73-151 CROSS REFERENCE SEARCH ROOM

June 29, 1965 E. W. HENDERSON 3,191,570

HORIZONTAL STABILIZATION OF FLOATING STRUCTURES

Filed March 4, 1963 3 Sheets-Sheet 1

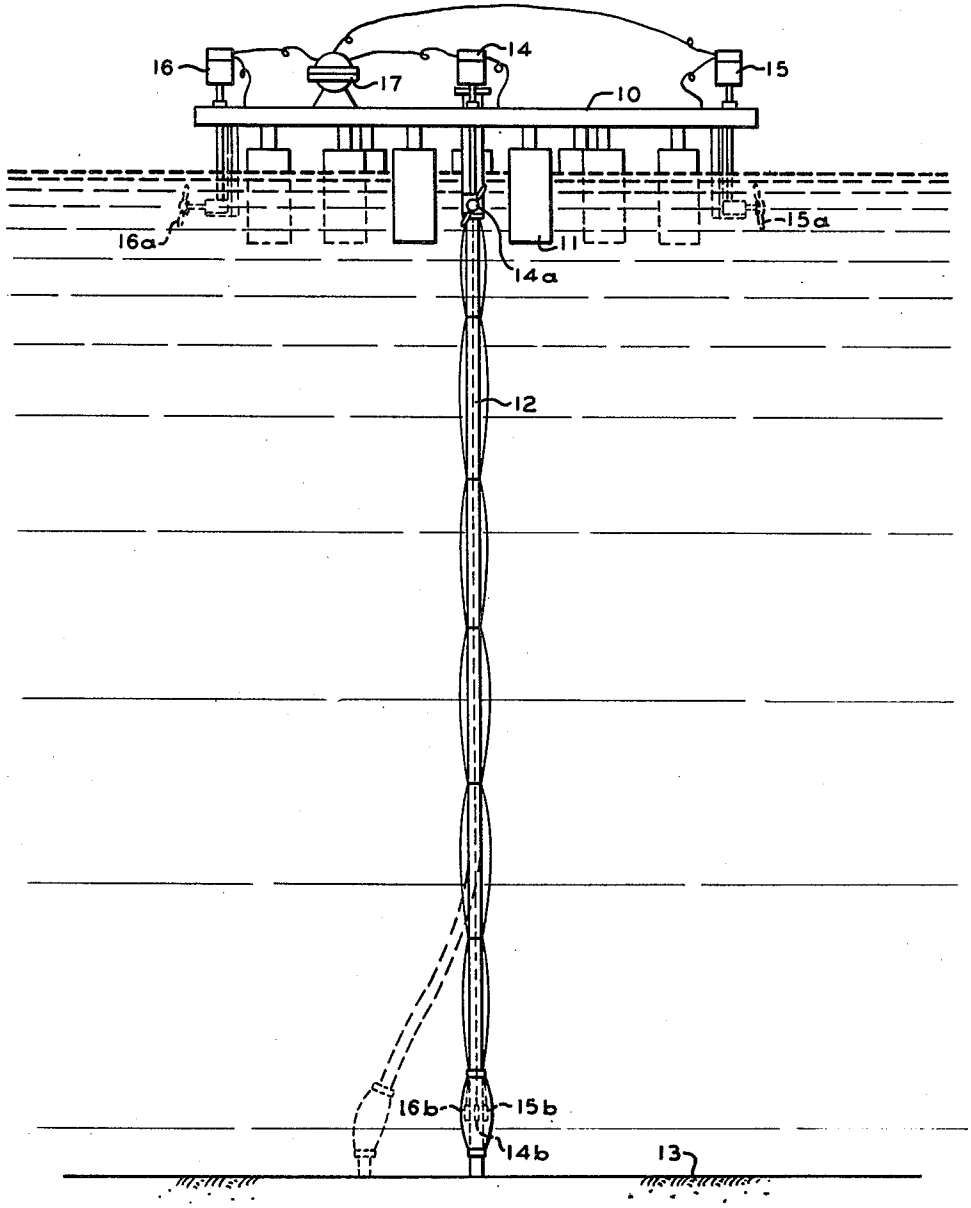


FIG. 1

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Filed March 4, 1963 3 Sheets-Sheet 2

