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Crooke

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[54] **DEEP WATER DRILL PIPE CONTROLLED MANIPULATOR**

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[73] Assignee: **Global Marine Inc.**, Los Angeles, Calif.

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[21] Appl. No.: **96,479**

[52] **U.S. Cl.**.....**61/69 R**, 61/46.5, 114/.5 D, 214/1 CM

[51] **Int. Cl.**.....**B63c 11/00**

[58] **Field of Search**.....61/46.5, 69, 72.1–72.3; 114/16, .5 D; 9/8; 166/.5, .6; 214/1 CM

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Attorney—Christie, Parker & Hale

[57] **ABSTRACT**

A manipulator for working on underwater oil drilling and production equipment and the like is supported on the lower end of a pendulous drill pipe suspended from a floating vessel. The drill pipe conducts hydraulic motive power to operate the manipulating arms of the manipulator. Hydraulic fluid is distributed by electrically controlled valves in a distribution manifold at the manipulator. Electric control signals are conducted to the control valves by a multi-conductor electric cable which is either secured to the exterior of the drill pipe or disposed within the interior of the pipe. Control signals alternately may be remotely transmitted by a sonar system for producing coded acoustical signals which are decoded at the manipulator and converted to electric control signals for operating appropriate control valves. Some motive power for operating the manipulator may be supplied by an electric cable led down the inside of the drill pipe, with control signals being carried by a low-voltage line either inside the drill pipe or secured to its exterior. The electric control signals may be multiplexed and decoded at the manipulator.

