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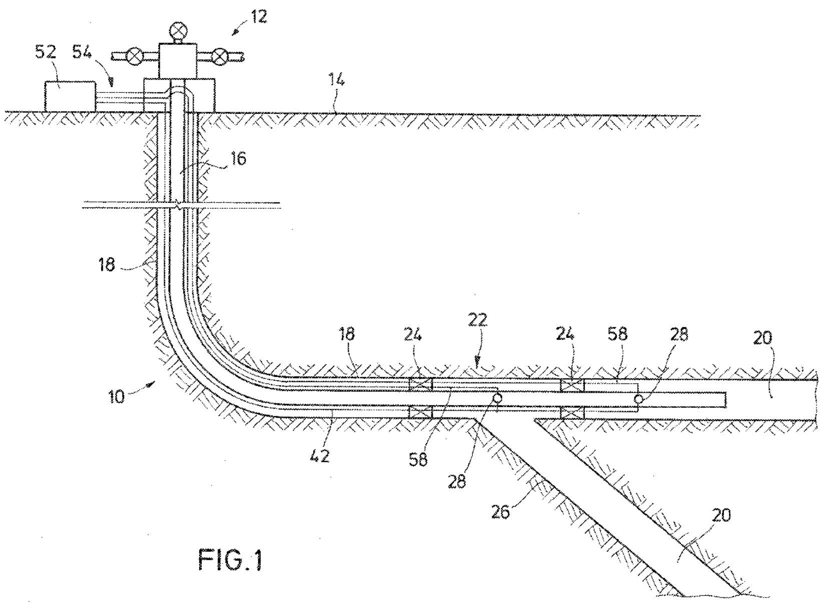

FIG.1

(57) Abstract: A system and method for automatically preventing cross flow in a subterranean well during a shutdown event includes a plurality of downhole control valves located within the subterranean well. An energy storage device releases a stored energy during a shutdown event. A primary fail device is a normally close, fail open device that moves to a primary open position during a shutdown event, providing a portion of the stored energy to each of the plurality of downhole control valves during a shutdown event. The portion of the stored energy delivered to each of the plurality of downhole control valves is sufficient to move each of the plurality of downhole control valves to a valve closed position.

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PCT PATENT APPLICATION

DOWNHOLE CROSS FLOW PREVENTION DURING WELL AND POWER SHUTDOWN

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BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

[0001] The present disclosure relates in general to the control of subterranean wells, and more particularly to automatically preventing downhole cross-flow of fluids in subterranean multizone intelligent completion wells.

2. Description of the Related Art

[0002] The production of oil and gas in multilateral or multizone wells typically requires the use of various valves and other downhole equipment commonly known as intelligent completions. For example, an inflow control valve (ICV) assembly can be inserted into the well bore, and can include an inflow valve 28 that regulates the flow of fluid through the bore. The communication of commands from an operator at the surface to such valves and other downhole equipment is important to production control of the well.

[0003] In some current multizone intelligent wells with inflow from multiple zones, only the surface valves and subsurface safety valves are closed during well shut down. The downhole valves remain open and will have cross flow between zones during the period of shutdown. The downhole control valves do not have a mechanism to automatically close and some current auto-close features available for such valves are subject to potential failures. In addition, adding automatic features downhole can be difficult to install, service, and replace.

[0004] During well shutdown, with some currently available systems, because the downhole valves will remain open, there will be cross flow from higher pressure zone to lower pressure zone through the downhole valve. This crossflow could affect reserves management and ultimately reduce overall recovery from the well.

SUMMARY OF THE DISCLOSURE

[0005] Embodiments of this disclosure provide systems and methods for automatically shutting down selected downhole control valves with elements that are located at the surface. Features of this disclosure can be added to the surface system, can be compatible with currently available intelligent completions, can be used with hydraulic or electric operated valves The system is operated during power failure or well shut in. Closing downhole valves will prevent downhole cross flow during shut in period. In certain embodiments of this disclosure, one or more of the downhole control valves can remain in an open position and remaining downhole valves closed to allow the well to be produced through the open valves at re-start of production so that no excess start-up operation is required at time of well start up. Once the well is stable, the closed downhole control valves can be opened in a traditional known manner, such as through supervisory control and data acquisition (SCADA).

[0006] In an embodiment of this disclosure, a system for automatically preventing cross flow in a subterranean well during a shutdown event includes a plurality of downhole control valves located within the subterranean well. The system also includes an energy storage device, the energy storage device releasing a stored energy during a shutdown event. The system further includes a primary fail device, the primary fail device being a normally close, fail open device that moves to a primary open position during a shutdown event, providing a portion of the stored energy to each of the plurality of downhole control valves during a shutdown event. The portion of the stored energy delivered to each of the plurality of downhole control valves is sufficient to move each of the plurality of downhole control valves to a valve closed position.

