United States Patent [19]

Lovie

[11] **3,967,457**

[45] **July 6, 1976**

[54] **SELF-ELEVATING OFFSHORE DRILLING UNIT LEGS**

[75] Inventor: **Peter M. Lovie**, Houston, Tex.

[73] Assignee: **Engineering Technology Analysts, Inc.**, Houston, Tex.

[22] Filed: **July 11, 1974**

[21] Appl. No.: **487,574**

[52] **U.S. Cl.** **61/46.5**; 61/53; 52/731; 74/29; 254/106

[51] **Int. Cl.²** **E02B 17/00; F16H 19/04**

[58] **Field of Search** 61/46.5, 46, 53; 52/731, 638, 726, 720; 37/73; 74/29; 254/106

[56] **References Cited**

UNITED STATES PATENTS

2,578,364	12/1951	Maxon, Jr.	52/638 X
3,183,676	5/1965	Le Tourneau	61/46.5
3,372,907	3/1968	Smulders et al.	61/46.5
3,445,129	5/1969	Penote	52/638
3,779,656	12/1973	Guy et al.	52/638

FOREIGN PATENTS OR APPLICATIONS

511,789	6/1952	Belgium	52/726
921,439	1/1947	France	52/731

Primary Examiner—Jacob Shapiro
Attorney, Agent, or Firm—Torres & Berryhill

[57] **ABSTRACT**

Leg apparatus for an offshore drilling unit of the self-elevating type having a floatable hull and a plurality of legs movable from a raised position, in which the legs are supported by the hull in a body of water, to a lowered position, in which the hull is supported by the legs on the floor of the body of water. The legs may comprise a plurality of mutually parallel tubular chord members rigidly interconnected by structural bracing members. The tubular chord members may comprise an elongated tubular body and an elongated plate member, whose longitudinal axis coincides with the axis of the tubular body, rigidly connected to and spanning the interior of the tubular body.

