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A system for a jack-up rig unit for offshore use and a method of securing the support legs of such a unit

The present invention relates to mobile, offshore self-elevating "jack-up units" or rigs for offshore oil work and more particularly to a system for making such a unit with its support legs rigid and, fixed when the legs are either up or down in a desired position, counteracting the major loads which these units must accommodate, namely fixed weights, variable weights, wind, currents and waves.

The term "jack-up unit" as used herein means any working platform used for drilling, work over, production, crane work, compressor stations, diving support or other offshore purpose in an elevated position above the water, and being supported on jackable legs to the ocean floor or other water bottom, with the inherent capability of relocating from one site to another by lowering to a floating position, and, after being supported on jackable legs to the ocean floor or other water bottom, with the inherent capability of relocating from one site to another by lowering to a floating position, and, after being moved to a new established location, raising again to an elevated position.

The present invention is intended to apply to any jackup rig unit which is raised or lowered with a jacking apparatus, a typical example of which is disclosed in U.S. Patent No. 3,606,251, or other pinion driven systems, that engage rack teeth on the legs.

Jack-up units equipped with rack and pinion type jacking systems have long been known as is shown, for example, in U.S. Patents Nos. 2,308,743, 3,183,676 and 3,606,251 (reissued as Re: 29,539). These units use the pinions to transfer the loads from the hull into the leg chords and vice versa, in conjunction with a guidance system required to take moments due to wind, waves or other imposed loadings. The pinion supported units of U.S. Patent No. 3,183,676 impose a horizontal component of the load transfer, due to the tooth pressure angle that directly imposes a moment in the leg chords. The units supported by the pinions in conjunction with a guidance system, have an inherent flexibility in the pinion gear train system that further introduces a moment in the leg chords through their guidance system.

The use of locking means to engage with the rack teeth of a leg is disclosed in U.S. Patent No. 3,343,371. In this specification a laterally movable locking device is employed, the device comprising a housing provided with a number of teeth, each tooth being arranged to pivot about a horizontal axis relative to the housing.

When the locking device is moved laterally into a locking position the teeth engage with the rack teeth to lock the leg in position. When the device is moved into a released position the teeth are clear of the rack teeth and permit adjustment. The locking device is arranged to be moved laterally by means of screw jacks.

Prior specification US-A-2589146 also discloses the use of locking means to engage with the rack teeth of a leg. The locking means is provided on only one side of the column hence the arrangement cannot take a bending moment, and therefore does not provide a rigid connection. A ground anchor is fixed to the underwater ground in order to take any bending moments, and it is at the ground anchor that rigidity is provided.

Typical examples of some prior patents which show some form or other of leg teeth engaging devices in jack-up units are U.S. Patent Nos: 103,899; 2,540,679; 2,862,738; 2,954,676; 3,007,317; 3,109,289; 3,290,007; 3,722,863; 3,876,181; and U.K. Patent No. 934,369.

The present invention does not introduce any large secondary bending stresses that can limit the performance of the jack-up unit.

The graph (accompanying drawing Figure 8) "Operational Analysis—Variation of Stress Components in Critical Member", identifies the influence on leg stress when the "jack tower guides" of the prior art are used to take the leg moments. This method is used for most if not all existing designs, either entirely or in part to handle the leg moments. The dotted lines represent the leg axial stress that the system of the present invention absorbs directly; while the solid line represents the additional secondary bending stress due to the use of a "jack-tower" guide system.

Other prior designs use a rack and pinion system that has its line of support radially from the centre of the leg. Due to the rack and pinion pressure angle, the leg receives a secondary bending load of approximately forty (40%) percent of the vertical loads.

These secondary bending stresses can be larger than the axial stress and have limited the potential for prior art jack-up units for going in to deeper waters and high wave sites.

To illustrate the basic development of forces and moments at the leg/hull interface, a simplified two-dimensional structural bent, as representing a typical leg/hull structure under environmental and weight loadings, illustrated in Figures 9A and 9B of the accompanying drawings should be considered.

From the force pictures of Figures 9A and 9B the forces applied to that section of leg within or adjacent to the hull structure may be determined (taken above the wave zone, and for the more highly loaded leeward leg).

The forces in the leg just below the hull are seen with reference to Figure 9B, to be directed almost entirely as axial loading in the chords, except for the nominal shear loading due to wind taken in the bracing. How these forces are taken in the hull depends primarily on the jack attachment as outlined below.

1. Resilient mounted jacks will deflect under load so that the leg will tend to rotate due to the overturning moment, and the guides will be required to resist some of this moment as a horizontal couple. In the extreme, with deep rubber pads that may deflect several centimetres or so, the jacks (pinions) will take only the vertical load imposed by the hull, $\frac{1}{2}(W/2+M/1)$, with the guides bearing all of the forces due to the moment, plus the wind shear. Thus, considerable stress must be borne by the bracings through this area, and in addition, the chords may be subject to large bending stresses (in addition to compressions), particularly if the guides are at mid-bay.

As a result, not only is the leg extremely heavy, but the jack towers supporting the upper guides must also be substantial to carry the upper reaction load into the hull.

2. Jack fixed to the hull will tend to absorb directly almost all of the axial loading of the chords, including that due to the vertical couple of the overturning moment. Due to some torsional deflection of the pinion gear train (which is small) and the stiffness of the bracing (again which is small, relative to the chords), there will be some transfer of overturning moment as a horizontal couple at the guides. Generally, this will be small, and even with the addition of the horizontal wind shear, the bracing size will remain nominal (except where single pinion racks are used; see item 3 below).

However, since the jacks will take almost the entire loading of overturning in addition to the hull weight, it is probable that for severe environmental conditions, the number of pinions required will be greater than that needed for the sole purposes of jacking up or down. Pinion ratings for holding loads (with brakes set) are generally twice that permitted for normal jacking, and thus the load due to overturning would be limited to the same as that due to weight support, or additional pinions would be required.

3. Single pinion racks and opposed pinion racks. Where rack/pinion arrangements provided only a one-sided rack with a single vertical line of pinions (note Figures 10A and 10B of the accompanying drawings), such as for example is the case in the "Le Tourneau" type-rigs (a majority of all-present jack-up rigs), there is a large components of the pinion force directed horizontally that must be transmitted through the chord and bracing structure into the racking on the opposite chord. With the pressure angle of the rack teeth of typically 20 to 25 degrees (note Figure 10A of the accompanying drawings), this horizontal force is in the order of 40% of the vertical force needed for rig support. This results in high bending stresses in the chords and high compressive stresses in the bracing, resulting again in an extremely heavy leg being required (whether the jacks are floating or fixed to the hull).

With opposed pinion racks (note Figures 11A

and 11B), such as for example is the case in the "National" type rigs (approximately 10% of all present jack-up rigs), the horizontal forces are directly taken through the individual rack in compression (normal to the vertical compression and readily absorbed) and there is no output into the leg assembly.

