# United States Patent [19]

**Lovie**

[11] **3,826,099**

[45] **July 30, 1974**


[54] **SELF-ELEVATING OFFSHORE PLATFORM WITH FOLDING LEGS**


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

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



[22] Filed: **Sept. 25, 1972**

[21] Appl. No.: **291,780**

[52] **U.S. Cl.** ..... **61/46.5,** 37/73, 114/0.5

[51] **Int. Cl.** ..... **E02b 17/00**

[58] **Field of Search** ..... 61/46.5, 46; 114/0.5; 37/73



[56] **References Cited**

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*Primary Examiner*—Jacob Shapiro

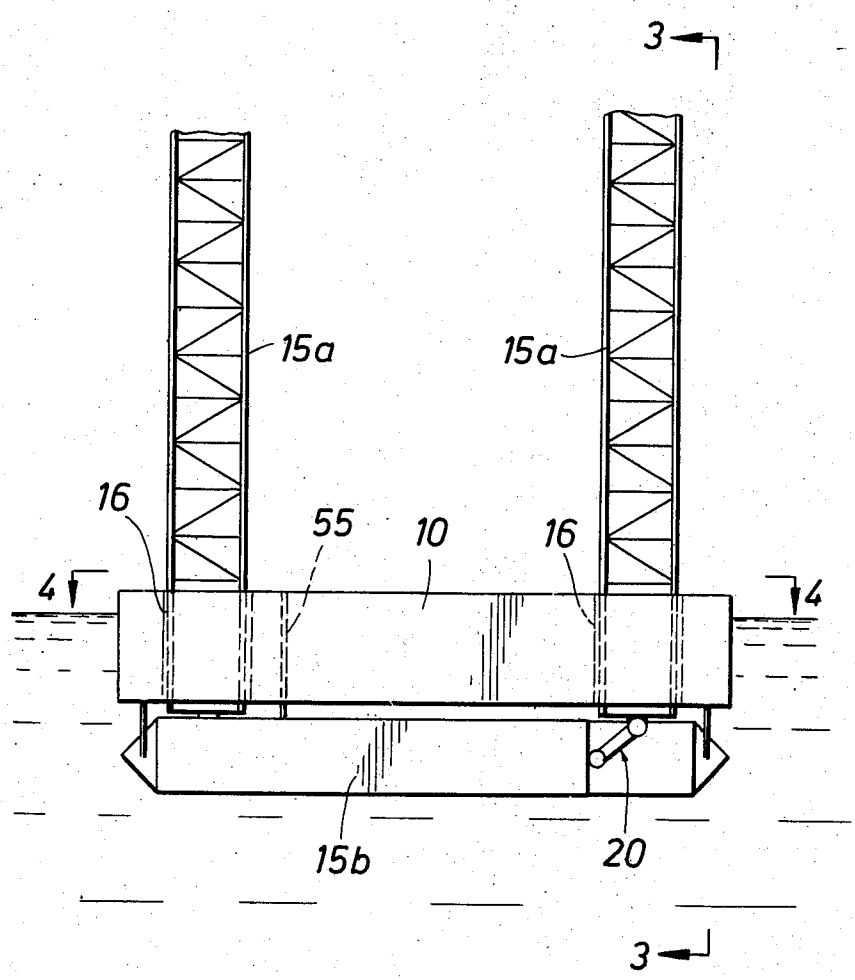
*Attorney, Agent, or Firm*—Torres & Berryhill



[57] **ABSTRACT**

An offshore drilling unit of the self elevating platform type having a floating hull and plurality of legs movable from a raised position, in which the legs are supported by the floating hull, to a lowered position engaging the floor of a body of water, in which the hull is supported on the legs. The legs are of articulated construction permitting a first portion of each leg, when in the raised position, to swing from longitudinal alignment with a second portion of the leg to horizontal alignment underneath the hull for carriage during water travel. Ballast means including tanks in the first portion of leg may be provided for moving the first leg portion between the longitudinally aligned position and the horizontal position underneath the hull. The first portion of the leg may be attached to the second portion by a pivot arrangement and disengageable fastening assembly.


