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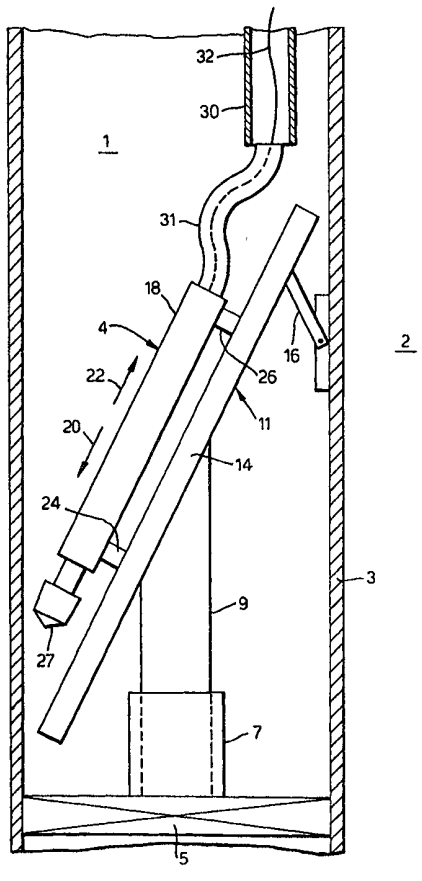
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(54) Title: MILLING SYSTEM FOR FORMING A WINDOW IN THE WALL OF A TUBULAR

(57) Abstract

A system is provided for milling a window in a casing of a borehole formed in an earth formation. The system comprises a milling tool for milling said window, a guiding device for guiding the milling tool along a selected path within the casing during milling said window, the guiding device having means for fixedly arranging the guiding device within the casing. The guiding device is provided with thrust means for thrusting the milling tool along the selected path during milling the window.



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MILLING SYSTEM FOR FORMING A WINDOW IN THE WALL OF A TUBULAR

The present invention relates to a system for milling a window in a casing of a borehole formed in an earth formation. In the technology of producing hydrocarbon fluid from a wellbore it has become practice to drill branch boreholes via corresponding openings formed in the casing of the main wellbore, such openings being generally referred to as windows. Conventionally a window is created by fixedly positioning a whipstock having a slanted guide-way, within the casing and guiding a milling tool along the guide-way during milling of the window. The downhole force required to progress the milling tool along the guide-way is supplied from surface via a pipe string connected to the milling tool. Fluid is pumped through the pipe string to operate the milling tool and to remove the milling cuttings from the borehole.

A problem of the conventional system for milling a window in a casing is that the downhole force required to progress the milling tool along the guide-way is insufficiently controllable. This is, for example, due to frictional forces which counter-act the downward force acting on the pipe string, and due to uncontrolled bending of the pipe string within the casing.

It is an object of the invention to provide an improved milling system which overcomes the problems of the conventional system.

In accordance with the invention there is provided a system for milling a window in a casing of a borehole formed in an earth formation, the system comprising a milling tool for milling said window, a guiding device for guiding the milling tool along a selected path within

the casing during milling said window, the guiding device having means for fixedly arranging the guiding device within the casing, wherein the guiding device is provided with thrust means for thrusting the milling tool along the selected path during milling the window.

The thrust force necessary for progressing the milling tool during milling is provided from the guiding device rather than from surface. For example, the guiding device can be provided with a hydraulic motor or an electric motor receiving power from surface via a suitable control system. With the system of the invention it is achieved that the problems of the conventional system are eliminated as it is no longer required to provide the downward force via an elongate element (such as a pipe string) extending from surface through the casing.

It is to be understood that in the context of the present invention the term "casing" refers to any elongate hollow element which is arranged in the borehole and in which a window is to be milled, such as a cemented casing or a wellbore liner.

Suitably the guiding device is provided with a guide-way defining said selected path and with means for preventing movement of the milling tool transverse to the guide-way. In this manner it is achieved that undesired "walk" of the mill during milling is prevented and that an accurate shape of the window is obtained.

In a preferred embodiment of the system, the selected path extends substantially parallel to the longitudinal axis of the casing. In this manner another problem of the conventional system, namely that the shape of the window deviates from the planned circular or oval shape, is solved. For example, in the conventional system whereby the milling tool is arranged at an inclination angle relative to the longitudinal axis of the casing, the

upper window portion is milled by the upper side of the mill and the lower window portion by the lower side of the mill. As a result the upper window portion will be biased in one direction (depending on the direction of rotation of the mill) and the lower window portion in the other direction. By selecting the path of the milling tool to be substantially in longitudinal direction of the casing it is achieved that only one side of the mill contacts the casing during the entire milling procedure.

The invention will now be described in more detail and by way of example with reference to the accompanying drawing in which:

Fig. 1 schematically shows an embodiment of the system according to the invention.

A borehole 1 has been formed in an earth formation 2 and provided with a steel casing 3. The embodiment 4 of the system according to the invention includes a retrievable downhole packer 5 fixedly positioned at a selected location in the casing 3 and provided with an upwardly extending latching element 7 adapted to receive and fixedly hold a support column 9 of a guiding device 11 in a selected orientation. The guiding device 11 includes a ramp element 14 rigidly connected to the support column 9 and provided with a secondary support element 16 which is radially extendible against the inner surface of the casing 3. The ramp element 14 extends inclined relative to the longitudinal axis of the casing 3 and defines inclined, opposite, directions 20, 22 of a path along which a milling tool 18 is movable, direction 20 being inclined downwardly and direction 22 being inclined upwardly. The ramp element 14 is internally provided with a thrust means in the form of a chain (not shown) movable in the directions 20, 22 and an electric motor (not shown) for driving the chain. The milling tool 18 has legs 24, 26 which are connected to

the chain 14 so that movement of the chain in directions 20, 22 results in corresponding movement of the milling tool 18. The milling tool is internally provided with a hydraulic motor (not shown) for driving a mill 27 of the milling tool, the hydraulic motor receiving hydraulic fluid via a coiled tubing 30 extending through the casing 3 to a hydraulic pump (not shown) at surface, the coiled tubing being connected to the hydraulic motor by means of a flexible hose 31. The mill 27 has a plurality of outlet nozzles (not shown) for hydraulic fluid from the motor. The coiled tubing is provided with a connector (not shown) for connecting the coiled tubing to the guiding device 11 so as to lower and retrieve the guiding device 11 and milling tool 18 through the wellbore 1.

An electric power supply cable 32 extends from a control unit (not shown) at surface, through the coiled tubing 30 and the hose 31, to the milling tool 18 and from there via one of the legs 24, 26 to the electric motor of the ramp element 14. The control unit is provided with controls for selectively moving the chain in direction 20 or 22. Furthermore, the control unit includes a control for selectively extending or retracting the secondary support element 16 relative to the inner surface of the casing 3.

During normal use the packer 5 with the latching element 7 connected thereto is fixedly positioned at a selected location in the casing 3 at an orientation corresponding to the desired orientation of the window to be milled. The guiding device 11 is connected to the coiled tubing 30 by means of the connector and the combined guiding device 11/milling tool 18 are then lowered by coiled tubing 30 through the casing 3 until the support column 9 latches into latching element 7. Subsequently the control unit at surface is operated to

provide a control signal via power supply cable 32 to the guiding device so as to radially extended support element 16 against the casing 3.

Hydraulic fluid is then pumped through the coiled tubing 30 thereby driving the hydraulic motor so as to rotate the mill 27. Simultaneously the control unit at surface is operated so as to move the chain and the milling tool 18 in the direction 20 in order to mill the window. The cuttings resulting from the milling operation are entrained and transported away by the hydraulic fluid exiting through the nozzles of the mill 27. After milling of the window has been completed, the control unit is operated to move the milling tool 18 in direction 22 away from the casing 3 and to retract the support element 16. The combined guiding device 11/milling tool 18 are then retrieved to surface by means of the coiled tubing 30. The packer 5 and latching element 7 are subsequently retrieved to surface in any suitable manner.

Instead of applying the milling tool and the guiding device as separate units, these devices can be integrated into one tool, optionally also including the packer and latching element.

In an alternative embodiment of the system according to the invention the thrust means is one of a worm-gear having a spindle extending in the direction along which the milling tool is guided and a hydraulic piston/ cylinder assembly extendible in said direction.

Furthermore, the milling device can be provided with measuring means for measuring parameters such as the torque delivered by the output shaft of the milling tool, the thrust force delivered by the thrust means, and the position of the milling tool along said path. Suitably the measuring means is in communication with a data receiving station at surface via a data transmission

cable extending through a tubing, e.g. the coiled tubing referred to above.

C L A I M S

1. A system for milling a window in a casing of a borehole formed in an earth formation, the system comprising a milling tool for milling said window, a guiding device for guiding the milling tool along a selected path within the casing during milling said window, the guiding device having means for fixedly arranging the guiding device within the casing, wherein the guiding device is provided with thrust means for thrusting the milling tool along the selected path during milling the window.

2. The system of claim 1, wherein the thrust means includes one of a chain movable in the direction of said path, a worm-gear having a spindle extending in the direction of said path, and a hydraulic piston/cylinder assembly extendible in the direction of said path.

3. The system of claim 1 or 2, wherein the guiding device is provided with a guide-way defining said selected path and with means for preventing movement of the milling tool transverse to the guide-way.

4. The system of any one of claims 1-3, wherein the said selected path extends substantially parallel to the longitudinal axis of the casing.

5. The system of any one of claims 1-4, wherein the milling tool has an output shaft driven by a hydraulic motor, the hydraulic motor being connected to a hydraulic fluid supply tubing extending through the casing to surface and having an outlet opening for hydraulic fluid arranged so as to allow the hydraulic fluid to entrain cuttings resulting from milling the window.

6. The system of claim 5, wherein the thrust means is driven by an electric motor connected to an electric power supply cable extending through said tubing.

7. The system of claim 5 or 6, wherein the tubing is a coiled tubing.

8. The system of any one of claims 1-7, wherein the milling device is provided with measuring means for measuring at least one of the torque delivered by an output shaft of the milling tool, the thrust force delivered by the thrust means, and the position of the milling tool along said path.

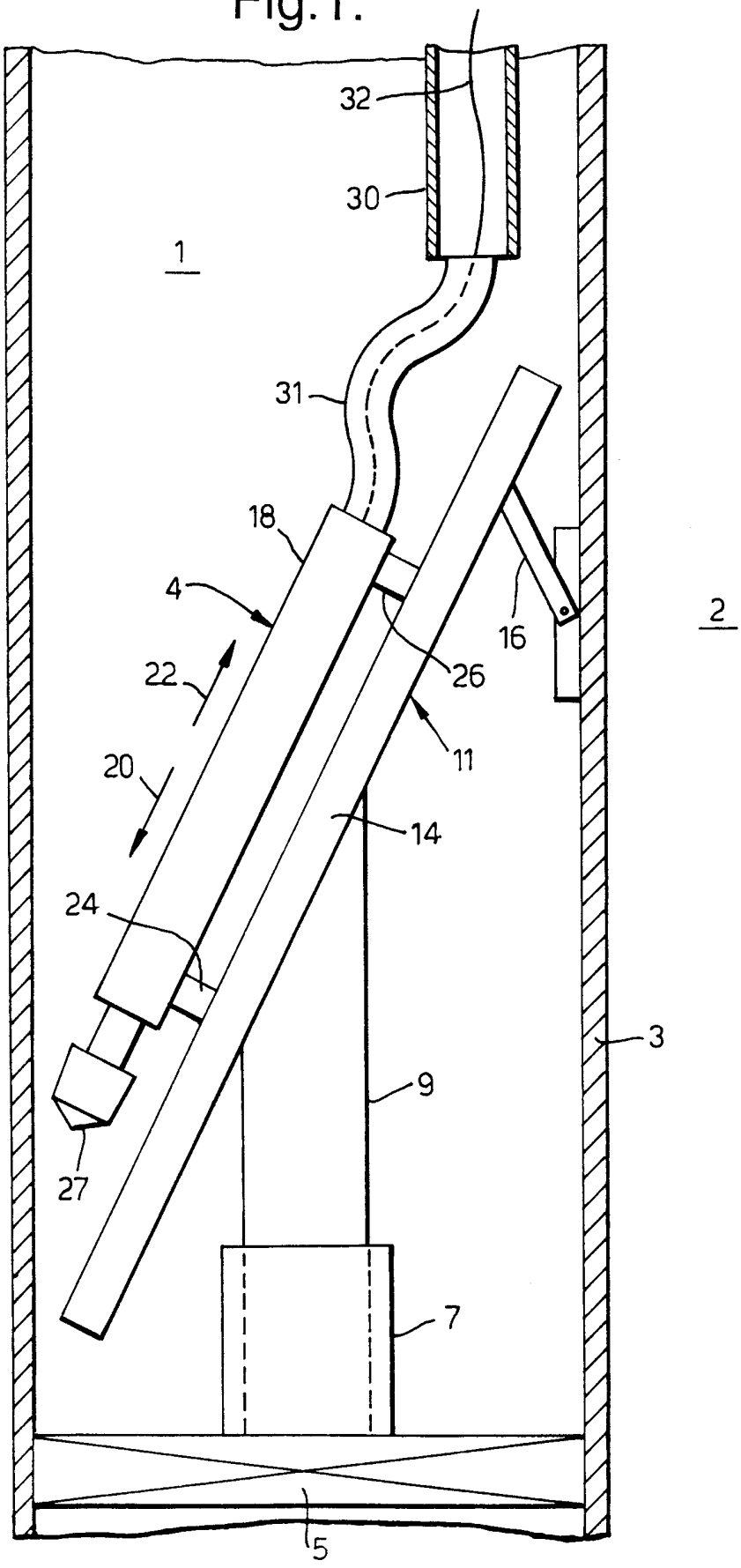
9. The system of claim 8 when dependent on claim 5, wherein the measuring means is in communication with a data receiving station at surface via a data transmission cable extending through said tubing.

10. The system of any one of claims 1-9, further comprising an indexing device for orienting the milling tool in different orientations relative to the guiding device so as to allow the window to be milled in multiple passes of the milling tool, wherein each pass corresponds to one of said orientations of the milling tool relative to the guiding device.

11. The system of any one of claims 1-10, wherein the selected path extends substantially in longitudinal direction of the casing.

12. The system substantially as described hereinbefore with reference to the drawing.

Fig.1.



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B29/06 E21B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 539 047 A (A. ARUTUNOFF) 23 January 1951 (1951-01-23) column 3, line 72 -column 4, line 58 figures 1-5	1,3,8
X	EP 0 791 722 A (SCHLUMBERGER LTD ;SCHLUMBERGER SERVICES PETROL (FR); SCHLUMBERGER) 27 August 1997 (1997-08-27) abstract column 4, line 38 -column 5, line 2 figures 1-4	1-3
A	US 2 631 821 A (J.P. CALDWELL) 17 March 1953 (1953-03-17) the whole document	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Category °	Citation of document, with indication,where appropriate. of the relevant passages	Relevant to claim No.
A	US 3 797 576 A (AZALBERT J ET AL) 19 March 1974 (1974-03-19) figure 6	1
A	US 4 007 797 A (JETER JOHN D) 15 February 1977 (1977-02-15) figures 1-4	1
A	US 4 640 353 A (SCHUH FRANK J) 3 February 1987 (1987-02-03) column 5, line 31-64; figure 1	1

1

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Interr ...nal Application No
PCT/EP 99/04700

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2539047 A	23-01-1951	NONE	
EP 0791722 A	27-08-1997	US 5687806 A	18-11-1997
		AU 1479497 A	28-08-1997
		CA 2197964 A	21-08-1997
		NO 970770 A	21-08-1997
US 2631821 A	17-03-1953	NONE	
US 3797576 A	19-03-1974	FR 2091931 A	21-01-1971
		CA 958979 A	10-12-1974
		GB 1342954 A	10-01-1971
US 4007797 A	15-02-1977	NONE	
US 4640353 A	03-02-1987	NONE	