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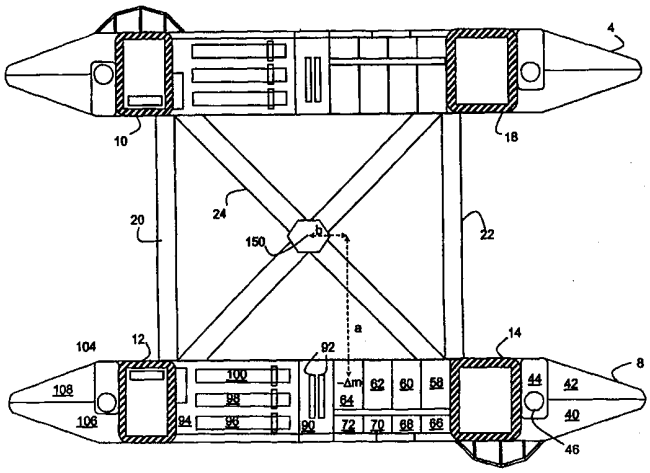

(57) Abstract

A semi–submersible structure is adapted to carry consumable solid or liquid material such as mud, and removable equipment, for example drilling tubulars. Both consumables and removable equipment are removed from the structure during use, thereby reducing the structure's total mass. The structure is provided with pontoon means (4, 8) containing a first set of compartments (66, 68, 70, 72, 84, 86, 88) for consumable material and ballast control means for introducing ballast into the first set of compartments to compensate for the removal of consumable material. The structure also includes dedicated ballast tanks (40, 42, 56, 106, 108), but the arrangement is such that, if the first set of compartments is empty, and no consumable material or removable equipment is being carried by the structure, the filling of the ballast tanks with ballast will not cause the structure to be submerged to an extent sufficient to achieve a semi–submerged condition (the structure therefore still being over–buoyant), whereas said condition would be achieved if the first set of compartments (66, 68, 70, 72, 84, 86, 88) were also at least partially filled. The structure thus includes "dual purpose" compartments which can accept either consumable materials or ballast, thereby increasing the effective deck load of the structure.

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Ballasting of Semi-submersible Rig

This invention relates to a semi-submersible structure and to a method of ballasting such a structure. The invention is of particular application to semi-submersible drilling rigs, such as are used in the field of oil extraction, but is also applicable to other types of semi-submersible structure, for example production rigs or tender rigs.

BACKGROUND OF THE INVENTION

Semi-submersible drilling rigs are generally regarded in the marine industry as being the most versatile of all drilling platforms. The rigs are capable of being used in shallow water or water which is too deep for self-contained fixed platforms.

Generally, such a rig comprises a platform which is supported on a pair of parallel elongate pontoons by a number of vertical columns, although many other shapes and geometrics of supporting structure are possible. The pontoons contain ballast tanks for allowing the rig to be partially submerged in a controlled manner.

When the ballast tanks are empty, the rig is in a transit condition, in which it floats on its pontoons and may therefore be readily transported, either by being towed or using an onboard propulsion system, to a site of interest. Once the rig has reached that site, ballast (ie sea water) is introduced into the tanks in the pontoons, causing the rig to become partially submerged. When ballasted down to the desired draft, the semi-submersible rig is in a semi-submerged condition, in which it provides a relatively stable platform from which the drilling operation can be conducted. When in this state, the rig is supported mainly by the immersed portions of the columns.

Numerous semi-submersible rigs have been designed, built and operated over the last thirty years, all striving to meet the

design goals of optimizing design size, weight, deck load and cost while ensuring that the two rig conditions can be achieved: a first, ballast free transit condition, and a ballasted, semi-submerged operating condition (in which the rig is stable).

To that end, various design considerations have to be taken into account, including

1. The pontoon size

2. The weight of the rig

3. The total volume of the ballast tanks

4. The volume of the rig legs

5. The positions of the centres of gravity and buoyancy of the rig (in both transit and semi-submerged conditions).

As a result, the rigs, when in the transit condition, are able to sail much like ships, but operate in a stable, fully ballasted and semi-submerged condition in which a relatively small surface area (i.e. that of the legs) is exposed to wave action.

It is desirable for the semi-submersible rig to be of as compact and cost effective a design as possible for a given deck load. However, constraints on the size of the rig design are imposed by the need to be able to accommodate various items of equipment and consumable materials for use in the drilling process. The equipment includes the drilling derrick, pipe handling equipment, and the or each engine (usually an internal combustion engine such as a diesel engine) for providing the power to operate the rig. Such an engine is generally referred to as a prime mover.

For the purposes of the present specification, consumable materials for a drilling rig are defined as solid or liquid

materials which are used up or taken off the rig during the drilling process, thereby reducing the rig's gross mass. Thus the consumable materials include drilling mud or the initially separate solid and liquid constituents of the mud, and fuel oil for operating the prime mover. During operation, the total mass of the rig is also reduced by the removal or deployment of drilling equipment, for example drilling tubulars (such as drill pipes, casings and risers). Such items of equipment are hereinafter referred to as removable equipment.

It will be appreciated that other types of semi-submersible structure may carry different consumable materials and items of removable equipment.

In order to be able to maintain the necessary draft in all possible operating conditions, known types of semi-submersible rigs need sufficient capacity for ballast to maintain stability of the rig both with and without the consumable materials, and/or drilling equipment (such as drilling tubulars) on the rig.

The present invention seeks to provide a semi-submersible structure which is of a more compact design while providing a relatively large deck load and starting capacity, and flexibility in deep sea conditions. A preferred form of invention seeks to enhance the provision of storage for equipment and consumables on the rig while limiting the size of the pontoons and still providing a sufficient amount of ballast to enable the structure to achieve the desired draft in its semi submerged condition.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a semi-submersible structure having a transit condition in which the structure is movable to a site of use, and a semi-submerged condition in which the structure is sufficiently stable to be

used at said site, the structure being adapted to carry consumable solid or liquid materials and removable equipment, which are to be removed therefrom during use, the structure comprising pontoon means containing first compartment means for containing consumable liquids, ballast control means for introducing ballast into the first compartment means to compensate for the removal of consumable materials from the structure, and second compartment means for receiving ballast, wherein the arrangement is such that, if the first compartment means were empty and no consumable material or removable equipment is being carried by the structure, the filling of the second compartment means with ballast will not cause the structure to be submerged to an extent sufficient to achieve said semi-submerged condition (it is in this sense "over-buoyant"), whereas said condition would be achieved if the first compartment means were also filled.

Conventionally, the pontoons of semi-submersible structures can provide little or no storage for consumable materials or equipment. In order to provide such storage, a pontoon of conventional design would have to be of a considerably larger volume than would otherwise be necessary. This in turn would increase the amount of ballast water which would have to be held by the structure if it is to achieve its semi-submerged condition, thus negating the advantages of using the pontoons for storage. The problem would not be solved by designing the pontoon to have an increased capacity since this would further increase the volume, and hence displacement, of the pontoons, and would correspondingly increase the amount of ballast which the structure would have to be able to hold.