[0007] In alternate embodiments, the system includes a secondary fail device. The secondary fail device can be a normally open, fail close device that moves to a secondary closed position during a shutdown event. The secondary fail device can be associated with a one or more of the downhole control valves and prevent such downhole control valves from moving to a valve closed position when the portion of the stored energy is provided to each of the plurality of downhole control valves and each of the other of the plurality of downhole control valves is moved to a valve closed position.

[0008] In certain alternate embodiments, the energy storage device can be an accumulator and the plurality of downhole control valves are hydraulic valves. Each downhole control valve can be a hydraulically operated valve and the secondary fail device can be a valve that is positioned to prevent a pressure media from traveling from the one of the downhole control valves when the secondary fail device is in a secondary closed position. In alternate embodiments, the energy storage device can be an electric storage device and the plurality of downhole control valves are electrically activated devices.

[0009] In other alternate embodiments, the energy storage device, primary fail device, and secondary fail device can be located at an earth's surface outside of the subterranean well. Each downhole control valve can be associated with a separate zone of the subterranean well and in the valve closed position, each downhole control valve restricts the flow of fluids into and out of the separate zone associated with such downhole control valve.

[0010] In other embodiments of the current disclosure, a system for automatically preventing cross flow in a subterranean well during a shutdown event includes a plurality of downhole control valves located within the subterranean well. An accumulator is associated with each of the plurality of downhole control valves, the accumulator storing a pressure media. The system also includes a primary fail device, the primary fail device being a valve that moves to a primary open position during a shutdown event, releasing a portion of the pressure media to the close side of each of the plurality of downhole control valves during a shutdown event. The system further includes a secondary fail device, the secondary fail device being a valve that moves to a secondary closed position during a shutdown event. The secondary fail device is associated with one of the downhole control valves and prevents such one of the downhole control valves from moving to a valve closed position when the portion of the pressure media is provided to each of the plurality of downhole control valves and each of the other of the plurality of downhole control valves is moved to a valve closed position.

[0011] In alternate embodiments, the accumulator, primary fail device, and secondary fail device can be located at an earth's surface outside of the subterranean well. Each downhole control valve can be associated with a separate zone of the subterranean well and in the valve closed position, each downhole control valve can restrict the flow of well fluids into and out of the separate zone associated with such downhole control valve. A control fluid return line can be associated with an open side of each of the plurality of downhole control valves and provide a fluid flow path for a trapped pressure control fluid media to exit the open side of the downhole control valve as the downhole control valve moves to a valve closed position.

The secondary fail device can be positioned in the surface panel between the open side of the one of the downhole control valves and the fluid return vent line so that in the secondary closed position, the secondary fail device prevents the trapped control fluid pressure media from exiting the open side of the one of the downhole control valves.

[0012] In yet other embodiments of the current disclosure, a method for automatically preventing cross flow in a subterranean well during a shutdown event includes locating a plurality of downhole control valves located within the subterranean well. During a shutdown event, a portion of a stored energy is provided to each of the plurality of downhole control valves. The portion of the stored energy is sufficient to move each of the plurality of downhole control valves to a valve closed position. The stored energy is released from an energy storage device with a primary fail device, the primary fail device being a normally close, fail open device that moves to a primary open position during a shutdown event.

[0013] In alternate embodiments the method also includes preventing one of the plurality of downhole control valves from moving to a valve closed position during a shutdown event with a secondary fail device. The secondary fail device can be a normally open, fail close device associated with a one or more of the downhole control valves that moves to a secondary closed position during a shutdown event, so that the one or more of the downhole control valves remains in a valve open position and each of the other of the plurality of downhole control valves is moved to a valve closed position.

[0014] In certain alternate embodiments, the energy storage device can be an electric storage device and the plurality of downhole control valves can be electrically activated devices. In such an embodiment, the step of releasing a stored energy from an energy storage device includes releasing a portion of stored electric energy to each of the plurality of downhole control valves during a shutdown event. In other alternate embodiments, the energy storage device is an accumulator and the primary fail device and the secondary fail device are hydraulic valves. In such embodiments, the step of releasing a stored energy from an energy storage device includes releasing a portion of a pressure media to a close side of each of the plurality of downhole control valves during a shutdown event.

[0015] In yet other alternate embodiments, the method includes providing a fluid flow path for a trapped pressure media to exit an open side of the downhole control valve as the downhole control valve moves to a valve closed position, with a fluid return line associated with the open side of each of the plurality of downhole control valves. The secondary fail device can be positioned between the open side of the downhole control valves and the fluid return line, preventing the trapped pressure media from exiting the open side of the downhole control valves with the secondary fail device when the secondary fail device is in the secondary closed position. The energy storage device, primary fail device, and secondary fail device can be located at earth's surface outside of the subterranean well. Each downhole control valve can be associated with a separate zone of the subterranean well so that in the valve closed position, each downhole control valve restricts the flow of fluids into and out of the separate zone associated with such downhole control valve.

