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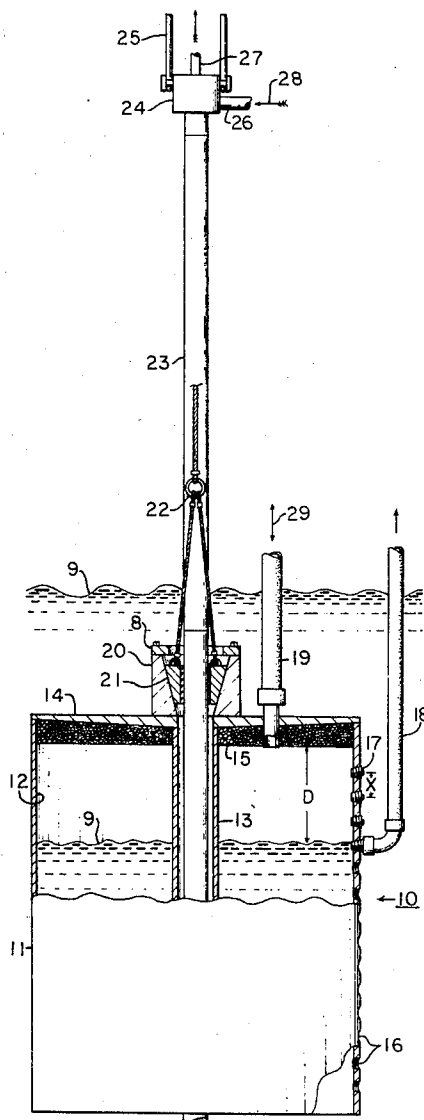
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[54] **BIT WEIGHT MAINTAINER FOR MARINE EARTH BORING**
 2 Claims, 6 Drawing Figs.

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 [51] Int. Cl. E21b 7/12
 [50] Field of Search 175/5, 6,
 27, 7; 166/.5, .6

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ABSTRACT: A device for use in marine earth boring that supports that portion of the drill pipe weight which is not desired on the drilling bit. The device comprises a large drum, closed at the top and open at the bottom, which drum is placed in the sea. The drum has a central pipe through which the drill pipe and bit passes. The drum is made to have the buoyancy desired by introducing a definite volume of air into the drum. The drum is locked to the drill pipe by means of conventional bowl-and-slips. As the borehole deepens the drum descends with the pipe, and means, manual or automatic, are provided to keep the volume of air constant. The drum is reset for each new length of drill pipe. The device is adapted for either turddrilling or rotary drilling.