The horizontal forces which increase the leg chord and bracing weight also require large size members for larger loads. These increases in turn incur larger waver loadings and then larger horizontal forces, etc. This "domino" effect has caused limitations on the capability of this prior art design unit.

The present invention outlined herein will eliminate the induced horizontal forces.

According to one aspect of the invention there is provided a system for a jack-up rig unit for offshore use, including at least one leg with a set of rack teeth fixedly connected thereto and disposed at least generally in a vertical direction along at least a substantial portion of the leg length, and a floatable hull supportable above the water line on said leg(s) comprising:

locking means carried by the hull for each of said leg(s) for locking the leg(s) to said hull said locking means including laterally movable rack teeth-engaging means for engaging the rack teeth of its respective leg in its locking disposition but laterally movable with respect to said rack teeth out of any engagement with said rack teeth when it is desired to jack said leg(s) up and down, characterised in that the locking means for each leg comprises at least three peripherally spaced rack chocks each having a plurality of matching chock teeth arranged in a series so that when the rack chocks are moved laterally into their locking disposition, the chock teeth of each rack chock are rigidly interdigitated with the rack teeth whereby the hull and the leg(s) is rigidified without introducing any substantial bending moments in the leg(s).

Preferably the teeth engaging means is also movable in the vertical, longitudinal direction with respect to said rack teeth independent of any hull movement, and conveniently the teeth engaging means is movably mounted on or above said hull to also allow both horizontal and vertical movement with respect to it, the hull itself being stationary with respect to said leg(s) during the movement of said teeth engaging means.

Normally the teeth engaging means comprises a series of matching chock teeth, preferably at least three chock teeth, extended into the rack teeth, in face to face, full line engagement therewith, and advantageously the series of chock teeth are mirror images of the rack teeth.

Preferably the system includes at least three separate leg(s) each having at least one of said rack chocks at each chord of each of said leg(s).

Furthermore, it is convenient if each of said leg(s) is of the opposed pinion type there being at least one rack chock for each of the opposed

set of rack teeth. Alternatively, however, each of said leg(s) can be of the single and loaded rack type, having a back plate, and wherein each rack chock includes a yoke supporting it on the hull which engages said back plate, the engaging of said teeth engaging means with the rack teeth locking said rack chock, said yoke and said back plate together.

The rack chock means may be located, for example, either within the confines of the hull between its bottom and upper deck or else above the leg jacking drives. In some embodiments of the present invention it is preferred for the rack chock means to further comprise two mating, inclined surfaces, a back surface and a backing guide surface, relative movement between said mating inclined surfaces causing the teeth engaging means to be simultaneously moved both laterally and longitudinally with respect to said rack teeth.

According to another aspect of the invention there is provided a method of securing the support leg(s) of an offshore jack-up rig unit having a hull, leg(s) with rack teeth and a jacking drive associated therewith, comprising the following steps:

(a) providing on said hull a separate locking means for each of said leg(s) which is operationally separate and apart from said jacking drive, which locking means have teeth-engaging portions which are at least laterally movable with respect to respective rack teeth to engage therewith when in a locking disposition.

(b) vertically positioning the leg(s) of the rig with respect to the rig hull to the height desired by means of said jacking drive, and

(c) after the foregoing steps, laterally moving the lockings means into locking engagement with its respective rack teeth and locking all of said locking means to said leg(s), characterised in that the locking means comprises at least three peripherally spaced rack chocks having a plurality of matching chock teeth arranged in a series so that when the rack chocks are moved laterally into the locking disposition, the chock teeth are rigidly interdigitated with the rack teeth whereby the hull and the leg(s) is rigidified without introducing any substantial bending moments in the leg(s).

In a preferred embodiment of the method said leg(s) each have at least one set of rack teeth on at least two opposed leg chords, and:

(a) said rack chocks are movable both longitudinally and laterally with respect to a rack of the leg(s) and has chock teeth sized and configured so that each chock tooth engages at least the upper and lower surfaces of two teeth on said rack;

(b) said rack chocks are moved longitudinally with respect to said rack until said teeth are positioned across from two respective teeth on said rack and moving said rack chocks laterally into face-to-face, in-line engagement with the upper and lower surfaces of said respective two teeth; and

(c) said rack chocks are rigidly locked to said rack and to said hull structure; and

(d) steps "a" through "c" are repeated for the rack(s) on at least two opposed chords for each leg of the unit to rigidify the leg(s) to the hull structure.

In this embodiment each of said leg(s) is of the single end loaded rack type with a back structure at each chord of the leg and wherein each rack chock includes a yoke supporting structure which supports each rack chock and which engages said back structure and wherein there is included the further step of locking said rack chock, said yoke and said back structure rigidly together when engaging said rack chock and said rack.

In the present invention, in for example, the embodiment as developed for use with opposed racks (Figures 2—4 of the accompanying drawings), each of the "rack chock" elements of the system of the present invention is designed to absorb the maximum axial chord loading and transmit it directly into the hull. It is preferably configured with a number of matching teeth for exact, in-line engagement with the leg rack teeth, and is capable of being adjusted for vertical alignment to mate with the rack teeth position. By a series of screw jacks and/or secondary chocks, it will provide rigid contact with both the legs and the hull structure, and will eliminate the requirement for the jack pinions to take load, as is done in the prior art, in either jacked-up or ocean tow dispositions.

Among the major advantages of the present invention are the following:

a. The legs will be of minimum scantling and weight, consistent with the design loads and environmental conditions, which in addition to cost reduction, will provide greater capability under ocean tow conditions with legs raised and subject to roll dynamics;

b. There will be no need to provide additional pinions to take environmental loadings (for the case of jacks fixed to the hull). The jacks can be selected just for the service requirements of jacking up and down;

c. Pinions and their gear trains will not be subject to oscillating loads which cause wear and fatigue damage. This is of particular significance when under tow with high dynamic reversals of load; and

d. With the rack chocks fully engaged in final position, complete jack assemblies may be removed for overhaul or replacement, or for use on other installations.

For the purposes of the following general discussion of the present invention, the legs of the rig are considered to be of the truss type, each leg having three or more chords and each chord incorporating, for example, a dual rack section having two opposed sets of rack teeth, each extending along one of the two edges of the rack bar. However, the present invention is applicable to legs of any structural form having any multiplicity of single or dual rack sections.

The present invention provides an improved method of rigidly supporting the "jack-up unit" in an elevated position on the legs of the unit, and/or of rigidly supporting the legs in a raised position when the unit is in an afloat disposition. In the present invention, the dual rack section is engaged with opposed, matching rack sections, which can be fixed to the unit. In the preferred embodiment, each matching rack section, called a "rack chock", can be adjusted vertically up and down along the leg chord dual rack section and horizontally in and out to engage or disengage the leg chord dual rack section.

