

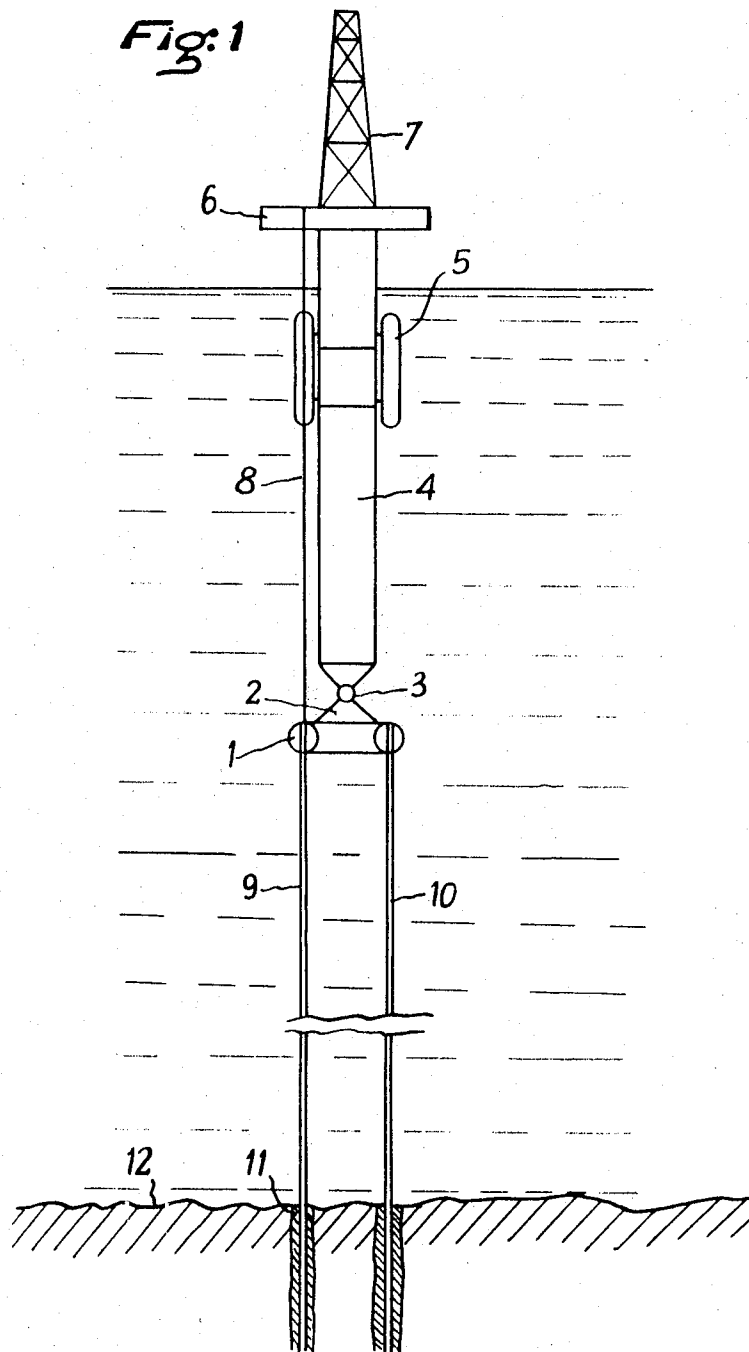
Dec. 14, 1971

71 M. LAFFONT 3,6
EMERGENT INSTALLATION FOR DRILLING AND PRODUCTION
AT GREAT DEPTH AT SEA

3,626,701

Filed March 26, 1970

8 Sheets-Sheet 1