By contrast, the pontoon means of a structure in accordance with the present invention can provide a significant amount of storage for consumable materials, since the same part of the pontoon means, ie the first compartment means, can be used to hold consumable liquid and ballast, thus decreasing the proportion of the pontoon means (relative to conventional design) which is required for dedicated ballast tanks.

Indeed, the pontoon means can be designed to provide further storage in addition to that provided by the first compartment means, and to that end preferably includes third compartment means for housing other consumable materials or fixed equipment.

The consumable materials contained in the third compartment means may, for example, comprise fuel oil, drilling equipment or anchor lines. Preferably, the third compartment means comprises a compartment of sufficient size to house at least one prime mover for the structure.

The situating of one or more prime movers in the pontoon means not only increases the amount of usable space (for a given size of structure) above the pontoons, but also significantly lowers the center of gravity of the structure, giving rise to a significant increase in deck load capacity for a given steel weight of the structure.

Preferably, the first compartment means comprises a plurality of tanks for the consumable liquid and ballast. Furthermore, the structure is preferably adapted to carry a sufficient weight of consumable materials, outside the first compartment means, to enable the semi-submerged condition to be achieved when at least one of the tanks of the first compartment means is empty.

Consequently, the ballast control means can be arranged to add water only to those tanks of the first compartment means which contain substantially no consumable liquid, thus enabling ballast to be added to those tanks even if the consumable liquids must not be mixed with the ballast.

According to a second aspect of the invention, there is provided a semi-submersible structure comprising pontoon means having first compartment means for containing consumable liquid, second compartment means, exclusively for containing ballast, and ballast control means for adding ballast to the first compartment means, wherein the capacity of the second

compartment means lies in the range of 40% to 45% of the total volume of the pontoon means.

Preferably, the capacity of the second compartment means is approximately 40% of the total volume of the pontoon means.

It has been found that, when the structure is in its semi-submerged condition, the pontoon means should constitute 70% of the total volume of the submerged portion of the structure, if the structure is to have the desired stability. Accordingly, if all the ballast compartments are to be housed in the pontoon means, those compartments must be able to receive a volume of water equivalent to at least 30% of the total submerged volume of the structure in order to counteract the increase in displacement as the structure moves into the semi-submerged condition. This defines the lower limit of the above range: if the capacity of the second compartment means is less than approximately 40% of the pontoon volume, the semi-submerged condition will not be achieved by flooding the second compartment means if, before said flooding, the pontoon means were at the water surface.

The same criterion applies to conventional semi-submersible structures, but such designs require additional capacity in their ballast tanks to take into account the removal of consumable materials or removable equipment on deck. On the other hand, a structure in accordance with the present invention does not need the extra capacity since the first compartment means is also used to contain ballast water when necessary.

If the capacity of the second compartment means exceeds 45% of the volume of the pontoon means, then the structure will sit too high in the water when in its transit condition (with the second compartment means empty), and the pontoon means would be larger than is necessary.

According to a third aspect of the invention, there is provided a semi-submersible structure adapted to carry consumable solid

or liquid materials to a site of use, the structure comprising pontoon means having first compartment means for containing consumable material, second compartment means for containing ballast, sensing means for detecting the amount of consumable material in the first compartment means and ballast control means connected to the sensing means and arranged to introduce ballast water to the first compartment means to compensate for the loss of mass due to the removal of consumable material.

Preferably, the first compartment means comprises a plurality of tanks, and the ballast control means is arranged to add ballast to one or more selected tanks that no longer contain consumable material.

The invention also lies in a method of ballasting a semi-submersible structure having pontoon means which include a plurality of tanks containing consumable liquids, which are progressively extracted from the tanks during use of the structure, the method comprising determining which, if any, of the tanks has been substantially emptied of consumable liquid and introducing ballast into that tank or at least one of those tanks.

Preferably, if a plurality of tanks containing the same type of consumable liquid are partially full, the method further comprises determining whether the volume of consumable liquid remaining in one of the tanks is less than or equal to the spare capacity of the other tank or tanks, and if it is transferring the liquid to said other tank or tanks to enable said one tank then to receive ballast.

Preferably the structure is an offshore drilling rig.

Preferably, the pontoon means comprises a pair of elongate, parallel, spaced apart pontoons.

These and other features of the invention, preferred embodiments and variants thereof, possible applications and advantages will

become appreciated and understood by those skilled in the art from the following detailed description and drawings.

DRAWINGS

FIG. 1 is a perspective view of the rig, when in its semi-submerged condition;

FIG. 2 is a side elevation of part of the rig;

FIG. 3 is a partially sectioned, partially cut away plan view of the rig, the section being taken along the plane of the water line indicated in FIG. 2;

FIG. 3 is a cut away plan view of a pontoon for the rig;

FIGs. 4 to 10 are sectional end views of the pontoon taken along the lines V-V to X-X respectively;

FIG. 11 is a sectional plan view taken along the line XI-XI of FIG. 6;

FIG. 12 is a sectional view taken along the line XII-XII of FIG. 10;

FIG. 13 is a schematic view of the system for controlling the ballast for the rig; and

FIG. 14 is a table giving examples of sizes of various parts of the rig structure..

MODE(S) FOR CARRYING OUT THE INVENTION

With reference to FIG. 1, a semi-submersible drilling rig comprises a platform 2 mounted on a pair of elongate, parallel

pontoons 4 and 8 through columns 10, 12, 14 and 18. In order to provide additional rigidity to the structure, the rig includes fore and aft lateral bracing members 20 and 22, extending between the columns 10 and 12 and 14 and 18 respectively and cross-bracing members 24 extending between diametrically opposed pairs of the columns. Each of the pontoons 4 and 8 is provided with a respective pair of thrusters, three of which are shown in FIG. 1 at 26, 28 and 30 driven by electric motors housed in pontoons 4 and 8. The azimuth of each of the thrusters is adjustable to enable the thrusters to be used in the dynamic positioning of the rig, ie to counteract any tendency of the rig to drift away from a drilling site on the sea floor. In addition, when the rig is in its transit condition, the columns 10, 12, 14 and 18 are substantially entirely above the water line and the thrusters can be used to transport the rig to a site of use. The fourth thruster is shown at 27 in FIG. 2.

The rig includes a derrick 32 mounted at its aft end, and racking (not shown) for drilling tubulars, ie drill pipes, drilling casings and drilling risers, (not shown) is situated adjacent the derrick 32. As can be seen from FIG. 2, the aft columns 18 and 14 are of a larger cross-sectional area than the fore columns 10 and 12. When the rig is in use, this reduces any pitch caused by change of load at the aft end of the rig since any such change would tend to be counteracted by the increased change in displacement caused by the columns 18 and 14.

