United States Patent

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[54] METHOD AND APPARATUS FOR REENTRY OF SUBSEA WELLHEADS

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[51] Int. Cl. E21b 33/035

[58] Field of Search 166/.5, 6, 77, 83, 84, 69, 166/70

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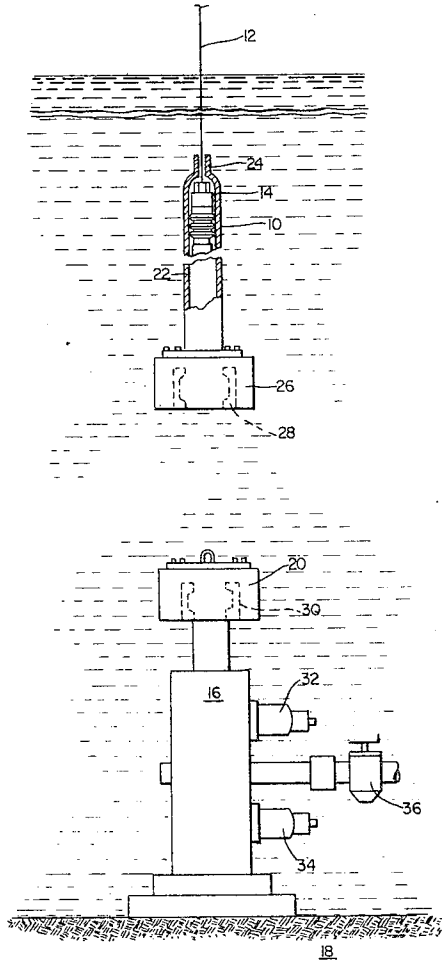
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[57] ABSTRACT

A lubricator for use in reentry of a subsea well and a workover tool enshrouded within the lubrication are lowered from the surface to a subsea wellhead on a wire line. The lubricator is then connected to the wellhead by a hydraulically actuated latch and the workover tool is lowered into the well to perform a workover operation.

8 Claims, 4 Drawing Figures



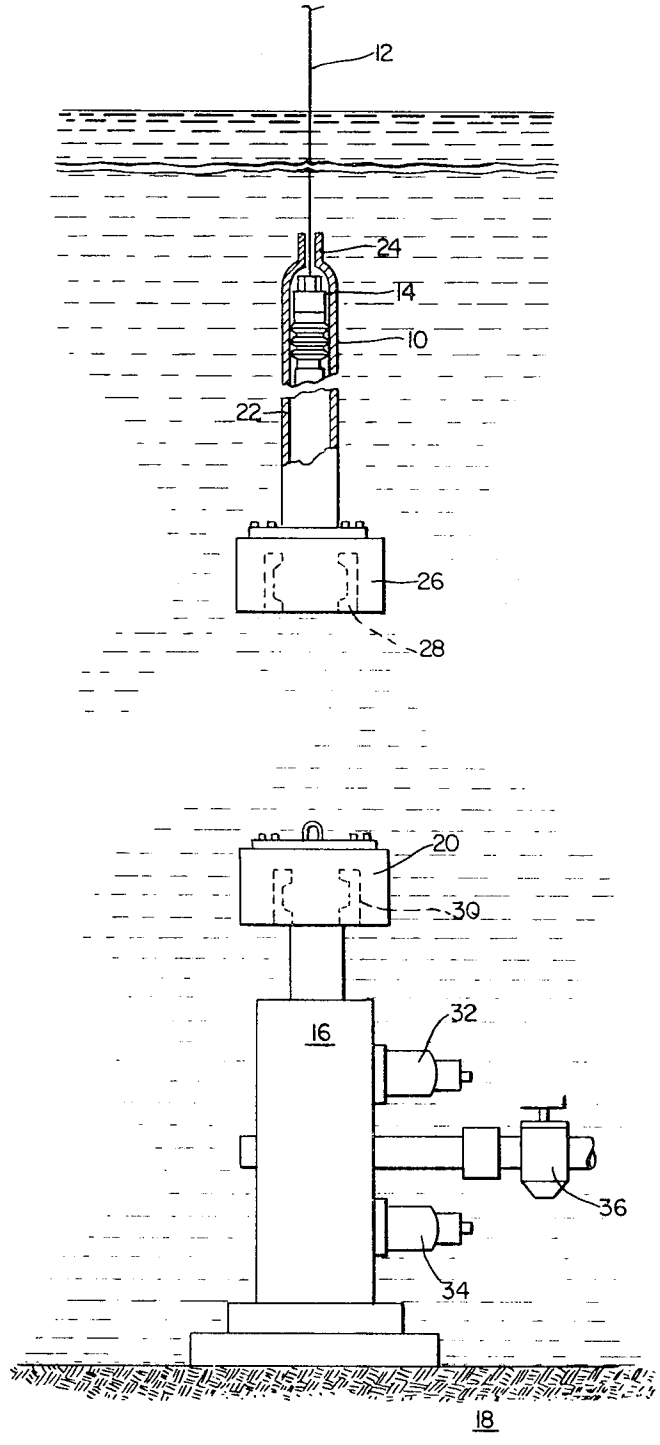


Fig. 1

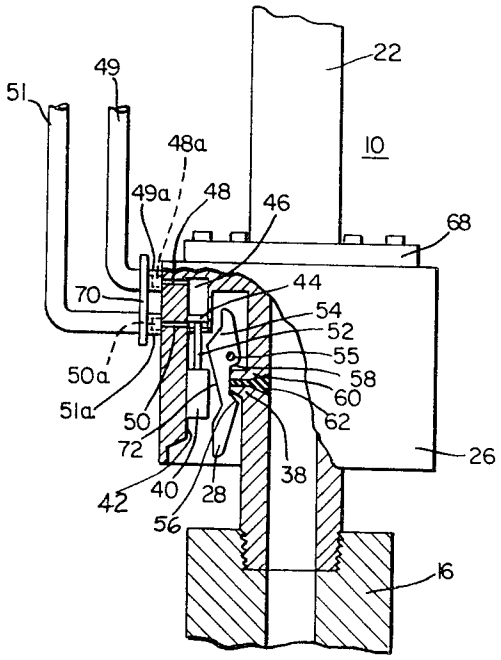


Fig. 2

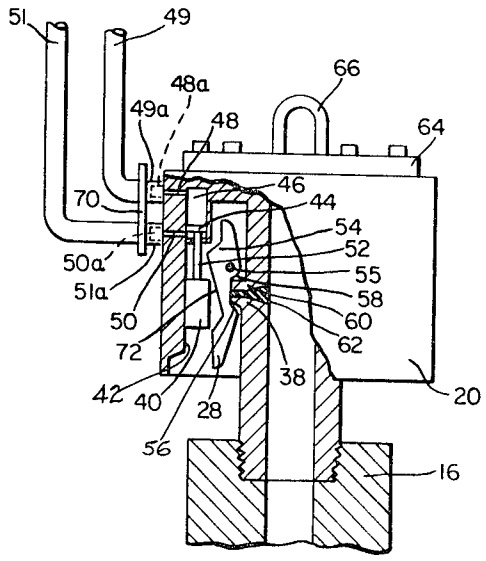


Fig. 3

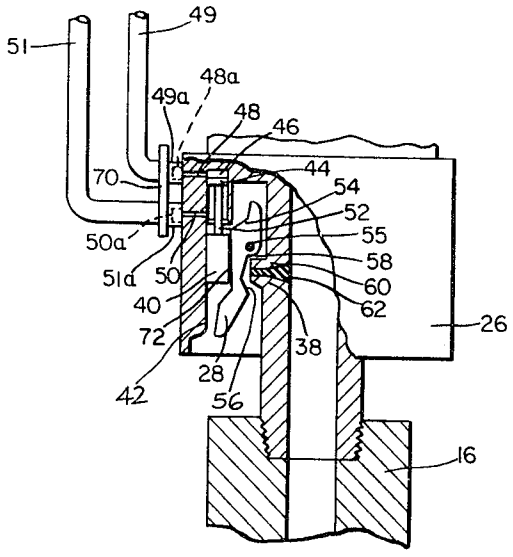


Fig. 4

METHOD AND APPARATUS FOR REENTRY OF SUBSEA WELLHEADS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to lubricators for reentry of fluid mineral wells, and more particularly, to lubricators for reentry of wells having subsea wellheads.

A lubricator is a tubelike member, substantially closed at one end, which is connected to the top of a wellhead at an open end during reentry of a well. In effect, the lubricator serves as an extension of the wellhead which enshrouds a workover tool or other apparatus before the tool or other apparatus is lowered into the well on a wire line which passes through the substantially closed end. Once the lubricator is connected to the wellhead, the swab valve of the wellhead may be opened and the tool or other apparatus may be lowered into the well.

The function of the lubricator is twofold. First, the lubricator seals off the top of the wellhead to prevent fluid minerals from escaping during reentry of the well. In the case of a low-pressure subsea well, the lubricator also prevents water from entering the well through a subsea wellhead during reentry of the well. Second, the lubricator which seals off the top of the wellhead equalizes the pressure on the enshrouded tool or other apparatus to permit the tool or other apparatus to be lowered into the well under the force of gravity alone.

THE PRIOR ART

The conventional lubricator tube, whether intended for use with surface wellheads or subsea wellheads, has been connected to the wellhead by threads. Thus, for each tool or other apparatus which is to be lowered into the well, the lubricator which enshrouds the tool before lowering into the well must be screwed onto and unscrewed off of the wellhead. While rotational motion of the lubricator incident to the screwing onto and unscrewing off of the wellhead may be easily achieved at a surface wellhead, it is difficult, and in some instances impossible, to achieve at a subsea wellhead for the following reasons.

It is virtually impossible for a submersible unit to achieve this rotational movement. It is possible for a diver to achieve the rotational movement, but divers cannot be used at deepwater wellhead locations and their use for this purpose at shallow water wellhead locations is very time consuming and, therefore, costly. Thus, a conventional lubricator cannot be utilized with a deepwater subsea wellhead and can only be utilized at a shallow water subsea wellhead with great time and money expenditures.

An alternative to the conventional lubricator has been proposed for use with very shallow water wellhead locations. Briefly, this alternative has involved the use of a lubricator of greater length than the depth of the water at the subsea wellhead which is lowered to the subsea wellhead through a flexible conduit. Such a lubricator is highly impractical even for use with shallow water wellheads at a depth in excess of 100 feet. Of course, the use of such a lubricator with a deepwater wellhead would be out of the question.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a method and apparatus for facilitating the connection of a lubricator to a subsea wellhead.

It is another object of this invention to provide a method and apparatus permitting connection of a lubricator at a subsea wellhead regardless of depth.

In accordance with these and other objects, the lubricator is lowered, with a workover tool or other apparatus inside it, from the surface to a subsea wellhead on a wire line. On reaching the wellhead, the lubricator is latched thereto and the workover tool or other apparatus is lowered into the well.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the invention and further objects and advantages thereof, reference is made to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a pictorial view of a partially cutaway lubricator being lowered from the surface to a capped subsea wellhead;

FIG. 2 is a vertical section of a portion of the lubricator latched to the subsea wellhead;

FIG. 3 is a vertical section of the well cap latched to the subsea wellhead; and

FIG. 4 is a vertical section of a portion of the lubricator or a portion of the well cap unlatched from the wellhead.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a lubricator **10** is being lowered with the aid of a wire line **12** and an attached workover tool **14** from a surface vessel (not shown) to a subsea wellhead **16** at the sea bottom **18**. In addition to the wire line **12**, conventional surface-to-bottom guidelines and a conventional spacer frame (not shown) may be utilized to guide the lubricator **10** to the wellhead **16**. When the wellhead **16** is reached, a well cap **20** is removed from and the lubricator **10** is connected to the wellhead **16**.

The lubricator **10** comprises a central tube **22** which is very short relative to the depth of the wellhead **16**, i.e., 10 feet; a stuffing box **24** at an upper substantially closed end; and a wellhead connector **26** at a lower open end. The connector **26** includes a latching mechanism comprising a collet **28**, shown in phantom, which may be latched to the wellhead **16**. The well cap **20** includes a similar latching mechanism comprising a collet **30**, also shown in phantom, which is latched to the wellhead **16**.

During its descent, the lubricator **10** rests upon the workover tool **14** which is enshrouded within the lubricator **10** at the stuffing box **24**. When the lubricator **10** reaches the bottom **18**, the collet **30** of the well cap **20** is unlatched from the wellhead **16** by a diver or submersible unit with a wellhead swab valve **32** closed. The lubricator **10** is then connected to the wellhead **16** by the diver or submersible unit by latching the collet **28** thereto. With the lubricator **10** connected to the wellhead **16**, the swab valve **32** may be opened either by a diver or submersible unit or by a remote control facility and the tool **14** may be lowered down through the lubricator **10** and into the wellhead **16** and the well below on the end of the wire line **12** which passes freely through the stuffing box **24**. In certain instances, safety considerations may dictate closing a master valve **34** on the wellhead **16** before the connection of the lubricator **10** and then opening the master valve **34** after the connection of the lubricator **10** to permit the tool **14** to pass through the wellhead **16** and into the well. A production valve **36** may be closed or remain open depending upon whether it is desirable to continue production during the particular workover operation.

When the workover operation is completed, the tool **14** may be withdrawn from the well and into the lubricator **10**. The swab valve **32** may then be closed along with the master valve **34** where desired and the collet **28** unlatched. In some instances, it may be desirable to provide a bleeder valve (not shown) somewhere along the lubricator **10** to bleed off the fluid minerals and reduce the pressure within the lubricator **10** before the collet **28** is unlatched to prevent an explosive separation of the lubricator **10** from the wellhead **16**. The wellhead **16** is then capped with the well cap **20** and the lubricator **10** is raised on the wire line **12** along with the tool **14** to the surface vessel.

In FIG. 2, the lubricator **10** has been connected to the wellhead **16** at the connector **26**, more particularly, the collet **28** of the connector **26** has been latched to a nipple **38** of the wellhead **16**. In the latched position, as shown, the hydraulic actuating mechanism, including a sleeve **40**, which moves between the collet **28** and a wall **42** of the connector **26**, is in the lowermost position. This lowermost position is achieved

when a piston 44 is forced to the bottom of a chamber 46 by hydraulic fluid entering the upper portion of the chamber 46 through a passageway 48. As the piston 44 is forced to the bottom of the chamber 46, hydraulic fluid below the piston 44 is forced out of the lower portion of the chamber 46 through a passageway 50 and a rigid linkage 52 drives the sleeve 40 to the lowermost position.

When the sleeve 40 is in the lowermost position as shown, each of a plurality of fingers 54 of the collet 28 is rotated about a ring 55 to a nearly vertical position. When in the nearly vertical position, a latching surface 56 on each finger 54 of the collet 28 engages the nipple 38. Simultaneously, a latching surface 58 of each finger of the collet 28 engages a nipple 60 of the lubricator connector 26 to compress a seal 62 which is located between the nipple 60 and the nipple 38.

The hydraulic connections for the hydraulically actuated latching mechanism are easily made externally of the connector 26. Terminals 48*a* and 50*a* of the passageways 48 and 50 respectively extend outwardly from the connector 26 and are received by snap-on terminals 49*a* and 51*a* of hydraulic lines 49 and 51 respectively which are held in mutually spaced and fixed positions by a bracket 70. Thus, it will be understood that the hydraulic terminals 49*a* and 51*a* may be easily connected to the terminals 48*a* and 50*a* by a diver or a submersible unit.

In FIG. 3, the well cap 20 has been shown as connected to the wellhead 16, more particularly, the collet 30 of the well cap 20 has been shown as latched to the nipple 38 of the wellhead 16. It will be seen that the hydraulically actuated latching mechanism of the well cap 20 is substantially identical to the hydraulically actuated latching mechanism of the lubricator connector 26. In order to make this identity perfectly clear, the elements of the hydraulically actuated latching mechanism in the well cap 20 have been designated with the same numbers used to designate the elements of the hydraulically actuated latching mechanism in the lubricator connector 26.

The only real difference between the well cap 20 and the connector 26 is that the top of the well cap 20 is closed by a bolt-retainer plate 64 including an eye 66. The purpose of the eye 66 is to permit the connection of a wire line to facilitate the capping and uncapping of the wellhead 16. In contrast, the connector as shown in both FIGS. 1 and 2 is open at the upper end which is bolted to a flange 68 of the tube 22.

It will be appreciated that the hydraulic lines 49 and 51 will usually be removed from the well cap 20 after reentry has been completed. In order to protect the hydraulically actuated latching mechanism from the corrosive effects of sea water, it may be desirable to cover the hydraulic terminals 48*a* and 50*a* with a protective cover after the hydraulic lines 49 and 51 have been removed.

In FIG. 4, which represents either the lubricator connector 26 or the well cap 20, the hydraulically actuated latching mechanism has been unlatched. In the unlatched condition, the piston 44 has been driven to the upper portion of the chamber 46 by the application of hydraulic fluid to the lower portion of the chamber 46 through the hydraulic line 51. As a result, a camming surface 72 on each of the fingers of the collets 28 or 30 has been forced inwardly by the sleeve 40 and the latching surface 56 of each of the fingers of the collets 28 or 30 has been rotated outwardly about the ring 55. The lubricator 10 or the well cap 20 is now ready for connection to or disconnection from the wellhead 16.

As best illustrated in FIG. 4, which represents a portion of the lubricator 10 connected to the wellhead 16 or a portion of the well cap 20 connected to the wellhead 16, the identity between the hydraulically actuated latching mechanism exists externally as well as internally of the lubricator connector 26 and well cap 20. Accordingly, the hydraulic lines 49 and 51 may be mounted on the bracket 70 which maintains a fixed spacing between the terminals 49*a* and 51*a* to facilitate the connection of the lines 49 and 51 to the connector 26 or the well cap 20 interchangeably.

It will be understood that the hydraulic lines 49 and 51 will be attached to and detached from the lubricator connector 26 and the well cap 20 by a diver or submersible unit. Furthermore, it has been suggested that the swab valve 32, the master valve 34, and the production valve 36 may be opened and closed by a diver or a submersible unit. But in accordance with the objects of this invention, the underwater activities of a diver or a submersible unit are well within the capability of a diver or a submersible unit. In particular, the latching mechanism of the lubricator connector 26, as well as the well cap 20, greatly simplifies the necessary connection. Furthermore, the underwater activity required by the latching mechanism is simplified to the point that a submersible unit may perform the activity, thus permitting connection of the lubricator 10 at any subsea wellhead regardless of the depth.

Although FIG. 1 discloses a particular workover tool 14, it will be understood that the invention is in no way limited to that particular tool. Rather, the invention may be utilized in conjunction with a number of workover operations including the scraping of paraffin off the walls of the well and the removal of sand bridges in the well. In fact, the system described in the foregoing may be utilized for reentry of a well whenever it is desirable to lower any apparatus of any kind into the well.

Although the present invention has been described in connection with details of a specific embodiment thereof, it is to be understood that such details are not intended to limit the following claims. Furthermore, the terms and expressions employed are used in a descriptive and not a limiting sense and there is no intent to deprive the following claims of a full breadth of equivalents.

What is claimed is:

1. A wire line lubricator assembly for workover operations at a subsea wellhead comprising:
   - a wire line adapted to be lowered from the surface to said wellhead;
   - a lubricator having a substantially closed end receiving said wire line and an open end including hydraulically actuated means adapted to latchably connect said lubricator to said wellhead; and
   - a workover tool supported on said wire line and adapted to support said lubricator at said closed end as said lubricator is lowered to said subsea wellhead to be latched thereto at said open end and further adapted to move through said lubricator after said lubricator is latched to said wellhead.

2. The wire line lubricator assembly of claim 1 wherein said means adapted to latchably connect said lubricator to said wellhead comprises a plurality of collet fingers adapted to engage a nipple on said wellhead.

3. A system for workover of subsea wells comprising:
   - a submerged wellhead of a subsea well;
   - a wellhead cap connected to said wellhead during production periods, said wellhead cap being connected to and disconnected from said wellhead by a latching mechanism;
   - a wire line adapted to be lowered from the surface to said wellhead;
   - a lubricator having a substantially closed end receiving said wire line and an open end for receiving said wellhead, said open end being connected to and disconnected from said wellhead by a latching mechanism, and
   - a reentry apparatus supported on said wire line and adapted to support said lubricator at said closed end as said lubricator is lowered to said wellhead and adapted to be moved through said lubricator and into said wellhead after said lubricator is latched to said wellhead.

4. The system of claim 3 wherein said latching mechanism at said wellhead cap and said latching mechanism of said lubricator are hydraulically actuated.

5. The system of claim 4 wherein said wellhead cap includes hydraulic terminals external thereto, said lubricator includes hydraulic terminals external thereto, said wellhead cap

hydraulic terminals being substantially identical to said lubricator hydraulic terminals and substantially identically spaced.

6. The system of claim 5 wherein said submerged wellhead includes a nipple and said latching mechanism of said wellhead cap and said latching mechanism of said lubricator includes a plurality of collet fingers for engaging said nipple.

7. A method of reentering subsea wells having subsea wellheads including the following steps:

suspending a lubricator tube from a wire line;

lowering said lubricator tube to one of said subsea wellheads with said wire line;

unlatching a wellhead cap from said one of said wellheads;

removing said wellhead cap from said one of said wellheads;

hydraulically latching said lubricator tube to said one of said wellheads; and

lowering the reentry apparatus into said one of said wellheads.

8. The method of claim 7 wherein said wellhead cap is hydraulically unlatched from said one of said wellheads.

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