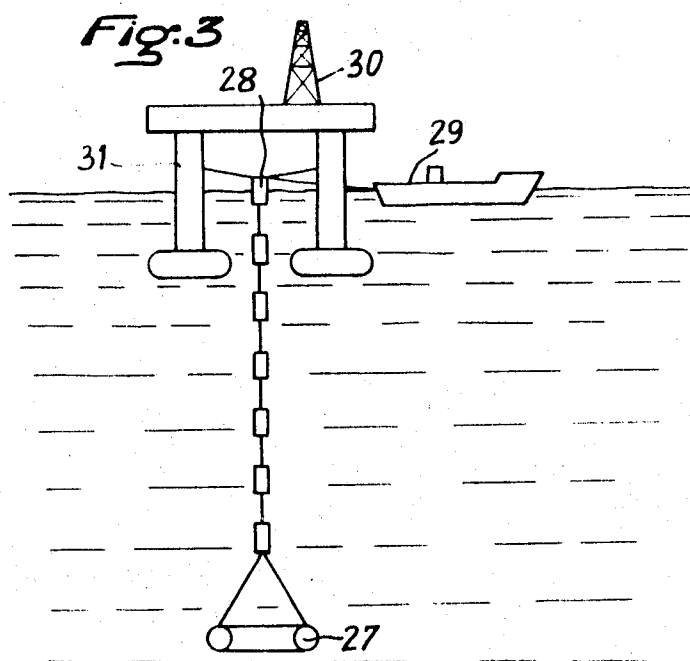
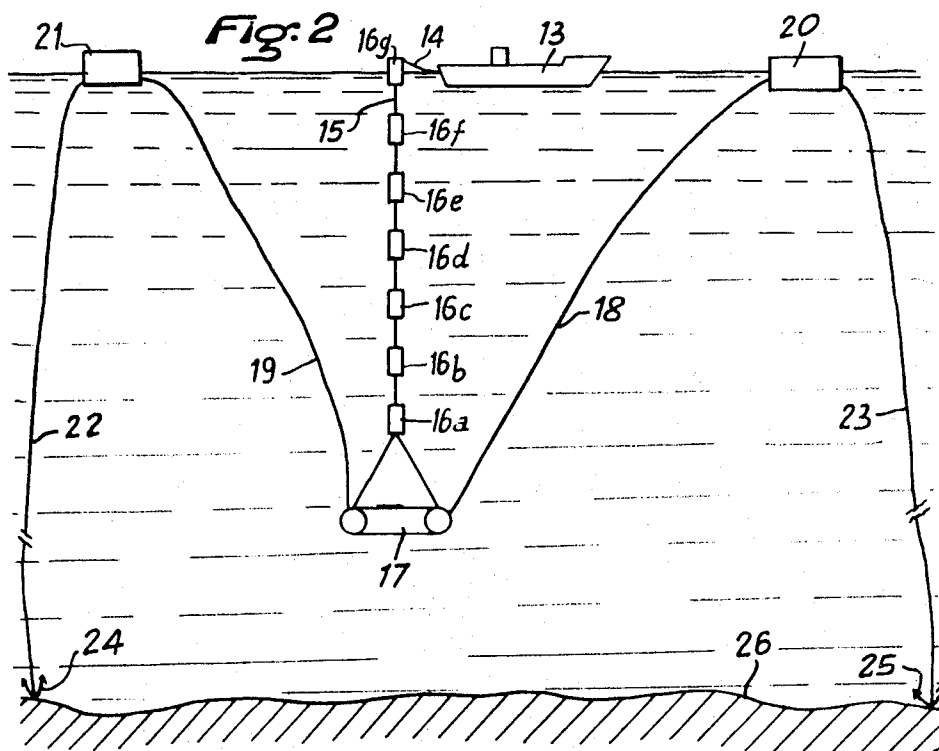
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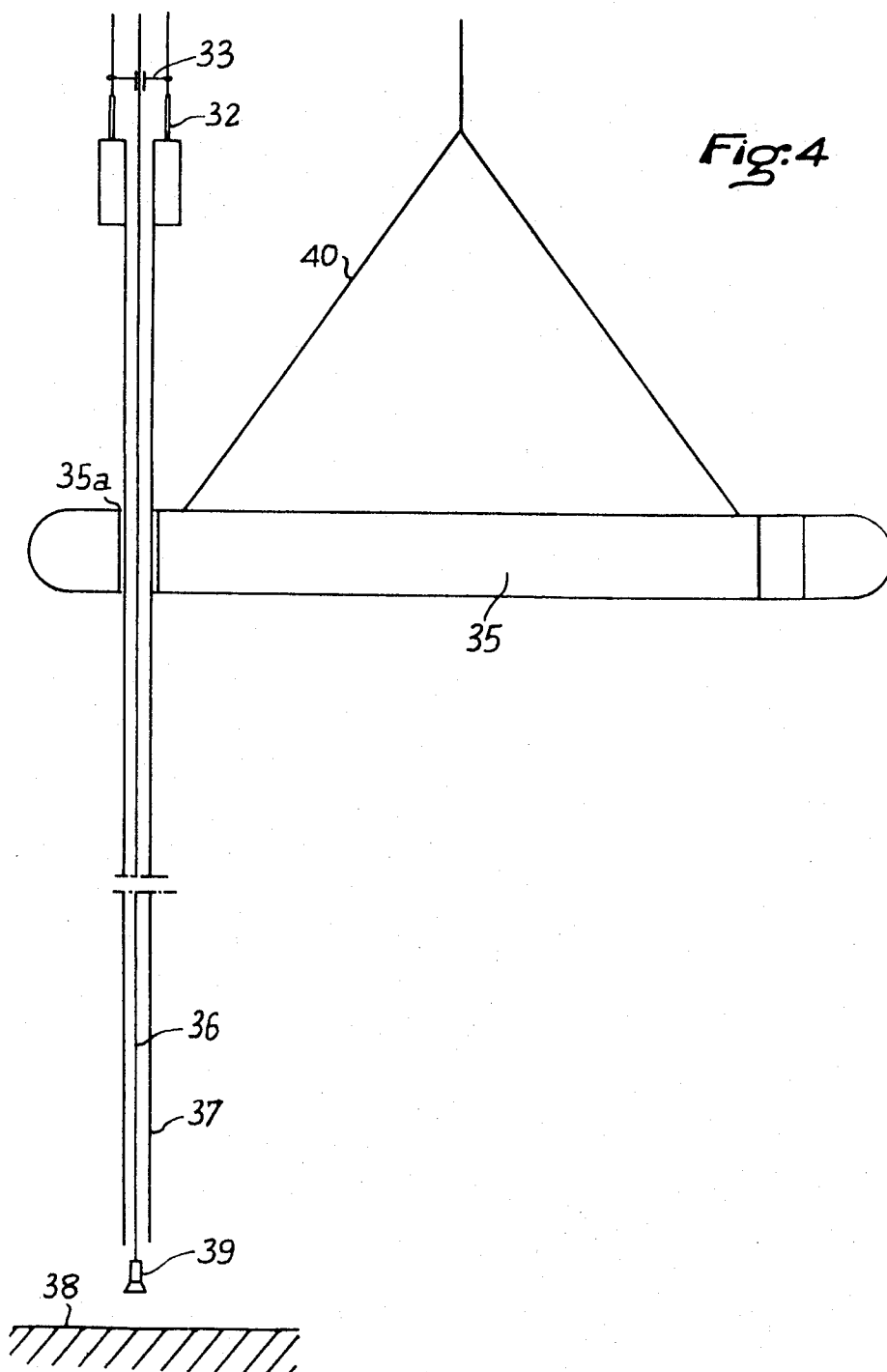