[0016] In still other alternate embodiments, fluid from the subterranean well can be produced through the one or more of the downhole control valves during normal production. After a shutdown event, the primary fail device can be moved to a primary closed position, and the secondary fail device can be moved to a secondary open position. At least one of the other of the plurality of downhole control valves can be moved to the valve open position to restart production from desired zones and the energy storage device can be recharged.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] So that the manner in which the above-recited features, aspects and advantages of the invention, as well as others that will become apparent, are attained and can be understood in detail, a more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof that are illustrated in the drawings that form a part of this specification. It is to be noted, however, that the appended drawings illustrate only preferred embodiments of the invention and are, therefore, not to be considered limiting of the invention's scope, for the invention may admit to other equally effective embodiments.

[0018] Figure 1 is a schematic section view of a subterranean well with downhole control valves in accordance with an embodiment of this disclosure.

[0019] Figure 2 is a schematic diagram of a cross flow prevention system in accordance with an embodiment of this disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The Specification, which includes the Summary of Disclosure, Brief Description of the Drawings and the Detailed Description of the Preferred Embodiments, and the appended Claims refer to particular features (including process or method steps) of the invention. Those of skill in the art understand that the invention includes all possible combinations and uses of particular features described in the Specification. Those of skill in the art understand that the invention is not limited to or by the description of embodiments given in the Specification. The inventive subject matter is not restricted except only in the spirit of the Specification and appended Claims.

[0021] Those of skill in the art also understand that the terminology used for describing particular embodiments does not limit the scope or breadth of the invention. In interpreting the Specification and appended Claims, all terms should be interpreted in the broadest possible manner consistent with the context of each term. All technical and scientific terms used in the Specification and appended Claims have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs unless defined otherwise.

[0022] As used in the Specification and appended Claims, the singular forms “a”, “an”, and “the” include plural references unless the context clearly indicates otherwise. As used, the words “comprise,” “has,” “includes”, and all other grammatical variations are each intended to have an open, non-limiting meaning that does not exclude additional elements, components or steps. Embodiments of the present invention may suitably “comprise”, “consist” or “consist essentially of” the limiting features disclosed, and may be practiced in the absence of a limiting feature not disclosed. For example, it can be recognized by those skilled in the art that certain steps can be combined into a single step.

[0023] Spatial terms describe the relative position of an object or a group of objects relative to another object or group of objects. The spatial relationships apply along vertical and horizontal axes. Orientation and relational words including “uphole” and “downhole"; "above" and "below" and other like terms are for descriptive convenience and are not limiting unless otherwise indicated.

[0024] Where the Specification or the appended Claims provide a range of values, it is understood that the interval encompasses each intervening value between the upper limit and the lower limit as well as the upper limit and the lower limit. The invention encompasses and bounds smaller ranges of the interval subject to any specific exclusion provided.

[0025] Where reference is made in the Specification and appended Claims to a method comprising two or more defined steps, the defined steps can be carried out in any order or simultaneously except where the context excludes that possibility.Looking at Figure 1, subterranean well 10 is shown. Wellhead 12 is located at earth's surface 14 at the opening of well 10. Tubing 16 extends a distance into well 10. Well 10 is shown as a multilateral well having a plurality of bores including a main bore 18, and a lateral bores 20. In the embodiment shown, tubing 16 is not cemented and does not extend to the first lateral bore 20. Included in at least one of the main bore 18 and one of the lateral bores 20 is an inflow control valve (ICV) assembly 22.

[0026] In the example embodiment of Figure 1, ICV assembly 22 is a device that regulates the flow of fluid up through well 10 toward wellhead 12. To accomplish this, the example ICV assembly 22 has one or more cased hole or open hole packers 24 that substantially seal the hole around the ICV assembly 22, thereby forcing fluid to pass through the ICV control valve 28 in order to move to the top of the well 10.

[0027] The flow of fluid through the ICV assembly 22 can be regulated by downhole control valve 28 within the ICV assembly 22. When downhole control valve 28 is open, fluid can freely pass through the ICV assembly 22. Conversely, when downhole control valve 28 is closed, fluid is restricted from passing through the ICV assembly 22. The position of downhole control valve 28 (valve open, valve closed, or valve partially open) can be controlled by an operator at the earth's surface 14. By manipulating the position of downhole control valve 28, the operator can control how much fluid passes through the ICV assembly 22 towards the top of the well 10. Each downhole control valve 28 can be associated with a separate zone or region of well 10 so that when a downhole control valve 28 is in the valve closed position, such downhole control valve 28 restricts the flow of fluids into and out of the separate zone associated with such downhole control valve 28.

[0028] In the example embodiment of Figure 1, downhole control valve 28 is a hydraulically operated valve with an internal piston cavity divided into close side 28a and open side 28b by piston 28c. If pressure media is injected into close side 28a, downhole control valve 28 will move to a valve closed position. If pressure media is injected into open side 28b, downhole control valve 28 will move to a valve open position. When moving between the valve open and valve closed positions, pressure media is not only injected into one side 28b, 28a of downhole control valve 28, but pressure media trapped in the opposite side 28a, 28b, must exit such opposite side 28a, 28b in order for piston 28c to move within the piston cavity.

