

May 1, 1962

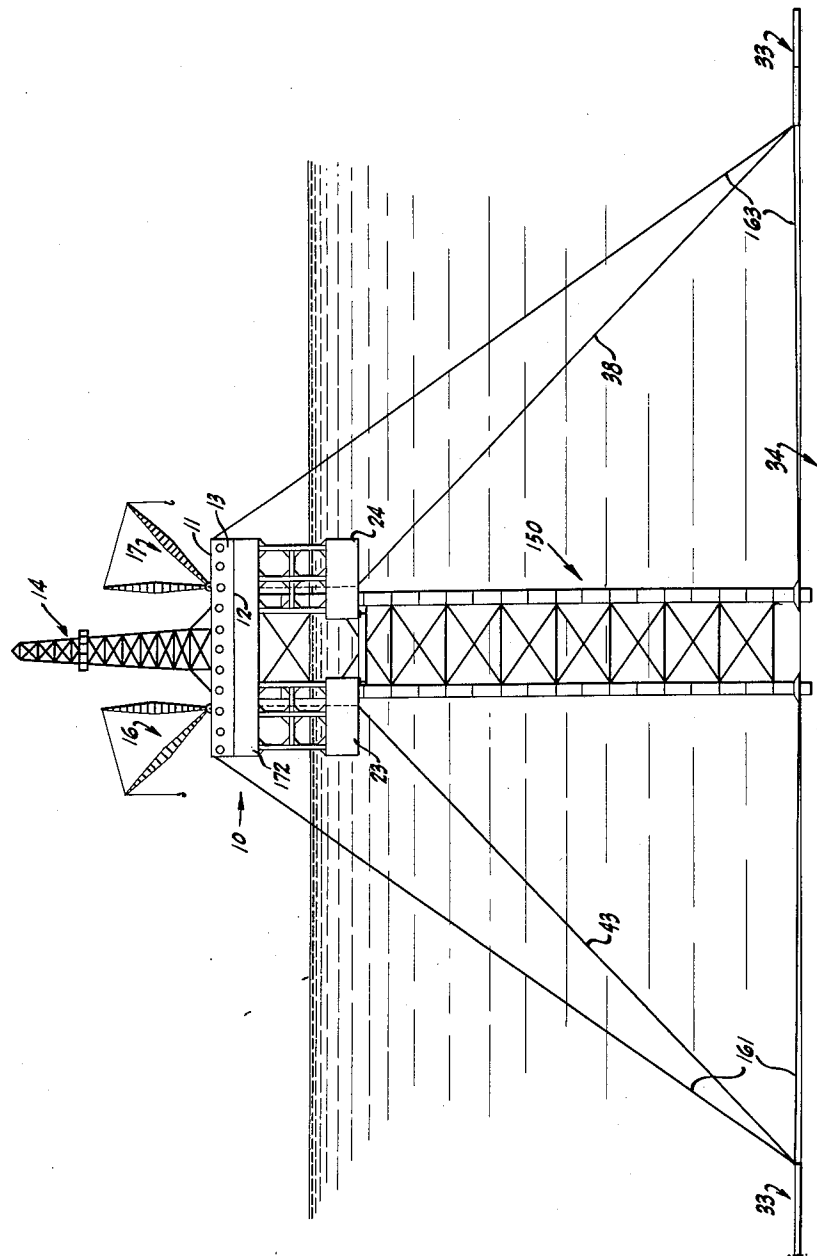
W. A. NESBITT
FLOATING PLATFORM

3,031,997

Filed April 30, 1957

6 Sheets-Sheet 1

FIG. 1



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