12 Claims, 4 Drawing Figures

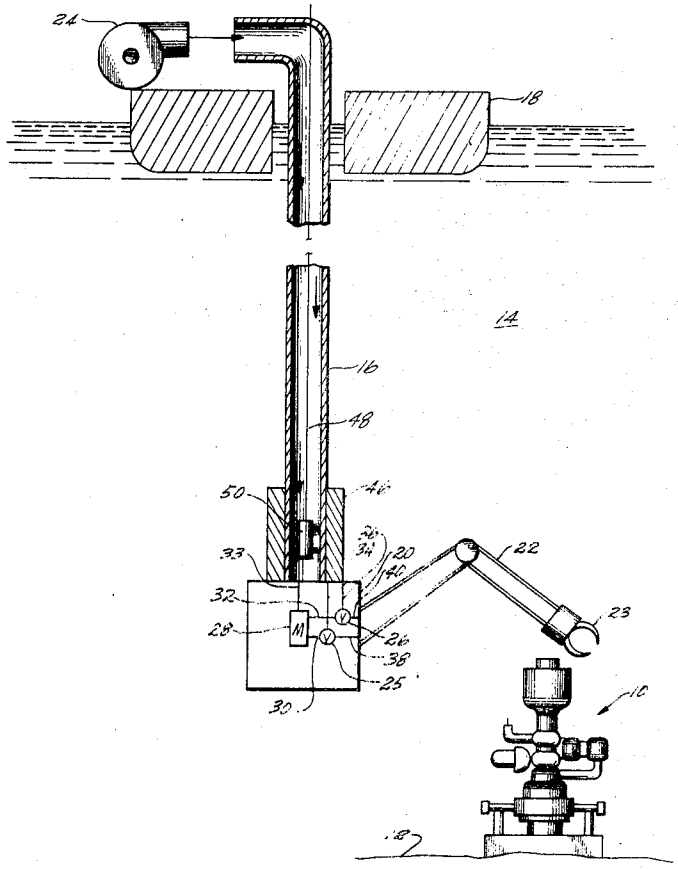
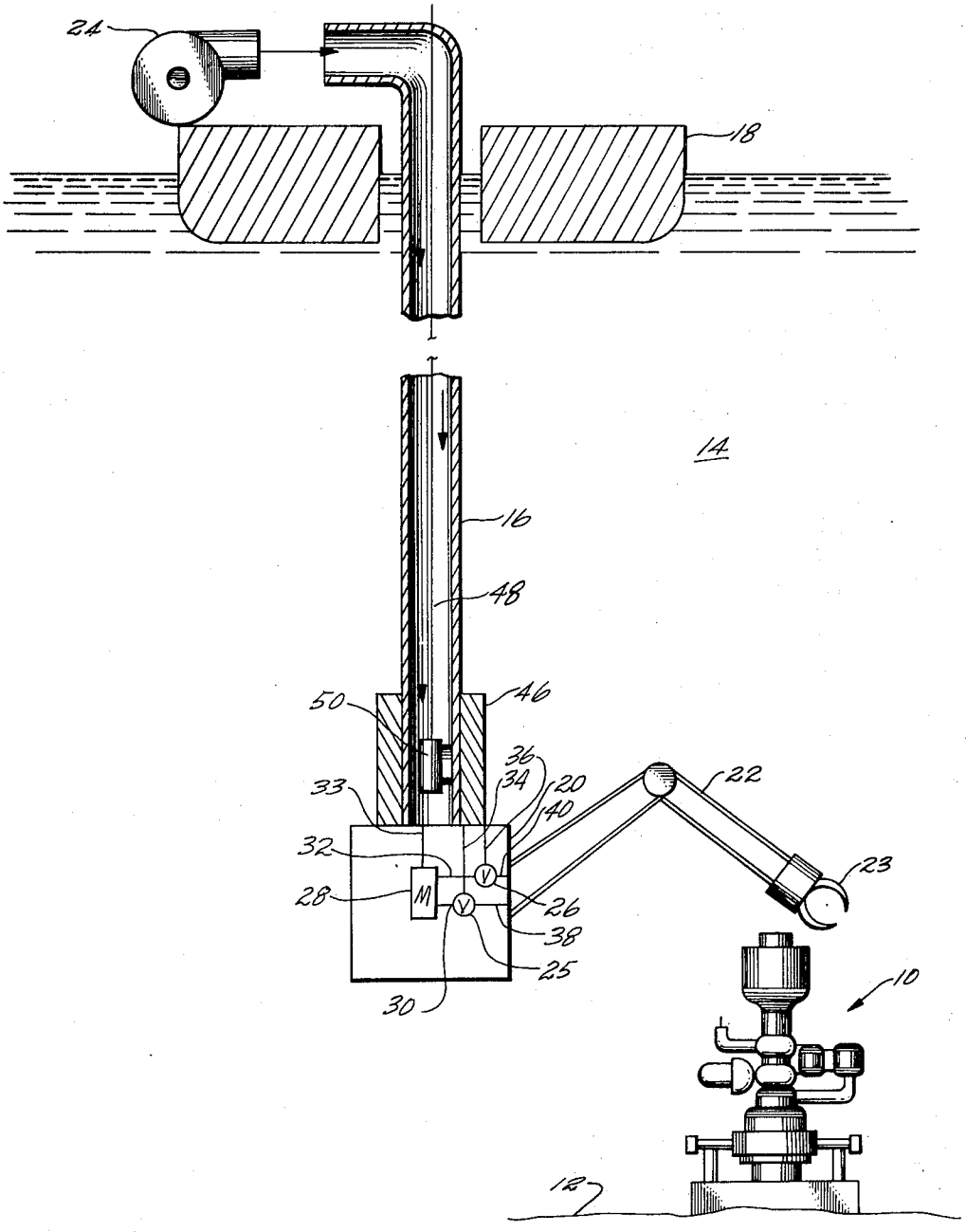


FIG. 1



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FIG. 2

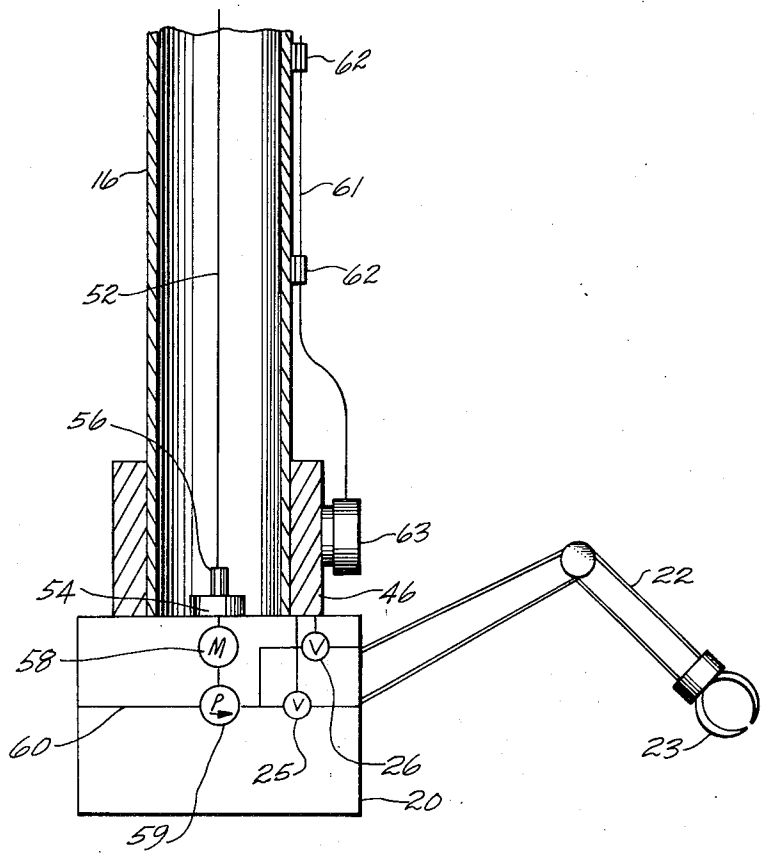

62
16
61
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46
22
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M
V
P
V
60
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23
20
59