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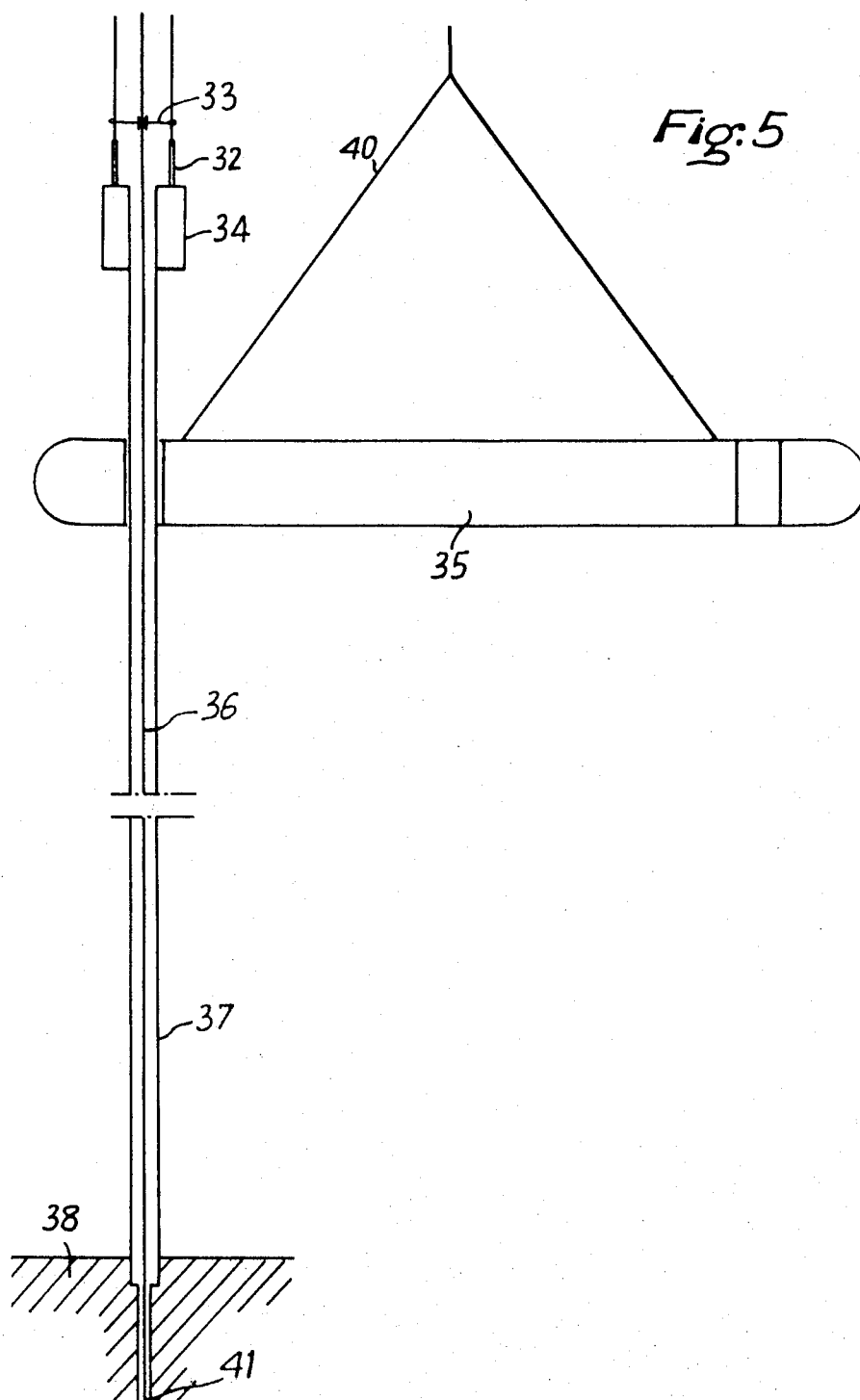
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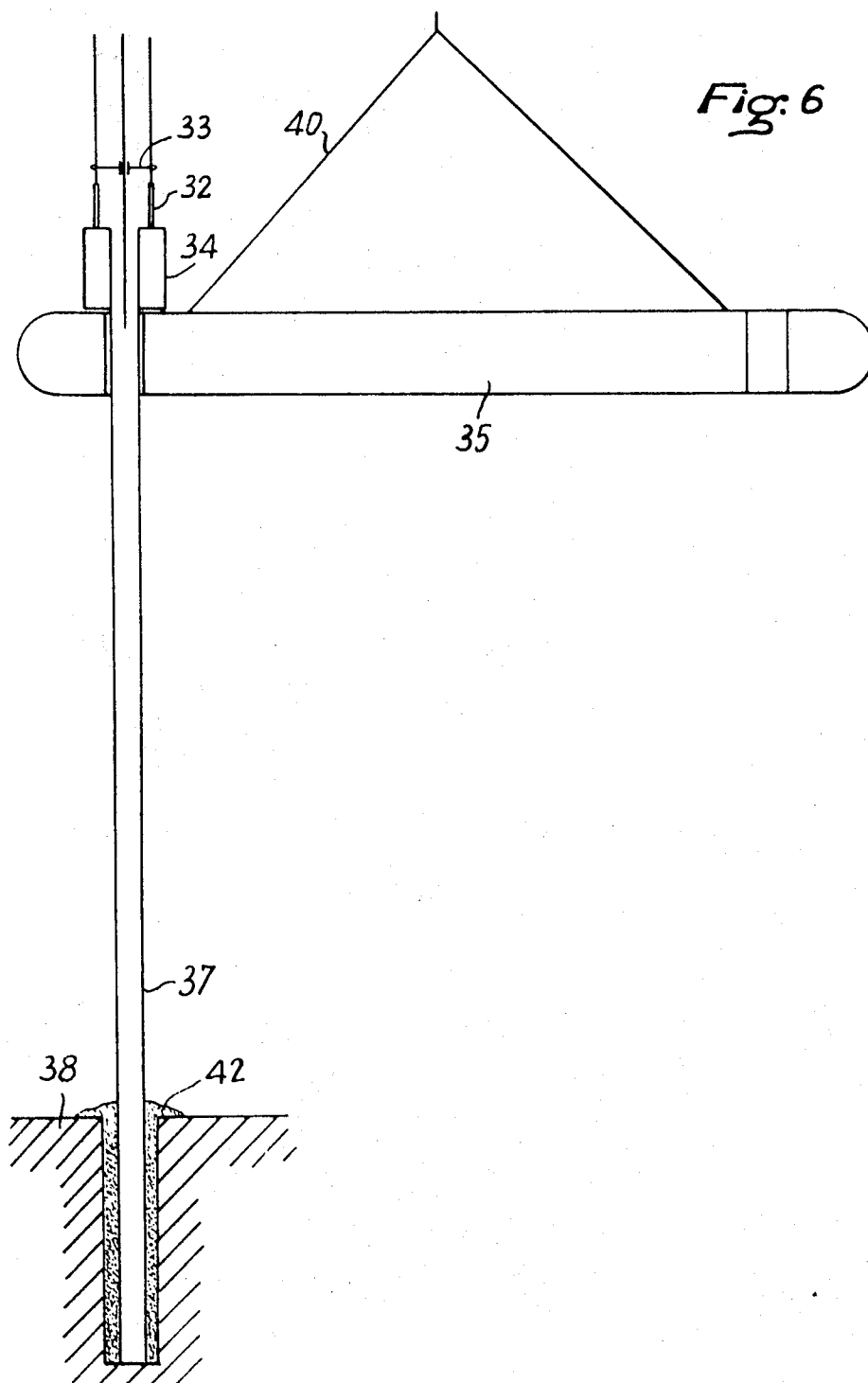
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