**17 Claims, 10 Drawing Figures**



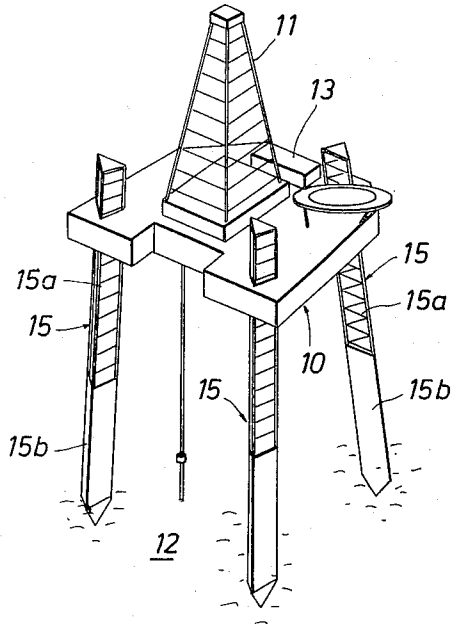
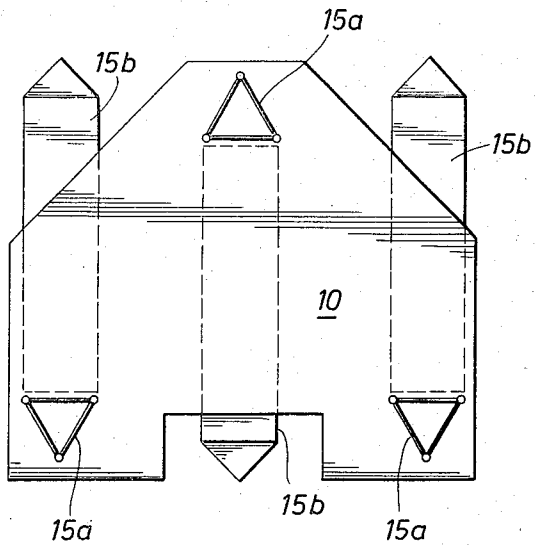