17 Claims, 10 Drawing Figures

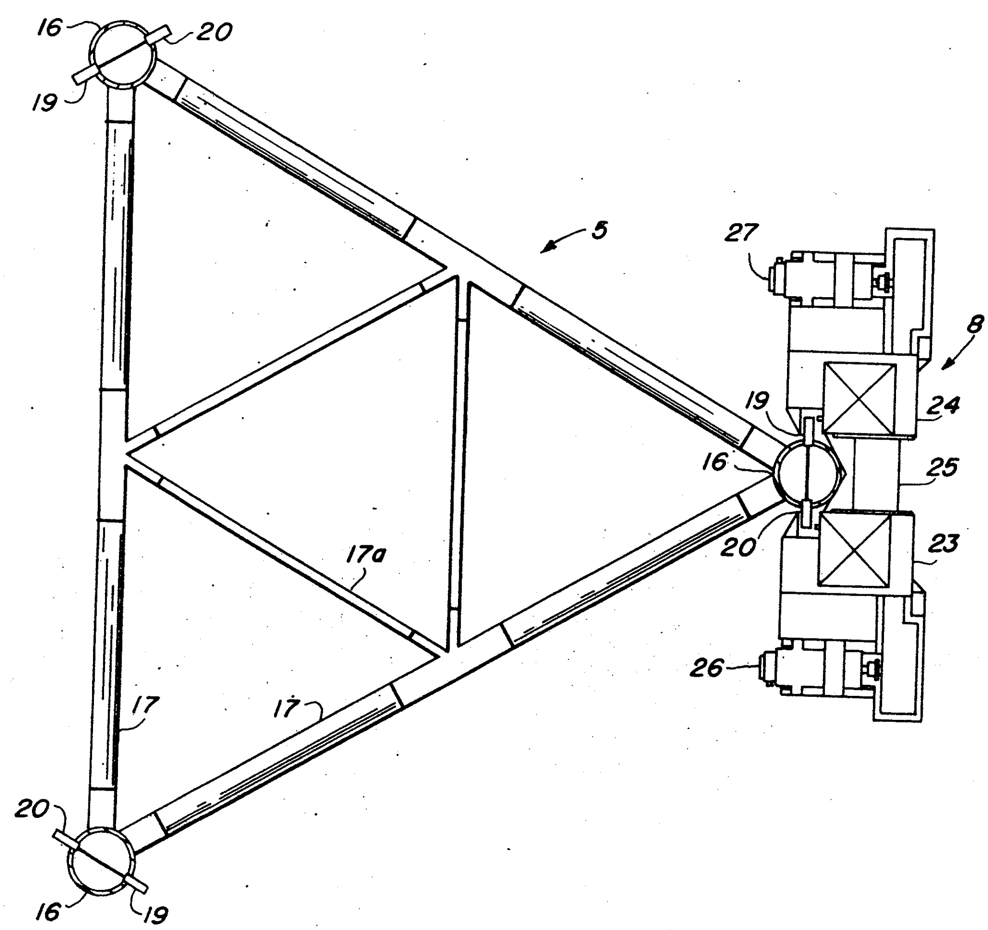


FIG. 1