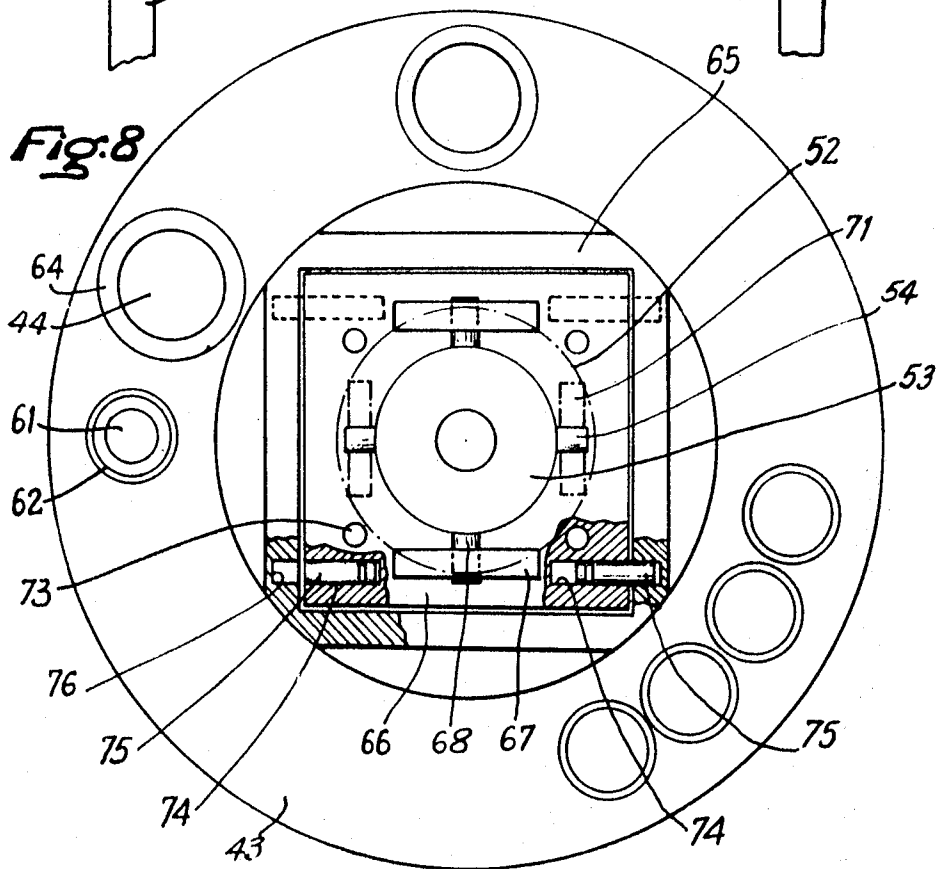
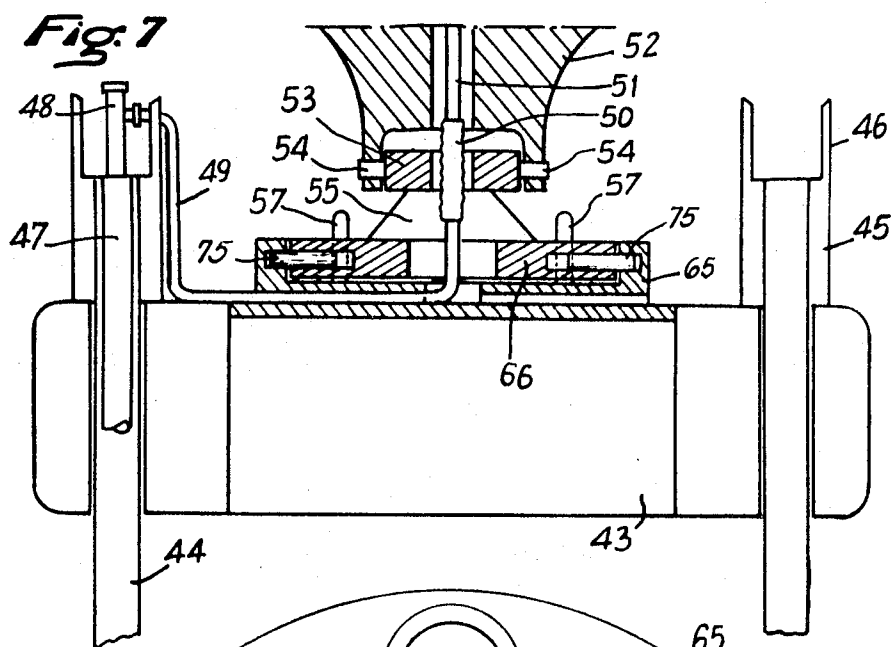
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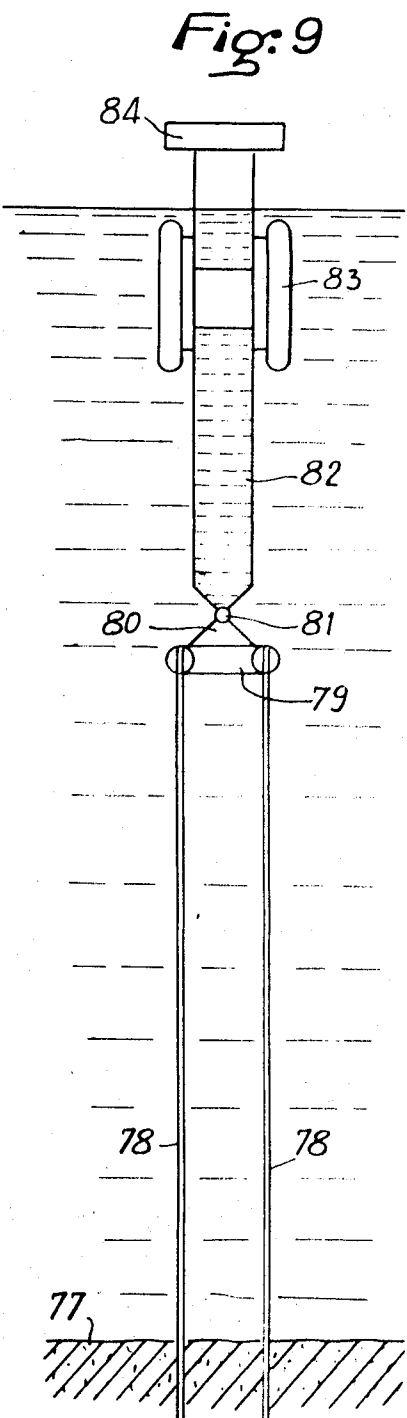