Each of the columns 14 and 18 also includes a tank for containing potable water. The tank in column 12 is denoted by the reference numeral 38.

Each of the fore columns 10 and 12 includes containers, such as are denoted by reference numerals 34 and 36 (and 34' in FIG. 10), for solid powder which is to be mixed with brine or drilling water to form mud. The columns 10 and 12 each house a respective chain locker (not shown), whilst all four columns

include elevators to facilitate access to the interior of the pontoons 4 and 8.

As can be seen from FIG. 3, each of the pontoons 4 and 8 is divided into a number of compartments. The arrangement of compartments is substantially identical, and only the compartments of the pontoon 8 will therefore be described with reference to FIG.s 4-10.

The pontoon 8 includes two aft ballast tanks 40, 42 situated adjacent a thruster chamber 44 for housing a 7,000 or 8,000kw electric motor 46 for the thruster 27. Adjacent the tanks 40, 42 and the chamber 44 is a winch room 48 located beneath the base of the column 14. The winch room 48 contains a winch 50 for anchor cable for the rig. A further dedicated ballast tank 52 is situated at one side of the chamber 48 opposite a tank 54 for base oil. A further ballast tank 56 is located beneath the floor of the chamber 28 (see FIG. 6).

In front of the chamber 48, the pontoon contains a pair of drill water tanks 58 and 60 adjacent which a pair of fuel oil tanks 62 and 64 are situated. Each of the tanks 58, 60, 62 and 64 abuts a respective one of four reserve mud tanks 66, 68, 70 and 72. Each of the reserve tanks includes a respective level sensor and a pair of pumps for pumping liquids into and out of the reserve mud tanks.
Two of the level sensors (for the tanks 68 and 70) are shown, referenced 152 and 154 in FIG. 13. That FIG. also shows the pair of pumps, referenced 114 and 133, for the tank 68, and the corresponding pumps 116 and 130 for the tank 70.

Each of the reserve mud tanks is fitted with a respective one of four stirrers, 74, 75, 76 and 78, and is provided with a respective access hatch, for example as is shown at 80 and 82 in FIG.s 7 and 8.

Three brine tanks 84, 86 and 88 are interposed between the reserve mud tanks and the outer skin of the pontoon 4. An electrical control room 90 situated immediately in front of the tanks 64 and 78 contains power distribution switch gear 92 for distributing power generated by three prime movers situated in the next compartment 94. Each of the prime movers, referenced 96, 98 and 100 comprises a 4.4 megawatt diesel engine connected to a respective electrical generator.

With the prime movers 96, 98, 100 located in the pontoon 8, it is necessary to convey, treat and in some instance store all of the operating consumables (fuel, air, lube oil, etc) to the machinery spaces in the pontoon 8.

Fuel is loaded at the levels of the main deck via a fuel loading system (not shown), and stored in the main fuel tanks 62 and 64. From these tanks, it is treated/filtered and then pumped to and stored in a secondary tank 200 periodically as required. From these secondary tanks, the treated fuel is pumped to the engines on demand, via a series of supply lines which may be fitted with inline filters. In the event that the fuel pumping system is inoperable, the fuel is transferred to the engines on demand via gravity transfer. This is achieved via a secondary fuel supply line (not shown) which bypasses any inline filters, when a normally closed electric solenoid valve is de-energised either through loss of power (black out), on command from the engine/power management system (automatic, or operator requested), or via manual intervention. Fuel delivered to the engines in excess of the demand is returned to the secondary storage tank via a fuel return line (not shown). All fuel tanks are vented at the main deck level.

Air required for combustion is supplied to the prime movers via a series of coarse filters, fine filters and any secondary treatment to preheat, cool or assist with the conveyance (fan/blower) of the air via duct work as required. The ductwork is fitted with sufficient means to isolate the engine intakes from the ductwork in the event of downflooding, or gas ingress. The duct intake(s) are located at the main deck level, and are

situated along the side of the deck box in such a way as not to interfere with the main deck space, and draw air from a safe area (non classified space). These intakes are fitted with the necessary equipment to ensure that wind/wave borne water spray does not invade the intake ductwork. The intakes are also fitted with the equipment required to insure the watertight integrity of the unit should the duct intake become submerged.

Ventilation for the machinery space(s) in the pontoon 8 is forced, and provided via a series of coarse filters, fine filters, and any secondary treatments required, and ductwork. The air is supplied in sufficient quantity to adequately remove any excess/waste heat generated by the prime movers and related machinery, as well as all ancillary and propulsion equipment and machinery. The ductwork is fitted with sufficient means to isolate the machinery spaces from the ductwork in the event of downflooding, or gas ingress. The duct intake(s) are located at the main deck level, and are situated along the side of the deck box in such a way as to not interfere with the main deck space, and draw air from a safe area (non classified space). These intakes are fitted with the necessary equipment to ensure that wind/wave borne water spray does not invade the intake duct work. The intakes are also fitted with the equipment required to insure the watertight integrity of the unit should the duct intake become submerged. The ventilation ductwork is arranged in a configuration which ensures adequate air movement within each space to prevent the accumulation of heat, vapours, and moisture, (no isolated pockets of air). The ventilation exhaust is returned to surface via ductwork and exhausted to a safe area. The exhaust duct work is fitted with the same facilities for ensuring isolation and water tight integrity as the intake duct work. The exhaust air is not treated or filtered.

Prime mover exhaust is conveyed to the main deck level via shielded exhaust manifolds 156 and ductwork. The shielding is designed to minimise the heat radiated into the machinery spaces, void spaces, columns etc in the vicinity of the manifolds and ductwork. The exhaust ductwork is fitted with

sufficient means to isolate the primemover exhaust manifolds in the event of downflooding. Additionally, the exhaust ductwork can be fitted with spark arresting facilities.

Prime Mover control is provided via an engine and power management system, which incorporates facilities for automatic, remote and manual operation of the engines, as well as alarm and supervisory functions. The system is designed to selectively start or shut down primemovers as required, as well as initiated emergency shutdown ensuring that the vessel integrity is maintained by isolating fuel, air and exhaust ducting as required.

Ancillary vessel services, such as compressed air for engine starting, air tools and fresh/potable water, etc are provided via the respective distribution networks (not shown) with sufficient takeoff connection points to enable efficient operations.

Further information on housing the prime movers in the pontoon is given in the UK Patent Application entitled Semi-submersible Structure filed concurrently herewith under case reference 694/S.

Compartment 94 is situated adjacent the base of the column 12, which overlies a further ballast tank 102. A further, substantially C-shaped ballast tank 104 extends behind the floor, ceiling and one wall of the room 94.