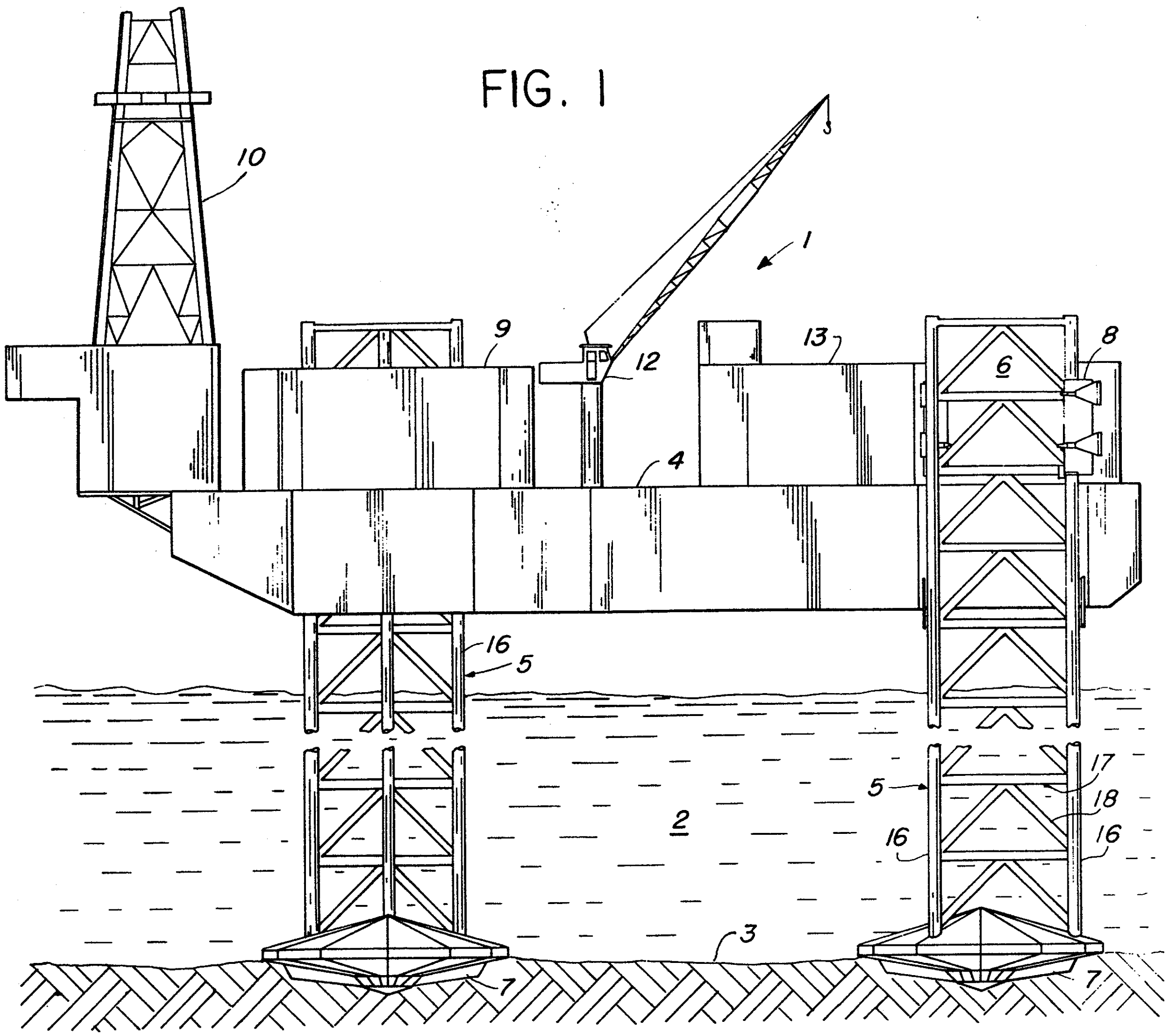


FIG. 2

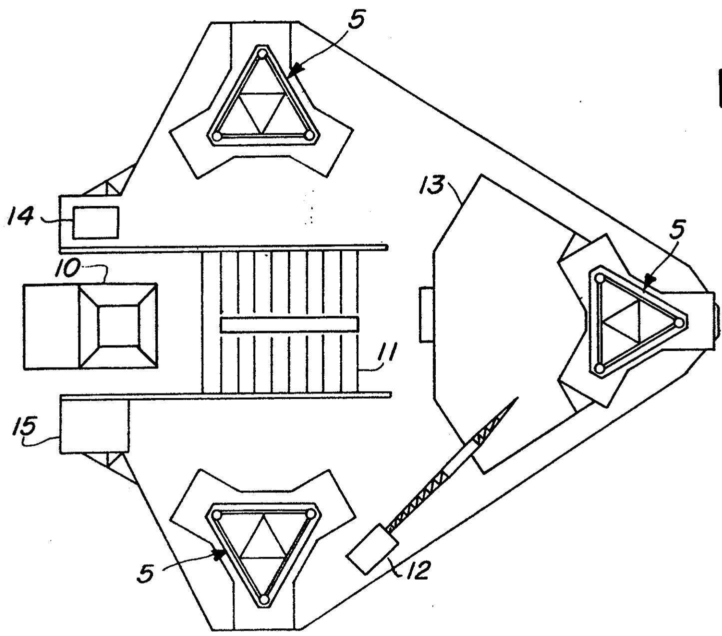