FIG. 1

FIG. 4



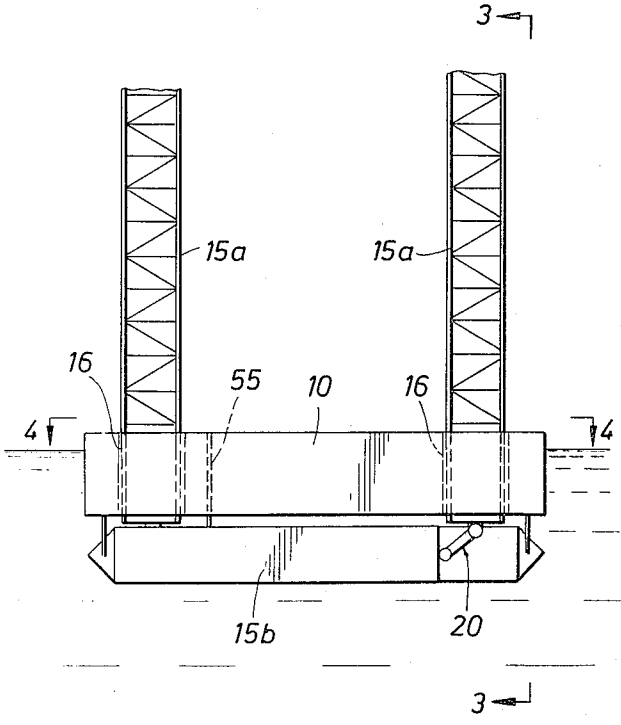




FIG. 2

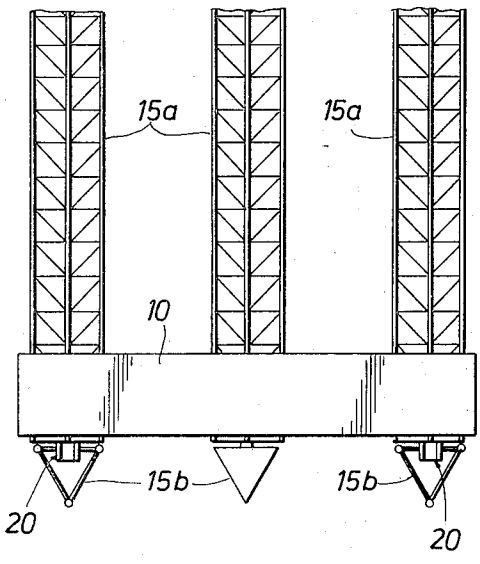



FIG. 3

FIG. 5

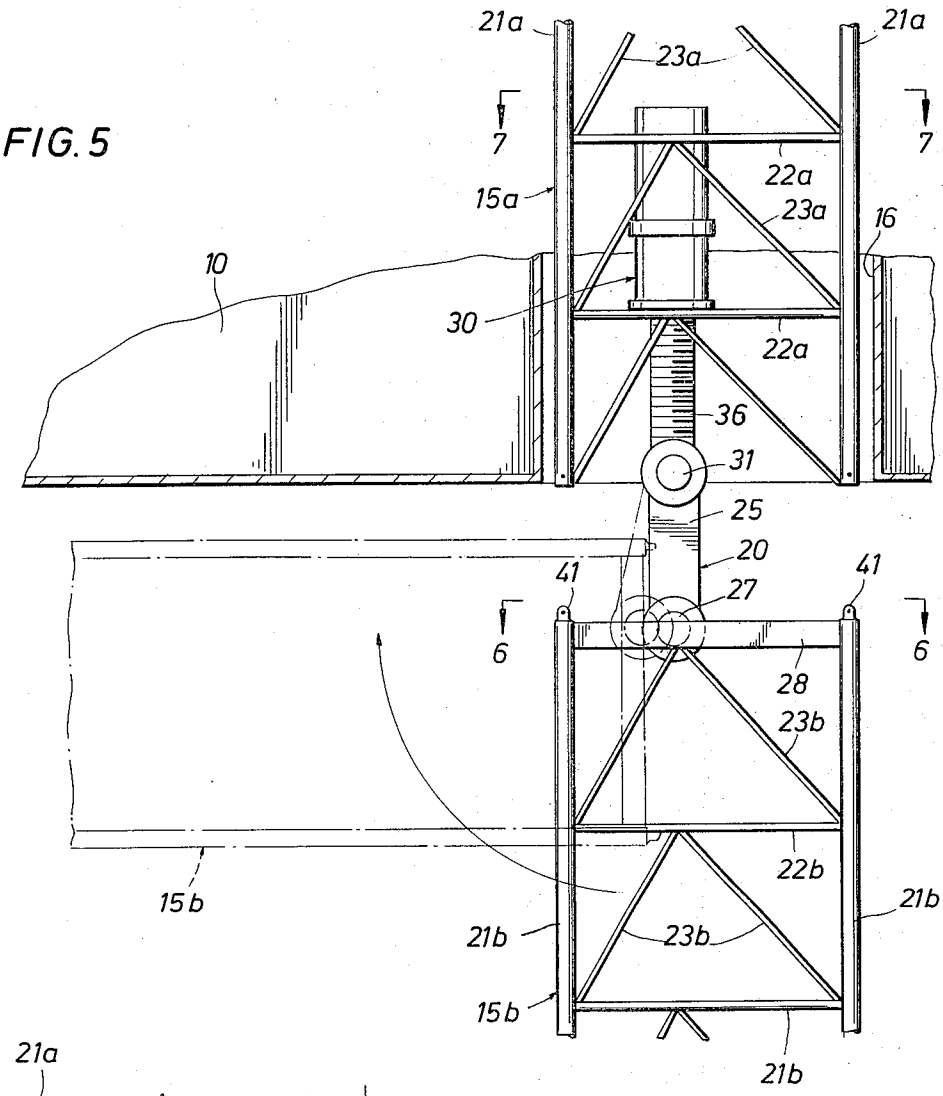
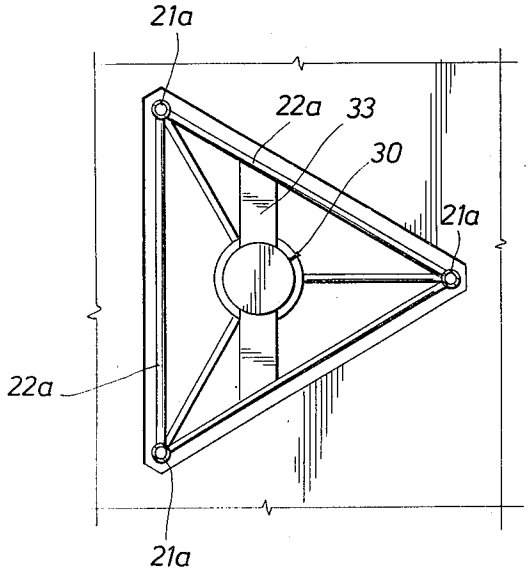