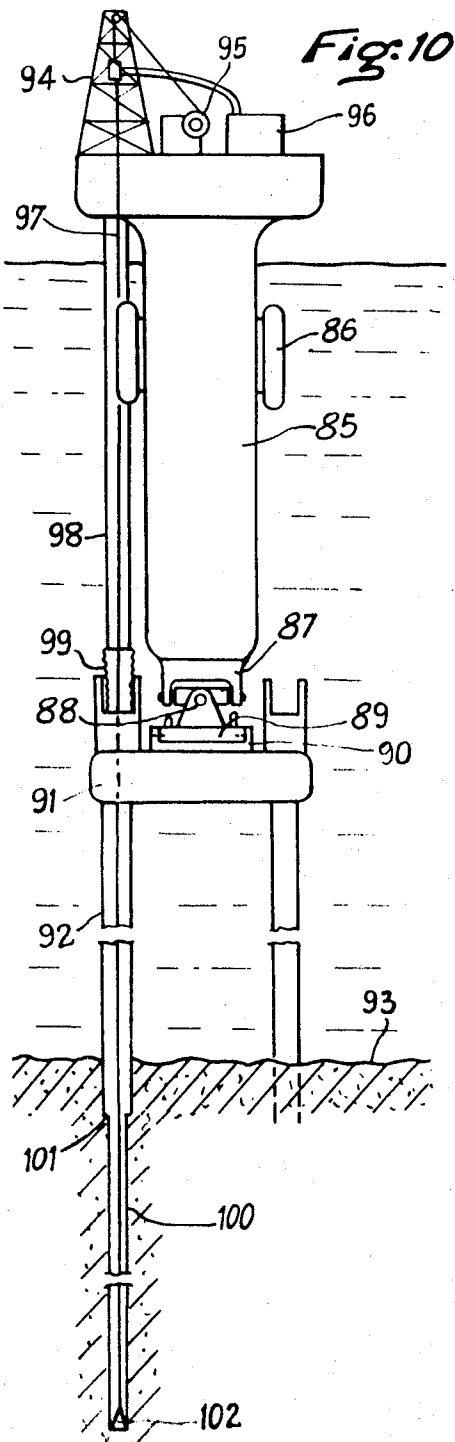
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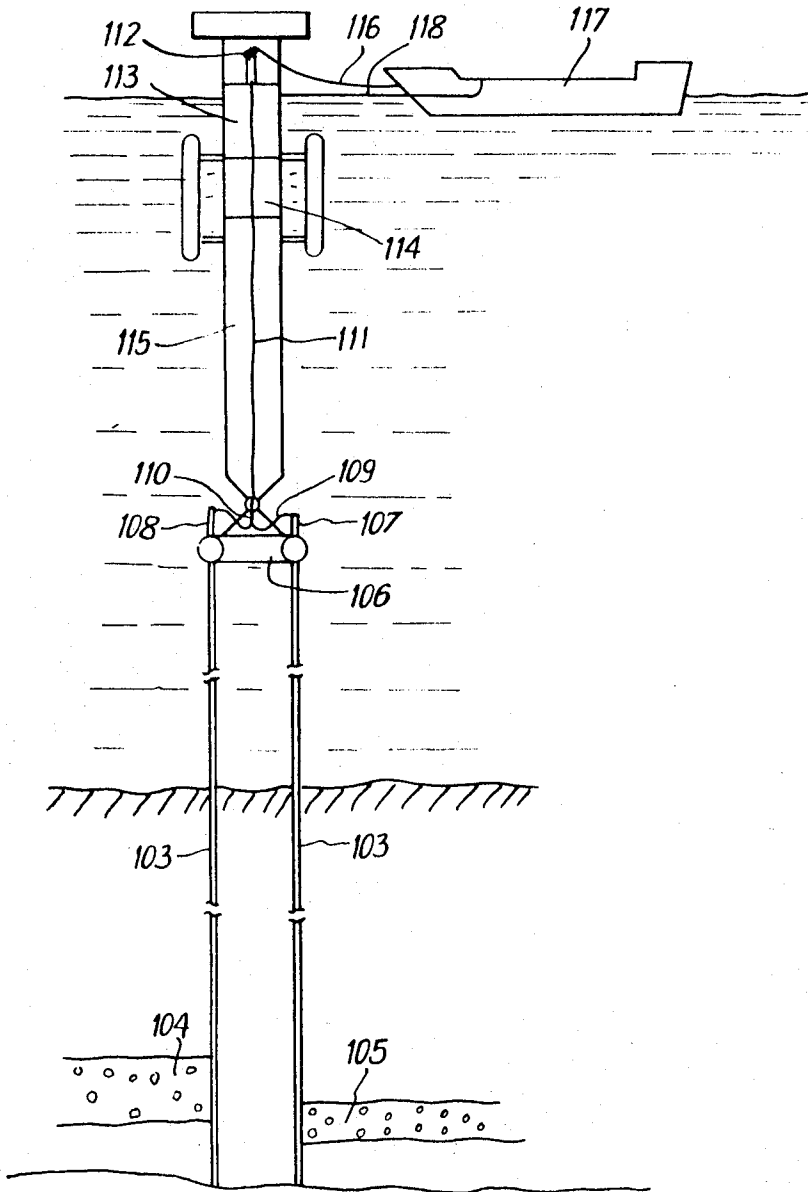
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Fig. 11