The "rack chock" of the rigidification system of the present invention transfers the loads from the hull into the leg chords or from the leg chords back into the hull. The "rack chock" elements accomplish at least in part this load transfer, and eliminate the introduction of moments in the leg chords which would otherwise occur due to either the guidance system, or to pinion reactions in the jacking system.

In the present invention, the load transfer can be either through the "rack chocks" only or else jointly with the pinions as desired.

The "rack chock" elements used in the present invention utilize the necessary number of in-line tooth engagements to safely transfer the load, and can have metalized tooth surfaces to distribute the load across the teeth evenly.

The "rack chock" elements can be engaged with the leg chord rack bar, pre-loaded to eliminate movement in the contacting tooth surfaces.

The "rack chock" elements of the rigidification system can be moved vertically by mechanical or hydraulic means, such as, for example, cylinders, screws, wedges, etc. The vertical positioning permits the indexing of the "rack chock" teeth with the leg chord rack bar teeth.

Each "rack chock" element can be fixed to the hull structure, after vertical positioning, by chocks, screws, wedges, etc. Fixing to the hull can be accomplished both above and below the "rack chock".

The horizontal movement to engage or disengage each of the "rack chock" elements with its respective leg chord rack can be by mechanical or hydraulic means, such as for example cylinders, screws, wedges, etc.

The "rack chock" horizontal contact with the leg chord rack bar is maintained by chock, screws, wedges, etc., and the "rack chord" leg sections may be of any numerous types.

With the use of the rigidification system of the present invention the jacking systems are no longer needed to lock the legs in position and can be removed for use elsewhere, enhancing the economics of the present invention. Additionally, with the availability of the present invention on a rig, it is estimated that perhaps as much as one thousand tons (~1,016 tonnes) of steel can be saved in the fabrication

of the rig. Also, with the present invention, it is believed that jack-up rigs will now have an extended range with respect to water and wave depths which may be twice that which it was before the present invention.

The present invention will be further illustrated with reference to the accompanying drawings in which like parts are given like reference numerals, and wherein:

Figures 1A and 1B are perspective and side, respectively, views of an exemplary jack-up rig to which the present invention can be applied and include schematic representations of the force loadings on the rig legs; while Figure 1C is a schematic representation of a leg having three chords.

Figure 2 is a partial, close-up side view of one of the rig legs showing the relative positions with respect to the leg of the hull and leg jacking drive and the "rack chock" elements of the first, preferred embodiment of the present invention as applied to a leg of the double, opposed pinion rack or "National" type of rig;

Figure 3 is a still further close-up side view showing in further detail the "rack chock" element of the embodiment of Figure 2;

Figure 4 is a top view of the element of Figure 3;

Figure 5 is a partial, close-up side view, similar to Figure 2, but of a second, preferred embodiment of the present invention as applied to a leg of the single, pinion or "Le Tourneau" rack type of rig;

Figure 5A is an end view of the sub-system of Figure 5;

Figure 6 is a still further close-up side view showing in further detail the "rack chock" element of the embodiment of Figure 5;

Figure 7 is a top view of the element of Figure 6;

Figure 8 is a graphical illustration of the operations analysis of the variation of stress components in critical members of a rig such as that illustrated in Figure 1A;

Figure 9A is a side, schematic view of a simplified two-dimensional structural vent, as representing a typical leg/hull structure under environmental and weight loadings to illustrate the basic development of forces and moments at the leg/hull interface;

Figure 9B is a close-up, partial view of the schematic view of Figure 9A showing in detail the forces of the leg/hull interface;

Figure 10A is a side, partial view of a support leg of the single, pinion rack type for a "Le Tourneau" type rig showing the angled force interfacing between the teeth of the jacking pinions and the simple row of rack teeth at each chord of the leg;

Figure 10B is a plan view of the elements of Figure 10A;

Figure 11A is a side, partial view of a typical support leg of the double, opposed rack type for a "National" type rig showing the angled force interfacing between the teeth of the jacking

pinions and the double, opposed rows of the rack teeth at each chord of the leg;

Figure 11B is a plan view of the elements of Figure 11A;

Figures 12A, 12B and 12C are plan views of three exemplary types of simple, end loaded racks for legs using a jacking system like the "Le Tourneau" type to which the present invention can be applied with Figure 12B being similar to that of Figure 10B;

Figures 13A, 13B and 13C are plan views of three exemplary types of double opposed pinion racks for legs using a jacking system like the "National Supply" jack, to which the present invention can be applied with Figure 13B being similar to that of Figure 11B; and

Figure 14 is a side partial view of a jack-up rig in the legs-up, floating disposition showing one of the legs with a further, alternate, sliding embodiment of the rack chock, rigidification element.

Figure 1A—1C are generalized sketches and are provided for making a simplified leg load analysis for a better understanding of the purpose, operation and effect achieved by the use of the preferred embodiments of the present invention. Figure 1A is not intended to be of any specific unit and the number of legs could be three or more. The legs 2 considered are for illustrative purposes of the trussed type made with three or more chords.

With reference to the standard engineering symbols and abbreviations used in Figure 1A and 1B and assuming that the fixed weights (W_f) and the variable weights (W_v) are evenly distributed with each leg taking one third of the W_f and W_v , the overturning moment (OT) is computed as follows:

$$OT = (\Sigma W \cdot H_w) + (W_{L1} + W_{L2} + W_{L3}) \times H_{wa}$$

(Where W designates the wind force; and W_L designates the wave force on a particular leg (see Figure 1)),

while each of the leg loads—horizontal (R_H) are computed by:

$$\begin{aligned} R_{HL1} &= W_{L1} + 1/3 \Sigma W \\ R_{HL2} &= W_{L2} + 1/3 \Sigma W \\ R_{HL3} &= W_{L3} + 1/3 \Sigma W \end{aligned}$$

and the leg loads—vertical (R_v) are:

$$R_{vL1} = 1/3 (W_f + W_v) + \frac{OT}{S}$$

$$R_{vL2} = 1/3 (W_f + W_v) - \frac{OT}{2S}$$

$$R_{vL3} = 1/3 (W_f + W_v) - \frac{OT}{2S}$$

As can be seen from the foregoing, the leeward leg receives the highest loading, and this will be examined further. The legs are like cantilevers with fixity in the hull 1 and pin joints below the mud line (note Figure 1B).

$$\text{No. 1} = 1/3 R_{vL1} - (R_{HL1} \times H)/L$$

$$\text{No. 2} = 1/3 R_{vL1} + 1/2 (R_{HL1} \times H)/L$$

$$\text{No. 3} = 1/3 R_{vL1} + 1/2 (R_{HL1} \times H)/L$$

(where No. 1, No. 2 and No. 3 designate respective chord loadings of a leg at the points of fixity).

