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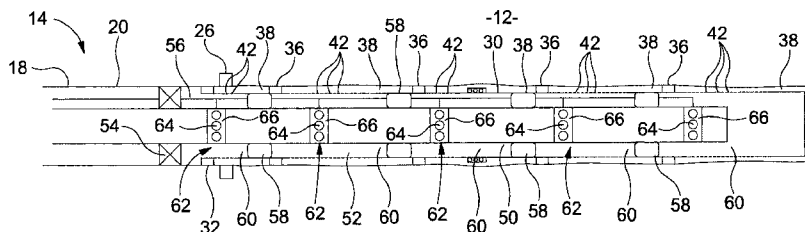


FIG. 3

(57) **Abstract:** A well completion system comprises an outer tubular skin comprising a plurality of axially distributed stimulation fluid ports for facilitating flow through a wall structure of the outer tubular skin, and an inner tubular skin located within the outer tubular skin and defining an inner annulus with the outer tubular skin, wherein the inner tubular skin comprises a plurality of axially distributed flow control ports for facilitating flow through a wall structure of the inner tubular skin. A plurality of outer packers are axially distributed along the outer surface of the outer tubular skin for establishing a plurality of isolated outer zones, and a plurality of inner packers are axially distributed along the inner annulus for establishing a plurality of isolated inner zones, wherein at least one stimulation port and at least one flow control port is located between adjacent inner packers. A first flow control arrangement is provided and is configurable from a closed configuration in which one or more of the stimulation fluid ports are at least partially blocked, to an open configuration in which one or more of the stimulation ports are open. A second flow control arrangement is provided and is operable to control flow through the flow control ports.



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WELL COMPLETION

FIELD OF THE INVENTION

5 The present invention relates to systems and methods for use in well completion, and in particular to well completion which supports stimulation regimes, such as acid stimulation regimes.

BACKGROUND TO THE INVENTION

10 In the oil and gas exploration and production industries wellbores are drilled from surface to intercept subterranean formations or reservoirs. These wellbores may be used to produce fluids, such as oil and gas, from a subterranean reservoir to surface. Further, these wellbores may be used to inject a fluid, such as water or gas, into a subterranean region, for example to assist in recovery of a further fluid to surface, for disposal, and the like.

15 Wellbores are typically formed in stages, with a first section drilled and then lined with casing which is cemented in place for sealing and support. A further section may then be drilled to advance the bore, with the further drilled section also lined with casing. This process is repeated until the bore intercepts the target formation or reservoir, with the reservoir section of the bore typically being lined with a reservoir
20 liner, which may be cemented in place or sealed via open-hole liner packers.

Once the reservoir section is lined, this may be perforated at various locations along its length to establish fluid communication between the reservoir and the wellbore. A production/injection completion may then be installed, which includes a tubing string with multiple flow ports along its surface to facilitate entry of reservoir
25 fluids to be communicated to surface, or injection of fluids from surface into the reservoir.

In many instances efficient production or injection rates can only be achieved if the reservoir is first stimulated. Many stimulating techniques are known, such as fracturing and acid stimulation, which usually function to effectively increase the
30 permeability or porosity of the reservoir at least in the near-wellbore region and effectively improve the fluid connectivity between the reservoir and wellbore.

The present applicant has developed a technique known as the Perforate, Stimulate and Isolate (PSI) completion system, in which individual sealed zones within the perforated liner are established by use of a number of packers mounted on the
35 production/injection string. The production/injection string includes sliding sleeves

which are opened to permit outflow of a stimulating fluid, such as an acid, fracturing fluid and the like, into each isolated zone and ultimately into the reservoir via the liner perforations. These sliding sleeves are typically operated by coiled tubing extended from surface, and as such the total length of this type of completion may be restricted to the reach of the coiled tubing. Other factors may also limit the achievable depth of these conventional liner based and zoned completions. A maximum reach of this type of completion may be in the region of 4877 m (16,000 feet).

The provision of a zoned completion, such as in the PSI type completion, allows stimulation to occur on a zone-by-zone basis, which can be advantageous. Also, during subsequent production or injection the individual zones may permit a more localised control of fluid transfer between the wellbore and reservoir. For example, water breakthrough during production may be addressed by closing off only the affected zones, allowing the reservoir to continue to produce via the remaining zones.

To maximise the interface area between the wellbore and the reservoir and maximise recovery rates it is desirable to extend wellbores beyond the depth dictated by conventional completion techniques. For example, although certain conventional completion techniques might have a maximum reach of around 4877m (16,000 feet), drilling techniques nevertheless permit depths significantly beyond this to be achieved, such as up to 12192 m (40,000 feet). However, the process of drilling the bore often has a detrimental effect on the bore/reservoir interface region, causing damage in the near-wellbore region, resulting in a reduction in porosity and permeability and thus restricting inflow of reservoir fluids. This damage or reduction in porosity and permeability is often termed the wellbore skin, and must be addressed to ensure efficient production rates are achieved. In addition to this, the reservoir itself may also require a degree of stimulation to permit efficient production rates to be achieved. However, providing appropriate stimulation at such extended depths is challenging.

The present applicant has developed a very successful technique for use in stimulating extended reach reservoir sections, which is disclosed in EP 1 184 537 and in SPE paper 78318 entitled "Controlled Acid Jet (CAJ) Technique for Effective Single Operation Stimulation of 14,000+ ft Long Reservoir Sections". The disclosure of each of these documents is incorporated herein by reference. This technique involves running a liner into an open drilled bore which extends beyond an existing lined upper bore section. The liner includes pre-drilled holes along its length at a desired spacing. An acid, such as hydrochloric acid, is pumped through the liner and exits the pre-drilled holes into the annulus between the liner and the bore wall. This acid functions to break

down mud cake which may be formed on the wellbore surface and then flow into the reservoir to stimulate the reservoir. The spacing of the holes is selected to provide substantially uniform distribution of the acid along the length of the liner. The present applicant identifies this technique as a Controlled Acid Jet (CAJ) technique, and the associated liner with drilled holes as a CAJ liner. In such CAJ liner techniques subsequent production, or even injection, is achieved via the pre-drilled holes.

This CAJ liner technique is very effective and has permitted significantly extended wellbore sections to become viable. However, the CAJ liner technique as described above treats the entire extended wellbore section as a single zone.

Furthermore, it is well known in the art that recovery from a reservoir may be maximised by controlling or balancing the inflow profile along the length of an associated wellbore. This may be achieved by use of inflow control devices (ICDs) which are installed along the length of a completion in individual completion zones. The ICDs function to choke inflow from the reservoir, and by setting each ICD to provide a necessary choking effect for its associated zone, the inflow from the reservoir can be balanced. Such inflow control may be used for many purposes, for example to permit lower permeability zones to contribute more evenly with higher permeability zones. For example, ICDs associated with high permeability zones may provide an increased choking effect compared with the ICDs in lower permeability zones. This may assist to avoid adverse events such as water coning and early water breakthrough in individual regions. Establishing a necessary flow profile may also be employed in injection wells, in which the outflow profile is controlled, perhaps allowing a more even pressurising of the reservoir.

However, in the conventional single zone CAJ liner technique described above such flow control may be difficult to achieve.

WO 2010/149643 and WO 2010/149644 propose a completion assembly for use in extended reach wellbores which provides the ability to use this CAJ stimulation regime while providing zonal isolation and permitting flow control to be achieved. In such a completion system a tubing string includes a number of packers along its length, such that when the tubing string is located within a wellbore the packers may be activated to isolate individual zones. Within each zone the tubing string includes first and second sets of ports. Each port of the first set includes a check valve which only permits outflow from the tubing. As such, the first set of fluid ports are intended to accommodate outflow of an acid into the surrounding reservoir. In some disclosed embodiments the first set of fluid ports may each include valves which function to

selectively close the first set of ports to flow in any direction. The second set of ports include a valve, such as a sliding sleeve valve, which is controllable to selectively open and close the second fluid ports. In operation, acid is delivered through the first fluid ports for stimulation purposes, and production is achieved via the second fluid ports.

5 Inflow control may be achieved via the second fluid ports by the selective control of the associated valves.

However, the systems disclosed in WO 2010/149643 and WO 2010/149644 are particularly sensitive to the reliability of the individual valves, in particular the valves associated with the first fluid ports. That is, if the valves associated with the first fluid

10 ports fail to check inflow from the reservoir, or fail to close during production, then inflow will by-pass the second fluid ports, thus eliminating any desired inflow control. In well completions which include perhaps more than 50, for example more than 150 valves to operate the first fluid ports, reliability concerns can be significant.

Further, although the systems disclosed in WO 2010/149643 and WO

15 2010/149644 generally provide a zoned completion system, there is no disclosure of independent control of the first fluid ports between different zones to achieve stimulation on a zone-by-zone basis. Instead, all zones would be stimulated simultaneously.

Also, in extended reach wells physical intervention may be difficult to facilitate

20 actuation of the individual valves. As such, extended reach completion systems which employ relatively sophisticated valves, such as valves which must both open and close, may require associated control lines to extend from surface. Such control lines would typically be located externally of the completion, and thus at risk of damage by engagement with the open drilled section. Also, during running operations into

25 extended reach wells it is advantageous for an operator to have the ability to rotate the deployed tubing string, for example to assist with insertion, which may be difficult where external control lines are present.