[0029] Turning to Figure 2, cross flow prevention system 30 can include downhole control valves 28 and can be used to close some or all of the downhole control valves 28 during a shutdown event. A shutdown event can include, for example, an emergency well shutdown, a power failure, an equipment failure, or other event that disrupts electrical or other service to the well systems. Energy storage device 32 can be, for example, an accumulator charged with a pressurized media. The amount of stored energy in energy storage device 32 will be enough to operate each of the downhole control valves 28 and move each of the downhole control valves 28 to a valve closed position. Energy storage device 32 can be charged with pressure media from fluid reservoir 34. Pump and motor assembly 36 can be used to pump pressure media from fluid reservoir 34 to energy storage device 32. After energy storage device 32 has been charged, storage valve 38 can be closed so that pressure media cannot return from energy storage device 32 to fluid reservoir 34. Although pressure media is generally described herein as a hydraulic fluid, other pressurized liquids or gasses could alternately be utilized.

[0030] Cross flow prevention system 30 is shown in the example of Figure 2 as having downhole control valves 28 operated with a pressure media. In alternate embodiments, downhole control valves 28 can be electrically operated valves. Cross flow prevention system can therefore be a hydraulically operated system, an electrically operated system, or a combination of hydraulic and electrically operated system. In alternate embodiments, energy storage device 32 can therefore alternately be an electrical storage device such as batteries and the batteries can be charged and maintained as part of an open circuit so that the batteries retain their charge.

[0031] Looking at Figure 2, primary fail device 40 retains the stored energy within energy storage device 32 when primary fail device 40 is in the primary closed position. Primary fail device 40 is a normally close, fail open device that moves to a primary open position during a shutdown event. When primary fail device 40 moves to a primary open position, the stored energy is released. A portion of the stored energy is delivered to each of the plurality of downhole control valves 28. The portion of the stored energy delivered to each of the downhole control valves 28 during a shutdown event is sufficient to move each of the plurality of downhole control valves 28 to a valve closed position.

[0032] In the example of Figure 2, pressure media stored within energy storage device 32 is delivered to close side 28a of each of the plurality of downhole control valves 28 during a shutdown event. Pressure media will be delivered through close delivery line 42. Which is the line to close all the downhole valves Pressure media can pass through one way valve 44 and close line valve 46, which are located along close delivery line 42 between energy storage device 32 and downhole control valves 28.

[0033] As pressure media is delivered to close side 28a of each of the plurality of downhole control valves 28, an open line 58 associated with open side 28b of each of the plurality of downhole control valves 28 will provide a fluid flow path for trapped pressure media within open side 28b to exit open side 28b as the downhole control valve 28 moves to a valve closed position. The trapped pressure media will return to fluid reservoir 34.

[0034] In an alternate embodiment, primary fail device 40 can be a gate that closes to allow power stored within batteries of energy storage device 32 to be delivered to electrically operated downhole control valves 28.

[0035] Looking at the example embodiment of Figure 2, cross flow prevention system 30 can also include at least one secondary fail device 50. Secondary fail device 50 is a normally open, fail close device. During a shutdown event, the secondary fail device 50 moves to a secondary closed position. One of the secondary fail devices 50 can be associated with one or more of the downhole control valves 28 and can be located between the open side 28b and the return line 48 so that in the secondary closed position, the secondary fail device 50 prevents the trapped pressure media in the open side 28b from exiting the open side 28b of the downhole control valve 28. Because the trapped pressure cannot exit the open side 28b, piston 28c cannot move and such downhole control valve 28 will be prevented from moving to a valve closed position, even when pressure media is being supplied to close side 28a of downhole control valve 28.

[0036] In alternate embodiments, secondary fail device 50 can be a gate that is part of an electrical operated valve system. During a shutdown event, the gate of secondary fail device 50 will open, causing the circuit associated with one of the downhole control valves 28 to be incomplete so that such downhole control valve 28 cannot be signaled to move to the closed position.

[0037] Looking at both Figures 1 and 2, energy storage device 32, primary fail device 40, and each secondary fail device 50 are located at an earth's surface 14 outside of the subterranean well 10 and can be part of surface control panel 52. Connector line 54 can extend from surface control panel 52, down well 10, to downhole control valves 28. Connector line 54 can include, for example, a portion of close delivery line 42 and open line 58. Connector line 54 as well as the downhole control valves and associated ICV assemblies 22 can be standard or pre-existing equipment. Therefore in order to include cross flow prevention system 30, an operator would only need to add elements located at the earth's surface 14 and would not have to make changes or install additional components downhole.