FIG. 7



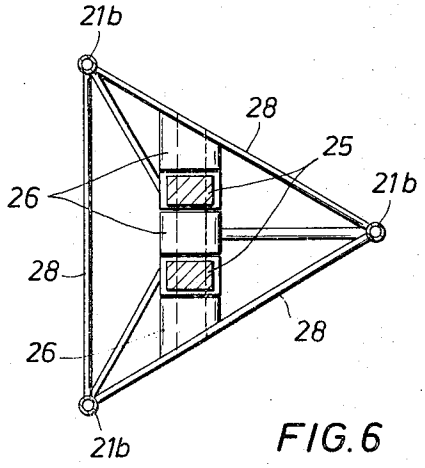




FIG. 6

FIG. 8

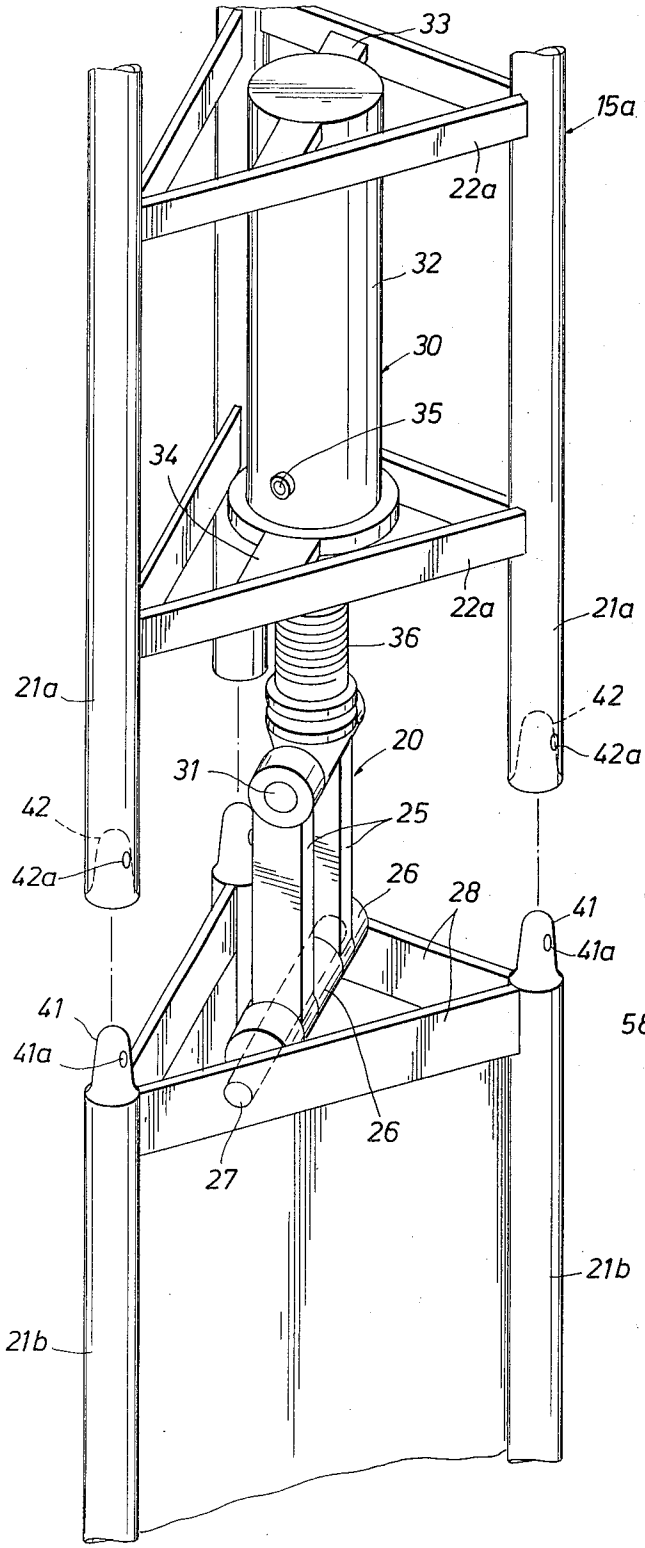
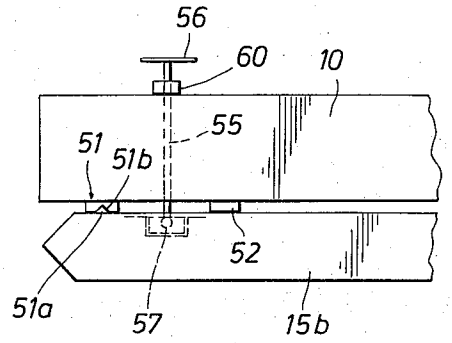



FIG. 9



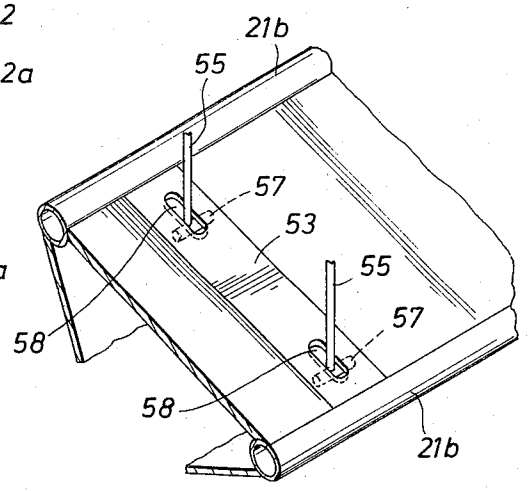




FIG. 10

# SELF-ELEVATING OFFSHORE PLATFORM WITH FOLDING LEGS

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to offshore drilling units. In particular, it relates to drilling units of the self elevating platform type which have a floating hull for moving from site to site and a plurality of legs for supporting the unit on the floor of a body of water at a particular site. When moving from site to site the legs are raised and supported by the hull. Once on site the legs are lowered through the body of water until they contact the floor. The hull or platform is then elevated above the water, being supported by the legs.