The front of the pontoon 8 houses another 7,000 or 8,000kw thruster motor 104 for the thruster 26 and two fore ballast tanks 106 and 108 similar to the tanks 40 and 42.

The first tank means of the pontoon 8 is constituted by the drilling water tanks 58 and 60, the reserve mud tanks 66, 68, 70 and 72 and the brine tanks 84, 86 and 88.

Each of these tanks accordingly is connected to inlets for its consumable liquid, ie drilling water, mud or brine, and for ballast water. Similarly, the tanks are connected to outlet conduits either for ballast water to be expelled and for the consumable liquid to be used. The ballast tanks 40, 42, 52, 54, 102, 104, 106, and 108, however, only accept ballast, and only have outlets for ballast discharge. Accordingly, these are dedicated ballast tanks which constitute the second compartment means of the pontoon 8. The remaining compartments/spaces in the pontoon 8 constitute the third compartment means.

In the present example, the pontoon 8 has a total volume of approximately 11,000 m^3, the dedicated ballast tanks, ie the second compartment means, have a combined capacity of approximately 4,500 m^3, whilst the drill water, brine and reserve mud tanks have a total capacity of approximately 1,700 m^3. Thus the capacity of the dedicated ballast tanks amounts to approximately 40% of the volume of the pontoon 8. The capacities of the individual tanks are set out in the table of FIG. 14.

In a paper entitled "The Design Process of the Semi-Submersible Drilling Vessel "DSS-20"" P J Shepman, J A van Santen and C Y Ho discuss the various factors influencing the design of the pontoons and the columns of a semi submersible rig.

From these discussions, it can be deduced that, with the rig in its semi-submerged condition, the volume of the submerged columns should constitute around 30% of the total volume of water displaced by the rig, whilst the volume of the (submerged) pontoons therefore amounts to 70% of the total submerged volume. Accordingly, at least 40% of the volume of the pontoons must be capable of being flooded with ballast water in order to counteract the buoyancy of the columns, so that the rig may move from its transit condition into the semi-submerged condition. However this is not achieved if the drilling water, reserve mud and brine tanks are empty and no other consumables are being carried by the rig. Consequently, when one of the those tanks

has been emptied of its consumable liquid, it is important for it to be available for ballast. FIG. 13 shows an example of one ballast control system for achieving this.

The ballast control system will only be described in relation to the reserve mud tanks 75 and 76, although it will be understood that the system operates on the other tanks constituting the first compartment means in a similar fashion.

Each of the tanks 75 and 76 has a respective inlet 110 and 112 for recirculated drilling mud or ballast. Each inlet is associated with the respective pump 114 and 116 for filling the tank with whichever liquid is required. The inlet to each pump can be selectively connected to any one of a mud supply conduit 118, a ballast water supply conduit 120 or a mud transfer conduit 122 by means of valves 123 to 128. A similar arrangement of pumps, 130 and 132 and valves 133 to 138 can be used to selectively supply liquid from each tank via a respective outlet to a selective one of a ballast water discharge conduit 140, a mud outlet conduit 142 or a transfer conduit 144 and 156 which is in turn connected to the inlet of another of the reserve mud tanks.

The operation of the valves and motors is all controlled by a control unit 148. The controller is also connected to the level sensors 75 and 76 and, in use, monitors the level of drilling mud in the reserve mud tanks. If mud is required from any of those tanks, a mud supply system (not shown) sends an appropriate signal to the controller 148, which supplies mud along the conduit 140 using either the pump 132 or the pump 130 (or both). As this happens, the controller 148 continues to monitor the level of mud in each of the tanks, and when one of the tanks is empty, closes the valve connecting the outlet of that linked to the conduit 142, and opens the valve between the inlet of the tank and the ballast conduit 120. The pump 114 or 116 is then operated to urge water into the reserve mud tank (which now no longer contains mud) if necessary in order to maintain the desired draft and orientation of the structure. If

one of the reserve mud tanks is almost empty, and the other has spare capacity, the controller 148 may open the valve 135 or 138 and 128 or 123 and thus allowing mud to be pumped from one of the reserve mud tanks to the other, thus freeing the first of those tanks to receive ballast.

The brine and drilling water tanks can similarly be filled with ballast once emptied of their consumable liquids.

The controller 148 controls all of the tanks which can receive ballast (in both pontoons), and is programmed so that the moments about the structure's centre of gravity caused by the removal of liquid from any of the tanks are balanced by the moments caused by the introduction of compensating ballast to other tanks. Thus, referring to FIG. 3, the removal of m kg of mud from the tank 60 produces a moment of m x a and m x b about the centre of gravity 150. In order to compensate for this, the liquid introduced into the other tanks must be equal and opposite moments about the centre of gravity 150. This requirement can be expressed in the form of series of simultaneous equations (which may have a plurality of solutions). In addition, the controller may also be connected to equipment for detecting the pitch or roll in the structure and to add or remove ballast to compensate for this movement.

The structure can be modified so that they form part of the first compartment means, and can be used either to store brine or hold ballast.

The storage provided in the pontoons 4 and 8 enable the rig to have a very large bulk and liquid mud storage capacity for its size: the rig can store 4,800 billion barrels of mud at the platform 2, whilst the pontoons have a capacity for 2,650 billion barrels of reserve mud, 2,400 billion barrels of base oil and 1,925 billion barrels of brine. This allows for two or three separate mud systems to be operated on the rig concurrently, which saves time and cost when changing over mud systems considered no longer necessary to stop to clean pits.

Additionally, pontoon mud tanks can be served by dedicated supply and discharge piping thereby minimising the risk of product contamination. The mud pumping and circulating system does not form part of the subject matter of the present invention.

In addition to the equipment and processes described above, the rig incorporates equipment and facilities which are configured to integrate the handling, storage, preparation, use and disposal of all drilling, completion and work over fluid which may be used during the well construction process. These include the equipment required to maintain multiple fluid systems on board concurrently. Additionally, certain equipment items, processes and controls have been configured to enable dual use (ie cement and mud mixing and pumping using common equipment). The integrated fuel management system incorporates local, remote and manual operation and controls facilities which enable the fluid system to be configured remotely by a driller from a dog house on the platform 2, locally from a fluid process control centre or manually at each tank/manifold. The drilling fluid process control room is located in the mud house and houses all of the equipment required for fluid process management monitoring and alarm functions, pump control, test and analysis.