Further, in extended reach situations it is often desired to be able to deploy infrastructure in sections, for example using tubing latches, polished bore receptacles

30 and the like. However, the presence of control lines would necessitate the use of far more complex downhole connections, such as wet-mate connectors, which introduces additional potential failure points within the system.

SUMMARY OF THE INVENTION

An aspect of the present invention relates to a completion system for use in a wellbore.

5 The completion system may facilitate a treatment operation of or within an associated wellbore and/or formation surrounding the wellbore. Such a treatment may include a stimulation treatment, such as fracturing, acid matrix stimulation or the like.

The completion system may facilitate production from the formation, for example following a treatment operation. The completion system may facilitate injection into the formation, for example following a treatment operation.

10 The completion system may be utilised in any wellbore at any depth. However, advantages of the completion system may address issues associated with extended reach wellbores, such as wellbores with depths exceeding 3000m (around 10,000 feet), for example exceeding 4877 m (16,000 feet). As such, the completion system may define an extended reach completion system.

15 The completion system may be capable of providing controlled inflow from the formation during production from the formation, and/or controlled outflow into the formation during injection into the formation. Such controlled inflow and/or outflow may permit a desired production or injection profile to be achieved along a necessary length of a wellbore.

20 The completion system may include outer and inner tubular skins mounted generally concentrically. In such an arrangement the outer tubular skin, when located within a wellbore, may define an outer annulus between said outer skin and a wall surface of a wellbore, such as might be defined by an open drilled wellbore, and/or a previously cased or lined wellbore. Further, an inner annulus may be defined between
25 the outer and inner tubular skins.

The inner and outer tubular skins may be axially fixed relative to each other, at least when the inner skin is mounted, for example fully installed, within the outer skin.

30 The outer tubular skin may be configured to facilitate flow through a wall structure thereof. The outer tubular skin may be configured to facilitate outflow and/or inflow relative to a central bore of the outer skin. Generally, the outer tubular skin may facilitate fluid communication between a central bore of the outer tubular skin and an outer space, such as an outer annulus, defined externally of the outer tubular skin. More particularly, the outer tubular skin may facilitate fluid communication between an outer space, such as an outer annulus, externally of said outer tubular skin, and an
35 inner annulus defined between the outer and inner tubular skins.

The outer tubular skin, or portions thereof, may be configured to prevent fluid communication therethrough.

5 The inner tubular skin may be configured to facilitate flow through a wall structure thereof. The inner tubular skin may be configured to facilitate inflow and/or outflow relative to a central bore of the inner skin. Generally, the inner tubular skin may facilitate fluid communication between a central bore of the inner tubular skin and an inner annulus defined between the outer and inner tubular skins. The inner tubular skin may be configured to facilitate choked flow, such as choked inflow and/or outflow. Such choked flow may permit control over production and/or injection rates to be achieved, for example by providing a desired flow profile along a length of the completion system. Further, in such an arrangement the inner tubular skin may be configured to provide a desired flow choking effect, substantially independently of the outer skin. Accordingly, the operation of the outer skin, such as reliability of associated components, may provide minimal influence on the choking effect provided by the inner tubular skin.

15 Permitting both the inner and outer skins to provide fluid communication through the respective wall structures may facilitate a continuous fluid communication path between the central bore of the inner skin and a space, such as an annulus, externally of the outer skin. This may permit a treating fluid, for example, to be delivered downhole via the inner skin, and communicated outwardly from the completion system and into the associated wellbore and/or surrounding formation. Further, this arrangement may permit or accommodate fluids from a surrounding formation, such as hydrocarbon fluids, to enter the completion system, into the central bore of the inner skin, and delivered towards surface via said inner skin.

20 The outer tubular skin may comprise a plurality of stimulation ports configured to facilitate fluid communication through a wall structure of said outer skin. The stimulation ports may facilitate fluid communication to and/or from a central bore of the outer skin, particularly to and/or from an inner annulus defined between the outer and inner tubular skins. The stimulation ports may be configured to accommodate outflow of a treating fluid, such as an acid, fracturing fluid or like, into a formation surrounding an associated wellbore. The stimulation ports may facilitate inflow from the surrounding formation, such as inflow of hydrocarbon fluids, for example following a treating operation. The stimulation ports may facilitate injection into the formation, such as injection of water, for example following a treating operation.

The stimulation ports may be arranged axially along the outer skin. A single stimulation port may be provided at a single axial location. Multiple stimulation ports may be provided at a single axial location, for example circumferentially distributed around the outer skin. Multiple pairs of axially adjacent stimulation ports may be arranged at a common axial spacing or pitch. In some embodiments at least one pair, and in some embodiments multiple pairs of adjacent stimulation ports may be separated by, for example, between 6.1 and 152.5 m (between 20 and 500 feet), for example between 30.5 and 91.4 m (between 100 and 300 feet), for example around 61 m (around 200 feet). In an exemplary embodiment a 9144 meter (30,000 feet) long outer tubular skin may comprise around 150 stimulation ports arranged along its length.

Multiple pairs of axially adjacent stimulation ports may be arranged at a different axial spacing or pitch. Such an arrangement may facilitate a desired stimulation flow characteristic from the outer skin.

In some embodiments the stimulation ports may be arranged in accordance with acid stimulation practices, such as described in SPE paper 78318 entitled "Controlled Acid Jet (CAJ) Technique for Effective Single Operation Stimulation of 14,000+ ft Long Reservoir Sections".

The completion system may comprise a first flow control arrangement associated with the stimulation ports. The first flow control arrangement may be configurable from a closed configuration, in which one or more of the stimulation ports are blocked, to an open configuration in which one or more of the stimulation ports are open. When in the closed configuration the first flow control arrangement may partially block one or more stimulation ports to restrict flow therethrough. However, in some embodiments, when in the closed configuration the first flow control arrangement may completely block one or more of the stimulation ports to prevent flow therethrough.

The first flow control arrangement may be initially provided, or commissioned, in its closed configuration. In such an arrangement the first flow control arrangement may block or close the stimulation ports during deployment of the outer tubular skin into a wellbore. Initially blocking the stimulation ports may permit the outer tubular skin to be floated into the wellbore. Initially blocking the stimulation ports may permit isolation between the outer tubular skin and the wellbore, for example an annulus formed between the outer skin and a bore wall, which may provide advantages in terms of well control and safety during deployment. Initially blocking the stimulation ports may permit circulation through the wellbore annulus to be achieved, for example during deployment or following deployment and prior to the stimulation ports being opened.

Such circulation may be utilised to displace a fluid from the wellbore, to introduce a desired fluid into the wellbore, such as a fluid with a desired fluid density, for example for use in well control and the like. Further, initially blocking the stimulation ports may permit pressure within the outer skin to be elevated, for example to facilitate performance of downhole operations. Such downhole operations may include actuation of downhole components. For example, such downhole operations may include actuation of packers. That is, by initially closing the stimulation ports, the pressure within the outer tubular skin may be elevated, for example to hydraulically actuate the packers or other components.

In some embodiments the first flow control arrangement may be configurable only from its closed configuration to its open configuration. In such an arrangement the first flow control arrangement may comprise a single acting fluid control arrangement, configured only to open the stimulation fluid ports from an initial closed configuration. That is, the first flow control arrangement may intentionally not be capable or required to be subsequently reconfigured from its open configuration to its closed configuration. Such an arrangement may facilitate the ability to simplify the first flow control arrangement. Such simplification may permit a more reliable system to be provided. For example, any failure mode associated with any requirement to subsequently close the stimulation ports following opening may be substantially eliminated.

The first flow control arrangement may comprise an activator system, configured to initiate reconfiguration from the closed configuration to the open configuration. The activator system may be configured to retain the first flow control arrangement in its closed configuration, wherein the activator system allows reconfiguration of the first flow control arrangement to its open configuration in response to a stimulus.

The first flow control arrangement may be operated or actuated to open the stimulation ports by a downhole or ambient stimulus. Such an ambient stimulus may include a downhole condition or property in the downhole region or environment associated with the first flow control arrangement.

The use of an ambient stimulus may minimise the requirement to provide dedicated control systems and apparatus within the completion system to otherwise facilitate operation of the first flow control arrangement. For example, configuring the first flow control arrangement to be operated by an ambient stimulus may eliminate or minimise the requirement to provide dedicated control lines, such as electrical conductors, hydraulic lines and the like, extending from surface along the length of the

outer tubular skin. Such control lines may present potential additional failure modes within the completion system. Further, control lines are typically mounted externally of downhole tubulars, and as such may be at risk of damage due to contact with a bore wall, which may be of particular concern in open hole conditions where contact with the subterranean rock structure is possible. Also, the presence of control lines may increase the friction drag during deployment into a wellbore. Further, the use of control lines may render it difficult to allow rotation of the outer tubular skin during deployment, which may be desirable by an operator, for example to assist by providing an additional mechanical degree of freedom in movement.

The first flow control arrangement may be operated or actuated by an ambient fluid stimulus. The ambient fluid stimulus may comprise or be defined by a property of a fluid in the downhole environment. Such a fluid may be defined as an ambient fluid. Such a fluid may comprise a naturally occurring downhole fluid, such as a fluid which is released from a surrounding formation. Alternatively, or additionally, such a fluid may comprise an artificially occurring fluid, including a fluid delivered from surface, such as a drilling mud, completion fluid, treating fluid, acid, fracturing fluid, cement or the like.