The chord loads are essentially tension or compression. The horizontal or shear loads are taken by the bracings. These loads for typical drilling units like the Friede and Goldman Ltd, L-780, Le Tourneau 82, or 116 will be in the following range of 200 feet (61 metres) of water:

WF—8,000 to 10,000 kips (3.6×10^6 to 4.5×10^6 Kg.)

W_v —1,000 to 5,000 kips (4.5×10^5 to 2.5×10^6 Kg.)

OT—200,000 to 300,000 foot kips (9.0×10^7 to 1.4×10^8 Kg.)

W —400 to 600 kips (1.8×10^5 to 2.7×10^5 Kg.)

W_{L1} (2 or 3)—60 to 150 kips 2.7×10^4 to 6.8×10^4 Kg.)

A leg with a chord span (L) of 30 feet (9.1 metres) would have a chord load of (using minimum values).

$$\begin{aligned} &1/3 R_{vL1} + 1/2 (R_{HL1} \times H)/L \\ &= (1/3) \times (1/3) \times 9000 + 200,000/100 \\ &+ [(1/2) \times (60 + 400/3) \times 265]/30 \\ &= 1000 + 2000 + 854 = 3854 \text{ Kips } (1.75 \times 10^6 \text{ Kg.}) \end{aligned}$$

With a chord area of 100 sq. in. (645 sq. cm), the stress would be 38.5 ksi. (2707 Kg. per sq. cm). Using maximum values the leg chord load would be:

$$\begin{aligned} &(1/3) \times (1/3) \times 15,000 + 300,000/100 \\ &+ [(1/2) \times (150 + 600/3) \times 265]/30 \\ &= 1667 + 3000 + 1546 = 6212 \text{ Kips } (2.8 \times 10^6 \text{ Kg.}) \end{aligned}$$

With a chord area of 130 sq. in. (839 sq. cm), the stress would be 48.7 ksi. (3425 Kg. per sq. cm.)

Larger units would have greater dead loads, wind loads, wave loads etc. The units would have leg spacings of 200 feet (61 metres) in lieu of 100 feet (30 metres) and chord spacings of 50 feet (15 metres) in lieu of 30 feet (9.1 metres). Chord areas would be in the 350 to 400 sq. in. (2258 to 2580 sq. cm.) range.

The approach of the present invention to the leg design of a rig is to have the leg chord stresses absorbed directly into the hull 1. In order to accomplish this, the support system of

back plate 105c, enhancing the rigidification results of the present invention.

The yoke 115 can stay in position above the "Le Tourneau" guides 113 while the leg 102 is being raised or lowered. When the rack chock 107 is engaged with the rack chock teeth 114 on the leg 102, then the vertical jacks 104 can be positioned to take the vertical loads if desired.

The foregoing constitutes two exemplary rack chock embodiments of the system of the present invention as applied to jack-up legs with exemplary double opposed pinion racks and a simple end loaded rack, respectively. However, it should be understood the foregoing has been directed merely to exemplary applications, and the principles of the present invention can be applied to all other types of jack-up units with one or more racks.

Other exemplary single end loaded rack structures known in the prior art to which the invention could be applied are illustrated in plan views in Figures 12A and 12C, each having a leg chord structure 105A, 105C with a single rack 106A, 106C, respectively. Figure 12B of course illustrates the "Le Tourneau" type structure previously described with reference to Figures 5—7 (2nd embodiment) and 10A and 10B. As mentioned above, the single end loaded rack system of Figure 12B includes a back plate 105c to which the supporting yoke 115 for the rack chock 107 is locked in the engagement of the rack chock 107 with the rack 106. A similar yoke inter-engagement with the rack structures of the leg chords 105A and 105C could also be designed by either appropriately modifying the yoke structure or the back chord structure or both.

Other exemplary double opposed pinion rack structures known in the prior art to which the invention could be applied are illustrated in plan views in Figures 13A and 13B, each having leg chord 5A, 5B with a double rack 6A, 6B, having teeth 14A, 14B, respectively. Figure 13C of course illustrates the "National Supply" type structure previously described in reference to Figures 2—4 (1st embodiment) and 11A and 11B.

Also, it should be understood that the separate, independent vertical (longitudinal) screw system 8, 108 and the horizontal (lateral) screw systems 9, 109, were also merely exemplary. The two degrees of adjustment could be achieved for example simultaneously if desired. Such an alternate rack chock system is illustrated in Figure 14 as a third, exemplary embodiment.

In the embodiment of Figure 14, the leg 202 shown is in its raised disposition into the leg opening 203 with the jack-up unit hull 201 floating, ready for example for an ocean voyage in being towed from one location to another. The leg 202, which has a double opposed pinion type rack 206, is locked and rigidified

into position with the hull 201 by means of the sliding rack chocks 207.

The rack chocks 207 were, prior to their rigidifying the legs to the hull, in the upper, phantom line locations shown in Figure 14. After each leg 202 was raised to its generally desired, raised position, the chocks 207 were allowed to move down against their inclined guide surfaces 289 which simultaneously caused the rack chocks 207 to be moved both longitudinally from and laterally against the rack 206 until the rack chocks 207 at least generally interdigitated with the teeth 214 of the rack 206. The legs 202 were then lowered to the extent needed to jam and lock the rack 206 into the rack chocks 207 against the sides of the guides surfaces 289.

For a long voyage or for added locking rigidity without any need for keeping the jacking pinions engaged or locked, steel plates 218 and 219 are welded into place for a complete and rigid locking of the legs 202 to the hull 201.

It should become apparent that many changes may be made in the various parts of the invention without departing from the scope of the invention as claimed.

Claims

1. A system for a jack-up rig unit for off-shore use, including at least one leg (2) with a set of rack teeth (14) fixedly connected thereto and disposed at least generally in a vertical direction along at least a substantial portion of the leg length, and a floatable hull (1) supportable above the water line on said leg(s) (2) comprising: locking means (7) carried by the hull (1) for each of said leg(s) (2) for locking the leg(s) (2) to said hull (1), said locking means (7) including laterally movable rack teeth-engaging means for engaging the rack teeth (14) of its respective leg (2) in its locking disposition but laterally movable with respect to said rack teeth (14) out of any engagement with said rack teeth (14) when it is desired to jack said leg(s) (2) up and down, characterised in that the locking means (7) for each leg (2) comprises at least three peripherally spaced rack chocks (7) each having a plurality of matching chock teeth arranged in a series so that when the rack chocks (7) are moved laterally into their locking disposition, the chock teeth of each rack chock (7) are rigidly interdigitated with the rack teeth (14) whereby the hull (1) and the leg(s) (2) is rigidified without introducing any substantial bending moments in the leg(s) (2).

2. A system as claimed in Claim 1, characterised in that said teeth engaging means is also movable in the vertical, longitudinal direction with respect to said rack teeth independent of any hull movement.

3. A system as claimed in Claim 2, characterised in that said teeth engaging means is movably mounted on or above said hull (1) to also allow both horizontal and vertical move-

back plate 105c, enhancing the rigidification results of the present invention.

