Feb. 6, 1968 C. A. RYBICKI 3,367,119

FLOTATION DEVICE FOR OFFSHORE PLATFORM ASSEMBLY

Filed Jan. 20, 1966 4 Sheets-Sheet 1

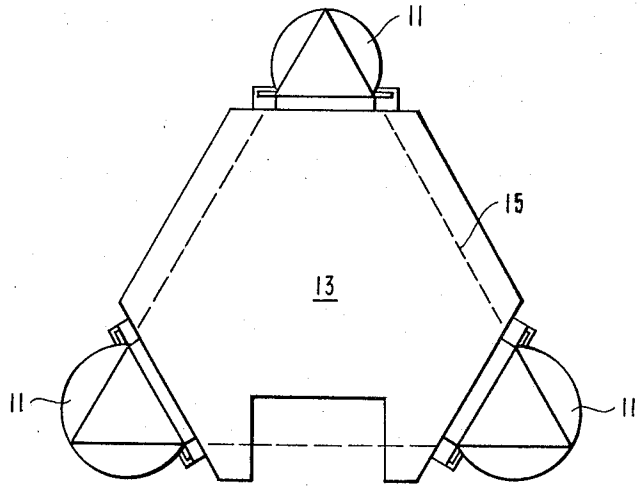


FIG. 1

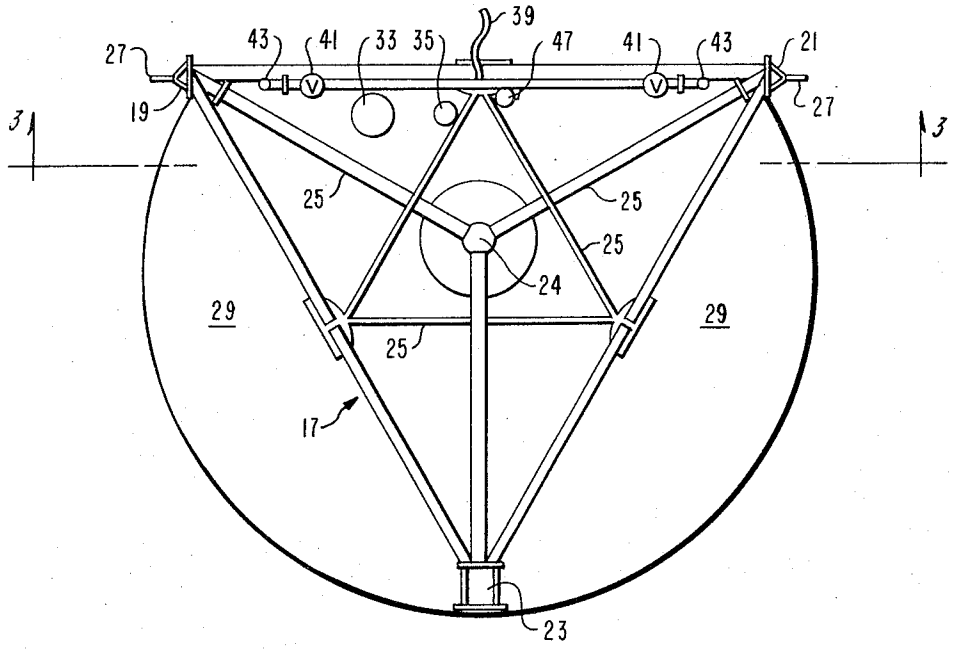