FIG. 3

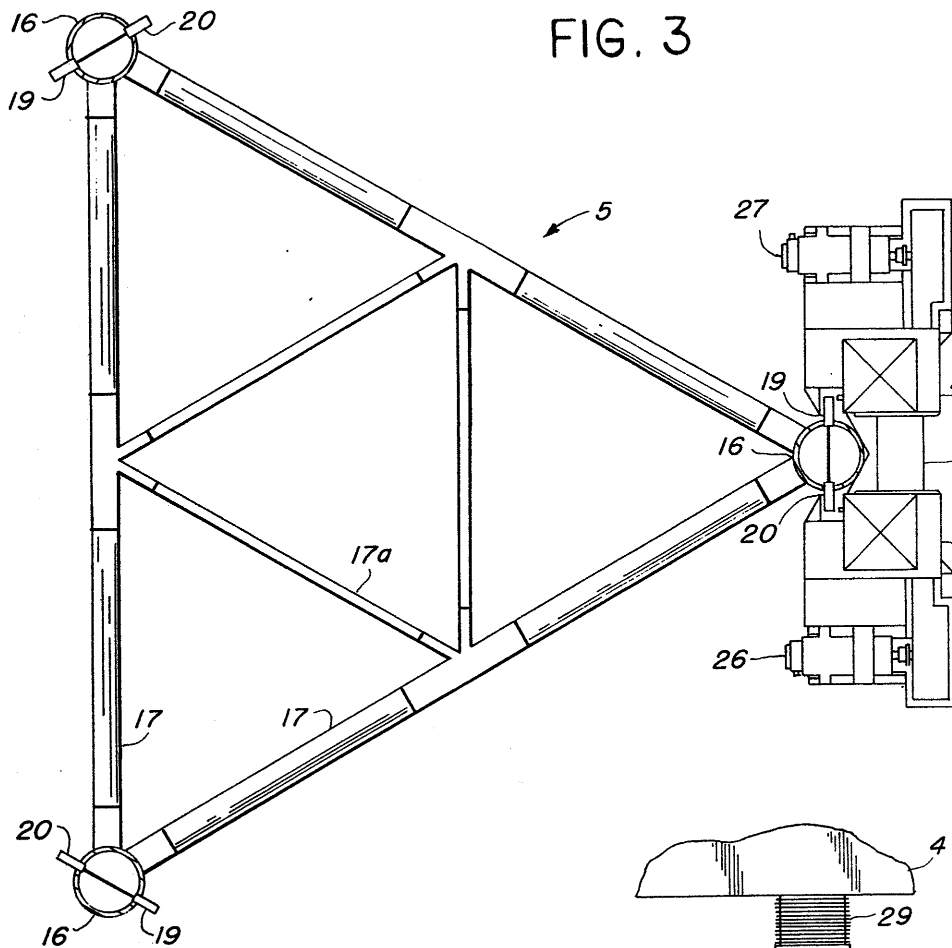
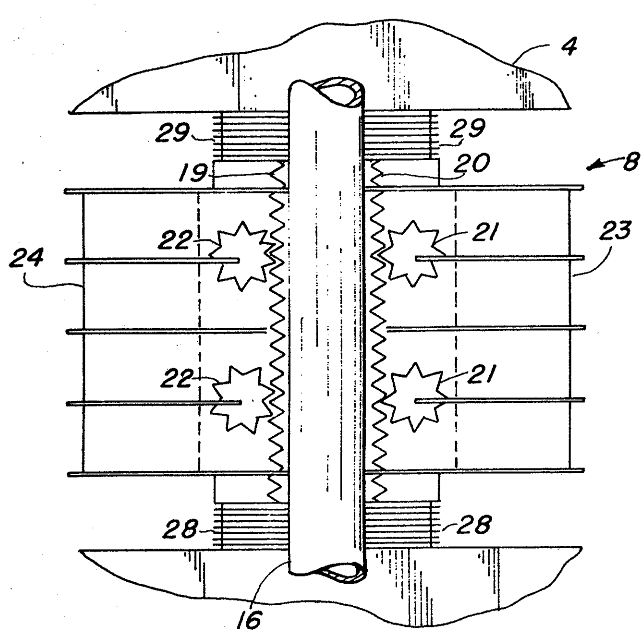