The decision to locate the prime movers and related power generation and distribution switchgear and machinery in the pontoons of the vessel was taken to achieve a number of design objectives including, but not limited to:

1. Reducing the steel weight of the vessel for a given displacement

2. Reducing the machinery deck space requirements

3. Satisfying the dual independent engine room requirements for DPS3 classification

4. Reducing the noise and vibration exposure at main deck level

5. Lowering the Centre of Gravity of the vessel which increases the variable deckload capacity

6. Reducing the amount of ballast required to lower the rig to operation draft

To enable the safe and efficient operation of the prime movers in this configuration, the rig is arranged to:

1. Provide adequate ventilation and cooling of the machinery spaces

2. Condition the engine and machinery space intake air

3. Remove radiant heat from the machinery space

4. Convey a combustion exhaust to surface

5. Provide for prime mover cooling via closed loop heat exchangers, using a combination of salt water/fresh water coolant heat exchangers in conjunction with pipe runs within the ballast tanks.

6. Provide gravity fuel feed in the event that fuel transfer/pumping is interrupted.

Rig Construction

The rig structure is based on a series of simple boxes, and rectangular hull forms. This feature facilitates prefabrication and final assembly. The modular nature of the construction means that the individual modules could be pre-assembled and outfitted prior to final assembly in a different location, which minimizes overall construction time.

CLAIMS

1. A semi-submersible structure having a transit condition in which the structure is movable to a site of use, and a semi-submerged condition in which the structure is sufficiently stable to be used at said site, the structure being adapted to carry consumable solid or liquid materials and removable equipment, which are to be removed therefrom during use, the structure comprising pontoon means containing first compartment means for containing consumable material, ballast control means for introducing ballast into the first compartment means to compensate for the removal of consumable materials from the structure, and second compartment means for receiving ballast, wherein the arrangement is such that, if the first compartment means is empty and no consumable material or removable equipment is being carried by the structure, the filling of the second compartment means with ballast will not cause the structure to be submerged to an extent sufficient to achieve said semi-submerged condition, whereas said condition would be achieved if the first compartment means were also at least partially filled.

2. A structure according to claim 1, in which the pontoon means includes third compartment means for housing other consumable materials or fixed equipment.

3. A structure according to claim 2, in which the third compartment means comprises a compartment of sufficient size to house a prime mover for the structure.

4. A structure according to claim 1, in which the first compartment means comprises a plurality of tanks for the consumable material and ballast.

5. A structure according to claim 4, in which the structure is preferably adapted to carry a sufficient weight of consumable material to enable the semi-submerged condition to be achieved

when at least one of the tanks of the first compartment means is empty.

6. A semi-submersible structure comprising pontoon means having first compartment means for containing consumable liquid, second compartment means, exclusively for containing ballast, and ballast control means for adding ballast to the first compartment means, wherein the capacity of the second compartment means lies in the range of 40% to 45% of the total volume of the pontoon means.

7. A structure according to claim 6, in which the capacity of the second compartment means is approximately 40% of the total volume of the pontoon means.

8. A semi-submersible structure adapted to carry consumable solid or liquid materials to a site of use, the structure comprising pontoon means having first compartment means for containing consumable material, second compartment means for containing ballast, sensing means for detecting the amount of consumable material in the first compartment means and ballast control means connected to the sensing means and arranged to introduce ballast water to the first compartment means to compensate for the loss of mass due to the removal of consumable material.

9. A structure according to claim 8, in which the first compartment means comprises a plurality of tanks, and the ballast control means is arranged to add ballast to one or more selected tanks that no longer contain consumable material.

10. A method of ballasting a semi-submersible structure having pontoon means comprising at least one compartment containing consumable material which is progressively extracted during use of the structure, the method comprising the steps of determining the amount, if any, of consumable material in the compartment and adding ballast to the compartment after at least some consumable material has been removed.

11. A method according to claim 10, in which the ballast is added to the compartment only after it has been substantially emptied of consumable material.

12. A method according to claim 11, in which the compartment comprises one of a plurality of tanks in the pontoon means, the tanks containing consumable liquids, which are progressively extracted from the tanks during use of the structure and the method comprises determining which, if any, of the tanks has been substantially emptied of consumable liquid and introducing ballast into that tank or at least one of those tanks.

13. A method according to claim 12, further comprising the step determining whether the volume of consumable liquid remaining in one of the tanks is less than or equal to the spare capacity of the other tank or tanks containing the same consumable liquid, and if it is transferring the liquid to said other tank or tanks to enable said one tank then to receive ballast.

14. A semi-submersible structure according to claim 1, in which the structure is an offshore drilling rig.

15. A semi-submersible structure according to claim 1, in which the pontoon means comprises a pair of elongate, parallel, spaced apart pontoons.

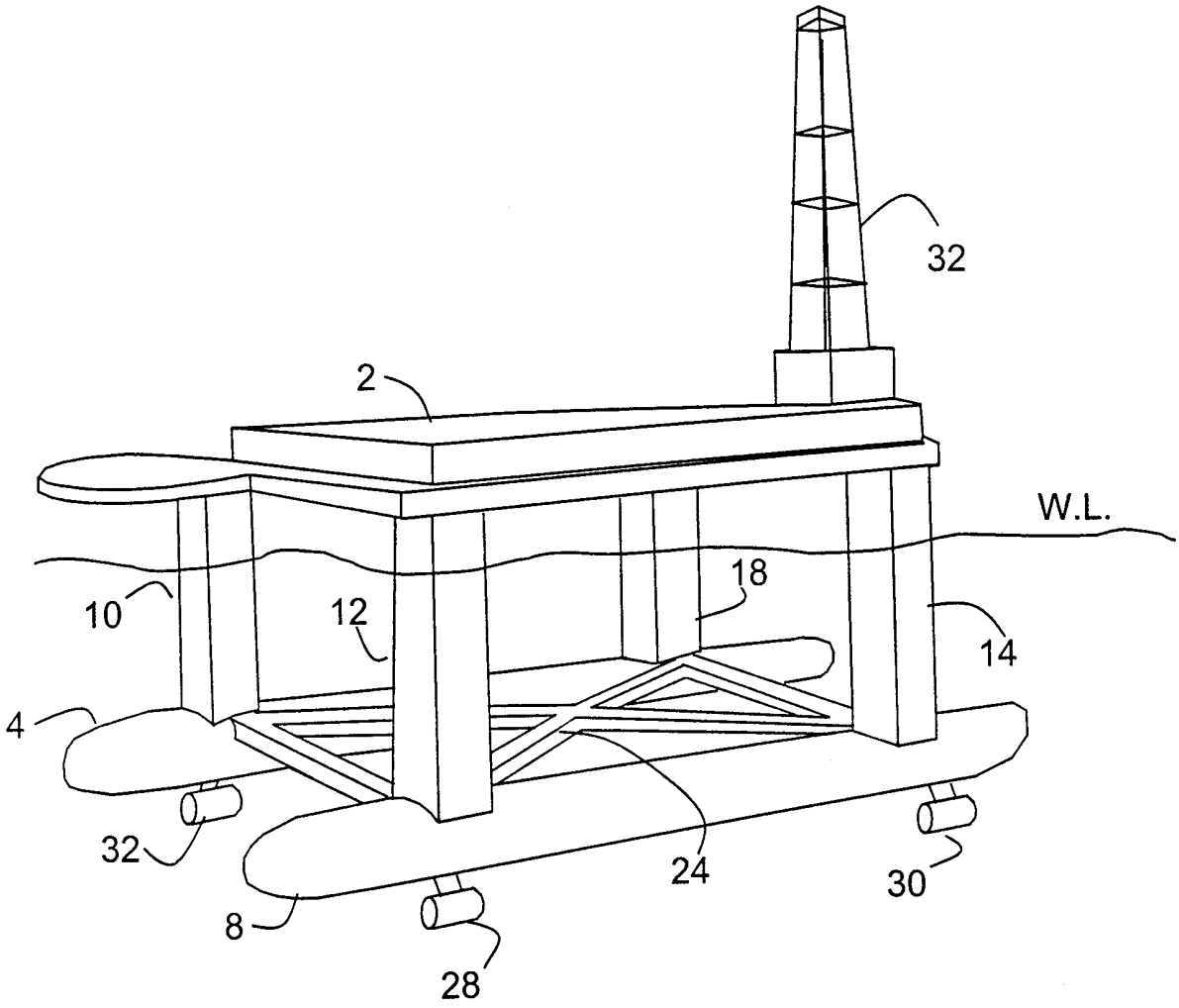


FIG. 1

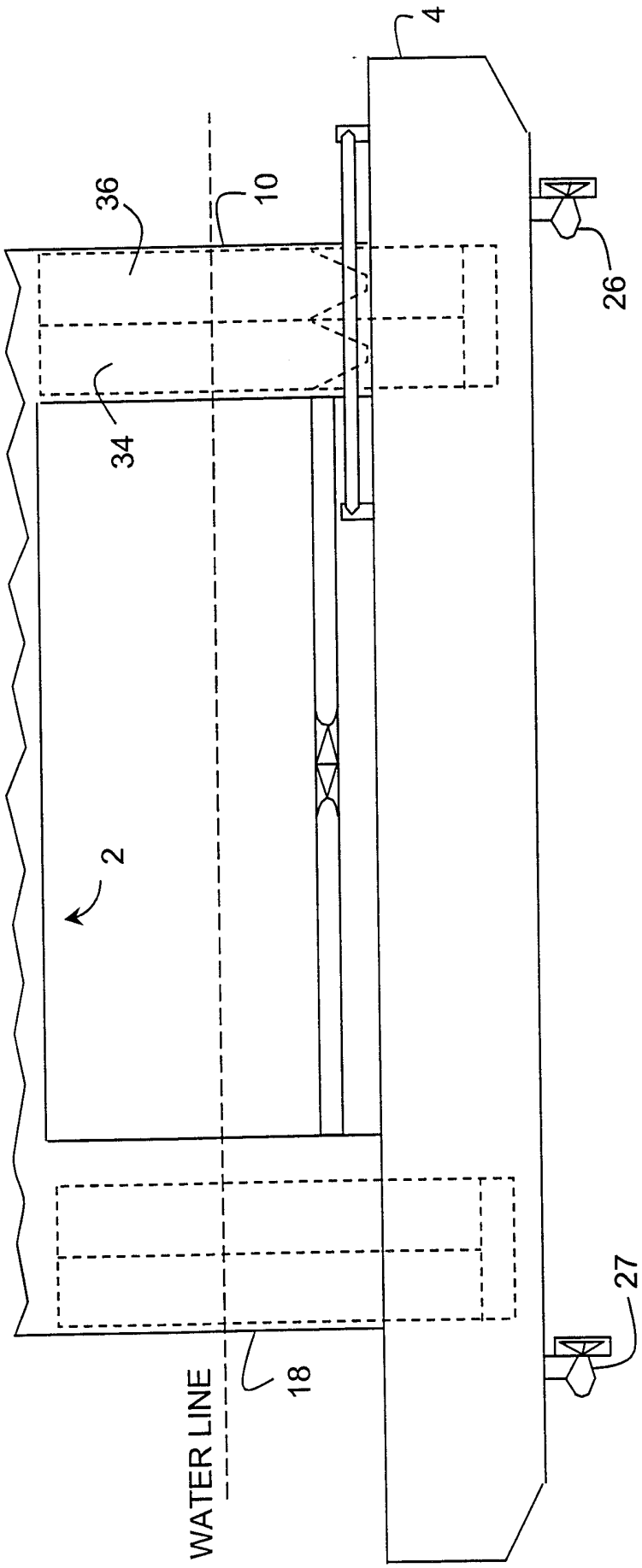
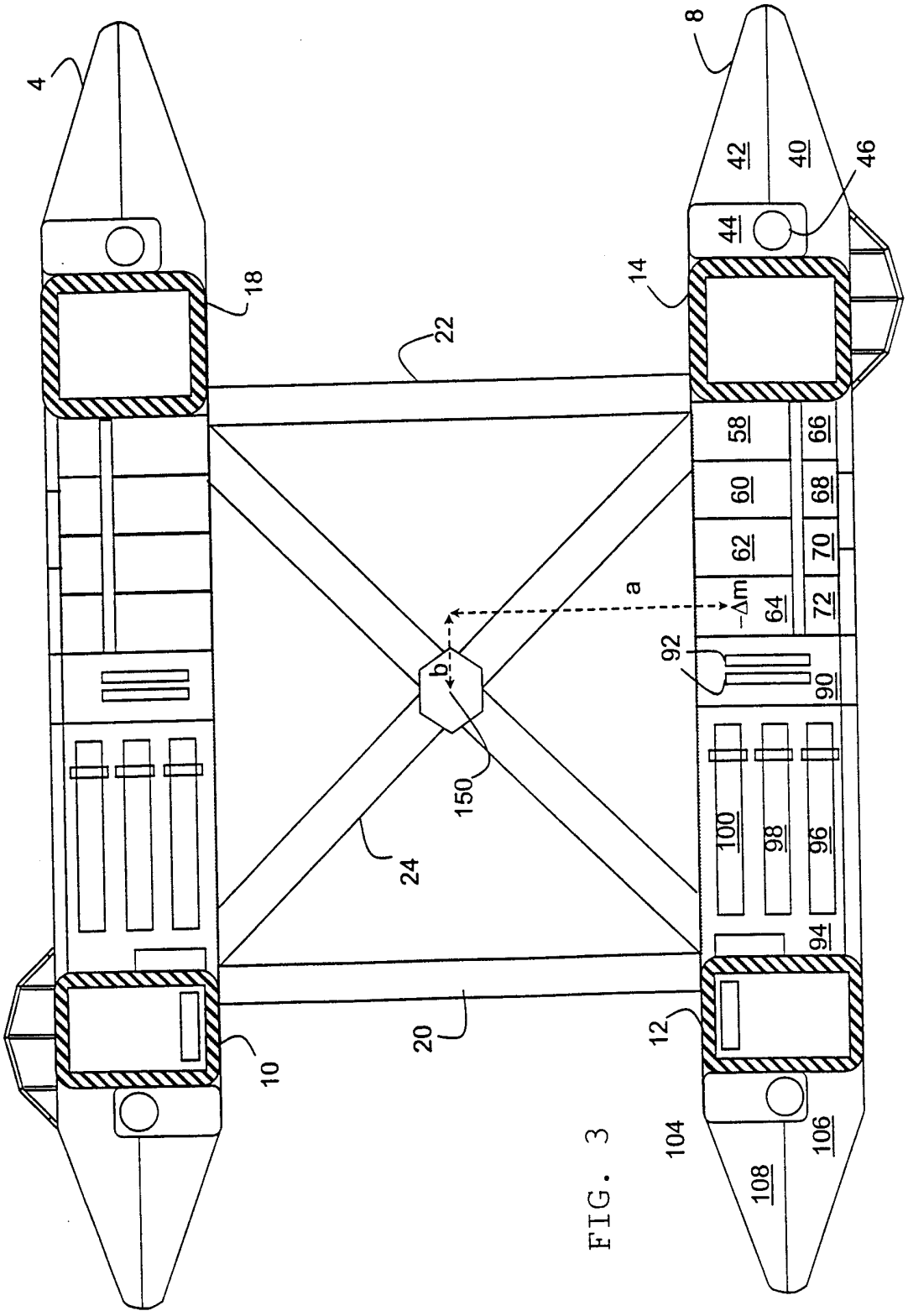