FIG. 2

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FLOTATION DEVICE FOR OFFSHORE PLATFORM ASSEMBLY

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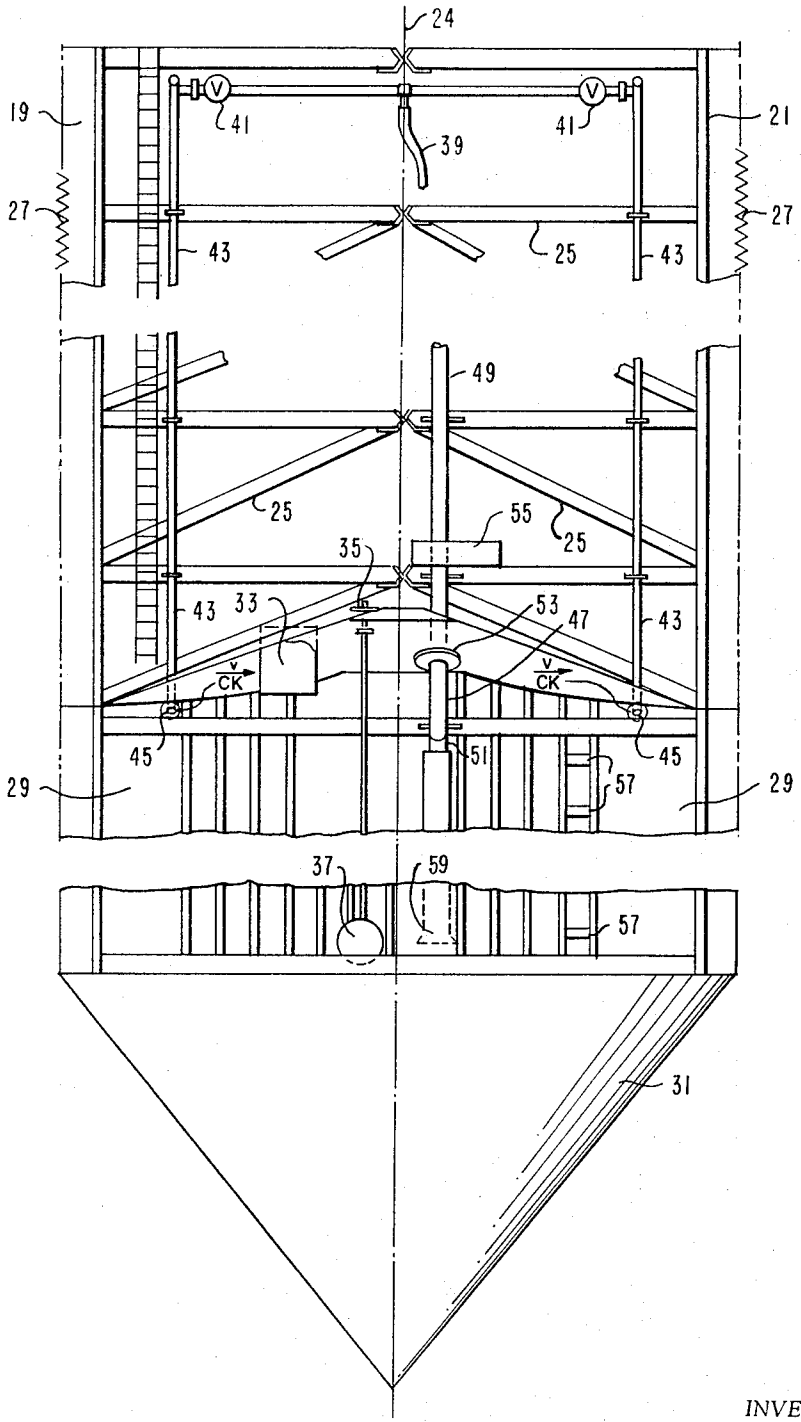