The ambient fluid stimulus may comprise fluid pressure. For example, exposure to a predetermined pressure may facilitate operation or actuation of the first flow control arrangement. For example, exposure of an associated activator system to a predetermined fluid pressure may initiate operation of the first flow control arrangement to open the stimulation ports.

The ambient fluid stimulus may comprise a fluid type. For example, exposure to a particular fluid or fluid type, such as water, hydrocarbons, an acid or the like may facilitate operation or actuation of the first flow control arrangement. For example, exposure of an associated activator system to a particular type may initiate operation of the first flow control arrangement to open the stimulation ports.

The ambient fluid stimulus may comprise a fluid chemical property.

The ambient fluid stimulus may comprise a fluid density.

The first flow control arrangement may be operated or actuated by an operator controlled ambient stimulus. In such an arrangement an operator may control or modify ambient conditions to create or establish a necessary, for example predetermined, stimulus to facilitate operation of the first flow control arrangement to open the stimulation ports.

The first flow control arrangement may be operated or actuated in response to an operator modified, for example increased, fluid pressure within the outer tubular skin

towards an activation pressure. For example, an operator may modify fluid pressure within the outer tubular skin towards an activation pressure, to operate the first flow control arrangement to open the stimulation ports. Providing the first flow control arrangement in an initially closed configuration may permit an operator to modify the fluid pressure within the outer tubular skin.

The first flow control arrangement may be operated or actuated in response to an operator modified fluid type within the outer tubular skin, for example to expose the first flow control arrangement to a desired fluid stimulus. That is, an operator may deliver an activator fluid into the outer tubular skin, which may displace a resident fluid, to operate the first flow control arrangement to open the stimulation ports. In such an arrangement the completion system may be configured to accommodate circulation therein, for example to permit an operator to deliver a desired fluid from surface to displace an original or resident fluid. Such circulation may be achieved by use of a circulating bottom hole assembly, which may be secured to an end region of the outer tubular skin. Such an arrangement may be achieved by use of tubing, such as coiled tubing, extending into the outer skin. In one embodiment the activator fluid may comprise a treatment fluid, such as a fracturing fluid, an acid, such as hydrochloric acid, or the like. In such an arrangement the activator fluid may function as an appropriate stimulus to operate the first flow control arrangement to open the stimulation ports, and subsequently be delivered into the associated wellbore and/or formation via the opened stimulation ports to perform a desired treatment.

The first flow control arrangement may comprise a stimulation valve arrangement or assembly.

The first flow control arrangement may comprise a plurality of stimulation valve assemblies associated with the stimulation ports. Each stimulation port may be associated with a respective stimulation valve assembly.

At least one stimulation valve assembly may be configurable from a closed configuration, in which an associated stimulation port is at least partially blocked, and in some embodiments fully blocked, to an open configuration in which an associated stimulation port is open.

At least one stimulation valve assembly may be operated or actuated by an ambient stimulus, for example as defined above.

At least one stimulation valve assembly may comprise or define a self-opening valve assembly, for example in response to an ambient stimulus.

At least one stimulation valve assembly may define a single acting stimulation valve assembly, operable only to open an associated stimulation port.

At least one stimulation valve assembly may comprise a valve member configured to be moved relative to an associated stimulation port to permit said port to become opened. The valve member may be moveable in response to a stimulus, such as an ambient stimulus.

At least one stimulation valve assembly may comprise a force arrangement configured to apply a motive force to an associated valve member to move said valve member relative to an associated stimulation port to permit said port to become opened.

The force arrangement may be operated in response to an ambient stimulus.

The force arrangement may comprise a swellable body configured to swell upon expose to an activator fluid, such as water, oil or the like. Such swelling may displace an associated valve member to open an associated stimulation port.

The force arrangement may comprise an energy storage device. The energy storage device may be configured or permitted to release stored energy and move an associated valve member in response to a stimulus, such as an ambient stimulus.

The energy storage device may be charged prior to deployment of the outer tubular skin into a wellbore. As such, any requirement to deliver energy to the valve assembly while in situ downhole may be minimised or eliminated.

The energy storage device may comprise an elastic member, such as a spring member, elastically deformable body or the like.

The energy storage device may comprise a pressure chamber, such as a vacuum chamber, pressurised chamber or the like.

At least one stimulation valve assembly may comprise a latch arrangement configured to temporarily secure an associated valve member in a closed position. Such a latch arrangement may be releasable in response to exposure to an ambient stimulus. Following release, a force arrangement, such as an energy storage device, may cause the valve member to move to open the associated stimulation port. Such a latch arrangement may be frangible, dissolvable or the like. Such a latch arrangement may comprise a shear screw, dissolving pin or the like.

The outer skin may be configured to be deployed as a continuous tubular string. For example, the outer skin may comprise a unitary or single length of tubular, such as coiled tubing or the like. Alternatively, the outer skin may comprise multiple tubular

components secured together, for example by threaded connections, at surface level, and then deployed into a wellbore as a single or continuous tubular structure.

The outer skin may be configured to be deployed in multiple sections. In such an arrangement the completion system may comprise a plurality of outer skin sections or segments arranged to be deployed into a wellbore independently of each other and coupled together downhole. Such an arrangement may avoid or minimise complexities associated with running extended continuous lengths of tubulars. Further, such an arrangement may facilitate improved subsequent workover or intervention operations. For example, any requirement to retrieve the outer tubular skin, for example to replace faulty components does not necessarily require the entire outer skin to be recovered to surface.

The outer tubular skin may comprise one or more downhole connectors configured to permit individual outer skin sections to be coupled together at a downhole location. A downhole connector may comprise a seal stem. A downhole connector may comprise a Polished Bore Receptacle (PBR). A downhole connector may comprise a latch arrangement.

Where the requirement for control lines are minimised or eliminated, for example as an ambient stimulus is used to actuate or operate the first flow control arrangement, this may in turn minimise or eliminate the requirement to also provide suitable connectors for control lines. Downhole connectors for control lines are recognised as a significant failure point within wellbore systems, and as such eliminating the requirement for control lines may in turn eliminate the requirement for control line connectors, minimising the number of possible failure points within the entire completion system.

The completion system may comprise a plurality of outer packers axially distributed along the outer surface of the outer tubular skin. The outer packers may be arranged to establish sealing engagement with an inner surface of a wellbore, such as might be defined by an open drilled wellbore, and/or a previously cased or lined wellbore. The outer packers may be arranged to establish a plurality of isolated outer zones along an outer annulus defined between the outer tubular skin and an inner surface of a wellbore.

The axial spacing between adjacent pairs of outer packers may define the extent of individual zones. Any suitable spacing between adjacent pairs of outer packers may be provided. At least one pair of adjacent packers may be axially separated by, for example between 152.4 and 3048 m (between 500 and 10,000 feet),

for example between 610 and 2286 m (between 2,000 and 7,500 feet), for example by around 1524 m (around 5,000 feet).

At least one stimulation port may be provided between axially adjacent outer packers. As such, in some embodiments, where the outer packers are activated to
5 create multiple isolated outer zones, at least one stimulation port may provide fluid communication between the outer tubular skin and each outer isolated zone.

In some embodiments a plurality of axially separated stimulation ports may be provided between axially adjacent outer packers. Any number of stimulation ports may be provided between axially adjacent outer packers. In some embodiments between 2
10 and 50, for example between 15 and 35, such as around 25 axially separated stimulation ports may be provided between adjacent outer packers. In one exemplary embodiment a pair of axially adjacent outer packers may be separated by around 1524 m (5000 feet), and around 25 axially separated stimulation ports may be provided between said pair of adjacent packers. In this exemplary embodiment the stimulation
15 ports may be axially separated by around 61 m (200 feet).

The outer packers may be of any suitable form, such as swellable packers, inflatable packers, axially compressible packers, hydraulically actuated packers or the like, or any suitable combination. The outer packers may define open hole packers.

The inner tubular skin may be deployed simultaneously with the outer tubular
20 skin. Alternatively, the inner tubular skin may be deployed subsequently to the outer tubular skin.

The stimulation ports of the outer tubular skin may be configured to be opened before the inner tubular skin is deployed. In some embodiments a treating operation may be performed prior to running the inner tubular skin. Alternatively, or additionally,
25 a treating operation may be performed after deployment of the inner tubular skin. Alternatively, the stimulation ports may be opened after deployment of the inner tubular skin.

The inner tubular skin may comprise a plurality of flow control ports configured to facilitate fluid communication through a wall structure of said inner skin. The flow
30 control ports may facilitate fluid communication to and/or from a central bore of the inner skin, particularly fluid communication between a central bore of the inner skin and an inner annulus defined between the outer and inner tubular skins.

The flow control ports may be configured to accommodate outflow of a treating fluid, such as an acid, fracturing fluid or the like, into the inner annulus. Such a treating
35 fluid may be subsequently communicated outwardly from the inner annulus through the

wall structure of the outer tubular skin, for example via one or more stimulation ports formed in the outer skin.

5 The flow control ports may be configured to facilitate inflow from the inner annulus, for example inflow of hydrocarbons which have been received within the inner annulus via the outer tubular skin, such as via one or more stimulation ports in the outer tubular skin.