FIG. 3

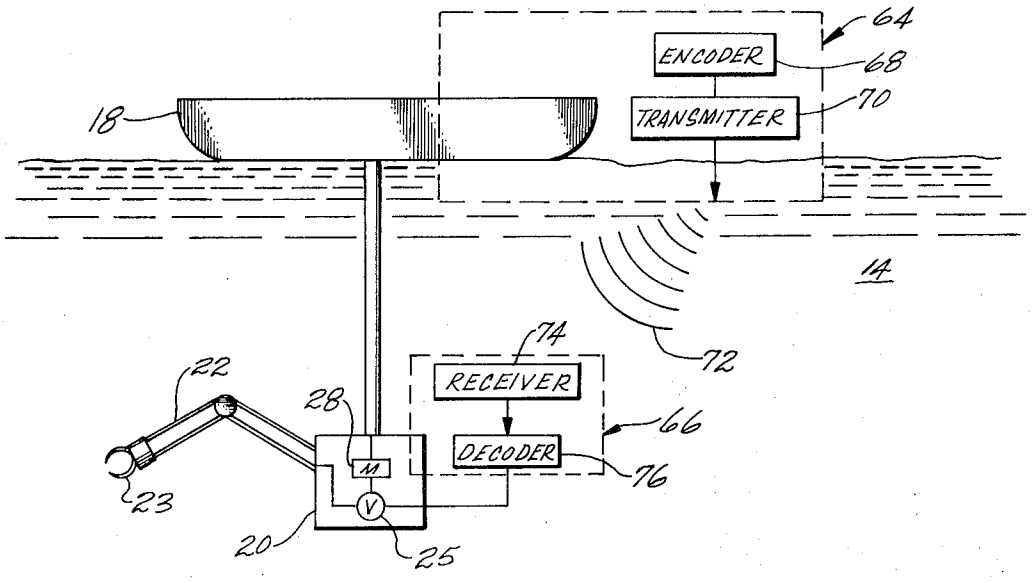
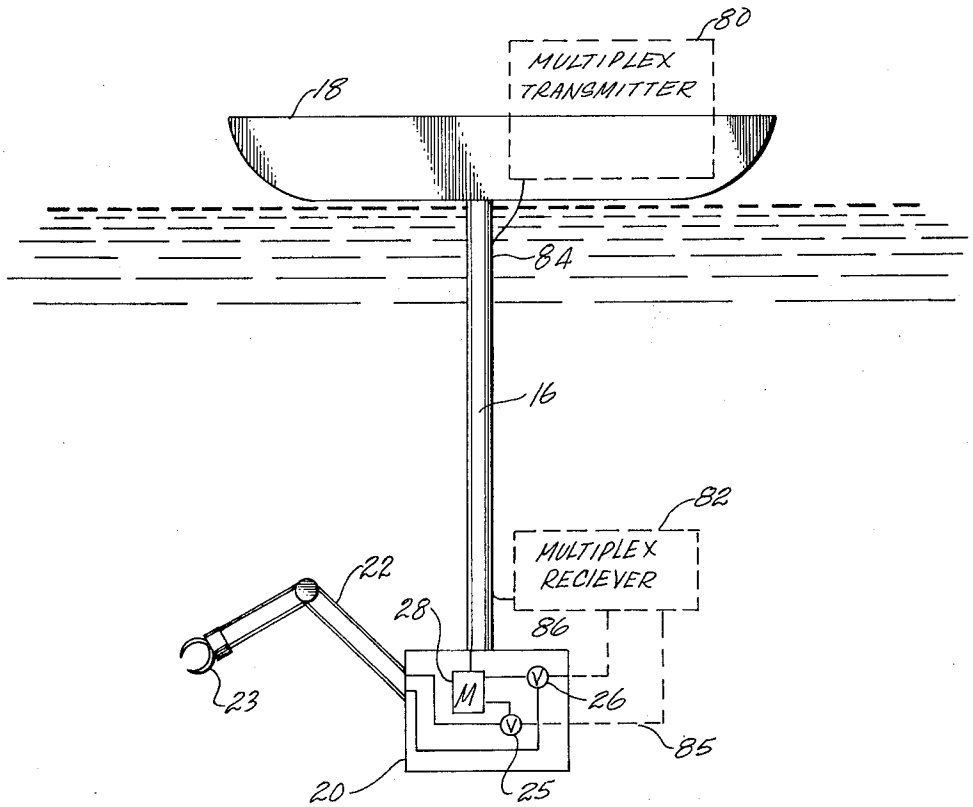

64
ENCODER
68
TRANSMITTER
70
18
14
74
72
22
RECEIVER
28
66
DECODER
76
M
V
23
20
25

FIG_4


80
MULTIPLEX
TRANSMITTER
18
84
16
82
MULTIPLEX
RECIEVER
22
28
86
M
V
26
V
23
85
20
25

DEEP WATER DRILL PIPE CONTROLLED MANIPULATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to underwater manipulating apparatus, and more particularly to a deep water manipulator supported from the bottom of a drill pipe independently of the ocean floor.

2. Description of the Prior Art

Underwater well drilling and production equipment requires means for installing it on the ocean floor and for continuously making adjustments to maintain it in effective operation once installed. Deep water manipulating devices have been described for opening and closing underwater valves, handling wellhead equipment, such as blow-out preventers and Christmas trees, connecting flow lines to Christmas trees, and performing other similar tasks in deep water.

Some deep water manipulators are deep diving manned submersibles with movable manipulating arms for performing underwater tasks under the control of a person inside the submersible. Manned submersible manipulators have the disadvantage of being limited in the amount of power available to perform underwater tasks, and in the amount of time they can be present at a desired underwater location, and they become more unsafe as water depths increase and thus are not useful at great depths. Other conventional deep water manipulators are tethered on a cable and remotely controlled from the floating vessel by numerous hydraulic lines and electric cables leading from the vessel to the manipulator. A major problem with existing tethered unmanned submersibles is the great possibility of fouling or snarling of the power and control cables, even when they are collected in an umbilical arrangement. These unmanned manipulators are also limited in the amount of power available, which limits the type of functions they may perform as water depths increase; also, they, like most manned submersibles are sensitive to movement by underwater currents.

SUMMARY OF THE INVENTION

Briefly, this invention provides a supportive conduit, such as oil well drill pipe, supported from a vessel such as a conventional floating drilling vessel floating at the surface of a body of water. A manipulating device is supported on the lower end of the conduit independently of the bottom of the body of water. The manipulating device is operable to perform manipulations on underwater well drilling and producing equipment, for example, in response to receiving motive power supplied along the conduit from the vessel.

Thus, the manipulating device is put in position at the required depth by the location of the supporting vessel so its movable manipulating arms may perform a variety of useful functions, such as installing and making controlled adjustments of drilling and production equipment. The conduit provides a path for conducting a substantially greater amount of motive power to the manipulating device than is available to conventional manned submersible manipulators or manipulators tethered on a cable. Thus, the performance and safety of the present manipulator are not limited as they are in manned and tethered unmanned submersible manipulators. Moreover, the drill pipe conduit makes the positioning of the manipulating device much less a problem when storms or strong currents are present.

In a preferred form of the invention, control signals for operating the manipulating device are conducted to a remote electric control circuit at the manipulating device by an electric cable which is either led down the interior of the drill pipe conduit, or fastened to the exterior of the conduit. Alternately, control signals may be transmitted to the remote electric control circuit by an acoustical transmitter on the drilling vessel, with an acoustic receiver at the manipulating device receiving acoustical control signals and converting them to electric control signals for operating the control members of the manipulating device. The acoustical control signals are preferably coded when transmitted, and are decoded at the manipulating device to produce control signals for performing certain operating functions on the manipulating device.

In another form of the invention, control signals may be multiplexed onto a low voltage signal and decoded at the manipulating device to produce control signals for performing specified operating functions.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features of the invention are more fully set forth in the following detailed description of the embodiments of the invention which are presently preferred, such description being presented with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic elevation view showing a manipulating device supported on the lower end of a drill pipe pendulously supported from a drilling vessel floating on a body of water;

FIG. 2 is a schematic elevation view showing an alternative form of the invention in which electric power is supplied by a cable extending down the interior of a drill pipe, with control signals being conducted by an electric cable secured to the exterior of the drill pipe;

FIG. 3 is a schematic elevation view showing a system for transmitting coded acoustical control signals; and

FIG. 4 is a schematic elevation view showing a system for multiplexing control signals on a low voltage signal.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, FIG. 1 shows a submerged wellhead 10 of an oil well in a formation 12 underlying a body of water 14. An upright, elongated hollow drill pipe 16 extends downwardly to the vicinity of the wellhead from a drilling vessel 18 floating on the body of water.

A deep water manipulator 20 is supported on the lower end of drill pipe 16. The manipulator may be any one of the presently known general purpose manipulating devices used to perform underwater tasks, such as the manipulators carried by the manned submersible known as "Beaver", which has been designed by Autonetics Division of North American Aviation, Inc. The manipulator shown in the drawings includes an elongated, articulated movable manipulating arm 22 and other manipulating members (not shown) for performing underwater operations on wellhead 10. A

wrenching claw device 23, for example, at the end of manipulating arm 22 is operative to open and close valves on wellhead 10. Manipulator 20 also may have a clamping device (not shown) for installing flow lines and other underwater wellhead equipment. Other manipulating members may be supplied with magnets, suction cups, or stud guns (such as those described for use with the manipulators of the manned submersible "Beaver") to lock the arm to an object and then relax the joints so that relative motion may take place between the working end of the arm and the body of the manipulator.

Hydraulic motive power is supplied to manipulator 20 through the interior of drill pipe 16 by a hydraulic pump 24 mounted on drilling vessel 18. A hydraulic system within manipulator 20 distributes the hydraulic fluid pumped down the drill pipe to power manipulating arm 22. A control system for the manipulator includes a plurality of electrically activated hydraulic control valves, two of which are represented by valves 25 and 26 shown in FIG. 1 and which may be of the throttling type. A valve manifold 28 receives hydraulic fluid pumped down the drill pipe and delivers the fluid to control valves 25 and 26 through hydraulic lines 30 and 32, respectively. Hydraulic fluid is supplied to valve manifold 28 from the drill pipe through a hydraulic line 33. Control valves 25 and 26 are operated by electric control signals (to be described in detail below) supplied to the valves by electric lines 34 and 36, respectively.

In use, when control valve 24 is actuated by an electric control signal, hydraulic fluid is supplied from the valve manifold through the valve and hydraulic line 38 to the manipulating arm 22 under a specified amount of pressure determined by valve 24, for example, to move the arm in a desired direction, or in a desired movement. Similarly, when valve 26 is actuated by an electric control signal, the valve supplies hydraulic fluid through a hydraulic line 40 to the manipulating arm to move it in a different direction, or in a different movement.

Expended hydraulic fluid is discharged to the sea through hydraulic fluid exhaust lines (not shown) in the hydraulic system of the manipulator. Alternatively, hydraulic fluid may be supplied in a closed loop system in which expended hydraulic fluid is returned to pump 24 on the drilling vessel 18. Sea water is the preferred motive fluid for the manipulator because then the hydraulic system may be an open loop system in which the sea water is exhausted to the sea after performing the desired drive functions in the manipulator. When a closed loop hydraulic system is used, the hydraulic fluid may be a conventional hydraulic oil.

A housing 46 at the lower end of drill pipe 16 contains remote electric control circuits connected to the respective hydraulic control valves in manipulator 20. For example, one of the remote electric control circuits in the housing 46 is connected to valve 25 through electrical lead 34. A multiconductor electric cable 48 is led down the interior of drill pipe 16. A remote electric disconnect fitting 50 at the lower end of cable 48 latches the different conductors in the cable to appropriate ones of the control circuits in housing 46. Connections between plugs in the remote electric disconnect fitting 50 and the electric control circuits may be made of self-connecting spear-type connectors (not shown) remotely stabbed into the appropriate receptacles leading to the electric control circuits in housing 46. Alternatively, a jointed sinker bar (not shown) of sufficient weight to force the plugs and their receptacles into engagement may be used to remotely connect the electric cable 48 to the control circuits. The cable 48 is preferably led down the interior of the drill pipe by securing a weight to its lower end and pumping it down the pipe with the hydraulic fluid from pump 24. A rupturable diaphragm (not shown) sized to fit the inside diameter of the pipe may be secured to the weighted end of the cable for use in pumping the cable down the pipe. When the cable reaches its desired location, the diaphragm is overloaded with fluid pressure to rupture it so the cable may be latched to the control circuit, and so that hydraulic fluid may thereafter be supplied past the disconnect fitting to manifold 28.

A remote connection between cable 48 and disconnect fitting 50 is desired where electrical control signals are supplied to the manipulator via the interior of drill pipe conduit 16. The drill pipe conduit is assembled (by coupling elongated pipe sections together in accordance with conventional deep water drilling techniques), to place the manipulator at the desired depth below vessel 18, and the cable is thereafter connected to the manipulator. Conversely, the cable is removed from the interior of the conduit before the conduit is disassembled in the process of retrieving the manipulator after the manipulator has served its purpose.