FIG. 3

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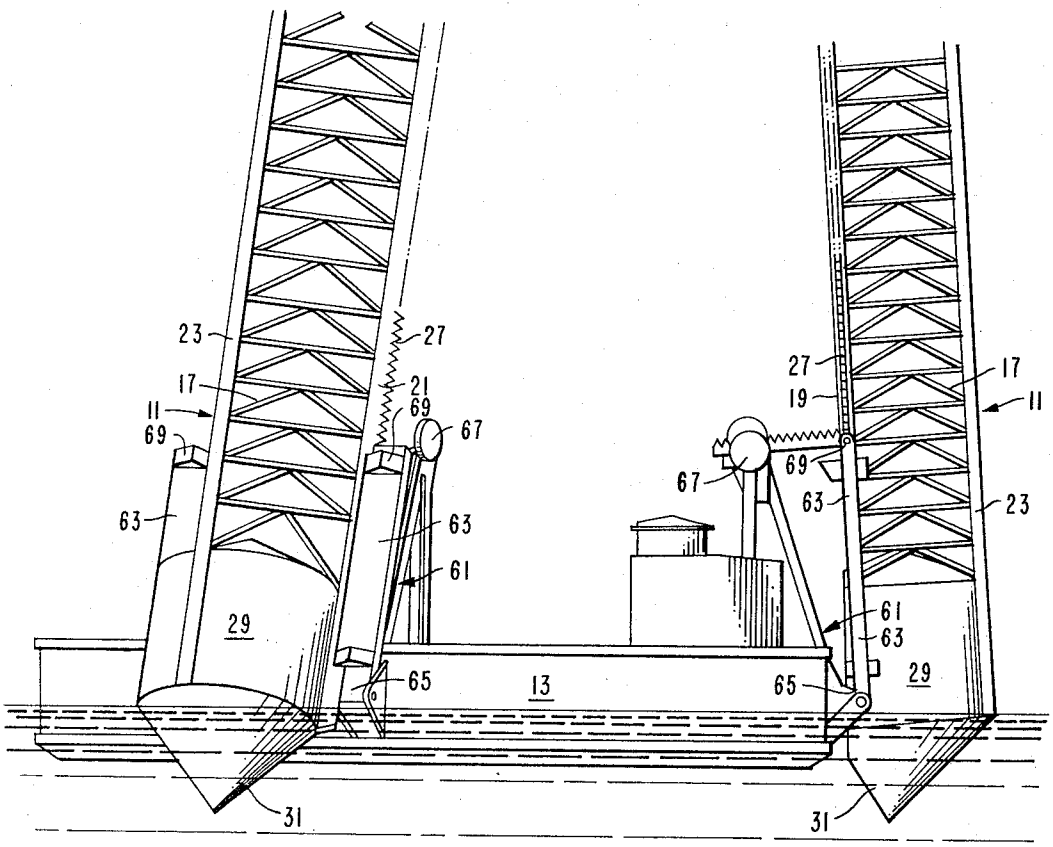


FIG. 4

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FLOTATION DEVICE FOR OFFSHORE PLATFORM ASSEMBLY

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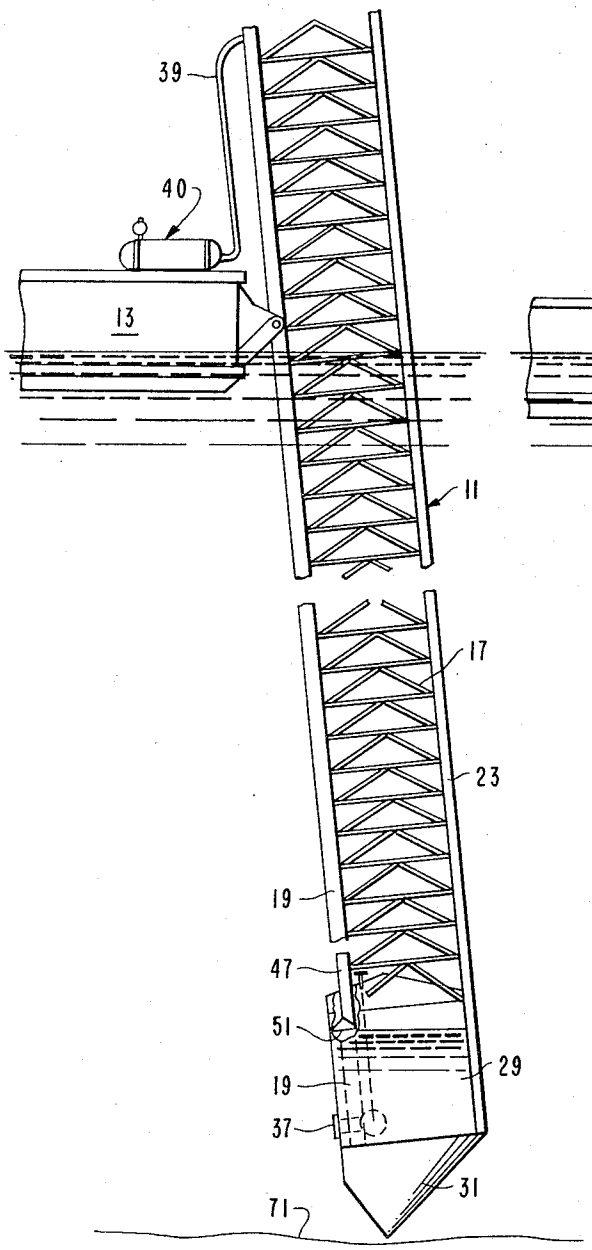