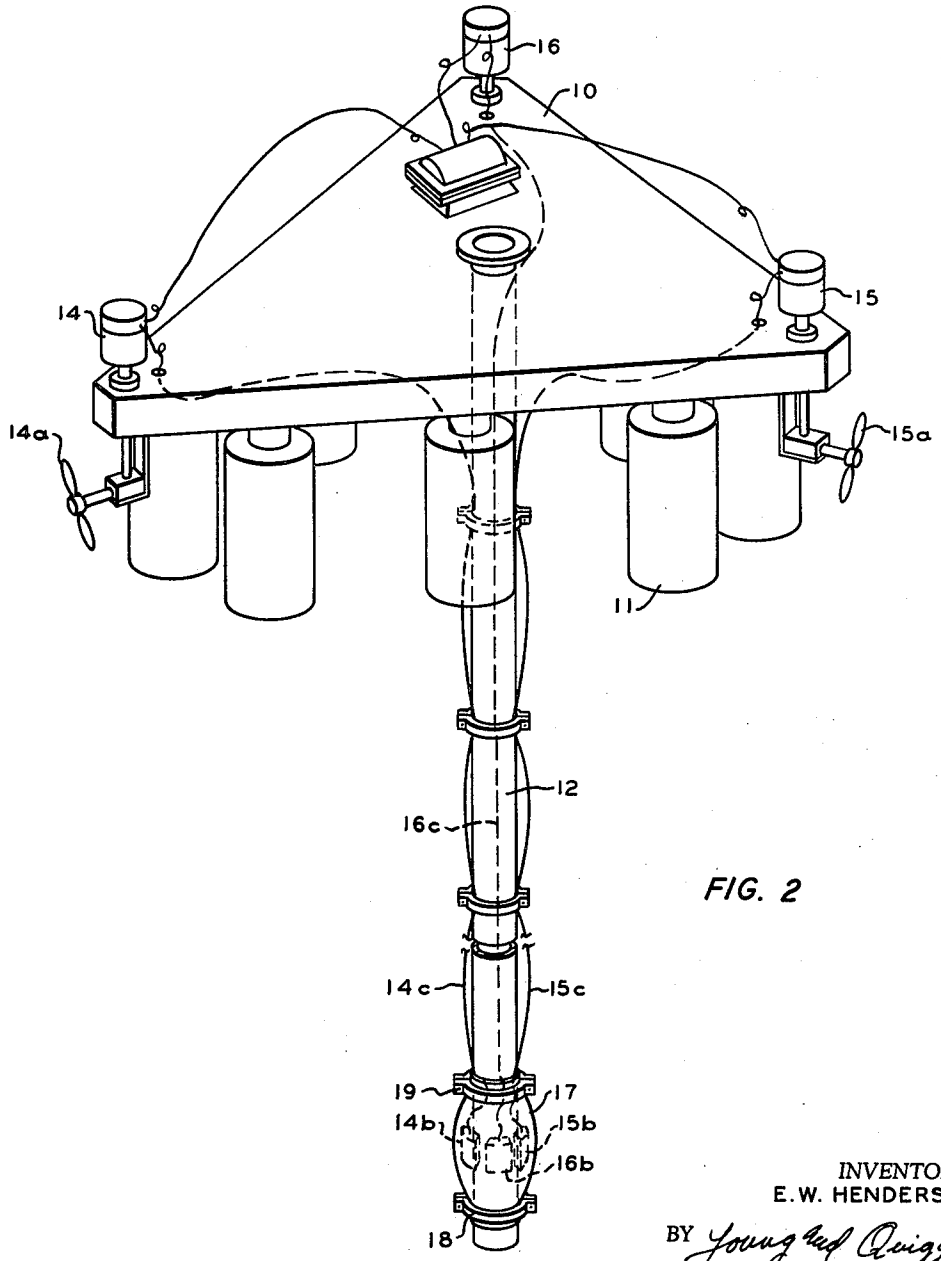


FIG. 2

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Filed March 4, 1963 3 Sheets-Sheet 3

