July 30, 1963 G. D. JOHNSON 3,099,316

UNDERWATER WELLHEAD APPARATUS AND METHOD

Filed April 25, 1960

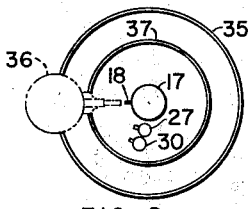

FIG. 6

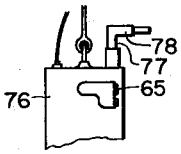

FIG. 7

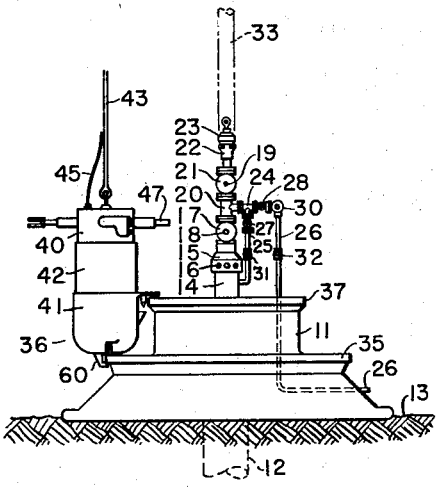

FIG. 1

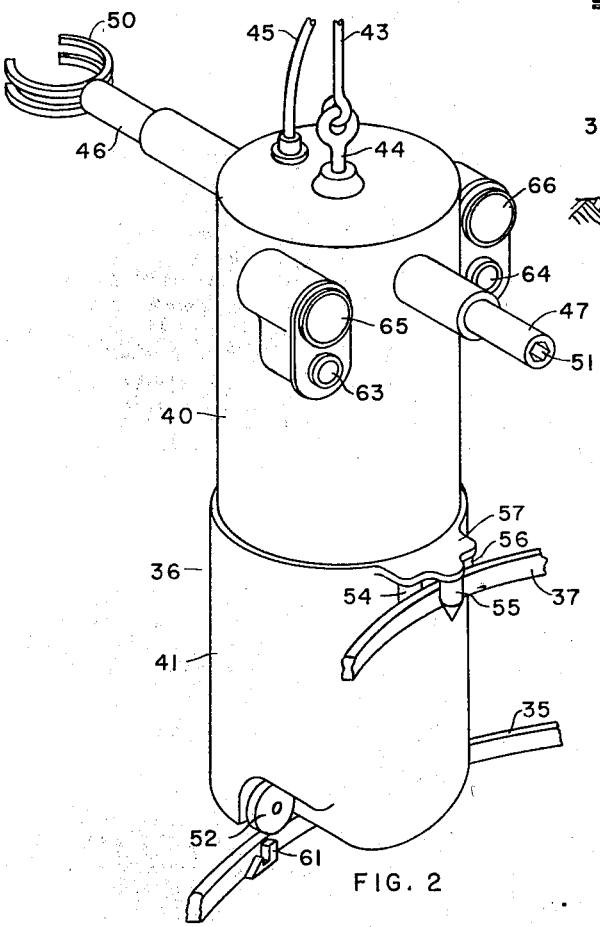

FIG. 2

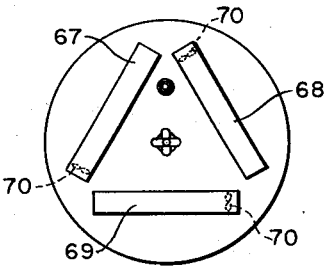

FIG. 4

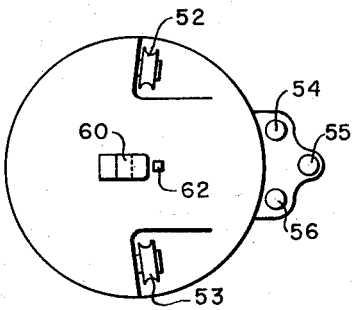

FIG. 3

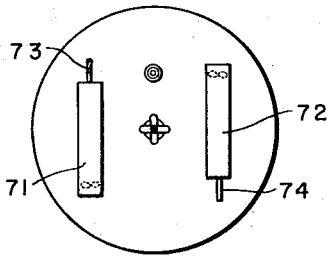

FIG. 5

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UNDERWATER WELLHEAD APPARATUS AND METHOD

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Filed Apr. 25, 1960, Ser. No. 24,558
39 Claims. (Cl. 166—46)

This invention relates to offshore wells drilled in earth formations lying below a body of water, wherein the wellhead equipment of the well is positioned below the surface of the water. The invention pertains more particularly to a method and apparatus for manipulating equipment in the vicinity of, or which are components on, an underwater wellhead.

At present, offshore wells are drilled either from stationary platforms anchored to the ocen floor, movable barges temporarily positioned on the ocean floor or from movable barges floating on the body of water in which drilling operations are being carried out. Regardless of the manner in which the wells are drilled, most wells are completed in a manner such that the outermost tubular member of the well extends upwardly from the ocean floor to a point above the surface of the water where a wellhead assembly or Christmas tree is mounted thereon for controlling the production of the well.

Wellheads extending above the surface of the water constitute a hazard to the navigation of vessels in the area as well as constituting a structure which is readily attacked by wave action, it being well known that the corrosive action of seawater and the air readily attack the normal steel platforms unless they are protected in a suitable manner by corrosive-resistant material. However, with the wellhead and/or casing head extending above the surface of the water, the flow controlling components of the wellhead may be readily adjusted by an operator working from a platform adjacent the wellhead structure above the surface of the water. Additionally, any workover or reconditioning operations carried out on the well may be readily accomplished as all of the portions of the wellhead structure which must be disassembled in order to carry out these operations, are above the surface of the water where they may be reached by maintenance crews.

Recently, however, methods and apparatus have been developed for drilling and completing oil and gas wells in the ocean floor in a manner such that after completion of the well, the wellhead assembly, including various components, such as flow control valves, is positioned beneath the surface of the water, preferably on the ocean floor. These facilities are often positioned in water depths greater than the depth at which a diver can safely and readily work. It may therefore be seen that the adjustment of any of the wellhead components from time to time, or the re-entry of a well to carry out maintenance or reconditioning work, presents a considerable problem when the wellhead assembly is positioned below the surface of the water.

It is therefore a primary object of the present invention to provide a method and apparatus for manipulating equipment in the vicinity of, or components on, a wellhead assembly positioned below the surface of the water.

A further object of the present invention is to provide a remotely-controlled manipulator device adapted to move through the body of water and be temporarily secured to an underwater wellhead while being movable therearound for carrying out any of the various operations of setting, adjusting, connecting or the disconnecting of a wellhead assembly, components or associated equipment thereof.

A further object of the present invention is to provide

a device adapted to be movably-positioned temporarily on a track adjacent an underwater wellhead, said device being provided with a rotatable object-engaging arm which is movable in any direction in a vertical or horizontal plane within the vicinity of the wellhead assembly.

Another object of the present invention is to provide a wellhead apparatus adapted to be positioned underwater for receiving on said apparatus and movable thereon a manipulator device adapted to engage the various components of the wellhead assembly.

Still another object of the present invention is to provide a method and apparatus for remotely adjusting the flow of fluid from an underwater wellhead assembly from a remote location.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic view illustrating one form of a manipulator device of the present invention positioned on a wellhead assembly located on the ocean floor;

FIGURE 2 is an isometric view of another form of a wellhead manipulator device in accordance with the present invention;

FIGURE 3 is a bottom view of the manipulator device of FIGURE 2;

FIGURES 4 and 5 are top views of two different forms of a manipulator device similar to FIGURE 2;

FIGURE 6 is a plan view of the wellhead assembly of FIGURE 1; and,

FIGURE 7 is a side view of another form of the manipulator device of the present invention.

Referring to FIGURE 1 of the drawing, a wellhead assembly 11 is connected to the conductor pipe 12 or the outermost casing string of a well drilled in the ocean floor 13, or in a formation covered by a body of water. For purposes of illustration, the wellhead assembly 11 is shown as being positioned on the ocean floor 13. However, in many circumstances, for example, where the ocean floor is very muddy, it may be desirable to position the wellhead assembly 11 at some distance above the ocean floor 13 on the upper end of the conductor pipe 12.

In the foregoing description, the term "wellhead assembly" is meant to include any assemblage of components either fixedly or removably secured to the top of one or more strings of pipe extending into the ocean floor, either during the drilling, completion, production, re-working, or maintenance of a well. Thus, during the drilling of a well the wellhead assembly may comprise certain components such as blow-out preventers, slips, etc., which would not be included therein when the well was being produced. Likewise, certain wellhead components of a producing well would be removed in order to carry out certain maintenance operations thereon. For illustration purposes, the top of the wellhead assembly 11 is shown as that of a producing well which generally includes such components as a casing head 14, an adaptor 15 secured to the top of the casing head, as by bolts 16, a master valve 17, a T 20, a swabbing valve 21, a coupling 22 and a closure member 23, all of said elements being connected coaxially together and in coaxial relationship with the tubing and casing in the well. The valves 17 and 21 are provided with valve handles or shafts 18 and 19 in the form of outwardly-extending horizontal movable elements, preferably extending on a radial line of the wellhead assembly or along radial lines extending from the manipulator device 36 when it is fixedly positioned at one point on the wellhead assembly, as illustrated in FIGURE 6. A nut, preferably outwardly tapered for alignment purposes is provided at the end of each movable element 18 and 19. Extending from the

T 20 is another T 24 from which extends a pressure equalization line 25 and a production flowline 26 equipped with valves 27 and 28, choke 30 and couplings 31 and 32. The couplings are provided with movable elements, such as element 18 on valve 17, for disconnecting the mating portions of the couplings. The wellhead assembly, or the assembled components of the wellhead assembly above the adaptor 15, may be lowered together into place by means of a pipestring 33 which is subsequently removed.

Fixedly secured to the wellhead assembly 11 is a substantially horizontal track 35 forming anchor means or base means on which a remotely-controlled manipulator device 36 is mounted for circumferential movement in either direction. Preferably, a second track 37 is affixed to the wellhead assembly 11 in spaced relationship with the track 35. Any desired spacial relationship of the tracks 35 and 37 may be employed. While track 37 is shown as being spaced both vertically and horizontally away from track 35, with track 37 the higher of the two tracks, their positions could be reversed with the outer track 35 being the higher track, or both tracks may be in the same horizontal plane with the manipulator device 36 riding on them or between them. Alternatively, tracks 37 and 35 may be of the same diameter while being spaced vertically with the manipulator device hanging from both of them. Preferably, the tracks 35 and 37 extend entirely around the wellhead assembly 11 and flowlines 25 and 26 so that the manipulator device 36 may be positioned at any point on the circumference of the track to carry out operations on any component of the wellhead assembly, for example, such as unscrewing all of the horizontally-directed bolts 16 in the adaptor 15.

A preferred form of the track-mounted manipulator device 36 is shown in greater detail in FIGURE 2, although it is to be understood that the manipulator device may take any suitable form for carrying out the operations as described with regard to this invention. As shown in FIGURE 2, the manipulator device 36 comprises upper and lower telescoping body sections 40 and 41, respectively, which are preferably mounted in rotatable and fluidtight relationship with each other. Suitable arrangements for mounting two body sections for telescoping and rotatable movement are described in U.S. Patents 453,545—647,774—1,296,688—2,673,452. U.S. Patents 867,982 and 2,776,817 illustrate means by which telescoping body sections are prevented from separating. If desired, one or more intermediate body sections 42 (FIGURE 1) may be built into the manipulator device to increase the height to which it may be extended vertically, say to a distance of 10 feet or more. A cable 43 is secured to an eye-bolt 44 in the top of the upper body section 40 of the manipulator device for lowering the manipulator device through the water. In the event that the prime mover means (not shown) within the manipulator device are electrically-operated, the cable 43 may be a combined weight-bearing and power-transmission cable combined in one nuit. Alternatively, electric power or hydraulic fluid could be transmitted through a separate conduit 45 or conduits into the manipulator device 36 for energizing the various elements of the manipulator device. The prime mover means, which may be of any suitable type, employed to rotate, extend and retract the various sections of the body sections 40 and 41 with respect to each other, or the various sections of the arms 46 and 47 with respect to each other, are contained within the manipulator device 36, while the circuitry employed to energize and actuate selectively the various elements may be contained in the manipulator device, or in a controller at the operating base above the surface of the water, or split between the two locations.

Mounted preferably near the top of the upper body section of the manipulator 36 are one or more outwardly-extendible, inwardly-retractable, and axially-rotatable arms 46 and 47 which are of a size and design suitable for performing the work on the wellhead structure and in the vicinity thereof for which the present invention is designed. For example, each arm 46 or 47 may comprise one or more telescoping sections extendible from the manipulator device 36 preferably to the center line of the well. With an arm of this length being employed, the manipulator device 36 would be adapted to engage any of the wellhead components of the wellhead if the manipulator device 36 is able to travel all the way around the well. The arm 46 is shown as being provided with grapple elements 50 adapted to be opened and closed about a piece of equipment, while the end of arm 47 is illustrated as being provided with a wrench socket 51 for turning in one direction or the other, bolts adapted to fit therein. The telescoping or advancing type arm and power wrench may be of any suitable design and construction as for example similar to that shown in U.S. Patents 2,637,527 and 2,673,452. Alternatively, the end of the arm 47 may be provided with a wrench socket (not shown) set at 90 degrees to the axis of the arm 47 for turning bolts or other devices whose axis is positioned normal to the axis of the arm 47. A power wrench of this design is shown in U.S. Patent 2,854,217.

The lower body section 41 of the manipulator device 36 is provided, preferably near the bottom thereof, with suitable guide means, for example, a pair of wheels 52 and 53 (FIGURE 3) adapted to be positioned on one of the tracks surrounding the wellhead, preferably the lower track 35. The lower body section 41 of the manipulator device 36 is also preferably provided with stabilizing rollers or wheels 54, 55 and 56 rotatably secured to an outwardly-extending arm 57 on the lower body section 41. Preferably, the stabilizing rollers 54, 55 and 56 are positioned on the extending arm 57 in a manner such that they are located on both sides of the track 37 to prevent horizontal forces from forcing the manipulator device off the tracks. The arrangement of the wheels 52 and 53 and the arrangement of the stabilizing rollers 54, 55 and 56 with regard to their position on the lower body section 41 is preferably such that the wheels and rollers readily seat on the respective tracks 35 and 37 when the manipulator device 36 is lowered into place thereon. For example, the wheels 52 and 53 are so positioned on the lower body section 41, and the lower body section 41 is in turn shaped in a manner such that there is little or no tendency for the wheels 42 and 43 to hang up on the upper track 37 when the manipulator device 36 is being lowered into place. Any hanging up tendency on the part of the wheels 52 and 53 may be substantially minimized by employing the proper design for the upper track 37.

In most cases, the weight of the manipulator device 36 is sufficient to keep it on the tracks 35 and 37 during all normal operations carried out by the manipulator device 36 on the wellhead assembly 11. However, in some instances it is desirable to provide the manipulator device 36 with suitable clamping means adapted to be remotely actuated after the manipulator device 36 has been positioned on the tracks 35 and 37 so as to clamp onto one of the tracks from the bottom or opposite side thereof. For example, as shown in FIGURES 1 and 3, a pivoted clamp 60 is mounted on the bottom of the lower body section 41 and may be recessed therein, the clamp 60 being adapted to be actuated and pivoted to the under side of the lower track 35 after the wheels 52 and 53 have been seated thereon. Track clamps of this type are shown in U.S. Patents 233,015—938,490—1,442,194—2,364,785.

In order to index the entire manipulator device at a predetermined position on the track 35, any suitable indexing device may be provided. For example, as shown in FIGURE 2, a notched indexing element 61 may be affixed, for example to the lower track 35 on the inner wall thereof, at various positions along the track 35, while the bottom of the manipulator device 36 is provided with a remotely retractable latching device or pin 62 (FIGURE 3) adapted to be dropped down or swung into the

notch of the indexing element 61 as the manipulator device 36 moves around the track. Any number of these indexing devices may be employed. Additionally, since the upper body section 40 is rotatable about a vertical axis with regard to the lower body section 41, the two sections may be provided with remotely controlled and disengageable mating, indexing and aligning elements similar to 61 and 62 for selectively securing the two body sections 40 and 41 together at various positions in which secured positions the body sections are secured against relative rotation yet are free to telescope as desired. One preferred position in which the two body sections 40 and 41 are rigidly secured together is that at which the horizontal axis through one of the arms 46 and 47 intersects the axis of the well or the wellhead assembly 11. With the body sections 40 and 41 locked in the described manner, and with the manipulator device 36 locked in the suitable indexing device 61 on the lower track 35, it is only necessary to raise the upper body section 40 which in turn elevates the arm 47 to the proper height and extend the wrench socket 51 outwardly in order to come in register with one of the bolt heads 16 of the adaptor, for example. Thus, it may be seen that a more accurate placement of the wrench socket 51 on the bolt head 16 may be obtained. The arm 47 is preferably provided with a ratcheting device (not shown) which would cause the arm to over-ride when excessive torque was applied to the wrench socket 51, thus preventing twisting a head off of one of the bolts. Alternatively, the wrench arm 47 could be provided with a strain gauge to measure the amount of torque imposed by the wrench socket 51 in turning an element.

A preferred form of a wellhead assembly is shown in FIGURE 6 wherein the master valve 17, valve 27 and choke 30 are arranged in an arc, when viewed from above, with the center of the arc being the center of a manipulator device which is indexed at a predetermined position which is in line with the axis of the handle 18 of the master valve 17. The operating handle or shaft of valve 27 and choke 30, are preferably directed along radii of a circle whose center is the pivot center of the manipulator device 36. Thus, with the manipulator device positioned at a single point on tracks 35 and 37, several operations could be carried out by merely sweeping arm 47 in an arc horizontally and moving it up or down in order to align it with a component to be operated.

To observe operations being carried out at the wellhead assembly 11 by the manipulator device 36, the manipulator device 36 is provided with one or more swivel-mounted flood lights 63 and 64 and one or more television cameras 65 and 66, for lighting the area in the vicinity of the wellhead and observing operations therein. Both the lights 63 and 64 and the television cameras 65 and 66 are remotely-controlled by an operator positioned, say, at the surface on an operating barge, the signal from the cameras 65 and 66 being transmitted through cable 43. Prior to conducting operations with the apparatus of the present invention, the underwater wellhead may be located in any manner well known to the art, such as by sonar equipment which may be carried by the vessel at the surface of the water or by the manipulator device below the surface of the water.

In using the manipulator device 36 of the present invention on a wellhead designed to receive it as described hereinabove, the manipulator device 36 is lowered through the water on the cable 43 from a hoist (not shown) on a drilling barge or other vessel (not shown) on the surface of the water. Alternatively, the manipulator device 36 could be lowered by providing it with a large float chamber on the top of the manipulator device with a signal being transmitted through cable 43 to an electrically controlled flood valve in said chamber for partially flooding the chamber and altering its buoyancy so as to allow the manipulator device 36 to sink into place on the tracks 35 and 37. The manipulator device 36 may be guided into place by the support cable 43. Alternatively, the manipulator device 36 may be provided with one or more propellers, preferably in the form of Kort tubes 67, 68 and 69 (FIGURE 4) which are open-ended tubes provided with propellers 70 therein driven by unidirectional or reversible motors (not shown). One type of propulsion means suitable for the present apparatus is shown in U.S. Patents 1,344,518—1,958,997—2,583,059. Alternatively, as shown in FIGURE 5, a pair of Kort tubes 71 and 72 may be employed having remotely adjustable rudders 73 and 74 attached thereto. The Kort tubes are preferably mounted on the top of the manipulator device 36 so as to be out of the way of the normal operations and positioned so that they are unlikely to be damaged by contact with other elements. Thus, when the manipulator device 36 is lowered on the cable 43 into position near the wellhead assembly 11, by energizing the motor in one or more of the Kort tubes 67, 68 or 69 (FIGURE 4), the manipulator device 36 would be propelled through the water to its position adjacent the wellhead assembly 11, at which point it may be lowered into place on the tracks 35 and 37. Alternatively, as a guide in lowering the manipulator device 36 into place on the tracks 35 and 37, the upper section 40 of the manipulator device 36 may be rotated so that the arm 46 and its grapple member 50 engages the pipe string 33 extending upwardly from the wellhead assembly 11. Thus, with the arm 46 extended a distance so that the wheels 52 and 53 and the rollers 54, 55 and 56 would seat on their respective tracks 35 and 37, the entire manipulator device may be lowered by its cable 43 down onto the tracks 35 and 37.

One or more of the Kort tubes may be energized in order to supply power to move the manipulator device around the tracks 35 and 37. Alternatively, one or more of the rollers 52, 53, 54, 55 or 56 may be powered, as by electric or hydraulic motor (not shown) within the manipulator device 36, for driving the manipulator device around the tracks 35 and 37 to any preselected position thereon.

While only one general type of manipulator device 36 has been described in detail, it is understood that any other type of manipulator device may be employed which is movable along a track adjacent a wellhead assembly. It is understood that the manipulator device may take other forms. For example, as shown in FIGURE 7, a single body 76 may be employed having an arm 77 vertically-extending in a telescoping and rotatable manner from the top of the body, with a telescoping and rotatable side arm 78 extending in a horizontal plane from the top of the vertically-extending arm, thus providing movement in both vertical and horizontal planes.

The manipulator device of the present invention may be employed to carry out operations at any well production facilities positioned below the surface of a body of water which is provided with a suitable track or tracks on which the manipulator device may be propelled to its various indexed positions around the facilities. Underwater well production facilities, as employed herein, may comprise a wellhead assembly together with flow lines as described hereinabove. It may also include other production equipment such as underwater tanks positioned below the surface of the water for collecting, storing or metering production fluid from underwater wells, or for treating or separating the production fluid and then handling the separate phases thereof. Underwater tanks, if used are preferably positioned around a wellhead assembly so that the manipulator device 36 (FIGURE 1) could be employed on its tracks 35 and 37 by merely rotating the operative arm 47 of the manipulator 36 so that it is directed outwardly away from the wellhead assembly where it could engage, control or adjust the operative components such as valves, connectors, level controllers, etc., of normal production facilities. Also, well production facilities having a track for a manipulator de-

vice could be positioned on the ocean floor between two or more wells.

I claim as my invention:

1. An underwater apparatus having components adapted to be remotely manipulated at said underwater apparatus from an operational base positioned above the surface of the water, said apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, and base means mounted adjacent said pipe, said base means adapted to receive thereon a remotely movable and actuatable manipulator device for manipulating components of said underwater apparatus.

2. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, base means mounted adjacent said wellhead assembly, said base means adapted to receive thereon a remotely movable and actuatable manipulator device for manipulating components of said underwater apparatus.

3. An underwater wellhead apparatus having components with movable portions adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formation underlying said water, the top of said pipe being above the formation and below the surface of the water, track means rigidly mounted adjacent said pipe, said track means adapted to receive thereon a remotely controlled manipulator device adapted to manipulate said wellhead components.

4. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, track means mounted on said wellhead assembly, said track means adapted to receive and support thereon a remotely controlled manipulator device adapted for actuating wellhead component means mounted on said wellhead apparatus, and wellhead component means mounted on said wellhead assembly, said wellhead component means having actuatable elements extending therefrom.

5. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, horizontally-positioned track means mounted on said wellhead assembly concentric therewith, said track means adapted to receive and support thereon a remotely controlled manipulator device adapted for actuating wellhead component means mounted on said wellhead apparatus, a casinghead secured to the top of said string of pipe and coaxial with said wellhead assembly, and wellhead component means mounted on said casinghead and said wellhead assembly, said wellhead component means having actuatable elements extending horizontally outwardly therefrom.

6. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, horizontally-positioned track means mounted on said wellhead assembly concentric therewith, said track means adapted to receive and support thereon a remotely controlled manipulator device adapted for actuating wellhead component means mounted on said wellhead apparatus, a casinghead secured to the top of said string of pipe and coaxial with said wellhead assembly, wellhead component means including connector means mounted on said casinghead and said wellhead assembly within an area defined by a vertical line moving around said track means, said wellhead component means having actuatable elements extending horizontally outwardly therefrom on a radial line of said track means, a production flowline in communication between said casinghead and a distant discharge point, said flowline passing downwardly through said track means and then outwardly beneath said track means, coupling means in said flowline above said track means, movable elements in said coupling means for disconnecting said coupling, said movable elements extending horizontally outwardly from said coupling means.

7. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, first and second horizontally-positioned track means mounted in spaced relationship on said wellhead assembly concentric therewith, said track means adapted to receive and support thereon a remotely controlled manipulator device adapted for actuating wellhead component means mounted on said wellhead apparatus, a casinghead secured to the top of said string of pipe and coaxial with said wellhead assembly, and wellhead component means including valve means and well control means and connector means mounted on said casinghead and said wellhead assembly within an area defined by a vertical line moving around said track means, said wellhead component means having actuatable elements extending horizontally outwardly therefrom on a radial line of said track means.

8. An underwater wellhead apparatus having components adapted to be remotely manipulated from an operational base positioned above the surface of the water, said wellhead apparatus comprising a string of pipe extending into the formations underlying said water, the top of said pipe being above the formation and below the surface of the water, a wellhead assembly secured to said pipe near the top thereof, first and second horizontally-positioned track means mounted in spaced relationship on said wellhead assembly concentric therewith, said track means adapted to receive and support thereon a remotely controlled manipulator device adapted for actuating wellhead component means mounted on said wellhead apparatus, a casinghead secured to the top of said string of pipe and coaxial with said wellhead assembly, wellhead component means including valve means and well control means and connector means mounted on said casinghead and said wellhead assembly within an area defined by a vertical line moving around said track means, said wellhead component means having actuatable elements extending horizontally outwardly therefrom on a radial line of said track means, a production flowline in communication between said casinghead and a distant discharge point, said flowline passing downwardly to one side of said track means and then outwardly beneath said track means, flowline coupling means and flow control valve means in said flowline above said track means, movable elements in said

coupling means for disconnecting said coupling means and movable elements in said valve means for controlling the flow therethrough, said movable elements extending horizontally outwardly from said coupling means and valve means, and removable plug means closing the top of said wellhead apparatus.

9. Apparatus for carrying out operations at an underwater installation positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising an underwater installation positioned below the surface of a body of water, component means mounted on said installation, means carried by said installation for anchoring said installation to said earth formation, track means mounted on said underwater installation, manipulator means lowerable through said water and removably positionable on said track means for movement thereon, prime mover means carried by said manipulator means for selectively moving said manipulator means on said track means, arm means carried by said manipulator means for engaging and actuating at least movable portions of said component means of said installation, and prime mover means for actuating said arm means.

10. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, anchoring means affixed to said wellhead assembly, said anchoring means anchoring said wellhead assembly to said earth formation, base means mounted adjacent said wellhead assembly adapted to receive manipulator means, manipulator means lowerable through said water and removably positionable on said base means, and movable arm means carried by said manipulator means for engaging well equipment at the wellhead, and prime mover means for actuating said arm means.

11. The apparatus of claim 10 wherein said base means is fixedly positioned in spaced relationship to the vertical axis of said wellhead assembly.

12. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, manipulator means lowerable through said water and removably positionable adjacent said wellhead assembly, means carried by said manipulator means for fixedly securing said manipulator means to said wellhead assembly, and arm means carried by said manipulator means operable for engaging portions of said wellhead assembly, and prime mover means for actuating said arm means.

13. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, horizontally-positioned track means mounted on said wellhead assembly and adjacent thereto, manipulator means lowerable through said water and removably positionable on said track means and adapted for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means on said track means adjacent said wellhead assembly, and arm means carried by said manipulator means operable for engaging and actuating movable portions of said component means of said wellhead assembly, and prime mover means for actuating said arm means.

14. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, horizontally-positioned track means mounted on said wellhead assembly and adjacent thereto, manipulator means lowerable through said water and removably positionable on said track means and adapted for movement in a horizontal plane thereon, guide means affixed to said manipulator means and engageable with said track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means through the water, said manipulator means including arm means movable in vertical and horizontal planes for engaging and actuating movable portions of said component means of said wellhead assembly, and prime mover means for actuating said arm means.

15. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, horizontally-positioned track means mounted on said wellhead assembly and adjacent thereto, manipulator means lowerable through said water and removably positionable on said track means and adapted for movement in a horizontal plane thereon, guide wheel means affixed to said manipulator means and engageable with said track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means on said track means, extendible arm carried by said manipulator means and movable in vertical and horizontal planes for engaging and actuating movable portions of said component means of said wellhead assembly, connector means carried at the outwardly extending end of said arm means for engaging objects within the periphery of said track means and within the area capable of being swept by said arm means as the manipulator means moves on said track means, and means secured to said manipulator means for moving said manipulator means between the base above the surface of the water and the wellhead assembly therebelow.

16. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth

formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, horizontally-positioned track means mounted in spaced relationship on said wellhead assembly concentric therewith, manipulator means lowerable through said water and removably positionable on said track means and adapted for movement in a horizontal plane thereon, guide wheel means affixed to said manipulator means and engageable with said track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means on said track means, outwardly-extendible and inwardly-retractable and axially-rotatable arm means carried by said manipulator means and movable in vertical and horizontal planes for engaging and actuating movable portions of said component means of said wellhead assembly, connector means carried at the outwardly-extending ends of said arm means for engaging objects within the periphery of said track means and within the area capable of being swept by said arm means as the manipulator means moves on said track means, weight-supporting and signal- and power-transmission means extending from said manipulator means upwardly through said water to the operations base thereabove, and first and second indexing means, one of said indexing means carried by said manipulator means and the other indexing means carried by said track means, whereby the engagement of said indexing means causes the manipulator means to be positioned on said track means for registering with a component of said wellhead assembly to be engaged by the arm means of said manipulator means.

17. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, said wellhead assembly including component means having movable portions thereof, a string of pipe affixed near its upper end to said wellhead assembly, said string of pipe extending downwardly into said earth formation anchoring said wellhead assembly to said earth formation, first and second horizontally-positioned track means mounted in spaced relationship around said wellhead assembly concentric therewith, manipulator means lowerable through said water and removably positionable on said first and second track means and adapted for movement in a horizontal plane thereon, guide wheel means affixed to said manipulator means and engageable with said first and second track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means on said track means, outwardly-extendible and inwardly-retractable and axially-rotatable arm means carried by said manipulator means and movable in vertical and horizontal planes for engaging and actuating movable portions of said component means of said wellhead assembly, connector means carried at the outwardly-extending ends of said arm means for engaging objects within the periphery of said track means and within the area capable of being swept by said arm means as the manipulator means moves around said track means, light means carried outwardly on said manipulator means for lighting at least a portion of the area in the vicinity thereof, television camera means carried outwardly on said manipulator means for remotely observing any desired portion of said lighted area outside said manipulator means, weight-supporting and signal- and power-transmission means extending from said manipulator means upwardly through said water to the operations base thereabove, and first and second indexing means, one of said indexing means carried by said manipulator means and the other indexing means carried by at least one of said track means, whereby the engagement of said indexing means causes the manipulator means to be positioned on said track means for registering with a component of said wellhead assembly to be engaged by the arm means of said manipulator means.

18. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, a casinghead having an upper end coaxially positioned relative to said wellhead assembly and fixedly secured thereto, said wellhead assembly including component means having movable portions thereof, said component means including valve means and well control means and connector means, a string of pipe affixed near its upper end to said casinghead, said string of pipe extending downwardly into said earth formation anchoring said casinghead and said wellhead assembly to said earth formation, first and second horizontally-positioned track means mounted in spaced relationship around said wellhead assembly concentric therewith, manipulator means lowerable through said water and removably-positionable on said first and second track means and adapted for movement in a horizontal plane thereon, guide wheel means affixed to said manipulator means and engageable with said first and second track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means in any predetermined direction through the water and on said track means, outwardly-extendible and inwardly-retractable and axially-rotatable arm means carried by said manipulator means and movable in vertical and horizontal planes for engaging and actuating movable portions of said component means of said casinghead and said wellhead assembly, connector means carried at the outwardly-extending ends of said arm means for engaging objects within the periphery of said track means and within the area capable of being swept by said arm means as the manipulator means moves around said track means, light means carried outwardly on said manipulator means for lighting at least a portion of the area in the vicinity thereof, television camera means carried outwardly on said manipulator means for observing any desired portion of said lighted area outside said manipulator means, weight-supporting and signal- and power-transmission means extending from said manipulator means upwardly through said water to the operations base thereabove, and first and second indexing means, one of said indexing means carried by said manipulator means and the other indexing means carried by at least one of said track means, whereby the engagement of said indexing means causes the manipulator means to be positioned on said track means for registering with a component of said wellhead assembly to be engaged by the arm means of said manipulator means.

19. Apparatus for carrying out operations at a wellhead positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a wellhead assembly positioned below the surface of a body of water and at the top of a well drilled into the earth formations underlying said body of water, a casinghead having an upper end coaxially positioned relative to said wellhead assembly and fixedly secured thereto, said wellhead assembly including component means having movable portions thereof, said component means including valve means and well control means and connector means, a string of pipe affixed near its upper end to said casing-

head, said string of pipe extending downwardly into said earth formation anchoring said casinghead and said wellhead assembly to said earth formation, first and second horizontally-positioned track means mounted in spaced relationship around said wellhead assembly concentric therewith, manipulator means lowerable through said water and removably positionable on said first and second track means and adapted for movement in a horizontal plane thereon, guide wheel means affixed to said manipulator means and engageable with said first and second track means for movement thereon, retractable lock means carried by said manipulator means for locking said manipulator means on at least one of said track means, prime mover means carried by said manipulator means for selectively propelling said manipulator means in any predetermined direction through the water and on said track means, outwardly-extendible and inwardly-retractable and axially-rotatable arm means carried by said manipulator means for engaging and actuating movable portions of said component means of said casinghead and said wellhead assembly, connector means carried at the outwardly-extending ends of said arm means for engaging objects within the periphery of said track means and within the area capable of being swept by said arm means as the manipulator means moves around said track means, a wrench socket carried as a connector means at the end of one of said arm means, a grapple device carried as a connector means at the end of another of said arm means, light means carried outwardly on said manipulator means for lighting at least a portion of the area in the vicinity thereof, television camera means carried outwardly on said manipulator means for observing any desired portion of said lighted area outside said manipulator means, weight-supporting and signal- and power-transmission means extending from said manipulator means upwardly through said water to the operations base thereabove, and first and second indexing means, one of said indexing means carried by said manipulator means and the other indexing means carried by at least one of said track means, whereby the engagement of said indexing means causes the manipulator means to be positioned on said track means for registering with a component of said wellhead assembly to be engaged by the arm means of said manipulator means.

20. A method of remotely connecting and disconnecting removable elements and operating components on a wellhead assembly positioned underwater at the top of a string of pipe and provided with at least one horizontally-positioned track thereon, said method comprising moving a manipulator device through the water from an operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device on said track of said wellhead assembly, moving said manipulator device to a known position on said track, engaging a portion of said wellhead assembly with a portion of said manipulator device, and actuating said engaged portion of said wellhead assembly by said manipulator device.

21. Apparatus for carrying out operations at a well production facility positioned below the surface of a body of water while controlling said operations from a base positioned above said body of water, said apparatus comprising a well production facility positioned below the surface of a body of water and in the vicinity of a well drilled into the earth formations underlying said body of water, component means mounted on said well production facility, means carried by said well production facility for anchoring said well production facility to the formation underlying said body of water, horizontally-positioned track means mounted on said well production facility, manipulator means lowerable through said water and removably positionable on said track means for movement thereon, prime mover means carried by said manipulator means for selectively propelling said manipulator means on said track means, and arm means carried by said manipulator means for engaging and actuating movable portions of said component means of said well production facility, and prime mover means for actuating said arm means.

22. A method of remotely carrying out an operation at a wellhead assembly positioned underwater at the top of a string of pipe, said method comprising moving a manipulator device through the water from an operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device adjacent said wellhead assembly in spaced relationship to the vertical axis thereof, engaging at least a portion of said wellhead assembly with at least a portion of said manipulator device, and remotely controlling the manipulator device to carry out said operation with said engaged portion of said wellhead assembly.

23. A method of remotely connecting and disconnecting removable elements and operating components on a wellhead assembly positioned underwater at the top of a string of pipe and provided with at least one horizontally positioned track thereon, said method comprising locating the underwater wellhead assembly from an operational base above the surface of the water, lowering a manipulator device through the water from said operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device on said track of said wellhead assembly, moving said manipulator device to a predetermined position on said track, latching said manipulator device on said track at said indexed position, engaging a portion of said wellhead assembly with a portion of said manipulator device, actuating said engaged portion of said wellhead assembly in a predetermined manner, and subsequently disengaging said manipulator device from said portion of wellhead assembly by said manipulator device.

24. A method of remotely connecting and disconnecting removable elements and operating components on a wellhead assembly positioned underwater at the top of a string of pipe and provided with at least one horizontally positioned track thereon, said method comprising locating the underwater wellhead assembly from an operational base above the surface of the water, lowering a manipulator device through the water from said operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device on said track of said wellhead assembly, moving said manipulator device to a predetermined indexed position on said track, latching said manipulator device on said track at said indexed position, engaging a portion of said wellhead assembly with at least a portion of said manipulator device, actuating said engaged portion of said wellhead assembly by said manipulator device in a predetermined manner, subsequently disengaging said manipulator device from said portion of wellhead assembly, and remotely observing the several actions of said manipulator device at any time during the operation thereof.

25. A method of remotely connecting and disconnecting removable elements and operating components on a wellhead assembly positioned underwater at the top of a string of pipe and provided with at least one horizontally positioned track thereon, said method comprising locating the underwater wellhead assembly from an operational base above the surface of the water, lowering a manipulator device through the water from said operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device on said track of said wellhead assembly, moving said manipulator device to a predetermined indexed position on said track, latching said manipulator device on said track at said indexed

position, engaging a portion of said wellhead assembly with at least a portion of said manipulator device, actuating said engaged portion of said wellhead assembly by said manipulator device in a predetermined manner, subsequently disengaging said manipulator device from said portion of wellhead assembly, unlatching said manipulator device from said indexed position on said track, moving said manipulator device to a second indexed position on said track, latching said manipulator device at said second indexed position, subsequently re-engaging said manipulator device and said wellhead assembly to actuate another component thereof, and remotely observing the several actions of said manipulator device at any time during the operation thereof.

26. A method of remotely connecting and disconnecting removable elements and operating components on a wellhead assembly positioned underwater at the top of a string of pipe and provided with at least one horizontally positioned track thereon, said method comprising locating the underwater wellhead assembly from an operational base above the surface of the water, lowering a manipulator device through the water from said operational base thereabove, guiding said manipulator device to said underwater wellhead assembly, removably positioning said manipulator device on said track of said wellhead assembly, temporarily locking said manipulator on said track for movement therealong, moving said manipulator device to a predetermined indexed position on said track, latching said manipulator device on said track at said indexed position, engaging a portion of said wellhead assembly with a portion of said manipulator device, actuating said engaged portion of said wellhead assembly by said manipulator device in a predetermined manner, subsequently disengaging said manipulator device from said portion of wellhead assembly, unlatching said manipulator device from said indexed position on said track, moving said manipulator device to a second indexed position on said track, latching said manipulator device at said second indexed position, subsequently re-engaging said manipulator device and said wellhead assembly to actuate another component thereof, and remotely observing the several actions of said manipulator device at any time during the operation thereof.

27. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned beneath a body of water, said manipulator device comprising a closed fluidtight housing, means carried by said housing adapted to fixedly position said housing relative to an underwater installation, outwardly extendible arm means carried by said housing, prime mover means contained within said housing for extending and actuating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting said prime mover means to a remote source of power.

28. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned beneath a body of water, said manipulator device comprising a closed fluidtight housing having at least two housing sections, means carried by said housing adapted to fixedly position said housing relative to an underwater installation, outwardly extendible arm means carried by one section of said housing, one section of housing being rotatably mounted with respect to the other section of said housing, first prime mover means contained within said housing for rotating said housing sections with respect to each other, second prime mover means contained within said housing for extending and actuating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

29. A remotely controlled manipulation device for carrying out operations underwater, said manipulator device comprising a closed fluidtight housing having at least two vertically telescoping housing sections arranged for limited movement, guide means on the lower section of said housing adapted to engage track means for movement thereon, outwardly extendible arm means positioned adjacent the top of the upper section of said housing, said upper section of housing being rotatably mounted with respect to the lowermost section of said housing, first prime mover means contained within said housing for rotating and telescoping said housing sections with respect to each other, second prime mover means contained within said housing for extending and retracting and rotating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

30. The apparatus of claim 29 wherein said arm means includes one arm having a wrench socket in one end thereof adapted to engage movable elements of an underwater wellhead assembly.

31. The apparatus of claim 29 wherein said arm means includes one arm having actuatable grapple means rotatably mounted on the end thereof adapted to engage elements of an underwater wellhead assembly.

32. The apparatus of claim 29 including remotely-controlled directionally-adjustable light means and television camera means for lighting and observing the area in the vicinity of the manipulator device.

33. The apparatus of claim 29 wherein the guide means includes at least one set of rotatable elements adapted to rotate on a vertical axis and positioned in spaced relationship so that some of said rotatable elements are positionable on either side of at least a portion of said track means to prevent horizontal forces from tipping said manipulator device off said track means.

34. The apparatus of claim 29 wherein said guide means are guide wheel means and including reversible third prime mover means contained within said housing and operatively connected to at least one of said wheel means for propelling said housing in either direction about said wellhead assembly.

35. The apparatus of claim 29 including motor-driven propulsion means carried on said housing for moving said housing through a body of water to a selected position therein.

36. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned at the top of a well drilled in the formation beneath a body of water, said manipulator device comprising a closed fluidtight housing having at least two vertically telescoping housing sections arranged for limited movement, guide wheel means on the lower section of said housing adapted to engage track means for movement thereon at the top of a well, outwardly-extendible and inwardly-retractable and axially-rotatable horizontal arm means positioned near the top of the upper section of said housing, said upper section of housing being rotatably mounted with respect to the lowermost section of said housing, retractable position indexing means for fixedly latching said housing at selected points on a track means, motor-driven propulsion means carried on said housing for moving said housing through a body of water to any selected position therein, first prime mover means contained within said housing for rotating and telescoping said housing sections with respect to each other, second prime mover means contained within said housing for extending and retracting and rotating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

37. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned at the top of a well drilled in the formation beneath a body of water, said manipulator device compris-

ing a closed fluidtight housing having at least two vertically telescoping housing sections arranged for limited movement, guide wheel means on the lower section of said housing adapted to engage track means for movement thereon around the top of a well, outwardly-extendible and inwardly-retractable and axially-rotatable horizontal arm means positioned near the top of the upper section of said housing for movement at least along a line normal to a vertical line through the center of said housing, said upper section of housing being rotatably-mounted with respect to the lowermost section of said housing, retractable position indexing means for fixedly latching said housing at selected points on a track means, motor-driven propeller means carried on said housing for moving said housing through a body of water to any selected position therein, weight supporting cable means secured to said housing for raising or lowering said housing in a body of water, first prime mover means contained within said housing for rotating and telescoping said housing sections with respect to each other, second prime mover means contained within said housing for extending and retracting and rotating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

38. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned at the top of a well drilled in the formation beneath a body of water, said manipulator device comprising a closed fluidtight housing having at least two vertically telescoping housing sections arranged for limited movement, first and second guide wheel means on the lower section of said housing adapted to engage and lock on track means for movement thereon around the top of a well, reversible first prime mover means contained within said housing and operatively connected to at least one of said wheel means for propelling said housing in either direction on said track means, outwardly extendible and inwardly retractable and axially rotatable rigid horizontal arm means positioned near the top of the upper section of said housing for movement along a line normal to a vertical line through the center of said housing, said upper section of housing being rotatably mounted with respect to the lowermost section of said housing, means for locking said housing to said track means while permitting sliding movement therealong, retractable position indexing means for fixedly latching said housing at selected points on a track means, motor-driven propeller means carried on said housing for moving said housing through a body of water to any selected position therein, weight supporting cable means secured to said housing for raising or lowering said housing in a body of water, second prime mover means contained within said housing for rotating and telescoping said housing sections with respect to each other, third prime mover means contained within said housing for extending and retracting and rotating said arm means, and power-transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

39. A remotely controlled manipulator device for carrying out operations underwater at an assembly positioned at the top of a well drilled in the formation beneath a body of water, said manipulator device comprising a closed fluidtight housing, an arm extendible vertically from said housing for limited movement therefrom, guide means on the housing adapted to engage track means mounted adjacent said underwater assembly, outwardly-extendible arm means positioned near the extendible end of the vertically-extendible arm, said arm being rotatably mounted with respect to said housing, first prime mover means contained within said housing for rotating and telescoping said vertically extending arm with respect to said housing, second prime mover means contained within said housing for extending and retracting said outwardly-extendible arm means, and power transmission conduit means extending in a fluidtight manner through the wall of said housing operatively connecting all of said prime mover means to a source of power.

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