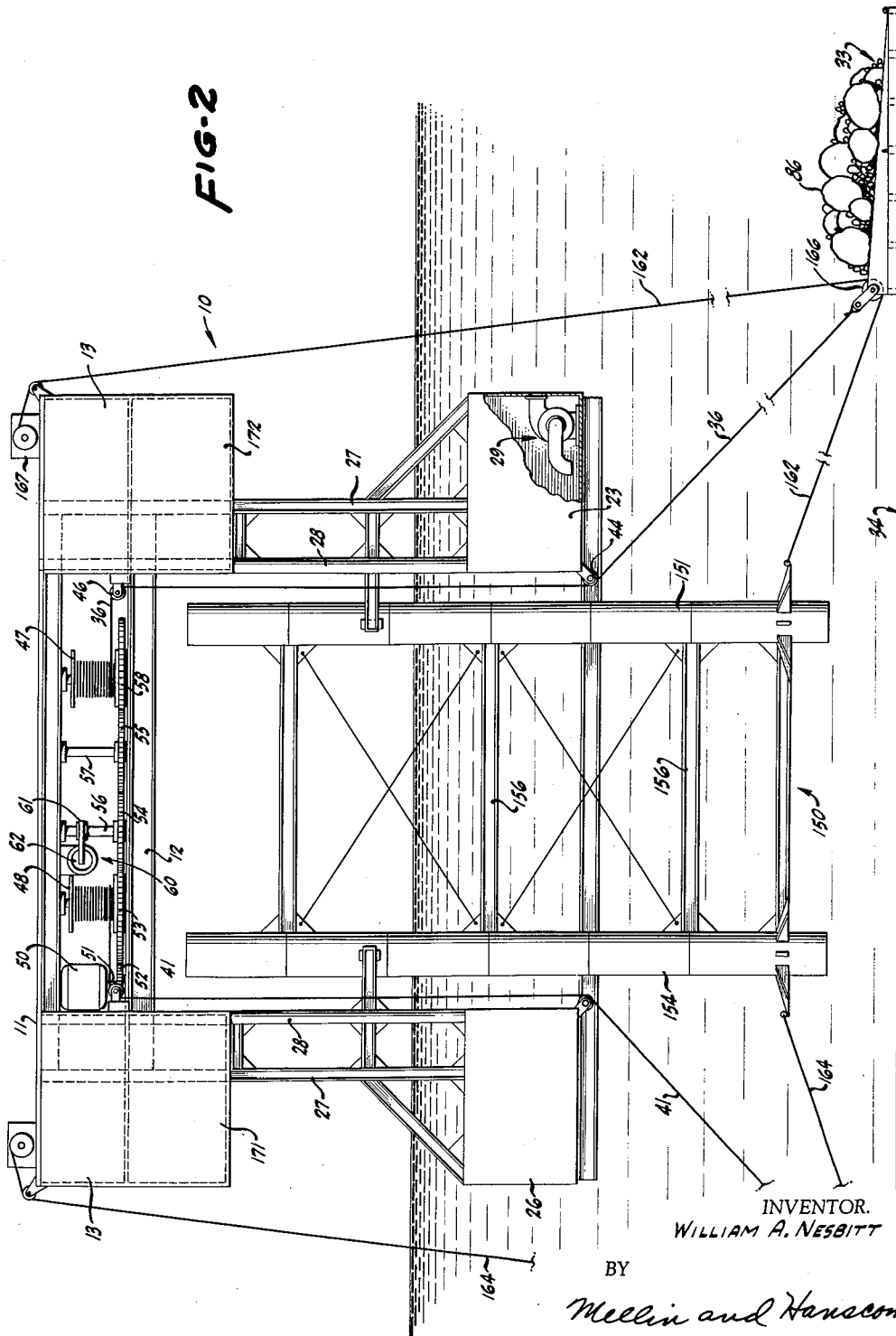
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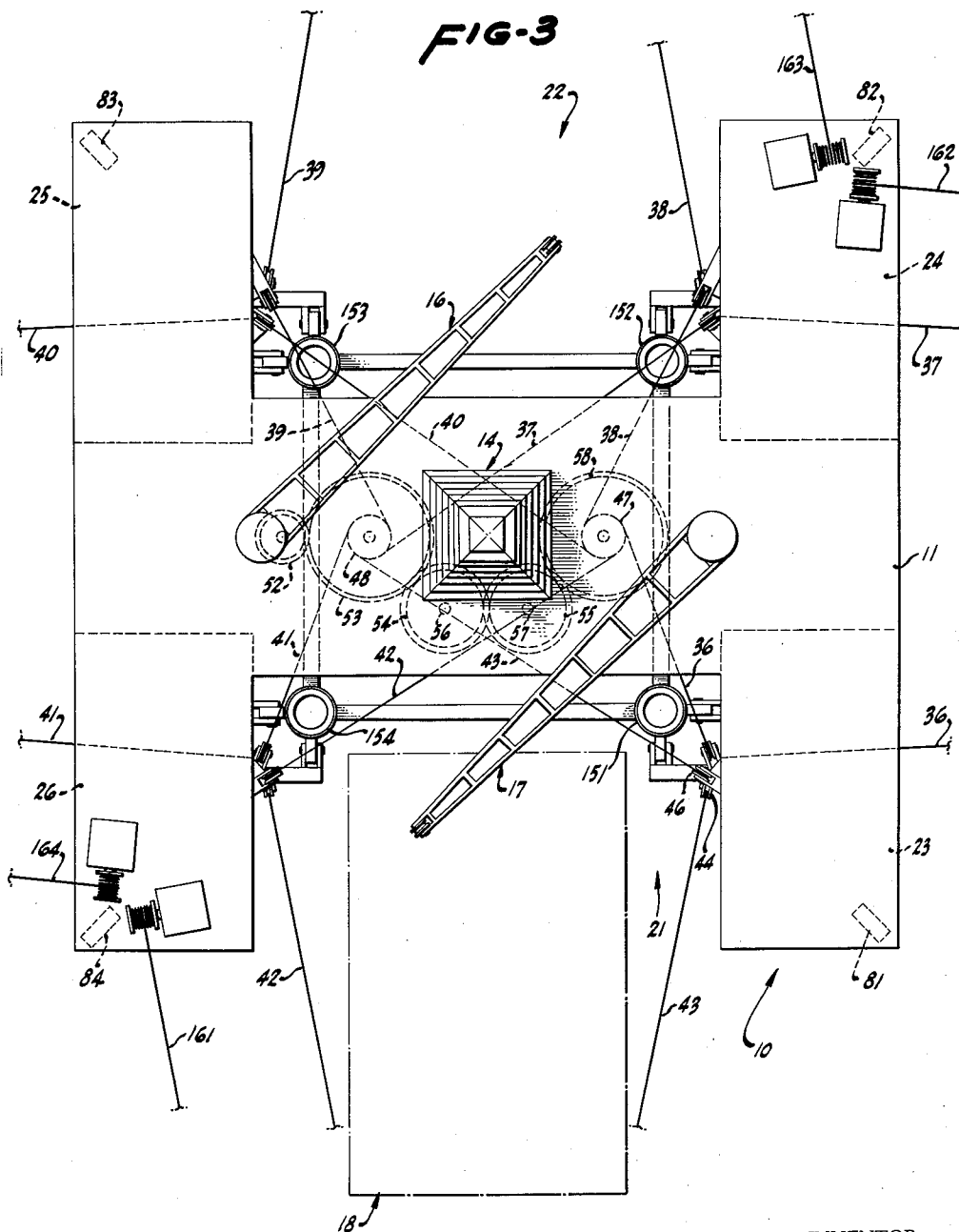
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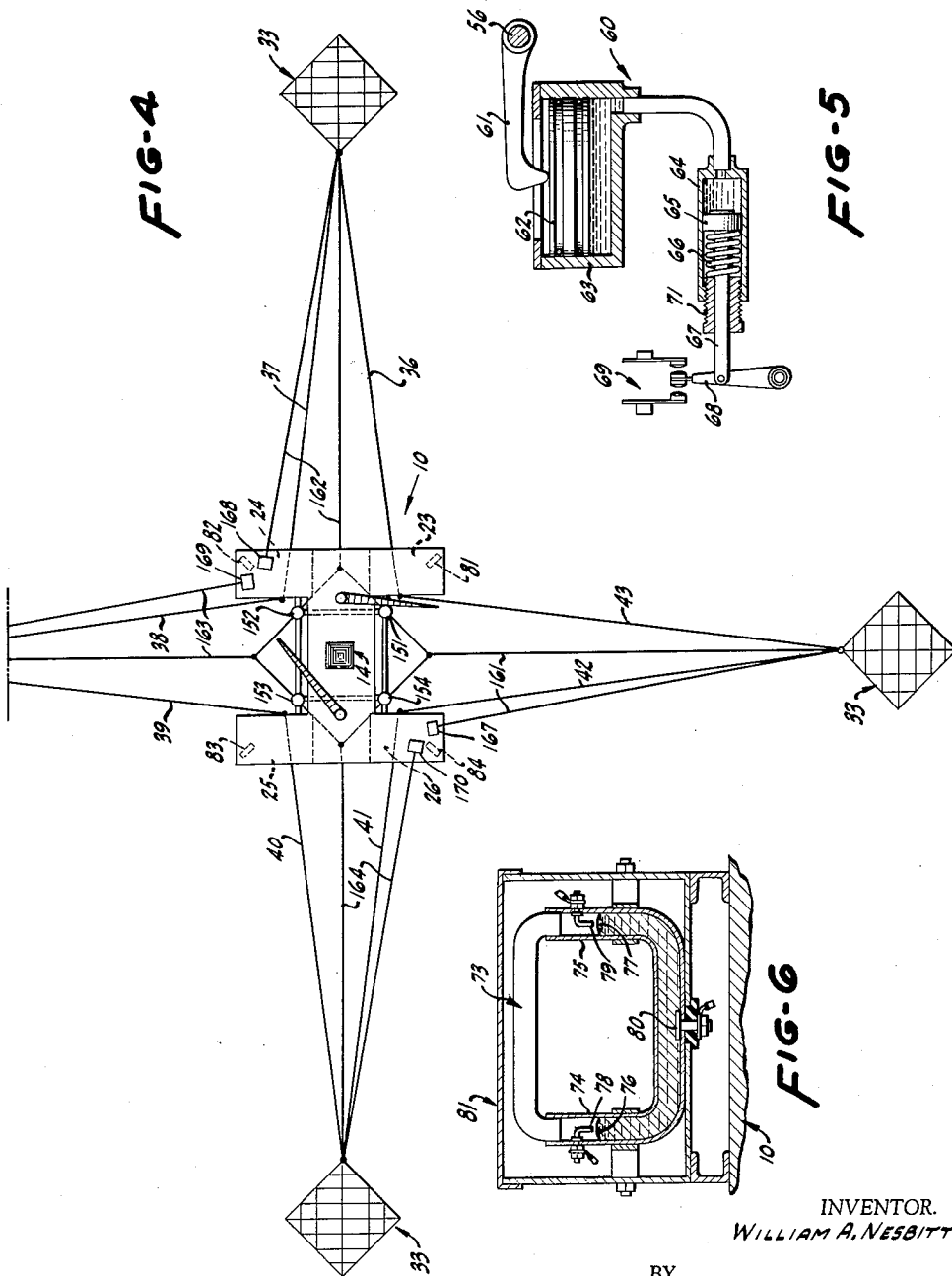