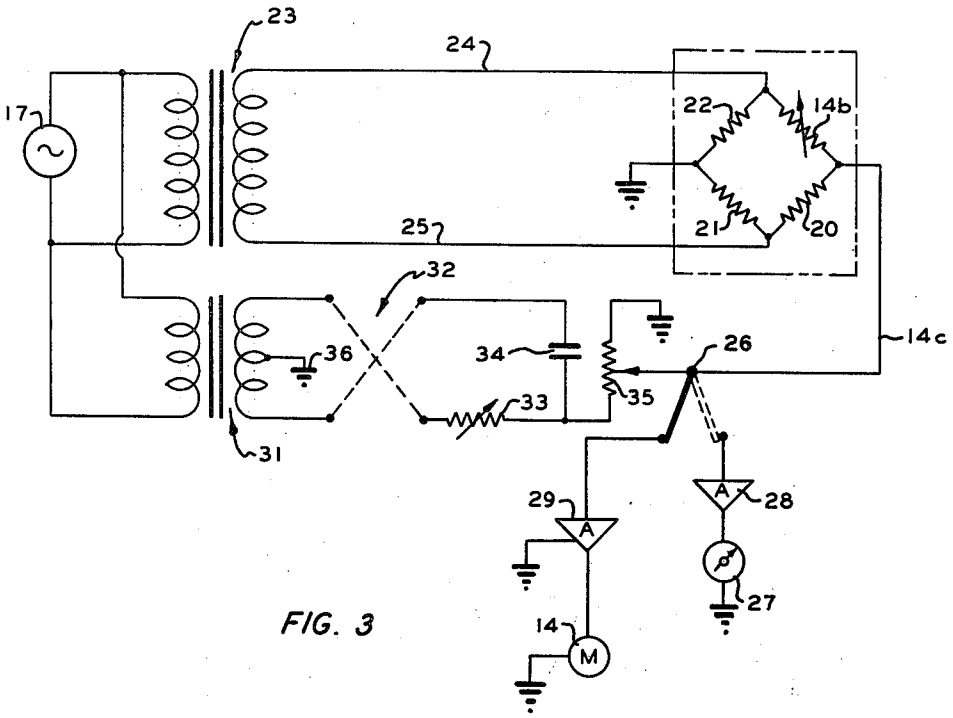


FIG. 3

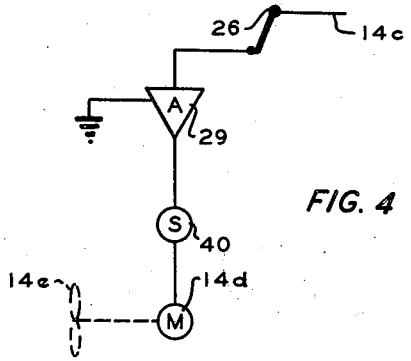


FIG. 4

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3,191,570

HORIZONTAL STABILIZATION OF FLOATING STRUCTURES

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2 Claims. (Cl. 114—144)

This invention relates to horizontal stabilization of floating structures such as drilling platforms used in offshore drilling operations. Stated in different terms this invention relates to a method and means for maintaining a floating structure on location. In one aspect this invention relates to a method and means for maintaining a floating drilling platform on location so as to avoid undue bending of the casing which extends from the drilling platform into a formation beneath the water.

In the continuing search for oil, offshore wells are being drilled in ever increasing depths of water so that stationary structures rigidly anchored to the underwater formation are often not feasible and drilling locations are now being conisdered where anchor lines are impractical. In drilling an oil well it is desirable and oftentimes necessary to maintain a closed circulation system of drill fluid and this requires an installation of casing firmly secured in an earthen formation and extending upward to the drilling platform. If an oil well is drilled into earthen formations from a floating drilling platform in 200 feet of water, it is advisable to maintain the upper end of the casing within a 10-foot circle which represents a deviation of 5 feet from vertical. Presently known systems are not capable of maintaining such precise horizontal location of a free floating structure.

The present invention provides a reliable and automatic system for maintaining a free floating structure on location by detecting deviations from the vertical of the casing extending from the earthen formation to the drilling platform and correcting such deviation by providing horizontal thrust to the platform to oppose the bend in the casing.

It is therefore an object of the invention to provide an automatic means to maintain a floating platform on location for an offshore drilling operation. It is also an object of this invention to provide a means for detecting and correcting a deviation from vertical in a casing extending from an earthen formation to the surface of an overlaying body of water. A further object of this invention is to provide a method for detecting the deviation from vertical of a casing extending from an earthen formation to the surface of an overlaying body of water and for correcting such deviation. Other objects and advantages of the invention will become apparent to one skilled in the art upon studying the present disclosure including the detailed description of the invention wherein:

FIGURE 1 is a schematic elevation of a floating drilling platform according to the invention;

FIGURE 2 is a perspective view of the platform of FIGURE 1;

FIGURE 3 is a schematic circuit diagram of the circuit which connects the horizontal thrust means to the means for detecting deviations from the vertical of the casing; and

FIGURE 4 illustrates one alternate propulsion control means.