10 The flow control ports may facilitate controlled fluid communication to and/or from the central bore of the inner skin. Such controlled fluid communication may comprise flow choking. Different flow control ports may provide different flow control, for example different levels of flow choking. Such an arrangement may permit a desired flow profile to be achieved within the completion system, for example along the length of the completion system. In this respect, any desired flow control, such as choking, provided by the flow control ports, including any desired flow profile provided by the flow control ports, may be substantially unaffected by the outer tubular skin, for
15 example by components of the outer tubular skin, such as stimulation ports and/or the first flow control arrangement. For example, the failure of one or more stimulation valves may have minimal effect of the function of the flow control ports of the inner tubular skin. In such an arrangement isolation of the flow control ports and the function of the inner skin from the outer skin and associated components may permit reliability concerns and sensitivities associated with the outer skin and associated components to
20 be minimised, allowing simpler components and structures to be utilised.

One or more flow control ports may define a flow restriction, such as an orifice, configured to choke flow flowing therethrough. Different flow control ports may define different flow restrictions, to provide different levels of flow choking.

25 One or more flow control ports may define a variable flow restriction. Such an arrangement may permit flow control to be modified.

The flow control ports may be arranged axially along the inner skin. A single flow control port may be provided at a single axial location. In some embodiments multiple flow control ports may be arranged at a single axial location, for example
30 circumferentially distributed around the inner tubular skin.

At least one pair of axially adjacent flow control ports may be axially separated by, for example between 152.4 and 3048 m (between 500 and 10,000 feet), for example between 610 and 2286 (between 2,000 and 7,500 feet), for example by around 1524 m (around 5,000 feet). In an exemplary embodiment a 9144 meter

(30,000 feet) long inner tubular skin may comprise at least one flow control port at 6 axially separated regions along the length of the inner tubular skin.

The completion system may comprise a second flow control arrangement associated with the flow control ports of the inner tubular skin.

5 The second flow control arrangement may comprise a flow restriction associated with one or more flow control ports.

The second flow control arrangement may facilitate variable control of flow through the flow control ports. For example, the second flow control arrangement may facilitate selective variable control of flow through the flow control ports. Such selective
10 variable control of flow may provide a variable control of flow choking.

In one embodiment, the second flow control arrangement may be configured to independently control individual flow control ports, or individual groups of flow control ports, for example groups of flow control ports located at a common axial location along the length of the inner tubular skin. Such an arrangement may permit independent
15 control of individual zones along the completion system. For example, a treatment operation may be facilitated or controlled on a zone-by-zone basis. Further, inflow may be facilitated or controlled on a zone-by-zone basis.

The second flow control arrangement may be configurable between a closed configuration in which one or more the flow control ports are at least partially blocked, for example fully blocked, and an open configuration in which one or more flow control
20 ports are open.

The second flow control arrangement may be configured in its closed configuration during deployment of the inner tubular skin into a wellbore. Such an arrangement may provide a number of advantages, such as permitting the inner tubular skin to be floated into a wellbore and the like.
25

The second flow control arrangement may be configurable from its closed configuration to its open configuration. This may permit one or more closed or blocked flow control ports to become opened, for example to permit a treating fluid to flow outwardly from the inner skin, and/or to permit inflow of a fluid, such as hydrocarbons,
30 into the inner skin.

The second flow control arrangement may be configurable from its open configuration to its closed configuration. This may permit one or more open flow control ports to become closed, or further choked, and prevent or restrict flow through said ports. Such an arrangement may permit isolation of one or more flow control
35 ports, for example to minimise or prevent inflow from particular sections or zones of the

completion system. Such an arrangement may facilitate zonal isolation of regions with early water breakthrough, for example.

5 The second flow control arrangement may be configured to be operated from surface. The second flow control arrangement may be configured to be operated via one or more control lines, such as electrical control lines, hydraulic control lines, optical control lines, or the like. In such an arrangement the completion system may comprise one or more control lines extending along or adjacent the inner tubular skin for use in operation of the second flow control arrangement. One or more control lines may extend along an outer surface of the inner tubular skin. In such an arrangement the
10 presence of the outer tubular skin may provide a degree of protection to the one or more control lines. Further, the outer tubular skin may define a lower coefficient of friction relative to an open drilled bore, such that running the inner tubular skin into the outer tubular skin may be achieved with less frictional drag and risk of damage than running through an open drilled bore.

15 The second flow control arrangement may be configured to be operated by rig (for example via a workstring) or rigless intervention.

The second flow control arrangement may be configured to be operated via one or more elongated members deployed from surface.

20 The second flow control arrangement may be configured to be operated by coiled tubing deployed from surface.

The second flow control arrangement may be configured to be operated by wireline, slickline, e-line, braided line or the like for example by use of an associated actuating/shifting tool. In such an arrangement the wireline may be deployed via a tractor.

25 The second flow control arrangement may comprise a flow control valve arrangement or assembly.

The second flow control arrangement may be configured for wireless actuation. The second flow control arrangement may be configured for actuation via a timer arrangement. The second flow control arrangement may be configured for actuation
30 via an external stimulus, such as temperature absolute pressure, differential pressure, stress, strain, flow rate, acoustic signals, pressure variations or profiles, or the like.

The second flow control arrangement may comprise one or more Inflow Control Valves (ICVs) or Inflow Control Devices (ICDs).

35 The second flow control arrangement may comprise a plurality of flow control valve assemblies associated with the flow control ports. Individual flow control valve

assemblies may be distributed along the length of the inner tubular skin. Each flow control valve assembly may be associated with one or more flow control ports located at a common axial location along the length of the inner tubular skin.

5 At least one flow control valve assembly may be configurable between a closed configuration, in which one or more associated flow control ports are at least partially blocked, and in some embodiments fully blocked, and an open configuration in which one or more associated flow control ports are open.

At least one flow control valve assembly may be configured to vary flow choking through an associated flow control port.

10 At least one flow control valve assembly may comprise a sleeve slidably mounted relative to the inner tubular skin. Such a sleeve may move relative to one or more flow control ports to selectively open and close said one or more flow control ports. The sleeve may define a Sliding Sleeve Door (SSD).

15 At least one flow control valve assembly may be operated from surface, for example via one or more control lines, coiled tubing or the like.

20 The completion system may comprise a plurality of inner packers axially distributed along an inner annulus defined between the outer and inner tubular skins. The inner packers may be arranged to establish sealing between the outer and inner tubular skins. The inner packers may be arranged to establish a plurality of isolated inner zones along the inner annulus.

The inner packers may assist or function to axially secure the inner string relative to the outer string.

25 One or more of the inner packers may be mounted on the outer surface of the inner tubular skin. In some embodiments one or more of the inner packers may be mounted on the outer tubular skin, for example on the inner surface of the outer tubular skin.

30 The inner packers may be located along the completion system to generally correspond to the positioning of the outer packers. In such an arrangement isolated inner zones formed within the inner annulus between the outer and inner tubular skins may be generally aligned and correspond with isolated outer zones formed within an outer annulus defined between the outer tubular skin and an inner surface of a wellbore. Accordingly, the inner and outer packers may be configured or operated to define individual zones along the length of the completion system.

35 The axial spacing between adjacent pairs of inner packers may define the extent of individual inner zones. At least one pair of adjacent inner packers may be

axially separated by, for example between 152.4 and 3048 m (between 500 and 10,000 feet), for example between 610 and 2286 m (between 2,000 and 7,500 feet), for example by around 1524 m (around 5,000 feet).

5 At least one flow control port may be provided between axially adjacent inner packers. As such, in some embodiments, where the inner packers are activated to create multiple isolated inner zones, at least one flow control port may provide fluid communication between the inner tubular skin and each inner isolated zone.

10 A circumferential array of flow control ports may be provided between axially adjacent inner packers. In some embodiments a single circumferential array of flow control ports may be provided between axially adjacent inner packers. In such an arrangement a single axial location along an isolated inner zone may permit fluid communication with the inner tubular skin. The single circumferential array of flow control ports may be located towards an uphole end of an isolated inner zone.

15 At least one stimulation port may be located between axially adjacent inner packers. As such, at least one stimulation port may provide fluid communication between an isolated inner zone and an isolated outer zone. As such, complete fluid communication between the central bore of the inner tubular skin and an isolated zone within a wellbore may be achieved via one or more flow control ports and one or more stimulation ports within each zoned region.

20 The inner packers may be of any suitable form, such as swellable packers, inflatable packers, axially compressible packers, hydraulically actuated packers or the like, or any suitable combination.

 The inner packers may define feed-through packers, configured to accommodate passage of control lines, for example.

25 The completion system may be deployable through an upper lined wellbore section and into a lower drilled bore section. The completion system may be secured to a lower portion of a liner within an upper wellbore section. For example, the completion system may be secured via a liner hanger. In one embodiment the outer tubular skin may be secured to the liner within the upper wellbore section via a liner hanger.
30

 The inner tubular skin may extend upwardly beyond the upper end of the outer tubular skin. The inner tubular skin may extend upwardly into a liner provided in an upper wellbore section. An upper end of the inner tubular skin may be sealed relative to an upper end of the outer tubular skin and/or a lower end of a liner provided in an

upper wellbore section via a packer. Such a packer may define a feed-through packer to accommodate passage of one or more control lines.