FIG. 5

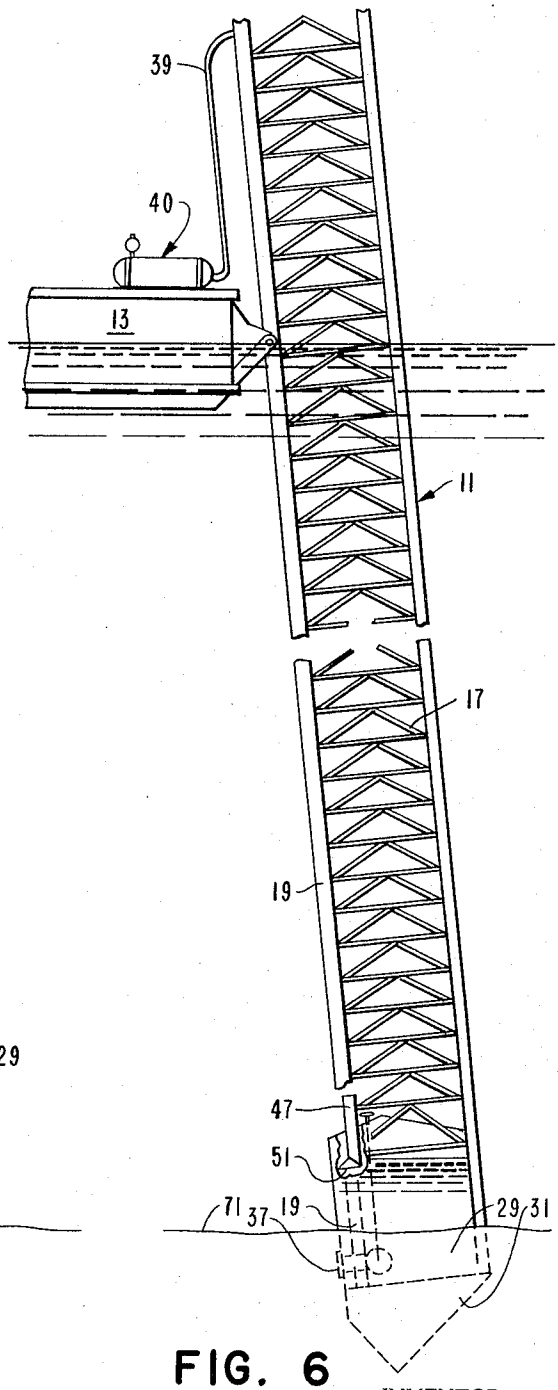


FIG. 6

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United States Patent Office 3,367,119
Patented Feb. 6, 1968

3,367,119

FLOTATION DEVICE FOR OFFSHORE PLATFORM ASSEMBLY

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Filed Jan. 20, 1966, Ser. No. 528,329
7 Claims. (Cl. 61—46.5)

ABSTRACT OF THE DISCLOSURE

An offshore platform assembly comprises a platform and a plurality of depending legs, means connected to the platform and the legs to adjustably position the legs vertically and laterally relative to the platform, wherein each of the legs comprises a rigid frame structure having a submersible lower portion and wherein at least one of the legs includes a closed chamber disposed in the submersible portion of the frame with means for opening the chamber to allow the entry of water and an adjustable standpipe communicating with the exterior of the chamber and extending to a predetermined level within the chamber whereby the amount of air and water within the chamber may be automatically and adjustably controlled.

The present invention generally relates to offshore platform assemblies which are adapted to be erected in a body of water, and more particularly relates to portable offshore platform assemblies having adjustable legs which can be lowered to erect and support the platform thereof over a body of water and which can be raised for transit of the platform.

Various conventional offshore platforms heretofore have been provided for such purposes as offshore oil drilling operations, mining operations and the like. Such platforms usually are towed to a desired location by a barge, after which they are secured in place, as by legs, anchors, etc. In some instances, the platforms are supported above the water level by a plurality of legs. The legs are connected to the platform and set into the floor beneath the body of water, after which the platform is jacked up or otherwise raised to a level above the surface of the water, whereupon an operation such as offshore drilling is commenced. When it is desired to relocate the platform, the platform is lowered into the water, the legs are withdrawn from the floor and raised, and the platform and legs are towed to a new location.