[0038] In an example of operation, in order to produce fluids from well 10 through ICV assemblies 22, an operator can open downhole control valves 28. To open downhole control valves 28, pressure media can be pumped from fluid reservoir 34 with pump and motor assembly 36 to open side 28b of downhole control valves 28. Pressure media can be pumped through open control valves 56 to open lines 58 to reach open side 28b of downhole control valves 28. This moves the piston in the ICV 28 in the open direction and pushes the control fluid to surface through close line 42. This control fluid is vented to the tank through devices 50 and line 48. Valve 46 in closed position stops this fluid from going to the pump line. Open control valves 56 can be normally closed valves that are kept in a closed position during normal operations and opened when downhole control valves 28 are to be moved to a valve open position. When pumping pressure media to open side 28b of downhole control valves 28, close line valve 46, which is normally open, can be closed so that close delivery line 42 is blocked and pressure media from the pump 36 will not reach close side 28a of downhole control valves 28 during the operation to open the ICVs 28. Return line valve 60, which is normally open, will be closed while pumping pressure media to open side 28b of downhole control valves 28 so that pressure media being used to fill open side 28b will not instead return through return line valve 60 to fluid reservoir 34. Device 50 in line 58 will be in the closed position while opening the downhole valves 28.

[0039] As downhole control valves 28 are opening, pressure media trapped in close side 28a of downhole control valves 28 can exit close side 28a and return to fluid reservoir 34 by way of one of the secondary fail devices 50 and return line 48. During normal operating conditions, secondary fail devices 50 are in a secondary open position. During the operation to open the ICVs 28, it is acceptable for the fluid in close side 28a to flow through close delivery line 42 and secondary fail device 50, return line 48 to reach the fluid reservoir 34.

[0040] After downhole control valves 28 are opened, close line valve 46 can be returned to its normal open position, open control valves 56 can be returned to their normal closed positions, and return line valve 60 can be returned to its normal open position. Secondary fail device 50 will be brought to an open position. A number of pressure gauges 62 can be used to monitor the pressure within varies flow lines of the cross flow prevention system 30. During normal operating conditions, energy storage device 32 is charged and primary fail device 40 is in a closed position. Fluids can be produced from well 10 from a number of zones through ICV assemblies 22.

[0041] During a shutdown event, the power or force retaining primary fail device 40 in a primary closed position will be cut off and primary fail device 40 will move to a primary open position. Device 50 in line 42 will also move from a primary open position to close position. This will allow the stored energy of energy storage device 32 to be released and be delivered to close side 28a of each downhole control valve 28. Such energy will be sufficient to move downhole control valves 28 to the valve closed position. The control fluid displaced from the valves during the closing operation will return to surface through control lines 58.

[0042] In certain embodiments, no secondary fail device 50 is included in the return lines 58 that will block the path of pressure media returning to fluid reservoir 34. In such an embodiment, all of the downhole control valves 28 will move to a valve closed position and production of fluids from, and injection of fluids into, all zones of well 10 will be stopped.

[0043] In the example embodiment of Figure 2, one or more of the plurality of downhole control valves 28 is prevented from moving to a valve closed position during a shutdown event with a secondary fail device 50 in the return line 58. Secondary fail device 50 in line 58 will move from primary open to closed position during power shutdown. This blocks the fluid flow path to the return line 48 for the trapped pressure media in open side 28b so that the pressure media in open side 28b cannot exit the downhole control valve 28. In such an embodiment, the downhole control valve 28 associated with the secondary fail devices 50 in control line 58 will remain in the open position while downhole valves associated with return line valve 60 will move to the closed position.

[0044] After the shutdown event, in order to resume normal operation of well 10, primary fail device 40 can be returned to the primary closed position. Secondary fail devices 50 can be returned to the secondary open position. During well start up well 10 can continue to be produced from the open zones that is associated with the downhole control valve 28 that is in the valve open position. This will expedite the start of production after shut down by reducing the number of steps required to return the well 10 to normal operating conditions. Once the flow is stable, the other zones can be remotely opened by moving at least one of the downhole control valves 28 to the valve open position, and the downhole control valves 28 can otherwise be opened and closed as deemed appropriate by the operator. Energy storage device 32 can be recharged and cross flow prevention system 30 is then ready to operate during a subsequent shutdown event.

[0045] Embodiments described herein, therefore, are well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.

[0046] Therefore as described herein, during operation, surface control panel 52 has three distinct operating conditions. In a first operating condition, normal well production is undertaken with multiple downhole control valves 28 in the open position. Accumulator 32 is charged, primary fail device 40 is closed, and all secondary fail devices 50 are in an open position. This is a waiting period with no valves moving and the system is waiting for a trigger to close one or more downhole control valves 28.

[0047] In a second operating condition, a trigger such as, for example, a power failure, to close one or more downhole control valves occurs. As a result of the trigger, primary fail device 40 is open and secondary fail devices 50 are closed. Pressure is applied through the close delivery line 42. This causes the selected downhole valves 28 that are associated with open return line valves 60 to close to and selected downhole control valves 28 that are associated with secondary fail devices 50, which are in a closed position, to remain open.