The yoke 115 can stay in position above the "Le Tourneau" guides 113 while the leg 102 is being raised or lowered. When the rack chock 107 is engaged with the rack chock teeth 114 on the leg 102, then the vertical jacks 104 can be positioned to take the vertical loads if desired.

The foregoing constitutes two exemplary rack chock embodiments of the system of the present invention as applied to jack-up legs with exemplary double opposed pinion racks and a simple end loaded rack, respectively. However, it should be understood the foregoing has been directed merely to exemplary applications, and the principles of the present invention can be applied to all other types of jack-up units with one or more racks.

Other exemplary single end loaded rack structures known in the prior art to which the invention could be applied are illustrated in plan views in Figures 12A and 12C, each having a leg chord structure 105A, 105C with a single rack 106A, 106C, respectively. Figure 12B of course illustrates the "Le Tourneau" type structure previously described with reference to Figures 5—7 (2nd embodiment) and 10A and 10B. As mentioned above, the single end loaded rack system of Figure 12B includes a back plate 105c to which the supporting yoke 115 for the rack chock 107 is locked in the engagement of the rack chock 107 with the rack 106. A similar yoke inter-engagement with the rack structures of the leg chords 105A and 105C could also be designed by either appropriately modifying the yoke structure or the back chord structure or both.

Other exemplary double opposed pinion rack structures known in the prior art to which the invention could be applied are illustrated in plan views in Figures 13A and 13B, each having leg chord 5A, 5B with a double rack 6A, 6B, having teeth 14A, 14B, respectively. Figure 13C of course illustrates the "National Supply" type structure previously described in reference to Figures 2—4 (1st embodiment) and 11A and 11B.

Also, it should be understood that the separate, independent vertical (longitudinal) screw system 8, 108 and the horizontal (lateral) screw systems 9, 109, were also merely exemplary. The two degrees of adjustment could be achieved for example simultaneously if desired. Such an alternate rack chock system is illustrated in Figure 14 as a third, exemplary embodiment.

In the embodiment of Figure 14, the leg 202 shown is in its raised disposition into the leg opening 203 with the jack-up unit hull 201 floating, ready for example for an ocean voyage in being towed from one location to another. The leg 202, which has a double opposed pinion type rack 206, is locked and rigidified

into position with the hull 201 by means of the sliding rack chocks 207.

The rack chocks 207 were, prior to their rigidifying the legs to the hull, in the upper, phantom line locations shown in Figure 14. After each leg 202 was raised to its generally desired, raised position, the chocks 207 were allowed to move down against their inclined guide surfaces 289 which simultaneously caused the rack chocks 207 to be moved both longitudinally from and laterally against the rack 206 until the rack chocks 207 at least generally interdigitated with the teeth 214 of the rack 206. The legs 202 were then lowered to the extent needed to jam and lock the rack 206 into the rack chocks 207 against the sides of the guides surfaces 289.

For a long voyage or for added locking rigidity without any need for keeping the jacking pinions engaged or locked, steel plates 218 and 219 are welded into place for a complete and rigid locking of the legs 202 to the hull 201.

It should become apparent that many changes may be made in the various parts of the invention without departing from the scope of the invention as claimed.

Claims

1. A system for a jack-up rig unit for off-shore use, including at least one leg (2) with a set of rack teeth (14) fixedly connected thereto and disposed at least generally in a vertical direction along at least a substantial portion of the leg length, and a floatable hull (1) supportable above the water line on said leg(s) (2) comprising: locking means (7) carried by the hull (1) for each of said leg(s) (2) for locking the leg(s) (2) to said hull (1), said locking means (7) including laterally movable rack teeth-engaging means for engaging the rack teeth (14) of its respective leg (2) in its locking disposition but laterally movable with respect to said rack teeth (14) out of any engagement with said rack teeth (14) when it is desired to jack said leg(s) (2) up and down, characterised in that the locking means (7) for each leg (2) comprises at least three peripherally spaced rack chocks (7) each having a plurality of matching chock teeth arranged in a series so that when the rack chocks (7) are moved laterally into their locking disposition, the chock teeth of each rack chock (7) are rigidly interdigitated with the rack teeth (14) whereby the hull (1) and the leg(s) (2) is rigidified without introducing any substantial bending moments in the leg(s) (2).

2. A system as claimed in Claim 1, characterised in that said teeth engaging means is also movable in the vertical, longitudinal direction with respect to said rack teeth independent of any hull movement.

3. A system as claimed in Claim 2, characterised in that said teeth engaging means is movably mounted on or above said hull (1) to also allow both horizontal and vertical move-



the present invention utilizes a "Rack Chock" System as shown in the two embodiments of Figures 2—4 and 5—7 and described more full below, as well as in the third embodiment of Figure 14. The rack chocks of the double, opposed type embodiment of Figures 2—4 and Figure 14 will not introduce any appreciable horizontal loads or moments into the legs.

A first preferred embodiment of the present invention as applied to a double, opposed, pinion rack type jacking leg system, for example of the National Supply type (note Figures 11A and 11B) is illustrated in Figures 2—4.

Figure 1A shows an arrangement of an exemplary "jack-up" unit. Hull 1 supports all of the machinery, quarters, outfit, etc. The hull 1 in this illustrated unit is raised by three legs 2, which are located in leg wells 3 forming openings in the hull 1.

In Figures 1A and 1B, the hull 1 is shown raised above the water level and supported by the legs 2. The raising or lowering is accomplished by the jacks 4 driving pinions 4' illustrated in Figures 1B and 2 and which can be, for example, a "National Supply" type jack. U.S. Patent 3,606,251 discloses in some detail the particulars of a typical jack arrangement which could be used.

The legs 2 shown have three chords 5 (note Figure 1C). As best shown in Figures 2, 11A and 11B, each chord 5 incorporates a rack plate 6, which the jack pinions 4 engage to raise or lower the "jack-up unit" hull on the legs 2.

When the hull 1 is elevated to the proper position, the "rack chocks" 7 of the present invention are then engaged. Each "rack chock" 7 can be located within the hull leg wells 3 above the hull 1. Two laterally opposed "rack chocks" 7 (note Figure 3) are used with each leg chord rack 6 to equalize the horizontal forces due to the rack tooth pressure angle.

The elevated position of the hull 1 is variable and is not absolutely predetermined. The "rack chock" 7 is raised or lowered vertically (note in Figure 3 which threadably engage and ride in hull support structure 1 phantom line position "a" to phantom line position "b"); by screws 8. The operation of the screws 8 can, for example, be manual or actuated with a pneumatic powered wrench or by other suitable means.