2. Description of the Prior Art

There are several types of drilling units which are presently used for offshore drilling of oil and/or gas wells: fixed platform, submersible, semisubmersible, self-elevating platform, and floating vessel. The self-elevating platform or jack-up type rigs have become increasingly popular for drilling in depths of up to 300 feet. The jack-up rig offers the mobility of semisubmersibles and floating vessel rigs and the stability of submersible and fixed platform rigs.

The working platform, derrick and other drilling equipment of a jack-up rig are carried on a floating hull. The rig is provided with a plurality of support legs which, when moving from site to site, are carried by the hull drawn up in a vertical attitude. On site the legs are vertically lowered until they penetrate the floor of the water body sufficiently to support the hull and the equipment carried thereon. The hull is then elevated to a position above the surface of the water from which drilling operations proceed.

One disadvantage of self-elevating platform units is that the length of the legs contribute to raising the center of gravity of the unit when the legs are in the drawn up position for ocean tow. This contributes to instability of the unit when moving from site to site and often requires removal of upper portions of the legs prior to ocean tow or making it necessary to lower the legs partially in severe storm conditions. Such removal or partial lowering of the legs is expensive and inconvenient. However, in the units capable of drilling in water depths of 300 feet this may be mandatory. Since such units are the largest and the most expensive to operate, the inconvenience and expense of partial leg removal is great.

When the leg of a self-elevating platform type rig is cut off and subsequently welded back on, or where a mechanical connection is provided for removal of part of a leg, the joint is made at a relatively high position on the leg. It is usually this portion of the leg which is under the most severe stress during operation and storm conditions.

## SUMMARY OF THE INVENTION

The present invention concerns a new and improved jack-up drilling rig design in which the legs are of articulate construction, permitting a first portion of each leg to swing from a vertical position to a horizontal position underneath the floating hull for carriage during water travel. The first portion of the leg may be attached to the second portion by a pivot connection and disengageable fastening means. The engagement of the fastening means allows rigid longitudinal alignment of the leg portions in the vertical position while disengagement of the fastening means permits the lower portion to swing about the pivot connection to the horizontal position underneath the hull. A retaining device may be provided for maintaining this position. Ballast means, including tanks carried by the lower leg portions, may be provided for moving the lower leg portion between the vertical and horizontal positions.

With such a design the length of the leg above the hull, during ocean tow, is substantially reduced, lowering the center of gravity and substantially improving the stability characteristics of the unit. It also avoids the problems associated with making and breaking joints in the leg. Furthermore, the connection between leg sections is located at lower points in the leg structure, where the loadings are less severe, resulting in a more reliable design. In addition, an increase in buoyancy may be obtained when the ballast tanks in the leg portions are carried underneath the hull. This results in increased stability and improved load carrying characteristics. Further objects and advantages of the present invention will become apparent from the description which follows when read in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

In the description which follows references will be made to the accompanying drawings in which:

FIG. 1 is a perspective representation of a jack-up drilling rig, according to a preferred embodiment of the invention, shown with its legs lowered in an on site position for drilling;

FIG. 2 is a side elevation view of a folding leg jack-up rig, according to a preferred embodiment of the invention, showing the legs in a folded or horizontal position for ocean travel;

FIG. 3 is an end elevational view of the jack-up rig of FIG. 2;

FIG. 4, taken along line 4—4 of FIG. 3, is a cross sectional view of the jack-up rig of FIGS. 2 and 3;

FIG. 5 is a detailed side elevation view of a portion of one of the legs of the jack-up rig of the present invention, illustrating details of construction;

FIG. 6, taken along line 6—6 of FIG. 5, is a cross-sectional view of the lower portion of the leg of FIG. 5;

FIG. 7, taken along line 7—7 of FIG. 5 is a cross-sectional view of an upper section of the leg of FIG. 5;

FIG. 8 is a perspective view of the leg of FIGS. 5–7 more fully illustrating the connection between upper and lower sections of the leg prior to elevation of the lower section by an elevator assembly and prior to connection of the chord members of the upper and lower sections;

FIG. 9 is a partial side elevation view of the jack-up rig of the present invention illustrating apparatus suitable for retaining the legs in a folded or horizontal position during ocean tow; and

FIG. 10 is a detailed perspective view of a portion of the leg shown in FIG. 9 more fully illustrating apparatus for retaining the leg in a horizontal position.

## DESCRIPTION OF A PREFERRED EMBODIMENT

Referring first to FIGS. 1 through 4, a jack-up drilling

rig, according to a preferred embodiment of the invention, will be described. The rig comprises a floating hull or platform **10** on which is mounted a drilling derrick **11** and other equipment required for drilling operations, including living quarters **13**, etc. The rib also comprises a plurality, three in the present case, of support legs **15**.