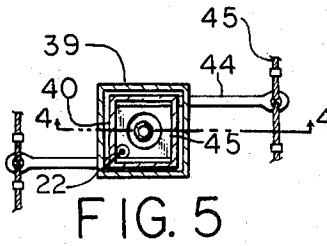
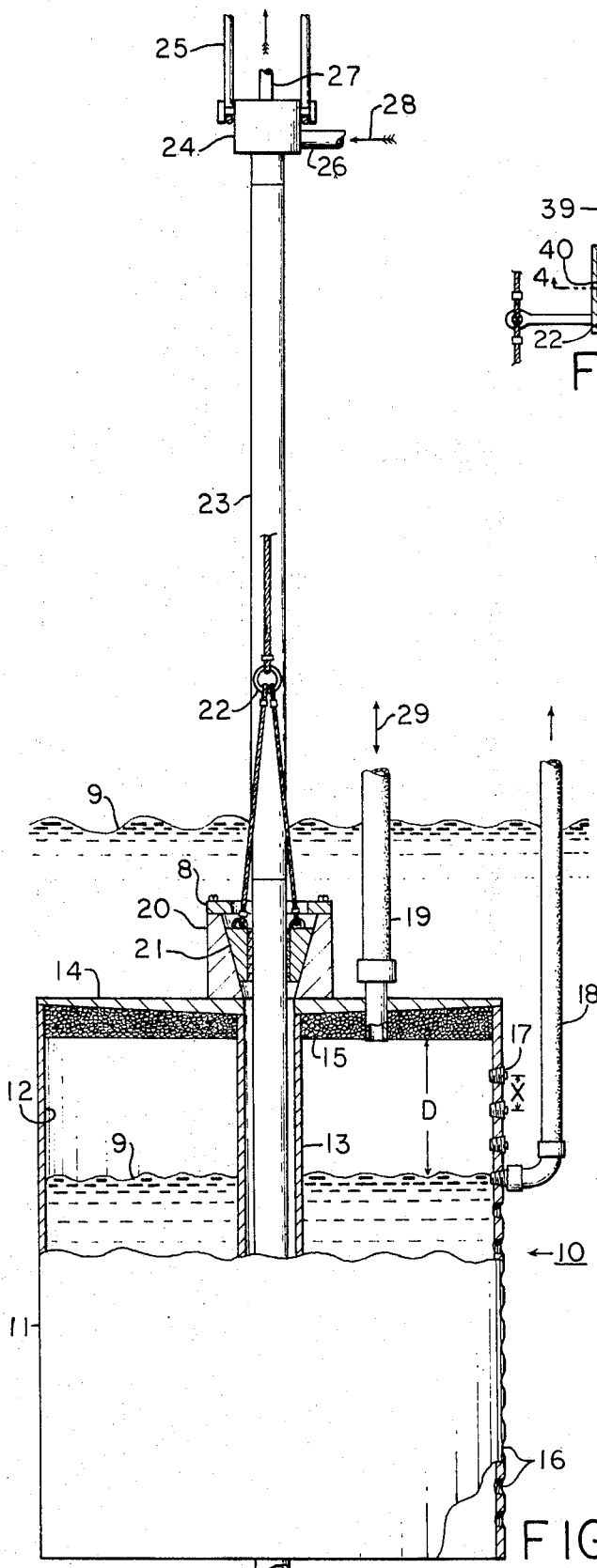


