(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 June 2015 (11.06.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/085148 A1

(51) International Patent Classification:
E21B 34/06 (2006.01) *E21B 43/12* (2006.01)
E21B 21/08 (2006.01)

(21) International Application Number:
PCT/US2014/068747

(22) International Filing Date:
5 December 2014 (05.12.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/912,351 5 December 2013 (05.12.2013) US

(71) Applicant *(for CA only)*: **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 125 -9 Avenue SE, Calgary, Alberta T2G 0P6 (CA).

(71) Applicant *(for FR only)*: **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, F-75007 Paris (FR).

(71) Applicant *(for GB, JP, NL only)*: **SCHLUMBERGER HOLDINGS LIMITED**; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola, 1110 (VG).

(71) Applicant *(for all designated States except AE, AO, BH, CA, CN, FR, GB, GH, IN, JP, LY, MA, MZ, NA, NG, NL, PH, SD, SY, US, VN)*: **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83-89m, NL-2514 JG The Hague (NL).

(71) Applicant *(for AE, AO, BF, BH, BJ, CF, CG, CI, CM, CN, GA, GH, GN, GQ, GW, IN, KM, LY, MA, ML, MR, MZ, NA, NE, NG, PH, SD, SN, SY, TD, TG, VN only)*: **PRAD RESEARCH AND DEVELOPMENT LIMITED**; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola, 1110 (VG).

(71) Applicant *(for US only)*: **SCHLUMBERGER TECHNOLOGY CORPORATION** [US/US]; 300 Schlumberger Drive, Sugar Land, Texas 77478 (US).

(72) Inventors: **DU, Michael Hui**; 2810 Joshua Tree Ln, Manvel, Texas 77578 (US). **LORETZ, Yves D.**; 5527 Benning Drive, Houston, Texas 77096 (US).

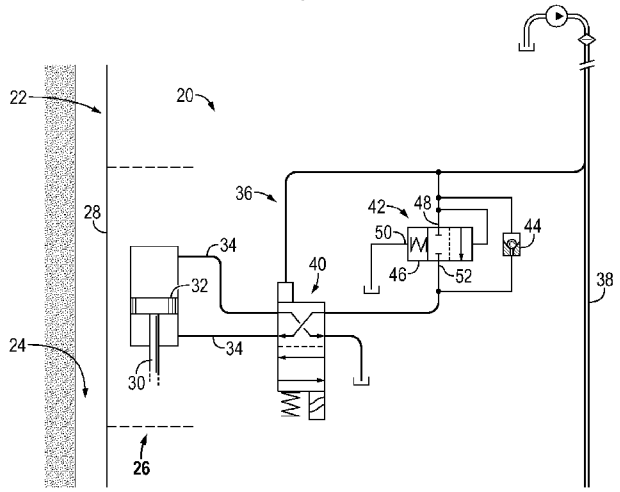
(74) Agents: **GROESBECK, David J.** et al.; 10001 Richmond Avenue, IP Administration Center of Excellence, Room 4720, Houston, Texas 77042 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,

[Continued on next page]

(54) Title: SYSTEM AND METHODOLOGY FOR UTILIZING A FLOW CONTROL VALVE

FIG. 1



(57) Abstract: A technique facilitates controlling fluid flow in a well system or other flow related system. The control of fluid flow may be accomplished by utilizing a flow control valve which is selectively actuated via the controlled application of an actuating fluid. An isolation valve is positioned along the flow of actuating fluid at a location upstream of the flow control valve. The isolation valve establishes a preset pressure which is applied to establish flow of actuating fluid to the flow control valve and also isolates detrimental pressure transients. For example, the isolation valve may be used to reduce or block the propagation of detrimental pressure transients along the actuating fluid to other controlled devices.

WO 2015/085148 A1

KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

PATENT APPLICATION

SYSTEM AND METHODOLOGY FOR UTILIZING A FLOW CONTROL VALVE

DOCKET NO.: IS13.4227-WO-PCT

INVENTORS: Michael Hui Du
Ives Loretz

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present document is based on and claims priority to U.S. Provisional Application Serial No.: 61/912,351, filed December 5, 2013, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Hydrocarbon fluids such as oil and natural gas are obtained from a subterranean geologic formation, referred to as a reservoir, by drilling a well that penetrates the hydrocarbon-bearing formation. Once a wellbore is drilled, various forms of well completions may be deployed downhole and positioned along one or more well zones. Flow control devices, such as flow control valves, may be utilized to control flow along the well completions. Many types of flow control devices are controlled by hydraulic actuating fluid delivered via control lines. However, pressure transients, e.g. pressure fluctuations, in the control line can detrimentally impact other hydraulically actuated devices located along the well completion.

SUMMARY

[0003] In general, a system and methodology are provided for controlling fluid flow, e.g. fluid flow in a well. The control of fluid flow may be accomplished by utilizing a flow control valve which is selectively actuated via the controlled application of an actuating fluid. An isolation valve is positioned along the flow of actuating fluid at a location upstream of the flow control valve. The isolation valve establishes a preset pressure level, and the pressure of the supplied actuating fluid is raised above the preset pressure level to establish flow of actuating fluid to the flow control valve. The isolation valve also isolates detrimental pressure transients. For example, the isolation valve may be used to reduce or block the propagation of detrimental pressure transients along the actuating fluid to other controlled devices.