When traveling from site to site with jack-up rigs of the prior art, the legs are drawn up within leg wells provided in the hull and the legs extend upwardly above the hull for almost the entire length of the legs. This causes the center of gravity of the unit to be raised during ocean tow resulting in decreased stability. In deep water units, having long legs, it is common to remove the upper portion of the legs so that they might be laid on the hull reducing the center of gravity for ocean tow or storm conditions. Such removal of the legs is expensive and requires that, before getting on location, the removed leg portions be reconnected by welding or other means to the rest of the leg. Such a connection is usually made in the upper portion of the leg where the loading is most severe during drilling operations and storm conditions. When over the selected site or location, the legs are lowered through their wells by suitable means, such as a rack and pinion arrangement, until the legs contact the ocean floor **12**, as shown in FIG. **1**. Then the hull or platform **10** may be elevated by the same rack and pinion arrangement to the desired height above the water surface for drilling.

The legs **15** of the jack-up rig of the present invention are of articulated construction having an upper section **15***a* and a lower section **15***b*. The upper section **15***a* assumes an essentially vertical position, as in units of the prior art, and are disposed in a vertical leg well **16**. The lower section is connected to the upper section by a hinge or pivot device **20**, which will be described in more detail hereafter. The hinge **20** allows the lower section **15***b* to be folded or moved to the horizontal position of FIGS. **2–4**, directly underneath the hull **10**. A suitable retainer device **55**, to be described hereafter, may be provided to hold the legs in such a position for ocean travel. Thus the center of gravity of the unit is reduced during ocen tow, making it unnecessary to remove upper portions of the legs **15**. Furthermore, the lower leg sections **15***b* can be plated in to provide ballast tanks by which the hull **10** can be made to support a greater payload.

Once the drilling unit of the present invention reaches a site or location, the lower leg sections **15***b* are released from their horizontal position and moved to a vertical position substantially in longitudinal alignment with the upper sections **15***a*. This movement may be accomplished by flooding the ballast tanks of the lower sections **15***b*. After the lower sections **15***b* are rigidly fastened in alignment with the upper sections **15***a*, the legs **15** may be lowered into contact with the floor of the body of water in which the unit is located. Then the hull or platform may be elevated above the water surface to the drilling position illustrated by FIG. **1**.

Referring now to the detail drawings of FIGS. **5–8** the connection between upper and lower sections **15***a* and **15***b* will be described in more detail. The upper and lower leg sections **15***a* and **15***b* are generally constructed in a manner similar to other jack-up drilling rig legs having vertical chord members **21***a* and **21***b* and conventional bracing **22***a*, **22***b*, **23***a* and **23***b*. However, at least a portion of the lower section may be plated in as best seen in FIG. **2** to provide ballast tanks. The legs **15** are shown as being triangular in cross section. However, they could be of any framed cross-sectional structure desired or, for that matter, solid in section, such as a circular or noncircular caisson.

In the horizontal position, illustrated by dotted lines, and in the vertical position prior to fastening, the lower leg section **15***b* is attached to the upper section **15***a* by a special hinge mechanism **20**. It is this connection which allows the lower section **15***b* to be moved between the vertical and horizontal position. In an exemplary embodiment, the hinge connection comprises a pair of hinged links **25**, the lower ends of which are disposed between spacers **26**, welded to the lower section **15***b*, for pivoting about a pin **27** placed in coaxial holes in the spacers **26** and links **25**. The lower section **15***b* may be provided with heavy box beams **28** to support the hinge pin.

The upper ends of hinge links **25** are connected by a pin **31** to an elevator device **30**, which in the present case is illustrated as a screw jack. The housing or stationary part of the jack **32** may be rigidly affixed to the upper leg section **15***a* by platen and beam members **33** and **34**. Such a jack may be provided with an aperture **35** through which the jack mechanism may be mechanically actuated to cause the jack screw **36** to be extended or retracted within the housing **32**. Such jacks are commonly known in the art and no further description of its construction will be given. Other elevator devices could be used. For example, a rack and pinion mechanism would serve just as well. The elevator device **30** is normally in the extended position shown in FIGS. **5** and **8**, prior to going on location.

Once the unit has been towed to the proper site or location, the lower leg sections **15***b* are moved from the horizontal position to the vertical position shown in FIG. **5**. This may be done, as previously suggested, by flooding the ballast tanks carried by the lower leg sections or by controlled release of the flooded tanks. When the upper and lower leg sections **15***a* and **15***b* are properly aligned in a longitudinal direction, the elevator device **30** may be actuated, causing the lower section **15***b* to be drawn upwardly toward the upper section **15***a*. The upper end of lower chord members **21***b* may be provided with pins **41** which are engageable with corresponding sockets **42** at the lower end of upper chord members **21***a*. As the lower leg section **15***b* is pulled upwardly the pin **41** engages the socket **42** preventing further upward movement of the lower section **15***a*. The elevator device **30** should preferably be of the type having a mechanical efficiency of less than 0.5 so that this condition may be maintained without running back due to the weight of the legs. Although the elevator device **30** could maintain this connection, the pin and socket connections **41** and **42** may be provided with holes **41***a* and **42***a* in which pins or screws may be inserted to positively secure the lower leg sections **15***b* to the upper section **15***a*. Compressive load is transferred between chords by the pin and socket connections. Tensile load is transferred through the pins inserted in holes **41***a* and **42***a*. Shear is transferred by the socket connection.