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EMERGENT INSTALLATION FOR DRILLING AND PRODUCTION AT GREAT DEPTH AT SEA
Maurice Laffont, La Celle-Saint-Cloud, France, assignor to Societe Nationale des Petroles d'Aquitaine, Paris, France

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U.S. Cl. 61—46.5

5 Claims

ABSTRACT OF THE DISCLOSURE

An emergent drilling and production installation for operating at great depths at sea, especially for the production of hydrocarbons from a field under the sea-bed, comprising the combination of an oscillating column having a positive buoyancy, supporting at its upper portion a drilling and production platform and articulated at its lower portion, with two degrees of freedom, on a base having a high positive buoyancy and fixed to the sea-bed at a pre-determined distance therefrom by anchorage members under tension driven and cemented into the sea-bed. The oscillating column may be provided with internal storage compartments for receiving part of the products obtained.

The invention relates to an emergent installation for drilling and production at great depth at sea, supported on an immersed structure maintained in a fixed position with respect to the sea-bed.

So-called oscillating platforms are already known, which are supported on an articulated column by a member giving two degrees of freedom on a base placed on the bottom of the sea; the column has a positive buoyancy created by floats arranged at its upper portion. Units of this kind are described in French Patent No. 1,519,891 and in the Review "Science et Vie" (February 1969, page 120); they may be utilized for drilling work and also for the production or even the storage of hydrocarbons, for example. However, the normal application of these platforms is limited to sea depths of a few hundred metres.

The present invention enables the difficulties encountered in deep water to be overcome, and provides emergent drilling and production installations which can be utilized at depths of more than 400 metres.

A drilling and production installation at great depths at sea according to the invention is characterized by the combination of a column with positive buoyancy supporting at its upper portion a drilling and production platform, articulated at its lower portion with two degrees of freedom on a base with high positive buoyancy, which is fixed to the sea bottom by traction elements having a length such that the articulation of the column on the base is maintained under tension.

According to one characteristic feature of the invention, the positive buoyancy of the base is very much higher than the maximum load which it is capable of receiving at any moment.

According to another characteristic feature of the invention, the base with positive buoyancy is coupled to the sea-bed, while remaining at a fixed distance from this latter, by means of a plurality of piles which are kept under tension by the force due to the positive buoyancy of the chamber.

Following a further characteristic feature of the inven-

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tion, the pull applied by the piles on the base is adjusted by the buoyancy given to the said base, thus ensuring relative stability of the base about its theoretical position.

The invention will be better understood from the description which follows below of one example of construction of the installation according to the invention, reference being made to the accompanying drawings, in which:

FIG. 1 shows a diagrammatic view of the whole installation;

FIG. 2 illustrates the lowering of the base to the desired depth in the sea;

FIG. 3 shows the placing in position of a service boat above the base for the purpose of fixing the said base;

FIG. 4 shows the lowering of a tube for fixing the base;

FIG. 5 illustrates the drilling of a centering hole for a tube intended for anchoring the base;

FIG. 6 shows an anchorage tube placed in position, and its coupling to the base of the platform;

FIG. 7 represents a vertical cross-section of the base when it has been placed in position;

FIG. 8 shows a view looking on the top of the base, illustrating a junction device between the base and the articulation element fixed to the foot of the oscillating column;

FIG. 9 shows the assembly of the base and the column after they have been coupled together;

FIG. 10 shows a utilization of this platform for drilling operations;

FIG. 11 shows a utilization of this platform for the storage of hydrocarbons.

In FIG. 1, there has been shown at 1 a base, preferably of metal, which is constituted by a chamber, the interior of which can be kept under air pressure. At 2 there has been shown the plinth supporting the articulation element 3 which coupled the whole of the base and the fixed support of the articulation element 3 to the column 4. This column is provided with floats 5 so as to give it at the same time a positive buoyancy and a restoring couple permitting its stabilization about a mean vertical position.

At 6 is shown the platform which is adapted to receive, above the surface of the water, all the equipments necessary for drilling and production. In particular, there is shown at 7 a drilling derrick which supports a train of rods 8. This train of rods is engaged in a tube 9 rigidly fixed to the base, and is engaged at 11 in the sea-bed shown at 12. There has also been shown at 10 a second tube coupling the base 1 to the sea-bed at a second point.

The base 1 is given a high positive buoyancy. It is held in position by a certain number of tubes such as 9 and 10, which are anchored to the sea-bed 12 and are subjected to a tensile force in consequence of the positive buoyancy of the base 1.

The chamber is thus stabilized. In fact, it is only affected by the sea currents, the effect of the swell being very small at the depth of immersion, which is of the order of 100 to 400 metres. The base is thus in a fixed position, and the oscillating column 4, 5, 6 which is also subjected to a positive buoyancy by means of the floats 5, only applies tensile forces to this base, at least during normal use. A supporting force is applied by the column 4 on the base 1 at the moment of immersion of the column 4, in order to permit the plinth 2 carrying the articulation element to be locked on the base 1.

FIG. 2 illustrates the placing in position of the base 17. For this purpose, the base having a large positive buoyancy is brought to the place of immersion by towing,

The base is then lowered by giving it a fairly small negative buoyancy which is compensated by the positive buoyancy of a series of floats 16a, . . . 16g, which are immersed successively. These floats are connected by a line 14 to a boat 13.

In order to guide the downward movement of the base 17, there is employed a series of mooring cables 18 and 19, connected to floating bodies 20 and 21 which are in turn coupled by anchor chains 22 and 23 to anchors 24 and 25 which are engaged in the sea-bed 26. The immersion of the base, which has been previously provided with one or a number of chains of floats, is also carried out when its buoyancy is slightly negative. The whole assembly being in equilibrium, the first float is filled in order to annul its buoyancy, which enables the base to be lowered to a certain depth. The various floats are then successively immersed, which permits the lowering of the base to be controlled in a very precise manner and permits its stabilization very exactly at a known depth.

FIG. 3 shows the base 27 after it has been put in position and suspended from the chain of floats 28. There is then brought above the position of immersion, a floating platform equipped for drilling and boring operations. This platform is shown at 31 and carries a drilling derrick 30. The boat which has been employed during the immersion operations is shown at 29. It is connected by a cable to the chain of floats 28 which supports the base 27.