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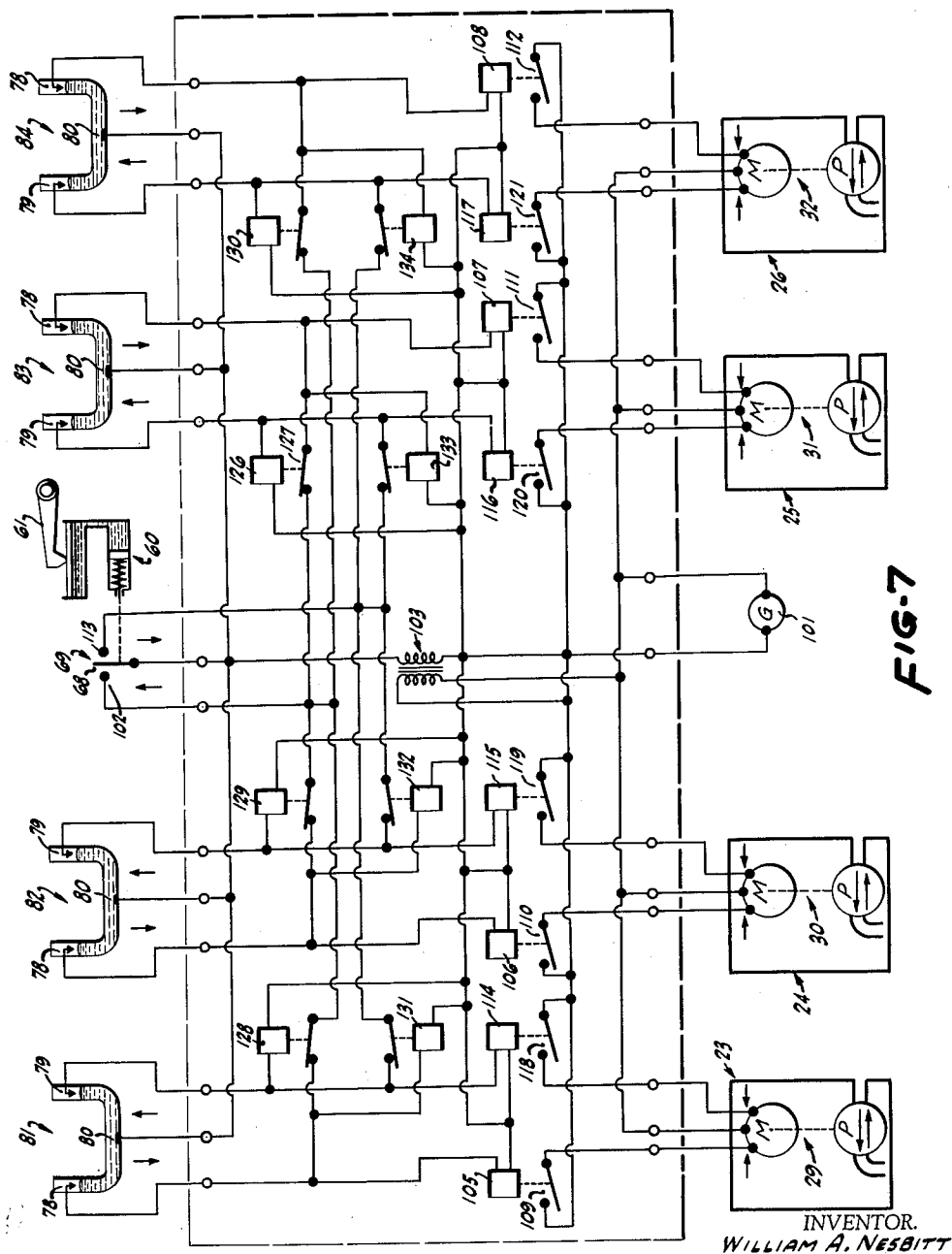
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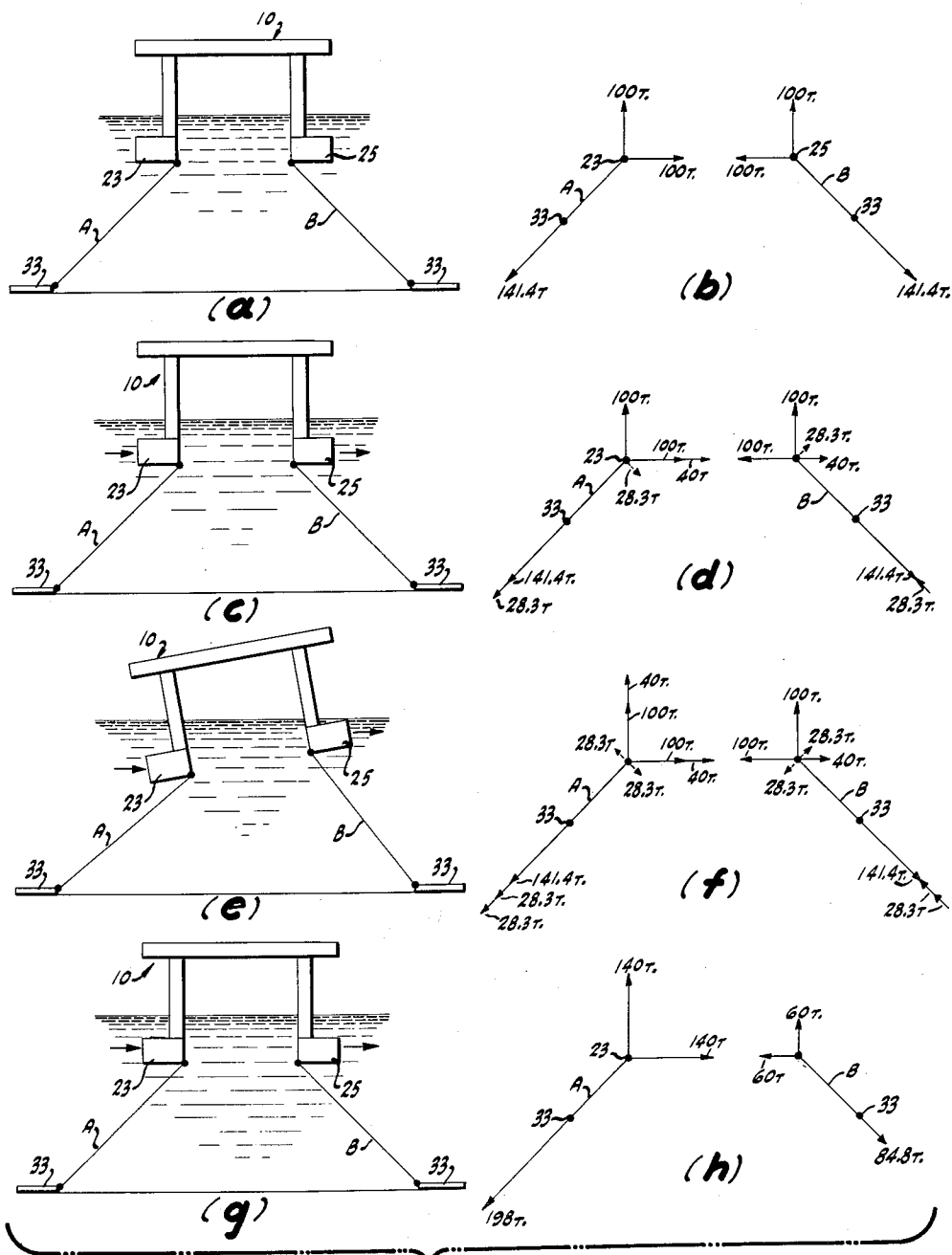