The upper wellbore section may comprise a completion system, such as a Perforate, Stimulate and Isolate (PSI) completion system.

5 Terms such as "upper", "lower", "upwardly", "downwardly", "below" and "above", and other similar terms, as used herein should be assumed in relation to the entry point of a bore, such that a region or section nearer to an entry point may be defined as an upper region, and a region further from an entry point may be defined as a lower region. In this respect, the drilled bore may extend vertically, horizontally, and/or
10 inclined.

The outer tubular skin may comprise a plug arrangement located at the lower end thereof. Such a plug arrangement may be configured to isolate, for example partially or fully isolate, the lower end of the outer tubular skin. The plug arrangement may comprise a sealing bottom hole assembly. The plug arrangement may comprise a
15 float shoe. Such a float shoe may facilitate circulation within the wellbore via the outer tubular skin.

An aspect of the present invention relates to a method for installing a completion system, such as a completion system defined herein, into a wellbore.

The method may comprise deploying the completion system through an upper
20 lined wellbore section and into a lower drilled bore section.

The completion system may be configured for use in a bore associated with a carbonate formation.

An aspect of the present invention relates to a method for completing a wellbore, for example using a completion system defined herein.

25 An aspect of the present invention relates to a wellbore system comprising a completion system as defined herein.

The wellbore system may comprise a bore extending from surface level. The completion system may be deployed along the entire length of the bore. The completion system may be deployed partially along the length of the bore. In one
30 embodiment the completion system may be deployed in a lower section of the bore. The lower section of the bore may extend below an upper section of the bore. The upper section of the bore may be lined, for example with a cemented liner. The upper section of the bore may comprise a separate completion system. The separate completion system may be a PSI type completion system.

An aspect of the present invention relates to a method for forming a wellbore system, comprising drilling a bore and deploying a completion system into the drilled bore, such as a completion system as defined herein.

5 The method may comprise extending a previously lined bore to create a lower drilled bore section, and then deploying a completion system through the lined bore and into the lower drilled bore section.

An aspect of the present invention relates to a well completion system, comprising:

- an outer tubular skin;
- 10 an outer packer arrangement mounted on the outer skin for establishing an isolated outer zone;
- a stimulation port for facilitating flow through a wall structure of the outer tubular skin in the region of the outer zone;
- a first flow control arrangement configurable from a closed configuration in
15 which the stimulation fluid port is at least partially blocked, to an open configuration in which the stimulation port is open;
- an inner tubular skin located within the outer tubular skin and defining an inner annulus with the outer tubular skin;
- an inner packer arrangement provided within the inner annulus for establishing
20 an isolated inner zone which is axially overlaps the outer zone;
- a flow control port for facilitating flow through a wall structure of the inner tubular skin in the region of the inner zone; and
- a second flow control arrangement operable to control flow through the flow control port.

25 The outer packer arrangement may be configured to define multiple isolated outer zones. A stimulation port may be provided in the region of two or more, for example each, outer zone.

The inner packer arrangement may be configured to define multiple isolated inner zones. Two or more, for example each, inner zone may axially overlap
30 respective outer zones. A flow control port may be provided in the region of two or more, for example each, inner zone.

An aspect of the present invention relates to a well completion system, comprising:

- an outer tubular skin comprising a plurality of axially distributed stimulation fluid
35 ports for facilitating flow through a wall structure of the outer tubular skin;

a plurality of outer packers axially distributed along the outer surface of the outer tubular skin for establishing a plurality of isolated outer zones, wherein at least one stimulation port is provided between adjacent outer packers;

5 a first flow control arrangement configurable from a closed configuration in which one or more of the stimulation fluid ports are at least partially blocked, to an open configuration in which one or more of the stimulation ports are open;

10 an inner tubular skin located within the outer tubular skin and defining an inner annulus with the outer tubular skin, wherein the inner tubular skin comprises a plurality of axially distributed flow control ports for facilitating flow through a wall structure of the inner tubular skin;

a plurality of inner packers axially distributed along the inner annulus for establishing a plurality of isolated inner zones, wherein at least one stimulation port and at least one flow control port is located between adjacent inner packers; and

15 a second flow control arrangement operable to control flow through the flow control ports.

Features defined in relation to one aspect may be applicable to any other aspect.

20 In use, the outer packers may establish a plurality of isolated outer zones along an outer annulus defined between the outer tubular skin and an inner surface of a wellbore, which may be defined by an open drilled bore, or a previously cased or lined wellbore.

In some embodiments an outer and/or inner zone may be defined only by a single packer. For example a lowermost packer may define a single region with the lowermost end of the bore.

25 In use, the completion system may permit zonal isolation along the length of an associated wellbore to be achieved. Furthermore, the completion system may permit treatment, such as stimulation, to be achieved within separate isolated zones. Further, the completion system may permit flow control to be achieved between the completion system and an associated wellbore within isolated zones, for example during
30 production and/or injection. In this respect, providing the stimulation ports and flow control ports on separate tubular skins minimises the sensitivity of the flow control ports to possible failure or improper operation of the first flow control arrangement. That is, fluid will not be permitted to bypass the flow control ports, and thus any desired flow control, such as flow choking, will be permitted to be achieved and maintained
35 irrespective of the proper function of the first flow control arrangement.

Permitting both the inner and outer skins to provide fluid communication through the respective wall structures, via the respective stimulation and flow control ports, may facilitate a fluid communication path between a central bore of the inner skin and a space, such as an outer annulus, externally of the outer skin. This may permit a treating fluid, for example, to be delivered downhole via the inner skin, and communicated outwardly from the completion system and into the associated wellbore and/or surrounding formation, within individual isolated zones. Further, this arrangement may permit or accommodate fluids, such as hydrocarbon fluids, from individual isolated zones along a surrounding formation to enter the completion system, into the central bore of the inner skin, and delivered towards surface via said inner skin.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of an extended reach wellbore, which extends beyond a previously lined wellbore section;

Figure 2 is a diagrammatic illustration of installing an outer tubular skin of a completion system according to an embodiment of the present invention into the open hole section;

Figure 3 is a diagrammatic illustration of installing an inner tubular skin within the outer tubular skin, of a completion system according to an embodiment of the present invention;

Figure 4 illustrates a zoned stimulation treatment being performed with the installed completion system of Figure 3;

Figure 5 illustrates subsequent production via the installed completion system of Figure 3;

Figure 6 illustrates subsequent isolation of production from one of the zones in the installed completion system of Figure 3;

Figures 7A to 7C illustrate sequential stages of operation of an exemplary valve assembly of an outer tubular skin of a completion system according to an embodiment of the present invention; and

Figures 8A and 8B illustrate sequential stages of operation of an alternative exemplary valve assembly of an outer tubular skin of a completion system according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 provides a diagrammatic illustration of a lower region of a subterranean well, generally identified by reference numeral 10, which extends to intercept a subterranean formation 12. The well 10 includes an upper section 14 which includes a drilled bore 16 which is lined with a wellbore liner 18, cemented in place by a cement sheath 20, in accordance with known principles. The well 10 further includes a lower section 22 which extends beyond the upper section 14, and which is defined by an open drilled bore 24.

In the exemplary embodiment shown the lower end of the liner 18, which includes a cement shoe 26, may extend to a depth of, for example, around 4,877 m (16,000 feet). Such a depth is typically dictated by conventional wellbore completion techniques, such as a PSI type completion. That is, conventional completion techniques may only permit a finite depth of lined wellbore to be completed to accommodate stimulation of and subsequent production from the formation 12. However, to maximise recovery it is desirable to extend wellbores beyond the depth dictated by conventional completion techniques. In this respect although certain conventional completion techniques might have a maximum reach of around 4,877 m (16,000 feet), drilling techniques nevertheless permit depths significantly beyond this to be achieved, such as up to 12,192 m (40,000 feet). As such, the lower wellbore section 22 may be readily formed to significant extended depths, such as up to and exceeding 12,192 m (40,000 feet).

However, although the extended reach lower wellbore section 22 may be formed by drilling techniques, difficulties arise in permitting a suitable stimulation treatment at such extended depths to be achieved, while providing certain advantages usually associated with more conventional, shallower completions, such as the ability to provide zonal isolation and the like. The present invention provides a completion system which can permit extended reach wellbores to be appropriately completed, while supporting zonal isolation and both stimulation and production.

An exemplary embodiment of a completion system according to one or more aspects of the present invention will be described below with reference initially to Figures 2 and 3, which show sequential stages of installing the completion system within the lower wellbore section 22.

Referring first to Figure 2, an outer tubular skin 30 is deployed through the upper lined bore section 14 and into the lower open drilled bore 24. The outer skin 30 is secured and sealed to the liner 18 via a liner hanger and liner top packer 32.

In the exemplary embodiment illustrated the outer tubular skin 30 is provided in multiple sections 30a, 30b which are independently deployed into the open bore 24, and coupled together via a downhole connector 34, which may include a seal stem and a Polished Bore Receptacle (PBR) latch. Although two outer skin sections 30a, 30b are illustrated in combination with a single connector 34, any number of individual sections and corresponding connectors may be provided. The ability to deploy the outer tubular skin 30 in independent sections may avoid complications associated with deploying extended lengths of tubulars, for example by reducing friction drag, accommodating wellbore deviations such as dog-legs, assisting with well control during deployment, and the like.