Once the upper and lower sections **15***a* and **15***b* are securely fastened in a rigid condition, the entire leg **15** may be lowered, by suitable apparatus, toward contact with the floor of the body of water. The leg lowering and raising mechanism may be of any conventional

type, e.g., rack and pinion, and since such construction is well known in the art it will not be described herein. Once the lower end of the legs **15** have contacted the ocean floor, the hull or platform **10** may be elevated, by the same leg lowering mechanism, to the desired elevation above the surface of the water. Then drilling operations may proceed.

After a well has been drilled and it is desired to move to another location, the legs **15** may be raised, by the leg lowering and raising mechanism, to a position where the connection of the upper and lower sections **15***a* and **15***b* is just beneath the underside of the hull **10.** Then the pin and socket connections **41** and **42** may be released and the elevating mechanism **30** extended as shown in FIG. **5.** Then the lower leg section **15***b* may be pivoted upwardly, by displacing water in its ballast tanks, until it again assumes the horizontal or traveling position shown by the dotted lines in FIG. **5.**

Referring now to FIGS. **9** and **10,** suitable apparatus for retaining the lower leg sections **15***b* in the horizontal position will be described. The lower side of the hull **10** may be provided with bearing pads **51** and **52** against which the lower leg section **15***b* may bear. A transverse connection bar **53** may be welded between a pair of chord members **21***b* for engagement by a connection pin **55.** The connection pin **55,** which extends through the hull **10** may be provided with a handle **56** at its upper end and a cross bar **57** at its lower end. The cross bar **57** is designed to slide through an aperture or slot **58** in connection bar **53** until it is below the connection bar **53.** Then the pin **55** may be rotated **90°** by handle **56** until the cross bar **57** assumes a position substantially parallel to chord members **21***b*. A detent or depression (not shown) may be provided on the lower side of connection bar **53** to retain the cross bar **57** in this position. A jacking device **60** may be provided which, when actuated, causes the connection pin **55** to be moved upwardly applying an upwardly directed force to leg **15** through the cross bar **57.** Enough pressure is applied through the jacking device **60** to firmly hold the leg **15***b* against the bearing pads **51** and **52** for travel from place to place. To release the legs the jacking device **60** is reversed until the pin member **55** is free to turn 90° to its original position, allowing the cross bar **57** to disengage apertures **58.**

Horizontal restraint is necessary between the hull **10** and the submerged, horizontal leg portion **15***b* during ocean tow, in order to resist rough seas. This may be provided by proper design of at least one of the bearing pads, **51** in the illustrated case. The pad **51** is provided with a tapered groove **51***a* for engagement by a correspondingly tapered registration member **51***b* welded to leg section **15***b*. This also assists in "stabbing" the legs in position when moving to the horizontal position.

Thus, with the folding leg design of the present invention the center of gravity of a jack-up rig can be greatly reduced. This results in much greater stability during ocean tow and particularly during storm conditions. Furthermore, it is done without removal and reattachment of an upper portion of the leg as has been done in the prior art. The connection of the upper and lower leg sections of the present invention is made at a point where stresses are less critical than in cases where the leg is separated and reattached as in the prior art. In addition, this connection is provided with redundancy in the elevator device. The particular pivot and elevator device design of the present invention allows conventional leg raising and lowering apparatus to be used without alteration, allowing the leg chords to pass through leg guides and racking mechanisms. Also the racking mechanism can be operated above the waterline. The upper and lower leg sections can also be connected above the waterline by elevating the legs before inserting the pins to secure the pin and socket connection.

Although only one preferred embodiment of the invention has been described herein, it is obvious that many variations may be made by those skilled in the art. It is therefore intended that the scope of the invention be limited only by the claims which follow.

I claim:

**1.** An offshore work platform comprising:

a. a floating hull on which is carried a working deck and associated apparatus;

b. a plurality of legs attached to said hull and vertically movable from a raised position, supported by said hull, to a lowered position engaging the floor of a body of water, in which said hull is supported on said legs;

c. means for moving said legs from said raised position to said lowered position and for elevating said hull above said body of water; and

d. each of said legs comprising an upper section and a lower section, said lower section being pivotally connected to said upper section for arcurate movement from a position depending downwardly from said hull to a horizontal position underneath said hull for carriage during water travel, each of said legs being provided with positioning means for moving said lower leg section between said downwardly depending position and said horizontal position underneath said hull.