Following one of the methods contemplated for fixing the base to the bottom, there have been shown in FIG. 4 at 32, two suspension cables which support a column of tubes 37 provided at its upper portion with a float 34 having a positive buoyancy. On these cables 32 there is fixed a guiding stirrup 33 provided with an opening at its central portion. Through this opening there is lowered a train of drilling rods 36 provided at its lower portion with an ultra-sonic transmitter-receiver device 39. The column of tubes 37 is first lowered from the surface to a depth slightly greater than the depth of immersion of the base 35, after which the train of rods 36 is lowered. By means of the ultra-sonic device and using orientatable jets of fluid, this train of rods can be guided and passed through one of the openings 35a formed on the periphery of the base 35. The train of tubes 37 can then be engaged in the same opening 35a, this opening having a diameter slightly greater than that of the tubes 37.

The train of rods 36 is then lowered until its lower extremity is in contact with the sea-bed. Three ultra-sonic transmitters having pre-determined frequencies have previously been prepared. By means of the transmitter-receiver, it is possible to know the position of the extremity of the train of rods with respect to the ultra-sonic transmitters. A similar method is described in French Pat. No. 1,417,248. By means of a fluid-jet piloting device, the extremity of the train of rods can be guided so as to bring it into a previously determined position.

When this operation has been completed and the column of tubes placed in position, the train of rods is withdrawn and a drilling tool is then fitted on its extremity.

In FIG. 5, the train of drilling rods provided with a boring tool 41 has been lowered, and there is drilled at the extremity of the column of tubes a pilot hole, as shown, in the sea-bed 38. When this pilot hole has been drilled, a widening tool is employed to increase the diameter sufficiently to be able to introduce the column of tubes into it and to cement the column in position.

The cementing operation is shown in FIG. 6. In addition to the two previous figures, the cement is shown at 42, permitting the anchorage of the train of tubes 37. After blowing out the chamber of the base, the latter has a positive buoyancy and is held against the lower surface of the floats 34.

The above operation is carried out a certain number of times, thereby permitting a series of columns of tubes to be placed in the periphery of the base, the various columns being arranged parallel to each other. There is thus

available a base which is fixed to the sea-bed by a series of tubes which are distributed as uniformly as possible. The base is thus fixed to the sea-bed by means of a series of 20 or 40 tubes for example, having a diameter of 250 to 500 mm. As these tubes are strongly anchored to the sea-bed, they can withstand a considerable tensile force, this force being obtained by giving the base a large positive buoyancy by driving out the water which partly filled the internal space of the base, by means of compressed-air injected from the surface.

FIG. 7 shows the detail of the base when it has been placed in position.

At 43 is shown the body of the base, which is a chamber into which water can be introduced so as to give it a very low apparent weight, after which this water may be expelled by compressed-air brought from the surface so as to give the base a large positive buoyancy. This base is held in position by tubes such as 44, installed in the manner indicated above. These tubes are provided at their upper portion with floats 45 which serve at the same time as floats for the adjustment of the weight of the column of tubes and as fixing members between the upper part of the column of tubes and the upper face of the base. At 46 there have been shown guides intended to facilitate subsequent operations for placing in position a production well-head.

At 47 is shown a petroleum well tubing which passes through the column of tubes 44. In fact, through the interior of tubes of large size, petroleum wells may be drilled, and the boring may for example be carried out in deviation, starting from the point of entry into the sea-bed. The anchorage tubes may also be separate from the well tubes.

The tubes are connected to a well-head 48. The production conduit 49 connects the well-head 48 to a flexible coupling 50 which is fixed on the one hand to the production conduit fixed rigidly on the base, and on the other hand to a tube 51 rigidly fixed to the column of oscillating platform 52.

This oscillating platform is articulated on the base 43. The lower part of the oscillating platform supports a first block 53 which can rotate about an axis formed by two trunnions 54 which are engaged in the portion 52. The block 53 is provided with two trunnions located on a perpendicular axis which is not shown in the drawing.

These trunnions are engaged in two parallel parts 55 supported by the column foot 66. This column foot is engaged at the moment when the column is placed in position on the base in a certain number of fixing devices 57.

In one possible form of construction, the column foot is provided on its periphery with a certain number of jacks 75. The sliding shafts of these jacks are passed into the column foot during the lowering of this latter. By applying pressure to the jacks, the sliding rods 75 are disengaged and come into position in housings provided for that purpose in a member 65 rigidly fixed on the base.

The fixing of the oscillating platform to the base is effected by locking with the jacks 75 and by guides 57 of the column foot 66 with the support 65 carried by the base.

There can be seen in the assembly, the base 43 having a positive buoyancy and held in position by the forces applied to the series of tubes 44 anchored to the bottom of the sea. This base supports the oscillating platform through the intermediary of the coupling. This platform has a slight negative buoyancy at the moment when it is placed in position. However, as soon as this operation is completed, the water is expelled from the floats of the oscillating platform, thus giving it a high positive buoyancy, greater than the load which the platform is intended to carry.

The base is subjected to the effects of sea currents, but the swell only produces limited forces at the level of the base.

On the other hand, the oscillating platform follows the movements due to the swell and surge of the sea.

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The assembly of the base and the oscillating platform is given a positive buoyancy greater than the maximum load which can be applied on the platform. This assembly is articulated at the level of the upper face of the base.

The depth of use of an assembly of this kind may reach 1,000 metres or even more. The assembly can also be utilized at relatively shallow depths of the order of about a hundred metres, although for shallow depths the advantage of this assembly is less.

FIG. 8 shows a plan view of the junction between the base and the oscillating platform. The base has been shown at 60 and in this case is of cylindrical shape, although bases of rectangular shape may be employed. In the vicinity of the periphery of this base are shown a series of tubes serving to fix the said base. There is indicated at 61 a tube of small diameter, essentially employed for fixing the base on the sea-bed, the contact surface between the fixing device of the tube 61 and the upper face of the base being shown at 62. At 44 there is also shown a tube of large diameter, the internal space of which can be employed for the passage of a tool or a production column. The junction of this tube and the base is shown at 64. As a result of its positive buoyancy, the base applies a support against this surface, which is constituted by a shoulder on the outer part of the tube 63.