One of the most difficult problems encountered in erecting an offshore platform assembly is that of lowering the legs and properly positioning them before embedding them into the ocean, lake or sea floor. The legs are unually extremely long, for example, several hundred feet long, because of the substantial depths of water which are frequently encountered at locations where the platform is to be erected. Also, the legs are usually relatively heavy because of the heavy-duty construction necessary to support the platform and all of the equipment on it, such as a derrick in the case of oil drilling operations. Strong currents and tides and occasional severe storms place additional strength requirements on the legs. The heavy legs incur "dead-weight" moments which frequently result in damage to the legs, such as buckling, and/or damage to the means connecting the legs to the platform. Such damage results in considerable loss of time and money and may necessitate towing the platform to shore in order to effect necessary repairs.

Because of the relatively great length of the legs with respect to the overall dimensions of the platform, the legs are often positioned outward from the platform at a small angle from the vertical to provide a larger foundation area for the erected platform.

It is therefore an object of this invention to provide an improved offshore assembly which includes improved supporting legs.

It is a further object of this invention to provide an improved offshore assembly which includes one or more legs adapted to minimize undesirable blending forces exertable on the leg during installation of the assembly.

It is a still further object of this invention to provide an improved drilling rig platform assembly which incorporates a plurality of legs adapted to reduce the apparent weight thereof and stresses thereon during installation of the assembly.

The foregoing and other objects are accomplished, in accordance with the invention, by providing an improved platform assembly which includes a plurality of depending legs adjustably mounted to a platform in a manner so that they can be lowered into a body of water and can be positioned vertically and laterally. At least one of the legs and preferably all of the legs include improved components adapted to reduce the apparent weight thereof and minimize the bending forces.

The improved components of the leg(s) comprise a closed container, the interior of which defines a closed, water-tight chamber. The container is mounted adjacent the lower end of the leg and is adapted to provide the leg with a sufficient amount of buoyancy to reduce, at least partially, the effect of bending forces created by the deadweight of the leg as it is lowered in the water. For this purpose, the container is equipped with means for admitting water to and expelling water from the chamber to a predetermined level.

As a specific example, an offshore drilling rig platform assembly has been provided for oil drilling operations in the North Sea. The assembly includes a horizontal platform which is massive, in generally hexagonal configuration, with an inset docking area. Its major diameter is 175 feet, and its minor diameter is 164 feet. At three approximately equally spaced points on the exterior of the platform are pivotally connected, adjustable, vertically extending legs, each of which has an overall length of about 400 feet and a weight of about 1,750,000 pounds, of which 500,000 pounds is a flotation can, and the remainder is structural tubing, etc. Each leg is generally equilaterally triangular in cross-section, with a length per side of about 38 feet, and with the flotation can disposed at the lower end thereof and configured to provide a wedge-shaped lower terminus for embedding the leg in the sea floor. The can has an overall length of about 75 feet and is of suitable cross-section to conform generally to the size and shape of the leg.

The can is provided with a standpipe utilized in combination with other components to establish, upon demand, a predetermined volume of air within the can. The standpipe is mounted in the can with an upper portion extending outside the can and a lower portion within the can and adjacent the vertical side of the can which is closest to the platform so as to maximize the air volume in the can when the portion of the leg below the platform is inclined away from the platform at an angle from the vertical. A pair of valves and air lines are provided so that the water level in the can can be established at the bottom end of the lower portion of the standpipe. By passing air below this level to the outside of the can, the standpipe serves to define a maximum volume of air which may be established within the can. By positioning the standpipe close to the wall of the leg frame adjacent the platform, the volume of air which can be stored in the can varies, depending upon the amount of inclination of the leg, a greater inclination of the leg permitting a greater volume of air to be stored in the can, thereby automatically compensating for increased bending moment and stress which

is likely to result from the increased inclination of the leg during lowering of the leg.