FIG-8

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3,031,997

FLOATING PLATFORM

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9 Claims. (Cl. 114—5)

This invention relates to a floating platform and an anchorage system therefor, and has for its main object the provision of compensation for the platform such that the platform is maintained at a constant elevation above the bottom of the sea and at a constant level position in spite of changes in deck loading and the effects of tide, waves, wind and under-water currents acting on the platform. More specifically, the invention relates to such a platform as is usable in off-shore drilling operations, either as a platform usable directly for well drilling, or as a means for the erection of a permanent drilling platform in deep water.

Many valuable pools of oil have been discovered in the tidewater areas of the United States, and many off-shore drilling operations have been carried out to produce this oil. However, the present operations have been restricted to areas in which the water has been relatively shallow, such that pilings or towers could be erected which would support the drilling apparatus directly on the sea floor. As yet, it has not been practical to carry out drilling operations in deep water, because of the inability to provide a constantly level drilling platform at a fixed height above the sea floor. As is obvious, for any drilling to be carried out in deep water, the drilling apparatus must be fixed at an elevation above water level, and must not be subjected to changes in its level position. In such a drilling operation, the drill pipe is fixed with respect to the sea floor, and is also fixed with respect to the drilling platform. If the platform is free to rise and fall with tide and waves, an undue strain will be placed on the well string, which would cause it to pull apart. If the platform were to be tilted, as from wind or sea currents, a flexing force would be applied to the well string which would also cause a rupture of the well string. Similarly, if the well string was being launched from the platform, a tilting of the platform would result in a tilting of the well string such that the well would not be produced from the point desired.

There have been attempts to produce a platform which would overcome the tide and wave actions by providing submersible pontoons spaced below the platform so that the pontoons could be submerged below the lowest water level to be encountered, with the pontoons being anchored to the bottom of the sea. Such systems have the disadvantage that the platform can only be loaded to the amount of buoyancy acting upwardly on the platform. If the buoyancy factor is relatively large so as to enable fairly large loads to be taken aboard, very heavy anchors and anchor cable must be provided to withstand the buoyancy of the system when the platform is unloaded. If the initial buoyancy is small, enabling lighter anchors and anchor cables to be used, then the amount of loading which the platform can handle is diminished. Furthermore, the changes in buoyancy of the system will vary as the loading varies, thus producing changes in anchor cable tension and thus varying the length of the cables. It is a feature of the present invention that such a platform can be loaded between wide limits, without affecting the tension in the anchor cables, thus enabling the system to be more stable.

Another, and more serious, drawback of the devices which have been proposed is that there has been no compensation for the tilting effect of a sideways force on the platform, as from tidewater currents or wind. Any submerged platform system, anchored by cables to the sea floor, will present a system in which a sideways

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force will tilt the platform. It is another feature of the present invention that automatic means are provided to vary the individual buoyancy of the submerged pontoons in such a manner, as will be explained, as to overcome the tendency of an applied sideways force to tilt the platform.

It is an object of the present invention to provide a floating platform having submergible pontoons, or buoyancy tanks, anchored by cables to a sea floor with means responsive to vertical loading of the platform to adjust the buoyancy of the buoyancy tanks to compensate for changes in the vertical loading of the platform.

It is a further object of the invention to provide a floating platform having submerged buoyancy tanks anchored by cable to a sea floor, with means responsive to horizontal loading of the platform for adjusting the buoyancy of the buoyancy tanks to compensate for said changes in horizontal loading to prevent tilting of the platform.

It is a yet further object to provide a floating platform having submerged buoyancy tanks anchored by cables to a sea floor with means responsive to variations in vertical loading of the platform to maintain a constant total tension in the cables, and with means responsive to variations in horizontal loading of the platform for adjusting the buoyancy of the buoyancy tanks to prevent tilting of the platform.

Other objects and advantages will be apparent in the course of the following detailed description.

In the drawings, forming a part of this application, and in which like reference numerals are used to designate like parts throughout the same,

FIG. 1 is an elevational view of the platform and mooring means therefor.

FIG. 2 is an enlarged view of the platform and mooring means.

FIG. 3 is a plan view on an enlarged scale of the platform of FIG. 1.

FIG. 4 is a plan view of the platform and mooring means shown in FIG. 1.

FIG. 5 is a fragmental view illustrating a tension responsive means for indicating the total cable tension of the mooring means.

FIG. 6 is a fragmental view illustrating a level responsive means usable for indicating the levelness of the platform.

FIG. 7 is a wiring diagram illustrating the manner in which the reversible pumps in the buoyancy tanks of the platform are controlled by the tension responsive and level responsive means of FIGS. 5 and 6.

FIG. 8 is a series of schematic figures and force diagrams illustrating the operation of the invention.

In the drawings, wherein for purposes of illustration is shown a preferred embodiment of the invention, the reference numeral 10 refers generally to the platform structure, which comprises an upper deck 11 and lower deck 12, each being generally H-shaped in surface area, and spaced apart to form rooms or compartments 13 therebetween. These rooms are used as living quarters, machine shops, generator rooms, storage rooms and the like.

A drilling derrick 14 is provided on the upper deck, generally centrally thereof, along with crane booms 16 and 17, the latter being usable for loading and unloading barges, such as 18, which may be brought within the bays 21 and 22 formed by the H-shape of the platform 10.

Secured to and spaced beneath the platform 10 are a plurality of pontoons, or buoyancy tanks, 23, 24, 25 and 26, one of each being spaced below one corner of the platform structure by suitable framing structure 27. Each of the framing structures has at least one hollow pipe, as at 28, communicating the interior of the pon-

toon to which it is connected with atmosphere, to provide a vent for that pontoon. Each pontoon 23, 24, 25 and 26 has disposed therewithin a reversible motor-pump, 29, 30, 31 and 32, respectively, adapted to pump water into, or out of each pontoon, so that the buoyancy of the pontoons may be individually adjusted, in a manner to be hereinafter described.