FIG. 5

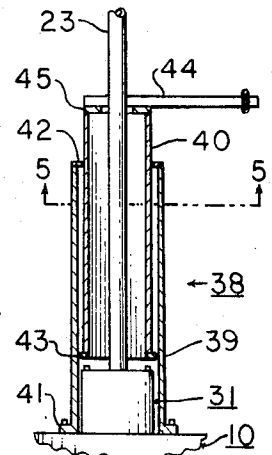


FIG. 4

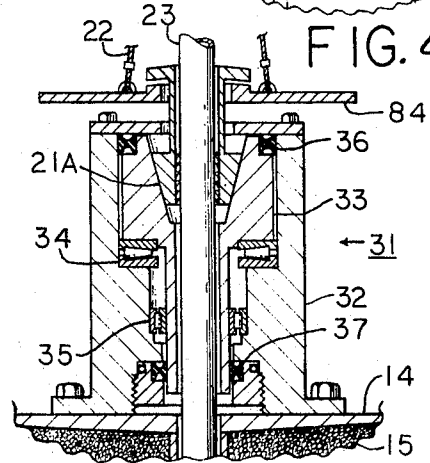


FIG. 3

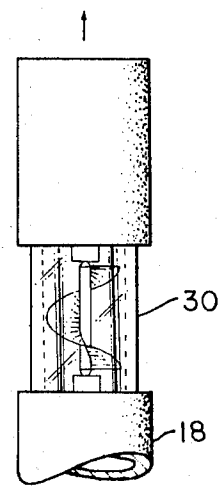


FIG. 2

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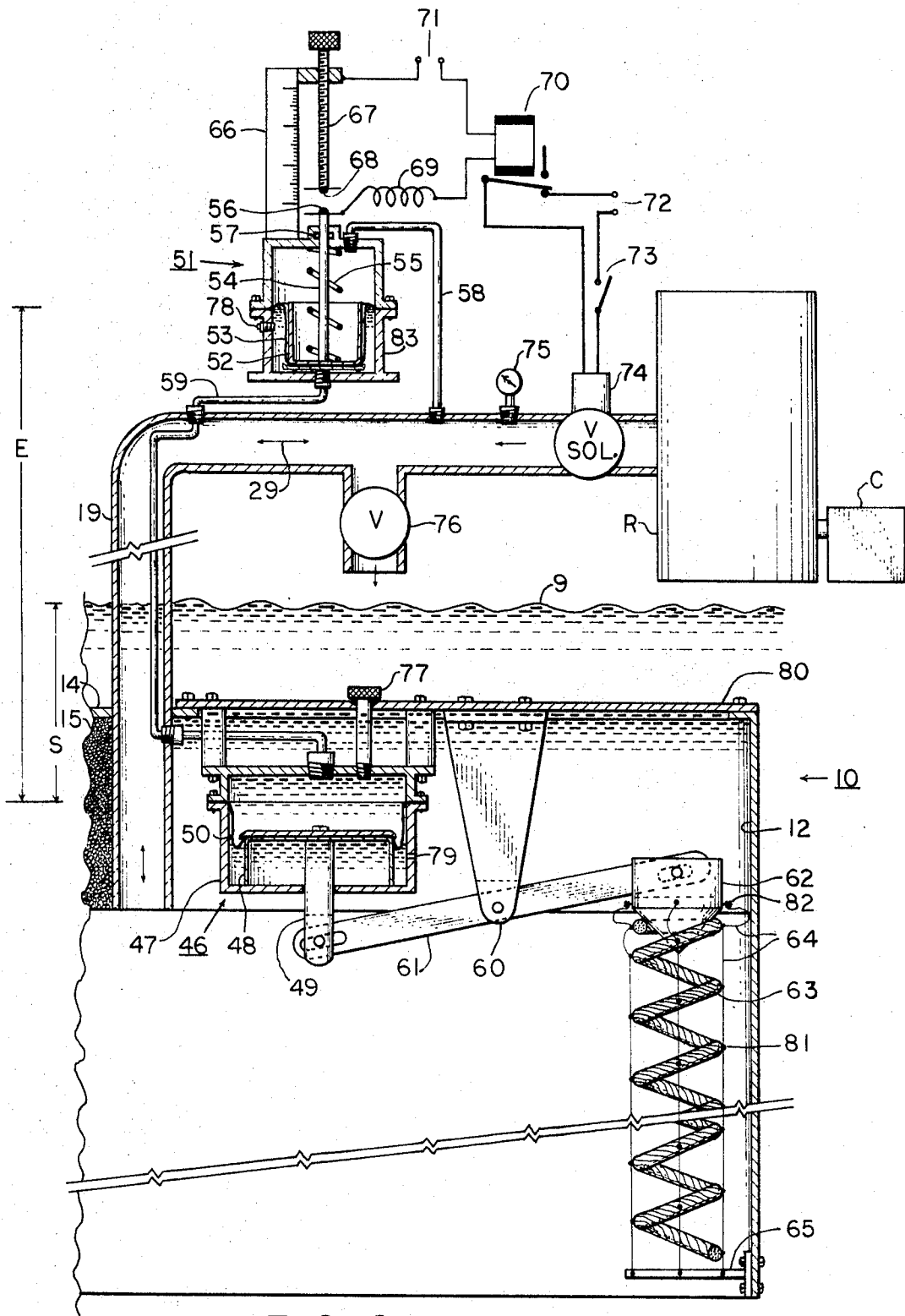


FIG. 6

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BIT WEIGHT MAINTAINER FOR MARINE EARTH BORING

DESCRIPTION

When earth boring from a floating vessel on the surface of the sea the rocking and pitching of the vessel due to the sea's surface waves causes the top of the drilling mast to oscillate, and since the top of the mast supports the drilling string of pipe, such oscillation results in the raising and lowering of the drill pipe and resultant fluctuations of the pipe weight imposed upon the drilling bit. For any type of bit to drill efficiently it must be loaded with the optimum weight. Underloading causes a big decrease in boring efficiency, while overloading causes bit damage and high drill pipe torque. When a roller bit is overloaded the bit bearings fail prematurely and usually the cuttings are not removed effectively. When a diamond bit is overloaded the exposed diamonds bury themselves in the earth's formation blocking drilling fluid flow around the diamonds and the diamonds become overheated and are destroyed.