The outer completion skin 30 does not include any associated control lines running along its length. Accordingly, the downhole connector 34 may be significantly simplified in that corresponding connections between control line sections will not be necessary. Further, the absence of any control line connectors eliminates potential additional failure points within the system. Also, the absence of any control lines eliminates the risk of damage to such lines, for example by contact with the bore wall during deployment. Also, friction drag between the outer skin 30, or skin sections 30a, 30b may be reduced due to the absence of control lines. Further, the absence of control lines may permit an operator to rotate the outer skin sections 30a, 30b during deployment, which may assist by providing an additional mechanical degree of freedom in movement.

The outer tubular comprises a closed lower end 28, which may be provided by a sealing bottom hole assembly, a float shoe or the like.

The outer tubular skin 30 comprises a plurality of open hole packers 36 arranged along the outer surface thereof for use in establishing sealing engagement with the wall of the bore 24. When activated, the packers 36 define a number of individual isolated outer zones 38 along an outer annulus 40 formed between the bore wall and the outer skin 30. The outer packers 36 may comprise hydraulically operated packers, for example by use of hydrostatic pressure within the bore 24, and/or by use of pressure within the outer tubular skin 30, which may be controlled from surface.

The outer tubular skin 30 comprises a plurality of stimulation ports 42 arranged axially along its length, which ports 42 facilitate fluid communication through the wall structure of the outer skin 30. A plurality of stimulation ports 42 are provided or arranged within each zone 38, such that fluid communication with each zone 38 is permitted. For example, between 2 and 50, such as around 25 stimulation ports may

be provided within each zone 38. Accordingly, the ports 42 may permit a fluid, such as a treating fluid, for example an acid, to be delivered into each zone 38, and into the adjacent region of the formation 12 to effect suitable treatment of the formation, such as acid matrix stimulation. Also, as multiple ports 42 are provided along the length of
5 each zone 38, substantially uniform fluid communication along the extent of each zone 38 may be achieved. Further, the ports 38 may permit a fluid, such as a hydrocarbon fluid, released from the formation 12 into the individual zones 38 to be communicated into the outer tubular skin 30, for subsequent production to surface.

The outer tubular skin 30 comprises a first flow control arrangement associated
10 with the stimulation ports 42 for use in providing a degree of control through the ports 42. In the present embodiment the first flow control arrangement comprises a plurality of stimulation valves (not individually shown in Figure 2) wherein each valve is associated with a respective stimulation port 42. The stimulation valves are configurable from a closed configuration in which an associated stimulation port 42 is
15 blocked, to an open configuration in which an associated stimulation port 42 is opened. More specifically, the stimulation valves are configured only to be opened, and as such may be defined as single acting or single shot valves. That is, the valves are not intended to provide any additional reconfiguration once they are opened. As such, once the stimulation valves are opened, they are intended to remain open. Such an
20 arrangement may permit simplified valves to be utilised, which may in turn improve reliability of the valves and the desired operation of the outer tubular skin 30.

The stimulation valves are initially provided and installed within the outer tubular skin 30 in their closed configuration. In such an arrangement the stimulation ports 42 may be blocked during deployment of the outer tubular skin 30 into the bore 24.
25 Initially blocking the stimulation ports 42 may permit the outer tubular skin 30 to be floated into the bore 24. Initially blocking the stimulation ports 42 may permit isolation between the outer tubular skin 30 and the wellbore annulus 40, which may provide advantages in terms of well control and safety during deployment. Initially blocking the stimulation ports 42 may permit circulation through the wellbore annulus 40 to be
30 achieved, for example during deployment or following deployment and prior to the stimulation ports 42 being opened. Such circulation may be utilised to displace a fluid from the wellbore, to introduce a desired fluid into the wellbore, such as a fluid with a desired fluid density, for example for use in well control and the like. Further, initially blocking the stimulation ports 42 may permit pressure within the outer skin 30 to be

elevated, for example to facilitate performance of downhole operations, such as activating the outer packers 36, operating the stimulation valves or the like.

5 The stimulation valves are arranged to be configured towards their open configuration in response to a local or downhole ambient stimulus, such as upon exposure to a particular fluid type, a predetermined pressure or the like. As such, the valves may be considered to be self-opening valves. In such an arrangement, activation by a downhole ambient stimulus may eliminate the requirement for dedicated control lines run from surface level. Some exemplary embodiments of suitable stimulation valves will be described later.

10 In the present described embodiment, once the outer skin 30 is suitably deployed, the packers 36 may be set, and the stimulation valves may be activated by a downhole ambient stimulus, such as by elevated pressure or by exposure to a particular fluid, such as an acid, to be reconfigured to their open configuration, thus causing the stimulation ports 42 to be opened. However, as will be described in more
15 detail below, in other embodiments the packers 36 and/or stimulation valves may, at this stage, remain unset or in their initially deployed configuration.

Referring now to Figure 3, once the outer skin 30 is appropriately deployed, an inner tubular skin 50 is deployed concentrically inside the outer skin 30 such that an inner annulus 52 is defined therebetween. The inner skin 50 is sealed against the liner
20 18 of the upper bore section 14 via a feed-through packer 54 which facilitates passage of a control line 56. The inner skin 50 includes a number of inner packers 58 arranged along the outer surface thereof for use in establishing sealing engagement with the outer skin 30. When activated, the packers 58 define a number of individual isolated inner zones 60 along the inner annulus 52. The inner packers 58 may comprise
25 hydraulically operated packers, for example operated by use of hydrostatic pressure within the bore 24, and/or by use of pressure within the inner tubular skin 50, which may be controlled from surface. The inner packers 58 also permit feed-through of the control line 56.

The inner packers 58 are generally aligned with the outer packers 36 of the
30 outer skin 30, such that the defined outer and inner isolated zones 38, 60 are also generally aligned. Further, in such an arrangement the stimulation ports 42 facilitate fluid communication between the aligned outer and inner isolated zones 38, 60.

The inner skin 50 further comprises multiple circumferential arrays 62 of flow control ports 64 distributed along the length of the inner skin 50. Specifically, in the
35 embodiment shown a single array 62 of flow control ports 64 is provided in each

defined inner isolated zone 60. Each array 62 of ports 64 may form part of an Inflow Control Valve (ICV).

5 The flow control ports 64 facilitate controlled fluid communication between the inner skin 50 and the inner isolated zones 60. Further, when all ports 42, 60 are opened, fluid communication between the inner skin 50 and the formation 12 may be achieved via the flow control ports 64, inner isolated zones 60, the stimulation ports 42 and the outer isolated zones 38. Thus, a treating fluid, such as an acid, may be injected into the formation on a zone-by-zone basis by being initially delivered from surface via the inner skin 50. Further, a fluid produced from the formation may be
10 received into the inner skin 50 on a zone-by-zone basis to be delivered to surface.

The flow control ports 64 may be configured to choke flow, for example by defining a restriction to flow, such as by use of an orifice or the like. Such ability to choke flow may permit controlled inflow and/or outflow relative to the inner skin 50. Different arrays 62 of flow control ports 64 may provide different levels of flow choking.
15 This may allow a desired production and/or injection profile to be achieved along the length of the completion system. The principles of such inflow control are generally known in the art. However, the desired flow control achieved by the flow control ports 62 may advantageously be largely insensitive or unaffected by the operation, or failure, of the stimulation ports 42 and associated stimulation valves. That is, in all cases,
20 even where one or more stimulation valves may fail, fluid communication into or from the inner tubular skin 50 can only ever be achieved via the flow control ports 64, which will thus always provide the desired flow control.

The inner skin 50 comprises a second flow control arrangement associated with the flow control ports 62 for use in providing a degree of flow control through the ports
25 42. In the embodiment shown the second flow control arrangement comprises a plurality of Sliding Sleeve Doors (SSDs) 66, wherein each SSD 66 is associated with a respective array 62 of flow control ports 64. Such SSDs are known in the art. In the present embodiment the SSDs 66 are controlled from surface via the control line 56 (or multiple control lines). In this respect, although a control line 56 is present, this will be
30 largely protected by the outer skin 30. Further, the outer skin 30 will define a lower coefficient of friction than the rock structure of an open hole, and as such the inner skin 50 and control line 56 will be subject to lower frictional drag than would be present in an open hole. The individual SSDs 66 are controllable independently of each other, which will permit flow associated with individual zones to be independently controlled,
35 as will be illustrated below.

The SSDs 66 may be operated to slide relative to the flow control ports 64 to selectively open and close said ports 64. Further, the SSDs may be operated to selectively vary the choking effect of the flow control ports 64.

5 In use, the SSDs 66 may be initially set to close the associated ports 64, such that said ports may be closed during deployment of the inner skin 50. Following deployment of the inner skin 50 the SSDs 66 may be configured to open the associated ports 64, for example to permit outflow of a treating fluid such as acid, and/or to permit inflow of production fluids from the formation 12, such as hydrocarbon fluids.

10 In the embodiment shown the completion system may be defined as a dual skin completion system. The inner skin is intended to provide a desired flow control or profile, in particular to provide an appropriate inflow profile of production fluids along the length of the completion. The outer skin is intended to facilitate transfer of fluids to and/or from a surrounding formation, and in particular to facilitate and support an appropriate treatment operation sufficiently across complete isolated zones. In
15 particular, the outer skin may facilitate a formation to be treated via extended reach wellbores in accordance with acid stimulation practices, such as described in SPE paper 78318 entitled "Controlled Acid Jet (CAJ) Technique for Effective Single Operation Stimulation of 14,000+ ft Long Reservoir Sections".

20 Further, the completion system may extend to wellbore depths of up to, and possibly beyond 12,192 m (40,000 feet).

Once the inner skin 50 is fully deployed, the formed completion system may support a zoned stimulation operation to be performed, as illustrated in Figure 4. In this exemplary embodiment, the lowermost SSD 66a may be operated to open the associated flow control ports 64, while all other SSDs remain closed. A treating fluid,
25 such as an acid, may then be delivered, for example by pumping from surface, through the inner skin 50 and outwardly through the opened flow control ports 64, through the corresponding stimulation ports 42 and into an adjacent formation zone 70a to perform a desired treatment therein. As multiple stimulation ports 42 are provided along the isolated zone, then the treatment fluid may be appropriately and generally uniformly
30 delivered across the entire region. This may permit treatment to be achieved in accordance with acid stimulation practices, such as described in SPE paper 78318 noted herein. Once appropriate treatment of formation zone 70a has been achieved, the lowermost SSD 66a may be again closed, and further formation zones 70b-70e may then be treated in the same manner, in any desired sequence.

Following appropriate treatment of the formation 12, the completion system may be arranged to accommodate production of fluids, such as hydrocarbon fluids, from the formation 12. Such production is illustrated in Figure 5, in which production is achieved via all zones, as illustrated by arrows 80. In this respect, although inflow may be permitted via all of the stimulation ports 42 which are arranged along the length of each zone, eventual inflow into the inner skin 50 is only permitted via the individual arrays of flow control ports 64, which will apply the necessary flow control, such as flow choking.

In some cases water breakthrough may occur in one zone before others, and in such circumstances the completion system permits only the affected zone or zones to be isolated. This is illustrated in Figure 6 in which the lowermost zone has experienced water breakthrough, and to address this the lowermost SSD 66a has been closed to prevent further production from this zone, allowing the remaining zones to continue to produce.

As noted above, each stimulation port 42 of the outer tubular skin 30 is associated with a respective stimulation valve. In some embodiments such stimulation valves are self-opening valves, actuated by a downhole ambient stimulus. Many different types of stimulation valve may be utilised. However, two exemplary embodiments will now be described, the first with reference to Figures 7A, 7B and 7C, and the second with reference to Figures 8A and 8B.

Referring initially to Figure 7A, the exemplary stimulation valve 100 includes a stimulation port 42, and a gate valve member 102 which includes an aperture 104 therethrough. The valve member 102 is shown in an initial closed position in Figure 7A, in which the aperture 104 is misaligned from the port 42, wherein sealing of the port 42 is achieved via seals 106, 108 provided on the valve member 102 on opposing sides of the port 42. A spring 110 is located in a chamber 112 on one side of the valve member 102, wherein the spring 110 is initially compressed and acts in a direction to push the valve member 102 towards an open position. The chamber 112 may be provided at atmospheric pressure, or may be in communication with the annulus 40 externally of the outer skin 30, for example to avoid hydraulic lock within the chamber 112. A shear screw 120 extends from the outer surface of the valve 100 to engage and retain the valve member 102 in the closed position illustrated in Figure 7A. A chamber 114 on an opposing side of the valve member 102 is in fluid communication with the central bore 116 of the outer skin 30 via weep port 118. Accordingly, pressure within the outer skin 30 may act on the valve member 102 across the area of the seal 106.

When an operator wishes to open the valve 100, pressure within the outer skin 30 may be elevated, thus applying an increased force on the valve member 102. When an appropriate fluid pressure force is achieved the shear screw 120 will shear, as illustrated in Figure 7B, and the valve member 102 will further compress the spring 110. In such a position the port 42 will remain closed. It should be noted that a movement limiter, such as a no-go profile, may be provided to prevent over compression of the spring 110. Such an arrangement may permit pressure integrity within the outer skin 30 to be maintained, which may permit the shear screws of every similar stimulation valve within the system to be sheared.

An operator may then reduce the pressure within the outer skin 30, which will permit the compressed spring 110 to move the valve member 120, eventually aligning the aperture 104 of the valve member 102 with the port 40, thus permitting the port to be opened, as illustrated in Figure 7C.

Although not illustrated, the valve may comprise a latch, such as a ratchet, snap ring or the like, which locks the valve member 102 in its open position.

An alternative embodiment of a stimulation valve, in this case identified by reference numeral 200, is illustrated in Figure 8A. Valve 200 is almost identical to valve 100 of Figure 7A, and as such only the differences will be highlighted. In this respect the function of the shear screw 120 of valve 100 of Figure 7A is replicated in valve 200 of Figure 8A by a dissolvable pin 130 which in an initial form holds the valve member 102 open against the bias of the spring 110. Upon exposure to a particular fluid, such as an acid, within the outer skin 30, for example achieved via weep port 118, the pin 130 will dissolve, as illustrated in Figure 8B, allowing the spring 110 to move the valve member 102 to its open position.

It should be understood that the embodiments described herein are merely exemplary and that various modifications may be made thereto without departing from the scope of the present invention. For example, in the above described embodiments the outer packers 36 and stimulation valves of the outer skin 30 are actuated prior to running of the inner skin 50. However, in an alternative embodiment the inner skin 50 may be deployed before the outer packers 36 and stimulation valves are actuated. Such an alternative embodiment may provide advantages in wells which are operating on losses, for example where wellbore fluids are being lost to the formation. Running equipment in such well loss circumstances may require appropriate and complex well control systems and procedures to be employed. Maintaining the outer skin 30 sealed relative to the formation, for example by keeping the stimulation valves closed, may

prevent losses during deployment of the inner skin 50, possibly simplifying the required well control.

In this respect, referring again to Figure 2, the outer skin 30 may be deployed and the liner hanger and liner top packer 32 set, with the outer packers 36 remaining
5 unset and the stimulation valves still closed. In such a condition the outer skin 30 may isolate the entire formation, preventing losses and allowing deployment of the inner skin 50 to be simplified. Following this, the inner skin 50 may be deployed, as illustrated in Figure 3, with the feed-through packer 54 and inner packers 58 being set. Following this, the SSDs 66 may be operated via control line 56 to open the flow
10 control ports 64, thus allowing the outer skin 30 to be pressurised and cause activation of the outer packer 36 and stimulation valves.

CLAIMS:

1. A well completion system, comprising:
 - an outer tubular skin comprising a plurality of axially distributed stimulation fluid
5 ports for facilitating flow through a wall structure of the outer tubular skin;
 - a plurality of outer packers axially distributed along the outer surface of the
outer tubular skin for establishing a plurality of isolated outer zones, wherein at least
one stimulation port is provided between at least one adjacent pair of outer packers;
 - a first flow control arrangement configurable from a closed configuration in
10 which one or more of the stimulation fluid ports are at least partially blocked, to an open
configuration in which one or more of the stimulation ports are open;
 - an inner tubular skin located within the outer tubular skin and defining an inner
annulus with the outer tubular skin, wherein the inner tubular skin comprises a plurality
of axially distributed flow control ports for facilitating flow through a wall structure of the
15 inner tubular skin;
 - a plurality of inner packers axially distributed along the inner annulus for
establishing a plurality of isolated inner zones, wherein at least one stimulation port and
at least one flow control port is located between at least one pair of adjacent inner
packers; and
 - 20 a second flow control arrangement operable to control flow through the flow
control ports.
2. The completion system of claim 1, wherein the stimulation ports facilitate fluid
communication to and/or from the inner annulus defined between the outer and inner
25 tubular skins.
3. The completion system of claim 1 or 2, wherein the inner packers are located
along the completion system to correspond to the positioning of the outer packers.
- 30 4. The completion system of claim 1, 2 or 3, wherein a plurality of axially
separated stimulation ports are provided between at least one pair of adjacent outer
packers.
5. The completion system of any preceding claim, wherein a circumferential array
35 of flow control ports is provided between at least one pair of adjacent inner packers.