[0004] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0006] Figure 1 is a schematic illustration of an example of a well system deployed in a borehole, the well system comprising a flow control assembly, according to an embodiment of the disclosure;

[0007] Figure 2 is a schematic illustration of an example of a well system having a plurality of flow control assemblies, according to an embodiment of the disclosure;

[0008] Figure 3 is a schematic illustration of an example of an isolation valve which may be used in the flow control assembly, according to an embodiment of the disclosure;

[0009] Figure 4 is a schematic illustration of another example of an isolation valve which may be used in the flow control assembly, according to an embodiment of the disclosure;

[0010] Figure 5 is a schematic illustration of another example of an isolation valve which may be used in the flow control assembly, according to an embodiment of the disclosure;

[0011] Figure 6 is a schematic illustration of another example of an isolation valve which may be used in the flow control assembly, according to an embodiment of the disclosure; and

[0012] Figure 7 is a schematic illustration of another example of an isolation valve which may be used in the flow control assembly, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0013] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0014] The disclosure herein generally involves a system and methodology which facilitate various well operations or other operations by controlling fluid flow, e.g. controlling a primary fluid flow in a well. The control of fluid flow may be accomplished by utilizing a flow control valve which is selectively actuated via the controlled application of an actuating fluid. The actuating fluid may be the form of a hydraulic liquid delivered to the flow control valve via a control line. In a variety of well applications, a plurality of flow control valves may be located along a wellbore in different well zones. The individual flow control valves are actuated to control the flow of well fluid at the different well zones.

[0015] An isolation valve, e.g. a sequence valve, is used in cooperation with each flow control valve. For example, each isolation valve may be positioned along the flow of actuating fluid at a location upstream of a corresponding indexing device with respect to the supplied actuating fluid. The indexing device works in cooperation with a corresponding flow control valve. The isolation valve may be used to establish a preset pressure level. Pressure in the control line is raised above the preset pressure level to actuate the isolation valve and to thus enable flow of actuating fluid to the flow control valve. The isolation valve also may be used to isolate the actuating fluid within the control line from detrimental pressure transients. For example, the isolation valve may be used to reduce or block the propagation of detrimental pressure transients along the actuating fluid to other controlled devices, e.g. other flow control valves.

[0016] In an embodiment, a flow control assembly comprises a flow control valve and a sequence valve, the sequence valve having a reverse check valve. Flow control assemblies may be positioned along a well string for multi-zone flow control applications in which hydraulic fluid supplied by a hydraulic pump is used to actuate individual flow control valves in corresponding well zones. In this example, each flow control assembly comprises a flow control valve, an indexing device, e.g. a mini-indexer, and an isolation valve, e.g. a sequence valve, with a reverse check valve. Each sequence valve is installed upstream of the indexing device to isolate pressure transients introduced during actuation

of a flow control valve, e.g. shifting of a flow control valve piston. Upstream refers to upstream along the supplied actuating fluid controlled by the isolation valve and used to selectively actuate the flow control valve.

[0017] Without the isolation/sequence valve, the onset of movement in a flow control valve during actuation of the flow control valve can effectively drawdown fluid and pressure in the control line. This drawdown can lead to undesired pressure fluctuations in other zones connected to the same control line. In some embodiments, the isolation valve may comprise a sequence valve having an inlet port, a reference pressure port, and an outlet port. The outlet port is placed in fluid communication with the inlet port when the inlet pressure exceeds a preset pressure level value relative to the reference pressure level.

[0018] In some applications, the mini-indexer or other suitable indexing device in each flow control assembly is used as a hydraulic switch which switches, for example, upon experiencing a pressure level or upon counting a predetermined number of pressure signals/pulses provided from the surface via the control line. In a multi-zone application, the indexing devices often do not make the switches at the same time due to differences between the indexing devices and differences in the well conditions at the various well zones. When one of the indexing devices switches, the hydraulic actuating fluid is suddenly exposed to a low-pressure region due to the shifting piston in the corresponding flow control valve. Without the isolation valve, this low-pressure region causes a corresponding pressure drop in the hydraulic system, including a pressure drop in the control line.

[0019] If the control line is exposed to the pressure drop and the pressure drop exceeds a certain value, other indexing devices could interpret the pressure drop as part of a surface control signal and count the actuation cycle incorrectly. Then, when the pressure in the control line recovers upon completing actuation of the corresponding flow control valve, the increase in pressure could be counted as the next actuation signal by other indexing devices. As a result, the actuation of a given flow control valve could

initiate false indexing cycles counted by the other indexing devices coupled along the control line. In embodiments described herein, the isolation valve is constructed and located to block these false pressure cycles and other detrimental pressure transients from propagating along the control line to other pressure actuated devices, e.g. other indexing devices and flow control valves. Consequently, the specific flow control assemblies are actuated in a more consistent and dependable manner based on proper counting of pressure signals imposed by a surface pump and/or other pressure signal control system.

[0020] Referring generally to Figure 1, a well system 20 is illustrated as comprising a well string 22 deployed in a borehole 24, e.g. a wellbore. The well string 22 comprises a flow control assembly 26 and in some applications comprises a plurality of flow control assemblies 26 located at different well zones along borehole 24. In this example, the flow control assembly 26 comprises a flow control valve 28 which may be shifted to allow or block a primary flow of fluid, e.g. production fluid, along the well string 22. The flow control valve 28 is actuated between different flow positions via an actuator 30 which may comprise a piston 32 moved between different actuation positions via pressurized hydraulic fluid supplied via fluid lines 34 of a hydraulic circuit 36. The hydraulic circuit 36 is part of a control line 38 which provides pressurized hydraulic actuating fluid from a surface pump or other suitable device. The illustrated flow control assembly 26 also comprises an indexing device 40, e.g. a mini-indexer, and an isolation valve 42, e.g. a sequence valve. The flow control valve 28, indexing device 40, and isolation valve 42 are connected by hydraulic circuit 36 as illustrated.