FIG. 2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70
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72
-Δm
a
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92
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150
24
100
98
96
94
20
12
10
104
106
108

FIG. 3

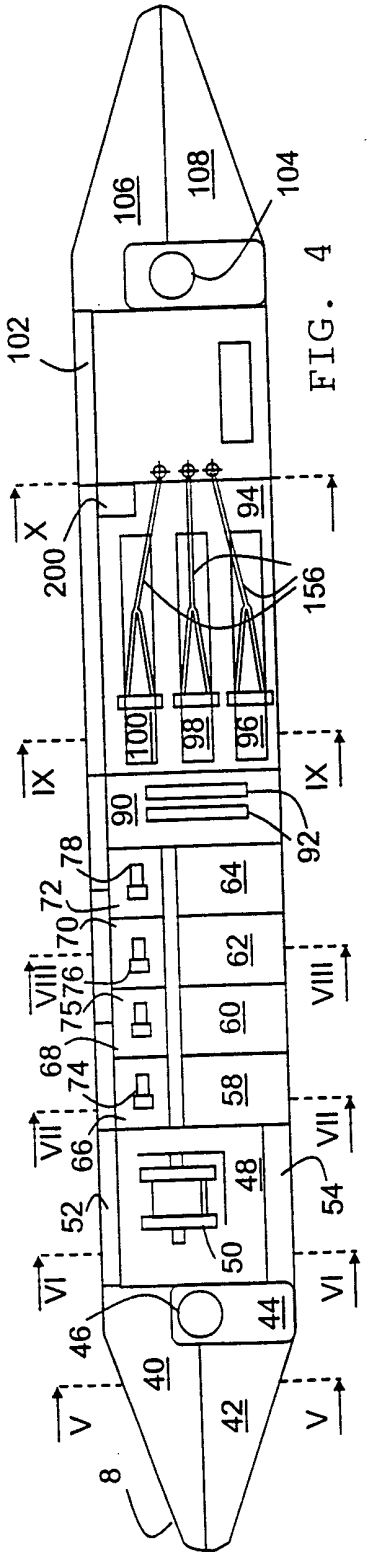

FIG. 4

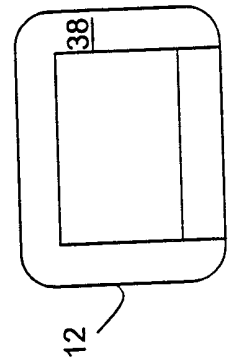

FIG. 12

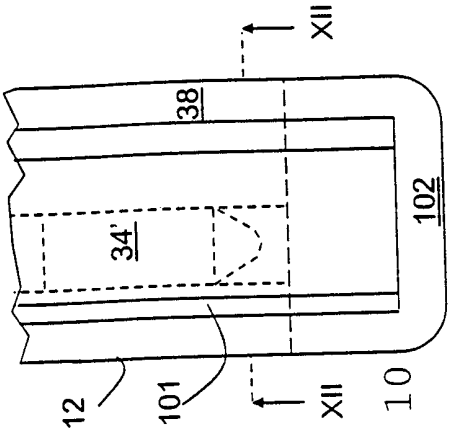

FIG. 10

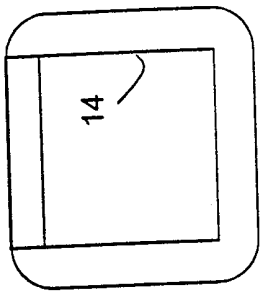

FIG. 11

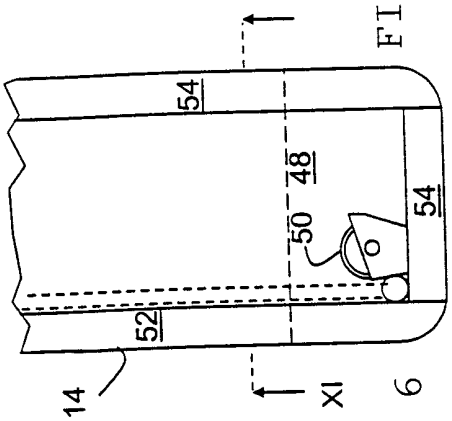

FIG. 6

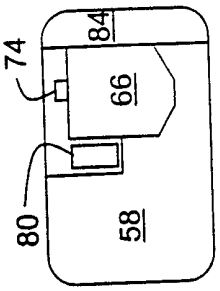

FIG. 7

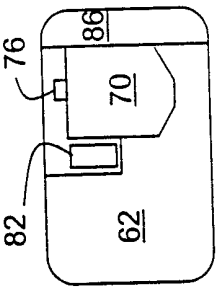

FIG. 8

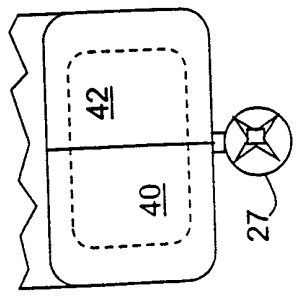

FIG. 5

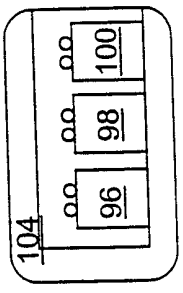

FIG. 9

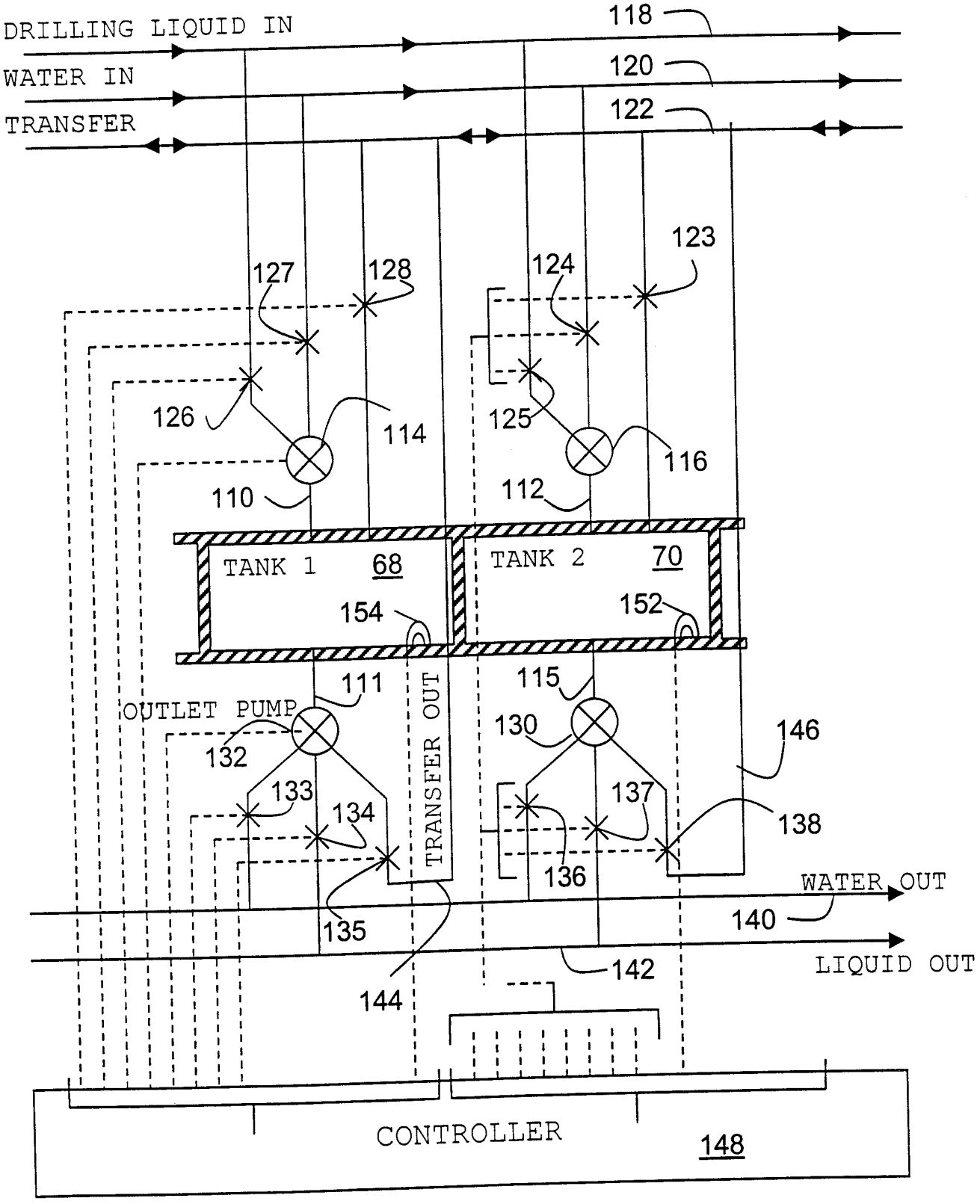
DRILLING LIQUID IN
WATER IN
TRANSFER
118
120
122
123
124
125
126
127
128
114
116
110
112
TANK 1
68
TANK 2
70
154
152
111
115
OUTLET PUMP
TRANSFER OUT
130
146
132
133
134
137
138
136
WATER OUT
140
135
142
LIQUID OUT
144
CONTROLLER
148

FIG. 13

Ref No			SECTION	AREA	VOLUME BY PONTOON	VOLUME FOR 2 PONTOONS
40,42 106, 108	1	Ballast 1.2.9.10		62 m2	4x720 m3	5760 m3
102	2	Ballast 3		425 m2	425 m3	850 m3
18	3	Aft Column Pedestal		82 m2	820 m3	1640 m3
104	4	Ballast 4		49 m2	1070 m3	2140 m3
90	5	Electrical Room		75 m2	375 m3	750 m3
84, 86, 88	5	Brine Tank 1.3.5		125 m2	3x110.4 m3	662.4 m3
62, 64	7	Fuel Oil Tank 1.2		74.35 m2	2x400 m3	1600 m3
66, 68 70, 72	8	Root 1.2.3.4		26 m2	4x140 m3	1120 m3
58, 60	9	Drill Water 1.2		74.35 m2	2x400 m3	1600 m3
	10	Usual Area		10.3 m2	221 m3	442 m3