**2.** An offshore work platform as set forth in claim **1** in which said positioning means comprises ballast means including tanks carried by said lower leg section.

**3.** An offshore work platform as set forth in claim **1** comprising fastening means on said upper and lower leg sections for rigidly fastening said leg sections together when said lower section is in said downwardly depending position.

**4.** An offshore work platform comprising:

a. a floating hull on which is carried a working deck and associated apparatus;

b. a plurality of legs attached to said hull and vertically movable from a raised position, supported by said hull, to a lowered position engaging the floor of a body of water, in which said hull is supported on said legs, each of said legs comprising an upper section and a lower section, said lower section being pivotally connected to said upper section for arcuate movement from a position depending downwardly from said hull to a horizontal position underneath said hull for carriage during water travel, said lower leg section being adapted for limited longitudinal movement relative to said upper section, in said downwardly depending position, between a non-fastened position and a fastened position;

c. fastening means on said upper and lower leg sections for rigidly fastening said leg sections together when said lower section is in said downwardly depending fastened position; and

d. means for moving said legs from said raised position to said lowered position and for elevating said hull above said body of water.

**5.** An offshore work platform as set forth in claim **4** comprising elevator means connected to said upper and lower leg section for moving said lower section from said non-fastened position to said fastened position.

**6.** An offshore work platform as set forth in claim **3** comprising elevator means connected to said upper and lower leg section for forcibly aligning said sections to permit said fastening by said fastening means.

**7.** An offshore work platform as set forth in claim **6** in which said elevator means comprises a stationary portion affixed to said upper leg section operatively engaging a longitudinally movable portion affixed to said lower leg section.

**8.** An offshore work platform as set forth in claim **7** in which said elevator means comprises rack and pinion apparatus.

**9.** An offshore work platform as set forth in claim **7** in which said elevator means comprises a power screw device.

**10.** An offshore drilling unit of the self-elevating platform type having a floating hull and a plurality of legs movable from a raised position, in which said legs are supported by said floating hull, to a lowered position engaging the floor of a body of water, in which said hull is supported on said legs, characterized in that said legs are of articulated construction permitting a first portion of each leg, when in said raised position, to swing from longitudinal alignment with a second portion of the leg to a horizontal position underneath said hull for carriage during water travel, said first portion of said leg being attached to said second portion in rigid longitudinal alignment therewith by pivot means and disengageable fastening means, disengagement of said fastening means permitting said lower portion to swing about said pivot means, when in said raised position, between said longitudinal alignment and said horizontal position underneath said hull; positioning means being provided with each of said legs for moving said first leg portion between said longitudinal alignment and said horizontal position underneath said hull.

**11.** An offshore drilling unit as set forth in claim **10** in which said positioning means comprises ballast means including tanks carried by said first leg portion.

**12.** An offshore drilling unit as set forth in claim **11** comprising retainer means on said first leg portion and said hull engageable to retain said first leg in said horizontal position.

**13.** An offshore drilling unit of the self-elevating platform type having a floating hull and a plurality of legs movable from a raised position, in which said legs are supported by said floating hull, to a lowered position engaging the floor of a body of water, in which said hull is supported on said legs; characterized in that said legs comprise articulated first and second portions connected by pivot means allowing said first portion, when in said raised position, to swing from longitudinal alignment with said second portion to a horizontal position underneath said hull for carriage during water travel, said first and second portions of said leg being attached in rigid longitudinal alignment by disengageable fastening means, disengagement of said fastening means permitting said first portion to swing about said pivot means, when in said raised position, between said longitudinal alignment and said horizontal position underneath said hull, elevator means being connected to said first and second leg portions for moving said fastening means into engagement.

**14.** An offshore drilling unit as set forth in claim **13** in which said first leg portion is adapted for limited longitudinal movement by said elevator means when in said longitudinal alignment with said second leg portion.

**15.** An offshore drilling unit as set forth in claim **14** in which said fastening means comprises pin means on one of said leg portions and a socket means on the other, said pin means being telescopically received by said socket means on said engagement of said fastening means.

**16.** An offshore drilling unit as set forth in claim **14** in which said pivot means comprises link means pivotally connected at one end to said elevator means and at the opposite end to one of said leg portions.

**17.** An offshore drilling unit as set forth in claim **16** in which said leg portions comprise longitudinal chord members, said fastening means comprising pins at the ends of the chord members of one of said leg portions and sockets at the ends of the chord members of the other of said leg members, said limited longitudinal movement of said first leg portion by said elevator means effecting the engagement of said pins and sockets for said rigid longitudinal alignment.

* * * * *

# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,826,099 Dated July 30, 1974

Inventor(s) Peter M. Lovie

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 49, please delete "11" and insert therefor -- 10 --.

Signed and sealed this 19th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
★ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.