[0048] In a third operating condition, the opening of downhole control valves 28 through providing pressure through open control valves 56 and open lines 58 is undertaken. Close line valve 46 and return line valve 60 are closed. Secondary fail device 50 associated with open line 58 will be closed while secondary fail device 50 associated with close delivery line 42 will be in an open position

CLAIMS

What is claimed is:

1. A system for automatically preventing cross flow in a subterranean well during a shutdown event, the system comprising:

a plurality of downhole control valves located within the subterranean well;

an energy storage device, the energy storage device releasing a stored energy during the shutdown event; and

a primary fail device, the primary fail device being a normally close, fail open device that moves to a primary open position during the shutdown event, providing a portion of the stored energy to each of the plurality of downhole control valves during the shutdown event, the portion of the stored energy delivered to each of the plurality of downhole control valves being sufficient to move each of the plurality of downhole control valves to a valve closed position.

2. A system in accordance with claim 1, further comprising a secondary fail device, the secondary fail device being a normally open, fail close device that moves to a secondary closed position during the shutdown event, the secondary fail device being associated with a one of the downhole control valves and preventing such one of the downhole control valves from moving to the valve closed position when the portion of the stored energy is provided to each of the plurality of downhole control valves and each of the other of the plurality of downhole control valves is moved to the valve closed position.

3. A system in accordance with claim 2, wherein the energy storage device is an accumulator and the plurality of downhole control valves are hydraulic valves.

4. A system in accordance with claim 2, wherein the energy storage device is an electric storage device and the plurality of downhole control valves are electrically activated devices.

5. A system in accordance with any of claims 2-4, wherein the energy storage device, primary fail device, and secondary fail device are located at an earth's surface outside of the subterranean well.

6. A system in accordance with any of claims 2-5, wherein each downhole control valve is a hydraulically operated valve and the secondary fail device is a valve that is positioned to prevent a pressure media from traveling from the one of the downhole control valves when the secondary fail device is in the secondary closed position.

7. A system in accordance with any of claims 1-6, wherein each downhole control valve is associated with a separate zone of the subterranean well and in the valve closed position, each downhole control valve restricts a flow of fluids into and out of the separate zone associated with such downhole control valve.

8. A system for automatically preventing cross flow in a subterranean well during a shutdown event, the system comprising:

a plurality of downhole control valves located within the subterranean well;

an accumulator associated with each of the plurality of downhole control valves, the accumulator storing a pressure media;

a primary fail device, the primary fail device being a valve that moves to a primary open position during the shutdown event, releasing a portion of the pressure media to the close side of each of the plurality of downhole control valves during the shutdown event; and

a secondary fail device, the secondary fail device being a valve that moves to a secondary closed position during the shutdown event, the secondary fail device being associated with one of the downhole control valves and preventing such one of the downhole control valves from moving to a valve closed position when the portion of the pressure media is provided to each of the plurality of downhole control valves and each of the other of the plurality of downhole control valves is moved to the valve closed position.

9. A system in accordance with claim 8, wherein the accumulator, primary fail device, and secondary fail device are located at an earth's surface outside of the subterranean well.

10. A system in accordance with claim 8 or claim 9, wherein each downhole control valve is associated with a separate zone of the subterranean well and in the valve closed position, each downhole control valve restricts a flow of fluids into and out of the separate zone associated with such downhole control valve.

11. A system in accordance with any of claims 8-10, further comprising a fluid return line associated with an open side of each of the plurality of downhole control valves and providing a fluid flow path for a trapped pressure media to exit the open side of the downhole control valve as the downhole control valve moves to the valve closed position.

12. A system in accordance with claim 11, wherein the secondary fail device is positioned between the open side of the one of the downhole control valves and the fluid return line so

that in the secondary closed position, the secondary fail device prevents the trapped pressure media from exiting the open side of the one of the downhole control valves.

13. A method for automatically preventing cross flow in a subterranean well during a shutdown event, the method comprising:

locating a plurality of downhole control valves located within the subterranean well; and

during the shutdown event, providing a portion of a stored energy to each of the plurality of downhole control valves, the portion of the stored energy being sufficient to move each of the plurality of downhole control valves to a valve closed position, the stored energy being released from an energy storage device with a primary fail device, the primary fail device being a normally close, fail open device that moves to a primary open position during the shutdown event.

14. A method in accordance with claim 13, further comprising preventing one of the plurality of downhole control valves from moving to the valve closed position during the shutdown event with a secondary fail device, the secondary fail device being a normally open, fail close device associated with a one of the downhole control valves that moves to a secondary closed position during the shutdown event, so that the one of the downhole control valves remains in a valve open position and each of the other of the plurality of downhole control valves is moved to the valve closed position.

15. A method in accordance with claim 14, wherein the energy storage device is an electric storage device and the plurality of downhole control valves are electrically activated devices, and wherein the step of releasing the stored energy from the energy storage device includes releasing a portion of stored electric energy to each of the plurality of downhole control valves during the shutdown event.

16. A method in accordance with claim 14, wherein the energy storage device is an accumulator and the primary fail device and the secondary fail device are hydraulic valves, and wherein the step of releasing the stored energy from the energy storage device includes releasing the portion of a pressure media to a close side of each of the plurality of downhole control valves during the shutdown event.