An object of this invention is to provide a buoyant device that supports the desired drill pipe load and is passive to surface wave motion. This means, if the drill pipe string weighs 15,000 pounds (in water) and it is desired that 5,000 pounds be imposed upon the bit, that this device supports 10,000 pounds of the load and leaves 5,000 pounds for the bit to support.

Another object of this invention is to provide a device that permits the drill pipe to descend uniformly and in unison with the bit's drilling rate, whatever that may be, while simultaneously maintaining the desired load on the bit. Such a perfect bit feed has long been sought.

Another object of this invention is to provide an inexpensive device to maintain the proper load on a bit and is adapted for rotary drilling as well as turbodrilling.

Still another object of this invention is to provide an air-buoyant device for drill pipe support in which the volume of air within the device, hence the buoyancy, is either manually or automatically maintained constant as the borehole, and the device, deepens.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an elevational view, partly in section, showing a submerged drum member, partly air filled, supporting a turbodrill string of drill pipe. This is a manually controlled embodiment.

FIG. 2 shows an elevational view of a flow indicator.

FIG. 3 is an elevational view, in section, of the rotary table support, needed when drilling with rotating pipe.

FIG. 4 is an elevational view, in section, of the rotation-preventing device needed when drilling with rotating pipe. This section is taken on section plane 4-4 of FIG. 5. This FIG. shows only the rotation-preventing devices, this to avoid congestion of the FIG.

FIG. 5 is a sectional view taken on the section plane 5-5 of FIG. 4.

FIG. 6 is an elevational, sectional view of the automatic components used when the automatic embodiment is desired.

With reference to FIG. 1, the numeral 10 indicates generally the buoyant, open bottom drum, shown submerged, with an air section D. Said air section is of such volume as to support the desired load of drill pipe. The vent tube 18 is set at the required depth D to accomplish this. Compressed air is admitted through tube 19 as shown by the tailless flow arrows 29. Any excess of air is exhausted through vent tube 18. The operator knows when air is being vented by the rotation of the multicolored, very light flow vane 30, at the top of tube 18, as shown by FIG. 2. As the borehole is deepened the buoyant drum gets correspondingly deeper submerged and the air within the buoyant drum is correspondingly compressed. If the proper buoyancy is to be maintained compressed air must be

admitted through tube 29 to compensate for the compression and maintain a constant air volume. In practice the operator may have a needle valve, not shown, feeding compressed air into the tube 29 at a slow rate, just enough to keep the flow vane 30 slowly turning, evidence that the air-water interface is being maintained at D.

In the center of the drum 11 is a vertical pipe 13, which pipe has an inside diameter large enough to pass the drill pipe 23, and the bit, not shown.

The side of the drum 11 has threaded holes 16 spaced at desired intervals X, in which X may be the necessary increase of D for each length of drill pipe. When a bore hole is started in shallow water (under 200 feet) all of the pipe load is needed on the bit. In which case all of the holes 16 are open, as well as the fill tube 19, and water fills the tank 11 up to the flotation foam 15. The sole purpose of the flotation foam is to reduce the weight of the drum 10 when in water to facilitate handling, so if desired, it may be eliminated.