A plurality of anchor elements 33 are disposed on the floor 34 of the ocean, in a pattern corresponding generally to the number and spacing of the pontoons 23, 24, 25 and 26, to provide a bottom anchorage for anchor cables 36 to 43, inclusive. As best seen in FIGS. 2, 3 and 4, cables 36 and 37 are both connected at their lower ends to a single anchor element, with cable 36 extending upwardly therefrom, passing upwardly around pulley 44 mounted on the lower edge of pontoon 23, and passing around pulley 46 to the capstan 47 to be secured thereto in a conventional manner. The other cable 37 passes around the pontoon 24 in a similar manner and is secured to capstan 48. Similarly, each of the other groups of cables 38—39, 40—41 and 42—43 extend from a different anchor element upwardly around the pontoons on the sides thereof facing the vertical axis of the platform, with one cable of each group being secured to a different capstan; i.e., cables 36, 38, 40 and 42 are secured to capstan 47 and cables 37, 39, 41 and 43 are secured to capstan 48. The cables on the two capstans 47 and 48 are wound around the capstans in opposite directions to balance the torque action of the cables on the platform.

The capstans are adapted to be rotated by a common drive means, indicated on FIG. 2 as a motor 50, having a drive shaft 51 connected to driving gear 52 in mesh with gear 53 which has capstan 48 rigidly fixed in a coaxial relation thereto. Idler gears 54 and 55, fixedly mounted on shafts 56 and 57 rotatably journaled in platform 10, transmit the rotative movement of gear 53 to gear 58 on which capstan 47 is rigidly fixed in a coaxial relation, so that capstan 47 turns in an equal amount and opposite direction to capstan 48. Gears 53 and 58 are spaced apart to provide an opening directly beneath derrick 14 so that unobstructed drilling operations may be carried out. It is to be realized that the particular gearing shown whereby capstans 47 and 48 are rotated is not critical, as other forms of drive to accomplish this function may be used, if desired.

By the operation of motor 50, the capstans 47 and 48 may be rotated to pull the pontoons 23—26 downwardly under the surface of the water to a desired position. At such a position, the pontoons 23—26 will be below their normal flotation level and will exert an upward pull on the anchor cables 36—43.

It is important in the operation of the invention that means be provided to indicate a change in the total tension of the anchor cables. One example of such means, illustrated generally in FIG. 5 by the reference numeral 60, is a device wherein a brake lever 61 is provided which is adapted to be rigidly secured by conventional means to idler gear shaft 56 after the platform pontoons have been submerged to a desired level. The total cable tension will be exerted on shaft 56, which is then prevented from rotating under this tension by the braking action of lever 61 on piston 62 of the oil filled reservoir 63. The reservoir 63 is fixedly secured to platform 10. The pressure on the oil in the reservoir exerted by the brake lever 61 is transmitted into cylinder 64 to act on one side of piston 65 reciprocable therein. Compression spring 66 on the other side of piston 65 balances the force exerted by the oil on the piston, and rod 67 transmits the reciprocable movement of piston 65 to the movable switch arm 68 of switch 69. If the total cable tension increases, the brake force on piston 62 will increase, causing the oil to flow into cylinder 64 to move the piston 65 leftwardly against the bias of spring 66 and thus to move switch arm 68 to the left. If the total cable tension decreases, the brake pressure on piston

62 will decrease, and spring 66 will move piston 65 to the right, causing switch arm 68 to move to the right.

The spring 66 abuts adjustment member 71 which is threadedly secured to cylinder 64 and is longitudinally adjustable relative thereto so that the spring bias of spring 66 may be varied as desired, in order to adjust the mechanism so that switch element 68 will be in the neutral or "off" position for any desired amount of total cable tension.

Again, it is to be understood that the particular form of means to indicate the change in total cable tension herein illustrated is intended merely as an example of one such device, and that other devices capable of indicating tension and changes thereof may be used in the present invention.

It is also important in the practice of the invention to provide a plurality of level indicating means which will be responsive to a tilting of the platform. A simple form of such an indicating means is that illustrated in FIG. 6, wherein a closed ring tube 73 of electrically non-conductive material is suitably mounted on a portion of platform 10, with the legs 74 and 75 of the tube extending in a generally vertical direction. The tube 73 is filled with mercury such that when the platform 10 is in a level position, the mercury will be at levels 76 and 77, respectively, in legs 74 and 75. A first contact element is positioned in leg 74 slightly above the normal height of the mercury level 76 therein, and a second contact element 79 is positioned in leg 75 slightly above the normal height of the mercury level 77 therein. A third contact element 80 is positioned in the lower part of ring tube 73 so as to be in contact with the mercury at all times. The operation of the leveling means is quite simple. If the platform 10 should tilt such that the left side of the platform should be lower than the right side, as viewed in FIG. 6, the contact 78 will be immersed in the mercury to complete a circuit between contacts 78 and 80. Similarly, if the platform tilts in the opposite direction, a circuit will be completed between contacts 79 and 80. If the platform 10 is level, both contacts 78 and 79 will be above the mercury level and no circuit will be complete through the device.

The level indicating means illustrated in FIG. 6 are disposed, one in each corner of the platform, as in the dotted positions 81, 82, 83 and 84, and are arranged such that the vertical legs 74 and 75 thereof are generally in the vertical plane defined by the vertical axis of the platform and the respective pontoons disposed below each corner of the platform 10. In this manner the level indicating means associated with each corner of the platform will only be operative to close an electrical circuit if the particular corner is displaced from a level position with respect to the center of the platform. For example, if the platform 10 should tilt about the diagonal line through the center of the platform and the corners thereof above pontoons 23 and 25, the level indicating means at 82 and 84 will be tilted to close circuits therethrough, while the level indicating means at 81 and 83 will not be so tilted as to complete a circuit. Similarly, if the platform 10 should tilt about the diagonal line extending through the center of the platform and the corners thereof above pontoons 24 and 26, the level indicating means at 81 and 83 will be operative to close electrical circuits while the level indicating means at 82 and 84 will not be tilted so as to close any circuit therethrough. If the platform is tilted in any other direction, all of the level indicating means will be inclined to complete electrical circuits therethrough.

Again, the particular form of level indicating means need not be of the precise form as that illustrated herein, as any similar means which will be responsive to tilting motion of the platform 10 may be utilized, if desired.

In the operation of the device thus far described, a suitable site for exploratory drilling is selected and the anchor elements 33 are lowered into position. Each anchor

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element is in the form of a rigid lattice structure and is relatively light and easy to maneuver into position. After the anchor elements are bottomed on the sea floor, rubble 86 is dumped onto the anchors to provide sufficient weight thereon to avoid any shifting of the anchor elements.

The platform 10 is then towed into position, and the anchor cables 36-43, which have been held above water by suitable means, are passed around the pontoons and secured to the capstans 47 and 48 as previously described, with an approximately equal tension in each of the anchor cables.

The motor 50 is then actuated to take up on the anchor cables and to pull the platform 10 downwardly so that the pontoons 23, 24, 25 and 26 are submerged below the lowest sea level to be encountered, as from low tides and/or wave action. The height of the bottom of the platform decks above the pontoons is sufficiently great such that the platform decks will always be above the highest sea level to be encountered, as from high tides and/or wave action. With the pontoon submerged to the desired level, the brake arm 61 is fixed to gear shaft 56 to act as a brake for the capstan, and as a tension indicating device, as explained previously. The capstan will not be again rotated until it is desired to move the platform 10 to a new location.

Each pontoon 23-26 is designed to have a buoyancy force, when empty, of approximately 500 tons, and the total weight of the platform 10 and pontoons is approximately 800 tons. It is desired that the anchor cables furnish a downward force of 100 tons on each pontoon. In the drawings, the anchor cables are illustrated as extending at 45° angles from the anchor elements 33, although the precise angle is not critical and may be more or less, as desired. In the case illustrated, for the anchor cables to produce a 100 ton downward force on each pontoon, each cable will be tensioned to approximately 70.7 tons, or, the total cable tension of all eight cables will be approximately 565.6 tons. The spring member 66 of the tension responsive device 60 is set to this total tension amount, and the generator 101 is connected into the control circuit of FIG. 7 by an appropriate switch.

If the pontoons are empty, or of such buoyancy that the total upward force exerted by the pontoons on the anchor cables is greater than the amount for which the tension responsive device 60 is set, the switch member 68 will be moved into engagement with contact 102 of switch 69. This will complete a circuit from the low voltage secondary winding of transformer 103 through each of the control relays 104, 105, 106 and 107, to close the switches 108, 109, 110 and 111, respectively, thus closing the power circuits to the reversible motor-pump units 29, 30, 31 and 32, causing each unit to pump water into the pontoons 23, 24, 25 and 26. When the total weight of this water, or ballast, is such that the total cable tension is 565.6 tons, the switch arm 68 will be moved to its neutral, or off, position, opening the relay switches 109-112 to deactivate the pumps 29-32. Conversely, if the pontoons had had too much ballast therein, the switch arm 68 would have been in engagement with contact 113, and relays 114, 115, 116 and 117 would have been energized, causing switches 118, 119, 120 and 121 to close, thereby energizing the pumps 29, 30, 31 and 32 to pump water out of the pontoons, thus increasing the buoyancy of the pontoons until the total cable tension is increased to the 565.6 ton amount. The interior of each pontoon is vented to atmosphere through a pipe 28, enabling a constant air pressure to be present in the pontoon at all times.

With the platform in its state of equilibrium as above described, each pontoon will contain 200 tons of ballast, will be supporting 200 tons of the platform weight, and will be pulled downwardly by a force of 100 tons by the two anchor cables acting thereon.

If any weight is added to the platform, as, for example, when a load of supplies is taken aboard, the total platform load will increase, and the total downward force due

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to the anchor cables will decrease. This decrease of total cable force, or the tension therein, will cause the switch arm 68 to engage contact 113, thereby energizing the pumps 29, 30, 31 and 32 as above explained, to pump ballast out of each pontoon until the total cable tension is again at the desired amount. Conversely, if the total weight of the platform decreases, as, for example, if the platform is unloaded, the total cable tension will increase, causing switch arm 68 to engage contact 102, thereby causing the pumps 29, 30, 31 and 32 to increase the ballast therein to decrease the total cable tension to the desired amount.

With the apparatus thus described, the total weight of the platform and the ballast in the pontoons is kept at a constant amount by automatically varying the total amount of ballast inversely to the total amount of platform weight. In this manner, it is possible to avoid the disadvantages that would result from an excess of buoyancy, such as requiring stronger anchor cable and greater horizontal stresses on the pontoons. Also, it is possible to avoid the disadvantage of having too little buoyancy, which would limit the amount of weight which could be added to the platform. Further, by maintaining a constant tension on the cables, the amount of variation in elongation of the cables is minimized. As is apparent, the total weight of the platform and the load thereon can be varied from no weight to 1600 tons without changing the total tension in the anchor cables.

In the foregoing discussion it has been assumed that the addition or subtraction of weight to or from the platform has occurred on the vertical axis of the platform, so that the platform maintained a level position.

However, if the loading or unloading of the platform is eccentric, or if a horizontal force is applied to the platform, the level responsive devices at 81, 82, 83 and 84 will be actuated to maintain the platform at a level position, in a manner as will now be described.

FIG. 8 has been prepared to illustrate the manner in which the level responsive devices actuate the pumps when a horizontal force is applied, as from wind or tidal currents. The figure is simplified by considering the sideways force to be applied on a line through the pontoons 23 and 25, thus producing a tilting of the platform about a line through pontoons 24 and 26. In such a case, the level responsive devices at 82 and 84 will be inoperative and can be disregarded for purposes of illustration. Furthermore, the anchor cables are illustrated as fixed to the pontoons 23 and 25.

FIG. 8a thus schematically represents the pontoons 23 and 25, with the respective cables, at a point of normal equilibrium, and FIG. 8b represents the forces existing in the system at the normal equilibrium position. Each pontoon 23 and 25 has an upward buoyant force of 100 tons and a sideways force (exerted on the platform structure) of 100 tons tending to pull the pontoons apart, and each set of cables A and B (representing cables 43, 36 and 39, 40) has a tension force of 141.4 tons, the total tension in cables A and B being 282.8 tons.

FIG. 8c illustrates a sideways force of 40 tons as applied to the system of FIG. 8a, for example as from a tidal current, and FIG. 8d illustrates the forces on this system. The 40 ton sideways force increases the 100 ton sideways force on pontoon 23 to 140 tons, which produces an additional 28.3 tons tension in cable A, and which produces a force of 28.3 tons, tending to move the pontoon 23 in a downward direction at right angles to cable A, or tangentially to the arc of radius equal to the length of cable A and with the anchor 33 as a center. At the same time, the sideways force on pontoons 25 is decreased to 60 tons, which reduces the cable tension in B by 28.3 tons, and which produces a force of 28.3 tons, tending to move the pontoon 25 upwardly at right angles to cable B.

If the resultant forces of 28.3 tons tending to move pon-

toon 23 downwardly and pontoon 25 upwardly are not compensated for, the system will move to a new position of equilibrium, as shown in FIG. 8e, with the platform being tilted.