[0021] In the embodiment illustrated, the isolation valve 42 comprises a reverse check valve 44 positioned to eliminate or reduce the false pressure pulses described above. Although isolation valve 42 may comprise a variety of valve configurations, the illustrated example utilizes isolation valve 42 in the form of a sequence valve 46. The isolation valve 42 comprises an inlet port 48, a reference pressure port 50, and an outlet port 52.

[0022] When the flow control valve 28 is to be shifted to a different operational position, the indexing device 40 is switched to a flow position via a pressure signal, e.g. a predetermined pressure level or number of pressure pulses, supplied via control line 38. For example, a surface pump may be used to provide the appropriate pressure signal. According to an example, when the pressure level supplied by control line 38 reaches a "switch pressure" of the indexing device 40, the indexing device 40 actuates and switches to a flow direction which allows actuating fluid to flow to flow control valve 28 and to actuate the flow control valve 28 via actuator 30. However, the isolation valve 42 is installed in hydraulic circuit 38 to establish a preset actuation pressure level, e.g. a preset actuation pressure which may be referred to as a preset sequence pressure. To enable the flow of pressurized actuating fluid to reach the indexing device 40, the preset sequence pressure of isolation valve 42 is first exceeded by increasing the pressure of actuating fluid supplied via control line 38. Exceeding the preset sequence pressure actuates the isolation valve 42 to an open flow position and thus allows the actuating fluid/pressure to reach the indexing device 40 and to flow through the indexing device 40.

[0023] In the example illustrated, the preset sequence pressure is established by a pressure differential between inlet port 48 and reference pressure port 50 of isolation valve 42. When the pressure at inlet port 48 relative to the reference pressure at reference pressure port 50 exceeds the preset sequence pressure, the isolation valve 42 is actuated. Once actuated, hydraulic fluid can pass through the isolation valve 42, through outlet port 52, through indexing device 30, and to flow control valve 28 so as to actuate the flow control valve 28.

[0024] During the process of actuating flow control valve 28, if the pressure upstream of the isolation valve 42 falls below the preset sequence pressure, the isolation valve 42 shifts to a closed position. Once the isolation valve 42 is closed, the pressure does not drop further in the control line 38, thus avoiding false pressure pulses. If the surface pump or other device providing pressurized actuating fluid along control line 38 continues to operate, the pressure upstream of the isolation valve 42 again rises to actuate the isolation valve 42, thus allowing pressurized actuation fluid to flow through indexing

device 40 for actuation of the corresponding flow control valve 28 to a new actuation position. The reference pressure at reference pressure port 50 can be well pressure, a pressure related to well pressure, or another pressure established by a designated source.

[0025] Once the supply pressure of the actuating fluid supplied along control line 38 is removed, the higher pressure fluid downstream of the isolation valve 42 is released back to inlet port 48 through the reverse check valve 44. Consequently, the actuation of isolation valve 42 working in cooperation with reverse check valve 44 ensures that the unwanted pressure drops and other pressure transients do not propagate along the actuating fluid within control line 38. The reverse check valve 44, however, also enables controlled release of the downstream pressure so that the flow control assembly 26 may again be prepared for a subsequent actuation.

[0026] Referring generally to Figure 2, another embodiment is illustrated with a plurality of flow control assemblies 26 deployed along well string 22. Individual flow control assemblies 26 may be located along well string 22 at positions associated with corresponding well zones 54. As with the previous embodiment, various types of flow control valves 28, indexer devices 40, and isolation valves 42 may be employed in the individual flow control assemblies 26. For example, the isolation valves 42 may comprise a variety of sequence valves 46 or other types of valves which incorporate reverse check valves 44. In each of these embodiments, the isolation valve 42/reverse check valve 44 establish a preset pressure actuation level for providing actuating fluid to the corresponding flow control valve 28; block unwanted pressure drops and other pressure transients from acting on the actuating fluid within the control line 38; and enable controlled release of the high-pressure fluid located downstream of the isolation valve 42 once the pressure in control line 38 is sufficiently reduced.

[0027] When sequence valves 46 are employed in flow control assemblies 26, the cracking pressures of each sequence valve 46 in a given installation may be adjusted according to specific parameters. For example, the sequence valves 46 may be set collectively to actuate at roughly the same pressure. In other embodiments, however, the

preset actuation pressure may be selected individually for each sequence valve 46 so as to enable a specific order of actuation with respect to the flow control assemblies 26 positioned along corresponding well zones 54. This latter embodiment can be helpful when bringing production or injection formations online in a prescribed fashion. Use of the specific order of actuation avoids undesirable pressure spikes in the well that could otherwise adversely affect the reservoir or equipment in the well string 22.

[0028] Referring generally to Figure 3, an example of isolation valve 42 is illustrated. In this example, the isolation valve 42 is in the form of sequence valve 46 having reverse check valve 44. As illustrated, the sequence valve 46 comprises a manifold 56 having an internal cavity 58 in which a sequence piston 60 is slidably received. The piston 60 is acted on by a bias spring 62 oriented to bias piston 60 in a given direction as illustrated. The manifold 56 further comprises inlet port 48, reference pressure port 50 (sometimes referred to as a drain port), and outlet port 52. In this example, the reverse check valve 44 is connected between inlet port 48 and outlet port 52.

[0029] When the inlet pressure at inlet port 48 is increased enough to overcome the force exerted by bias spring 62 and the pressure acting on reference pressure port 50, the sequence piston 60 is shifted (upwardly in the illustrated example). In other words, the pressure at inlet port 48 relative to reference pressure port 50 is increased above the preset actuation pressure for actuating sequence valve 46 and thus actuating flow control valve 28. Specifically, the shifting of piston 60 to an open flow position fluidly couples the inlet port 48 with the outlet port 52. This open flow position allows the pressurized actuating fluid to pass to flow control valve actuator 30 and to shift the flow control valve 28 to another operational position, provided the indexing device 40 has been indexed to an appropriate flow-through position.

