenty-third Day of *May 1978*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks