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ABSTRACT

A system and method of developing a multilateral well for the production of formation fluids from a subterranean or subsea formation is disclosed. The multilateral well comprises a completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends. The method comprises: a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and the formation, the lateral wellbore completion string includes at least one ported sleeve positioned adjacent to a production zone of the formation; and, b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string to reconfigure the ported sleeve between an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string and a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus, wherein the intervention string terminates at its lower end in a kick-over tool.

A METHOD AND SYSTEM OF DEVELOPMENT OF A MULTILATERAL WELL

FIELD OF THE INVENTION

The present invention relates to a method and system for developing a multilateral well. The present invention relates particularly, though not exclusively to a method and system for accessing the primary wellbore annulus or the lateral wellbore annulus after completion of the multilateral junction.

BACKGROUND TO THE INVENTION

It is known to produce formation fluids such as hydrocarbons or water using wells which extend downwardly from the surface of the earth or downwardly from the sea bed into a reservoir or formation, which may be a consolidation, an unconsolidated or poorly consolidated formation or from shale gas or coal beds which are referred to in the art as "unconventional formations". Each well is drilled and completed ready for production using conventional cased-hole or open-hole well completion practices. A "cased-hole" well completion typically relies on casing being placed in the wellbore with cement being applied in the annulus between the casing and the wellbore to hold the casing in place. The casing is perforated to create one or more production zones referred to in the art as "intervals" through which formation fluids are encouraged to flow out of the formation and up the well bore to the surface during production. A production string or "liner" is placed inside the casing, creating an annulus between the casing and the production string. An "open-hole" well completion relies on placing the liner directly inside a well bore without first installing casing.

Multilateral wells are wells where a main or primary wellbore is drilled from the surface with one or more "lateral" wellbore diverging from that primary wellbore somewhere underground. Multilateral wells are designed to reduce overall costs, increase production and improve reservoir drainage. However, development of multilateral wells can be challenging and risky.

The production of hydrocarbons from unconsolidated or poorly consolidated formations may result in the production of sand along with the formation fluids. Produced sand is undesirable for many reasons. It is abrasive to components within the well, such as the liner, pumps and valves, and must be removed from the produced fluids at the surface or prevented from flow from the formation into wellbore. Further, it may partially or completely clog the well, thereby requiring an expensive intervention or workover. Sand control techniques in unconsolidated formations rely on setting an annulus support means (also known in the art as “sandface compliance”) to help to prevent collapse of the formation into the wellbore. If sections of the formation cave in, this can lead to a high flux of fine sands across the liner which ultimately erodes the liner. Various techniques have been developed to control the flow of sand from an unconsolidated or poorly consolidated formation into a primary wellbore well. One such technique involves the forming of a gravel pack in the well adjacent to part or all of the unconsolidated or poorly consolidated reservoir exposed to the well as described in US Patent 4,945,991 and US Patent 5,113,935. Current prior art techniques rely on gravel packing of lateral wells prior to the installation of the multilateral junction, relying on the installation and retrieval of a temporary scab liner or deflector to access the lateral. A significant drawback with this concept is that hydrostatic pressure on the well can be inadvertently reduced upon their removal, which can ultimately cause a collapse of the open hole risking an inability to complete the multilateral well.

It is known to use hydraulic fracturing to increase the permeability of the formation rock in unconventional consolidated formations. Prior art process rely on drilling and completing the wells and conducting hydraulic fracturing operations at all production zones in a single operation before handing the well over to the persons responsible for production of formation fluids from the completed well. A key drawback of such an approach is that production is dominated by the production zones located closest to the surface with a result that the effort taken up in fracturing the other production zones is largely wasted.

At least one of the above-identified drawbacks of the prior art is overcome, or alleviated, by the method and system of the present invention.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a method of developing a multilateral well for the production of formation fluids from a subterranean or subsea formation, the multilateral well comprising a completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and the formation, the lateral wellbore completion string includes at least one ported sleeve positioned adjacent to a production zone of the formation; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string to reconfigure the ported sleeve between an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string and a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus, and wherein the intervention string terminates at its lower end in a kick-over tool.

In one form, the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

In one form, the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

According to a second aspect of the present invention there is provided a method of providing sand control to a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string ;

c) using the intervention string to reconfigure the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string, wherein the intervention string terminates at its lower end in a kick-over tool; and,

d) installing an annulus retention means around the sand control device in the lateral wellbore annulus when the ported sleeve is in its open configuration.

In one form, the lateral wellbore completion string includes a sand control device. In one form, step d) comprises directing a settable permeable fluid to flow into the lateral wellbore annulus via the ported sleeve. In one form, the settable permeable fluids include a slurry of gravel or other particular material in a suitable carrier fluid such as brine or an oil-based fluid, or an expandable foam. In one form, the ported sleeve includes one or more communication ports and step c) comprises engaging the intervention string with a ported sleeve actuating means to open the one or more communication port(s) of the ported sleeve. In one form, the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, the lateral wellbore completion string includes an annulus sealing means and the annulus sealing means is expanded against the surrounding wall of open-hole lateral wellbore to isolate the lateral wellbore annulus prior to step c). In one form, the annulus retention means is an expandable element positioned around the sand control device, the expandable element forming one portion of the lateral wellbore completion string that is pre-installed in the lateral wellbore in step a). In one form, the expandable element and an expandable element actuating means are run into the lateral wellbore as part of the lateral wellbore completion string in step a) and wherein the expandable element is in a collapsed configuration during installation. In one form, step d) comprises engaging the intervention string with the expanded element actuating means to cause the expandable element to be expanded against the surrounding wall of open-hole lateral wellbore. In one form, the expandable element is hydraulically actuated, electrically actuated, or chemically actuated.

In one form, the production zone is one of a plurality of production zones and the lateral wellbore completion string is provided with a corresponding plurality of annulus retention means to allow for sand control operations to be conducted independently at each production zone. In one form, the ported sleeve is one of a plurality of ported sleeves, each ported sleeve being positioned adjacent to one of the plurality of production zones. In one form, step c) comprises opening one of the plurality of ported sleeves to conduct step d) at each of the plurality of production zones in a single operation. In one form, the ported sleeve is located at a first production zone that closer to the multilateral junction than a second production location. In one form, the method further comprises the step of performing sand control operations in the primary wellbore.

In one form, the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool. In one form, the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated. In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

According to a third aspect of the present invention there is provided a method of hydraulic fracturing of a subterranean or a subsea formation using a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string wherein the intervention string terminates at its lower end in a kick-over tool;

c) using the intervention string to reconfigure the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string; and,

d) injecting a fracturing fluid at high pressure into the formation via the ported sleeve in its open configuration to cause hydraulic fracturing of the formation.

In one form, the lateral wellbore completion string includes an annulus sealing means expanded against the surrounding wall of open-hole lateral wellbore to control the location of the fracturing along the length of the wellbore. In one form, the annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, a proppant is added to the fracturing fluid to keep the hydraulic fractures open after injection of the fracturing fluid stops. In one form, fracturing operations are used to extend existing hydraulic fractures or create new ones to increase extraction rates from the low permeability formation rock. In one form, fracturing operations are conducted in stages. In one form, the primary wellbore completion string is provided with one or a plurality of ported sleeves and the intervention string is used to conduct fracturing operations in the primary wellbore after completion of the multilateral junction.

In one form, the multilateral junction is completed and the intervention string locates and accesses the lateral wellbore to perform fracturing operations at a lateral wellbore production zone before being pulled out of the lateral wellbore and run into the primary wellbore to perform fracturing operations at a primary wellbore production zone. In one form, the intervention string can be run into the primary wellbore first to perform fracturing operations at a primary wellbore production zone before being pulled back in such a way as to close the primary wellbore isolation valve during removal. In one form, the production zone is one of a plurality of production zones and lateral wellbore completion string is provided with a corresponding plurality of ported sleeves and a corresponding plurality of annulus sealing means to allow the independent fracturing of a plurality of production zones. In one form, each ported sleeve is positioned adjacent to a production zone. In one form, a first ported sleeve is opened to conduct hydraulic fracturing at a first production zone and then left open to allow production of formation fluids from the first production zone. In one form, when production from the first production zone drops off over time, the intervention string is run into the primary or lateral wellbore to close the first ported sleeve at the first production zone and open a second ported sleeve at a second production location and hydraulic fracturing is conducted at the second production location. In one form, the second production location is closer to the multilateral junction than the first production location. In one form, the location of hydraulic fracturing along the length of the wellbore is controlled by setting a corresponding annulus sealing means to straddle a region to be fractured. In one form, the plurality of annulus sealing means is set in a single operation and a ported sleeve is opened to inject fracturing fluid into a corresponding production zone.

In one form, the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool. In one form, the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

According to a fourth aspect of the present invention there is provided a system for developing a multilateral well for the production of formation fluids from a subterranean or subsea formation, the multilateral well comprising a completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and the formation, the lateral wellbore completion string includes at least one ported sleeve positioned adjacent to a production zone of the formation; and,

an intervention string for running through the completed multilateral junction and through the lateral wellbore completion string for reconfiguring the ported sleeve between an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string and a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus, and wherein the intervention string terminates at its lower end in a kick-over tool.

In one form, the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool. In one form, the system further comprises a locating means positioned at a predetermined depth in the primary wellbore for tagging the kickover tool to locate the preset depth of the multilateral junction. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the system further comprises a ported sleeve actuating means in the lateral wellbore completion string, whereby, in use, the intervention string engages to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated. In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

According to a fifth aspect of the present invention there is provided a system for providing sand control to a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

an intervention string run through the completed multilateral junction and through the lateral wellbore completion string, for reconfiguring the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string, wherein the intervention string terminates at its lower end in a kick-over tool; and,

an annulus retention means installed around the sand control device in the lateral wellbore annulus when the ported sleeve is in its open configuration.

In one form, the lateral wellbore completion string includes a sand control device. In one form, the annulus support means comprises a settable permeable fluid in the lateral wellbore annulus via the ported sleeve. In one form, the settable permeable fluids include a slurry of gravel or other particular material in a suitable carrier fluid such as brine or an oil-based fluid, or an expandable foam. In one form, the ported sleeve includes one or more communication ports and the intervention string engages with a ported sleeve actuating means to open the one or more communication port(s) of the ported sleeve. In one form, the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, the lateral wellbore completion string includes an annulus sealing means and the annulus sealing means is expandable against the surrounding wall of open-hole lateral wellbore to isolate the lateral wellbore annulus. In one form, the annulus retention means is an expandable element positioned around the sand control device, the expandable element forming one portion of the lateral wellbore completion string that is pre-installed in the lateral wellbore. In one form, the intervention string is arranged to engage the expanded element actuating means to cause the expandable element to be expanded against the surrounding wall of open-hole lateral wellbore. In one form, the expandable element is hydraulically actuated, electrically actuated, or chemically actuated.

In one form, the production zone is one of a plurality of production zones and the lateral wellbore completion string is provided with a corresponding plurality of annulus retention means to allow for sand control operations to be conducted independently at each production zone. In one form, the ported sleeve is one of a plurality of ported sleeves, each ported sleeve being positioned adjacent to one of the plurality of production zones.

In one form, the kick-over tool has a first configuration in which it is straight for running into the primary wellbore, and a second configuration in which the kick-over tool is bent at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate for running into the lateral wellbore. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool. In one form, the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated. In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

According to a sixth aspect of the present invention there is provided a system for hydraulic fracturing of a subterranean or a subsea formation using a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the system comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

an intervention string run through the completed multilateral junction and through the lateral wellbore completion string for reeconfiguring the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string wherein the intervention string terminates at its lower end in a kick-over tool;

whereby, in use, a fracturing fluid is injected at high pressure into the formation via the ported sleeve in its open configuration to cause hydraulic fracturing of the formation.

In one form, the lateral wellbore completion string includes an annulus sealing means expanded against the surrounding wall of open-hole lateral wellbore to control the location of the fracturing along the length of the wellbore. In one form, the annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration. In one form, a proppant is added to the fracturing fluid to keep the hydraulic fractures open after injection of the fracturing fluid stops. In one form, the primary wellbore completion string is provided with one or a plurality of ported sleeves and the intervention string is used to conduct fracturing operations in the primary wellbore after completion of the multilateral junction. In one form, the production zone is one of a plurality of production zones and lateral wellbore completion string is provided with a corresponding plurality of ported sleeves and a corresponding plurality of annulus sealing means to allow the independent fracturing of a plurality of production zones. In one form, each ported sleeve is positioned adjacent to a production zone. In one form, a first ported sleeve is opened to conduct hydraulic fracturing at a first production zone and then left open to allow production of formation fluids from the first production zone. In one form, when production from the first production zone drops off over time, the intervention string is run into the primary or lateral wellbore to close the first ported sleeve at the first production zone and open a second ported sleeve at a second production location and hydraulic fracturing is conducted at the second production location. In one form, the second production location is closer to the multilateral junction than the first production location.

In one form, the kick-over tool has a first configuration in which the kick-over tool is straight for running into the primary wellbore, and a second configuration in which the kick-over tool is bent at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. In one form, the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction. In one form, the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string. In one form, the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool. In one form, the system further comprises a locating means positioned at a predetermined depth in the primary wellbore for tagging the kick-over tool to access the lateral wellbore window of the multilateral junction when the kick-over tool is activated from its first configuration to its second configuration. In one form, the locating means is a no-go collar or a locating sub located in the primary wellbore. In one form, the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string. In one form, the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration. In one form, the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve. In one form, the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated. In one form, the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction. In one form, the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate a more detailed understanding of the nature of the invention several embodiments of the present invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic side view of a multilateral well including a primary wellbore and a lateral wellbore intersecting at a multilateral junction, with a lateral wellbore completion string installed in the lateral wellbore;

Figure 2 is a schematic side view of the multilateral well of Figure 1 showing an intervention string tagging at a locating means in the primary wellbore;

Figure 3 is a schematic side view of the multilateral well of Figure 2 showing an intervention string with a kick-over tool activated to access the lateral wellbore;

Figure 4 is a schematic side view of the multilateral well of Figure 3 showing the intervention string located within the lateral wellbore completion string prior to activation of the sealing means and opening of the communication port(s) of the ported sleeve;

Figure 5 is a schematic side view of the multilateral well of Figure 4 after activation of the sealing means and setting of the annulus retention means;

Figure 6 is a schematic side view of the multilateral well of Figure 3 showing the intervention string located within the lateral wellbore completion string prior to activation of the expandable element;

Figure 7 is a schematic side view of the multilateral well of Figure 4 after setting of the annulus retention means by way of expansion of the expandable element;

Figure 8 is a schematic side view of the multilateral well of Figure 3 showing the intervention string located within the lateral wellbore completion string prior to injection of the fracturing fluids; and,

Figure 9 is a schematic side view of the multilateral well of Figure 8 after hydraulic fracturing operations have been conducted.

It is to be noted that the drawings illustrate only preferred embodiments of the invention and are therefore not to be considered limiting of the invention's scope as it may admit to other equally effective embodiments. Like reference numerals refer to like parts. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. Moreover, all drawings are intended to convey concepts, where relative sizes, shapes and other detailed attributes may be illustrated schematically rather than literally or precisely.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Particular embodiments of the method and system of the present invention for sand control of a lateral wellbore in a multilateral well are now described. The terminology used herein is for the purpose of describing particular embodiments only, and is not intended to limit the scope of the present invention. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs. Throughout this specification, the term “fluid” is used to refer to a gas or a liquid or slurry comprising solids suspended in a liquid.

Referring to Figure 1, a multilateral well (10) is shown with a primary wellbore (12) extending downwardly from the surface and a lateral wellbore (14) intersecting the primary wellbore at a multilateral junction (16) which is located at a set depth below the surface. A primary wellbore liner (18) is installed in the primary wellbore to direct formation fluids from the formation towards the surface. The primary wellbore liner terminates at its downhole end in a primary wellbore completion string (20). In an analogous manner, a lateral wellbore liner (22) is installed in the lateral wellbore to direct formation fluids from the formation towards the multilateral junction and thereafter to surface. The lateral wellbore liner terminates at its downhole end in a lateral wellbore completion string (24). When completed, the multilateral junction includes a primary wellbore access window (26) from which the primary wellbore liner extends, and a lateral wellbore access window (28) from which the lateral wellbore liner extends. The multilateral well may be a subterranean well or a subsea well and may be designed for the production of formation fluids from a production zone or a plurality of production zones. The primary wellbore and the lateral wellbore may be straight or deviating wells. The present invention is equally applicable to a secondary lateral wellbore being drilled from a pre-existing lateral wellbore. In that case, the pre-existing lateral wellbore is the "primary" wellbore and the secondary lateral wellbore is the "lateral" wellbore for purposes of the present invention.

For the purposes of illustration only, the primary wellbore and the lateral wellbore are shown in the figures which accompany this specification to intersect at the multilateral junction at an angle of separation of 90 degrees relative to the primary wellbore in side view. In reality, the angle of separation at the multilateral junction may be in the range of 0.5 to 5 degrees. It is to be understood that the lateral wellbore may deviate from this angle as it extends further away from the multilateral junction and may be a straight or deviated well depending on well design requirements. By way of example, the toe of the lateral wellbore may terminate at a depth that is less than the depth of the multilateral junction.

The lateral wellbore penetrates a subterranean or sub-sea formation from which formation fluids are to be produced from a production zone. Suitable formation fluids include water, or hydrocarbons in the form of oil or gas. The formation may be an unconsolidated or poorly consolidated formation, a consolidated formation or an unconventional formation. The lateral wellbore may be one of a plurality of lateral wellbores, each of which may be developed using the system and method of the present invention.

The primary wellbore is drilled from the surface using any suitable drilling technique known in the art and the primary wellbore is completed by way of installation of the primary wellbore liner and, optionally, the primary wellbore completion string. The primary wellbore may be cased or uncased, provided only that the primary wellbore liner is installed to facilitate creation of the multilateral junction. Thereafter a steel casing that includes an inclined plane, referred to in the art as a "whipstock", is installed in the primary wellbore liner at a predetermined depth. The whipstock (not shown) is used to cause deflection of the drill bill at an angle that allows for the lateral wellbore access window to be created in the primary wellbore liner. The whipstock is removed to allow drilling of the open-hole lateral wellbore to be conducted using any suitable drilling technique known in the art. The lateral wellbore completion string (24) is installed in the lateral wellbore (14), the lateral wellbore completion string having an outside diameter and an inside diameter. Installation of the lateral wellbore completion string forms a lateral wellbore annulus (30) between the outside diameter of the lateral wellbore completion string (24) and the formation (32). In Figure 1, the lateral wellbore completion string is shown after it has been installed in the lateral wellbore and the multilateral junction has been completed.

If the formation is consolidated, a pre-ported or slotted liner may be installed to allow flow of formation fluids. If the formation is unconsolidated or poorly consolidated, then the lateral wellbore completion string includes a sand control device. Various valves and inflow control devices can be incorporated to the primary wellbore completion string and the lateral wellbore completion string to direct or constrain flow as required, passively or dynamically depending on the multilateral well design. Suitable isolation packers are used to direct the flow of formation fluids into the liner from each production zone in the manner known in the art.

Using the method and system of the present invention, the lateral wellbore completion string (24) is provided with at least one ported sleeve (34) having one or more communication ports (36). The ported sleeve has an open configuration in which the communication port(s) are open to allow communication between the lateral wellbore annulus (30) and the internal diameter of the lateral wellbore completion string (24), and a closed configuration in which the communication port(s) are closed to prevent communication between the internal diameter of the lateral wellbore completion and the lateral wellbore annulus. The ported sleeve is maintained in its closed configuration during installation of the lateral wellbore completion string in the lateral wellbore. Pre-installing the at least one ported sleeve with the lateral wellbore completion string allows for the ported sleeve to be reconfigured from the closed configuration to the open configuration using a ported sleeve actuation means at a later time and in a controlled manner after the multilateral junction has been completed.

Referring to Figure 2, an intervention string (40) is shown being run into the primary wellbore (12) of a multilateral well through the primary wellbore liner (18). The intervention string terminates at its lower end in a kick-over tool (42) which is actuated in the manner described below to locate the lateral wellbore access window (16) so that the intervention string can be run through the lateral wellbore liner (22) and into the lateral wellbore completion string (24). The kick-over tool (42) has a first configuration (as seen in Figure 2) in which it remains straight as it is run in the primary wellbore, and a second configuration (as seen in Figure 3) in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate. The predetermined angle of the kick-over tool may be set as a function of the angle of deviation of the lateral wellbore (14) relative to the primary wellbore (12) at a given multilateral junction (16). Having located the lateral wellbore access window (28) in the multilateral junction, the intervention string (40) is run through the internal diameter of the lateral wellbore liner (22) and the lateral wellbore completion string (24). The invention string is then used to open or close the communication port(s) of the ported sleeve that was pre-installed as part of the lateral wellbore completion string as described in greater detail below.

In one embodiment of the present invention, the kick-over tool (42) is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string which can be rotated at set increments of, say 15 degrees (varied as required), each time that the kick-over tool is activated but fails to access the lateral wellbore access window on a previous attempt. The increment of rotation may be varied as required. Alternatively, the intervention string (40) may include an indexing sub (38) in addition to the kick-over tool (42), and the intervention string may be run into the primary wellbore using coiled tubing or joint pipe. In this embodiment, the indexing sub is used to provide rotation to assist in accessing the lateral wellbore access window as rotation from surface cannot be applied. In either embodiment, after each rotation, the intervention string can be re-tagged at a locating means (44) in the primary wellbore and pulled back up by the predetermined depth to reconfirm that the kick-over tool is positioned at the depth of the multilateral junction. The locating means is provided in the primary wellbore (12) at a predetermined depth, labeled as "D" in Figure 2, relative to the depth of the multilateral junction (16). Because the predetermined depth "D" of the locating means (44) relative to the depth of the multilateral junction (16) is known, the intervention string (40) tags the locating means (44) and is then pulled up to position the kick-over tool (42) at the preset depth of the multilateral junction relative to the surface. The distance that the intervention string is pulled back up is adjusted to allow for the bending of the kick-over tool. The kick-over tool is then activated from its first configuration to its second configuration to access the lateral wellbore window (26) as best seen in Figure 3.

The method and system of the present invention relies on tagging the intervention string at the locating means to confirm the location of the multilateral junction before attempting to access the lateral wellbore via the lateral wellbore access window. Prior art systems rely on reading pressure signals and flow rate changes when attempting to locate the lateral wellbore with the result that attempts to enter the lateral wellbore are often unsuccessful. The locating means positioned in the primary wellbore liner may be any suitable locating means such as a no-go collar or a locating sub providing only that tagging of the intervention string is achieved. Conveniently, when a main flow isolation valve has been pre-installed in the primary wellbore liner, the main flow isolation valve will be in the closed position to prevent the flow of formation fluids out of the primary wellbore whilst the multilateral junction is being completed. Thus the main flow isolation valve is one of the suitable locating means that the intervention string can use for tagging. When the "primary wellbore" is a pre-existing lateral wellbore, then the flow isolation valve of the pre-existing lateral wellbore can be used as the locating means for tagging the multilateral junction of a subsequent lateral wellbore.

The intervention string (40) may be used to conduct well development operations in the primary wellbore (12) or the lateral wellbore (14) or both after completion of the multilateral junction (16) if desired. The intervention string runs through the primary wellbore liner and the lateral wellbore liner. For this reason, the method and system of the present invention protects the multilateral junction from collapse because the intervention string does not interact with the formation. Advantageously, because the intervention string (40) is small enough to run through the primary wellbore liner (18) and the lateral wellbore liner (22), well development operations may be conducted in the primary wellbore or the lateral wellbore or both after the primary wellbore has been pressured up ready for production (after the upper completion string (62) has been installed in the primary wellbore and/or after installation of a production flow control device, such as a Christmas tree (not shown)).

Where the lateral wellbore (14) is one of a plurality of lateral wellbores and the multilateral junction (16) is one of a corresponding plurality of multilateral junctions, the method and system of the present invention can be used to conduct well development operations in each lateral wellbore by tagging the locating means with the intervention tool using the method and system described above and knowing the predetermined depth "D" of each of the plurality of multilateral junctions.

After access to the lateral wellbore (14) has been achieved using the kick-over tool (42), the intervention string (40) is run through the internal diameter of the lateral wellbore liner (22) and along the internal diameter of the lateral wellbore completion string (24) until it is landed at a ported sleeve actuating means (46) as best seen in the blown up section of Figure 4. The intervention string includes a sealing means (48) such as an inflatable packer or a set of bonded seals that are set within the internal diameter of the lateral wellbore completion string in such a way as to straddle the communication ports (36) of the ported sleeve (34). The sealing means may be hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated depending on the intervention string design. Once set, the sealing means is used to direct the flow of fluids to or from the lateral wellbore annulus after the ported sleeve has been reconfigured from the closed configuration to the open configuration.

In one form of the present invention, the lateral wellbore completion string (24) is further provided with an annulus sealing means (50), such as a swellable packer, which is positioned on the outer diameter of the lateral wellbore completion string. If desired, the annulus sealing means can be expanded against the surrounding wall of the formation in the lateral wellbore to isolate the lateral wellbore annulus and thus assist in preventing the flow of fluids along the lateral wellbore annulus back to the multilateral junction. By way of example, a stimulus fluid may be run through the lateral wellbore completion string to set the swellable packer in the lateral wellbore annulus whilst the ported sleeve is maintained in its closed configuration. Alternatively, the annulus sealing means may be a mechanically actuated isolation packer or a hydraulically actuated external casing packer. The annulus sealing means (50) is shown in its running configuration in Figure 4 and its expanded configuration in Figure 5.

The method and system of the present invention differs from prior art multilateral well development methods in that an intervention string is used to facilitate access to the lateral wellbore annulus after completion of the multilateral junction. The requirement to install and retrieve a deflector to access the lateral wellbore is avoided and the openhole behind the multilateral junction is protected against collapse during the well construction and devleopment. The primary wellbore may or may not be entirely completed (i.e. with upper completion and Christmas tree in place) when the present invention is applied.

The method and system of the present invention has a number of applications for the development of multilateral wells. By way of example, the ported sleeve may be opened after completion of a lateral well in an unconsolidated or poorly consolidated formation to allow sand control operations at a selected production zone to occur as described in greater detail below in Example 1. By way of further example, the ported sleeve may be opened during completion of a lateral well in an unconventional formation to allow fracturing operations at a selected production zone to occur as described in greater detail below in Example 2.

EXAMPLE 1: SAND CONTROL

The use of the present invention to provide sand control for an open-hole lateral wellbore is now described with particular reference to Figures 5 to 7. In this example, an annulus retention means (52) is installed to provide stability to the open-hole lateral wellbore (16) to assist in prevention of collapse of the lateral wellbore annulus (30) which can lead to migration of fine sands. In contrast to the systems and methods of the prior art, the annulus retention means (52) is installed after completion of the multilateral junction (16). In a first embodiment of this example of the present invention illustrated in Figure 5, the annulus retention means (52) relies on the pumping of a settable fluid into the annulus (30) via the ported sleeve (34). In a second embodiment of the present invention illustrated in Figures 6 and 7, the annulus retention means (52) relies on an expandable element (58) to create compliance against the formation.

The method and system of the present invention differs from prior art sand control methods in that the multilateral junction is completed prior to the commencement of sand control operations with the result that the sand control operations are conducted by running the intervention tool through the lateral wellbore access window and into the lateral wellbore completion string. The locating means and kick-over tool are used to locate and access the lateral bore access window in the multilateral junction in the manner outlined above.

The lateral wellbore completion string (24) is provided with a sand control device (54) such as a screen which is arranged around a portion of the outer diameter of the lateral wellbore completion string. The sand control device is positioned adjacent to the anticipated location of a production zone (56) where the lateral wellbore liner (22) is to be perforated or opened to allow ingress of formation fluids. The purpose of the sand control device is to allow formation fluids to enter the lateral wellbore liner while preventing the ingress of sand, gravel or other solid media. The sand control device may be a wire-wrapped screen, a mesh type screen (such as a premium mesh type screen) or an expandable element. The sand control device may equally be a slotted or perforated liner provided only that the slots or perforations are suitably sized to prevent the flow of sand, gravel or other solid media from the formation and/or annulus to enter into the lateral wellbore liner.

In a first embodiment of this example of the present invention, the annulus retention means (52) is formed by directing a settable permeable fluid to flow into the lateral wellbore annulus (30) via the ported sleeve (34) which was pre-installed with the lateral wellbore completion string (24). Suitable settable permeable fluids include a slurry of gravel or other particular material in a suitable carrier fluid such as brine or an oil-based fluid, or an expandable foam. The ported sleeve remained in its closed configuration during running and landing of the lateral wellbore completion string in the lateral wellbore. The intervention string (40) engages with the ported sleeve actuating means (46) to open the communication port(s) of the ported sleeve to allow the flow of the settable fluid into the lateral wellbore annulus. By way of example, the intervention string engages a collet to slide a cover away from the communication port(s) so that the communication port(s) are opened like a trap door to allow fluid communication with the lateral wellbore annulus.

Prior to reconfiguring the ported sleeve from its closed configuration to its open configuration, the sealing means (48) is set to form a straddle across the communication port(s). In addition, when the lateral wellbore completion string includes an annulus sealing means (50) such as a swellable packer, the annulus sealing means may be expanded against the surrounding wall of open-hole lateral wellbore (as shown in Figure 5) to isolate the lateral wellbore annulus (30) to assist in directing the flow of fluid or slurry to the required sand control location. The annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

If, by way of example, the annulus retention means is a gravel pack, then such gravel packing operations are conducted by adapting conventional methods in which a slurry of gravel in a carrier fluid is pumped into the lateral wellbore annuls between the sand control device and the formation. The carrier fluid leaks off into the formation or the screen, thereby forming a gravel pack in the lateral wellbore annulus. If desired, the lateral wellbore completion can be fitted with the gravel packing system described in US patent publication number US 2010/0314109 in which the gravel packing relies on the use of a plurality of shunts to mitigate the risk of sand bridging, with the gravel packing slurry being transmitted through a shrouded port closure sleeve to the lateral wellbore annulus via the shunts which are integral to the sand control means.

In an alternative embodiment of this example of the present invention now described with reference to Figures 6 and 7, the annulus retention means is an expandable element (58) positioned around the sand control device (54), the expandable element forming one portion of the lateral wellbore completion string (24) prior to installing the lateral wellbore completion string in the lateral wellbore. The expandable element is shown in its collapsed configuration in Figure 6 and in its expanded configuration in Figure 7. Suitable expandable elements include an expandable sand screen, an inflatable packer, a squeeze packer or other device capable of increasing its outer diameter to seal the liner against the lateral wellbore, effectively closing the annulus. In this embodiment, the expandable element (58) and an expandable element actuating means (60) are run into the lateral wellbore as part of the lateral wellbore completion string with the expandable element in a collapsed configuration during installation of the lateral wellbore completion string (24). The intervention string (40) engages with the expanded element actuating means to cause the expandable element to be expanded against the surrounding wall of open-hole lateral wellbore to form the annulus support means as shown in Figure 7. After installation of the annulus retention means has been completed, the intervention string is removed from the lateral wellbore through the multilateral junction as described above.

The expandable element may be hydraulically actuated, electrically actuated, or chemically actuated depending on the intervention string design. Expansion of the expandable element and activation of the sealing means is achieved by engagement of the intervention string with the expandable element actuating means. By way of example, the communication port(s) of the ported sleeve may be opened in the manner described above for Example 1 so that an activation fluid can be circulated via one or more shunt tubes connected to the ported sleeve to cause expansion of the expandable element. Alternatively, the ported sleeve may be opened to allow access to a mechanical or hydraulic expandable element actuating means that relies on pressure or force to cause expansion of the expandable element against the formation.

After installation of the annulus retention means has been completed, the intervention string is removed from the lateral wellbore. Conveniently, the intervention string may be provided with a means for automatically shutting a lateral wellbore flow isolation valve (60), such as a flapper valve or ball valve, during retrieval of the intervention string to surface. Alternatively, the lateral wellbore flow isolation valve may be left open if a barrier is to be installed at a later stage.

If the production zone is one of a plurality of production zones that are planned for a given formation, the lateral wellbore completion string may be provided with a corresponding plurality of annulus retention means to allow for sand control operations to be conducted independently at each production zone. In one embodiment of this example of the present invention, the ported sleeve that is pre-installed in the lateral completion string is one of a plurality of ported sleeves, each ported sleeve being positioned adjacent to one of the plurality of production zones. Using the intervention string of the present invention, a first ported sleeve is opened to conduct sand control operations at a first production zone. When production from the first production zone drops off over time, the intervention string is run into the lateral wellbore to open a second ported sleeve at a second production location. Sand control operations are then conducted at the second production location. For best results, the second production location is closer to the multilateral junction than the first production location. In a second embodiment of this example of the present invention, one ported sleeve is opened and sand control operations at each of the plurality of production zones in a single operation. By way of example, an activation fluid can be circulated via the open communication port(s) of the ported sleeve via an arrangement of shunt tubes whereby each of a plurality of expandable elements are caused to expand such that an annulus retention means adjacent to each of the plurality of production zones in a single operation. For best results, the ported sleeve is located at a first production zone that closer to the multilateral junction than a second production location.

The intervention string may equally be used to conduct sand control operations in the primary wellbore after completion of the multilateral junction if desired, provided only that the primary wellbore completion string was provided with one or a plurality of ported sleeves prior to installation of the primary wellbore completion string.

Example 2: Hydraulic Fracturing

The use of the present invention to conduct hydraulic fracturing operations is now described with particular reference to Figures 8 and 9. Hydraulic fracturing may be conducted in a multilateral well in any kind of formation but is considered to be particularly suited to unconventional formations such as shale rock or coal beds. Hydraulic fracturing may be used to increase or restore production from a multilateral well. In contrast to the systems and methods of the prior art, the hydraulic fracturing operations are conducted after the completion of the multilateral junction. In this example, the locating means and kick-over tool are used to locate and access the lateral bore access window in the multilateral junction in the manner outlined above. Thereafter, the intervention string (40) is run into the lateral wellbore (14) to set the sealing means (48) across the communication port(s) of the ported sleeve (34) in the manner described above. Thereafter, the ported sleeve actuating means (46) is activated to reconfigure the ported sleeve from its closed configuration to its open configuration. The lateral wellbore completion string (24) includes an annulus sealing means (50), such as a swellable packer, which may be expanded against the surrounding wall of open-hole lateral wellbore (14) to control the location of the fracturing along the length of the wellbore. The annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

After the sealing means (48) has been set and the ported sleeve (34) has been reconfigured into its open configuration, a fracturing fluid is injected at high pressure into the formation (32) via the communication port(s) of the ported sleeve to cause hydraulic fracturing of the formation rock. Selection of suitable pressure and injection rates for a given formation is conducted using methods known in the hydraulic fracturing art. The fracturing fluid is a slurry that is predominately water mixed with less than 10% proppant and/or other chemical additives which aid production such as such as acids, biocides, corrosion inhibitors, clay stabilizers, gelling agents, or surfactants. The proppant is added to the fracturing fluid to keep the hydraulic fractures open after injection of the fracturing fluid stops. Suitable proppants include sieved round sand, silica sand, natural sand, resin-coated sand, gravel, ceramic, or other particulates provided only that the proppant is capable of prevent the fractures from closing when injection of the fracturing fluids is stopped. By way of further example, sand containing naturally radioactive minerals may be used as a proppant so that the location of the hydraulic fractures can be measured. Additionally, gels, foams, and compressed gases, including nitrogen, carbon dioxide and air can be injected with the fracturing fluid if desired.

After fracturing operations have been completed for a given production zone, the intervention string is removed from the lateral wellbore through the multilateral junction. The fracturing operations may be used to extend existing hydraulic fractures or create new ones to increase extraction rates from the low permeability formation rock.

One key benefit of fracturing using the intervention string is that the multilateral junction does not see these fracturing pressures repeatedly, thereby reducing the risk of damage to the well. Another benefit is that production can now be optimised from each of the wellbores in a staged manner allowing the wells to be "farmed" more efficiently to extend the well life cycle and improve reservoir recovery. Using the method and system of the present invention reduces the risk of damage to the multilateral junction whilst increasing productivity which is an important driver for development of marginal unconventional formations.

Advantageously, because the intervention string is small enough to run through the primary wellbore liner, the lateral wellbore liner, the primary wellbore access window and the lateral wellbore access window, fracturing operations may be conducted in stages. The intervention string may equally be used to conduct fracturing operations in the primary wellbore after completion of the multilateral junction if desired, provided only that the primary wellbore completion string was provided with one or a plurality of ported sleeves prior to installation. Thus in one embodiment of this example of the present invention, the multilateral junction is completed and the intervention string locates and accesses the lateral wellbore to perform fracturing operations at a lateral wellbore production zone before being pulled out of the lateral wellbore and run into the primary wellbore to perform fracturing operations at a primary wellbore production zone. Alternatively, the intervention string can be run into the primary wellbore first to perform fracturing operations at a primary wellbore production zone before being pulled back in such a way as to close the primary wellbore isolation valve during removal. The intervention string is pulled up to a depth that is known to be above the preset depth of the multilateral junction and then dropped back down into the primary wellbore to use the primary wellbore isolation valve as the locating means used to tag the depth of the multilateral junction. The intervention tool is pulled up so that the kick-over tool can be activated to access the lateral wellbore to perform fracturing operations at a lateral wellbore production zone.

If more than one production zone is planned for a given formation, the lateral wellbore completion string may be provided with a corresponding number of ported sleeves and a corresponding number of annulus sealing means to allow the independent fracturing of a plurality of production zones (as best seen in Figure 8). Advantageously, the method and system of the present invention allows for “farming” of the formation in that each of the ported sleeves can be opened and closed independently. This allows for the staged development and thus staged production from a multilateral well. Each ported sleeve is positioned adjacent to the anticipated location of a production zone. Using the intervention string of the present invention, a first ported sleeve is opened to conduct hydraulic fracturing at a first production zone and then left open to allow production of formation fluids from the first production zone. When production from the first production zone drops off over time, the intervention string is run into the primary or lateral wellbore to close the first ported sleeve at the first production zone and open a second ported sleeve at a second production location. Hydraulic fracturing and production operations are then conducted at the second production location. For best results, the second production location is closer to the multilateral junction than the first production location.

The location of hydraulic fracturing along the length of the wellbore is controlled by setting the corresponding annulus sealing means to straddle the region to be fractured. This allows progressive hydraulic fracturing to be conducted along the length of the wellbore, without leaking fracture fluid out through previously fractured regions. The annulus sealing means may be set in stages as each production zone is fractured. Alternatively, all of the annulus sealing means may be set in a single operation so that the only operation required to conduct hydraulic fracturing operations for a given production zone is to open the corresponding ported sleeve in anticipation of injecting the fracturing fluid.

Now that several embodiments of the invention have been described in detail, it will be apparent to persons skilled in the relevant art that numerous variations and modifications can be made without departing from the basic inventive concepts. By way of example, if the angle of deviation of the lateral wellbore relative to the primary wellbore is small, a pre-fabricated multilateral junction can be run into the primary wellbore and set down at the predetermined depth of the multilateral junction to avoid the need to mill the lateral wellbore access window. By way of further example, the intervention string may include an array of geophones to estimate the size and orientation of the hydraulic fractures when the method and system of the present invention is used for hydraulic fracture operations. All such modifications and variations are considered to be within the scope of the present invention, the nature of which is to be determined from the foregoing description and the appended claims.

All of the patents cited in this specification, are herein incorporated by reference. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents forms part of the common general knowledge in the art, in Australia or in any other country. In the summary of the invention, the description and claims which follow, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

What is claimed:

1. A method of developing a multilateral well for the production of formation fluids from a subterranean or subsea formation, the multilateral well comprising a completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and the formation, the lateral wellbore completion string includes at least one ported sleeve positioned adjacent to a production zone of the formation; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string to reconfigure the ported sleeve between an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string and a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus, wherein the intervention string terminates at its lower end in a kick-over tool.

2. The method of claim 1 wherein the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate.

3. The method of claim 2 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

4. The method of any one of the preceding claims wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

5. The method of any one of the preceding claims wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

6. The method of any one of the preceding claims wherein the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window.

7. The method of claim 6 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

8. The method of claim 6 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

9. The method of any one of the preceding claims wherein the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration.

10. The method of claim 9 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

11. The method of claim 10 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

12. The method of any one of the preceding claims wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

13. The method of any one of the preceding claims wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

14. A method of providing sand control to a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string, wherein the intervention string terminates at its lower end in a kick-over tool;

c) using the intervention string to reconfigure the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string; and,

d) installing an annulus retention means around the sand control device in the lateral wellbore annulus when the ported sleeve is in its open configuration.

15. The method of claim 14 wherein the lateral wellbore completion string includes a sand control device.

16. The method of claim 14 or 15 wherein step d) comprises directing a settable permeable fluid to flow into the lateral wellbore annulus via the ported sleeve.

17. The method of claim 16 wherein the settable permeable fluids include a slurry of gravel or other particular material in a suitable carrier fluid such as brine or an oil-based fluid, or an expandable foam.

18. The method of any one of claims 14 to 17 wherein the ported sleeve includes one or more communication ports and step c) comprises engaging the intervention string with a ported sleeve actuating means to open the one or more communication port(s) of the ported sleeve.

19. The method of any one of claims 14 to 18 wherein the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

20. The method of any one of claims 14 to 19 wherein the lateral wellbore completion string includes an annulus sealing means and the annulus sealing means is expanded against the surrounding wall of open-hole lateral wellbore to isolate the lateral wellbore annulus prior to step c).

21. The method of claim 20 wherein the annulus retention means is an expandable element positioned around the sand control device, the expandable element forming one portion of the lateral wellbore completion string that is pre-installed in the lateral wellbore in step a).

22. The method of claim 21 wherein the expandable element and an expandable element actuating means are run into the lateral wellbore as part of the lateral wellbore completion string in step a) and wherein the expandable element is in a collapsed configuration during installation.

23. The method of claim 22 wherein step d) comprises engaging the intervention string with the expanded element actuating means to cause the expandable element to be expanded against the surrounding wall of open-hole lateral wellbore.

24. The method of any one of claims 21 to 23 wherein the expandable element is hydraulically actuated, electrically actuated, or chemically actuated.

25. The method of any one of claims 14 to 24 wherein the production zone is one of a plurality of production zones and the lateral wellbore completion string is provided with a corresponding plurality of annulus retention means to allow for sand control operations to be conducted independently at each production zone.

26. The method of claim 25 wherein the ported sleeve is one of a plurality of ported sleeves, each ported sleeve being positioned adjacent to one of the plurality of production zones.

27. The method of claim 26 wherein step c) comprises opening one of the plurality of ported sleeves to conduct step d) at each of the plurality of production zones in a single operation.

28. The method of claim 26 wherein the ported sleeve is located at a first production zone that closer to the multilateral junction than a second production location.

29. The method of any one of claims 14 to 28 further comprising the step of performing sand control operations in the primary wellbore.

30. The method of any one of claims 14 to 29 wherein the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate.

31. The method of any one of claims 14 to 30 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

32. The method of any one of claims 14 to 31 wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

33. The method of any one of claims 14 to 31 wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

34. The method of any one of claims 14 to 33 wherein the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window.

35. The method of claim 34 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

36. The method of claim 34 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

37. The method of any one of claims 14 to 36 wherein the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration.

38. The method of claim 37 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

39. The method of claim 38 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

40. The method of any one of claims 14 to 39 wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

41. The method of any one of claims 14 to 40 wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

42. A method of hydraulic fracturing of a subterranean or a subsea formation using a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a) pre-installing a lateral wellbore completion string in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

b) running an intervention string through the completed multilateral junction and through the lateral wellbore completion string, wherein the intervention string terminates at its lower end in a kick-over tool;

c) using the intervention string to reconfigure the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string; and,

d) injecting a fracturing fluid at high pressure into the formation via the ported sleeve in its open configuration to cause hydraulic fracturing of the formation.

43. The method of claim 42 wherein the lateral wellbore completion string includes an annulus sealing means expanded against the surrounding wall of open-hole lateral wellbore to control the location of the fracturing along the length of the wellbore.

44. The method of claim 43 wherein the annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

45. The method of any one of claims 42 to 44 wherein the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

46. The method of any one of claims 42 to 45 wherein a proppant is added to the fracturing fluid to keep the hydraulic fractures open after injection of the fracturing fluid stops.

47. The method of any one of claims 42 to 46 wherein fracturing operations are used to extend existing hydraulic fractures or create new ones to increase extraction rates from the low permeability formation rock.

48. The method of any one of claims 42 to 47 wherein fracturing operations are conducted in stages.

49. The method of any one of claims 42 to 48 wherein the primary wellbore completion string is provided with one or a plurality of ported sleeves and the intervention string is used to conduct fracturing operations in the primary wellbore after completion of the multilateral junction.

50. The method of claim 49 wherein the multilateral junction is completed and the intervention string locates and accesses the lateral wellbore to perform fracturing operations at a lateral wellbore production zone before being pulled out of the lateral wellbore and run into the primary wellbore to perform fracturing operations at a primary wellbore production zone.

51. The method of claim 49 or 50 wherein the intervention string can be run into the primary wellbore first to perform fracturing operations at a primary wellbore production zone before being pulled back in such a way as to close the primary wellbore isolation valve during removal.

52. The method of any one of claims 42 to 51 wherein the production zone is one of a plurality of production zones and lateral wellbore completion string is provided with a corresponding plurality of ported sleeves and a corresponding plurality of annulus sealing means to allow the independent fracturing of a plurality of production zones.

53. The method of claim 52 wherein each ported sleeve is positioned adjacent to a production zone.

54. The method of claim 52 or 53 wherein a first ported sleeve is opened to conduct hydraulic fracturing at a first production zone and then left open to allow production of formation fluids from the first production zone.

55. The method of claim 54 wherein, when production from the first production zone drops off over time, the intervention string is run into the primary or lateral wellbore to close the first ported sleeve at the first production zone and open a second ported sleeve at a second production location and hydraulic fracturing is conducted at the second production location.

56. The method of claim 55 wherein the second production location is closer to the multilateral junction than the first production location.

57. The method of any one of claims 52 to 56 wherein the location of hydraulic fracturing along the length of the wellbore is controlled by setting a corresponding annulus sealing means to straddle a region to be fractured.

58. The method of any one of claims 52 to 57 wherein the plurality of annulus sealing means is set in a single operation and a ported sleeve is opened to inject fracturing fluid into a corresponding production zone.

59. The method of any one of claims 42 to 58 wherein the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate.

60. The method of claim 59 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

61. The method of any one of claims 42 to 60 wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

62. The method of any one of claims 42 to 60 wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

63. The method of any one of claims 42 to 62 wherein the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window.

64. The method of claim 63 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

65. The method of claim 63 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

66. The method of any one of claims 42 to 65 wherein the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration.

67. The method of claim 66 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

68. The method of claim 67 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

69. The method of any one of claims 42 to 68 wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

70. The method of any one of claims 42 to 69 wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

71. A system for developing a multilateral well for the production of formation fluids from a subterranean or subsea formation, the multilateral well comprising a completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and the formation, the lateral wellbore completion string includes at least one ported sleeve positioned adjacent to a production zone of the formation; and,

an intervention string for running through the completed multilateral junction and through the lateral wellbore completion string for reconfiguring the ported sleeve between an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string and a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus, and wherein the intervention string terminates at its lower end in a kick-over tool.

72. The system of claim 71 wherein the kick-over tool has a first configuration in which it remains straight as it is run in the primary wellbore, and a second configuration in which the kick-over tool bends at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate.

73. The system of claim 72 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

74. The system of any one of claims 71 to 73 wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

75. The system of any one of claims 71 to 73 wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the

primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

76. The system of any one of claims 71 to 75 further comprising a locating means positioned at a predetermined depth in the primary wellbore for tagging the kickover tool to locate the preset depth of the multilateral junction.

77. The system of claim 76 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

78. The system of claim 76 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

79. The system of any one of claims 71 to 78 further comprising a ported sleeve actuating means in the lateral wellbore completion string, whereby, in use, the intervention string engages to reconfigure the ported sleeve between its open configuration and its closed configuration.

80. The system of claim 79 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

81. The system of claim 80 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

82. The system of any one claims 71 to 81 wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

83. The system of any one of claims 71 to 81 wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

84. A system for providing sand control to a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the method comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

an intervention string run through the completed multilateral junction and through the lateral wellbore completion string, for reconfiguring the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string, and, wherein the intervention string terminates at its lower end in a kick-over tool; and,

an annulus retention means installed around the sand control device in the lateral wellbore annulus when the ported sleeve is in its open configuration.

85. The system of claim 84 wherein the lateral wellbore completion string includes a sand control device.

86. The system of claim 84 or 85 wherein the annulus support means comprises a settable permeable fluid in the lateral wellbore annulus via the ported sleeve.

87. The system of claim 86 wherein the settable permeable fluids include a slurry of gravel or other particular material in a suitable carrier fluid such as brine or an oil-based fluid, or an expandable foam.

88. The system of any one of claims 86 to 87 wherein the ported sleeve includes one or more communication ports and the intervention string engages with a ported sleeve actuating means to open the one or more communication port(s) of the ported sleeve.

89. The system of any one of claims 84 to 87 wherein the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

90. The system of any one of claims 84 to 89 wherein the lateral wellbore completion string includes an annulus sealing means and the annulus sealing means is expandable against the surrounding wall of open-hole lateral wellbore to isolate the lateral wellbore annulus.

91. The system of claim 90 wherein the annulus retention means is an expandable element positioned around the sand control device, the expandable element forming one portion of the lateral wellbore completion string that is pre-installed in the lateral wellbore.

92. The system of claim 91 wherein the intervention string is arranged to engage the expanded element actuating means to cause the expandable element to be expanded against the surrounding wall of open-hole lateral wellbore.

93. The system of claim 91 or 92 wherein the expandable element is hydraulically actuated, electrically actuated, or chemically actuated.

94. The system of any one of claims 84 to 93 wherein the production zone is one of a plurality of production zones and the lateral wellbore completion string is provided with a corresponding plurality of annulus retention means to allow for sand control operations to be

conducted independently at each production zone.

95. The system of claim 94 wherein the ported sleeve is one of a plurality of ported sleeves, each ported sleeve being positioned adjacent to one of the plurality of production zones.

96. The system of claim 95 wherein the kick-over tool has a first configuration in which it is straight for running into the primary wellbore, and a second configuration in which the kick-over tool is bent at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate for running into the lateral wellbore.

97. The system of claim 96 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

98. The system of any one of claims 95 to 97 wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

99. The system of any one of claims 95 to 97 wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

100. The system of any one of claims 95 to 99 wherein the kick-over tool is tagged at a locating means at a predetermined depth in the primary wellbore and pulled back up to position the kick-over tool at the multilateral junction and the kick-over tool is activated from its first configuration to its second configuration to access the lateral wellbore window.

101. The system of claim 100 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

102. The system of claim 101 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

103. The system of any one of claims 84 to 102 wherein the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration.

104. The system of claim 103 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

105. The system of claim 104 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

106. The system of any one of claims 84 to 105 wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

107. The system of any one of claims 84 to 106 wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

108. A system for hydraulic fracturing of a subterranean or a subsea formation using a multilateral well comprising a completed multilateral junction, the completed multilateral junction having a primary wellbore access window from which a primary wellbore extends and a lateral wellbore access window from which a lateral wellbore extends, the system comprising:

a lateral wellbore completion string pre-installed in the lateral wellbore thereby forming an annulus between the lateral wellbore completion string and a subterranean or subsea formation, the lateral wellbore completion string includes at least one ported sleeve and at least one sand control device arranged around a portion of an outer diameter of the lateral wellbore completion string, the ported sleeve and the sand control device positioned adjacent to a production zone; and,

an intervention string run through the completed multilateral junction and through the lateral wellbore completion string for reeconfiguring the ported sleeve from a closed configuration in which the lateral wellbore completion string is sealed to prevent fluid communication between the internal diameter of the lateral wellbore completion string and the annulus to an open configuration in which the annulus is in fluid communication with an internal diameter of the lateral wellbore completion string, wherein the intervention string terminates at its lower end in a kick-over tool;

whereby, in use, a fracturing fluid is injected at high pressure into the formation via the ported sleeve in its open configuration to cause hydraulic fracturing of the formation.

109. The system of claim 108 wherein the lateral wellbore completion string includes an annulus sealing means expanded against the surrounding wall of open-hole lateral wellbore to control the location of the fracturing along the length of the wellbore.

110. The system of claim 109 wherein the annulus sealing means is set prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

111. The system of any one of claims 109 to 110 wherein the intervention string includes a sealing means and the sealing means is set to form a straddle across the communication port(s) prior to reconfiguring the ported sleeve from its closed configuration to its open configuration.

112. The system of any one of claims 108 to 111 wherein a proppant is added to the fracturing fluid to keep the hydraulic fractures open after injection of the fracturing fluid stops.

113. The system of any one of claims 108 to 112 wherein the primary wellbore completion string is provided with one or a plurality of ported sleeves and the intervention string is used to conduct fracturing operations in the primary wellbore after completion of the multilateral junction.

114. The system of any one of claims 108 to 113 wherein the production zone is one of a plurality of production zones and lateral wellbore completion string is provided with a corresponding plurality of ported sleeves and a corresponding plurality of annulus sealing means to allow the independent fracturing of a plurality of production zones.

115. The system of claim 114 wherein each ported sleeve is positioned adjacent to a production zone.

116. The system of claim 114 or 115 wherein a first ported sleeve is opened to conduct hydraulic fracturing at a first production zone and then left open to allow production of formation fluids from the first production zone.

117. The system of claim 116 wherein, when production from the first production zone drops off over time, the intervention string is run into the primary or lateral wellbore to close the first ported sleeve at the first production zone and open a second ported sleeve at a second production location and hydraulic fracturing is conducted at the second production location.

118. The system of claim 117 wherein the second production location is closer to the multilateral junction than the first production location.