17. A method in accordance with any of claims 14-16, further comprising providing a fluid flow path for a trapped pressure media to exit an open side of the downhole control

valve as the downhole control valve moves to the valve closed position with a fluid return line associated with the open side of each of the plurality of downhole control valves.

18. A method in accordance with claim 17, wherein the secondary fail device is positioned between the open side of the one of the downhole control valves and the fluid return line, the method further comprising preventing the trapped pressure media from exiting the open side of the one of the downhole control valves with the secondary fail device when the secondary fail device is in the secondary closed position.

19. A method in accordance with any of claims 14-18, further comprising locating the energy storage device, primary fail device, and secondary fail device at an earth's surface outside of the subterranean well.

20. A method in accordance with any of claims 14-19, further comprising after the shutdown event:

moving the primary fail device to a primary closed position;

moving the secondary fail device to a secondary open position;

moving at least one of the other of the plurality of downhole control valves to the valve open position; and

recharging the energy storage device.

21. A method in accordance with any of claims 13-10, further comprising associating each downhole control valve with a separate zone of the subterranean well so that in the valve closed position, each downhole control valve restricts a flow of fluids into and out of the separate zone associated with such downhole control valve.

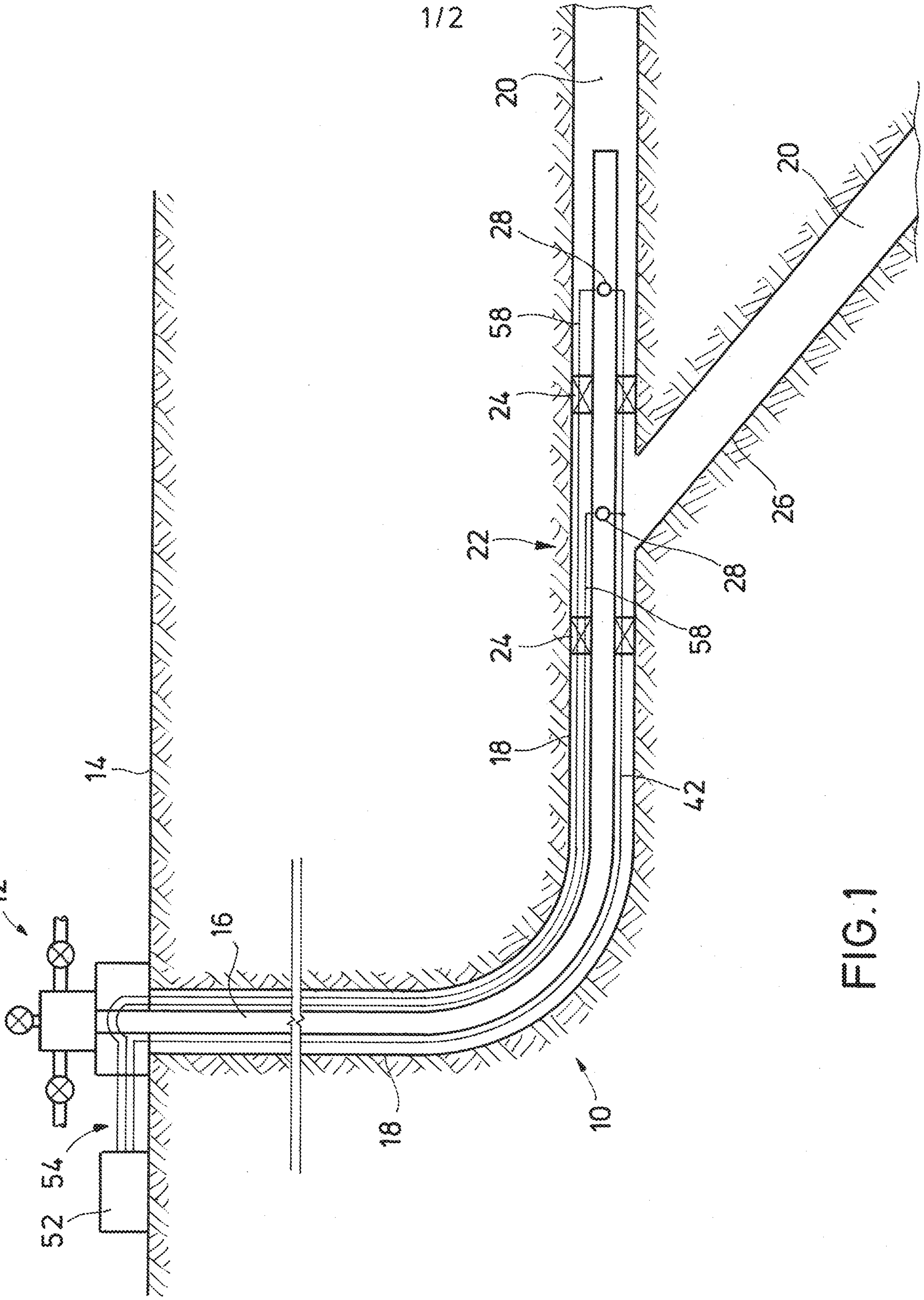

FIG.1

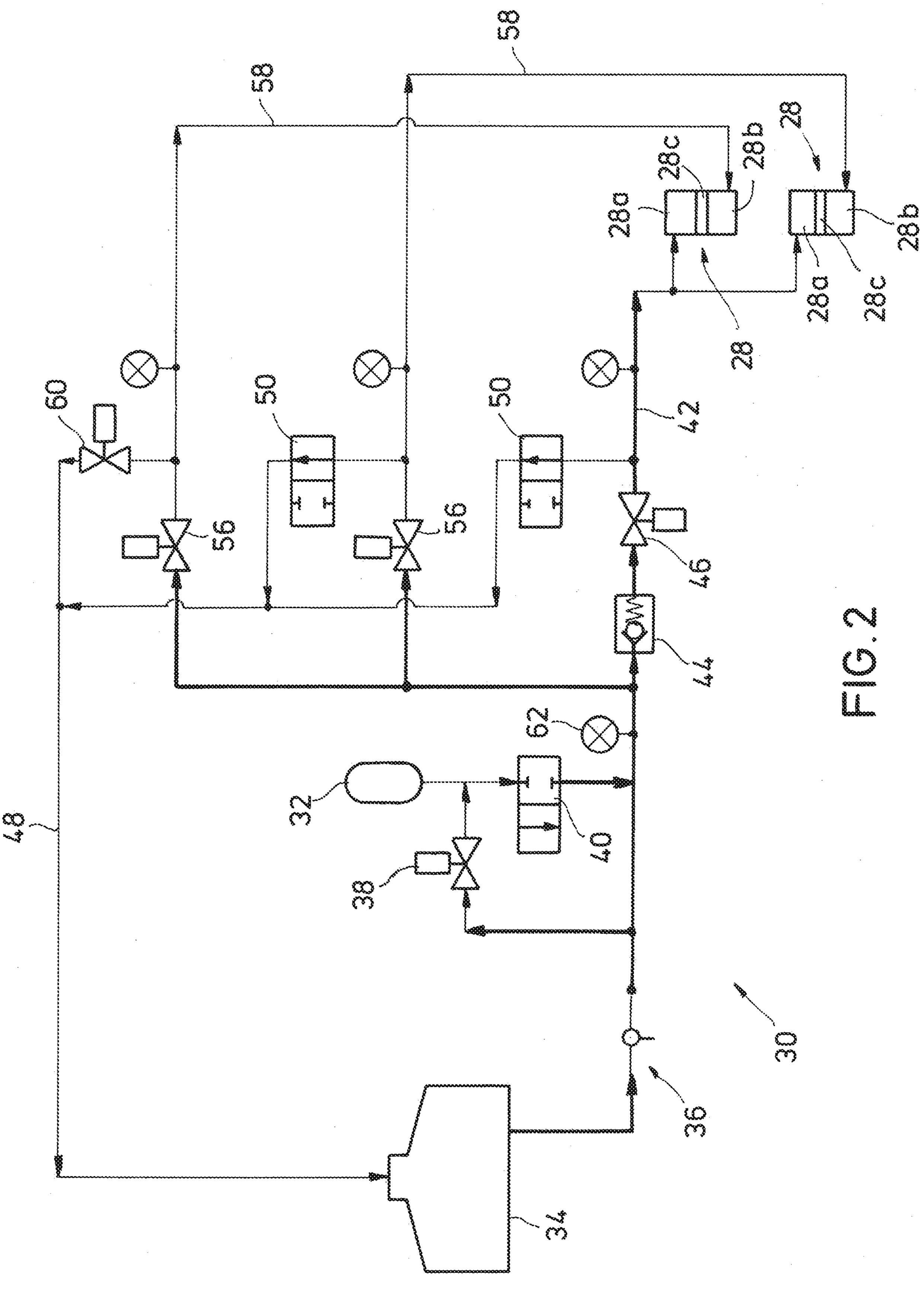
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FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/032446

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B34/16 E21B34/10 E21B43/14 E21B41/00
ADD.

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

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 practicable, search terms used)

EPO-Internal, WPI Data, TULSA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 547 029 A (RUBBO RICHARD P [GB] ET AL) 20 August 1996 (1996-08-20) column 3, line 22 - column 4, line 60 figures 1, 2	1-21
A	EP 1 290 311 A1 (WELLDYNAMICS INC [US]) 12 March 2003 (2003-03-12) paragraph [0014] - paragraph [0046]; figures 1-3	1-21
A	US 3 970 144 A (BOYKIN JR ROBERT O) 20 July 1976 (1976-07-20) column 5, line 14 - line 38; figures 2, 7	1-21
A	US 2 780 290 A (NATHO PAUL J) 5 February 1957 (1957-02-05) column 2, line 42 - column 4, line 3; figures 1, 2, 5	1-21
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 August 2016	04/10/2016

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/032446

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US2016/032446

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