52	11	Ballast 7		13 m2	156 m3	312 m3
56	12	Ballast 8		14.25 m2	171 m3	342 m3
10	13	Fore Column Pedestal		71 m2	852 m3	1704 m3
54	14	Base Oil Tank		26.5 m2	318 m3	636 m3
38	15	Potable Water		44.6 m2	334.5 m3	669 m3
24	16	Cross Brassing				275 m3

FIG. 14

INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/EP 98/07369

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B63B11/02 B63B35/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 091 760 A (LLOYD III SAMUEL HARRY) 30 May 1978 see abstract; figures 1,2,9 see column 4, line 32 - line 50 see column 7, line 12 - line 33 see column 12, line 31 - line 49 see column 12, line 68 - column 13, line 6	1,2,4,6, 10,11, 14,15
Y		3
A		8

A	ROGERS LESLIE C: "New rig floats on twin hulls" OIL AND GAS JOURNAL., vol. 65, no. 51, 18 December 1967, page 86 XP002097130 TULSA US see the whole document	1,6,8, 14,15

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 1999	01/04/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Häusler, F.U.

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 874 314 A (SANDERS JOHN P) 1 April 1975 see figure 1 see column 2, line 26 - line 44	3
A		1,2,14, 15
A	WO 88 08807 A (AKER ENG AS ;OLSEN & CO FRED (NO)) 17 November 1988 see claim 3; figures 1-4 see page 7, line 25 - line 29	1,14,15

INTERNATIONAL SEARCH REPORT

..nformation on patent family members

Inte . onal Application No
PCT/EP 98/07369

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4091760 A	30-05-1978	NONE	
US 3874314 A	01-04-1975	NONE	
WO 8808807 A	17-11-1988	NONE	