

Nov. 13, 1962

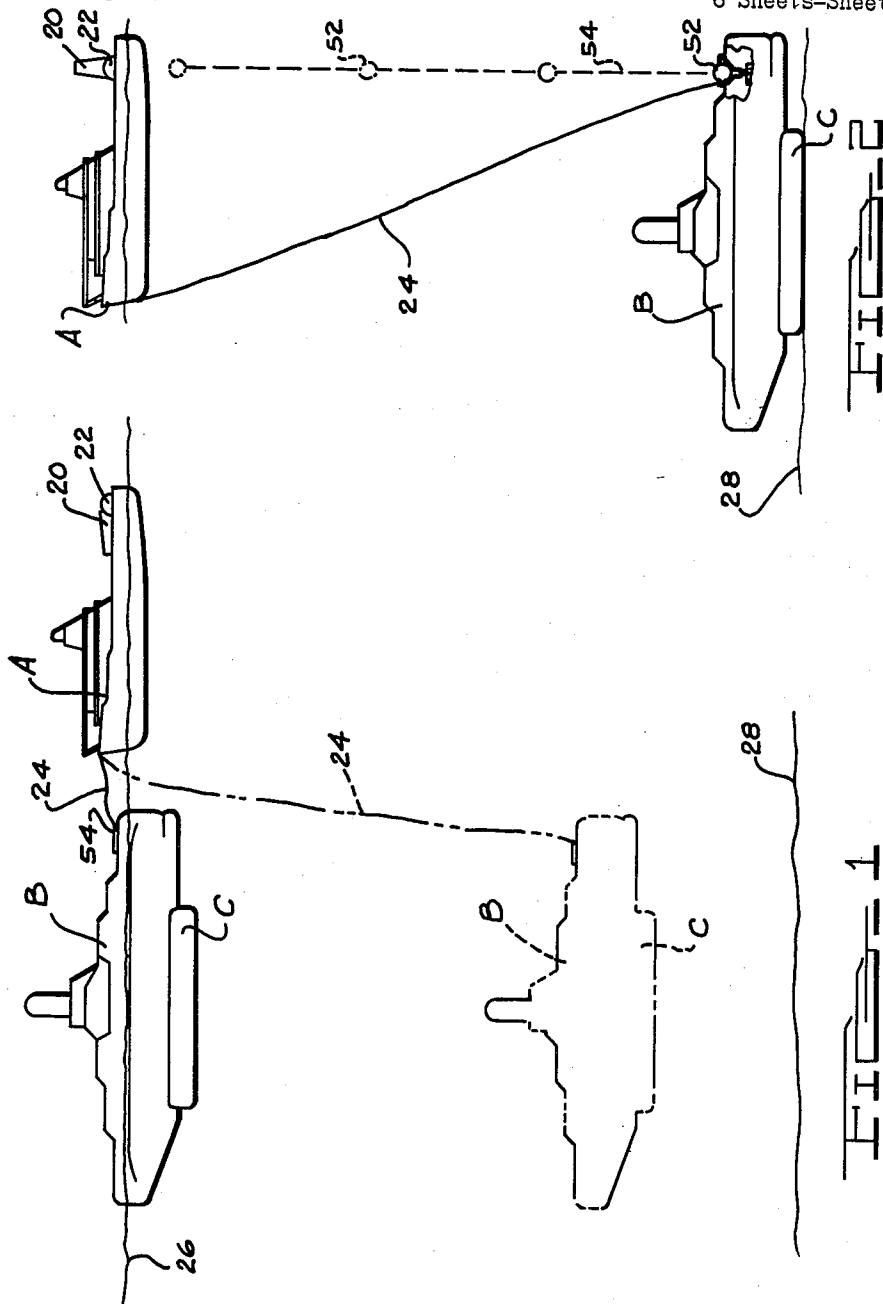
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3,063,507

METHOD AND APPARATUS FOR OFFSHORE DRILLING

Filed Aug. 7, 1958

6 Sheets-Sheet 1



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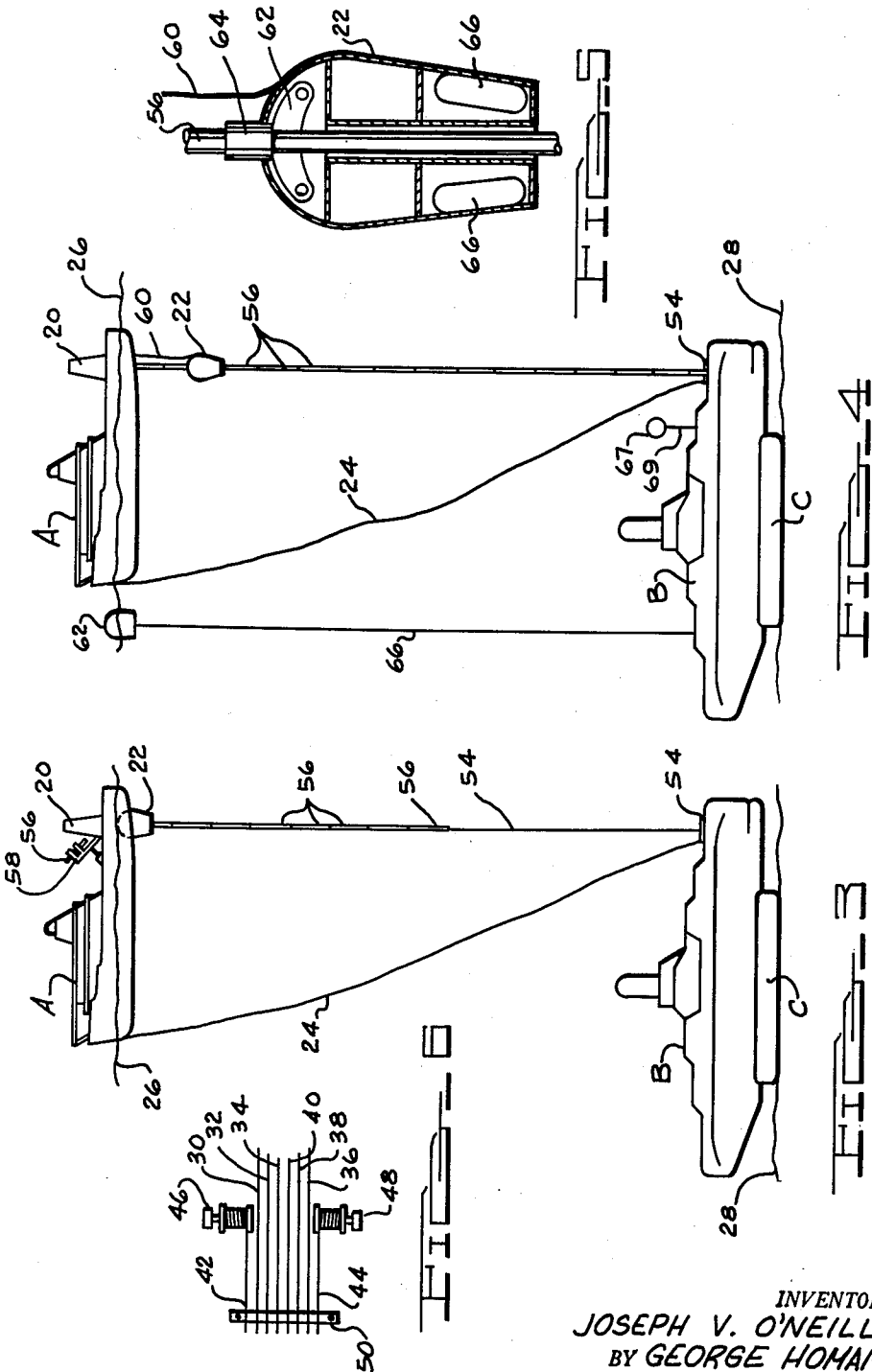
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6 Sheets-Sheet 2



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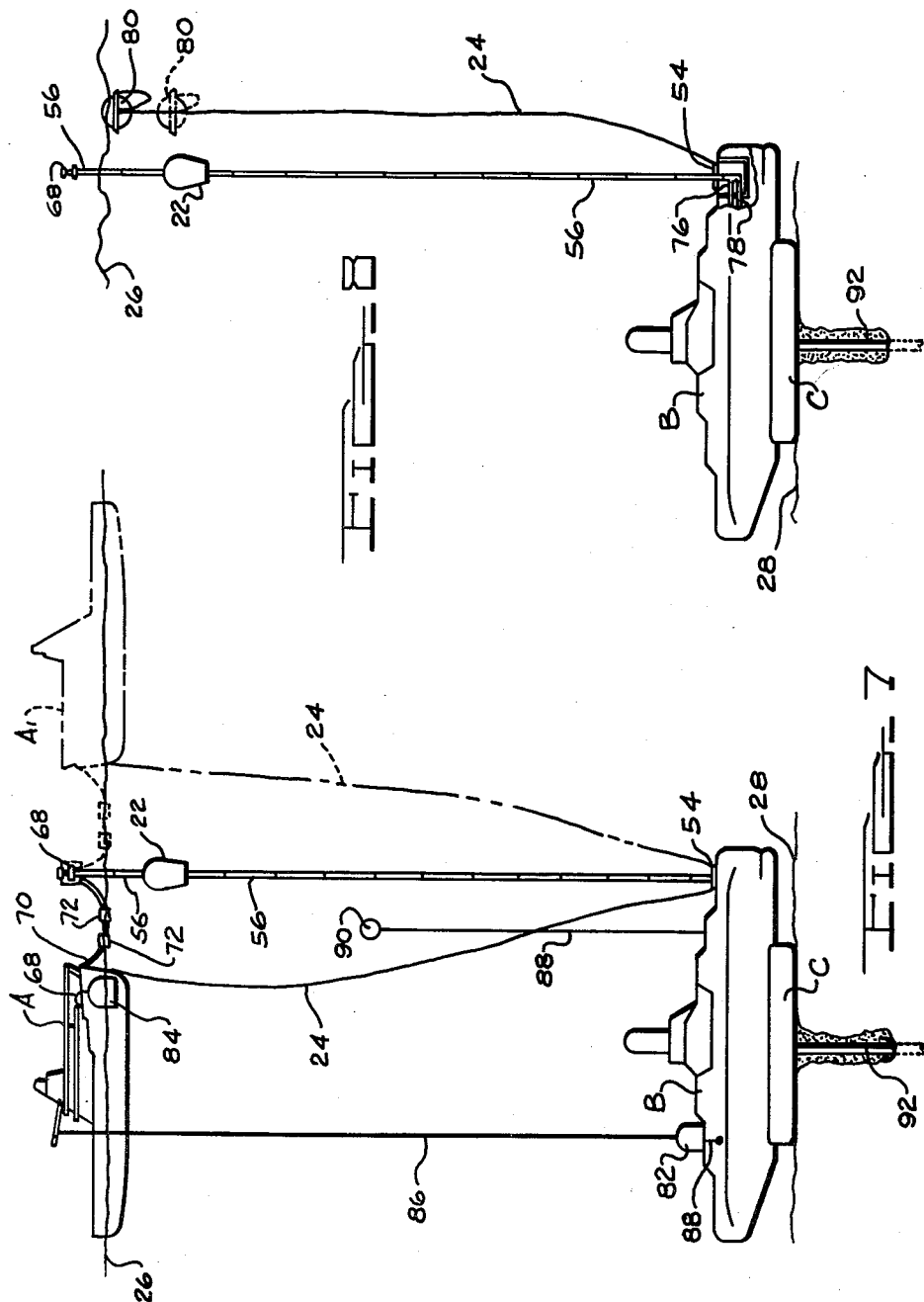
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6 Sheets-Sheet 3



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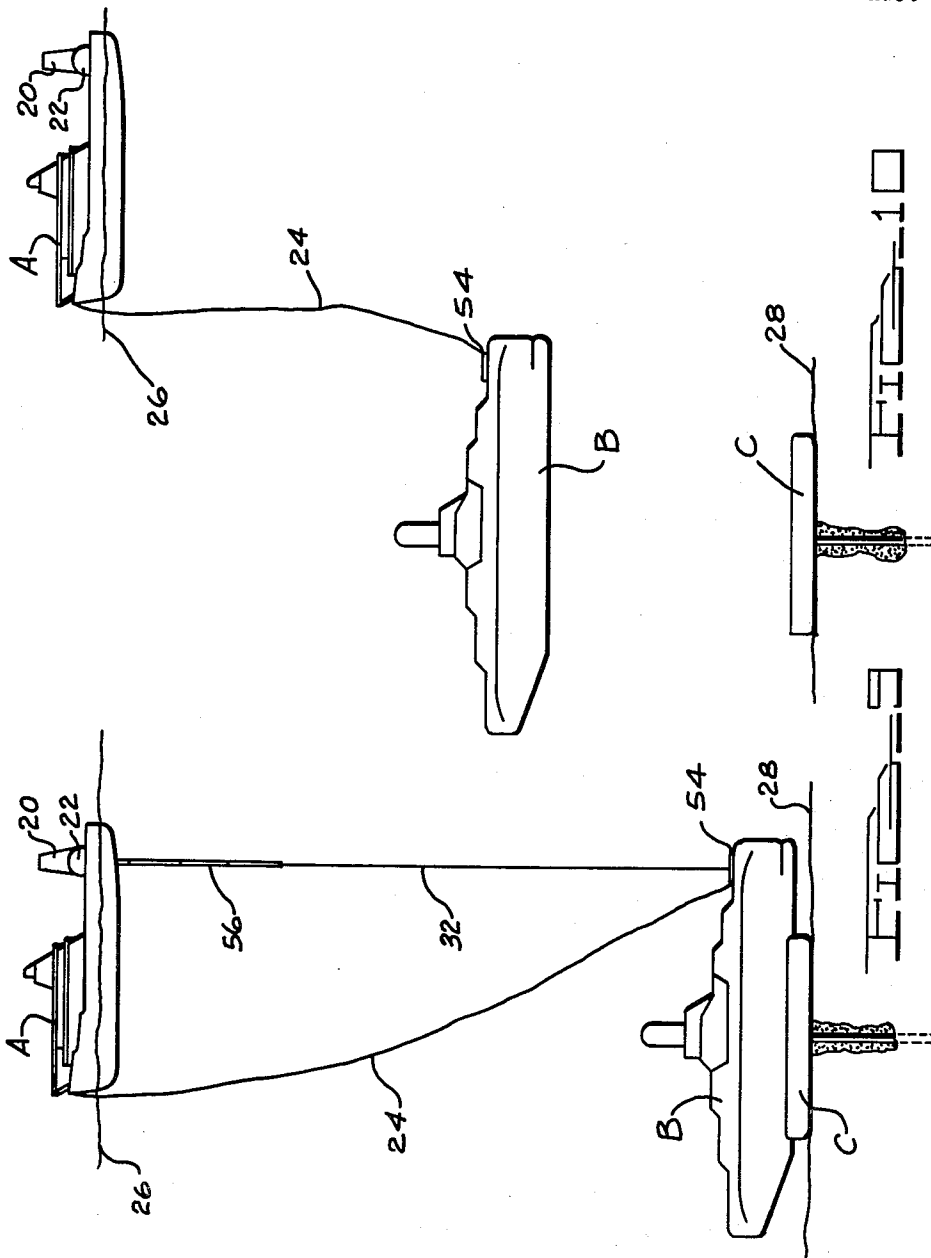
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6 Sheets-Sheet 4



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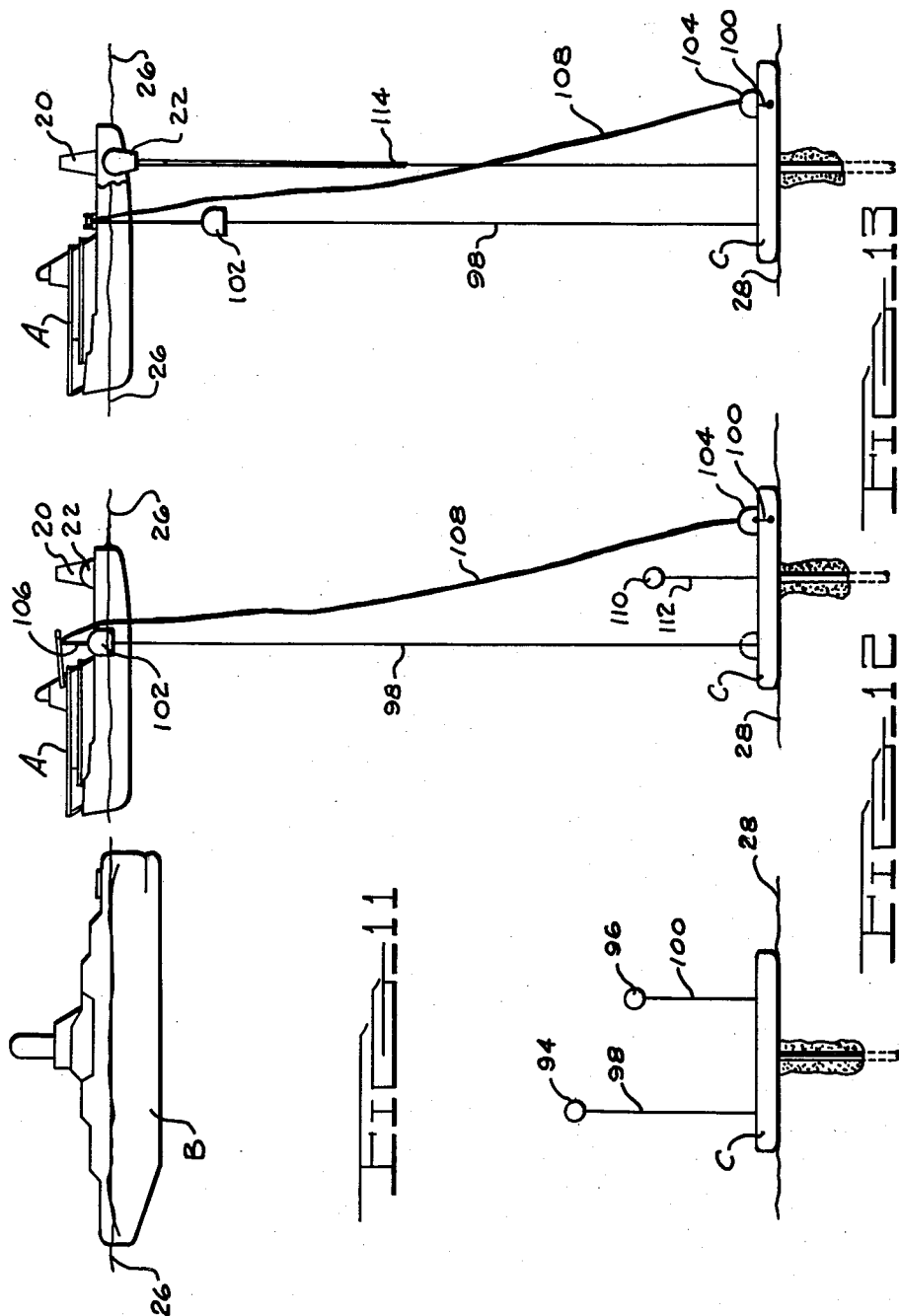
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6 Sheets-Sheet 5



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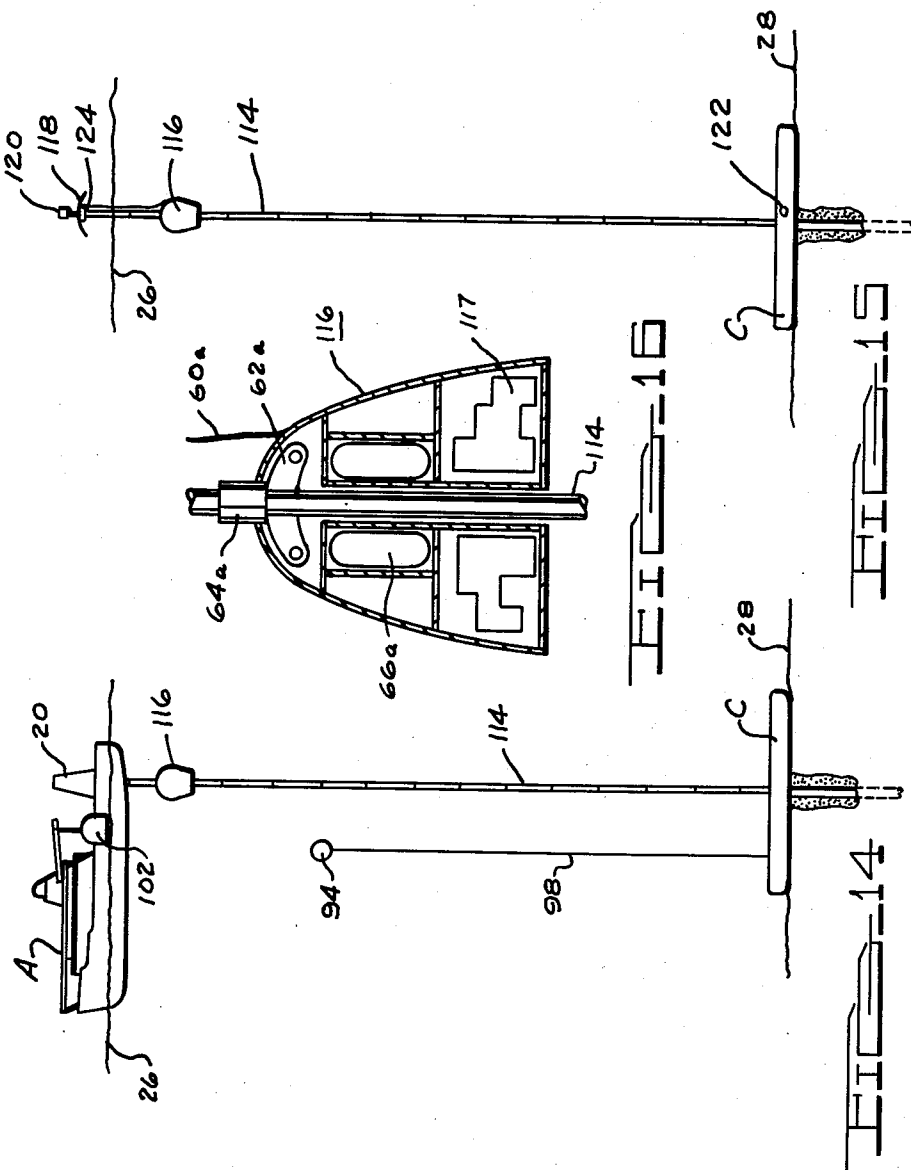
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METHOD AND APPARATUS FOR OFFSHORE DRILLING

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11 Claims. (Cl. 175-8)

This invention relates to oil well drilling apparatus and more particularly to a novel offshore method of drilling for oil in submerged lands by the use of the combination of a submarine and a surface vessel.

Many of the richest oil deposits are located beneath the so-called "continental shelves." In order to drill for these oil deposits it has been customary to employ a floating barge, a platform or to build up an island to the surface of the water to support conventional oil well drilling equipment. Such operations are expensive to install and to maintain, and their presence imposes a navigational hazard, particularly where fog obscures the location of the barge, drilling platform or island. Oil well drilling operations employing these presently used methods are limited from a practical point of view to the shallower water depths ranging down to only several hundred feet deep.

By our unique method we are able to drill oil wells in waters of great depths ranging down to 2500 feet or more below the surface of the water.

With the presently used equipment great complications arise in installing and maintaining the so-called oil well completion system whereby the well is connected to a storage tank or barge for storing oil after it is recovered from the ground. As contrasted with these complications our novel submerged oil well drilling system provides a readily accessible underwater oil well completion system wherein a storage tank communicating with the oil well is positioned on the floor of the ocean to receive the oil from the well, and wherein a conduit connected with the storage tank is provided for delivering the oil to surface vessels or tankers at convenient intervals.

Our unique submerged oil well drilling system comprehends the cooperative relation between a surface vessel and a submergible vessel, such as a submarine having an oil storage tank secured thereto for descent to the floor of the ocean, the oil well being drilled from within the submarine by substantially automatically operable apparatus of the type disclosed in copending application, Serial No. 790,486 filed February 2, 1959.

By our improved method of drilling for oil the submarine with the storage tank in place thereunder descends to the floor of the ocean and serves the function of a drilling platform, it being sheltered from disturbances caused by surface turbulence due to weather conditions.

An object of our invention is to provide a novel submerged method of drilling for oil by the cooperative relation between a surface vessel and a submergible vessel having an oil storage tank assembled therewith, the submergible vessel and tank being submerged as a unit to the ocean floor, a substantially automatically operable oil well drilling rig of unique design being positioned within the submerged vessel.

Another object of this invention is to provide a submerged oil well drilling mechanism wherein a submarine which functions as a well drilling platform on the ocean floor is connected through suitable cables and conduits with a surface vessel whereby power, air and other necessary supplies may be transmitted to the submarine as required.

A further object of our invention resides in the provision of a simplified submerged method of drilling oil wells in offshore installations wherein a submarine having

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an oil storage tank assembled therewith is employed to drill the well from the ocean floor, and when a producing oil well has been developed, the submarine may readily be detached from the tank for assembly with another tank for use in drilling another well at a new location.

Still a further object of our invention is to provide a submerged method of connecting a producing oil well with a submerged oil storage tank and having a floating standpipe connected with the storage tank whereby oil can periodically be removed from the submerged storage tank.

Another object of our invention is to provide a novel method of submerging and connecting up in operative relation the necessary power control lines and ductwork between a submerged submarine and a surface vessel whereby the submarine may remain submerged for long periods of time while performing a drilling operation.

Yet another object resides in the provision of an improved method of performing a mining operation whereby a submergible vessel having drilling equipment therein and serviced by a surface vessel may be submerged to the ocean floor for the performance of a drilling operation, and which may be moved to a new location when the desired mining operation is completed, leaving behind suitable storage or control facilities to harvest the fruits of the mining operation.

Still a further object of our invention is to provide a novel control mechanism between a submerged submarine and a surface vessel whereby cooperating control and anchor cables permit power from the surface vessel to be utilized to operate drilling equipment in the submarine, complete monitoring of the operative functions in the submarine being maintained in the surface vessel by means of television cameras and other suitable controls.

A further important object of our invention resides in the employment of an improved intercommunicating system between a submarine lying on the ocean floor and a surface vessel whereby personnel and necessary tools and equipment may readily be shuttled between the submarine and the surface vessel in powered buoys travelling on interconnecting cables.

Still another object of our invention is to provide a unique intercommunicating tube system between a surface vessel and a submerged submarine to accommodate necessary air passages and control lines to provide a leak-proof connection, the weight of the tube system being supported by a float submerged in the water beneath the draft level of vessels frequenting the area thereby avoiding the presence of a navigational hazard.

Another object of our invention resides in the provision of a novel air tube tension buoy which functions to support tubes interconnecting a submarine and a surface vessel in tension after all of the tube joints have been connected.

Yet a further object of our invention is to provide a novel system of submerged oil well drilling employing a cooperative relation between a submarine and a surface vessel, so constructed and arranged that in the event of severe storm conditions the surface vessel may leave the scene, the submarine being safely nestled on the ocean floor and adequately supplied with air through suitable air tubes projecting to a sufficient distance above the surface of the water to prevent water from entering the tube, the control and anchor cables for the surface vessel connected to the submarine being suspended by means of an auxiliary float or buoy.

Another object of our invention is to provide an improved system of guiding air tubes and power control and anchor cables into operative connection with a submerged vessel.

Still another object of our invention is to provide a novel cooperative relationship between a submarine and

an oil storage tank for use in the submerged drilling of oil wells whereby the submarine can leave the tank at the well site when a producing well has been developed, the tank having a standpipe arrangement floatingly suspended in the water and extending to above the water level to permit burning off excess gases and to permit oil to be pumped out of the storage tank at desired intervals.

Another object of our invention is to provide a co-operative relation between a submerged oil storage tank and a submarine whereby the submarine may return to the tank at a later date to perform oil well work-over and servicing as may be required.

Still a further object of our invention is to provide an air tube tension buoy having a suitable source of power supply to provide electrical power for driving circulating fans and blowers as may be required to carry off gases from the production tank, and if desired to supply power for the pumping of oil from the earth into the tank or from the tank to the surface.

Yet another object of our invention resides in the provision of a travelling buoy to permit personnel to periodically descend to the production tank to maintain the working components of the completion system of the storage tank in proper repair.

Another object of our invention is to provide a standpipe from a submerged oil storage tank supported by a float submerged beneath the draft level of vessels and wherein a standpipe extending above the water level may deflect on contact by a vessel thereby avoiding the presence of a navigational hazard.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIG. 1 is a schematic view illustrating the relative positioning of a submergible vessel to a surface vessel prior to the submersion of the submarine, and showing the submergible vessel in dash-dot lines in a partially descended position.

FIG. 2 is a schematic view showing the relation of the vessels when the submarine is on the ocean floor.

FIGS. 3 and 4 are views similar to FIG. 2 showing successive steps in the establishment of an operative interconnection between the surface and submerged vessels.

FIG. 5 is a sectional view on an enlarged scale showing the air tube tension buoy.

FIG. 6 is a fragmentary elevational view illustrating one desirable relation of control and anchor cable handling mechanism.

FIG. 7 is a schematic view illustrating the operative relation of the submarine to the surface vessel while performing a drilling operation.

FIG. 8 is a view similar to FIG. 7 illustrating the flotation of the interconnecting tube and the control and anchor cables when due to a severe storm it has been necessary for the surface vessel to take shelter elsewhere.

FIG. 9 is a schematic view illustrating the step of disconnecting the air tube assemblies preparatory to the submarine leaving the site after a drilling operation has been completed.

FIG. 10 is a view similar to FIG. 9 illustrating the step wherein the submarine is ascending after having left the production tank on the ocean floor preparatory to connecting the air tubes and the control cables to the production tank when an operative well has been developed.

FIG. 11 is a schematic view illustrating the relation of the units when the submarine is on the surface and the messenger buoy floats are shown ascending from the production tank.

FIG. 12 is a schematic view illustrating the connection of the messenger buoys from the surface vessel to travel

to the production tank and wherein the air tube guide float has been released from the production tank and is floating to the surface.

FIG. 13 is a schematic view illustrating a step in connection of the air tube assembly to the production tank, it being noted that in this view the submarine has departed and that one of the messenger buoys is near the surface while the other is located at the production tank.

FIG. 14 is a schematic view illustrating the completion of the air tube assembly with the production tank, and showing the surface vessel in position relative thereto, one of the messenger buoys having been withdrawn into the production tank and the other messenger buoy having been replaced by a float and in the process of being stowed in the production tank.

FIG. 15 is a view illustrating the air tube assembly projecting above the surface of the water for connection by tanker or other servicing vessels to withdraw oil from the production tank.

FIG. 16 is a sectional view illustrating a modified form of the tube tension and power buoy having a prime mover therein.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring now more particularly to FIG. 1 our invention is illustrated as embodied in a surface vessel A, and a submergible vessel, such as a submarine B having an oil storage or production tank secured thereto and marked C. Suitable securing means is shown in the aforementioned application, Serial No. 790,486.

The surface vessel A has an automatic tube feeding mechanism consisting of a derrick 20 movable from a horizontal stored position, FIGURE 1, to a vertical operative position as illustrated in FIG. 2. An air tube tension buoy 22 is illustrated in a carried position adjacent the stern of the surface vessel A. The vessel A has necessary power producing units such for example as diesel electric generators to produce power required for the drilling operations in the submarine as hereinafter described, and provides suitable additional storage compartments for necessary equipment and materials used in the performance of the drilling operation, and also quarters for the crew.

The submergible vessel B may be of the submarine type capable of travelling under its own power, or it may if desired be a submergible vessel adapted to be towed to the desired drilling location by the surface vessel A or otherwise. The submarine unit B used as illustrative of our invention is more fully disclosed in the aforementioned copending application, Serial No. 790,486. As there shown the submarine B has a well drilling apparatus and suitable storage compartments for lengths of drill pipe and casing, together with other necessary materials and equipment required in the performance of a drilling operation. As shown in the copending application, the oil well drilling rig is of a substantially automatic type so as to conserve space within the submarine B and to permit the drilling of oil wells under relatively cramped conditions.

Referring to the upper portion of FIG. 1 it will be noted that the power control and anchor cables 24 interconnect the front of the surface vessel A with the stern of the submarine B. As shown in dot-dash lines in FIG. 1 the submarine B with the production tank C in place thereon and with the control and anchor cables connected with the surface vessel A has descended to an intermediate position between the surface 26 of the water and the ocean floor or the earth 28 at the bottom of the water, it being

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noted that as the submarine descends the power control and anchor cables are payed out from the surface vessel A to the submarine B.

The power, control and anchor cables 24 may consist for example of three power cables 30, 32 and 34, three control cables 36, 38 and 40, and two anchor cables 42 and 44 illustrated in FIG. 6, as passing over powered drums 46 and 48. A plurality of spaced clamps 50 may be secured to the cables as shown in FIG. 6 to maintain the cables in a desired spaced relation relative to each other.

The power control and anchor cables 30 to 44 may be stored in the surface vessel by being coiled upon themselves to be withdrawn from spaced compartments or they may be wound upon a suitable reel capable of holding a sufficient quantity to permit the submarine to descend in water of the depth in which it is desired to operate. If desired power, control and anchor cables 30 to 44 in increments of a desired length, such for example as 500 feet may be wrapped on separate reels and can be connected together as required as the submarine descends.

It will be noted that as viewed in FIG. 1 the submarine B is descending under controlled power supplied for example through the cables, the power being taken off in a known manner through slip rings or otherwise. These power requirements are relatively low during descent because it is only necessary that sufficient power be available to operate the various valves and other controls required to operate the submarine. It will of course be understood that the control valves admit water to or expel it from suitable compartments in the submarine to control the descent or ascent of the submarine.

Attention is directed to the fact that the surface vessel A and the submarine B can each go independently to the well site under their own power, or if desired the submarine B or the surface vessel A can be towed to the well site. The power, control and anchor cables 30 to 44 may then payed out of the surface vessel A and be connected to the stern of the submarine B in a known manner.

As shown in FIG. 2 the submarine B with the oil storage tank C in place thereunder has descended to the ocean floor 28. If desired the tank C may have suitable leveling devices of the type shown in the aforementioned application Serial No. 790,486 to position the tank and submarine in a desired attitude. It will be noted that the power control and anchor cables 30 to 44 remain connected between the surface vessel A and the submerged units B and C. After the submerged unit has been properly levelled relative to the ocean floor 28, an air tube guide float 52 is released from a suitable hatch positioned near the stern of the submarine B and float upwardly as shown in the dotted positions. The air tube guide float 52 has secured to it one end of a cable 54 mounted on a suitable reel in the submarine so as to pay out cable as the float ascends. When the air tube guide float 52 reaches the surface, it is retrieved and the cable 54 is manually connected to the lower end of one of a plurality of lengths of air tube 56 in the derrick 20 which will have been moved from the horizontal position illustrated in FIG. 1 to the vertical operative position as illustrated in FIG. 2.

As shown in FIG. 3 after the first length of an air tube 56 has been manually connected to the air tube guide float cable 54 the derrick is utilized in the successive assembly of additional lengths of air tube 56.

Attention is directed to the fact that in adding successive lengths of air tube 56 a transfer arm 58 associated with the derrick 20 successively grasps individual pieces of air tube 56 and elevates them from the horizontal to the vertical position as illustrated in FIG. 3. When the lengths of air tube 56 have been elevated to the vertical position by the transfer arm 58, each length of tube is threaded into the previously assembled air tube string. The guide float cable 54 is maintained taut from within

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the submarine during the air tube assembly to guide the lower end of the air tube 56 into the proper relationship with a hatch located at the stern of the submarine B. The lower end of the air tube is connected to the submarine in an air tight relation to permit air to be pumped into the submarine B through the air tube 56. Any suitable sealing means may be provided in the submarine opening to seal the joint around tube 56.

As illustrated in FIG. 3 the air tubes are assembled in such a manner as to pass through the air tube tension buoy 22, as shown in FIG. 3 in a non-obstructing position relative to the derrick 20.

When the air tube 56 is suitably connected with the submarine B the air tube tension buoy 22 may be flooded to permit it to submerge on the air tube 56 to a desired depth, such for example as between 30 feet and 50 feet to position it at a level below the draft of any vessels frequenting the area. When the air tube tension buoy 22 has been submerged to the desired depth as determined for example by the length of a control cable 60, the cable 60 may supply current to operate suitable valves for air bottles 66 positioned in the buoy 22. Opening of the fluid valves releases air from the bottles to expel water from various compartments of the buoy 22 to induce a desired degree of buoyancy to the weight of the air tube 56 and to exert thereon a desired degree of tension. The buoy is held against upward displacement on tube 56 by means of a bowl chuck 62, the gripper arms of which may be operated to lock on the tube by any suitable power means (not shown) controlled from the surface vessel via cable 60. Prior to the placement of a buoy 22 in operative relation on the air tube 56 the entire weight of the string of air tube 56 is carried by the derrick 20 in the surface vessel A.

After the tension buoy 22 has been assembled on the air tube 56 as illustrated in FIG. 4 a suitable fitting 68 as shown in FIG. 7 is positioned in place at the top of the air tube 56. It will be apparent that the air tube 56 may be of any desired proportions and may carry a plurality of parallel individual conduits, or if desired concentrically disposed conduits may be employed to permit the pumping of air to the submarine, the bleeding of gases to the surface from the drilling operation where the gases can be burned off in a known manner, and to provide additional passages as may be required to transmit certain types of supplies to the submarine. A plurality of conduits 70 may connect to the fitting 68 and extend to the bow of the surface vessel A. It will be noted that suitable floats 72 may be positioned on the conduits 70 to float the conduits on the surface 26 of the water, or if desired a built-in flotation system may be employed. It will be noted as shown in FIG. 7 that the surface vessel A is not restricted to operation in a particular angular relation relative to the air tube 56 but rather can float all the way around the air tube 56 as necessitated by wind or sea conditions.

As illustrated at the lower section of FIG. 7 it will be noted that the air tube 56 and the power control and anchor cables 24 are connected to the submarine B through a rotatable fitting 54 which maintains a fixed angular relation between the power control and anchor cables 24 and the air tube 56 corresponding with the angular position of the surface vessel A relative to the air tube 56 and fitting 68. It will be noted that as shown in FIG. 8 the air tube 56 communicates through conduits 76 and 78 in the submarine B, for example to supply air to the submarine, and to permit escape of gases therefrom. It will be noted that the surface vessel A is anchored to the submarine B and to the storage tank C by means of the anchor cables 24 in such a manner that it is maintained relatively close to the air tube 56 but is free to move angularly around the tube 56 as shown in dash-dot lines in FIG. 7.

FIG. 8 illustrates the independence of the submarine B from the surface vessel A. If for example, during

violent weather it becomes expedient for the surface vessel to leave, the power, control and anchor cables 24 may be connected to a suitable float 30 having sufficient buoyancy to support the weight of the cables whereupon the surface vessel A may depart for sheltered quarters leaving the air tube 56 extending above the surface 26 of the water, and the float 30 may move freely in the water, or if desired it can be submerged to a desired depth to avoid the turbulence at the surface 26 of the water. As an alternative the cables 24 may be payed out radially from the submarine, and may be connected through a wire to a float on the surface 26 of the water.

Referring to FIG. 7 it will be noted that buoys 82 and 84 of suitable size to accommodate a desired number of men and equipment may be guided by cables 86 and 88 connected to the tops and bottoms of the buoys 82 and 84 to guide the buoys to the proper portions or hatches of the submarine B. It will be noted that in FIG. 7 messenger buoy 84 has not as yet been secured to the upper end of guide cable 88, while buoy 82 is in a lowered position on the submarine. Cables 88 are wound on drums in the submarine, and are initially carried up to vessel A by floats 90. The floats are then detached, and connections are made between cables 88 and buoys 82, 84. During gravitational lowering of buoys 82 and 84 a tension is maintained on cables 88 sufficient to guide the buoys to their desired positions on the submarine.

In the event of severe surface conditions the line 86 may be disconnected from the messenger buoy 82 and reeled into the surface boat A, leaving messenger buoy 22 secured to the submarine. The messenger buoy 84 is detached from the guide line 88 and retained with the surface vessel.

Secured to the upper end of the guide line 88 is the messenger buoy float 90, ascending upwardly to a desired position, as illustrated. Attention is directed to the fact that when it is desired to utilize the buoy 82 it may be released by suitable power control mechanism for ascent to the surface 26 of the water.

As shown in FIG. 7 the power cable in the power, control and anchor cables 24 are connected up with the power supplying system housed within the surface vessel A to provide the necessary power for the performance of the well drilling operations housed within the submarine B. As more fully described in the copending application identified hereinbefore, a substantially automatic drilling rig is housed within the submarine B and comprises a suitable bit carried by the drill pipe 92 which is rotated by suitable drive mechanism from within the submarine B to cut a hole of uniform diameter through the various earth formations as the well progresses to greater depths.

Substantially automatic pipe handling equipment is employed to connect up successive lengths of pipe within the submarine, these lengths of pipe being maintained of substantially uniform length to facilitate the handling and connecting of the pipes. The FIG. 7 illustration shows the relative positions of the various components of our novel oil well drilling development during the drilling of the well.

When the drilling of the well has been completed the submarine leaves the well site, if a producing well has been developed the submarine B is released from the storage tank C and the submarine ascends leaving the storage tank C submerged at the well site.

If it develops that the well is a "dry hole" the pipe is withdrawn and restored in the submarine in an automatic fashion and the submarine B with the storage tank C in place is prepared for ascent to the surface to be refitted for removal to a new site.

To prepare the submarine to leave a well site as shown in FIG. 9, it is necessary to disengage the lower end of the air tube 56 from the submarine from the lines 76 and 78 as described in connection with FIG. 8, and the derrick 20 is employed to withdraw the successive lengths of the tubes 56, successive sections being taken apart and stored

in the surface vessel A as depicted in FIG. 9. When the tube 56 has been thus removed the air tube guide float 52 (described in connection with FIG. 2) is attached to the end of the cable 54 and the cable is withdrawn into the submarine B for use during a subsequent operation.

Upon the completion of the drilling operation when a producing well has been developed, the submarine B is released from the production tank C. The submarine B is then floated to the surface by expelling water from its compartments in a known manner, the power, control and anchor cables 24 being withdrawn into the surface vessel A simultaneously as the submarine ascends as shown in FIG. 10. When the submarine B reaches the surface 26 of the water, the power, control and anchor cables 24 are released from the submarine and they are withdrawn into the surface vessel A for use in a subsequent operation. The submarine can then be moved to a new well site after having been refitted with necessary pipe and other equipment and supplies required in the performance of the drilling operation.

In the event that the well is a non-producing or dry hole the production tank C remains connected to the submarine B and the assembly is elevated whereupon the submarine B with the production tank C assembled therewith and the surface vessel A are moved to a new drilling location after being refitted. In this connection it will be noted that the power, control and anchor cables 24 are released from the submarine and are withdrawn into the surface vessel A and that the derrick 20 is preferably lowered to the stowed position in the surface vessel A.

The production tank C has compartments adapted for the reception of oil, and has additional compartments which can be flooded to assist in submerging the submarine and production tank assembly. When the submarine is detached from the production tank as illustrated in FIG. 10 the production tank C remains stationary on the ocean floor 28 because of the fact that the floodable compartments therein have been filled with water overcoming the buoyant effect of the chambers which are adapted for the reception of oil.

As illustrated schematically in FIG. 11 it will be noted that after the submarine B has left the production tank C, hatches are opened by suitable timing mechanisms or by remote control, and messenger buoy floats 94 and 96 secured to guide lines 98 and 100 are expelled from the production tank C and float to the surface 26 of the water, carrying with them the guide lines 98 and 100. The floats 94 and 96 are retrieved by the surface vessel A and messenger buoys 102 and 104 are attached to the guide lines 98 and 100 respectively.

As shown in FIG. 12 it will be noted that the bottom portion of the messenger buoy 102 is attached to the upper end of the guide line 98. The upper end of the messenger buoy 102 is connected to an intercommunication and power line 106 carried by the surface vessel A and adapted to reel off as the messenger buoy descends, the guide lines 98 being automatically reeled in on a power winch located in the lower portion of the messenger buoy 102. It will be noted from FIG. 12 that the messenger buoy 104 is connected to an intercommunication and power line 108 from the surface vessel A and has again descended to the production tank C, the guide line 100 having been reeled into a lower chamber of the messenger buoy 104 to guide the messenger buoy of a desired location on the surface of the production tank C.

Attention is directed to the fact that the messenger buoys 102 and 104 can conveniently be employed to transport personnel and necessary equipment and supplies from the surface vessel A to the production tank C.

Also as shown in FIG. 12 it will be noted that an air-oil tube guide float 110 carried by a guide line 112 is released from the production tank C and floats upwardly to the surface 26 of the water. It will be noted that the guide float 110 can be released automatically by a timing

mechanism, or if desired it can be triggered to release by electrical power communicated through the power line 108. When the air-oil tube guide float reaches the surface it is retrieved and taken into the surface vessel A. The float 110 is removed and the upper end of the guide line 112 is secured to the first section of the air-oil tube 114 as shown in FIG. 13. Additional lengths of tube 114 are then successively connected and the air-oil tube 114 is built downwardly to the production tank C in the manner previously described in connection with the tube 56 communicating with the submarine B.

As shown in FIG. 14 the tube 114 is constructed all the way down to the production tank C and is connected therewith as previously described in connection with the submarine. Personnel from the surface vessel A can, if desired, be available at the production tank C through the messenger buoys 102 and 104 as illustrated in FIG. 13 to assist in properly connecting up the air-oil tube with the production tank. It will also be apparent that if desired a power connection of the air-oil tube 114 to the production tank C can be made through power means thereby rendering it unnecessary for personnel to be present at this time in a manner similar to that described in connection with FIG. 8.

It will be apparent that the messenger buoys 102 and 104 may be removed from the guide lines 98 and 100 respectively, and that the floats 94 and 96 may be secured to the upper ends of guide lines 98 and 100. The guide lines may then be retracted under power all the way or to a desired submerged position by power reels in the production tank as shown in FIG. 14.

A tube tension and power buoy 116 is then lowered on the tube 114 and is secured thereto in the same manner as previously described in connection with the air tube tension buoy 22 illustrated in FIG. 7.

After the buoy 116 is connected to tube 114 a suitable cover 118 is provided to shield the intake of the tube, FIGURE 15. It will be noted that a fitting 120 extends above the cover 118 and provides an opening for exhaust gases from the well where, if desired these gases may be burned off in a known manner.

The tube tension and power buoy 116 being secured to the tube 114 below the draft level of surface vessels frequenting the area maintains the tube taut and if desired may provide a source of diesel electric or other power to elevate oil from the oil compartments of the storage tank C to tankers or other oil receiving vessels. It will also be apparent that if power is desired to facilitate the withdrawal of oil from the well into the production tank C the diesel electric or other power provided in the buoy 116 is available for that purpose.

It will be noted that if desired a pump 122, FIGURE 15, powered by any suitable source of power may be positioned in the production tank C to elevate oil from the production tank into a surface vessel, and also if desired to subject the well to suction to facilitate the withdrawal of oil from the earth. It will be apparent that separate pumps may be employed to perform these functions because it is desirable to withdraw oil from the production tank C at a relatively rapid rate, and therefore a high capacity unit is required, whereas a unit of much lower capacity will suffice to provide the desired constant suction to assist in withdrawing oil from the earth into the production tank C.

It will also be apparent that a surface vessel may provide the motive force to drive a pump such as a pump 122 located in the production tank to elevate oil to the surface from the tank, or in the event of failure or malfunctioning of the diesel electric power or other power source positioned within the tube tension buoy 116. It will of course be apparent that the diesel electric unit 117 housed within the buoy 116 is supplied with air to support combustion from one of the passages in the tube 114 or by means of an auxiliary passage extending to above the buoy 116.

A construction cable 124 extending upward from the

tube tension buoy 116 supplies necessary control power for releasing the tube buoy as may be required for servicing. If desired the cable required to supply the pump 122 with power may be housed within the tube 114 or it may extend alongside the tube 114 in the water.

After the unit has been set in operation as shown in FIG. 15 and the surface vessel A has departed, if it becomes necessary to service the production tank C, the messenger buoy floats 94 and 96 may be released through the control cable 124 to float to the surface 26 of the water to permit the securing thereto of messenger buoys 102 or 104 to permit personnel to descend to the production tank C taking with them any necessary servicing equipment that may be required.

It will be apparent that the submarine B carries a sufficient quantity of air that it can operate in a fully submerged condition on the earth 28 at the bottom of the water without any communication with the air above the surface 26 of the water for extended periods of time. It is also significant that the submarine can successively emerge several times to the surface 26 of the water from the deepest depths to which it can descend.

In summary, a drilling operation is conducted with the illustrated apparatus in the following manner:

Submarine B with connected tank structure C descends to the ocean floor by operating control mechanisms from surface vessel A, the electrically controlled devices in the submarine being operated via cable structure 24.

Float 52 is released from the submarine (FIG. 2) to carry the guide cable 54 up to the surface ship.

The lowermost air tube 56 is connected to cable 54 and the air tube assembly is formed through the use of derrick 20 and transfer arm 58. As the tube assembly is formed it is carried downwardly toward the submarine as shown in FIG. 3, with cable 54 being maintained in a taut condition to guide the tube assembly to a desired point of connection with the submarine.

With the tube assembly 56 still depending from surface vessel A, buoy 22 is lowered on the tube assembly to a desired position thirty to fifty feet below water surface 26, the lowering being accomplished by flooding certain of the chambers in buoy 22 through the mechanism of buoy-contained valves controlled from surface vessel A through cable 60.

When buoy 22 reaches the desired depth, chuck 62 is actuated to grip the tube assembly 56 and secure the buoy in the desired position; also air bottles 66 or their equivalent are opened to direct compressed air into the flooded compartments to expel water therefrom for buoying up the buoy to cause it to support the tube assembly weight.

As the next step, fitting 63 and conduit 70 are connected as shown in FIG. 7, with the buoy 22 and tube assembly 56 being independent of the surface vessel A except for the connection to conduit 70. In the event of stormy weather, the conduit 70 may be detached from fitting 63 to allow the surface vessel A to leave the area as shown in FIG. 8.

In the event manual servicing of submarine B is required, floats 90 are released from the submarine so as to permit man-carrying buoys 82 and 84 to be lowered from surface vessel A to the desired point on the submarine for entry of the men into the submarine, as shown in FIG. 7.

At conclusion of the drilling operation, in the event a producing well is developed, tube assembly 56 is drawn upwardly into surface vessel A, and the individual sections are disconnected using derrick 20 and transfer device 58. Thereafter submarine B is disconnected from tank section C, as shown in FIG. 10, and the submarine is moved upwardly away from the tank by remote control from surface vessel A (through the mechanism of cable 24).

To enable tank structure C to be manually serviced during extraction of oil from the well, floats 94 and 96 are released from the tank structure as shown in FIG. 11,

and man-carrying buoys 102 and 104 are lowered to a desired point on the tank structure through the guidance of tensioned cables 98 and 100.

The oil extracted from the well is fed, either by natural subterranean pressure or suction developed by pumps within the tank structure, into selected ones of the tank structure compartments. Other ones of the tank compartments are flooded to maintain the tank structure in position on the ocean floor.

In order to pump oil from the tank structure a tube assembly 114 is extended downwardly from surface vessel A as shown in FIG. 13. This tube assembly is built up in the same manner as previously mentioned tube assembly 56. Pumping of oil from the tank C is effected by pump mechanism preferably located in the tank structure, the final travel of the oil into the storage chambers of a vessel (not shown) being effected through a conduit similar to conduit 70.