119. The system of claim 118 wherein the kick-over tool has a first configuration in which the kick-over tool is straight for running into the primary wellbore, and a second configuration in which the kick-over tool is bent at a predetermined angle responsive to a fluid being pumped through the kick-over tool at a given pressure or flow rate.

120. The system of claim 119 wherein the predetermined angle of the kick-over tool is a function of the angle of deviation of the lateral wellbore relative to the primary wellbore at the multilateral junction.

121. The system of any one of claims 108 to 120 wherein the kick-over tool is a non-indexing kick-over tool and the intervention string is run into the primary wellbore on a drill string.

122. The system of any one of claims 108 to 120 wherein the intervention string includes an indexing sub in addition to the kick-over tool, and the intervention string may be run into the primary wellbore using coiled tubing and the indexing sub provides rotation to the kick-over tool.

123. The system of any one of claims 108 to 122 further comprising a locating means positioned at a predetermined depth in the primary wellbore for tagging the kick-over tool to access the lateral wellbore window of the multilateral junction when the kick-over tool is activated from its first configuration to its second configuration.

124. The system of claim 123 wherein the locating means is a no-go collar or a locating sub located in the primary wellbore.

125. The system of claim 123 wherein the locating means is a closed main flow isolation valve in the primary wellbore liner or in a primary wellbore completion string.

126. The system of any one of claims 108 to 130 wherein the intervention string engages a ported sleeve actuating means in the lateral wellbore completion string to reconfigure the ported sleeve between its open configuration and its closed configuration.

127. The system of claim 126 wherein the ported sleeve has one or more communication ports and the intervention string includes a sealing means for straddling the communication ports of the ported sleeve.

128. The system of claim 127 wherein the sealing means is hydraulically actuated, electrically actuated, mechanically actuated or chemically actuated.

129. The system of any one of claims 108 to 128 wherein the lateral wellbore completion string includes an annulus sealing means positioned on an outer diameter of the lateral wellbore completion string wherein the annulus sealing means is expandable to isolate the lateral wellbore annulus to prevent the flow of fluids along the lateral wellbore annulus back to the multilateral junction.

130. The system of any one of claims 108 to 129 wherein the lateral wellbore is one of a plurality of lateral wellbores and the multilateral junction is one of a corresponding plurality of multilateral junctions.