[0030] If the pressure at the inlet port 48 drops a sufficient amount, the bias spring 62 moves piston 60 back to the position illustrated in Figure 3 in which the outlet port 52 is disconnected from the inlet port 48. The piston 60 continues to block flow

between inlet port 48 and outlet port 52 until the pressure at inlet port 48 is once again increased above the preset actuation level established by bias spring 62 and the pressure acting at reference pressure port 50. For example, flow of actuating fluid through the sequence valve 46 may be blocked until a subsequent actuation of the flow control valve 28 is desired.

[0031] In some applications, the pressure drop at inlet port 48 may be caused by removing the supply pressure of the actuating fluid supplied along control line 38. At this stage, the higher pressure fluid located downstream of the sequence valve 46 is released back to inlet port 48 through the reverse check valve 44. Consequently, the reverse check valve 44 ensures controlled release of the higher pressure fluid downstream of the sequence valve 46 while protecting the upstream actuating fluid and control line 38 from unwanted pressure drops and other pressure transients.

[0032] According to some embodiments, the sequence valve 46 (or other type of isolation valve 42) comprises an adjustment mechanism 64 which may be used to adjust the force of spring 62 acting on piston 60. By adjusting the force of spring 62 acting on piston 60, the preset actuation pressure can be changed, e.g. lowered or raised, according to the parameters of a given application. The adjustment mechanism 64 also enables setting of different preset actuation pressures at different flow control assemblies 26 to facilitate the ordered actuation of flow control valves 28 at different well zones 54. In the illustrated example, the adjustment mechanism 64 comprises an adjustment screw 66 which may be threaded inwardly or outwardly to adjust the compression of spring 62 and thus the force exerted by spring 62 on piston 60.

[0033] In various well applications, the reference pressure port 50 may be in fluid communication with a well fluid. A protection mechanism 68 may be coupled with the reference pressure port 50 to protect the reference pressure port 50 from the well fluid, e.g. from pressure transients in the well fluid. As illustrated in Figure 4, the protection mechanism 68 may comprise a drain port check valve 70. In other applications, the

protection mechanism 68 may comprise a relief valve 72 coupled with the reference pressure port 50, as illustrated in Figure 5.

[0034] Depending on the application, the protection mechanism 68 also may comprise a compensated relief valve 74 coupled with the reference pressure port 50, as illustrated in Figure 6. By way of example, the compensated relief valve 74 may comprise a relief valve piston 76 which floats between the well fluid side and the sequence valve side while being biased by a relief valve spring 78. The relief valve spring 78 may be oriented to bias the relief valve piston 76 toward the sequence valve side. As illustrated in Figure 7, however, some applications may utilize a simpler protection mechanism 68 such as an extended piece of tubing 80.

[0035] The flow control assembly or assemblies 26 may be used in a variety of well and non-well related applications. In various well applications, the flow control assemblies 26 may be used in cooperation with a pressure-pulse counting controller for selectively actuating flow control valves 28 at multiple well zones before. In many applications, the flow control assemblies 26 described herein provide a more predictable and reliable system which utilizes the dynamic pressure control provided by the sequence valves 46. The embodiments described herein also reduce flow control valve operation/shifting time especially for operations which use flow control valves 28 having relatively large stroke volumes.

[0036] Controlling the pressure transients also lowers risk of damage to choke seals during shifting of the flow control valves 28. Use of the reverse check valve 44 also prevents trapped pressures within the flow control valve assemblies. Reducing trapped pressures and undesirable pressure transients is beneficial in improving the reliability of many types of well systems, including intelligent, multi-zone flow control systems.

[0037] The overall well system 20 may have a variety of components and configurations. For example, the well system 20 may comprise numerous types of completions for use in a variety of well environments. Additionally, various numbers of

flow control assemblies 26 may be used to control the flow of fluid with respect to a plurality of corresponding well zones 54. In production applications, the flow control assemblies may be used in combination with many other production completion components to control the flow of production fluid from the corresponding well zones 54.

[0038] Similarly, the individual flow control assemblies 26 may comprise various other and/or additional components. For example, various types of actuator pistons or other actuators may be used in the flow control valves 28, indexing devices 40, and/or isolation valves 42. Many applications utilize the indexing devices 40, but some applications may omit the indexing devices or use other types of controllable devices in cooperation with the corresponding flow control valve 28 and isolation valve 42 in each flow control assembly 26. Additionally, the materials used in constructing the flow control assemblies 26 as well as the size and configuration of the individual flow control assemblies 26 may vary according to the parameters of a given application.

[0039] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

1. A system for controlling flow in a well, comprising:

a well string located in a wellbore, the well string having:

a flow control valve positioned to control a fluid flow along the wellbore, the flow control valve being actuated by an actuating fluid supplied via a control line;

an indexing device controlling flow of the actuating fluid to the flow control valve; and

a sequence valve in fluid communication with the indexing device and the control line, the sequence valve being installed upstream of the indexing device in a manner which isolates pressure transients introduced into the control line during actuation of the flow control valve.

2. The system as recited in claim 1, wherein the sequence valve comprises a reverse check valve oriented to block unwanted pressure drops in the control line when the flow control valve is actuated, the reverse check valve further allowing controlled release of downstream pressure.

3. The system as recited in claim 2, wherein the sequence valve comprises an inlet port, a reference pressure port, and an outlet port.

4. The system as recited in claim 3, wherein the sequence valve comprises a piston slidably mounted in a manifold and biased toward a predetermined position by a spring, the manifold having the inlet port, the reference pressure port, and the outlet port.

5. The system as recited in claim 4, wherein the inlet port and the outlet port are selectively placed in fluid communication by shifting the piston via pressure in the control line.

6. The system as recited in claim 3, wherein the sequence valve comprises an adjustment mechanism enabling adjustment of a preset sequence pressure at which the sequence valve is actuated.

7. The system as recited in claim 3, further comprising a check valve positioned to protect the reference pressure port.

8. The system as recited in claim 3, further comprising a relief valve positioned to protect the reference pressure port.

9. The system as recited in claim 3, further comprising a compensated relief valve positioned to protect the reference pressure port.

10. The system as recited in claim 3, further comprising a tubing section positioned to protect the reference pressure port.

11. The system as recited in claim 1, wherein the well string extends through a plurality of well zones, each well zone having at least one of the flow control valve, the indexing device, and the sequence valve.

12. A method for controlling flow in a well, comprising:

positioning a flow control valve to control a flow of primary fluid;

controlling a flow of actuating fluid to the flow control valve with an indexing device;

locating an isolation valve upstream of the indexing device; and

using the isolation valve to establish a preset actuation pressure at which the actuating fluid flows to the indexing device while also isolating detrimental pressure transients introduced into the actuating fluid during actuation of the flow control valve.

13. The method as recited in claim 12, wherein using comprises using a reverse check valve to isolate the detrimental pressure transients and also to provide controlled release of downstream pressure.

14. The method as recited in claim 13, wherein locating comprises locating a sequence valve.

15. The method as recited in claim 14, further comprising providing the sequence valve with an inlet port, a reference pressure port, and an output port formed in a manifold.

16. The method as recited in claim 15, further comprising using a piston within the manifold to control fluid communication between the inlet port, the reference pressure port, and the outlet port.

17. The method as recited in claim 16, further comprising using an additional valve in combination with the reference pressure port.

18. A system, comprising:

a well string deployed in a wellbore located along a plurality of well zones, the well string comprising:

a plurality of flow control assemblies, each flow control assembly having:

a flow control valve actuated by an actuating fluid; and

an isolation valve located upstream of the flow control valve with respect to flow of the actuating fluid, the isolation valve establishing a preset actuation pressure at which the actuating fluid flows to the flow control valve while also isolating detrimental pressure transients introduced into the actuating fluid during actuation of the flow control valve.

19. The system as recited in claim 18, wherein the isolation valve comprises a reverse check valve oriented to block unwanted pressure drops in the actuating fluid when the flow control valve is actuated.

20. The system as recited in claim 19, wherein the isolation valve is in the form of a sequence valve having a piston slidably mounted in a manifold and selectively movable to control fluid communication between an inlet port and an outlet port.

FIG. 1

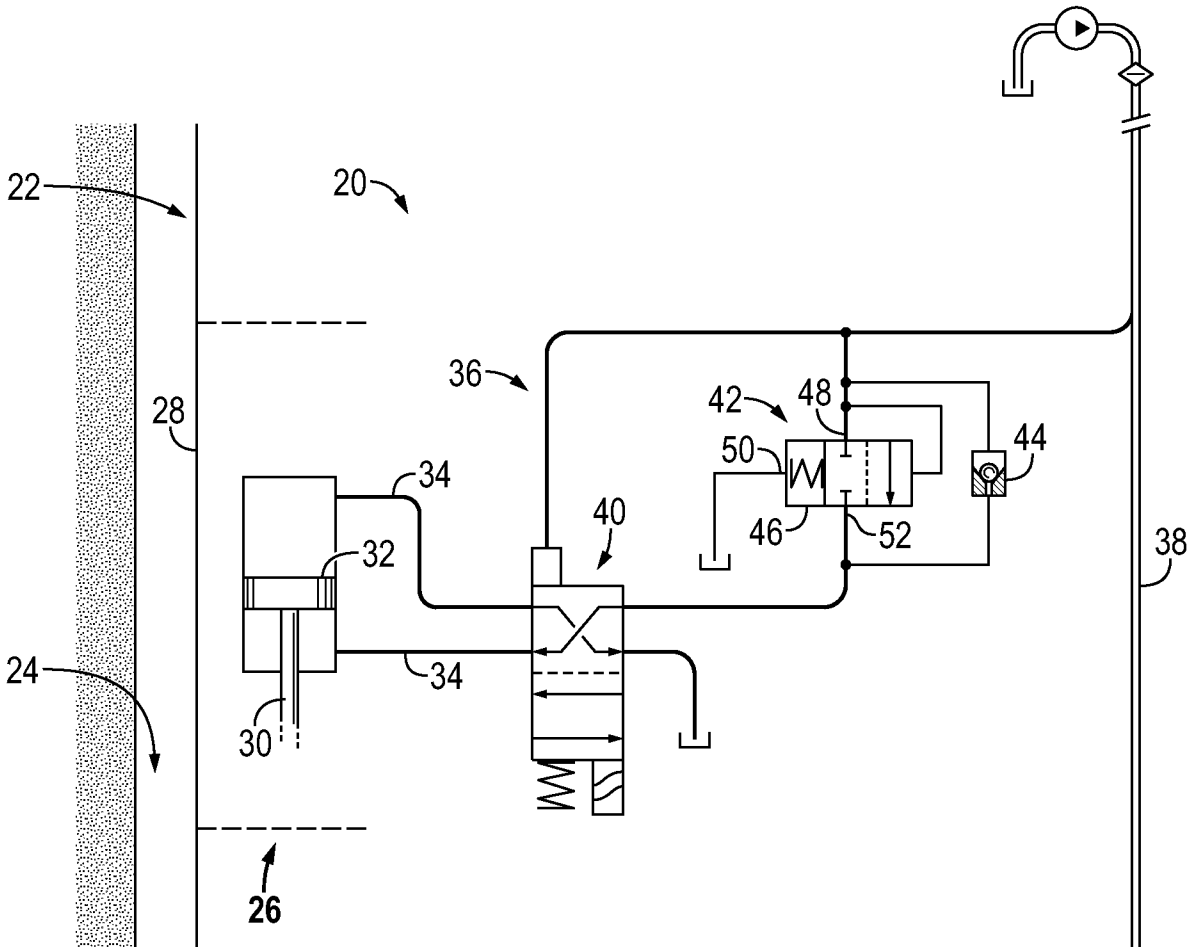


FIG. 2

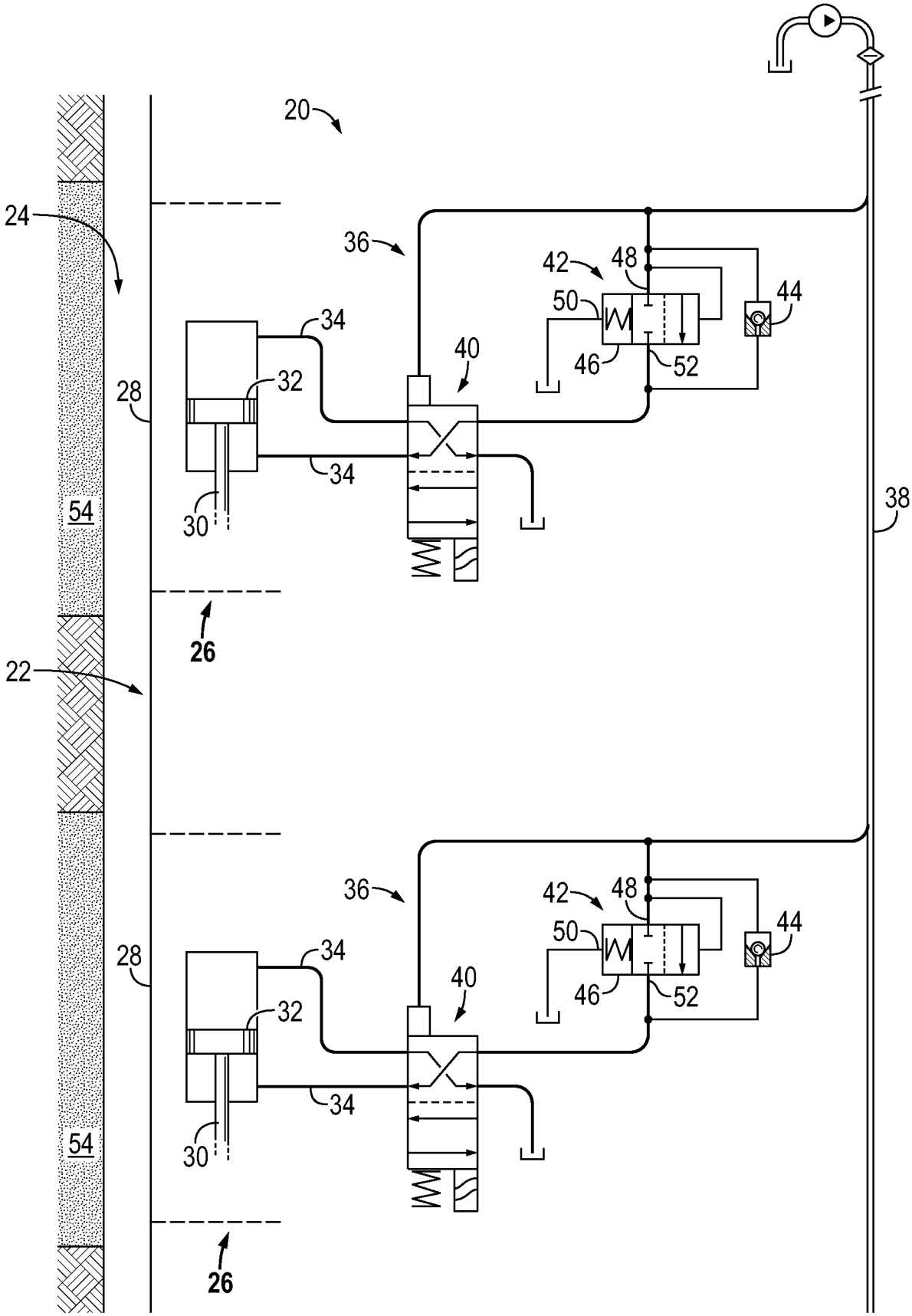

20
24
36
42
48
44
50
34
40
28
32
46
52
34
38
30
54
26
22
36
42
48
44
50
28
34
40
32
46
52
34
30
54
26

FIG. 5

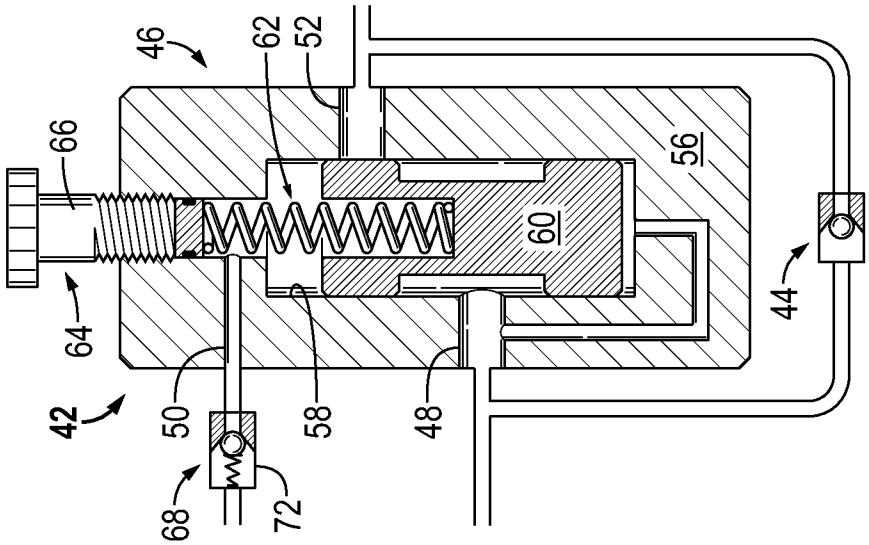


FIG. 4

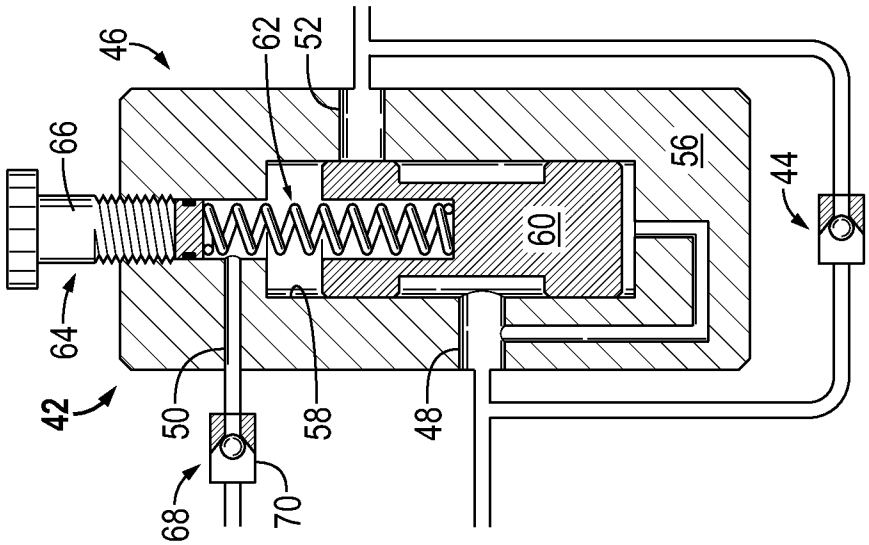


FIG. 3

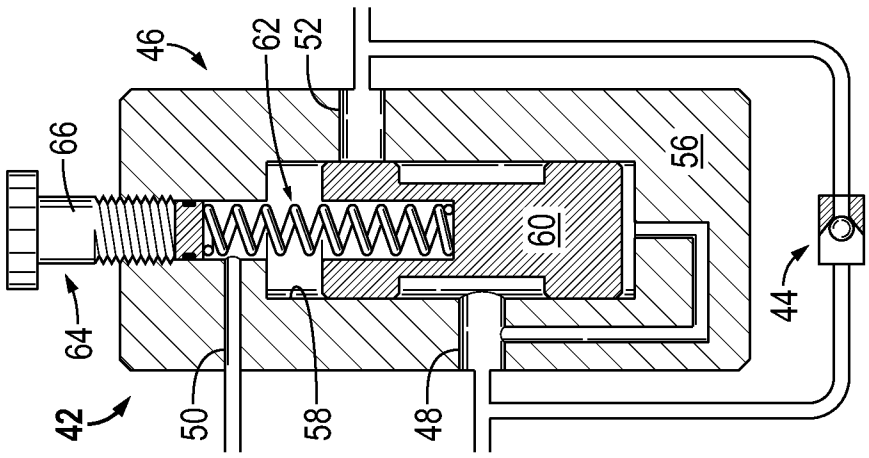


FIG. 7

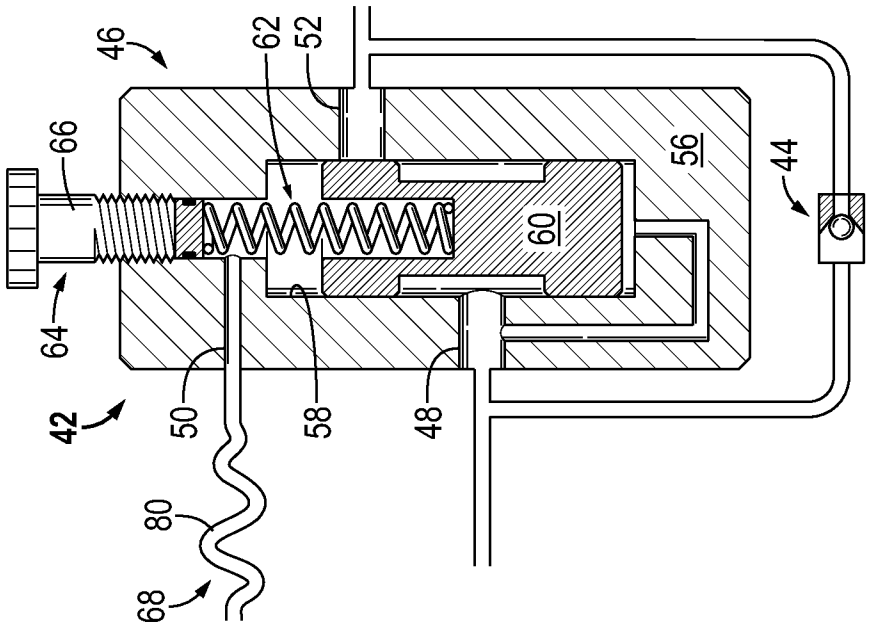
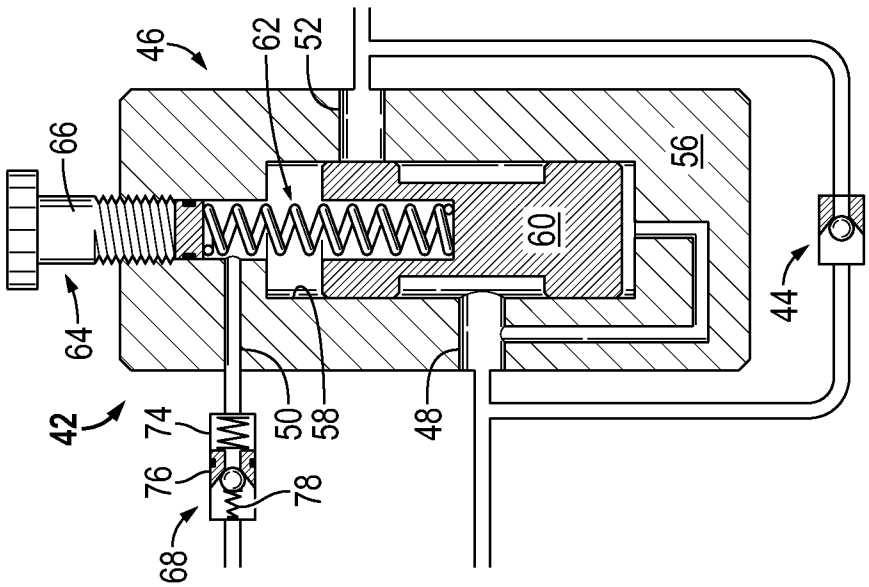

46
62
52
66
56
44
60
64
42
50
58
48
80
68

FIG. 6


46
62
52
66
56
60
44
64
42
74
50
58
48
76
78
68

WO 2015/085148

PATENT COOPERATION TREATY

PCT

PCT/US2014/068747

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference IS134227WO	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2014/068747**	International filing date *(day/month/year)* **06 December 2014 (06.12.2014)**	(Earliest) Priority Date *(day/month/year)* 05 December 2013 (05.12.2013)

Applicant

SCHLUMBERGER CANADA LIMITED et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **3** sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of :
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **1**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/068747

A. CLASSIFICATION OF SUBJECT MATTER

E21B 34/06(2006.01)i, E21B 21/08(2006.01)i, E21B 43/12(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 34/06; E21B 23/00; E21B 34/10; F16K 31/124; E21B 21/08; E21B 43/12

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: indexer, flow control valve, isolation valve, pressure, reverse check valve, piston and control line

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009-0065218 A1 (LORETZ et al.) 12 March 2009 See paragraphs [0017]-[0025] and figures 1A,2-3A.	1,11-12,18
A		2-10,13-17,19-20
A	US 2007-0163774 A1 (HOSATTE et al.) 19 July 2007 See paragraphs [0021]-[0048] and figures 1-12.	1-20
A	US 2013-0240212 A1 (BASMAJIAN et al.) 19 September 2013 See paragraphs [0019]-[0049] and figures 1-5.	1-20
A	EP 0923690 B1 (WELLDYNAMICS INC.) 26 October 2005 See claim 1.	1-20
A	US 8186444 B2 (PATEL, DINESH R.) 29 May 2012 See column 2, line 57-column 8, line 56 and figures 1-10.	1-20

☐ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
03 April 2015 (03.04.2015)	**03 April 2015 (03.04.2015)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. ++82 42 472 7140

Authorized officer
PARK, Tae Wook
Telephone No. +82-42-481-3405

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/068747

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0065218 A1	12/03/2009	GB 201004517 D0	05/05/2010
		GB 2464907 A	05/05/2010
		GB 2464907 B	07/03/2012
		MX 2010002421 A	30/03/2010
		NO 20100404A	31/05/2010
		US 7748461 B2	06/07/2010
		WO 2009-033042 A1	12/03/2009
US 2007-0163774 A1	19/07/2007	CA 2570250 A1	13/07/2007
		CA 2570250 C	03/06/2014
		GB 0624399 D0	17/01/2007
		GB 0902611 D0	01/04/2009
		GB 2434166 A	18/07/2007
		GB 2434166 B	06/05/2009
		GB 2455218 A	03/06/2009
		MX 2007000045 A	14/11/2008
		MY 141413 A	30/04/2010
		NO 20070135 A	16/07/2007
		US 7464761 B2	16/12/2008
US 2013-0240212 A1	19/09/2013	GB 201014553 D0	13/10/2010
		GB 2470676 A	01/12/2010
		GB 2470676 B	05/09/2012
		NO 20101210 A	14/10/2010
		US 2009-242199 A1	01/10/2009
		US 2012-018170 A1	26/01/2012
		US 8056643 B2	15/11/2011
		US 8776890 B2	15/07/2014
		WO 2009-120519 A1	01/10/2009
EP 0923690 B1	26/10/2005	AU 6672198 A	22/09/1998
		DE 69832027 D1	01/12/2005
		EP 0923690 A2	23/06/1999
		EP 0923690 A2	28/04/2004
		EP 0923690 A4	16/01/2002
		WO 98-39547 A2	11/09/1998
		WO 98-39547 A3	17/12/1998
US 8186444 B2	29/05/2012	BR PI0903393 A2	29/06/2010
		RU 2009131113 A	20/02/2011
		RU 2519241 C2	10/06/2014
		US 2010-038093 A1	18/02/2010