We claim:

1. In a method of making a bore into earth underlying a body of water, the steps of lowering a submergible drilling vessel from the surface of the body of water to rest upon the underlying earth, controlling lowering movement of said submergible vessel by line connection with a surface vessel, releasing a line carrying buoy from the submerged vessel into contacting engagement with said surface vessel, connecting said line to a conduit carried by said surface vessel, building a conduit downwardly from said surface vessel, guiding said conduit into connecting engagement with said submerged vessel by withdrawing said line into said submerged vessel, securing a buoy in supporting relation to said conduit at a submerged point, releasing said conduit from supported relation by said surface vessel to divert the weight of same to said buoy, and feeding operating supplies to said submerged vessel and removing waste therefrom via said conduit while drilling an earth bore from said submerged vessel into the subjacent earth.

2. In a method of making a bore into earth underlying a body of water, the steps of lowering a submergible vessel and a detachably connected fluid storage tank as a unit from the surface of the body of water to rest upon the underlying earth, controlling the lowering movement of the submergible vessel by line connection with a surface vessel, releasing a cable-carrying buoy upwardly from the submerged vessel, detaching said buoy from said cable and connecting said cable to the bottom end of a conduit supported by said surface vessel, building said conduit downwardly to extend in supported relation from said surface vessel to said submerged vessel, guiding said conduit into connection with said submerged vessel while maintaining tension on said cable from said submerged vessel, securing a buoy in supporting relation on said conduit at a submerged point, releasing said conduit from supported relation by said surface vessel to divert the weight of said conduit to said buoy, releasing a second cable carrying buoy upwardly from said submerged vessel into contacting engagement with said surface vessel, connecting said second cable to a man-transport buoy carried by said surface vessel, drawing said man-transport buoy to said submerged vessel by retrieving said second cable into said submerged vessel, drilling an earth bore from said submerged vessel into the subjacent earth, connecting said earth bore to said tank, disconnecting said submerged vessel from said storage tank, leaving said storage tank at said earth bore, and moving said submergible vessel to another locus.

3. In a method of making a bore into earth underlying a body of water, the steps of lowering a submergible vessel and a detachably connected crude oil storage tank as a unit downwardly through the water to rest upon the underlying earth, releasing a line carrying buoy from the submerged vessel upwardly toward a surface vessel positioned thereabove, connecting said line to a conduit carried by said surface vessel, building said con-

duit downwardly into contact with said submerged vessel while drawing said line into said latter vessel, securing a buoy in supporting relation on said conduit at a submerged point, releasing the conduit from supporting relation by said surface vessel to divert the weight of same to said buoy, feeding operating supplies into and exhausting waste from said submerged vessel via said conduit while drilling an earth bore from said submerged vessel into the subjacent earth, connecting said bore to said storage tank in fluid storage relation, disconnecting said submerged vessel from said storage tank, and moving said submerged vessel to another locus.

4. In a method of making a bore into earth underlying a body of water utilizing a submergible vessel containing control means connected by a line to a surface vessel, the steps of submerging the submergible vessel to a resting position upon the underlying earth, controlling submerging movement of said submergible vessel from the surface vessel, drilling an earth bore into the subjacent earth from said vessel, and moving said vessel away from said earth bore by control from the surface vessel.

5. In a method of making a bore into earth underlying a body of water at or below the continental shelf level, the steps of submerging a completely enclosed high pressure-resistant mobile vessel and a detachably connected fluid storage tank as a unit to a resting position upon the underlying earth, drilling an earth bore into the subjacent earth from said vessel, detaching said tank from said vessel at the earth bore site upon completion of said bore and connecting the tank in fluid storage relation to the earth bore, moving said vessel away from said earth bore site, connecting a conduit between said tank and the surface of said body of water, moving fluid from the earth bore into the tank, and then moving fluid from said tank up through said conduit to the surface of said body of water.

6. In a method of making a bore into earth underlying a body of water, the steps of submerging a completely enclosed high pressure-resistant mobile vessel and a detachably connected fluid storage tank as a unit to a resting position upon the underlying earth, drilling an earth bore into the subjacent earth from said submerged vessel, connecting the tank in fluid storage relation to the earth bore, detaching said vessel from said tank, moving said vessel away and leaving said tank at the bore site, releasing a line-carrying buoy from said tank upwardly into contacting engagement with a surface vessel positioned thereabove, feeding a conduit downwardly from said surface vessel while guiding the lower end of said conduit into connection with said tank by said line, moving fluid from the earth bore into the tank and then moving fluid from said tank to the surface of the body of water through said conduit.

7. In a method of moving oil from an oil storage tank positioned adjacent an oil well made into earth underlying a body of water and connected to the well, the steps of releasing a line-carrying buoy from the tank upwardly through the water, contacting the buoy with a surface vessel positioned above the tank, feeding a conduit downwardly from said surface vessel, guiding the lower end of said conduit into connection with said tank by said line, moving fluid from the well into the tank, and then moving fluid from said tank to the surface of said body of water through said conduit.

8. In a method of making a bore into earth underlying a body of water, the steps of moving a submergible drilling vessel downwardly through the body of water to rest upon the underlying earth, releasing a line-carrying buoy upwardly from the submerged vessel into contacting engagement with a surface vessel positioned thereabove, building a conduit downwardly by addition to the top thereof, guiding said conduit into connection with said submerged vessel by said line, securing a buoy in supporting relation to said conduit, transferring said conduit from supported relation by said surface vessel to

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supported relation by said buoy, feeding operating supplies to said submerged vessel and removing waste therefrom via said conduit while drilling an earth bore from said submerged vessel into the subjacent earth, transferring said conduit from supported relation by said buoy to supported relation by said surface vessel, disconnecting said conduit from said submerged vessel, removing said conduit upwardly to said surface vessel, and moving said submerged vessel away from said earth bore.

9. In a method of making a bore into earth underlying a body of water, the steps of moving a submergible vessel downwardly through the water to rest upon the underlying earth, releasing a line-carrying buoy from the submerged vessel upwardly to the surface of the water, contacting the buoy with a surface vessel positioned thereabove, building a conduit downwardly from said surface vessel while guiding the same into connection with said submerged vessel by said line, securing a buoy in supporting relation to said conduit, transferring said conduit from supported relation by said surface vessel to supported relation by said buoy, and feeding operating supplies to and exhausting waste from said submerged vessel through said conduit, and drilling an earth bore from said submerged vessel into the subjacent earth.

10. In a method of conducting an earth drilling operation in earth underlying a body of water, utilizing a first submergible vessel releasably connected to a second submergible vessel, the steps of

lowering the vessels in releasably connected relation through the body of water to the underlying earth, drilling an earth bore from the first vessel into the earth,

connecting the bore in direct flow fluid storage relation to the second vessel at the earth level, sealing the second vessel against entry of ambient water, releasing the first vessel from the second vessel and moving the first vessel away,

flowing fluids from the earth bore directly into storage in the second vessel, and periodically removing fluid from the second vessel to the surface of the body of water.

11. In a method of drilling a well into earth underlying a body of water utilizing a first submergible vessel

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releasably connected to a second submergible vessel, the steps of

submerging the vessels to a resting position upon the underlying earth,

drilling an earth bore into the subjacent earth from the first vessel and adjacent said second vessel,

completing the well at the underlying earth level by connecting the bore in direct, adjacent, fluid-storage relation to the second vessel,

detaching said first vessel and moving the first vessel away from the earth bore,

and moving fluids from the earth bore directly into storage in said second vessel.

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