As the bore hole reaches the depth wherein the full length of drill pipe just imposes the optimum desired load on the bit, then any subsequent additional lengths of drill pipe, added as the bore hole deepens, should have their weight absorbed by the buoyant drum 10. The buoyant drum is not needed when starting the bore hole, but it is usually desired to stabilize the drill pipe. When the critical depth is reached wherein the total weight of the drill pipe exceeds the optimum bit load, then the vent tube 18 is inserted in the uppermost hole 16. Whereupon compressed air is admitted through fill tube 19 until air flow is indicated at the flow vane 30. The buoyant drum 10 is locked to the drill pipe 23 by the slips 21, in the slip bowl 20, whenever the drum is buoyant and tends to rise relative to the pipe 23. When air is flowing from the tube 18, the weight on the bit is known to be correct and drilling resumes. Assuming that the drill pipe length is 30 feet, then as this length is drilled down, the drum 10 gets progressively deeper, up to 30 feet deeper. As the drum 10 gets deeper it is necessary to compensate for compression of the air section D, (which is approximately 16 p.s.i.a. near the sea's surface and increases to approximately 30 p.s.i.a. at a depth of 30 feet) and this is done by continuously admitting compressed air as discussed above.

After the first float-supported length of pipe has been drilled down to where its top is at the operator's platform it is necessary to add an additional length if drilling is to continue. To add an additional length, drilling is stopped, the pump is stopped, and if a rotary-type drill the rotary is stopped. The connection at the drilling head 24 is broken, a new length of drill pipe is added and made up at the drilling head, and to the in-hole pipe string, whereupon the pipe string is ready to resume drilling and the head 24 is in position to support the full drill pipe load. At this time the valve 76, FIG. 6, is opened to exhaust all of the air from the drum 10. When the air is exhausted the operator engages the winch which spools the line 22 and the drum 10 is raised to the sea's surface and adjustments are made to increase the air section D to support an additional length of pipe. The drum 10 is then lowered to slightly below the sea's surface, air is introduced into the drum until the required new air section D is reached; this sets the slips 21 and drilling is resumed.

When drilling with aluminum pipe the slips may tend to dig into the pipe when raising the drum 10, in which case a ring somewhat larger than the drill pipe may be inserted in the slip bridle so that the pull on the individual slip lines is not only up, but also outwardly, at the top of each slip 21. During drilling the slip line 22 is slack, but not so loose as to permit fouling.

The holes 16 in the tank 11, are shown threaded, as well as the plugs 17 and vent tube fitting 18, but it is much more convenient to make these conventional quick-change fittings.

FIG. 1 shows an embodiment adapted for turbodrilling, with nonrotating dual-tube drill pipe wherein 24 is the hoisting head, having elevator bails 25, a drilling fluid entrance pipe 26 and a drilling fluid outlet pipe 27. The tailed arrows 28 show the direction of drilling fluid flow. The surface of the sea is indicated by reference numeral 9, as is the air-water interface within the drum 11.

FIGS. 3, 4, and 5 show an adaption to accommodate rotating pipe. FIG. 3 shows the equivalent of a rotary table, with modified slips 21A, rotating slip bowl 33, housing 32 with bearings 34 and 35 to rotatably support the slip bowl within the housing 32. The housing 32 is secured to the drum deck 14. To prevent water invasion of the housing 32 two seals are provided, 36 and 37.

It is necessary to restrain the drum 10 from rotating and this may be done as shown by FIGS. 4 and 5, wherein a square section tubing 39 is positioned over the rotary housing 32 and is secured to the deck 14 by the tubing flange 41. Telescoping within the tubing 39 is a smaller square section tubing 40. The tubing 40 is of such a size that it cannot be rotated within the tubing 39 but is free for longitudinal movement, however it cannot be pulled upward out of the tubing 39 due to its own flange 43 and the tubing 39 flange 42. The smaller tubing carries arms 44 at its upper end to which arms are secured the anti-rotation cables 45. The rotational torque is not high being merely the friction of the bearings within the housing 32. The cables 45 may be secured to the boat or mast as by hooks, or vertical cables or tracks may be provided on which the terminals of cables 45 can travel vertically while still preventing rotation. The operation of this embodiment is substantially the same as for the nonrotating embodiment. The arms 44 are normally near the operator's platform or the boat deck, with the telescoping feature permitting the drum 10 with the rotary 32 to descend 30 feet as the hole is deepened. To conserve space in some installations it may be desirable to use more than two telescoping tubes in order to use shorter tubes.