It will also be understood that the maximum volume of water which may be established in the can can also be regulated by making the standpipe vertically and/or horizontally adjustable. Thus, it can be positioned at a preselected level and/or distance from the side of the can closest to the platform. Alternatively, level-sensing devices can be located at various levels within the can. Such level-sensing devices can be connected to a servo system which adjusts the pressure of the air supply to establish and maintain the water at a chosen level. In this manner by the buoyancy provided by the can may be adjusted for various depths and leg angle conditions, etc.

Further objects and advantages of the invention will be apparent from a study of the following detailed description and the accompanying drawings, of which:

FIGURE 1 is a schematic top plan view of an offshore platform assembly in accordance with the invention showing three legs adjustably connected to the platform;

FIGURE 2 is a detailed schematic top plan view of a leg of FIG. 1;

FIGURE 3 is a partial section of the leg of FIG. 2 taken along the section line 3—3 of FIG. 2;

FIGURE 4 is a schematic side elevation of the platform of FIG. 1 showing the legs in a raised position;

FIGURE 5 is a schematic side elevation showing a portion of the platform and a leg in a lowered position; and

FIGURE 6 is a schematic side elevation showing the legs embedded in the floor beneath a body of water.

Referring, more particularly, to FIG. 1 an offshore platform assembly **9** having three generally vertically extending legs **11** is schematically illustrated. The legs **11** are mounted on a generally horizontal extending platform **13**, the top surface of which may be used to support equipment such as a drilling derrick. It will be understood that the platform **13** may be supported by any number of legs **11** and that the legs **11** are usually generally uniformly spaced apart and disposed adjacent the periphery of the platform **13**. The platform **13** and legs **11** may be of any suitable size and shape and construction. In FIG. 1, the platform **13**, schematically illustrated, is generally hexagonal in shape with each of the legs **11** generally triangular in cross-sectionand located at a given side of the platform and positioned, relative to one another, at the corner of an equilateral triangle (shown partially in dotted outline). With the lower part of each of the legs **11** inclined outwardly from the platform **13** when in an installed position, the symmetrical arrangement of FIG. 1 affords considerable rigidity and resistance in a number of directions against bending forces.

FIGS. 2 and 3 schematically show details of one of the legs **11** of FIG. 1. Thus, the leg **11**, as shown in FIGS. 2 and 3, comprises a rigid, elongated frame **17** fabricated of a plurality of steel members, including three elongated generally vertically disposed beams **19**, **21** and **23** which are symmetrically arranged about a central axis. The beams **19**, **21** and **23** are joined together and maintained in triangular array by a plurality of interconnected cross-braces **25** of various sizes and shapes. The beams **19** and **21** are configured with the outer edges having a plurality of teeth **27** which are engaged by a geared mounting assembly (schematically shown in FIG. 4) connected to the edge of the platform **13** and adapted to adjustably position the leg and allow it to pivot for inclination of the leg at a desired low angle from the vertical. It will be understood that any suitable mounting mechanism can be employed to accomplish the intended purposes, including conventional devices. The precise construction of such mechanism does not form part of the present invention.

Of more importance, as shown in FIG. 4, a closed can **29** of substantially circular cross-section and having a wedge-shaped bottom end **31** adapted to be driven into the floor is mounted at the bottom end of the frame **17**. The interior of the can **29** defines a closed, water-tight chamber.

A manhole assembly **33** provides access to the interior of the can **29** for inspection and repairs when the leg **11** is raised out of the water. As shown in FIGS. 2 and 3, a valve handle **35** opens and closes a flooding valve **37** in the can **29** to admit water into the can. The flooding valve **37** is opened before the leg **11** is lowered into the water so that the can **29** may fill with water as the leg is lowered. When the platform assembly is to be relocated, the flooding valve **37** is opened upon raising the leg **11** out of the water in order to empty the can **29**, thereby reducing the weight of the leg for transit purposes.

An air hose **39** is connected between a compressor **40** on the platform **13** and a pair of manifold valves **41** located at the top end of the leg **11**. The manifold valves **41** are, in turn, connected to a pair of air lines **43** which terminate in a pair of check valves **45** inside the can **29**. The manifold valves **41** are normally open so that when the compressor **40** is operating, pressurized air flows through the air lines **43** and into the can **29**. Since the flooding valve **37** is opened before the leg **11** is lowered, the pressurized air is pumped into the can **29** as the leg is lowered to establish the desired buoyancy. Should trouble develop in one of the air lines **43** while the leg **11** is submerged, the manifold valve **41** associated with the faulty line may be closed to isolate the faulty line.