However, as soon as the platform begins to tilt, the level responsive devices 81 and 83 will also be tilted so that they may act to compensate for the side loading of the platform. The level responsive device 81 will connect contacts 78 and 80 therein to establish a circuit through relay 105 and transformer 103, closing switch 109 to energize the motor-pump 29 to pump ballast out of pontoon 23. At the same time, the level responsive device 83 will connect contacts 79 and 80 therein, to energize relay 116, closing switch 120 and actuating motor-pump 31 to pump ballast into pontoon 25. The pumps 29 and 31 will continue to operate until a sufficient amount of ballast has been removed from pontoon 23 and a sufficient amount of ballast has been added to pontoon 25 to counteract the tide force of 40 tons. The forces existing on the system at this time are shown in FIG. 8f, wherein an additional 40 tons of buoyancy acts directly upwardly on pontoon 23 (representing the decrease in ballast in pontoon 23) which in turn produces a 28.3 ton upward force on pontoon 23 at right angles to cable A in balancing opposition to the downward force therein produced by the 40 ton sideways force. Also, an additional 28.3 ton tension is produced in cable A. At the same time, an additional 40 ton force is exerted on pontoon 25 directly downwardly (representing the increase in ballast in pontoon 25), which produces a downward force of 28.3 tons on pontoon 25 at right angles to cable B in equal opposition to the 28.3 ton upward force thereon exerted by the 40 ton sideways force. The cable tension in cable B is also lessened by 28.3 tons.

FIG. 8g represents the system after the level responsive devices 81 and 83 have compensated for the sideways force, and FIG. 8h represents the forces acting on the system. The total buoyant force acting upwardly on pontoon 23 is 140 tons, and the anchor cable A tension is 198 tons; while the total buoyant force acting upwardly on pontoon 25 is 60 tons, with the cable B having a tension of 84.8 tons. It will be noted the combined vertical and horizontal forces acting on both pontoons 23 and 25, produce resultant cable forces at 45° angles downwardly, so that the platform is maintained at a level position.

It is to be noted that with a purely horizontal force applied, that the total cable tension in cables A and B remains at a constant value, although the individual tension in the different cables may vary, and thus the tension responsive device 60 is not actuated to operate switch 69.

If the sideways force had been applied to the system in any other direction than that just described, the operation of the level responsive devices would be the same, except that in such a situation all four of the level responsive devices would be tilted, and would actuate the pumps associated therewith, so that if any one corner of the platform were to tilt downwardly, the level responsive device at that corner would cause the pump in the pontoon at that corner to decrease the ballast and increase the buoyancy of that pontoon to compensate for the tilting. Similarly, if one corner of the platform tends to tilt upwardly, the buoyancy of the pontoon below that corner will be decreased to compensate for the tilting.

In the discussion thus far, the platform has been subjected to either purely vertical loads or purely horizontal loads. Any force applied to the platform can be regarded as made up of vertical and horizontal components, and the compensating systems thus described will compensate for each of these components simultaneously with the cable tension responsive device 60 compensating for the vertical force component, and the level responsive devices at 81, 82, 83 and 84 compensating for the horizontal force component.

Returning to FIGS. 7 and 8, let it be assumed that a

downward vertical force of 100 tons is applied at the same time that the 40 ton sideways force is applied. From the previous discussion, it has been found that 100 tons of ballast will be removed from the pontoons 23, 24, 25 and 26 to compensate for an addition of 100 tons to the platform, and thus switch arm 68 will close against contact 113 to energize relays 114, 115, 116 and 117 to actuate the pumps 29, 30, 31 and 32 to pump ballast out of each pontoon. However, as a result of the 40 ton horizontal force applied, the level responsive device 83 has been actuated to operate relay 107 so that the pump 31 will pump the ballast into pontoon 25 to level the platform. To avoid having pump 31 attempting to both pump ballast into and out of pontoon 25 at the same time, an interlock relay 126 is provided, to be energized by the closing of contacts 79 and 80 of level responsive device 83, so that when relay 126 is energized, it will open switch 127 to interrupt the circuit from switch 69 to control relay 107. In this manner, only a single of the control relays 107 and 116 can be operated at any one time. After the platform has regained its level position, the relay 126 will be de-energized, allowing switch 127 to close so that ballast may be pumped out of pontoon 25 to compensate for any vertical loading.

The pump 29 during this time has been energized by both the level responsive device 81 and the tension responsive device 60 to pump ballast out of pontoon 23. When the platform is level, the level responsive device contacts will open, but the pump will continue to pump ballast out of pontoon 23 until the tension responsive means is satisfied.

In a similar manner interlock relays 128, 129 and 130 have been provided so that if any of the level responsive devices 81, 82 or 84, respectively, signal that their respective pumps 29, 30 and 32 should be actuated to pump ballast into the pontoon, the tension responsive device cannot signal the pumps to pump ballast out of the pontoons. Similarly, interlock relays 131, 132, 133 and 134 are provided so that if any of the level responsive devices 81, 82, 83 or 84, respectively signal that their respective pumps 29, 30, 31 and 32 should be actuated to pump ballast out of the pontoons, the tension responsive device cannot signal the pumps to pump ballast into the pontoon.

In the control system thus described, the level responsive devices and tension responsive devices are each of a type wherein the devices give an "off" or "on" signal, with the level responsive devices overriding the tension responsive device in the control of the pumps in the pontoons. It is contemplated that other types of control systems may be used to accomplish the same overall function as that described herein, as, for example, the level responsive and tension responsive devices might be of the type wherein the magnitude of the change in level or tension is measured with suitable totalizing means being employed to summate the magnitude of the control signals in order to operate the ballast pumps in the pontoons to provide for the proper correction of ballast in the pontoon in accordance with the varying loading conditions on the platform.

In any event, if the buoyancy of the pontoons is controlled in accordance with the preceding description, the platform will remain at a fixed elevation above the floor of the sea and at a constant level position, even though the sea level may rise and fall due to tidal action and wave action, and even though sideways forces are applied to the platform, as from wind, water currents, or eccentric loading of the platform. Although FIG. 8 illustrates the platform as being canted a considerable amount from level with the addition of a sideways force, it is to be realized that such canting as illustrated is merely for the purpose of explanation. Under actual conditions of use, the sideways forces will be relatively

small and the inertia of the relatively large weight of the platform will prevent any sudden change in level position. It is desirable that the level responsive devices 81-84 be sufficiently sensitive to indicate a slight change from level position, and thus they will immediately start the ballast pumps into operation so that the pontoon buoyancies can compensate for the change in condition before the platform is tilted to any significant amount.

If, at any time, before or after exploratory drilling, it is desired to erect a permanent, caisson supported, oil production platform, such a platform is erected in the following manner. As illustrated, the permanent platform 150 is comprised of four vertically extending hollow caissons 151, 152, 153 and 154 connected together by conventional structural supports 156. The caisson structure is constructed in sections, with an uppermost section being added to the structure, and the whole platform 150 being then lowered in the water to provide working room at the top thereof to add another section. This operation is repeated until the bottom of the platform 150 extends to the bottom of the sea.

Each caisson 151-154 is plugged at the bottom thereof so that the interior of each caisson will be water-tight. In this manner, each caisson will be self buoyant so that the total weight on the platform will not be varied as the caisson grows in length. The platform structure 150 is sunk in the sea by introducing ballast into the caissons to overcome the buoyant force therein.