Since the slips 21A rotate with the pipe when drilling it would cause a winding-up of the slip line 22 should it be connected directly to the slips 21A. In this embodiment the slips have an extended neck as shown in FIG. 3, which neck extends through a hole in the center of a slip yoke 84. This yoke is a square plate of steel that fits loosely in the tubing 39 to prevent rotation of the yoke. The bridle 22 is secured to the yoke and runs upwardly, exiting through a hole in the centering plate 45 at the top of tubing 40 as shown in FIG. 5.

FIG. 6 shows an embodiment for automatically maintaining a desired section D of compressed air. This embodiment is based upon two rolling diaphragm bellows 46 and 51. The bellows 46 is larger than the bellows 51. The bellows 46 is in the drum 11 and bellows 51 is on the operator's platform or boat deck. Bellows 46 has a means for sensing the depth of air section D by measuring the weight of a lighter-than-water helix of polypropylene rope 63. This weight is transmitted by the beam 61 to the piston rod 49 of the bellows 46 and thence as a pressure through the liquid filled bellows 46 and liquid filled connecting tube 59 to the lower liquid filled portion of the smaller bellows 51. This pressure under the diaphragm 53 of the bellows 51 causes a force on the bellows piston 52, causing it to rise, compressing the spring 55. The amount of pressure, piston force, spring compression and length of rise of the piston 52 and piston rod 54 are directly proportional to the length of the unbuoyed section of the rope 63, which unbuoyed section is that portion of rope in the air section D. Thus the extension of the piston rod 54 indicates the section D of air within the drum 10. There is a multiplying factor in the relative movement of piston rod 54, relative to the piston rod 49. Since this is a closed hydraulic system the ratio of this movement is the inverse ratio of piston areas. The calibration on the bracket 66 permits the operator to observe the thickness of section D at any time.

FIG. 6 shows the status of this embodiment when at the sea's surface and with the drum 10 completely water filled, no air section D. The bellows 46 is mounted on a small mounting plate 80, together with a bracket 60, for supporting the beam 61. This small assembly is accommodated in a recess in the flotation foam 15. A hole in the deck 14 is left for insertion of this assembly and this hole is sealed by the mounting plate 80, which plate has sealing dope on the edges of its bottom to effect the seal. The connecting tube 59 is a small ($\frac{1}{8}$ inch) bore flexible tube to facilitate assembly. The plug 77 is removed to fill the bellows-tube assembly with liquid, the liquid being in-

troduced at the plug 78 of the bellows 51 and air allowed to escape at the plug 77. When the system is free of air the plug 77 is reinserted making a tapered thread seal in the wall of the bellows 46 and an O-ring seal between its own head and the mounting plate 80. Of course the plug 78 is reseated when the system is full of liquid.

It is noted that there is an elevational difference E between the upper bellows and the lower bellows. Thus the lower bellows experiences a pressure in its upper compartment corresponding to this elevational head and the density of liquid in the system. The lower compartment of the lower bellows senses the submergence head S since its lower case is open to the sea at the hole 79. The upper case of the upper bellows 51 sees the same air pressure as in the flow tube 19 due to the connecting tube 58. This air pressure is atmospheric when the drum 10 is at the sea's surface and the valve 76 is open, as shown. However, when the drum 10 is in operation and air is within the drum, then air surrounds the bellows 46; its lower chamber, the flow tube 19, and the upper chamber of the upper bellows 51, all see the same air pressure. When air is flowing in the tube 19 the tube 58 sees the friction flow loss of head between the bottom of tube 19 and the takeoff location of tube 58. This is a minor difference that an operator soon learns to sense and to compensate for. Even this small difference can be eliminated by running the tube 58 all the way to the bottom of the tube 19.

FIG. 6 shows the automatic feature of this embodiment, the control circuit having power supply terminals 71, and the power circuit with power supply terminals 72. The relay 70 is a normally closed relay. Assume the valve 76 is closed, and the compressor C has the receiver R filled with compressed air. Also that there is no air in drum 10 and it is desired to put a 2-foot section of air in the drum. If the switch 73 is closed the normally closed solenoid valve 74 opens and air begins to flow into the drum 10. As air displaces the water surrounding the bellows 46 the 2-pound mass of polypropylene head 62 is no longer buoyed by water and becomes a 2-pound weight on the beam 61 which is converted to pressure in the lower compartment of the bellows 51. The 2-pound weight is selected to compensate for the elevational head E and the unbuoyed weight of the drum 10. Polypropylene is selected because it has a specific gravity of 0.90 and is completely buoyed when submerged, with a 10 percent resultant upward force. As the air continues to enter the drum and the section D of air increases (air-water interface deepens) a portion of the coiled polypropylene rope 63 becomes air surrounded as the section D increases. The portion of rope in section D is no longer water supported and its weight is imposed upon the beam 61 generating pressure in the bellows system causing the piston 54 to rise in proportion to the weight of rope suspended in air. If the helix of rope has a weight of 1 pound per foot it contributes 1 pound of weight on the beam 61 for each foot of section D. The piston rod 54 rises accordingly. Thus when the section D is 2-feet thick the weight on the outer end of beam 61 is 4 pounds (2 pounds for the head 62, and 2 pounds for the rope in the section D). Therefore the regulating screw 67 is preset at 2 pounds for a 2-foot section of air, and when the air section D reaches 2 feet the piston rod 54 contacts the adjusting screw 67 closing the control circuit 71, which opens the relay 70, causing the closing of the normally closed solenoid valve 74. As drilling progresses and the hole gets deeper, the air section D is compressed due to the greater water head, and the section D decreases, the water-air interface rises within the drum submerging some of the rope that had been in section D thereby decreasing the load on the beam 61, resulting in the piston rod 54 receding and opening the control circuit. Thereupon the solenoid valve opens until the air section D is again returned to 2 feet, whereupon the control circuit is again closed, causing the solenoid valve to close.

The polypropylene rope 63 is coiled into a helix with sufficient turns per foot to approximate 1 pound per foot, and four flexible cords 64 are tied at 81, in 90° orientation to hold the rope in a helix. The lower ends of the tie cords are secured

to the four-legged spider bracket 65, and the upper ends are tied to the four pins 82 in the head 62.

The piston rod 54 may have an electrical contact 56, of silver, and a phosphor bronze spring 69 to permit free vertical travel and to tie it into the electric control circuit 71. The adjusting screw 67 may also have a silver contact 68.

Should one not need compressed air for other uses, the receiver R may be dispensed with and a low pressure rotary compressor substituted therefore. In such a case the power circuit includes the drive motor for the compressor.

The sensitive, low pressure gauge 75 serves as a check on the air pressure within the drum 10. Using this gauge and knowing the depth to the top of the drum 10, (the line 22 can be calibrated), one can compute the depth of the air-water interface in the drum, knowing that the pressure head of sea water is 0.444 p.s.i. per foot of depth. This is especially useful for manual operations. The operator can be supplied depth pressure curves to facilitate evaluations. He can operate without tube 18.

The tube 19 is preferably a flexible hose, normally spooled on a conventional grooved and swiveled hose reel. This hose should be large enough in diameter to permit rapid flow of air, 1 1/2 inches for instance. All of the equipment shown as being above sea level in FIG. 6 would be upstream from the swiveled hose reel.

The tube 59 should be flexible and small in diameter, say 1/8-inch internal diameter. Also, it would exit from tube 19, downstream from the hose reel.

The tube 18 of FIG. 1 should be flexible and smaller in diameter, such as 3/8-inch internal diameter. It may be lashed to the larger tube 19.

