Dec. 23, 1958 J. F. RICHARDS 2,865,454

OIL WELL FISHING APPARATUS AND METHOD

Filed July 2, 1956

2 Sheets-Sheet 1

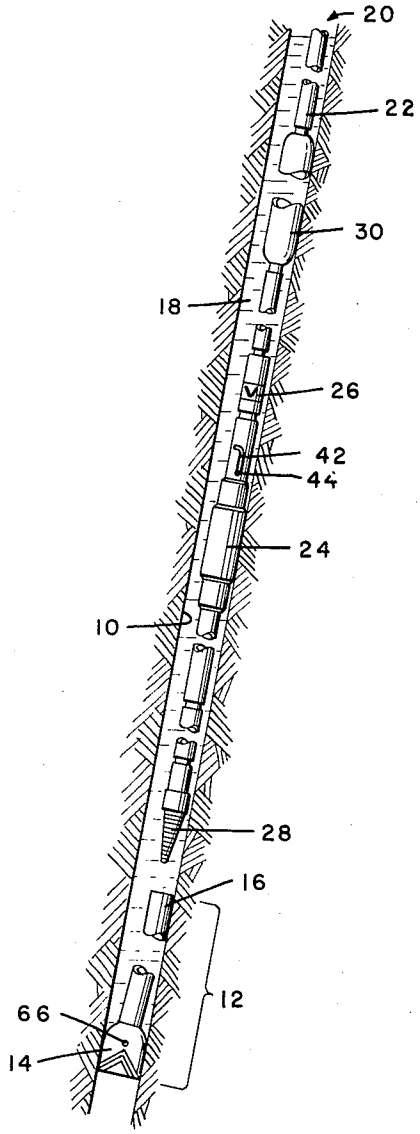


FIG. 1

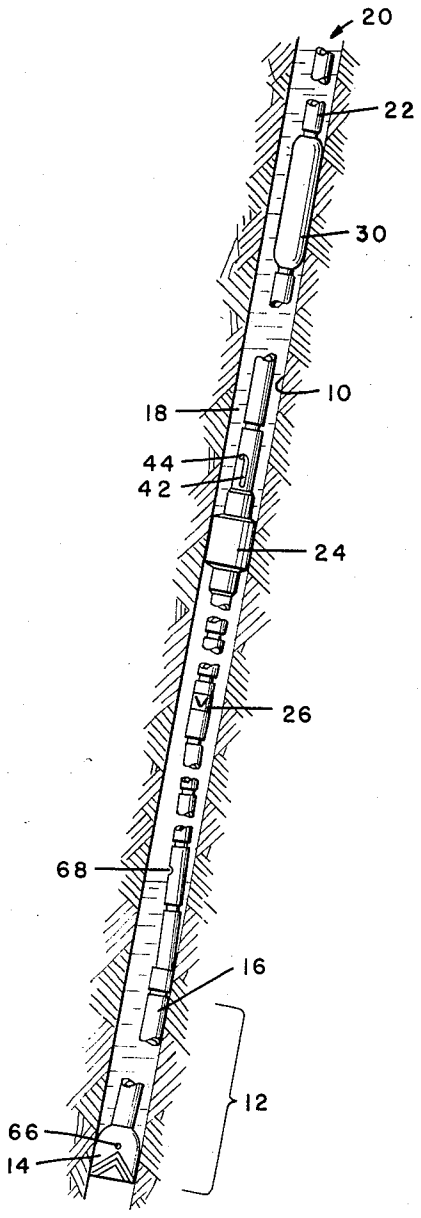


FIG. 2

INVENTOR

J. F. RICHARDS

BY

HIS ATTORNEY

Dec. 23, 1958 J. F. RICHARDS 2,865,454

OIL WELL FISHING APPARATUS AND METHOD

Filed July 2, 1956 2 Sheets-Sheet 2

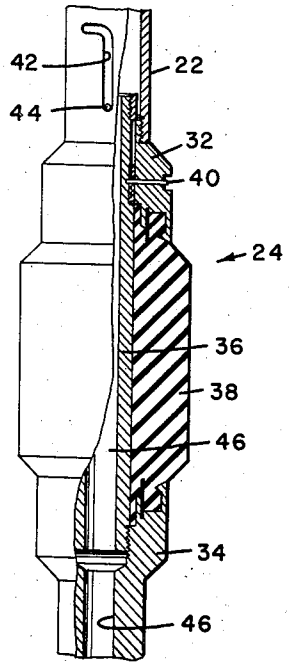


FIG. 3

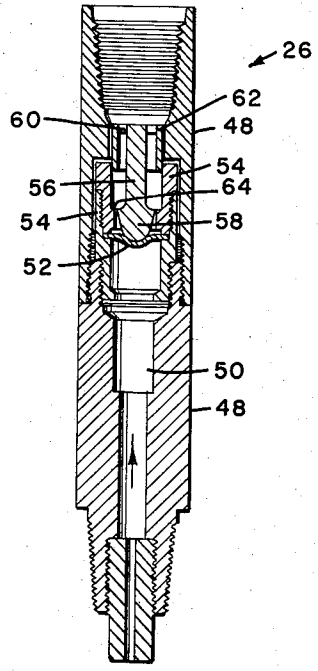


FIG. 4

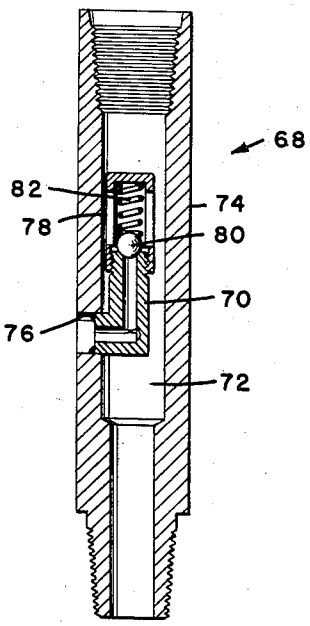


FIG 5

INVENTOR

J. F. RICHARDS

BY A. Alexander

HIS ATTORNEY

United States Patent Office 2,865,454 Patented Dec. 23, 1958

2,865,454

OIL WELL FISHING APPARATUS AND METHOD

John F. Richards, Seal Beach, Calif., assignor to Shell Development Company, New York, N. Y., a corporation of Delaware

Application July 2, 1956, Serial No. 595,273

5 Claims. (Cl. 166—46)

This invention pertains to a method and apparatus for carrying out fishing operations in a borehole and relates more particularly to a method and apparatus for freeing and recovering pipe which is stuck in a borehole due to a pressure differential between the hydrostatic pressure of the mud column in the borehole and the formation pressure.

In either slanted or substantially vertical boreholes the pressure differential can become exceedingly high, particularly, when the borehole is being drilled through depleted reservoirs having low formation pressures. For example, in one well, the pressure differential was found to be on the order of 2400 p. s. i. in the zone of a pipe or fish stuck at a depth of about 5100 ft.

The high pressure differential keeps the fish tightly pressed against the walls of the borehole, and, unless it is reduced, it may defeat all efforts to free and remove the fish. As a result, the conventional fishing methods such as oil spotting and jarring, or washing over with a washpipe have often proved to be unsatisfactory since none of these methods operates to relieve the pressure differential in the zone of the fish. Moreover, oil spotting normally requires a considerable amount of costly "rig down time" not only to soak and jar the fish, but also to return the drilling mud in the borehole to a suitable uncontaminated condition required for reservoir content interpretation tests. In addition, high stresses are imposed on the hoisting equipment during the extensive jarring operations which are frequently required. In the washing over method, the large diameter of the washpipe makes it an undesirable tool to run into many boreholes due to the danger of sticking the washpipe itself. In many cases, it is impossible to work the washpipe down to the fish.

Accordingly, an object of the present invention is to provide a new and improved method and apparatus for overcoming these and other deficiencies while freeing and recovering drill pipe and the like which is stuck in a borehole due to the pressure differential between the hydrostatic pressure of the mud column in the borehole and the formation pressure.

In accordance with one embodiment of the present invention, the free portion of the drill string is disconnected at a point above the fish and is removed from the borehole. A fishing string is then run into the borehole and attached to the fish, whereafter components of the fishing string are operated to eliminate or reduce the pressure differential on all sides of the fish to a value permitting removal of the fish, the fishing string and fish being then withdrawn from the borehole.

These and other objects and advantages of the present invention will be understood from the following description taken with reference to the attached drawings wherein:

Fig. 1 is a view illustrating one embodiment of the apparatus of the present invention after it has been run into a slanted borehole and before it has been attached to a fish stuck in the borehole;

Fig. 2 is a view illustrating another embodiment of the apparatus of the present invention after it has been attached to the fish and after the component parts have been operated for the purpose of eliminating or reducing the pressure differential on all sides of the fish to a value permitting removal of the fish;

Fig. 3 is a view in side elevation of a packer which may be used as a component part of the apparatus of the present invention and wherein part of the packer is shown in vertical section for illustrative purposes;

Fig. 4 is a view in vertical section of a frangible disk type valve which may be used as a component part of the apparatus of the present invention; and

Fig. 5 is a view in vertical section of another valve which may be used as a component part of the apparatus of the present invention.

The method and apparatus of the present invention may be used for freeing and removing a fish from either substantially vertical or directionally drilled and slanted boreholes. Referring now to the drawings, Fig. 1 shows a portion of a directionally drilled or slanted borehole **10** in which there is stuck a fish **12** such as, for example, a drill bit **14** attached to a portion **16** of a drill string immovably held against the wall of the borehole by the pressure differential between the relatively high hydrostatic pressure of the drilling mud column **18** and the relatively low formation pressure in the zone of the fish **12**. As previously noted, this pressure differential can become exceedingly high, and may reach a value precluding recovery of the fish by conventional fishing methods.

In accordance with the present invention, the pressure differential at the zone of the fish **12** is reduced to a value permitting removal of the fish by the use of a fishing string **20** of drill pipe **22** made up with a packer **24** arranged adjacent to the lower end of the fishing string, and a normally closed valve **26** which may be arranged either above or below the packer, as shown in Figs. 1 and 2, respectively. In addition, the lower end of the fishing string may be provided with a conventional type spear **28** to facilitate the making of a connection with the fish and an appropriate number of drill collars **30** for properly weighting the string **20**. A tool joint pin may be employed to make the connection instead of a spear.

The packer **24** may be of any suitable type such as, for example, an open hole sleeve packer having a construction as disclosed in U. S. Letters Patent 2,390,372, issued on December 4, 1945 to M. O. Johnston et al. Briefly, as illustrated in Fig. 3, this type of packer includes a pair of cylindrical upper and lower pressure elements **32** and **34**, respectively, a tubular mandrel **36** which is attached to the lower pressure element and extends slidably through the upper pressure element, and a cylindrical rubber packer sleeve **38** which is arranged between the pressure elements **32** and **34**. The pressure elements are axially relatively movable between an expanded position, as illustrated in Figs. 1 and 3 wherein the packer sleeve **38** is collapsed, and a contracted position for setting the packer and compressing the outer surface of the sleeve into a fluid tight seal against the wall of a borehole, as shown in Fig. 2. A shear pin **40** is provided for maintaining the pressure elements **32** and **34** in the expanded position and the sleeve **38** in a collapsed condition prior to setting the packer. The upper pressure element **32** and the mandrel **36** may be respectively provided with an inverted J slot **42** and pin **44** whereby the pressure elements may be locked into the contracted position after the packer is set. Finally, since the pressure elements **32** and **34** and the mandrel **36** are hollow, drilling mud may be circulated through the common central passage **46** of the packer.

The valve 26 may be a frangible disc valve of the type shown in Fig. 4. The valve is arranged in a two section sub 48 having a mud passage 50 which comprises a part of the mud passage of the fishing string. A frangible disc 52 forms a seal across the passage 50 and is carried by a hollow two piece insert 54, the lower end of which is threadably attached to the lower sub section. Slidably disposed in the insert 54 is a disc breaker or hammer 56, the enlarged head end 58 of which rests on the disc 52. The upper end of the hammer 56 is provided with a spider 60 through which drilling mud can circulate when the disc is broken. In order to open the valve and permit circulation through the fishing string, any suitable weight such, for example, as a metal bar, is dropped down the fishing string to drive the head end 58 through the disc 52 and the insert 54 until motion of the hammer is arrested by contact between the rim 62 of the spider and an internal shoulder 64 of the insert.

In carrying out fishing operations with the apparatus of the present invention, a determination is made of the location at which the drill string is stuck against the side of the borehole, and the free portion of the drill string above the stuck portion or fish 12 is removed from the borehole. The fishing string 20 of hollow drill pipe is then made up essentially including the packer 24 and the closed valve 26. The spear 28 and a number of drill collars 30 may be added if desired. With the upper end of the fishing string open to the atmosphere and the packer 24 in the collapsed condition, as shown in Fig. 3, the fishing string is run into the borehole as shown in Fig. 1, and the lower end thereof is attached to the fish 12, as shown in Fig. 2. Thus there is established a pipe column or mud passage adapted to communicate between the atmosphere and the fish or the portion of the borehole below the packer when the closed valve 26 is opened. The portion of the fishing string above the closed valve 26 is empty or nearly empty of drilling mud and subjected substantially to atmospheric pressure, the portion of the fishing string below the closed valve or seal 26 being subjected to the mud column pressure in the borehole. Downward pressure is then exerted on the fishing string to shear the pin 40, and the upper pressure element 32 is moved down on the mandrel 36 to set the packer 24, as shown in Fig. 2, and to establish a seal in the borehole above the fish. As the packer is being set, the pin 44 rides upwardly in the inverted J slot 42 and the packer is locked into the set position by rotating the fishing string clockwise as viewed from the lower end thereof. A weight is then dropped down the fishing string to drive the hammer 56 through the frangible disc 52 and open the valve 26. The hydrostatic head of the mud column in the borehole below the packer 24 and in the zone of the fish 12 is bled upwardly through the fishing string by virtue of the pressure differential between the atmospheric pressure in the fishing string above the valve 26 and the hydrostatic pressure of the mud column below the packer, the mud flowing into the mud passage opening 66 in the drill bit 14 and thence upwardly through the drill string. From the foregoing it may be seen that the pressure differential in the portion of the borehole below the packer will be reduced to where practically all sides of the fish are subjected to only the formation pressure, thus permitting removal of the fish from the borehole. By rotating the fishing string in a counter clockwise direction, as viewed from the bottom thereof, the pin 44 is moved free from the upper portion of the inverted J slot 42 and permits the portion of the fishing string below the packer to drop downwardly in the borehole to collapse the packer whereupon the fishing string and fish may be withdrawn from the borehole. Alternatively, after the pin 44 has been rotated, the packer may be collapsed by an upward pull on the fishing string, and preferably, at the instant it is collapsed, the fish is set in motion by rotating or reciprocating the fishing string to prevent the fish from becoming stuck again as the mud in the borehole flows down around the drill bit.

It is understood that any suitable type of packer may be used, and that the shear pin 40, the inverted J slot 42 and pin 44 are not essential parts of the present invention. Also any suitable type of valve may be used in place of the frangible disc type valve shown, for example, a hydraulic or other type of valve operated by rotation or the application of weight from the fishing string. The use of such a valve is preferred in cases where it is desired to establish return circulation through the mud passage in the fishing string the instant the fish has been freed.

In case the opening 66 in the drill bit has been plugged by rock chips, etc., thus stopping communication between the space within the fishing strings and the space in the borehole around it, the mud pressure in the borehole below the set packer may be bled through a bypass opening or valve 68 which is preferably arranged as closely as possible to the lower end of the fishing strings (Fig. 2) and below the valve 26 and packer 24. The bypass valve 68 may be a check valve, one type of which is illustrated in Fig. 5 as embodying an elbow 70 which is disposed within the mud passage 72 of a sub 74 or a section of drill pipe which is attached to the fishing string. The lower end of the elbow may be welded or otherwise attached to the wall of the sub in communication with an inlet opening 76 extending therethrough. Its upper end threadably receives a cage 78 including a ball valve member 80 which is urged downwardly into a seated position against the upper end of the elbow by a helical spring 82. The spring pressure should be such that the valve member 80 can be unseated by the mud column pressure below the packer, but is seated to close the valve by the combined pressure of the spring and the mud pressure in the fishing string if return circulation is established when the fish has been freed. Thus, after the valve 26 has been opened, and the pressure within the string released, the bypass valve 68 operates to permit flow of the mud below the packer through the valve 26 and up the fishing string as previously noted. Since the bypass valve is arranged above and closely adjacent to the fish, the pressure differential in the zone of the fish will be reduced to a nominal value readily permitting withdrawal of the fish. A perforated pipe may be substituted for the check valve, however the latter is preferred since it permits return circulation through the opening 66 in the drill bit after the fish has been freed.

Although not shown in the drawing, conventional jars and a safety may be connected above and/or below the packer 24, if desired, to facilitate the freeing and removal of the stuck equipment.

I claim as my invention:

1. A method of recovering a drilling string having a portion thereof stuck against the wall of a borehole by a pressure differential between the mud column pressure in the borehole and the formation pressure, comprising the steps of: detaching the free portion of the drilling string above the stuck portion and removing it from the borehole, running a string of pipe, capable of being attached to the upper end of the stuck portion of the drilling string, into the borehole, the interior of said string of pipe being closed at an intermediate point from communication with the upper end thereof, effecting the attachment of the lower portion of said string of pipe to the stuck portion of the drilling string, reducing the pressure differential around the stuck portion of the drilling string to a value permitting movement of the stuck portion in the borehole, said reduction of pressure differential being effected by closing the annular space between the borehole and the string of pipe at an intermediate point thereof and within the mud column, and by opening the interior of said string of pipe to the atmosphere, and withdrawing from the borehole the string of pipe together with the

drilling string attached thereto while reopening the annular space between the borehole and the string of pipe.

2. In cleaning petroleum wells, a method of recovering a fish immovably held against the wall of a well by a pressure differential between the mud column pressure and the pressure of the formation, comprising the steps of: lowering a tubular string into the well, providing an inner pressure-tight seal at a predetermined point within said string, connecting the lower end of said tubular string to said fish with the mud column pressure penetrating the lower portion of said tubular string below said inner seal while the upper portion of said tubular string above said inner seal is open to the atmosphere, forming an outer pressure-tight seal in the annular space between said tubular string and the walls of the well at a desired point above said fish but within the mud column, collapsing the inner seal to release the pressure in the borehole below said outer seal, thereby reducing the pressure differential holding said fish against the wall of the well, collapsing said outer seal while simultaneously moving said tubular string, and removing said tubular fishing string and said fish from the well before the pressure differential has built up to a value sufficient to hold the fish again tightly against the wall of the well.

3. A method of recovering a drilling string having a portion thereof stuck against the wall of a slanted borehole by a pressure differential between the mud column pressure in the borehole and the formation pressure comprising the steps of: detaching the free portion of the drilling string above the stuck portion and removing it from the borehole, assembling a pipe string, adapted to be attached by its lower part onto the upper end of the stuck drill pipe, and including a packer and a normally closed valve for blocking flow through the pipe string and a check valve arranged below the packer and the normally closed valve and near the lower end of the pipe string for permitting flow from the borehole into the pipe string, running the pipe string into the borehole and attaching the lower end thereof to the stuck portion to form a pipe column adapted to establish communication through the valves between the portion of the borehole below the packer and the atmosphere, setting the packer to form a substantially fluid tight seal in the borehole at a position above the stuck portion but with the mud column, opening the normally closed valve to bleed off through the check valve and pipe column the mud column pressure in the zone of the stuck portion, collapsing the packer while simultaneously moving said tubular string, and withdrawing the pipe string and said portion of the drill string from the borehole before the pressure differential builds up to a value sufficient to hold the drilling string stuck again against the borehole well.

4. A method of freeing a fish stuck against a wall of a slanted borehole by a pressure differential between the mud column pressure in the borehole and the formation pressure, comprising the steps of: lowering a tubular string into the well, providing an inner pressure-tight seal at a predetermined point within said string, connecting the lower end of said tubular string to said fish with the mud column pressure penetrating the lower portion of said tubular string below said inner seal while the upper portion of said tubular string above said inner seal is open to the atmosphere, forming an outer pressure-tight seal in the annular space between said tubular string and the walls of the borehole at a desired point above said fish, but within the mud column collapsing the inner seal to release the pressure in the borehole below said outer seal, thereby reducing the pressure differential holding said fish against the wall of the borehole and collapsing said outer pressure-tight seal while simultaneously moving said tubular string.

5. Apparatus for use in oil well drilling operations for freeing and removing a fish stuck in a borehole by a pressure differential between the hydrostatic pressure of the mud column in the borehole and the formation pressure in the zone of the fish comprising: a string of hollow pipe having its upper end vented to the atmosphere, fish attaching means carried by the lower end of said pipe string, a packer carried by said pipe string above the lower end thereof in a normally collapsed position to permit movement of the pipe string in the borehole, means mechanically connected to the packer and adapted to set the packer against the borehole walls to form a pressure-tight seal in the borehole, a normally closed valve carried in said pipe string for blocking fluid flow through the pipe string, said valve being adapted to be opened to permit fluid flow through said pipe string after the packer is set for bleeding off the hydrostatic pressure of the mud column within the borehole below said packer and a by-pass valve carried by said pipe string and disposed below the normally closed valve and the packer, said by-pass valve being adapted to permit fluid flow from the borehole and into said pipe string.

References Cited in the file of this patent

UNITED STATES PATENTS

1,683,031	Harris	Sept. 4, 1928
2,128,212	Mullins	Aug. 23, 1938
2,361,558	Mason	Oct. 31, 1944