The axis of the permanent caisson structure 150 is maintained in a vertical direction at all times by the aligning guides 157 mounted on the platform 10 which center the upper end of the caisson structure, and by the caisson cables 161, 162, 163 and 164 acting on the bottom of the caisson structure. As seen in FIGS. 2 and 4, cable 162 is bifurcated to form a yoke which is secured to caissons 151 and 152, the cable 162 being passed around pulley 166 on anchor element 33 to extend upwardly to winch 168 on platform 10. In a similar manner, cables 161, 163 and 164 are yoked to the bottom ends of caisson 151-154 and are passed around the anchor elements 33 upwardly to winches 167, 169 and 170, respectively. Each time the caisson structure 150 is lowered into the sea, the winches 167, 168, 169 and 170 are operated to take up an equal amount of cable, so as to center the axis of the caisson structure 150 with the axis of the platform 10.

Since the top and bottom of the caisson structure is horizontally fixed relative to the platform 10, the pontoons 23, 24, 25 and 26 will serve to maintain the axis of the caisson structure in a vertical direction against any side forces thereon, as from underwater currents, in the same manner as has been described.

After the caisson structure 150 has been bottomed on the sea floor, concrete is dumped around the bottom of the caisson units to provide a permanent footing. The platform anchor cables 36-43 are then fixed to the upper end of the caisson structure 150, preferably under water level, to provide lateral stability for the upper end of the caisson structure. Since the platform anchor cables 36-43 are passed around the inner sides of pontoons 23, 24, 25 and 26 in relatively close adjacency to the caissons 151, 152, 153 and 154, the operation of transferring the anchor cables from the pontoons to the caisson structure may be easily carried out.

The pontoons are then discharged of their ballast so that the platform 10 may be floated away from the permanent caisson structure 150 for the next operation, and a permanent platform can be then built on the top of the caisson structure so that permanent drilling operations may be carried out. The hollow caisson will serve as well casings so that drilling operations may be

carried out therethrough without any possibility or danger of contamination of the sea.

If desired, other forms of permanent caisson structures may be built, as, for example, a single large caisson may be erected.

If desired, the platform 10 may be constructed with auxiliary pontoons 171 and 172 disposed beneath the upper platforms 11 and 12 in order to provide a safety factor in the event that the buoyant force from pontoons 23, 24, 25 and 26 should be insufficient at any time to support the weight of the platform.

In the discussion of the platform 10, a form thereof has been illustrated in which four pontoons have been employed. However, the invention is not intended to be restricted to a four pontoon system, since the same operation will result if a different number of pontoons is employed. As, for example, the platform will operate in the same manner if there are only three such pontoons, if the three pontoons are in a non-linear relationship, such that a vertical line extending through the centroid of the platform passes through the triangle defined by the pontoons. Similarly, the platform will operate in the same manner if more than four pontoons are employed. In each such arrangement, each pontoon must have a level responsive device associated therewith and responsive to the tilting of the platform in the vertical plane defined by such pontoon and the vertical axis of the platform, so as to be able to operate the pump within that pontoon to adjust the buoyancy thereof to compensate for the tilting of the platform in that plane. Also, in each such arrangement, a tension responsive device must be provided to be responsive to the total anchor cable tension, regardless of the number of anchor cables employed.

It is to be understood that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of my invention or the scope of the attached claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A floating platform comprising a platform structure, a plurality of buoyancy tanks secured to and spaced beneath said platform, a plurality of cables anchored at their lower ends and secured at their upper ends to the platform, said cables being tensioned with a sufficient total force to submerge the buoyancy tanks below their flotation level; means responsive to a change in total cable tension to adjust the buoyancy of said buoyancy tanks to maintain the total tension in said cables with said sufficient total force; and means responsive to a change from the level position of said platform for adjusting the buoyancy of said buoyancy tanks to maintain the platform in its level position.

2. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure; at least three anchor elements adapted to be disposed on the bottom of the sea; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; and means responsive to a change in the total cable tension to operate said pumps to change the buoyancy of said buoyancy tanks to correct for said change.

3. A floating platform of undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure; at least three anchor elements adapted to be disposed on

the bottom of the sea; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; and means responsive to an increase in total cable tension to operate said pumps to pump water into said buoyancy tanks and responsive to a decrease in total cable tension to operate said pumps to pump water out of said buoyancy tanks, whereby said total cable tension is maintained at a desired amount.

4. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear relation; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; means responsive to a change in the total cable tension to operate said pumps to change the buoyancy of said buoyancy tanks to correct for said change; and means responsive to the tilting of said platform structure from a level position for operating said pumps to adjust the buoyancy of said buoyancy tanks to bring the platform structure back to its level position.

5. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear relation; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; means responsive to a change in the total cable tension to operate said pumps to change the buoyancy of said buoyancy tanks to correct for said change; means responsive to a tilting of said platform structure; and means responsive to a change of the platform structure from its level position for operating said pumps to bring said platform structure back to its level position.

6. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear relation; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means

responsive to the total cable tension in said cables; means responsive to an increase in total cable tension to operate said pump to pump water into said buoyancy tanks and responsive to a decrease in total cable tension to operate said pumps to pump water out of said buoyancy tanks, whereby said total cable tension is maintained at a desired amount; a plurality of level responsive devices, one each associated with an individual of said buoyancy tanks; and means operated by a change from a level position by one of said level responsive devices for operating the pump associated with the buoyancy tank associated with said one level device to return said platform structure to its level position.

7. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear relation; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; means responsive to an increase in total cable tension to operate said pump to pump water into said buoyancy tanks and responsive to a decrease in total cable tension to operate said pumps to pump water out of said buoyancy tanks, whereby said total cable tension is maintained at a desired amount; means responsive to a tilting of said platform structure in a vertical plane through each one of said buoyancy tanks and the center of said platform; and means actuated by said responsive means for actuating the pump associated with the buoyancy tank in said any one plane to return the platform structure to level position in that plane.

8. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear relation; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means responsive to the total cable tension in said cables; means responsive to an increase in total cable tension to operate said pump to pump water into said buoyancy tanks and responsive to a decrease in total cable tension to operate said pumps to pump water out of said buoyancy tanks, whereby said total cable tension is maintained at a desired amount; means responsive to a tilting of said platform structure in a vertical plane through each one of said buoyancy tanks and the center of said platform; and means actuated by said tilting responsive means upon dipping of said platform structure from level in any one of said planes for actuating the pump associated with the buoyancy tank in said any one plane to pump water out of said buoyancy tank, and upon rising of said platform structure from level in said any one plane for actuating said pump to pump water into said buoyancy tank.

9. A floating platform for undersea operations comprising: a platform structure; a plurality of buoyancy tanks secured to and spaced beneath said platform structure, said buoyancy tanks being in a non-linear rela-

tion; at least three anchor elements adapted to be disposed on the bottom of the sea in a non-linear relation; a plurality of cable elements, each having one end fixed to one of said anchor elements and the other end extending to said platform structure; means on said platform structure to produce a tension on said cables to submerge said buoyancy tanks below the surface of the sea; a reversible pump operatively associated with each of said buoyancy tanks operable to pump water in or out of said buoyancy tanks to adjust the buoyancy thereof; means to vent said buoyancy tanks to atmosphere; means responsive to the total cable tension in said cables; and means responsive to a change in the total cable tension to operate said pump to change the buoyancy of said buoyancy tanks to correct for said change.

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