A standpipe **47** is mounted in the top of the can **29** with an upper portion **49** communicating with the outside of the can and a lower portion **51** extending inside the can. With water flowing into the can **29** through the opened flooding valve **37** and pressurized air flowing into the can through the check valves **45**, the level of water in the can will rise to the open bottom end of the lower portion **51** of the standpipe **47**. If the water level is below the lower portion **51**, the air in the space between the upper surface of the water in the can **29** and the bottom of the lower portion **51** of the standpipe **47** will escape up the standpipe **47** and out the upper end thereof, thus permitting the water level in the can **29** to rise until it reaches the lower portion **51** at which point it cuts off the outflow of air and the level of water in the can is stabilized. In this manner the position of the sandpipe **47** determines the maximum volume of air which may be established in the can **29**.

In one embodiment of the invention, as shown in FIG. 3, the standpipe **47** is secured to the top of the can **29** through a flexible, water-tight seal **53** which enables the standpipe to be raised or lowered by a gearing mechanism **55** which is remotely controlled from the platform **13**. By raising and lowering the standpipe **47**, the relative maximum quantities of water and air in the can may be varied so as to change the buoyancy of the leg **11** and thereby compensate for different depths and angles of the leg in the sea.

The standpipe **47** is mounted adjacent the flat wall of the can **29**, as shown in FIG. 2, i.e. the wall adjacent the platform. If the leg is inclined at a small angle with respect to the vertical during the lowering process so that the lower portion extends away from the platform, a greater volume of air can be established within the can **29**, as shown in FIG. 5, in contrast to when the leg **11** is held vertical, since the water level in the leg can **29** is determined by the actual location of the bottom end of the lower portion **51** of the standpipe **47**. It has been found that the moment in the leg **11** tends to increase as the angle of the leg **11** increases with respect to the vertical. Therefore, the standpipe **47** automatically compensates for changes in the angle of inclination of the leg **11**, while without having to move the standpipe **47**.

In one embodiment of the invention, as shown in FIG. 3, a plurality of level sensing devices **57** are mounted at different levels on the inside surface of the can **29** and are connected through a conventional servo system (not shown) to the air compressor **40** on the platform **13**. The

level sensing devices **57** provide for the establishment of the water level in the can **29** at any one of a plurality of heights. In this regard, the standpipe **47** can be lowered to its lowest possible position **59** (shown in dotted outline in FIG. 3) near the bottom of the can **29**. The water level in the can **29** may then be raised to the desired height by feeding appropriate information into the servo system. Signals from the various water level sensing devices **57** activate the servo system to adjust the pressure of the air pumped into and/or withdrawn from the can **29** until the desired water level is reached, whereupon the servo system "null-balances" and the air pressure is held constant.

FIG. 4 shows the offshore platform assembly with the legs **11** in a raised position for transit. Each leg **11** is joined to the platform **13** by the geared mounting assembly **61** which includes a pair of pivotably mounted guides **63**. Each guide **63** has a slot which receives one of the beams **19, 21** and the associated plurality of teeth **27**. Gear arrangements mounted within the guides **63** engage the teeth **27** and raise or lower the legs **11** within the guides **63**. Each guide **63** is pivotally mounted to the platform **13** at its lower end **65** and pivotably mounted to an incline assembly **67** at its upper end **69**. The incline assembly **67** establishes the angle of inclination of the leg **11** by varying the angular position of the guides **63**.

FIGS. 5 and 6 show a leg **11** in lowered and installed positions, respectively. It will be noted that the leg **11** is inclined at a small angle with respect to the vertical to give the installed drilling platform assembly greater rigidity. While each leg **11** experiences considerable bending stress as it is being lowered, the greatest demands are placed on the legs **11** when they are in the lowered and fully inclined position of FIG. 5. Accordingly, the volume of air in the can **29** should be increased while the leg **11** is in this position, in order to minimize the bending moment experienced by the leg **11**. This is automatically accomplished, since the lower portion **51** of the standpipe **47** is positioned adjacent the lower side of the frame **17** when the leg **11** is inclined. Thus, the volume of air within the can **29** automatically increases as the angle of inclination of the leg **11** is increased, as shown in FIG. 5, the water level always remaining at the bottom of the lower portion **51** with full air pressure applied to the can.