Referring now to FIGURE 1, a drilling platform **10** is supported upon a plurality of floats **11** and supports a casing **12** which penetrates the floor **13** of a body of water which will usually be a marine body of water but can also be an inland lake. The derrick and other superstructure required in a drilling operation are not shown so as to simplify presentation of the invention. Reversible electric motors **14**, **15** and **16** are positioned upon the platform **10** and each connected by a suitable shaft to propellers **14***a*, **15***a* and **16***a*. The motors **14**, **15** and **16** are connected by means of a circuit, hereinafter described, to a source of alternating current such as generator **17**. Generator **17** can be opertaed by an internal combustion engine (or other conventional means) not shown.

Strain gauges **14***b*, **15***b* and **16***b* are secured to the casing **10** at a point above and adjacent the floor of the body of water so that strain gauge **14***b* is in the same vertical plane which passes through the center of the pipe and through the propeller **14***a* in the direction of horizontal thrust of propeller **14***a*; strain gauge **15***b* is positioned in the same vertical plane which passes through the center of the pipe and through the propeller **15***a* in the direction of horizontal thrust of propeller **15***a*; and strain gauge **16***b* is positioned in the same vertical plane which passes through the center of the pipe and through the propeller **16***a* in the direction of horizontal thrust of propeller **16***a*. Strain gauge **14***b* is connected to reversible motor **14** by conductor **14***c*; strain gauge **15***b* is connected to motor **15** by conductor **15***c*; and strain gauge **16***b* is connected to motor **16** by conductor **16***c*. The connecting conductors between the strain gauges and the motors can be more clearly seen in FIGURE 2. The strain gauges are protected from the water by suitable means such as a sleeve **37** secured around the casing by clamps **18** and **19**. The sleeve can be any water impermeable material which is adaptable to being sealed around the casing such as a flexible thermoplastic resin, resin-coated rubber, and the like. If desired or considered advisable, a positive atmosphere such as nitrogen can be maintained within the sleeve **37** to prevent possible entry of moisture into the sleeve. Other means for preventing access of moisture to the strain gauges and the conduits carrying the conductors connecting the strain gauges to the motors can be employed such as applying a heavy coating of asphalt or asphaltic paint as a covering for the strain gauges and conduits. Strain gauges and methods for bonding strain gauges to metal pipe are well known in the art.

The electrical circuit connecting each strain gauge to the respective motor in each vertical plane is shown in FIGURE 3. A strain gauge, for example strain gauge **14***b*, is connected to motor **14** in FIGURE 3. Strain gauge **14***b* forms one arm or resistance of a Wheatstone bridge and a matching resistance **20**, which can be a similar but inactive strain gauge, forms the adjacent arm of the bridge. Opposing resistance **21** and **22** form the opposing arms or resistance of the Wheatstone bridge circuit. A source of alternating current, which can be the generator **17**, is connected to the primary winding of a transformer **23** having a secondary winding the end portions of which are connected by conduits **24** and **25** to the Wheatstone bridge.

In order to overcome the effects of stray voltages between the strain gauge and the motor a neutralizing voltage is applied across the indicating terminals of the bridge, that is, between conductor **14***c* and ground, of the proper phase and amplitude to balance out the reactance and stray voltage effects. To accomplish this generator **17** is connected to the primary winding of a transformer **31** having center-tapped secondary winding, the end portions of which are connected through a reversing switch **32** to a phase shifting network consisting of a variable resistance **33** and a condenser **34** connected in series across the terminals of reversing switch **32**. The junction between resistance **33** and condenser **34** is connected to ground through a potentiometer **35**, the contactor of which is connected to conductor **14***c*.

