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(54) Title: MULTI-TOOL BOTTOM HOLE ASSEMBLY WITH SELECTIVE TOOL OPERATION FEATURE

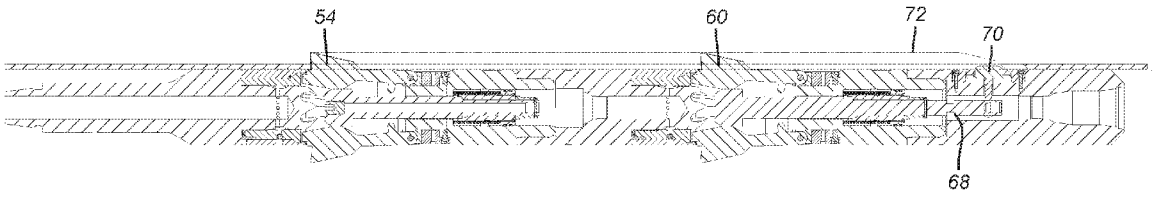

FIG. 5

(57) Abstract: Dual section mills are selectively sequentially operated by locking an actuator for the backup mill as the primary mill has blades extended with internal flow through a housing. When the primary mill is spent the support string is shifted to defeat a lock on an actuation piston for the backup mill so that its blades can extend and continue to mill to finish the job. The blades of the primary mill continue to rotate in the already milled portion of the window as the secondary mill enlarges the window. Another way the secondary mill is actuated is to open access to flow to the secondary mill by removing a pressure barrier such as a valve or a disappearing plug, for example.

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MULTI-TOOL BOTTOM HOLE ASSEMBLY WITH SELECTIVE TOOL OPERATION FEATURE

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FIELD OF THE INVENTION

[0001] The field of the invention is bottom hole assemblies with multiple tools that can be sequentially operated using a common operating force and more particularly sequentially operated mills where a second mill can take over after an initial mill wears in the same trip in the borehole.

BACKGROUND OF THE INVENTION

[0002] Rig time is expensive and is always the subject of efforts to minimize it. One way to do this when running tools that wear out in use is to run in with a backup tool that can be deployed to finish the job should the primary tool either wear out or experience some other operational difficulty. For example in section milling where a length of a tubular is to be milled away to facilitate a lateral exit from a borehole the mills typically have a series of pivoting blades that are held retracted for running in and powered out against the casing or other tubular. Milling can occur in an uphole or a downhole direction depending on blade orientation. The simpler of these devices are pressure actuated so that when flow is initiated an internal piston is pushed whose movement releases a retraction tab on the blades that was employed for running in and another portion of the internal piston pushes the blades from behind against the surrounding tubular. Flow continues out of the tool to remove cuttings from the blades as the assembly is rotated to remove the surrounding tubular. The internal piston using the flow through the tool maintains a contact force on the surrounding tubular as the blades pivot as the milling progresses. A return spring takes over when flow is cut off to again allow the blades to retract to the point where they can be held retracted for tool removal.

[0003] If a single tool is run the surface personnel who monitor the milling rate will know from experience that the blades have worn and depending on the progress of the milling at that time it may mean that the tool has to be pulled out of the hole (POOH) and the blades replaced. This is a time consuming process and expensive for the operator. Having a spare mill in the hole would solve this problem but creates another problem. That problem is how to sequentially operate a primary and secondary mill that feature blades extending in response to pressure. The preferred operating method is to run the first mill until it wears and then retract its blades and

finish the job with the second mill. The problem is that the same pressure that operates the first mill with extend the blades of the backup mill prematurely. Others skilled in the art have attempted to solve this problem but have failed to do it in a reasonably cost effective manner. Instead they have resorted to complex independent operating systems for the mills that use RFID tags and sensors to retract the blades of the spent mill and then to extend the blades of the second mill. This approach is shown in FIG. 13 of US 8141634. The cost of this approach is prohibitive and the size of the tool is potentially increased to house the signal and power components which can make the design too large for use in some applications. Instead, the present invention continues to employ fluid pressure to extend blades but prevents the blades from the backup mill from extending with a lock on its piston actuator that is simply defeated with tool repositioning or simply just prevents actuation pressure that operates the primary mill from reaching the backup mill until the desired time for a switchover between mills. These and other features of the present invention will be more readily apparent to those skilled in the art from a review of the detailed description of the preferred embodiment and the associated drawings while recognizing that the full scope of the invention is to be determined from the appended claims.

SUMMARY OF THE INVENTION

[0004] Dual section mills are selectively sequentially operated by locking an actuator for the backup mill as the primary mill has blades extended with internal flow through a housing. When the primary mill is spent the support string is shifted to defeat a lock on an actuation piston for the backup mill so that its blades can extend and continue to mill to finish the job. The blades of the primary mill continue to rotate in the already milled portion of the window as the secondary mill enlarges the window. Another way the secondary mill is actuated is to open access to flow to the secondary mill by removing a pressure barrier such as a valve or a disappearing plug, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a section view of a primary and backup mills with a removable barrier that prevents backup mill blade extension until the barrier is removed;

[0006] FIG. 2 is a section view of a primary and backup mills in the run in position with the backup mill mechanically locked;

[0007] FIG. 3 is a view of FIG. 2 with the blades of the primary mill extended for milling;

[0008] FIG. 4 is the view of FIG. 3 with the primary mill spent after making some of the hole;

[0009] FIG. 5 is the view of FIG. 4 with the backup mill blades extended;

[0010] FIG. 6 is a section view along line 6-6 of FIG. 3 showing circumferentially spaced retainers for the actuating piston of the backup mill.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Referring to FIG. 1, a primary mill **10** is selectively fluidly connected to a backup or secondary mill **20** through a coupling **22**. A tubular string **24** has a passage **26** that continues into the primary mill **10**. Lateral outlets **28** conduct flow to chamber **30** under actuating piston **32** that is biased in the downhole direction of arrow **35** by spring **34**. With no pressure applied in passage **26** the force of spring **34** pulls on tabs **36** to retract the blades **38**. With pressure applied in passage **26** piston **32** moves in the opposite direction to arrow **35**. The blades **38** are then extended as the spring **34** is compressed. Rotation of the blades **38** cuts into the surrounding tubular that is not shown. Fluid from passage **26** after moving out the blades **38** is exhausted near nozzles **40** that are used to remove cuttings away from the blades **38** and circulate the cuttings uphole for removal.

[0012] Chamber **30** is sealed at a lower end with a plug **42**. This plug **42** can be a valve or a disintegrating plug, rupture disc or another plug that can be removed by dissolving or some other process. Alternatively, the plug **42** can be retained with breakable members that are not shown to stay in place under pressures normally expected when only the primary mill **10** is operating alone. Raising the pump rate into passage **26** can raise the pressure to break the restraint on plug **42** to allow flow to continue into passage **44** to the secondary mill **20**. The mill **20** can preferably be the same as mill **10** whose operation was described above. Accordingly, when fluid under pressure begins to flow into passage **44** the blades **46** of mill **20** will extend and blades **38** will stay extended and rotate in an already milled zone where they should contact nothing since they will be worn and mill **20** will be used to continue milling. The plug **42** can be removed with adding a fluid to the flow down passage **26** such as water or another fluid that will initiate the failure of plug **42** to hold pressure in any one of a variety of ways. Another way to accomplish the removal of plug **42** is to make the plug responsive to pressure application and removal cycles used concurrently with a j-slot mounting such that after a predetermined number of cycles the plug can move into an enlarged passage to enable flow to go around it for extension of blades **46**.

[0013] FIGS. 2-6 reflect a mechanical locking of the actuating piston **50** of the backup or secondary mill **52**. FIG. 1 shows the run in position where blades **54** of the primary mill **56** are retracted in the manner previously described since there is no flow in passage **58**. Blades **60** are retracted for the same reason. In both cases in FIG. 2 the springs **62** and **64** are the force to keep blades **54** and **60** retracted. In FIG. 2 pressure in passage **58** extends blades **54** in the manner previously described but blades **60** stay retracted because actuating piston **50** is physically retained against axial movement by rods or detents **66** best seen in FIG. 6 extending into respective grooves **68** in the body of piston **50**. These grooves are best seen in FIG. 5 where the rods **66** have been moved axially with pressure that comes from passage **58** in combination with string manipulation that places caps **70** on rods **66** in alignment with a window **72** represented by a dashed line that has already been milled with blades **54**. Caps **70** are retained for limited extension out in the radial direction and are biased inwardly by a spring **74** shown in FIG. 2. It is the application of pressure from passage **58** that is communicated to chamber **76** that puts an outward force on the caps **70** against the bias of springs **74**. However, it is only when the delivered pressure is high enough and the caps **70** are free to move out radially that conditions are met to allow radially outward movement of caps 70 that takes the rods **66** out of their respective grooves **68**. Once the blades **60** come out, they take over the milling of the window **72**. The blades **54** stay out as milling continues but do not do any further milling. Alternative ways to mechanically lock the actuating piston **50** of the backup mill **52** are contemplated. The body of the piston **50** can be simply shear pinned to a surrounding housing wall and those pins can shear with enough force. A j-slot mechanism with applied and removed pressure cycles can free the piston **50** to move axially to extend blades **60**.

[0014] Those skilled in the art will appreciate that what has been described is a simple way to stagger the operation of two or move tools that are power in the same manner using simple devices that keep the tool cost down while offering reliable operation. When the tools are pressure operated the applied pressure is fed to the primary tool and the backup tool is isolated from such pressure until it needs to operate. At that point a barrier to the pressure is removed or a lock that prevents actuator movement while being exposed to the pressure can be defeated. In the preferred method of defeat of the mechanical locking the tools are repositioned to allow the pressure already present at the actuator for the backup tool to move a detent out of the way or fail such a detent to allow the piston to move and the associated blades with that piston to radially

extend for continuation of the milling after the primary mill has worn. Although the system is described in the context of identical mills the tools in question need not be identical or for that matter need not be mills. A variety of pressure actuated tools can have their operations staggered in the above described manner. An isolation valve triggered remotely with a signal can be used in FIG. 1 as the barrier **42**. The milling direction can be either uphole or downhole direction.

[0015] The above description is illustrative of the preferred embodiment and many modifications may be made by those skilled in the art without departing from the invention whose scope is to be determined from the literal and equivalent scope of the claims below:

We claim:

1. An assembly of borehole tools, comprising

a pressure operated primary tool (10) connected in selective pressure communication with a pressure operated secondary tool (20); **characterized by**

a selectively removable pressure barrier (42) between said tools to allow said primary tool (10) to operate with pressure when said barrier (42) is intact and to allow said secondary tool (20) to operate when said barrier is removed.

2. The assembly of claim **1**, wherein:

said primary and secondary tools comprise mills with pivoting blades (38,46).

3. The assembly of claim **1**, wherein:

said barrier disintegrates with a fluid delivered to create the pressure to operate said primary tool.

4. The assembly of claim **1**, wherein:

said barrier (42) is released to pass pressure when a retainer responsive to pressure applied to said barrier is broken.

5. The assembly of claim **1**, wherein:

said barrier (42) is released to pass pressure when cycles of application and removal of pressure are applied to said barrier.

6. The assembly of claim **1**, wherein:

said barrier fails by being dissolved.

7. The assembly of claim **1**, wherein:

said barrier comprises a remotely operated valve.

8. An assembly of borehole tools, comprising

a pressure operated primary tool (10) connected in pressure communication with a pressure operated secondary tool (20); **characterized by**

said secondary tool (20) selectively locked against actuation responsive to pressure therein with a mechanical lock (66,68,70) such that said primary tool (10) can pressure operate by itself until said lock (66,68,70) is defeated.

9. The assembly of claim **8**, wherein:

said lock(66,68) is defeated with axial movement of said secondary tool in the borehole.

10. The assembly of claim **8**, wherein:

said lock comprises at least one detent (68) selectively engaged to an actuating piston (50) for said secondary tool (20) that is axially movable in a housing for said secondary tool.

11. The assembly of claim **10**, wherein:

said actuating piston (50) further comprising at least one recess (68);

said at least one detent (66) extending into said at least one recess.

12. The assembly of claim **11**, wherein:

said at least one detent (66) is biased (74) into said at least one recess.

13. The assembly of claim **12**, wherein:

pressure in said housing provides a force on said at least one detent (66) away from said at least one recess (68).

14. The assembly of claim **13**, wherein:

said at least one detent (66) is only able to move out of said at least one recess (68) when said detent (66) is placed in alignment with a space created by operation of said primary tool.

15. The assembly of claim **14**, wherein:

said pressure on said at least one detent overcoming said bias when said detent (70) is aligned with said space (72) created by operation of said primary tool(10).

16. The assembly of claim **15**, wherein:

said primary and secondary tools comprise mills with pivoting blades (38,46).

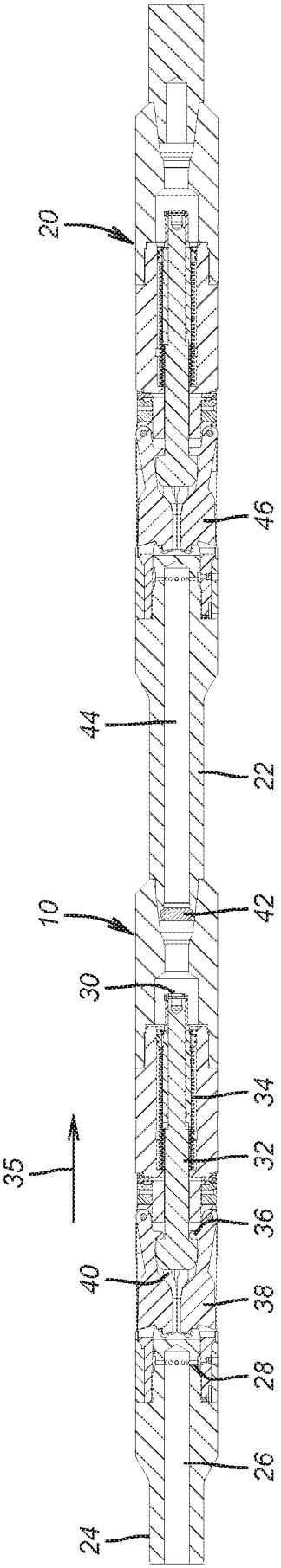

FIG. 1

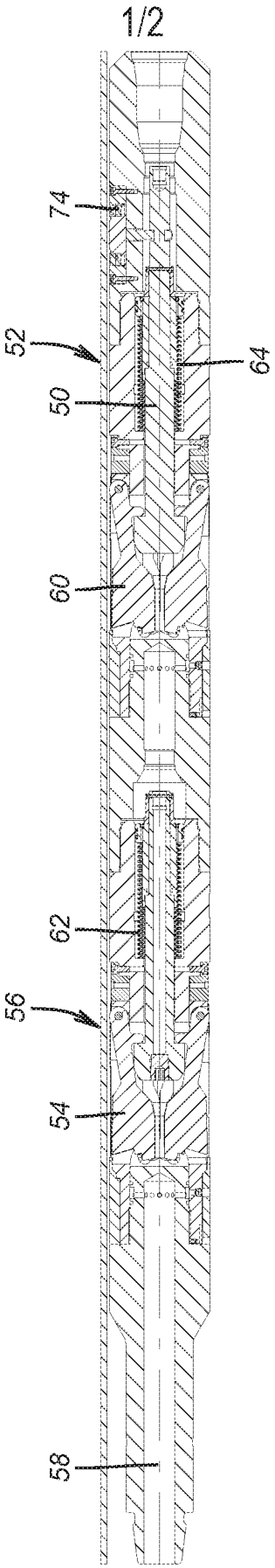

FIG. 2

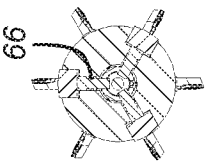

FIG. 6

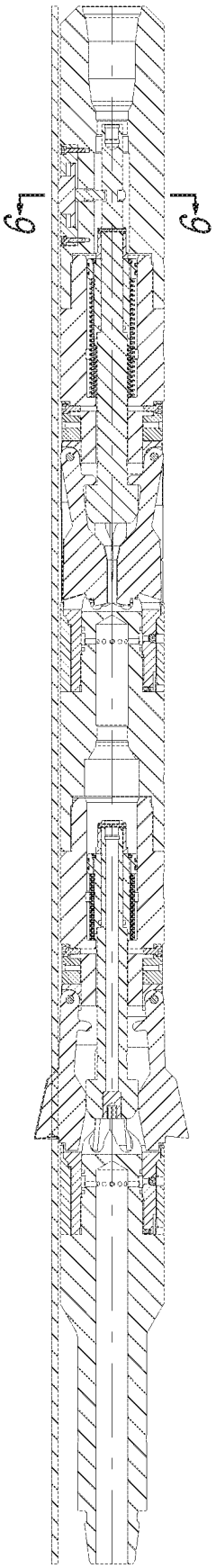

FIG. 3

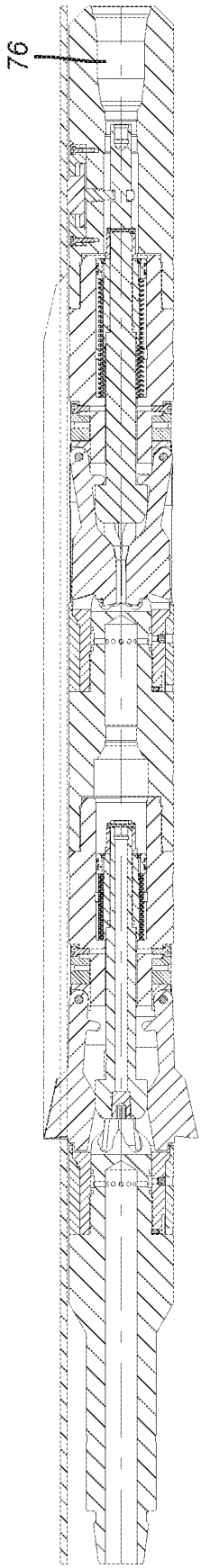

FIG. 4

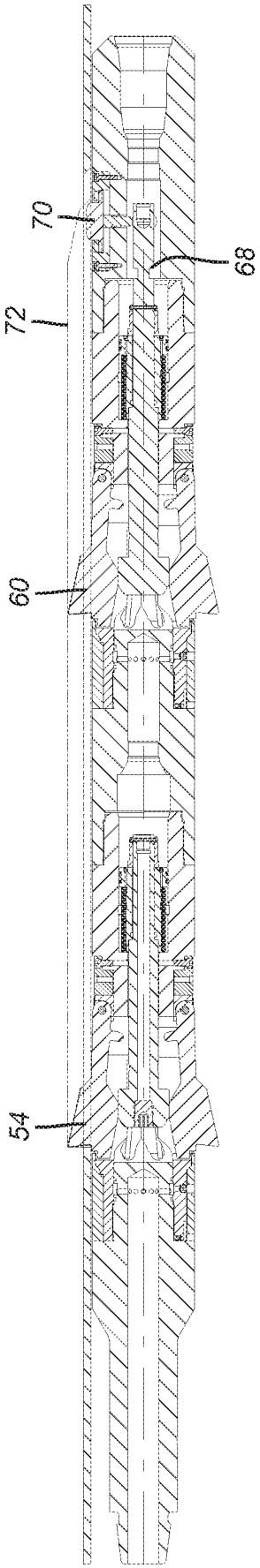

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/031110

A. CLASSIFICATION OF SUBJECT MATTER

E21B 29/00(2006.01)i, E21B 23/04(2006.01)i

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)
E21B 29/00; E21B 4/06; E21B 19/10; E21B 43/112; E21B 33/13; E21B 7/28; E21B 23/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: multi-tool, primary tool, secondary tool, mill, pivoting blades, pressure barrier, lock, piston, detent, groove, alignment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0034317 A1 (SMITH INTERNATIONAL, INC.) 06 February 2014 See paragraphs [0023]-[0026], [0039] and figure 1.	1-13
A		14-16
Y	US 2013-0299160 A1 (LOTT, CHARLES) 14 November 2013 See paragraphs [0033], [0035], [0040], [0042] and figures 1, 3A-3C, 8A, 8B.	1-13
Y	US 2005-0205305 A1 (STOUT et al.) 22 September 2005 See paragraphs [0056], [0072] and figures 6A, 6B, 7B.	9-13
A	WO 2015-073011 A1 (HALLIBURTON ENERGY SERVICES, INC.) 21 May 2015 See paragraphs [0069]-[0072] and figure 10.	1-16
A	US 2015-0354306 A1 (SMITH INTERNATIONAL, INC.) 10 December 2015 See paragraphs [0036]-[0045] and figures 3-5.	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 August 2017 (16.08.2017)	**17 August 2017 (17.08.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2017/031110

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