When the leg **11** is properly positioned on the ocean floor **71**, the can bottom **31** and a portion of the can **29** are driven into the floor to seat the leg in position. The flow of pressurized air to the inside of the can **29** is terminated and the can is bled of air, allowing the can to completely fill with water and giving the leg **11** increased weight and stability. Thereupon, the platform **13** is jacked up above the surface of the water to avoid being buffeted by waves, etc., and the platform is then ready for use, e.g. drilling operations, etc. When it is desired to relocate the platform assembly, the compressor is turned on, establishing a volume of air in the can **29** and the leg **11** is then cranked up from the floor **71**. Air is maintained in the can **29** to reduce the task of raising the leg **11** and to minimize strain on the leg **11**.

Accordingly, an improved offshore platform assembly is provided which includes one or more legs capable of minimizing the bending forces thereon through the use of a floodable container adjacent the lower end thereof. The improved construction of the legs allows the apparent weight of the legs to be increased, as for embedding the leg in the sea floor, and also to be decreased to minimize stress on the legs during installation and also during removal from the sea floor. Other advantages are as set forth in the foregoing.

Although a specific arrangement of an offshore platform assembly in accordance with the invention has been described for the purpose of illustrating the manner in which the invention may be used to advantage, it will be appreciated that the invention is not limited thereto. Accordingly, any and all modifications, variations or equivalent arrangements falling within the scope of the annexed claims should be considered to be a part of the invention.

What is claimed is:

1. An offshore platform assembly comprising, in combination, a platform and a plurality of depending legs, means connected to said platform and said legs and adapted to adjustably position said legs vertically and laterally relative to said platform, each of the legs comprising a rigid frame structure having a lower portion capable of being submerged in a body of water, at least one of said legs including a closed chamber disposed in the submergible portion of the frame structure thereof, means for opening the chamber upon demand when submerged to allow water to center the chamber, and an adjustable standpipe communicating with the exterior of the chamber and also having a portion extending to a predetermined level within the chamber and wherein means are connected to the adjustable standpipe and operable at said platform to vary the level of the standpipe within the chamber, whereby the maximum volume of air which can be established within the chamber is adjustably controlled.

2. The offshore assembly of claim **1** wherein the platform is generally horizontally extending, wherein each of said legs includes at least one of said chambers, wherein said means for establishing a volume of air comprises means for injecting air under pressure into the chamber upon demand and said adjustable standpipe associated with said air injecting means and adapted to pass air below a given level in the chamber to the outside of the chamber, thereby defining a maximum volume of air which may be established within the chamber for a given angular position of the leg.

3. The offshore assembly of claim **2** wherein said standpipe is positioned adjacent the side of said leg nearest said platform, whereby the volume of air which can be established in the chamber automatically increases with an increase in the angle of inclination of said leg relative to said platform.

4. The offshore assembly of claim **3** wherein means are provided in said chamber, which means are sensitive to the water level in the chamber and are adapted to control the operation of the air injection means so as to establish a desired level of water in the chamber.

5. The offshore assembly of claim **4** wherein said assembly is a drilling rig platform assembly and wherein the chamber is located at the lower end of each leg and has a wedge-shaped bottom adapted to be embedded in the sea floor.

6. The offshore drilling rig platform assembly of claim **5** wherein there are three of said legs, each generally triangular in transverse cross-section and pivotally mounted in equidistant spaced relation along the periphery of said platform.

7. The offshore drilling rig platform assembly of claim **6** wherein each of said legs is mounted in geared relation on said platform, whereby said platform can be raised above the water level when said legs are embeded in the sea floor.

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JACOB SHAPIRO, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,367,119 February 6, 1968

Chester A. Rybicki

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

Column 2, line 6, "blending" should read -- bending --. Column 3, line 13, cancel "by", first occurrence. Column 4, line 4, "repairs" should read -- repair --; line 43, "sand-pipe" should read -- standpipe --. Column 6, line 17, "center" should read -- enter --; line 61, "embeded" should read -- embedded --. Column 11, line 52, "unually" should read -- usually --.

Signed and sealed this 7th day of October 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents