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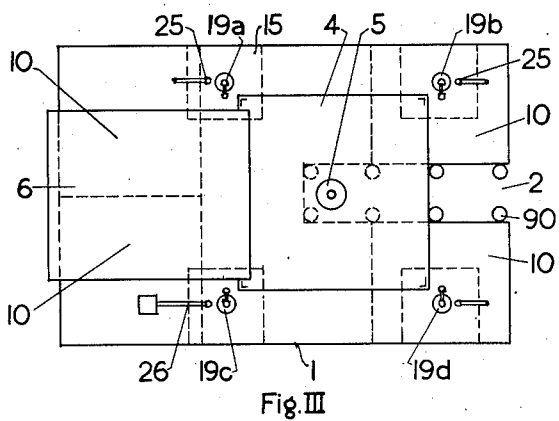
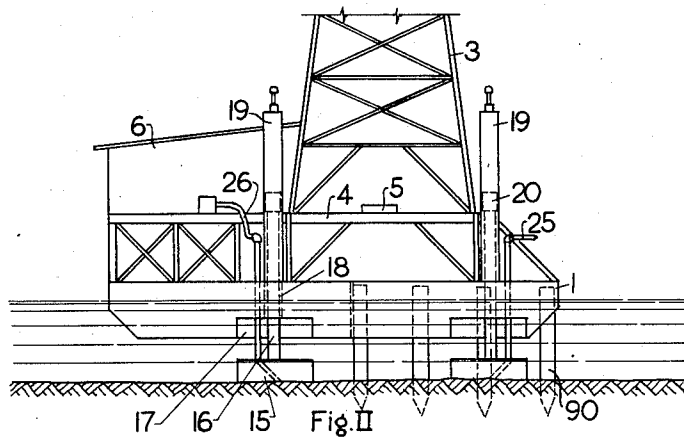
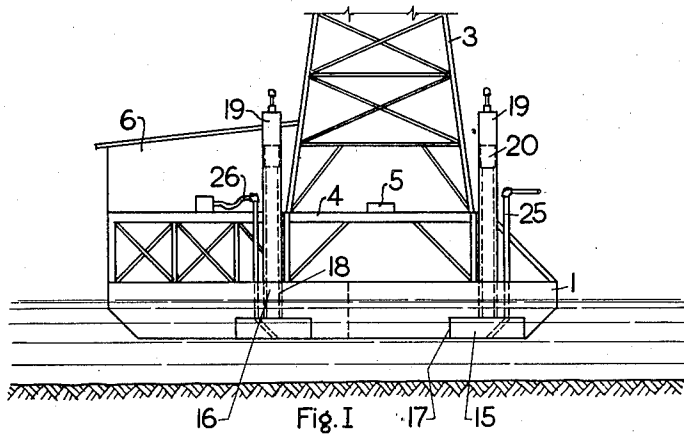
W. ST. M. E. CRAKE

2,334,992

FLOATING DRILLING BARGE

Filed Oct. 8, 1940

3 Sheets-Sheet 1



Inventor: Wilfred St. Maur Elmore Crake

By his Attorney: *[Signature]*

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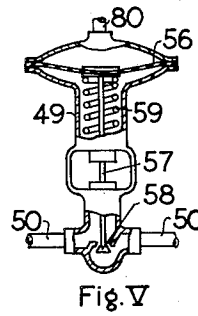
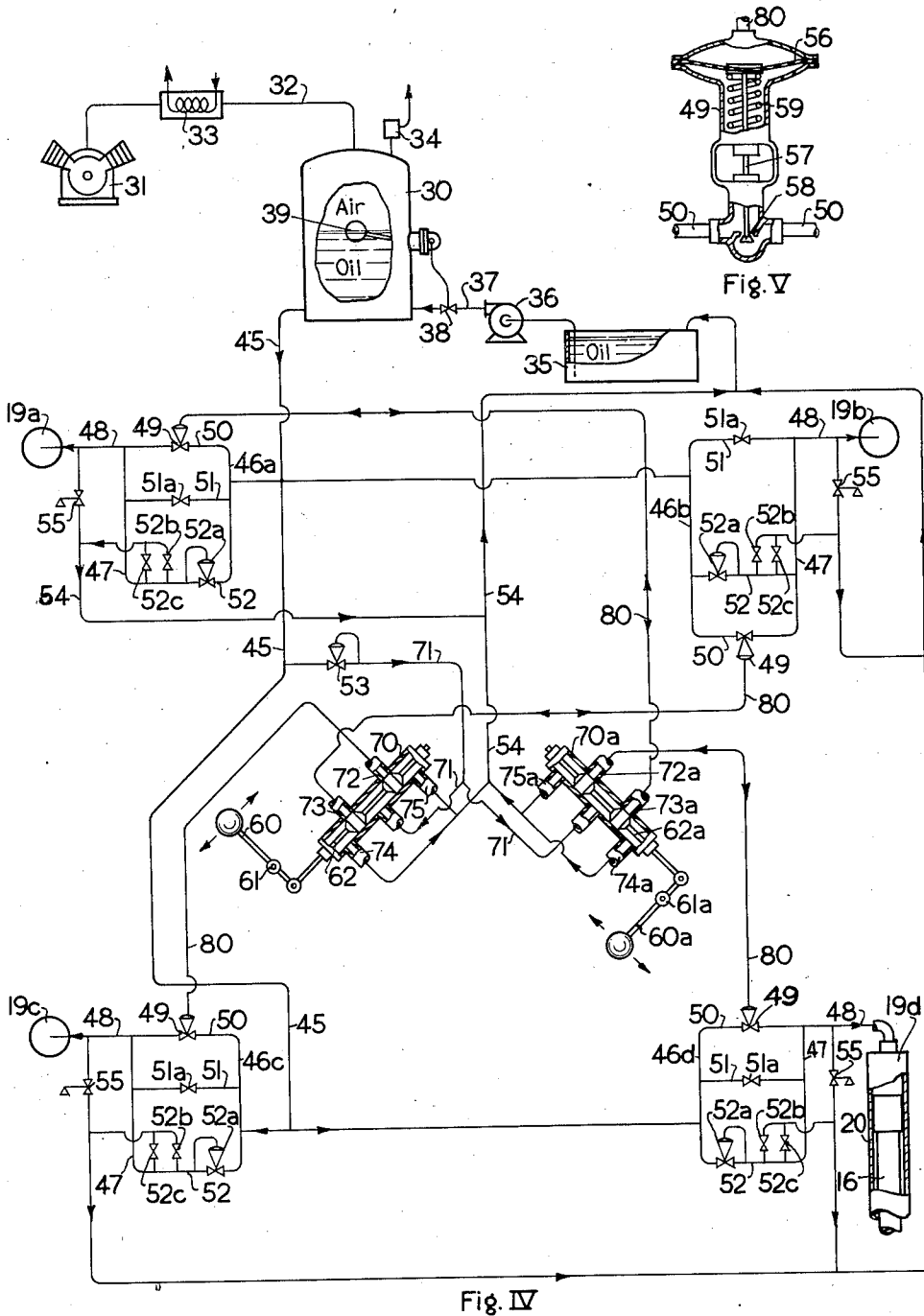
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3 Sheets-Sheet 2



Inventor: Wilfred St. Maur Elmore Crake

By his Attorney:

*W. St. Maur Elmore Crake*

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FLOATING DRILLING BARGE

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3 Sheets-Sheet 3

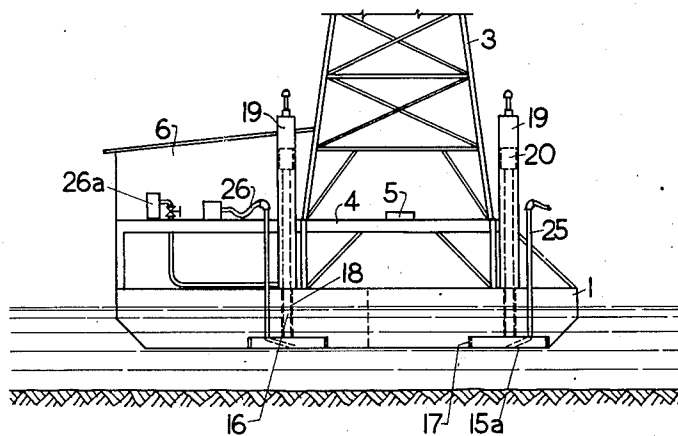


Fig. VI

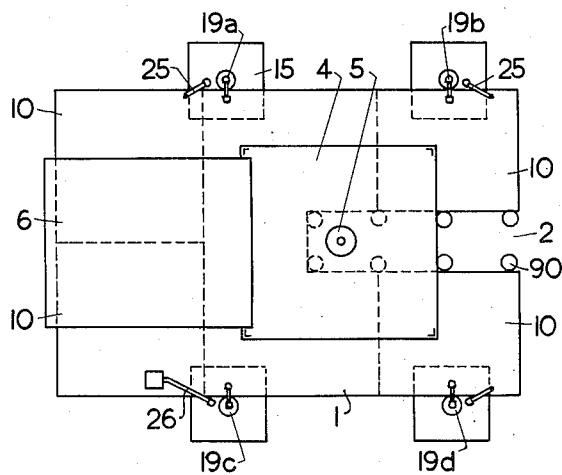


Fig. VII

Inventor: Wilfred St. Maur Elmore Crake

By his Attorney: 

## UNITED STATES PATENT OFFICE

2,334,992

## FLOATING DRILLING BARGE

Wilfred St. Maur Elmore Crake, Houston, Tex.,  
assignor to Shell Development Company, San  
Francisco, Calif., a corporation of Delaware

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7 Claims. (Cl. 61—46)

The present invention relates to methods and apparatus for drilling wells into ground submerged under water bodies, such as into formations beneath lakes, coastal swamps, marshes, etc., and pertains more particularly to improvement in the construction and use of floating drilling barges.

It is known to mount drilling equipment, such as drawworks, derrick, pump, etc., on barges, which may be floated to the desired location. However, when drilling is attempted from a floating barge, considerable difficulties are encountered due to rocking of the barge by wave action and to instability of the barge caused by eccentric loading of drilling operations, placement of materials, etc.

To overcome these difficulties, it has been proposed to use a barge which may be firmly grounded at the desired location by opening sea valves to the ballast tanks and sinking the barge hull to the bottom. The superstructure on the barge hull carries the derrick and necessary drilling equipment. These submersible barges are formed with a bay or open slot in the hull to permit the passage of the drill or casing string therethrough so that when the ballast tanks are emptied and the hull raised, the barge may be floated away from the well head to another location.

The normal barge hulls are 8 to 12 feet in height and have a draft of  $5\frac{1}{2}$  to 6 feet. In shallow marshes and swamps, canals about 6 $\frac{1}{2}$  feet deep are dug to allow the movement of the barges from one location to another.

However, when the water level varies to depths greater than about 12 feet, such as in some coastal swamps and lakes, the normal submersible drilling barges must be replaced by special barges of greater draft and height or must be supplemented with the necessary number of submersible foundation hulls.

In addition to the considerable expense in constructing these special submersible drilling barges, they have the drawback of being suitable only for drilling in deep water due to their greater draft, deeper channels being required to move these special barges to new locations over shallow marshes or swamps. Costly equipment thus becomes tied up and remains idle unless extensive drilling is being carried out at many points accessible to the special drilling barges.

It is, therefore, an object of this invention to overcome the disadvantages inherent to drilling with either floating barges or submersible barges by providing a floating drilling barge having ex-

tensible stabilizing shoes adapted to be rammed into contact with the bottom of a body of water.

It is another object to provide a floating barge having a stabilizing system to control out-of-balance or eccentric loads imposed on the barge.

It is a further object of the present invention to provide an automatically self-leveling floating barge.

Other objects will be apparent from the following description taken in reference to the drawings, wherein:

Figure I is a schematic elevation of a preferred embodiment of the present invention, showing the stabilizing shoes in retracted position.

Figure II is a view similar to Figure I, but showing the stabilizing shoes in extended operative position.

Figure III is a schematic plan view of the same embodiment.

Figure IV is a diagram of the automatic self-leveling control system of the present invention.

Figure V is a detailed view, partly in cross-section and partly in elevation, of a preferred type of diaphragm-controlled valve.

Figure VI is a schematic elevation of another embodiment of the present invention, showing the stabilizing shoes in the form of steel plates.

Figure VII is a schematic plan view of still another embodiment showing the hydraulic cylinders attached to the sides of the barge hull.

Briefly, the present invention comprises the usual barge having a bay or slotted opening in one side of the hull, stabilizing shoes spaced concentrically out from the normal center of gravity of the barge, which shoes comprise preferably buoyant tanks connected to vertical tubular rams thereabove, and hydraulic or other suitable means for operating said rams and extending said stabilizing shoes to the bottom. By applying a certain pressure in excess of that required to force the tanks to the bottom, the barge is caused to be partially supported by the rams and forced to rise in the water by an amount proportional to what may be called the artificial buoyancy due to said pressure. Thereby, the stabilizer rams cause the barge to be very stable and substantially unaffected by wave action and by eccentric loading, which forces cause normal full floating equipment to be unstable and difficult from which to operate.

Referring to Figures I, II and III of the drawings, a floating barge, generally designated as 1 is formed with an open drilling bay 2 through which the drilling and casing strings are lowered during the drilling operations and which allows

the hull to be floated away from the standing pipe after the completion of the well. The hull itself preferably comprises several water-tight compartments or ballast tanks 10, shown in Figure III by dotted lines, equipped with inlet and discharge valves so that the barge may be leveled when fully loaded and freely floating.

The barge is made of ample size and buoyancy to carry its superimposed load of full drilling equipment such as the derrick 3, derrick floor 4, rotary table 5, engine room 6 and its equipment, the subsequently-described stabilizing system, other auxiliaries and the full weight of drilling loads.

Suitably spaced in a horizontal plane about the normal center of gravity are preferably four or more stabilizing shoes comprising preferably buoyant tanks 15 which have grillage-type, corrugated steel bottom plates or other suitable load distributing foundation incorporated thereon, and are connected to tubular rams 16 at the top. Instead of buoyant tanks, the shoes may be formed of steel plates 15a as shown in Figure VI or the like, if desired. In retracted position, as shown in Figure I, the shoe tanks fit into recesses 17 in the bottom portion of the hull 1. Passageways 18 for the rams 16 are provided through the hull from the center of the recesses 17 to cylinders, generally designated as 19, and specifically 19a, 19b, 19c and 19d, on the deck thereof. If desired, however, the cylinders 19 may be attached to the sides of the barge hull and the stabilizer rams adapted for extension downward along the side of the barge, as shown in Figure VII. The upper end of each of the rams 16 is provided with a head 20 fitting closely and slidingly within its cylinder 19. In a preferred arrangement, the bore of the cylinder 19 and the diameter of the ram head 20 are slightly larger than the rest of the ram 16 and the bore of the passageway 18 through the hull, so that the shoulder formed thereby between the cylinder 19 and the passageway 18 will act as a stop limiting the downward travel of the stabilizing shoe. The stabilizing shoes may also be provided with suction breakers, for example, in the form of down-pipes 25 extending from the deck of the barge and terminating on the under side of the tanks 15. These down-pipes 25 are provided with suitable connections 26 at their upper ends and means associated therewith adapted to permit injection of air or water to underneath the tanks 15 in order to break the suction created between the tanks 15 and the lake bottom when the tanks are raised.

To provide for the extension or lowering of the stabilizing shoes, shown extended in Figure II, the upper end of each of the cylinders 19 is connected through suitable conduits to a source of fluid pressure in the stabilizer control system. In a preferred embodiment of the control system, as diagrammatically illustrated in Figure IV, the source of pressure fluid comprises, for example, a hydropneumatic tank 30 into which air is forced from the air compressor 31 through a line 32 fitted with a cooler 33. The tank 30 may be provided with a weighted relief valve 34 for release of excess pressure. Oil, or any other suitable liquid medium, from a reservoir 35 is forced into the tank 30 by means of a pump 36 through line 37 equipped with a valve 38 controlled by a float 39 in the tank 30, whereby the oil therein is maintained at an approximately constant level.

A high pressure oil line 45 leads from the tank 75

30 to the valve headers 46a, 46b, 46c and 46d provided respectively for cylinders 19a, 19b, 19c and 19d, of which cylinder 19d is shown in elevation for the purpose of illustrating the invention more clearly. To each header 46 (as shown with regard to header 46a) there are connected preferably three valved lines 50, 51, and 52, the other ends of which are connected to another valve header 47 which communicates with the cylinder 19 through line 48. Line 51 is provided with a manually-controlled valve 51a. Line 52 is fitted with a reducing valve 52a and branch lines comprising respectively a constant leak valve 52b and an auxiliary manual valve 52c, which discharge to an exhaust line 54. Line 50 contains a diaphragm motor valve 49, which is adapted to open when pressure is applied to one side of its diaphragm. A preferred form of valve 49 is shown in detail in Figure V and comprises diaphragm 56 connected to the valve 58 by means of valve stem 57 and a spring 59 acting against the lower side of the diaphragm and tending to close the valve 58. Referring again to Figure IV, line 48 from the header 47 to the cylinder 19 is fitted with a weighted relief 55 which discharges to the exhaust line 54, which in turn leads to the reservoir 35.

The diaphragm motor valves 49 are actuated by any suitable level-responsive mechanism, such as a pair of pendulum-operated "servo-motor" valves at right angles to each other, as illustrated in Figure IV, numerical characteristics designating the various parts of one of said valves and like parts in the other valve having the same numerical characteristic followed by the letter "a". In each of said mechanisms a pendulum 60 or 60a is free to oscillate in a vertical plane at right angles to the vertical plane in which the other pendulum oscillates, or, in other words, in a direction indicated by the arrows, it being understood that in Figure IV the pendulums are shown in elevation merely for purposes of illustration. Each pendulum oscillates in a vertical plane parallel, or approximately parallel, to that of a line joining the two diagonally opposite cylinders operated by that pendulum. For example, pendulum 60 swings in a vertical plane parallel to the line joining cylinders 19-b and 19-c, the motor valves 49 for which are controlled by the servo-motor valve 62 operated by pendulum 60. The arm of the pendulum 60 is provided with a pivot 61 and is pivotably connected at a point spaced from said pivot 61 to valve 62, which is housed in a casing 70 and is actuated by said pendulum 60. The valve 62 controls the application of pressure liquid from line 71, which communicates with pressure fluid distributing line 48, to either one of the motor valves 49 by means of control lines 80, and also controls the exhaust pressure liquid from the diaphragms, thus causing the motor valves to open and close. Opening a motor valve 49 allows pressure liquid to pass from lines 50 to the adjacent cylinder 19, thus applying pressure to a ram 16 and thereby leveling the barge. The arrangement of the valve mechanism is such that when one of the ports 72 or 73 is connected by the valve 62 with the high-pressure line 71, the other port is connected by the same valve 62 with the exhaust-collecting line 54 through ports 74 or 75. A reducing valve 53 in line 71 is provided to reduce the fluid passing therethrough to a suitable pressure.

In operation, a drilling barge, according to the present invention, is brought into position over the desired location by bringing the slotted por-

tion or bay 2 over guide piling 90 previously driven into the bottom of the water body, as shown in Figure III. Ballast tanks 10 at each corner of the barge are filled or emptied to level the barge when floating free with the stabilizer shoes retracted, as shown in Figure I.

The rams 16 and tanks 15 are then forced downwards into extended position, as shown in Figure II, by admission of oil pressure to the top of the cylinders 19 through valve 51a. The stabilizers are forced to bed themselves firmly on the bottom by application of pressure in excess of that necessary to sink the tanks 15. The pressures in the cylinders 19 are then all equalized or the barge leveled by adjusting the reducing valves 52a. These reducing valves 52a are adapted to be set to maintain any predetermined minimum pressure in the ram cylinders 19. The constant leak valves 52b relieve any oil from the cylinder 19 which may leak past said reducing valves 52a such as, for example, when less than the normal load is being applied to the cylinder due to waves, eccentric loading, etc., or by leaky valves. By means of these leak valves 52b, the barge may be kept fully floating or as nearly so as desired, irrespective of tidal changes, etc. The relief valve 55 communicating with each cylinder 19 is set to relieve overloads on the cylinders caused by large waves and tidal changes or suddenly applied eccentric or concentric loads, which cannot be rapidly enough relieved through leak valve 52b.

Upon loading the barge eccentrically, the pressure rises in each of the cylinders 19 by amounts depending upon the position of the load. This impresses a back pressure on the reducing valves 52a and causes them to close, whereby the eccentric load is applied to the fluid until it bleeds off through the constant leak valve 52b or by relief through valves 55 if of serious magnitude. This releasing action, however, requires some appreciable time so that normal wave motion will not cause deflection of the barge position. Suddenly applied loads due to setting drill pipe in slips, acceleration or deceleration of drill pipe, etc., will, therefore, not immediately affect the barge position.

It can be seen that the greatest out-of-balance force to be controlled, after balancing the barge with its normal dead load, is the weight of a string of drill pipe set back in the derrick plus wind, and this weight, being mainly concentrated close to the rotary table, may be balanced by a very much smaller upward force exerted near the outside edges of the barge by the stabilizers.

Self-leveling of the barge to compensate for the eccentric loading is obtained by the operation of the pendulum-actuated mechanisms which are positioned at right angles to each other so that the force vector of a dip in any direction resolves itself into two components in the pendulums 60 and 60a oscillating in two vertical planes at right angles to each other. Upon application of an eccentric load, the barge will gradually lean toward that direction from the center of gravity of the barge in which the eccentric load is placed as the oil leaks out through the constant leak valves 52b from the more heavily loaded ram cylinders 19 and as pressure fluid enters the more lightly loaded ram cylinders through the reducing valves 52a. Assume for the purposes of illustration and for simplicity's sake that the eccentric load is applied on the middle of one side, for instance half-way between the cylinder 19a and 19c, so that both pendulums 60 and 60a swing toward this side. As pendulum 60 swings toward cylinder

19c, the valve 62 is actuated so that port 72 is opened for application of pressure fluid from line 71 through the valve casing 70, port 72, and line 80 to the diaphragm 56 of the motor valve 49 adjacent cylinder 19c, whereby said motor valve 49 is opened and pressure fluid enters cylinder 19c from line 50 and raises this corner of the barge until restoration of level causes the motor valve to close. At the same time, pendulum 60a swings toward cylinder 19a, and in a similar manner the valve 62a is operated thereby to open the motor valve 49 of cylinder 19a and permit ingress of pressure fluid from line 50 to this cylinder until the proper level is restored. This motion will be self-compensating since, as level is restored, the constant leak valves 52b permit continual sinking of the barge in the direction of the eccentric load, the reducing valves 52a cause a minimum pressure to be maintained in each of the cylinders, and the pendulum-operated motor valves continually cancel sinking in any direction and bring the barge back to level.

When it is desired to move the drilling barge of the present invention, the stabilizer rams and shoes are raised by releasing the pressure in the cylinders 19 and allowing the buoyancy of the tanks 15 in the preferred type shoes to raise the rams 16 in the cylinder and the tanks into the recesses 17. However, when, as shown in Figure VI, the stabilizer shoes are formed of steel plates, suitable hydraulic means 26a or the like may be provided to act against the underside of the ram head 20 in order to raise the rams mechanically. After moving the barge away from the well head through the bay 2 provided therefor, the barge may be floated to any desired location.

A floating barge constructed according to the present invention affords many advantages over other methods of drilling, pumping, etc., wells in submerged areas. The present barge can be used in shallower water than a submersible barge, since the lack of necessity of superstructure to support the equipment above water level permits construction of a barge with a shallower draft. The state of flood water, within the range of the stabilizer rams, has no effect upon drilling operations except the addition or removal of extensions on the drilling Christmas tree assembly. For example, the present floating barge may be used in water 20 feet in depth, provided the stabilizer rams are of suitable length or extensions thereof are used. A further important advantage is that the present floating barges take less time to set in condition for operation and to move than is possible with submersible barges. Any washing out of the mud upon which the stabilizing shoes rest will be automatically compensated for by the self-leveling controls.

Although the illustrations have been drawn to drilling barges, the present invention may likewise be applied to other similar floating equipment confronted with similar problems such as, for example, pumping barges. Likewise, various modifications in the stabilizing and control systems can be made without departing from the spirit of the present invention as defined by the appended claims.

I claim as my invention:

1. A barge for working oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by the buoyancy, and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders

carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water, and control means adapted to regulate the pressure in each cylinder in response to the inclination of the barge from the horizontal.

2. A barge for drilling oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by its buoyancy, and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, stabilizing shoes attached to the lower end of said rams, hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water, and control means adapted to regulate the pressure in each cylinder in response to the inclination of the barge from the horizontal.

3. A barge for drilling oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by its buoyancy and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, a hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water, valve means tending to maintain said pressure at a substantially constant value, and control means adapted to regulate the pressure in each cylinder in response to the inclination of the barge from the horizontal.

4. A barge for drilling oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by its buoyancy and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge to provide the auxiliary support for said barge, a hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water, valve means

tending to maintain said pressure at a predetermined value for each of said rams, and control means adapted to regulate the pressure in each cylinder in response to the inclination of the barge from the horizontal.

5. A barge for drilling oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by its buoyancy and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, a hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water and gravity-responsive control means for varying the fluid pressure applied to each ram as a function of the inclination of the barge from the horizontal.

6. A barge for drilling oil wells located under a body of water comprising a main barge body adapted to be supported in said water body mainly by its buoyancy and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body in substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, a hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said rams are forced into contact with the bottom of the body of water and valve means for normally maintaining said pressure at a substantially constant value, and gravity-responsive control means for varying fluid pressure applied to each ram as a function of the angle of list of the barge, whereby said barge is returned to a substantially level position.

7. A barge for drilling oil wells located under a body of water comprising a barge body adapted to be supported in said water body mainly by its buoyancy and a stabilizing system for counteracting the inclination of the barge from the horizontal due to off-center loads, said system comprising a plurality of vertical hydraulic cylinders carried by said barge body and substantially symmetrical spacing with regard to the normal center of gravity of said barge, rams adapted for reciprocation within said cylinders, said rams extending vertically downwards from said barge body to provide the auxiliary support for said barge, a buoyant tank attached to the lower end of each of said rams, hydraulic means in communication with said cylinders for applying fluid pressure to said rams, whereby said tanks are forced into contact with the bottom of the body of water, and control means adapted to regulate the pressure in each cylinder in response to the inclination of the barge from the horizontal.

WILFRED ST. MAUR ELMORE CRAKE.