This equipment is primarily for exploration drilling, with hole depths being less than 3,000 feet, however it can be used for deeper drilling. The buoyant drum 11, may be 5 feet in diameter for shallow (2,000 feet) drilling and the deck 14 may be used as a working platform when it is surfaced. When so used the deck is given a surface of cork to increase its coefficient of friction when wet to assure good footing for the workmen. For deeper drilling the drum is increased in diameter.

The calibration on bracket 66 is normally made in an actual sea test. A distance measuring probe is inserted through the tube 19. This probe has exposed electrical electrodes on its lower end which are shorted upon salt-water contact. For various stable settings the extension of the piston rod 54 and the depth of water-air interface are determined and the scale on 66 so marked. Whenever there is no danger of explosive petroleum gas the automatic control device can be simplified by the expedient of two Nichrome resistance wires stretched from top to bottom of the tank 11. The resistance of these wires will vary with the percent of their length shorted by the salt water, which resistance can be very simply be used to determine the section D, of air, as well as for the control circuit for automatic control. Further, one can use an acoustic distance measuring device for determining the depth of section D.

The drum 10 is substantially passive to wave action when submerged, even when close to the sea's surface, provided it is deeper than the valley of the waves. When such is the case there is no buoyancy change due to increase in submerged volume as the wave passes over the drum, radically different from a surfaced supported body. The drum does see the change of pressure due to the difference of submergence

between wave crest and wave valley. This difference of pressure compresses the air within the drum 10 giving slightly lesser buoyancy when the drum is under the crest, hence a tendency to sink. This is offset by the rotary movement of the surface and near-surface water particles during a wave cycle. This water movement is upward as the crest approaches and downward as the valley approaches, it therefore compensates for the slight compression differences noted above. The effects of wave action diminish rapidly with depth. At a depth of 1/4 wave length the rotary movement is only 1/4 that at the surface, and at a depth of 1/2 wave length the effect is nil. Likewise the pressures due to wave crest and wave valley, radiate out as hemispheres and quickly become fully compensating.

This invention may be modified in various respects as will occur to those skilled in the art and the exclusive use of all modifications as come within the scope of the appended claims is contemplated.

I claim:

1. A drill bit weight maintainer for marine earth boring with a marine drilling rig, drill pipe and drill bit comprising:
 - a buoyant drum, sealed at the top and open at the bottom, displaced in the sea's water;
 - an open vertical tube passing through said buoyant drum and integral therewith, to permit passage therethrough of the drill pipe and the drill bit;
 - means for selectively locking said buoyant drum to the drill pipe, thereby transferring its buoyancy to the drill pipe;
 - a gas exhaust port in said buoyant drum placed at a predetermined depth below the top of said buoyant drum, at which depth the buoyant drum will have that buoyancy required to support that portion of the drill pipe weight which is not desired on the drill bit, when gas filled above said exhaust port; and
 - a gas-introducing tube extending from the drilling rig to the top of the buoyant drum for introducing compressed gas into said buoyant drum to maintain, as the buoyant drum sinks deeper and deeper, that said predetermined depth of gas, being the depth of said gas exhaust port.
2. A drill bit weight maintainer for marine earth boring with a marine drilling rig, drill pipe, and drill bit comprising:
 - a buoyant drum, sealed at the top and open at the bottom, displaced in the sea's water;
 - an open vertical tube passing through said buoyant drum and integral therewith, to permit passage therethrough of the drill pipe and the drill bit;
 - means for selectively locking said buoyant drum to the drill pipe, thereby transferring its buoyancy to the drill pipe;
 - a gas-depth sensing means within said buoyant drum and responsive to the depth of gas therein;
 - communicating means between the said gas-depth sensing means and the drilling rig to indicate at the drilling rig the gas depth within said buoyant drum;
 - a gas-conducting tube extending from the drilling rig to the top of the buoyant drum; and
 - gas-admitting means responsive to the said gas-depth sensing means to admit compressed gas into said buoyant drum via the gas-conducting tube to maintain that desired depth of gas in the buoyant drum that will provide in the buoyant drum that buoyancy required to support that portion of the drill pipe weight which is not desired on the drill bit.