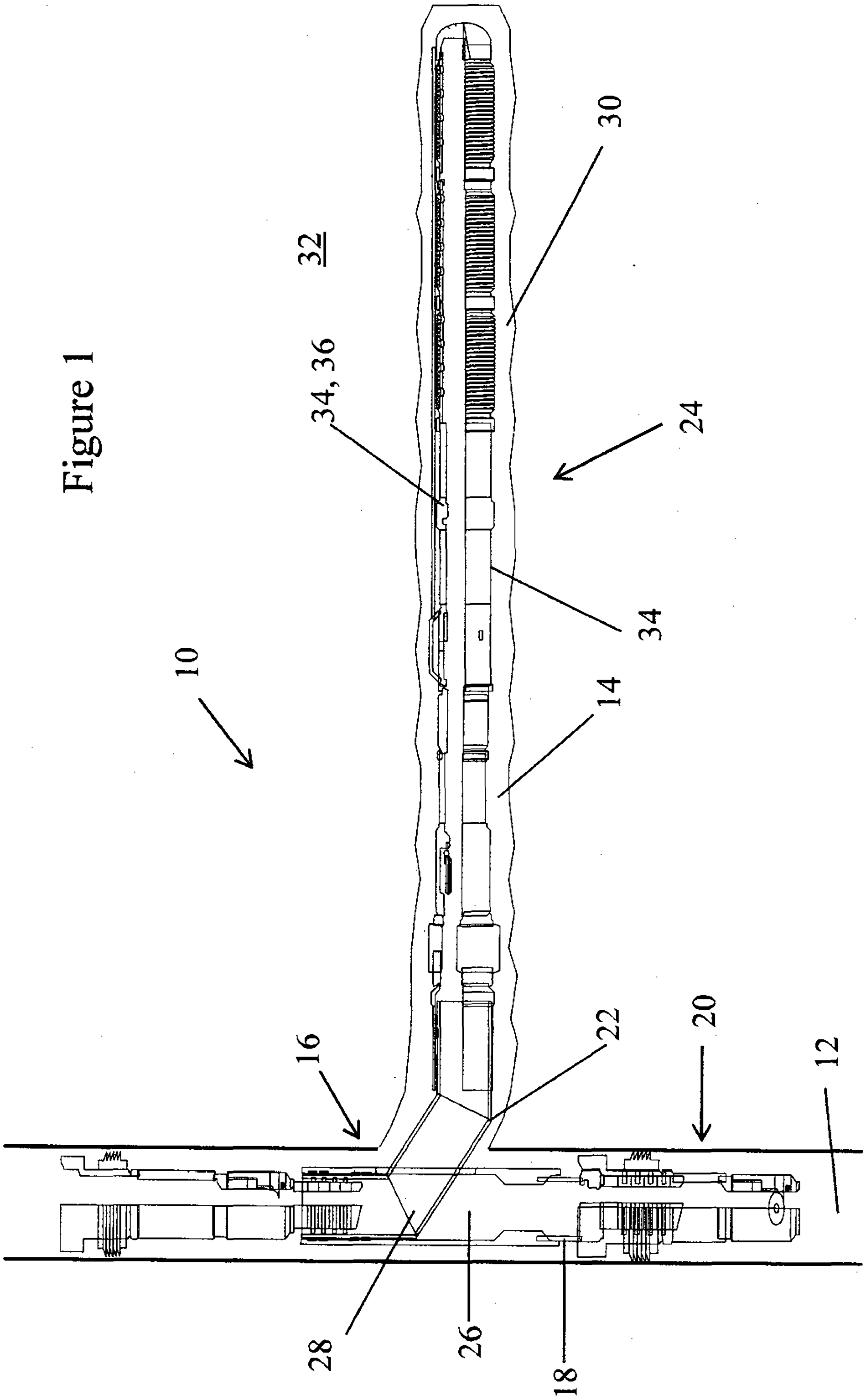


Figure 1

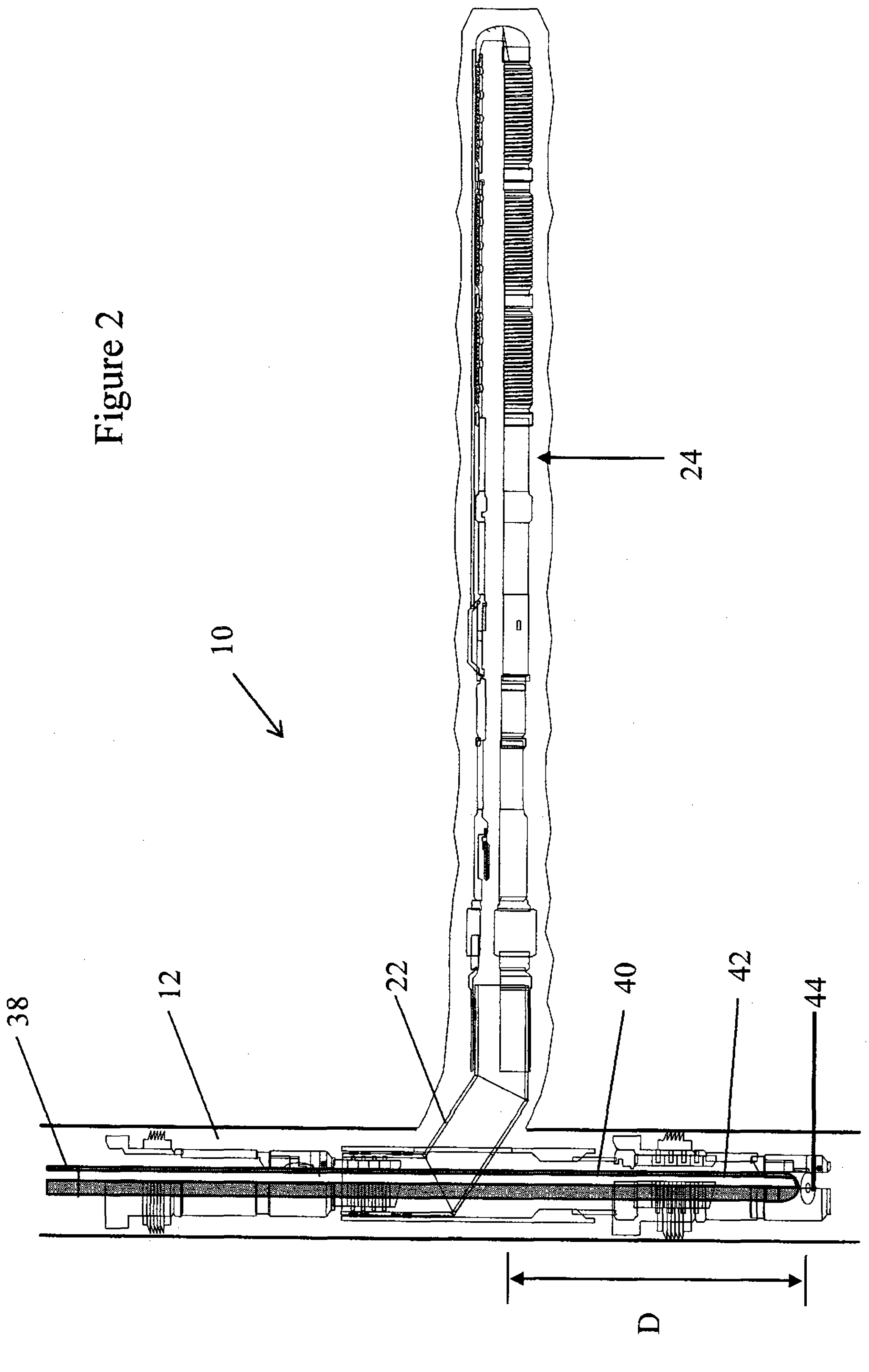
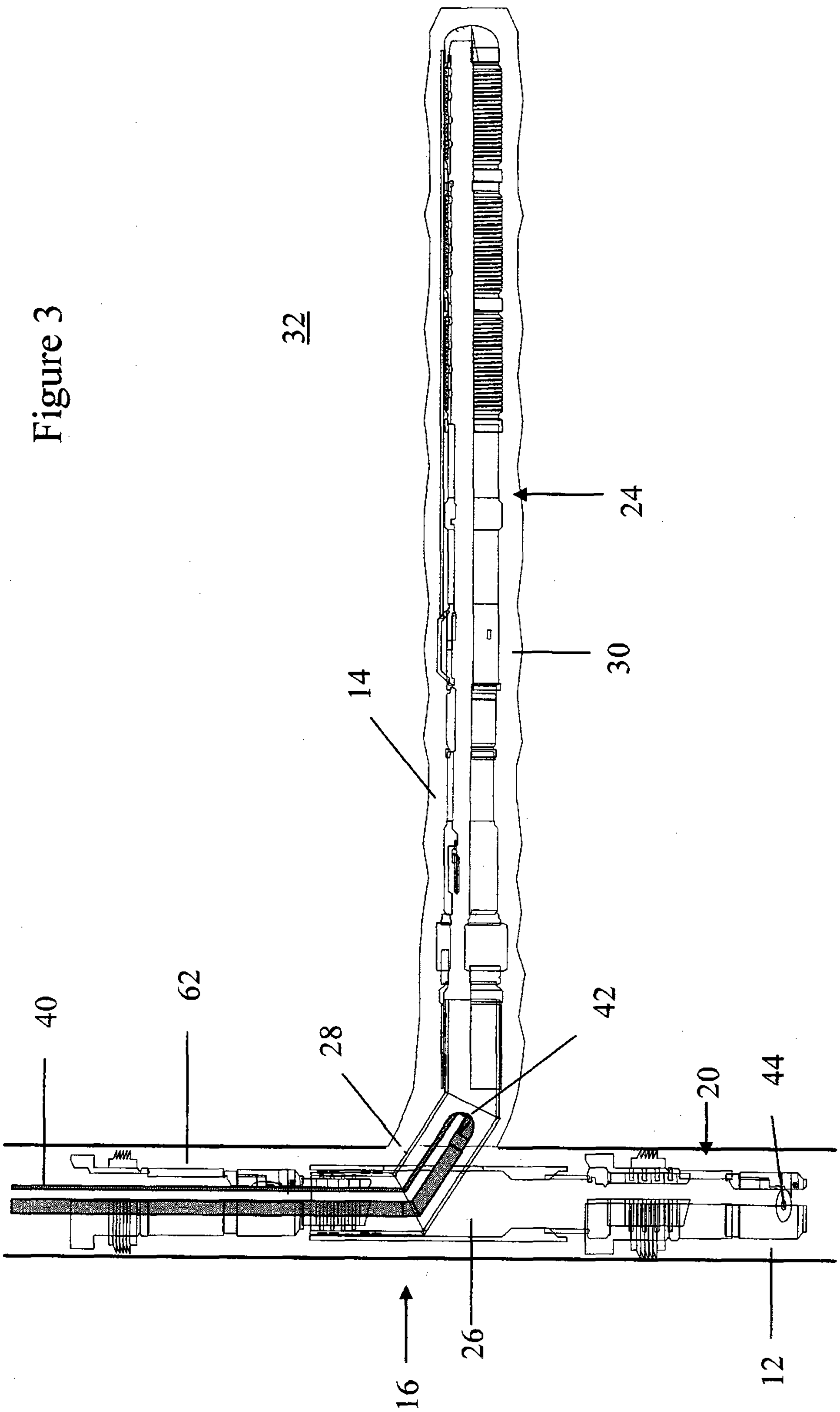
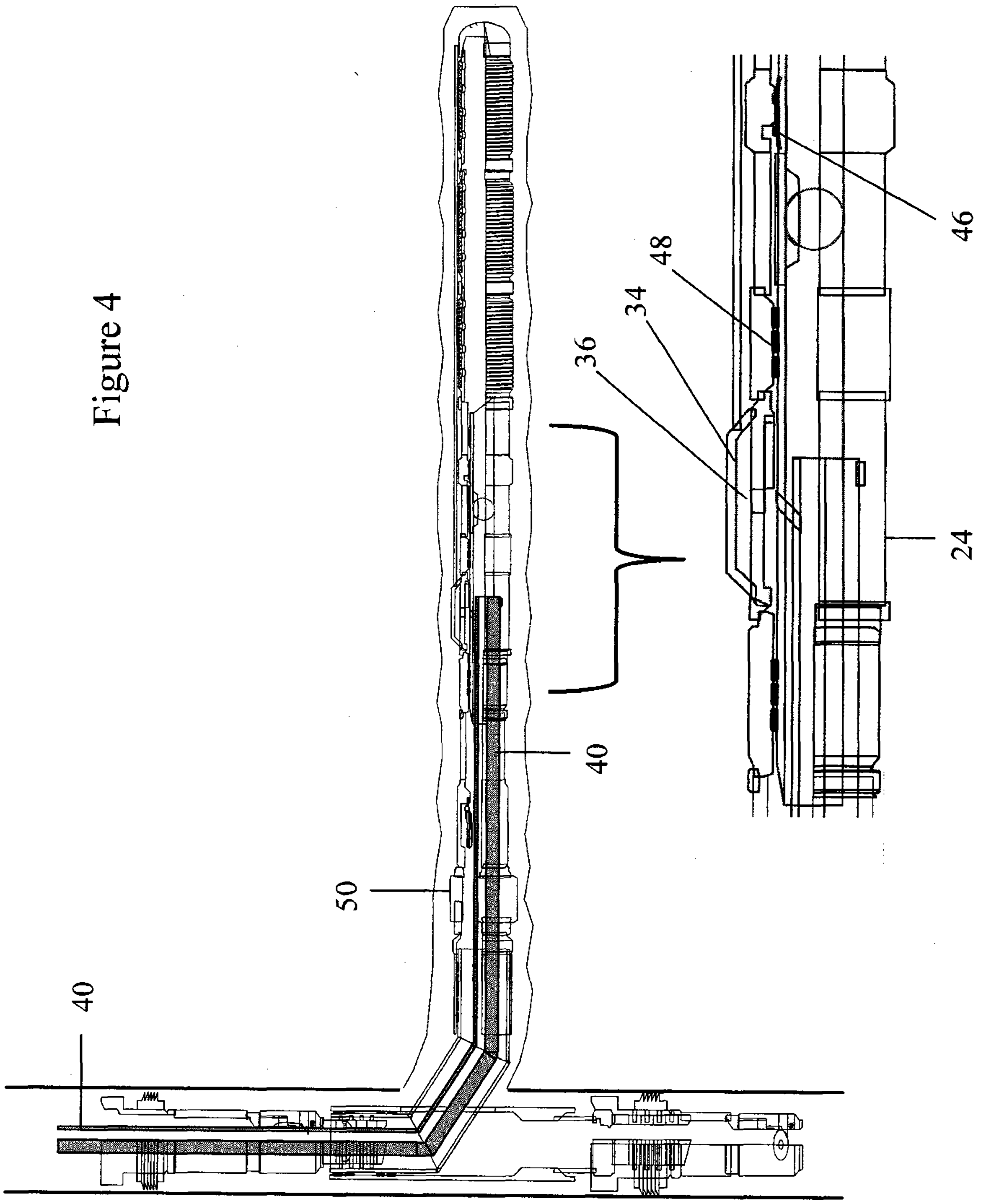


Figure 2

Figure 3





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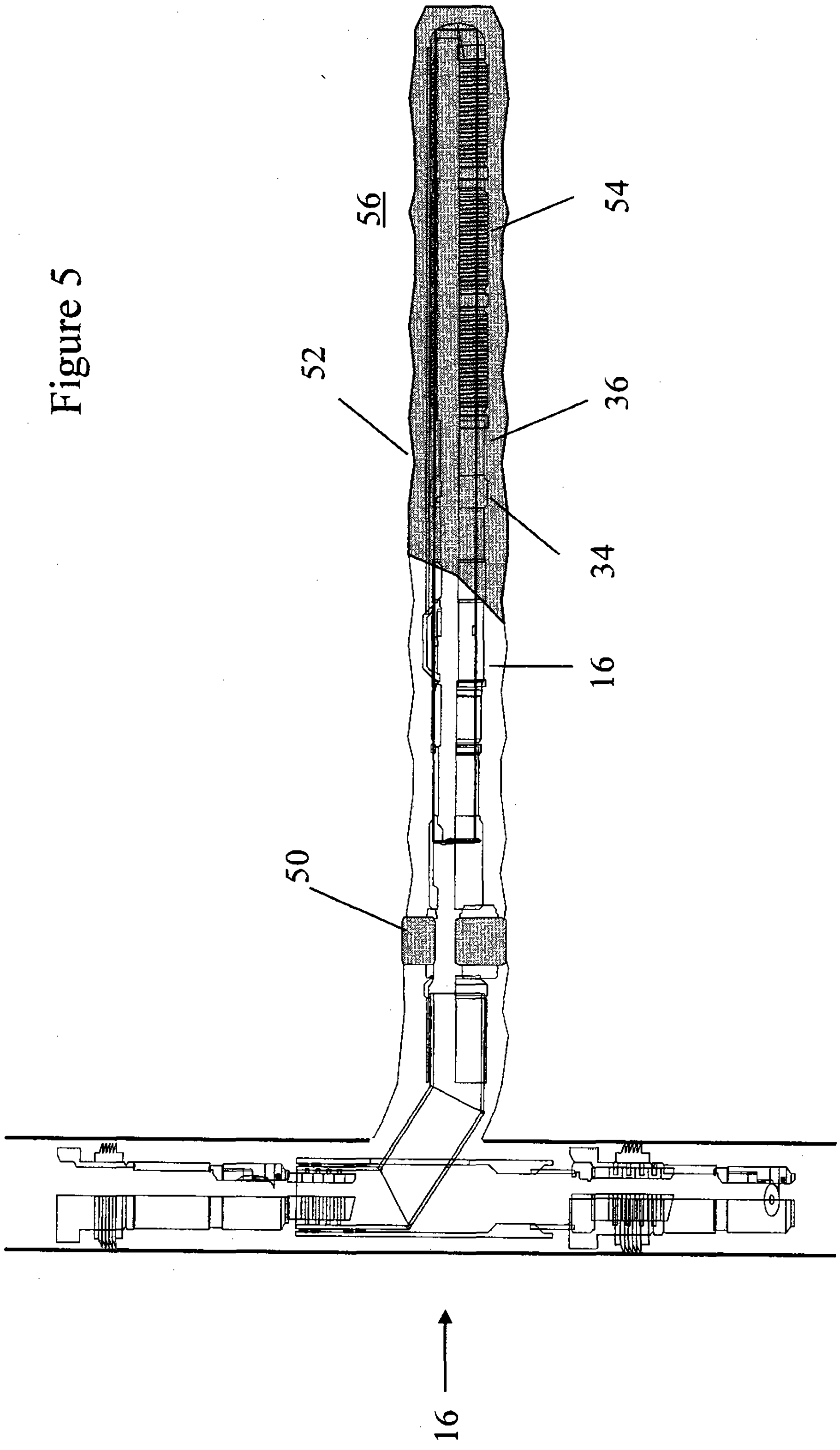
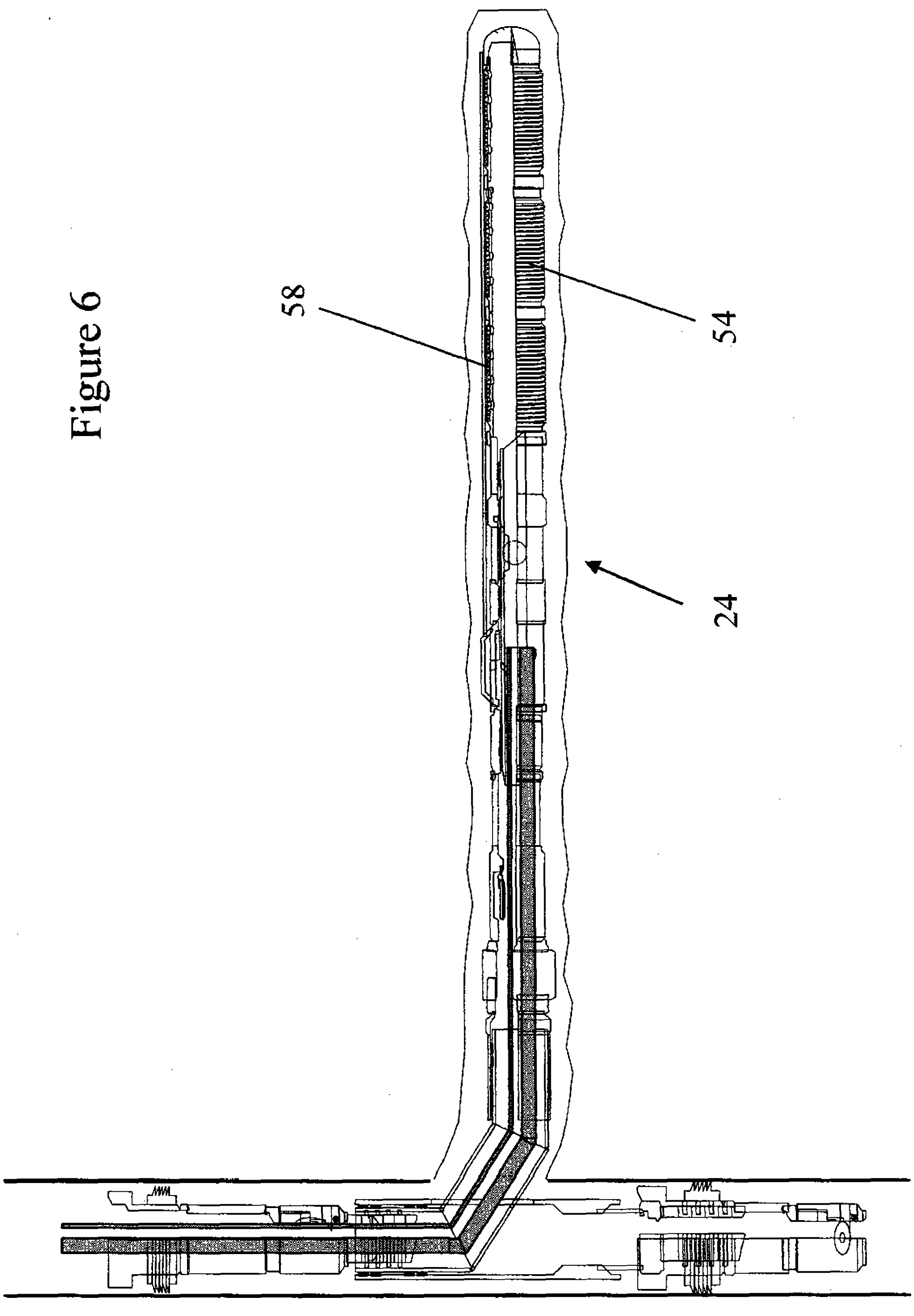


Figure 5



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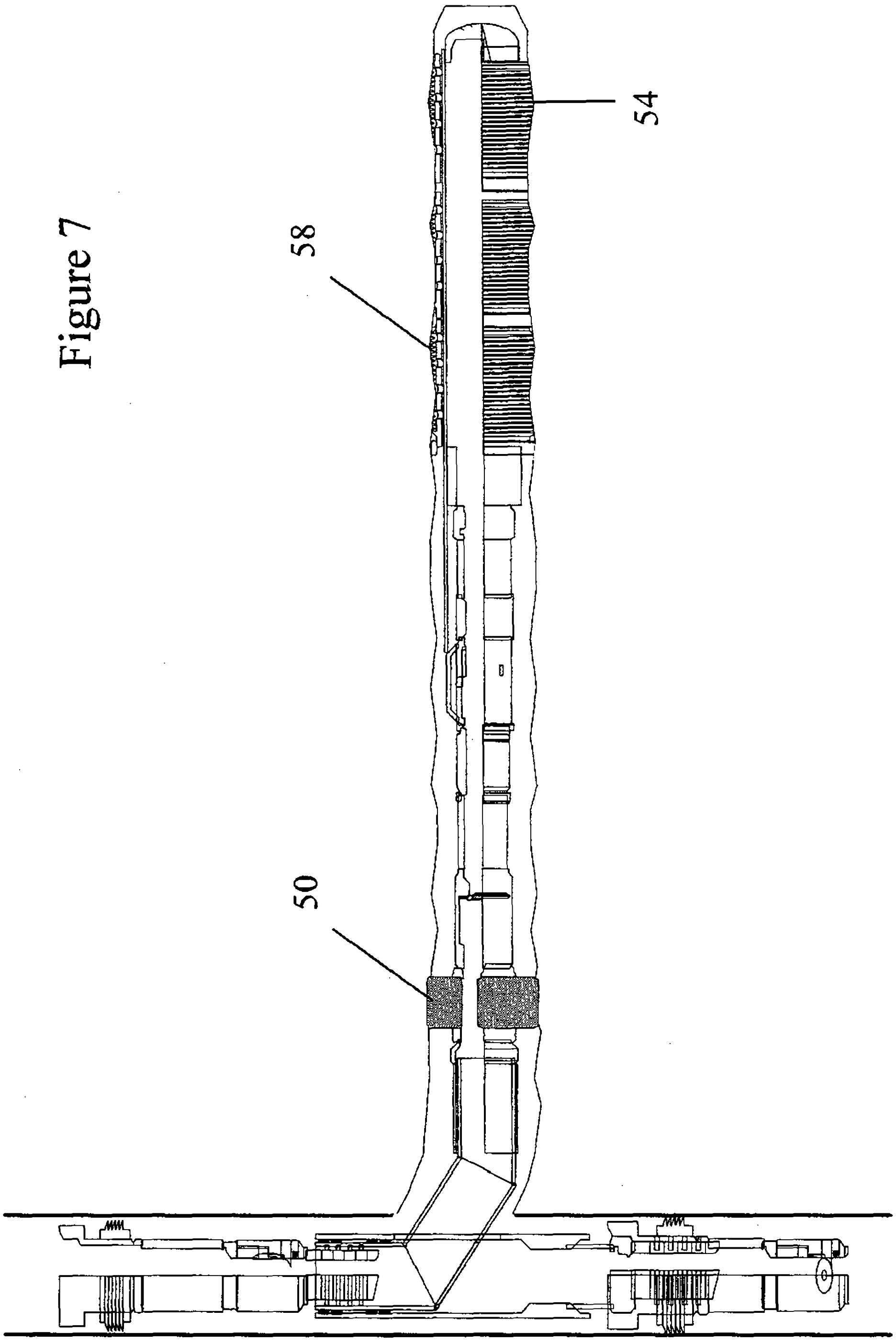

Figure 7

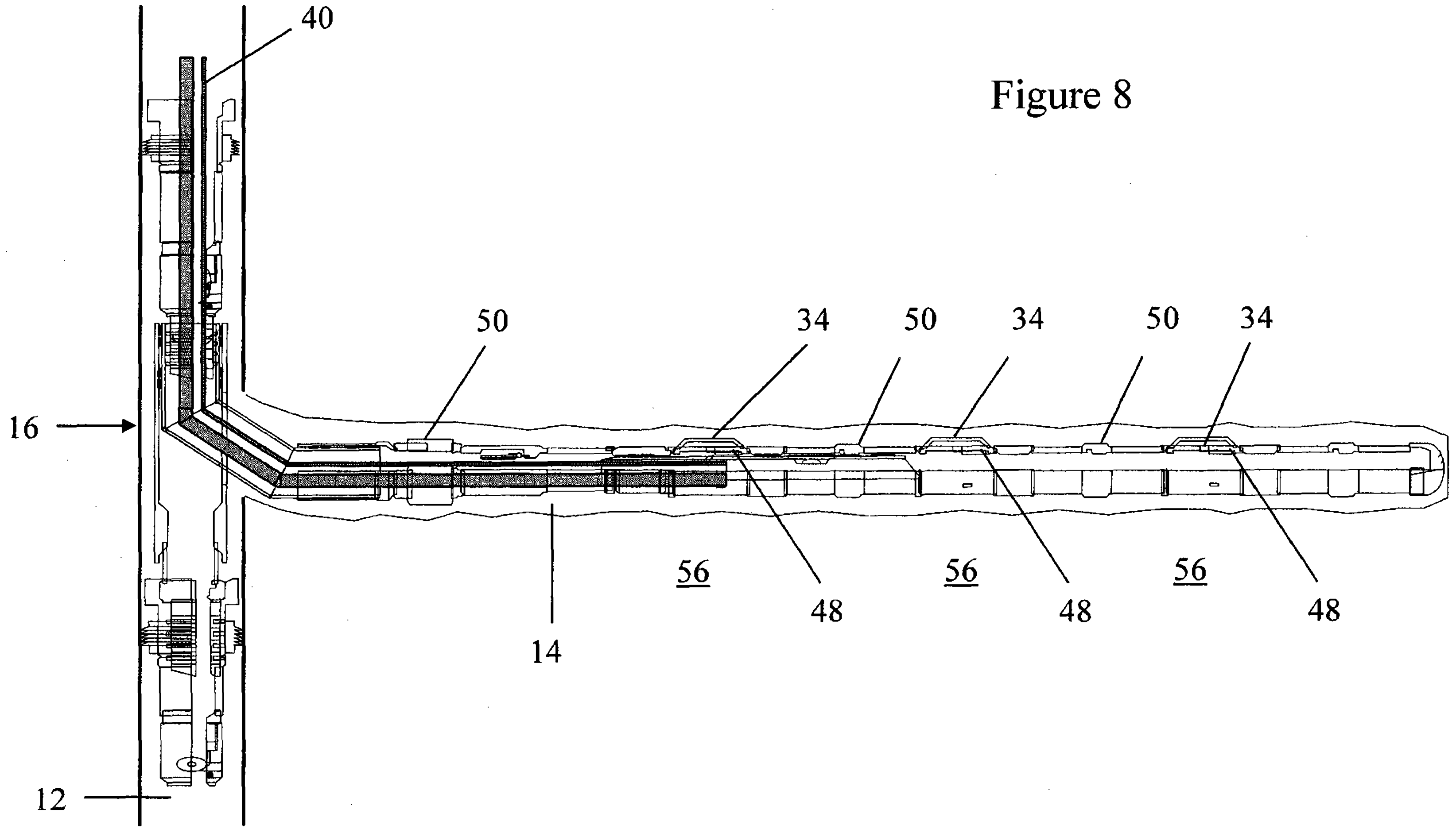

Figure 8

Figure 9