FIG. 4



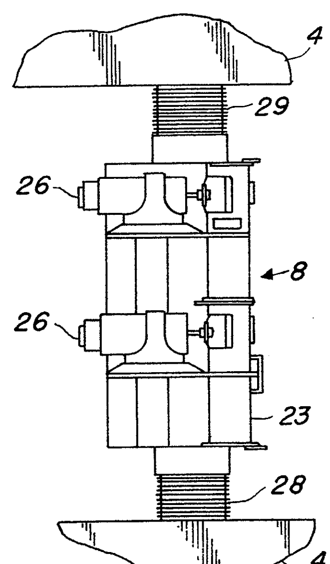


FIG. 5

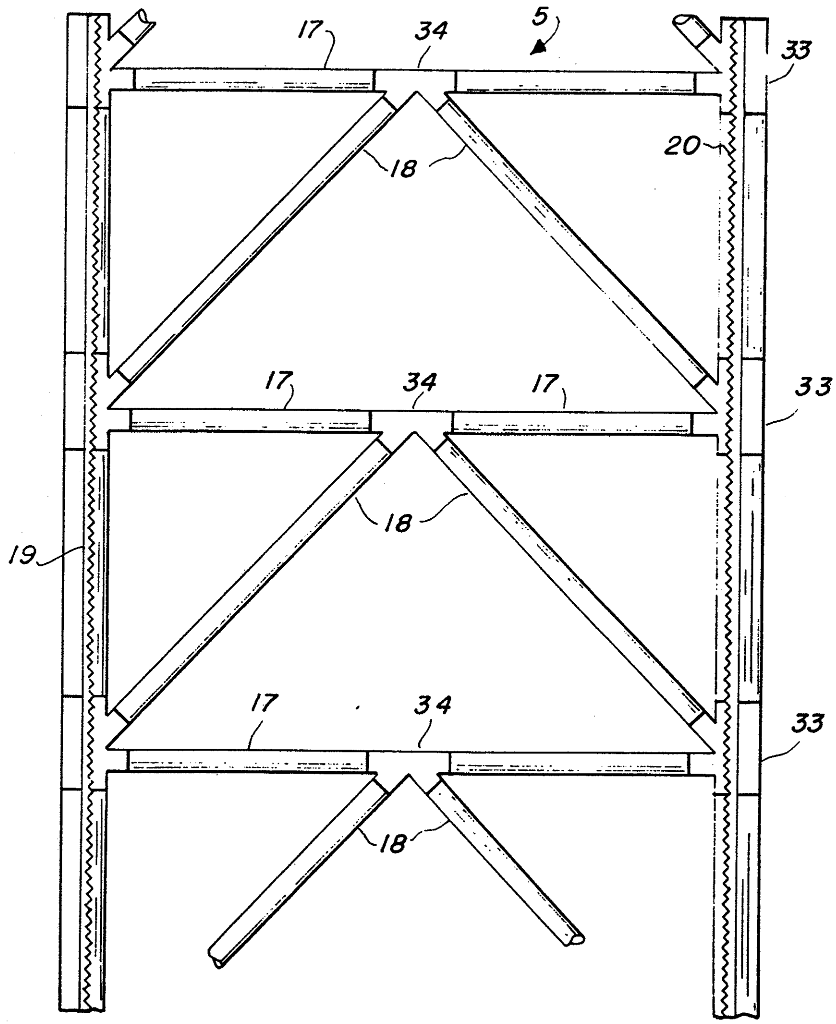
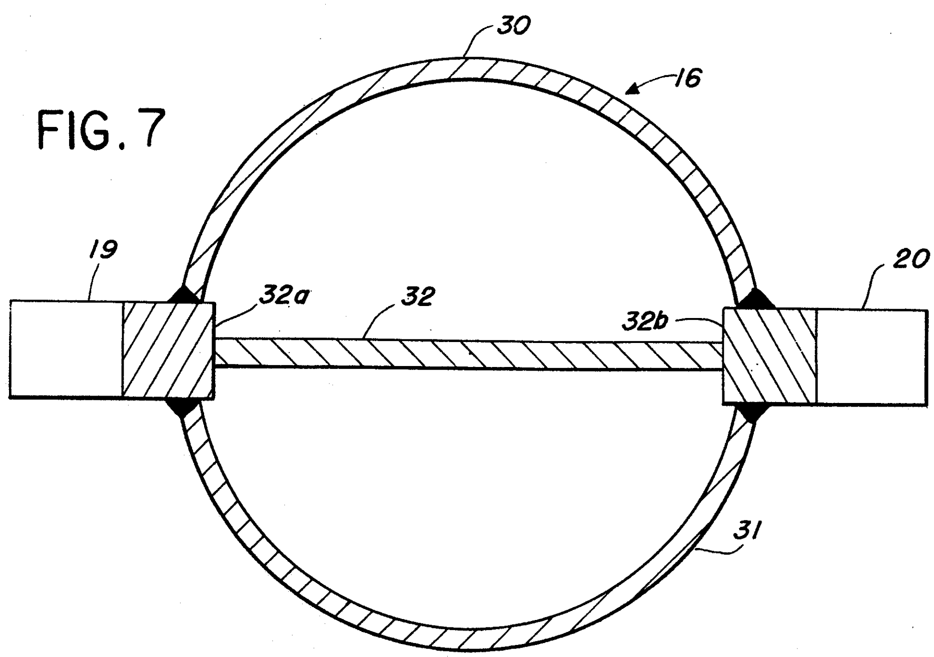


FIG. 6

FIG. 7



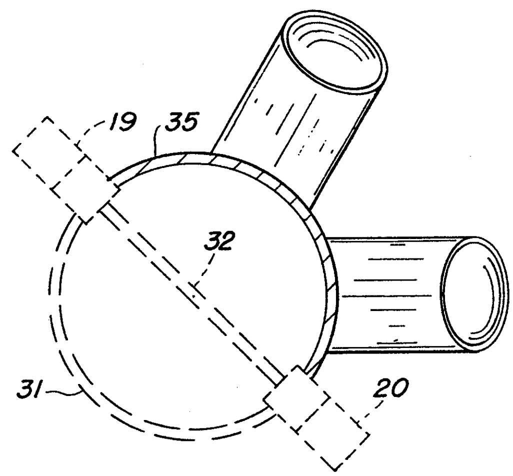


FIG. 8

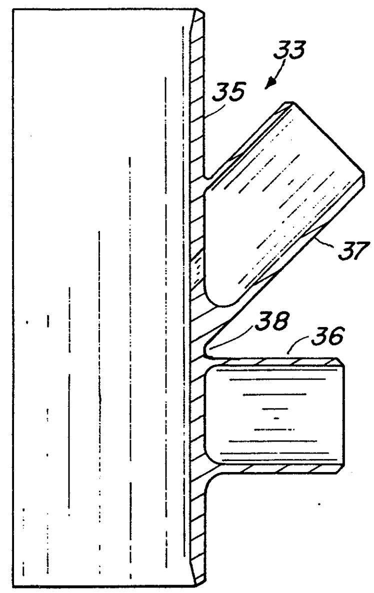


FIG. 9

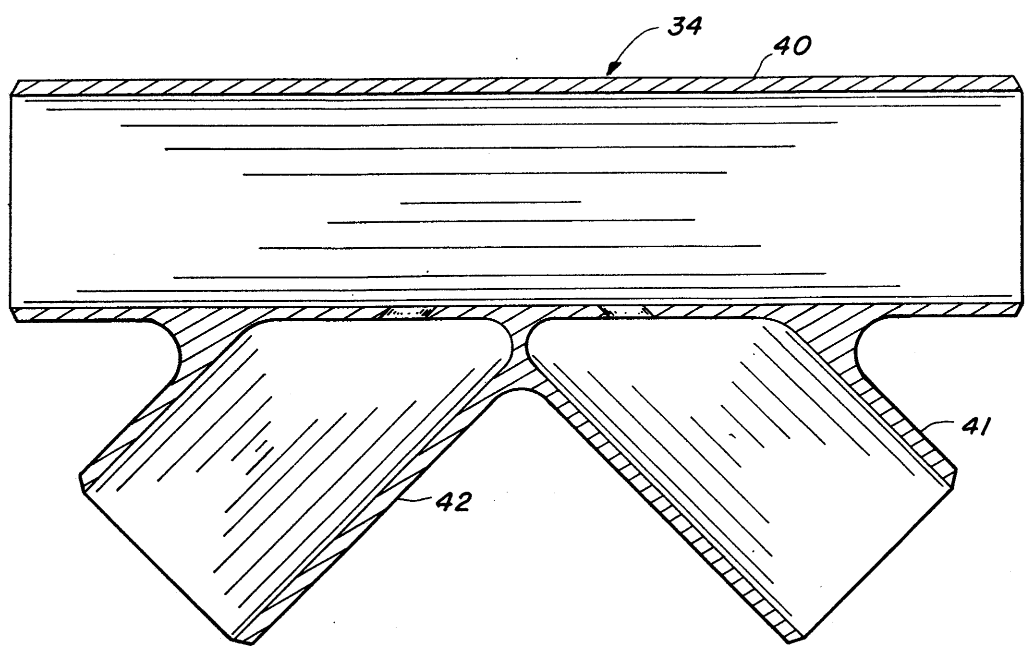


FIG. 10

SELF-ELEVATING OFFSHORE DRILLING UNIT LEGS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to offshore drilling units. In particular, it concerns offshore drilling units of the self-elevating type having a floatable hull and a plurality of legs movable from raised positions, in which the legs are supported by the hull in a body of water, to lowered positions in which the hull is supported by the legs on the floor of the body of water. More specifically, the present invention pertains to unique and improved construction for the legs of such a drilling unit.

2. Description of the Prior Art

There are several different types of rigs by which marine drilling is conducted. One of the first developed was the fixed platform rig in which the legs or supports of the rig are permanently installed, penetrating the floor of the body of water in which the well is to be drilled. Such a rig is limited by water depth and does not provide the mobility and flexibility of the mobile or portable type drilling rigs. For very deep water drilling, floating platforms or drill ships may be used. Depending upon the situation, drilling operations may also be conducted from submersible, semi-submersible, or self-elevating platform drilling units.

For use in water depths up to three hundred feet, and lately up to six hundred feet, the self-elevating platform or "jack-up" rig is quite popular. Such a rig is usually provided with a plurality of legs, frequently three or four in number, which are lowered from a floating platform or hull into the water for penetration of the water body floor. The platform is then elevated on the legs a sufficient distance above the water surface to prevent the platform from being subjected to wave action. Such rigs offer the advantage of being highly mobile, yet very stable when in place.

Some of the major design considerations in a self-elevating drilling rig are the construction of the legs and the means for elevating the platform or hull on the legs. Since the legs support the entire unit when in place, they must be designed for a great amount of strength and minimal effect from the constantly changing wave conditions. Three or four legged units, in which the legs comprise mutually parallel chord members interconnected by structural bracing members are popularly employed. The bottom of the legs are provided with spud feet or spud tanks for footing penetration of the floor of the body of water in which the unit is to be used. Examples of such units may be seen in U.S. Pat. Nos. 3,044,269 and 3,606,251.

One method of moving the legs between raised and lowered positions is to provide suitable rack and pinion arrangements. The pinions, which may be driven by powered elevating or jack units on the hull of the ship, are engageable with racks attached along the chord member of the legs. Rotation of the pinions causes the racks, and consequently the legs, to move in a vertical direction within wells provided in the hull. Such elevating mechanisms are shown in the above-mentioned U.S. Pat. Nos. 3,044,269 and 3,606,251. Others are shown in U.S. Pat. Nos. 2,924,077 and 3,014,346.

In the past, the legs of most jack-up drilling units have been constructed either in cylindrical form or as a "space frame" made up of angles, "I" beams or prismoidal structural of trapezium of tubular section. More recently, the legs have been constructed predominantly of tubular structural members. In any case, the vertical members or "chords", as they are sometimes referred to, are usually rigidly interconnected by horizontal and inclined or diagonal bracing members which are welded thereto. It is very difficult to obtain good welds under such circumstances and very often stress concentration points are created at points of the welds. Past experience has led to cracking and sometimes failure at such connections particularly in areas where severe loadings occur, often involving fatigue effects. This is particularly true in tubular construction, since the tubular members must be cut in such a fashion as to conform closely with curvilinear surfaces of another tubular member or quadrilateral sectioned member at inclined angles thereto.

The welding process causes imputs of heat to the structural sections which can easily cause distortion. Such "out of straightness" has frequently been a problem in jackup leg construction in prior art units, particularly when assymmetric leg chord sections are used. The symmetry and construction used have greatly reduced such problems.

In an effort to overcome some of the welding and stress concentration problems involved in connecting horizontal and diagonal bracing to the chord members of legs, preformed joints have been developed. An example of developments in this may be seen in U.S. Pat. Nos. 3,596,950 and 3,668,876.

Since the legs support the entire weight of the rig, when in position for drilling, they are required to be designed for great strength. When supported on the floor of a body of water, the greatest bending moments in the legs occur near the hull or platform. This means that the chord members must necessarily be stronger near the upper portion of the leg. In legs which use tubular chord members this requires that the wall thickness of the tubular members increase from the bottom of the leg upwardly. Non-uniform wall thickness of the chord member creates problems in construction of legs. For example, welds are harder to make and points of stress concentration are created. If the tubular chord members are not reduced in wall thickness toward the bottom of the legs, the unnecessary increased metal results in greater weight of the legs and increased costs thereof. Greater weights are particularly undesirable when the legs are in the raised, in-transit position, since the center of gravity of the unit is raised making the rig less stable in the water.

When a rack is welded to chord members, additional forces of the drive pinion requires additional strength in the chord member. Although the welding of longitudinal racks to the chords of a leg may increase the strength thereof, most jack-up rig legs depend upon the wall thickness of the chord member and the interconnecting bracing for strength.

Development continues in offshore drilling rigs in an attempt to build more economical, efficient and trouble free units. Since drilling is taking place in deeper and deeper water, floating rigs and self-elevating platform rigs are in the forefront of this development.

SUMMARY OF THE PRESENT INVENTION

In the present invention a unique leg construction is shown for a self-elevating type drilling unit. The legs may comprise a plurality of mutually parallel tubular chord members rigidly interconnected by structural provided with pinions which operatively engage cooperating racks attached to the legs 5 to provide the means for raising and lowering the legs 5. These components will be more fully described hereafter. For the present, it is sufficient to understand that the drilling rig 1 is transported to a drilling location with the legs elevated and the hull floating on the water. Once the drilling site is reached, the legs are lowered by the jack units 8 until spud tanks 7 engage the floor 3. Further operation of the jack units 8 causes the hull 4 to be elevated on the legs 5 to a sufficient height above the surface of the water body 2. From this position the drilling takes place.

Mounted on the hull or platform 4 is a derrick 10 from which wells are drilled. The derrick may be mounted for limited lateral movement in two directions so that it can be centered over a plurality of locations, permitting a number of wells to be drilled from the platform without changing the position of its legs 5. Auxiliary drilling equipment such as pipe racks 11, crane 12, etc. may be provided on the hull or platform 4. Additional support facilities such as quarters 13, test laboratories 14 and 15, etc. may also be provided.

Referring also to FIG. 3, each of the legs comprises a plurality, three in the present case, of mutually parallel chord members 16 rigidly interconnected by major horizontal and inclined or diagonal bracing 17 and 18, respectively. Smaller interior bracing 17*a* may also be provided. Further details of the chords 16, bracing 17 and 18 and their interconnection will be given hereafter. As best seen in FIG. 3, the chord members 16 are located at the points of triangular cross-sectional configurations of the legs. The number of chords and cross-sectional configuration is, however, not so limited.

Each of the chord members 16 is provided with a pair of rack members 19 and 20 longitudinally disposed therealong in a plane passing through the axis of chords 16 and parallel to but spaced from the central axis of the leg member 5. The outward edge or face of racks 19 and 20 are provided with rack teeth which cooperatively engage pinions carried by the elevating or jack units 8. (See also FIGS. 4 and 5.) Although only one jack unit 8 is shown in FIG. 3, there would normally be one for each chord member 16.

The jack units 8 are carried on the hull 4 within the jack houses 9 and each jack unit may comprise a pair of gear assemblies 23 and 24 rigidly connected by a structural member 25. The gear assemblies may also be provided with power means 26 and 27 such as hydraulic or electric motors. The jack unit may be provided with resilient pads 28 and 29 for absorbing the shock forces to which they be submitted. Since the jack units 8 are retained against vertical displacement by the hull, it can readily be understood that upon operation of the power means 26 and 27, causing rotation of pinions 21 and 22, the legs 5 will be raised or lowered depending upon the direction of rotation of pinions 21 and 22.

Referring now to FIGS. 6–10, specific details of the legs 5, according to a preferred embodiment of the invention, will be given. As already stated, the legs 5 may comprise a plurality of mutually parallel chord members 16 rigidly interconnected by horizontal and diagonal bracing 17 and 18. Also, as previously described, rack members 19 and 20 may be longitudinally disposed along the chord member 16.

The construction of chord members 16 is unique. As best seen in FIG. 7, the chord member 16 is tubular and may comprise a pair of semi-cylindrical members between the ends of which are welded the rack members 19 and 20. Spanning the interior of chord member 16 in a plane including the axis of chord member 16 and coinciding with the plane of rack members 19 and 20 is an elongated reinforcing plate member 32. The plate member may be welded along its edges, as at 32*a* and 32*b*, to the backs of rack members 19 and 20.

This internal reinforcing plate member is unique in the construction of drilling rigs and serves vital functions. It, of course, strengthens the chord member 16 against the normal compression, tension and bending forces to which the legs 5 are subjected. In addition, it strengthens the chord member 16 against the forces to which it is subjected from the rack and pinion mechanisms for raising and lowering the legs. One interesting advantage of such construction is that the design strength of the chord member 16 can be varied, without varying the wall thickness of the cylindrical portions 30 and 31, by simply varying the thickness of the reinforcing plate 32. Since the forces on the chord member 16 may vary, depending upon its position in the leg 5, the thickness of the plate 32 may be varied accordingly. This permits the cylindrical portion to be uniform throughout the length of the leg making welding of the chord member easier, more reliable and less subsceptible to stress concentration. Furthermore, the plate selected for rolling and forming the semi-cylindrical members 30 and 31 can be selected of a more easily rolled thickness and smaller diameter chord members can be used.

From FIG. 6, it will be noted that preformed joints 33 and 34 are employed in interconnecting the various sections of chord members 16 and horizontal and diagonal bracing 17 and 18, respectively. These joints may be conveniently performed by casting or other suitable methods in configurations shown in FIGS. 8–10.

The chord joint 33, as shown in FIGS. 8 and 9, may comprise a cylindrical trunk or body portion 35 and one or more tubular projections or branches 36 and 37. The horizontal branches 36 are provided for connection with horizontal bracing 17 while the inclined branches 37 are provided for connection with inclined or diagonal bracing 18. The body or trunk portion 35 may be approximately semi-cylindrically cast for welding to a semi-cylindrical section 31, rack members 19 and 20, and internal reinforcing plates 32, such as those shown in the chord cross-section of FIG. 7, and may actually be a continuation thereof.

By casting such a joint, areas of heavy stress concentration, such as the area 38 may be beefed up or reinforced in a way not permissible with conventional construction techniques. Furthermore, the open ends of the branch projections 36 and 37 lie in a plane perpendicular to the axes of these projections and the tubular bracing to which they are to be welded so that a simple circular butt weld may be made, rather than the complex curvature welds required when one tubular member is connected to another tubular member as in the prior art.

Similarly, the brace joints 34 may be cast as shown in FIG. 10. Such a K-shaped joint may comprise a tubular body or trunk portion 40, which will normally be in the horizontal position, and inclined tubular branch projections 41 and 42. The K-shaped bracing joint 34 offers the same advantages of the chord joint 33, namely easier and more reliable welding and strengthening of areas of high loading concentration, as well as reducing

12. An offshore drilling unit as set forth in claim **10** in which the plane in which said rack means and reinforcing member lie is parallel to but spaced away from the longitudinal centerline of said legs.

13. An offshore drilling unit as set forth in claim **10** in which said elevating means comprises at least a pair of pinion members, one of which engages a set of rack teeth on one side of said chord member and the other of which engages a set of rack teeth on the diametrically opposite side of said chord member.

14. An offshore drilling unit as set forth in claim **8** in which said structural bracing members comprise horizontal and inclined tubular members interconnected by welding to a tubular cast K-shaped joint.

15. An offshore drilling unit as set forth in claim **14** in which said horizontal and inclined tubular bracing

members are connected to said chord members by welding to tubular cast chord joints welded between sections of said chord members.

16. An offshore drilling unit as set forth in claim **15** in which said chord joints comprise a tubular trunk portion from which radially projects horizontal tubular branch portions and inclined tubular branch portions for connection with said horizontal and inclined bracing, respectively.

17. An offshore drilling unit as set forth in claim **16** in which said tubular trunk portion is provided with a reinforcing member spanning the interior of said trunk portion in a plane which includes the central longitudinal axis of said chord member.

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