It will be noted that the center tap of the secondary

winding of transformer **31** is grounded at **36** and, accordingly, a voltage is impressed upon phase shifting network **33, 34** which is alternately positive and negative with respect to ground, that is, with respect to the junction between resistance **21** and **22**. The network **33, 34** produces a phase shift of from 0 to 180 degrees in the voltage impressed thereon and, by the use of reversing switch **32**, the phase may be shifted between 0 and 360 degrees. Therefore at the output of the network **33, 34** an alternating voltage appears which is alternately positive and negative with respect to ground and which can have any desired phase relationship with the voltage impressed upon the bridge circuit. The amplitude of this voltage is controlled by the setting of the potentiometer **35**.

In the operation of the system of this invention the strain on the strain gauge when the casing is vertical is set at a zero reading by adjustment of potentiometer **35** with the switch **26** closed with respect to meter **27**, i.e., with switch **26** being in the dotted position so that the signal passing through conductor **14***c* is amplified by amplifier **28** and registers on meter **27**. When the meter reading is adjusted to zero with the casing in vertical position the switch is returned to the original position so that the signal through conductor **14***c* passes through amplifier **29** to motor **14**.

When the casing is deflected from vertical so that strain gauge **14***b* is compressed the unbalance of the bridge circuit causes a signal to pass through conductor **14***c* to motor **14** so that the motor operates the propeller **14***a* to provide the thrust required to move the platform **10** and bring the casing back to vertical. When the casing is bent so as to extend the strain gauge **14***b*, a signal opposite in sign passes through the conductor **14***c* to motor **14** and turns the propeller **14***a* in the opposite direction so as to bring the casing back to vertical and the bridge back to balance. The amount of thrust provided to the propeller **14***a* is determined by the amount of deviation from vertical from the casing which is, in turn, reflected in the amount of unbalance of the bridge circuit. Thus, the motors **14, 15** and **16** are constantly alert to any deviation from vertical of the casing **12** and instantly react to maintain the casing substantially vertical.

Anchors can also be employed to aid in maintaining the structure on location when the depth of the water does not prevent the use of anchors. Anchor line length is usually about 7 times the depth of the water and this will usually limit the use of anchors.

Strain gauges are well known and can be of the type disclosed in Simmons Patent 2,292,549 (1942), and when bonded to the casing the change in resistance of the gauge is proportional to the bend in the casing. The entire bridge circuit can be mounted at the bottom of the body of water or, alternatively, the strain gauge and matching resistor can be mounted at the body of water and the balancing resistors can be mounted at the surface with the motor control apparatus.

An alternate means for control of motors **14, 15** and **16** is shown in FIGURE 4 wherein the signal amplified by amplifier **29** actuates a servo system **40** which in turn controls motor **14***d* which can be the reversible electric motor **14** of FIGURE 3 or can be a unidirectional electric motor or air internal combustion motor or other prime mover. Servo **40** controls propeller **14***e*, which can

be a variable pitch or reversible pitch propeller, when the motor **14***d* is a unidirectional prime mover. Servo systems, variable pitch propellers and reversible pitch propellers are well known in the art.

That which is claimed is:

1. A free-floating, water-borne, well drilling platform system comprising a platform; a plurality of floats secured to said platform so as to support said platform above a body of water; a casing having the upper open end secured to said platform and the lower open end secured in an earthen formation beneath said platform; at least 3 strain gauges secured to said casing at a point above and adjacent the bottom of said body of water and equally spaced about the casing; at least 3 propulsion units positioned on said platform each of which is in a vertical plane which includes one of said strain gauges, the center of the pipe and the direction of thrust of one of said propulsion units; a prime mover operatively connected to each propulsion unit; and an electrical circuit comprising a Wheatstone bridge connecting each strain gauge with each motor in the same vertical plane wherein the strain gauge forms one arm of the Wheatstone bridge so that when the casing is bent thrust is produced to remove the bend from the casing.

2. A floating structure comprising a platform; flotation means to support said platform upon a body of water; a casing extending from said platform to a point within the earth beneath said platform; at least three propulsion units substantially equally spaced about the periphery of said platform and positioned so as to thrust along a line passing through said propulsion unit and the center of the casing at said platform; a reversible electric motor operatively connected to each propulsion unit; at least three strain gauges secured to said casing at a point adjacent the bottom of the body of water each of which is in the same vertical plane which includes the center of the pipe and the direction of thrust of the propulsion unit; and an electrical circuit connecting each strain gauge with each motor in the same vertical plane so as to produce thrust in the direction of said casing when the strain gauge is compressed and in the opposite direction when the strain gauge is expanded.

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