When each "rack chock" 7 has been visually aligned with its respective leg chord rack 6, then the "rack chock" 7 is moved horizontally (from phantom line position "c" to phantom line position "d" of Figure 3), into contact with the leg chord rack 6 by turning the horizontal engaging screws 9 which threadably engage the ride-in screw support member 10 fixed to the hull support members 1 which in turn are structurally and rigidly fixed to the hull structure 1 itself. "Rack chocks" 7 and the teeth 14 of the leg chord rackplate 6 is established, then each elevating screw 8 is backed out approximately one turn so as not engage the leg chord rack plate 6. The horizontal engaging screws 9

are then alternately pretorqued to a predetermined desired amount. The upper and lower elevating screws 8 are then brought in contact with their "rack chock" 7 and alternately pretorqued to a predetermined amount.

The load may then be totally transferred from the jacks 4 to the "rack chocks" 7 by releasing the jack brakes. Preferably, as shown best in Figure 3, each teeth engaging chock element 7 includes a multiple number of matching teeth to interdigitate and mate with the teeth 14 of the rack 6, an exemplary number of three being shown. As opposed to the rotatably movable tooth engagement of the pinions 4 only partially and intermittently contacting portions of the two adjacent teeth 14 of the rack 6 (note Figure 11A), the teeth contacting chock element 7 rigidly and fixedly engages in full, fall-to-fall in-line engagement at best two adjacent teeth 14 or, in the embodiment of Figure 3, four teeth 14, two of the four being lockably engaged on both sides by the element 7.

A second, preferred embodiment of the present invention as applied to a single end loaded rack jacking system, for example of the "Le Tourneau" type (note Figure 10A and 10B), is shown in Figures 5—7.

The "rack chock" rigidification system of the second embodiment operates similarly to the first embodiment and like reference numbers are used for corresponding elements with, for example, the hull 101 and legs 102 operating in substantially the same manner and way as hull 1 and legs 2, and hence for the sake of brevity the common characteristics and structures between the two will not be repeated in detail here.

As can best be seen in Figures 5 and 5A, the "Le Tourneau" type jack 104 is shown as mounted on the deck 111 of the jack-up hull 101. Above the jack unit 104 is a guide structure 113 which engages the back plate 105c of the chord 105.

The rack 107 is mounted above the guide structure 113 and is supported by the guide structure 113 by means of the support member 116. The rack chock 107 is thereby supported vertically in an up or down direction depending upon the screw positionings of vertical screws 108. The rack chock 107 engages the rack teeth 114 on the leg 102 so that loads can be transferred from the leg 102 into the rack chock 107, which in turn transfers the loads into the hull 101 and the jack-up unit.

As can best be seen in Figures 6 and 7, the rack chock 107 is engaged or disengaged from the rack 106 of the leg 102 by the horizontal screws 109. The rack chock 107 and horizontal screws 109 are guided on the leg chord by a yoke 115 as can best be seen in Figure 7, the yoke 115 can grip the back plate 105c of the up chord 105, and, when the rack chock 107 is forced into lateral engagement with the teeth 114 of the rack 106, by the screws 109 the yoke 115 locks into engagement with the



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ment with respect to it, the hull (1) itself being stationary with respect to said leg(s) (2) during the movement of said teeth engaging means.

4. A system as claimed in any of Claims 1 to 3 characterised in that there is included at least three separate leg(s) (2) each having at least one of said rack chocks (7) at each chord (5) of each of said leg(s) (2).

5. A system as claimed in any of Claims 1 to 4 characterised in that each of said leg(s) (2) is of the opposed pinion type (206); there being at least one rack chock (7) for each of the opposed set of rack teeth (214).

6. A system as claimed in any of Claims 1 to 4 characterised in that each of said leg(s) (2) is of the single end loaded rack type (106), having a back plate (105C), and wherein each rack chock (107) includes a yoke (115) supporting it on the hull (1) which engages said back plate (105C), the engaging of said teeth engaging means with the rack teeth (114) locking said rack chock (107), said yoke (115) and said back plate (105C) together.

7. A method of securing the support leg(s) (2) of an offshore jack-up rig unit having a hull (1), leg(s) (2) with rack teeth (14) and a jacking drive associated therewith, comprising the following steps:

(a) providing on said hull (1) a separate locking means (7) for each of said leg(s) (2) which is operationally separate and apart from said jacking drive (41), which locking means (7) have teeth-engaging portions which are at least laterally movable with respect to respective rack teeth (14) to engage therewith when in a locking disposition.

(b) vertically positioning the leg(s) (2) of the rig with respect to the rig hull (1) to the height desired by means of said jacking drive (41), and

(c) after the foregoing steps, laterally moving the lockings means (7) into locking engagement with its respective rack teeth (14) and locking all of said locking means (7) to said leg(s) (2), characterised in that the locking means (7) comprises at least three peripherally spaced rack chocks (7) having a plurality of matching chock teeth arranged in a series so that when the rack chocks (7) are moved laterally into the locking disposition, the chock teeth are rigidly interdigitated with the rack teeth (14) whereby the hull (1) and the leg(s) (2) is rigidified without introducing any substantial bending moments in the leg(s) (2).

8. A method according to Claim 7, characterised in that said leg(s) (2) each have at least one set of rack teeth (14) on at least two opposed leg chords (5), and further characterised in that:

(a) said rack chocks (7) are movable both longitudinally and laterally with respect to a rack (6) of the leg(s) (2), and has chock teeth sized and configured so that each chock tooth engages at least the upper and lower surfaces of two teeth (14) on said rack (6);

(b) moving said rack chocks (7) longi-

tudinally with respect to said rack until said teeth are positioned across from two respective teeth (14) on said rack (6) and moving said rack chocks (7) laterally into face-to-face, in-line engagement with the upper and lower surfaces of said respective two teeth (14); and

(c) rigidly locking said rack chocks (7) to said rack (6) and to said hull structure (1); and

(d) repeating steps "a" through "c" for the rack(s) (6) on at least two opposed chords (5) for each leg (2) of the unit to rigidify the leg(s) (2) to the hull structure (1).

9. A method as claimed in Claim 8, characterised in that each of said leg(s) (2) is of the single end loaded rack type (106) with a back structure (105C) at each chord (105) of the leg (102) and wherein each rack chock (107) includes a yoke (115) supporting structure which supports each rack chock (107) and which engages said back structure (105C), and wherein there is included the further step of locking said rack chock (107), said yoke (115) and said back structure (105C) rigidly together when engaging said rack chock (107) and said rack (106).

Patentansprüche

1. Für küstennahen Gebrauch bestimmte Bohrausrüstung, die mindestens ein Bein (2) mit einer Reihe von daran befestigten und mindestens im wesentlichen in vertikaler Richtung über einen wesentlichen Teil der Beinlänge angeordneten Zähnen (14) und eine flutbare Plattform (1) aufweist, die oberhalb der Wasserlinie von dem Bein bzw. den Beinen (2) getragen ist, und mit auf der Plattform (1) vorgesehenen Verriegelungsmitteln (7) für jedes Bein (2), um es gegenüber der Plattform (1) festzulegen, wobei die Verriegelungsmittel (7) seitlich bewegbare, den Zähnen zugeordnete Gegenmittel zum Kontakt mit den Zähnen (14) des betreffenden Beins in der verriegelten Stellung aufweisen, die jedoch relativ zu den Zähnen (14) außer Kontakt zu den Zähnen (14) bewegbar sind, wenn die Beine auf bzw. nieder verstellt werden sollen, dadurch gekennzeichnet, daß die Verriegelungsmittel (7) für jedes Bein (2) mindestens drei auf dem Umfang abständig angeordnete Haltekeile (7) aufweisen, die jeweils mit mehreren entsprechenden und in Reihe angeordneten Haltezähnen versehen sind, so daß bei seitlich in ihre Verriegelungsstellung überführten Haltekeilen (7) die Haltezähne jedes Haltekeils (7) fest parallel zu den Zähnen (14) gehalten sind, wodurch die Plattform (1) und die Beine (2) gegenseitig festgelegt sind, ohne daß wesentliche Biegemomente in den Beinen (2) auftreten.

2. Bohrausrüstung nach Anspruch 1, dadurch gekennzeichnet, daß die Gegenmittel auch in vertikaler Richtung entlang den Zähnen und unabhängig von einer Bewegung der Plattform bewegbar sind.

3. Bohrausrüstung nach Anspruch 2, da-



durch gekennzeichnet, daß die Gegenmittel auf oder oberhalb der Plattform (1) angeordnet und gegenüber der Plattform sowohl horizontal als auch vertikal bewegbar sind, und daß die Plattform (1) selbst während einer Bewegung der Gegenmittel gegenüber den Beinen (2) unverändert bleibt.

4. Bohrausrüstung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß mindestens drei unabhängige Beine (2) jeweils mindestens einen Haltekeil (7) an jedem Gurt (5) von jedem Bein (2) aufweisen.

5. Bohrausrüstung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß jedes Bein (2) mit zwei gegenüberliegenden Reihen von Zähnen (14) ausgestattet ist, und daß mindestens ein Haltekeil (7) für jede Reihe von Zähnen vorgesehen ist.

6. Bohrausrüstung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß jedes Bein (2) einseitig mit einer Reihe von Zähnen und mit einer Rückenplatte (105C) ausgestattet ist, und daß jeder Haltekeil (107) ein von der Plattform getragenes und sich an der Rückenplatte (105C) abstützendes Joch (115) aufweist, und daß der Kontakt der Gegenmittel zu den Zähnen (114) den Haltekeil (107), das Joch (115) und die Rückenplatte (105C) miteinander verriegelt.

7. Verfahren zum Festlegen des Beins bzw. der Beine (2) einer zum küstennahen Gebrauch bestimmten Bohrausrüstung mit einer Plattform (1) und einem Bein mit Zähnen (14) sowie einen damit verbundenen Windenantrieb, welches die folgenden Verfahrensschritte aufweist,

(a) Auf der Plattform (1) werden separate Verriegelungsmittel (7) für jedes Bein (2) getrennt betätigbar und angeordnet zu dem Windenantrieb vorgesehen, wobei die Verriegelungsmittel (7) mindestens seitlich relativ zu den Zähnen (14) bewegbare Gegenmittel zum Kontakt in der Verriegelungsstellung aufweisen.

(b) Relativ zu der Plattform (1) werden die Beine (2) der Bohrausrüstung auf die gewünschte Höhe durch den Windenantrieb eingestellt.

(c) Danach werden die Verriegelungsmittel (7) seitlich in Verriegelungskontakt mit den betreffenden Zähnen (14) gebracht und alle Verriegelungsmittel (7) mit den Beinen (2) verriegelt, dadurch gekennzeichnet, daß die Verriegelungsmittel (7) mindestens drei auf dem Umfang abständig angeordnete Haltekeile (7) aufweisen, die jeweils mit mehreren entsprechenden und in Reihe angeordneten Haltezähnen versehen sind, so daß bei seitlich in ihre Verriegelungsstellung überführten Haltekeilen die Haltezähne fest parallel zu den Zähnen (14) gehalten werden, wodurch die Plattform (1) und die Beine (2) gegenseitig festgelegt werden, ohne daß wesentliche Biegemomente in den Beinen (2) auftreten.

8. Verfahren nach Anspruch 7, dadurch gekennzeichnet, daß die Beine (2) jeweils mindestens eine Reihe von Zähnen (14) auf mindestens zwei gegenüber angeordneten Gurten (5) aufweisen, und weiterhin dadurch gekennzeichnet, daß

(a) die Haltekeile (7) sowohl in Längsrichtung als auch seitlich relativ zu einer Zahnstange (6) der Beine (2) bewegbar sind und Haltezähne aufweisen, die so dimensioniert und angeordnet sind, daß jeder Haltezahn mit mindestens der Unter- und der Oberseite von zwei Zähnen (14) der Zahnstange (6) in Anlage kommt;

(b) die Haltekeile (7) in Längsrichtung relativ zu der Zahnstange bewegt werden, bis die Haltezähne zwei entsprechenden Zähnen (14) an der Zahnstange gegenüberstehen und die Haltekeile (7) seitlich in Anlagekontakt mit der Unter- und Oberseite der zwei Zähne (14) überführt werden, und

(c) die Haltekeile (7) mit der Zahnstange (6) und der Plattform (1) fest verriegelt werden, und

(d) die Schritte (a) bis (c) für die Zahnstange bzw. Zahnstangen (6) an mindestens zwei gegenüber angeordneten Gurten (5) jedes Beins (2) der Ausrüstung wiederholt werden, um die Beine (2) mit der Plattform (1) fest zu verbinden.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß jedes Bein (2) einseitig mit einer Reihe von Zähnen und mit einer Rückenplatte (105C) an jedem Gurt (105) jedes Beins (102) ausgestattet ist, daß jeder Haltekeil (107) ein Joch (115) aufweist, das jeden Haltekeil (107) trägt und sich an der Rückenplatte (105C) abstützt, und daß der weitere Schritt des festen Verriegelns des Haltekeils (107), des Joches (115) und der Rückenplatte (105C) miteinander vorgesehen sind, wenn der Haltekeil (107) mit der Zahnstange (106) in Kontakt kommt.

Revendications

1. Système pour une plate-forme auto-élévatrice destinée à être utilisée au large du littoral, comprenant au moins une pile (2) munie d'un ensemble de dents (14) de crémaillère assujéti de façon fixe à cette pile et disposé d'une façon générale au moins dans une direction verticale le long d'au moins une partie notable de la longueur de la pile, et une coque (1) pouvant flotter et pouvant être supportée au-dessus de la ligne de flottaison sur la ou les dites piles (2) comprenant: un moyen de blocage (7) supporté par la coque (1) pour la pile ou chacune des dites piles (2) en vue de bloquer la ou les piles (2) sur ladite coque (1), ledit moyen de blocage (7) comprenant un moyen d'engrènement de dents de crémaillère, pouvant être déplacé latéralement et destiné à engréner avec les dents (14) de crémaillère de



sa pile correspondante (2) dans sa position de blocage mais pouvant être déplacé latéralement par rapport auxdites dents (14) de crémaillère de manière à cesser d'être engréné avec lesdites dents (14) de crémaillère lorsque l'on désire soulever et abaisser la ou lesdites piles (2), caractérisé en ce que le moyen de blocage (7) pour chaque pile (2) comprend au moins trois cales-crémaillères (7) espacées dans le sens périphérique et comportant chacune une pluralité de dents d'appariement disposées en série de telle sorte que lorsque les cales-crémaillères (7) sont déplacées latéralement jusque dans leur position de blocage, les dents de chaque cale-crémaillère (7) s'encastrent de façon rigide entre les dents (14) de crémaillère, la coque (1) et la ou les piles (2) étant ainsi rendues solidaires de façon rigide sans introduire de moments de flexion notables dans la ou les piles (2).

2. Système suivant la revendication 1, caractérisé en ce que ledit moyen d'engrènement de dents peut également être déplacé dans la direction verticale et la direction longitudinale par rapport auxdites dents de crémaillère indépendamment de tout déplacement de la coque.

3. Système suivant la revendication 2, caractérisé en ce que ledit moyen d'engrènement de dents est monté de façon mobile sur ladite coque (1) ou au-dessus de cette coque de manière qu'il puisse effectuer à la fois un mouvement horizontal et un mouvement vertical par rapport à cette dernière, la coque (1) elle-même étant fixe par rapport à la pile ou auxdites piles (2) pendant le déplacement dudit moyen d'engrènement de dents.

4. Système suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que au moins trois piles séparées (2) sont incluses, chacune d'elles comportant au moins une desdites cales-crémaillères (7) à chaque corde (5) de chacune desdites piles (2).

5. Système suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que chacune desdites piles (2) est du type (106) à pignons opposés, au moins une cale-crémaillère (7) étant prévue pour chacun des ensembles opposés de dents (214) de crémaillère.

6. Système suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que chacune desdites piles (2) est du type (106) à une seule crémaillère chargée à l'extrémité, comportant une plaque d'appui (105C), et dans lequel chaque cale-crémaillère (107) comprend une chape (115) qui la supporte sur la coque (1) et qui est en prise avec ladite plaque d'appui (105C), l'engrènement dudit moyen d'engrènement de dents avec les dents (114) de crémaillère solidarissant ensemble de façon bloquante ladite cale-crémaillère (107), ladite chape (115) et ladite plaque d'appui (105C).

7. Procédé pour fixer la ou les piles de support (2) d'une plate-forme auto-élevatrice

destinée à être utilisée au large du littoral et comportant une coque (1), une ou des piles (2) munies de dents (14) de crémaillère et un moyen de soulèvement et d'abaissement qui leur est associé, comprenant les phases suivantes:

(a) l'installation sur ladite coque (1) d'un moyen de blocage séparé (7) qui est destiné à la pile ou à chacune desdites piles (2) et qui est fonctionnellement séparé et placé à distance dudit moyen (41) de soulèvement et d'abaissement, ce moyen de blocage (7) comportant des parties d'engrènement de dents qui sont au moins mobiles latéralement par rapport aux dents (14) de crémaillère correspondantes de manière à engréner avec cette dernière lorsqu'il se trouve dans une position de blocage;

(b) le positionnement dans le sens vertical de la ou des piles (2) de la plate-forme par rapport à la coque (1) de la plate-forme jusqu'à la hauteur voulue à l'aide dudit moyen (41) de soulèvement et d'abaissement; et

(c) après les phases ci-dessus, le déplacement dans le sens latéral du moyen de blocage (7) de manière qu'il engrène de façon bloquante avec ses dents (14) de crémaillère correspondantes et le blocage de tous lesdits moyens de blocage (7) sur la ou lesdites piles (2), caractérisé en ce que le moyen de blocage (7) comprend au moins trois cales-crémaillères (7) espacées dans le sens périphérique et comportant une pluralité de dents d'appariement disposées en série de telle sorte que lorsque les cales-crémaillères (7) sont déplacées latéralement jusque dans leur position de blocage, les dents des cales-crémaillères s'encastrent de façon rigide entre les dents (14) de crémaillère, la coque (1) et la ou les piles (2) étant solidarisés de façon rigide sans introduction de moments de flexion notables dans la ou les piles (2).

8. Procédé suivant la revendication 7, caractérisé en ce que la ou lesdites piles (2) comportent chacune au moins un ensemble de dents (14) de crémaillère sur au moins deux cordes de piles opposées (5), et caractérisé en outre en ce que:

(a) on peut déplacer lesdites cales-crémaillères (7) à la fois dans la direction longitudinale et dans la direction latérale par rapport à une crémaillère (6) de la pile ou des piles (2) et que lesdites cales-crémaillères comportent des dents dimensionnées et configurées de manière que chaque dent de cale-crémaillère porte au moins contre les surfaces supérieure et inférieure de deux dents (14) de ladite crémaillère (6);

(b) on déplace lesdites cales-crémaillères (7) dans la direction longitudinale par rapport à ladite crémaillère jusqu'à ce que lesdites dents soient placées en travers de deux dents respectives (14) de ladite crémaillère (6) et on déplace lesdites cales-crémaillères (7) dans la direction latérale de manière qu'elles viennent porter, face contre face et en alignement, contre



les surfaces supérieure et inférieure des deux dents correspondantes précitées (14); et

(c) on bloque de façon rigide lesdites cales-crémaillères (7) sur ladite crémaillère (6) et sur ladite structure de coque (1); et

(d) on répète les phases "a" à "c" pour la ou les crémaillères (6) sur au moins deux cordes opposées (5) de chaque pile (2) de la plateforme de manière à solidariser de façon rigide la ou les piles (2) et la structure de coque (1).

9. Procédé suivant la revendication 8, caractérisé en ce que la pile ou chacune desdites piles (2) est du type (106) à une seule cré-

maillère chargée à l'extrémité, avec une structure d'appui (105C) à chaque corde (105) de la pile (102), et dans lequel chaque cale-crémaillère (107) comprend une chape (115) supportant une structure qui supporte chaque cale-crémaillère (107) et qui est en prise avec ladite structure d'appui (105C), et dans lequel est incluse la phase supplémentaire de solidification de façon bloquante et rigide de ladite cale-crémaillère (107), de ladite chape (115) et de ladite structure d'appui (105C) lors de l'engrènement de ladite cale-crémaillère (107) avec ladite crémaillère (106).

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