There has been shown at 65 a mechanical member rigidly fixed on the base and secured to the central portion of this latter. This member 65 comprises a central recess of rectangular shape and housings 76 intended to receive jack pistons, as will be explained later.

The foot of the oscillating column has been shown at 66. This foot has a complementary shape to the recess of the member 65 and can be engaged in this recess. For the purpose of correct positioning of this column foot, the member 65 is provided with a certain number of guiding elements 73. The column foot 66 has two lugs 67, each of which receives a trunnion 68 rigidly fixed to a working member 53. In a direction perpendicular to the trunnions 68, this member 53 carries two trunnions 54 which engage in two lugs 71 fixed on the lower portion of the oscillating platform shown at 52.

There has been shown at 74 a series of jacks which are actuated by hydraulic pressure applied from the top of the column. In the position of rest, the pistons 75 of these jacks are located inside the chamber 74, the end faces of the jacks being at the level of the outer face of the column foot. Under the action of hydraulic pressure applied from the surface of the water, and after the column foot has taken up its position correctly in the interior of the member 65, the column foot is locked by means of these pistons by causing the pistons to move forward into the housings 76.

The swivel-joint assembly 67, 68, 69, 70 and 71 permits movement in two directions at right angles, that is to say the column is capable of oscillating in any direction. The tractive pull of the oscillating platform on the base is transmitted through the intermediary of the pistons 75 of the jacks.

FIG. 9 shows diagrammatically the whole of the oscillating platform, the base and the tubes which serve to anchor the said face. The sea-bed has been shown at 77. At 78 there can be seen the tubes serving as an anchorage for the base 79. These tubes are kept under tension by the buoyancy of the base which is in contact with the flanges fixed on the upper parts of the tubes. These tubes may be subjected to a few bending stresses due to the movements of the base under the effect of the sea currents, and to forces caused by the action of the sea on the articulated platform. These displacements are however limited.

The base carries the column foot 80 which in turn supports the swivel joint 81 which is fixed to the column 82 in the manner explained above. The column 82 is provided with floats 83 which on the one hand give it a positive buoyancy and on the other hand provide a restoring

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couple which gives it stability about the vertical position.

Above the level of the sea, the column is equipped with a platform 84 which can be used to support a drilling equipment or various production devices.

In the upper part of the column located above the surface of the sea, there may be arranged rooms intended for the staff and for the storage of products. The column may be equipped with tubes serving for the passage of production lines. It may also be provided with storage space for the temporary storage of hydrocarbons.

FIG. 10 represents an oscillating platform with an anchored base, which is employed in boring a well.

At 85, the column has been shown in the working position after it has been anchored on the base by pivotal movement of the column, which is brought to the place of working in a horizontal position, the pivotal movement being effected by ballasting the column. There can be seen the floats 86 described above, the fixing of the swivel joint 87, the column foot 89 and the support 90 rigidly fixed on the base 91, and the anchorage tube 92 for the base in the sea-bed, shown at 93. A drilling derrick is shown at 94; this is located on the platform carried by the column together with the winch 95 and the group of sludge pumps 96 and motors. It carries a train of drilling rods 97 which is first engaged in a tube 98 fixed on the oscillating platform. The tube 98 is coupled by a flexible connection 99 to one of the anchorage tubes of the base 91. The train of drilling rods is engaged inside this tube 92, and a well 100 can be bored with a diameter less than the internal diameter of the tubes 93. The corresponding shoulder is shown at 101 and the drilling tool is indicated at 102. The lengths of the tubes 92 may attain several hundred metres and the height of the column supporting the oscillating platform may be of the order of 100 to 400 metres.

FIG. 11 shows an assembly which can be utilized for the storage of hydrocarbon products obtained from an underground field. The tubes 103 passing inside the anchorage tubes of the base (anchorage tubes not shown) permit the exploitation of the fields shown at 104 and 105. These tubes terminate just above the base 106 in conventional well-heads 107 and 108. These well-heads are connected by production conduits 109 to one or a number of flexible couplings such as 110, coaxial with the column.

The tube 110 is connected to production conduits 111 fixed on the column. These tubes are closed at the level of the oscillating platform by a series of valves 112 which enable the production taken from the field to be directed either towards the various storage compartments inside the column, shown at 113, 114 and 115, or by a flexible conduit 116 to a ship equipped for the transport of hydrocarbons, shown at 117.

The base 106 is substantially fixed, while on the other hand the column is movable in rotation around the swivel joint. The lateral movement of the oscillating platform on the surface is of the order of a few metres. When the sea is not too rough, its oscillation of a few metres may be absorbed by the movements of the production conduit 116 and the cable 118 which enables the ship to be moored to the column.

What I claim is:

1. An off-shore structure comprising:

- a plurality of piles projecting upward from and held in fixed positions relative to the bottom beneath a body of water;
- a hollow base carried by said piles at a fixed distance from said bottom, said base having a positive buoyancy which maintains said piles under tension;
- a column having a positive buoyancy projecting upward from said base with its upper end projecting above the surface of said body of water;
- and a platform fixed to said upper end of said column; said column being attached to said base by pivot means permitting said column and platform to swing as a unit above said base in at least two generally vertical planes about a single central point.

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2. A structure as claimed in claim 1 in which the buoyancy of said base is greater than the maximum load it is to be required to suport, and comprising means for adjusting the buoyancy of said base.

3. A structure as claimed in claim 1 in which said base is formed with vertical openings through which said piles may be lowered from said base and said piles carry stop means which prevent the upper ends of said piles from passing all the way through the base. 5

4. A structure as claimed in claim 1 in which at least some of said piles are hollow tubes adapted to guide a drilling string terminating in a drilling tool, so that said tool may be lowered through said tubes to drill holes in the bottom to receive said tubes. 10

5. A structure as claimed in claim 1 in which said pivot means is a double-trunnion swivel joint carried at the lower end of said column, said lower end being adapted to fit in a complementary recess in said base and carrying 15

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a plurality of cylinders holding fluid operated pistons, said structure comprising means for actuating said pistons from said platform and projecting them beyond the ends of said cylinders into registering recesses in said base.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

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