FIG. 2 shows an alternate system for powering and controlling movements of the manipulator. In this system, a high voltage electric cable 52 is led down the interior of drill pipe 16 to supply working power to the manipulator. The cable is remotely connected to high voltage electric power distribution circuits 54 at the manipulator by a plug 56 at the end of the cable. Electric power delivered by cable 52 may be used to drive a motor 58 for operating a hydraulic pump 59 that supplies hydraulic fluid to the electrically controlled valves 25 and 26 in the distribution manifold (not shown in FIG. 2) at the manipulator, in this case, sea water may be used to advantage as the manipulator motive fluid, and can be drawn from the sea through an intake line 60 and discharged to the sea adjacent the manipulator through an exhaust line (not shown).

As shown in FIG. 2, multi-conductor electric cable 61, if desired, may be fastened to the exterior of drill pipe 16 by brackets 62. A fitting 63 at the lower end of cable 61 latches the cable to a plug (not shown) in housing 46 to deliver electric power to the remote electric control circuits in the housing.

FIG. 3 shows a sonar system which provides alternate means for remotely controlling operation of the manipulator. The sonar system includes an acoustical transmitting system 64 onboard the drilling vessel 18, and an acoustical receiving system 66 at the manipulator. The acoustical transmitting system includes an encoder 68 and an acoustical transmitter 70 for transmitting a coded acoustical signal represented by sound waves 72. A power supply, such as a conventional 12-volt battery located at the manipulator, powers the acoustical control system and the electrical control valves for the manipulator. In use, each hydraulic con-

trol valve (only valve **25** is shown in FIG. **3**) in the hydraulic distribution manifold **28** at the manipulator has a specific code. Encoder **68** codes each acoustical signal generated by transmitter **70** with a specific frequency code, a time code, or the like, which corresponds to a particular one of the control valves to be actuated.

The acoustical receiving system **66** includes an acoustical receiver **74** and a decoder **76** for receiving the coded acoustical signal, decoding the signal, and converting it to an electrical control signal for operating the particular control valve corresponding to the code given the transmitted acoustical signal. Thus, the acoustical transmitting system operates hydraulic control valves in the manipulator without requiring the use of electric cables, hydraulic lines, or other physical connections between the water surface and the underwater manipulator, thereby avoiding the interference with underwater operations which is often caused by numerous control lines, cables, and the like.

FIG. **4** shows further alternate means for remotely transmitting control signals to manipulator **20**. In this form of the invention, a multiplex transmitter **80** onboard drilling vessel **18** is coupled to a multiplex receiver **82** at the manipulator by a low voltage control circuit preferably carried by a coaxial cable **84** secured to the exterior of drill pipe **16**. The control circuit includes an electrical conductor (not shown) for transmitting control signals to the multiplex receiver **82**, and a power line (not shown) for supplying electrical power to the multiplex system. Control signals are multiplexed on a low voltage signal transmitted by multiplex transmitter **80** to multiplex receiver **82**. The multiplex receiver decodes the multiplexed signal to produce command signals for actuating certain ones of the valves, or other operative devices, in manipulator **20**. In the example shown in FIG. **4**, multiplex receiver **82** produces commands **85** and **86** for actuating control valves **25** and **26**, respectively. Hydraulic fluid supplied through drill pipe **16** is delivered by manifold **28** to the control valves which distribute the fluid to manipulating arm **22** to perform a given control operative function.

If desired, the manipulator may be equipped with a TV camera and suitable lights so that the operations performed by the manipulator can be viewed safely aboard vessel **18**.

The drill pipe controlled manipulator **20** has the advantage over prior art manipulators of being held in position at the desired underwater work site without having its position continuously changed by strong currents. The manipulator may be positioned at any depth desired since its position and use are not dependent upon contact with the ocean floor; as noted, the manipulator is positioned independently of any physical contact with the ocean floor. The drill pipe conduit **16** is composed of readily available materials and supplies substantially more motive power to the manipulator than is available to underwater submersible manipulators which must carry their own power supplies. With substantially more power available, the manipulator **20** may operate in greater depths than submersible manipulators. The drill pipe controlled manipulator also performs a variety of useful functions without requiring the use of numerous electric cables, hydraulic lines, and guide lines which are susceptible to snarling and interfering with underwater operations and damage by boats or strong currents. Moreover, the invention eliminates the need for equipment such as propulsion devices, and the like, which add to the cost of a system. The drill pipe controlled manipulator also has the advantage of being mounted at its operative position independently of the ocean floor. Thus, in the event of an emergency, such as a blowout or storm, the manipulator apparatus may be removed from the work site relatively quickly without the necessity of unfastening it from the ocean floor.

This invention provides drill pipe controlled manipulating apparatus using state-of-the-art components in a novel, unobvious combination to overcome the problems encountered by prior art manned and unmanned submersibles. The invention includes a floating drilling vessel and drill pipe supported from the vessel, which is existing equipment that is readily available, well known, relatively inexpensive, reliable, and requires conventional procedures and techniques for operating it. Underwater manipulating devices are also well known, and available in many different forms depending upon the job to be performed.

I claim:

1. Underwater manipulating apparatus comprising

a manipulating device having at least one articulated manipulating member,

a hollow conduit pendulously supported from a vessel floating on a body of water in which the manipulating device is to be used and supporting the manipulating device at its lower end independently of the bottom of the body of water and of any elements connected between the vessel and an object submerged in the water, and

means for supplying motive power to the manipulating device from the vessel along the conduit for producing movement of the manipulating member.

2. Apparatus according to claim **1** wherein the manipulating device motive power is hydraulic power.

3. Apparatus according to claim **2** including an open loop hydraulic system for supplying hydraulic fluid to the manipulating device, and wherein the hydraulic fluid is sea water.

4. Apparatus according to claim **1** wherein the manipulating device motive power includes electrical power.

5. The method of assembling underwater manipulating apparatus comprising the steps of making up a hollow conduit pendulously supported from the vessel floating on a body of water; connecting a manipulating device to the lower end of the conduit and disposing the manipulating device at a desired depth below the vessel so the manipulating device is supported independently of the bottom of the body of water and of any elements connected between the vessel and an object submerged in the water; and thereafter extending an electrical cable down the interior of the conduit and connecting it to the manipulating device.

6. Underwater manipulating apparatus comprising

a hollow pipe pendulously supported from a vessel floating at the surface of a body of water, and

a manipulating device supported on the lower end of the pipe independently of the bottom of the body

of water and of any elements connected between the vessel and an object submerged in the water, the manipulating device having at least one articulated manipulating member,

the manipulating device being operative to perform manipulations of the manipulating member on the underwater equipment in response to receiving motive power conducted from the vessel through the interior of the pipe.

7. Apparatus according to claim 6 wherein the motive power is hydraulic power.

8. Apparatus according to claim 6 including an electric control circuit at the manipulating device for operating the manipulating device in response to receipt of a control signal,

an electric cable extending through the interior of pipe for conducting the electric control signal, and

means for coupling the cable to the control circuit.

9. Apparatus according to claim 6 including an acoustical transmitter for transmitting an acoustical control signal, and

an acoustical receiver at the manipulating device for receiving the acoustical control signal and converting it into an electrical control signal for regulating the motive power for operating the manipulating device.

10. Apparatus according to claim 9 including means for coding the transmitted acoustical control signal, and

means for decoding the coded acoustical signal when it is received and converting it into a decoded electrical control signal.

11. Apparatus according to claim 6 including a multiplex transmitter for transmitting multiplexed control signals, and

a multiplex receiver at the manipulating device for receiving the multiplexed control signals and decoding the signals to produce control signals for regulating the motive power for operating respective parts of the manipulating device.

12. Apparatus according to claim 6 including an electric cable extending through the interior of the pipe for conducting electrical motive power to the manipulating device.

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