6. The completion system of any preceding claim, wherein a single circumferential array of flow control ports is provided between at least one pair of adjacent inner packers.
- 5
7. The completion system of any preceding claim, wherein, when in the closed configuration the first flow control arrangement completely blocks one or more of the stimulation ports to prevent flow therethrough.
- 10
8. The completion system of any preceding claim, wherein the first flow control arrangement is initially provided in its closed configuration.
9. The completion system of any preceding claim, wherein the outer skin is deployable into a wellbore with the first flow control arrangement in its closed configuration.
- 15
10. The completion system of any preceding claim, wherein the first flow control arrangement is configurable only from its closed configuration to its open configuration.
- 20
11. The completion system of any preceding claim, wherein the first flow control arrangement comprises a single acting flow control arrangement, configured only to open the stimulation fluid ports from an initial closed configuration.
12. The completion system of any preceding claim, wherein the first flow control arrangement is configurable to its open configuration by a downhole ambient stimulus.
- 25
13. The completion system of claim 12, wherein the ambient stimulus comprises an ambient fluid stimulus.
- 30
14. The completion system of claim 12 or 13, wherein the ambient stimulus comprises a property of an ambient fluid in the downhole environment.
15. The completion system of claim 14, wherein the ambient fluid comprises at least one of a naturally occurring downhole fluid and an artificially occurring downhole fluid.
- 35

16. The completion system according to any one of claims 12 to 15, wherein the ambient stimulus comprises fluid pressure.
- 5 17. The completion system according to any one of claims 12 to 16, wherein the first flow control arrangement is configurable to its open configuration upon exposure to a predetermined pressure.
- 10 18. The completion system according to any one of claims 12 to 17, wherein the ambient stimulus comprises a fluid type, such that the first flow control arrangement is configurable to its open configuration by exposure to a particular fluid.
- 15 19. The completion system according to any preceding claim, wherein the first flow control arrangement is configurable to its open configuration by an operator controlled ambient stimulus.
- 20 20. The completion system according to any preceding claim, wherein the first flow control arrangement is configurable to its open configuration in response to an operator modified fluid pressure within the outer tubular skin towards an activation pressure.
21. The completion system according to any preceding claim, wherein the first flow control arrangement is configurable to its open configuration in response to an operator modified fluid type within the outer tubular skin.
- 25 22. The completion system according to any preceding claim, wherein the first flow control arrangement comprises a plurality of stimulation valve assemblies associated with the stimulation ports.
- 30 23. The completion system according to claim 22, wherein each stimulation port is associated with a respective stimulation valve assembly.
- 35 24. The completion system according to claim 22 or 23, wherein at least one stimulation valve assembly is configurable from a closed configuration, in which an associated stimulation port is at least partially blocked, to an open configuration in which an associated stimulation port is open.

25. The completion system according to claim 22, 23 or 24, wherein at least one stimulation valve assembly is operated or actuated by a downhole ambient stimulus.

5 26. The completion system according to any one of claims 22 to 25, wherein at least one stimulation valve assembly defines a self-opening valve assembly.

27. The completion system according to any one of claims 22 to 26, wherein at least one stimulation valve assembly defines a single acting stimulation valve assembly, operable only to open an associated stimulation port.
10

28. The completion system according to any one of claims 22 to 27, wherein at least one stimulation valve assembly comprises a valve member configured to be moved relative to an associated stimulation port to permit said port to become opened.
15

29. The completion system according to claim 28, wherein at least one stimulation valve assembly comprises a force arrangement for applying a motive force to an associated valve member to move said valve member relative to an associated stimulation port to permit said port to become opened.
20

30. The completion system according to claim 29, wherein the force arrangement comprises a swellable body configured to swell upon expose to an activator fluid to displace a valve member to open an associated stimulation port.

25 31. The completion system according to claim 29 or 30, wherein the force arrangement comprises an energy storage device, wherein the energy storage device is releases stored energy and moves an associated valve member in response to a stimulus.

30 32. The completion system according to claim 31, wherein the energy storage device is chargeable prior to deployment of the outer tubular skin into a wellbore.

33. The completion system according to claim 31 or 32, wherein the energy storage device comprises an elastic member.
35

34. The completion system according to any one of claims 28 to 33, wherein at least one stimulation valve assembly comprises a latch arrangement for temporarily securing an associated valve member in a closed position.
- 5 35. The completion system according to claim 34, wherein the latch arrangement is releasable in response to exposure to a downhole ambient stimulus.
36. The completion system according to any preceding claim, wherein the second flow control arrangement is provides flow choking.
- 10 37. The completion system according to any preceding claim, wherein one or more of the flow control ports form part of the second flow control arrangement.
38. The completion system according to any preceding claim, wherein the second flow control arrangement defines a flow restriction configured to choke flow.
- 15 39. The completion system according to any preceding claim, wherein the second flow control arrangement facilitates variable control of flow through the flow control ports.
- 20 40. The completion system according to any preceding claim, wherein the second flow control arrangement independently controls individual flow control ports or individual groups of flow control ports.
- 25 41. The completion system according to any preceding claim, wherein the second flow control arrangement is configurable between a closed configuration in which one or more flow control ports are at least partially blocked, and an open configuration in which one or more flow control ports are open.
- 30 42. The completion system according to claim 41, wherein the second flow control arrangement is configured in its closed configuration during deployment of the inner tubular skin into a wellbore.

43. The completion system according to claim 41 or 42, wherein the second flow control arrangement is configurable from its closed configuration to its open configuration, and is configurable from its open configuration to its closed configuration.
- 5 44. The completion system according to any preceding claim, wherein the second flow control arrangement is configured to be operated from surface.
45. The completion system according to any preceding claim, comprising one or more control lines extending along or adjacent the inner tubular skin for use in
10 operation of the second flow control arrangement.
46. The completion system according to any preceding claim, wherein the second flow control arrangement comprises a plurality of flow control valves associated with the flow control ports.
15
47. The completion system according to claim 46, wherein at least one flow control valve is variable to vary flow choking through an associated flow control port.
48. The completion system according to claim 46 or 47, wherein at least one flow
20 control valve assembly comprises a Sliding Sleeve Door (SSD).
49. The completion system according to any preceding claim, comprising a plurality of outer skin sections or segments deployable into a wellbore independently of each other and coupled together downhole.
25
50. The completion system according to claim 49, wherein the outer tubular skin comprises one or more downhole connectors for connecting individual outer skin sections together at a downhole location.
- 30 51. The completion system according to any preceding claim, deployable through an upper lined wellbore section and into a lower drilled bore section.
52. The completion system according to any preceding claim, wherein the inner and outer tubular skins are axially secured together.
35

53. A method for wellbore completion comprising deploying a completion system according to any preceding claim into a wellbore.

54. A wellbore system, comprising:

5 a drilled bore; and

a completion system according to any one of claims 1 to 52 located within the drilled bore.

10 55. The wellbore system according to claim 54, wherein the drilled bore extends through a carbonate formation.

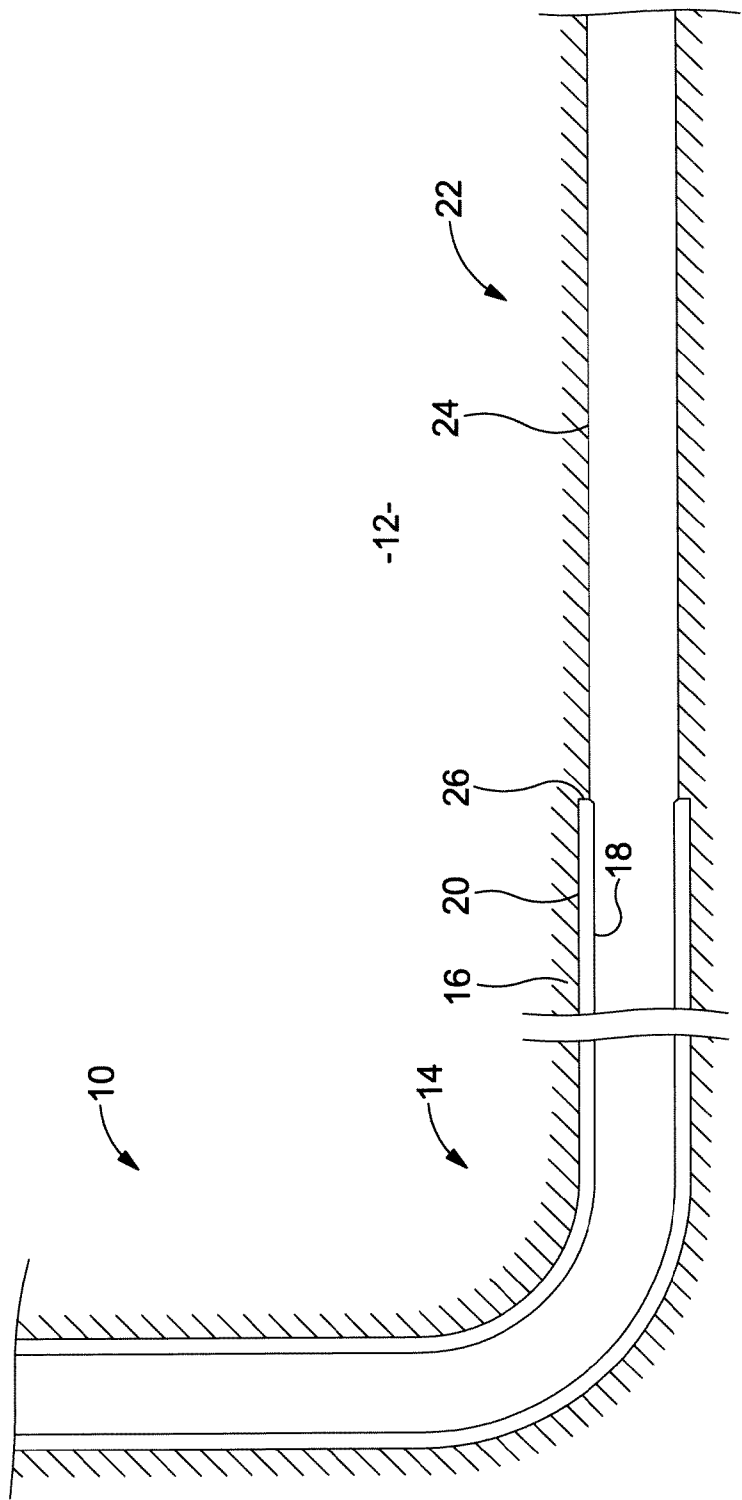
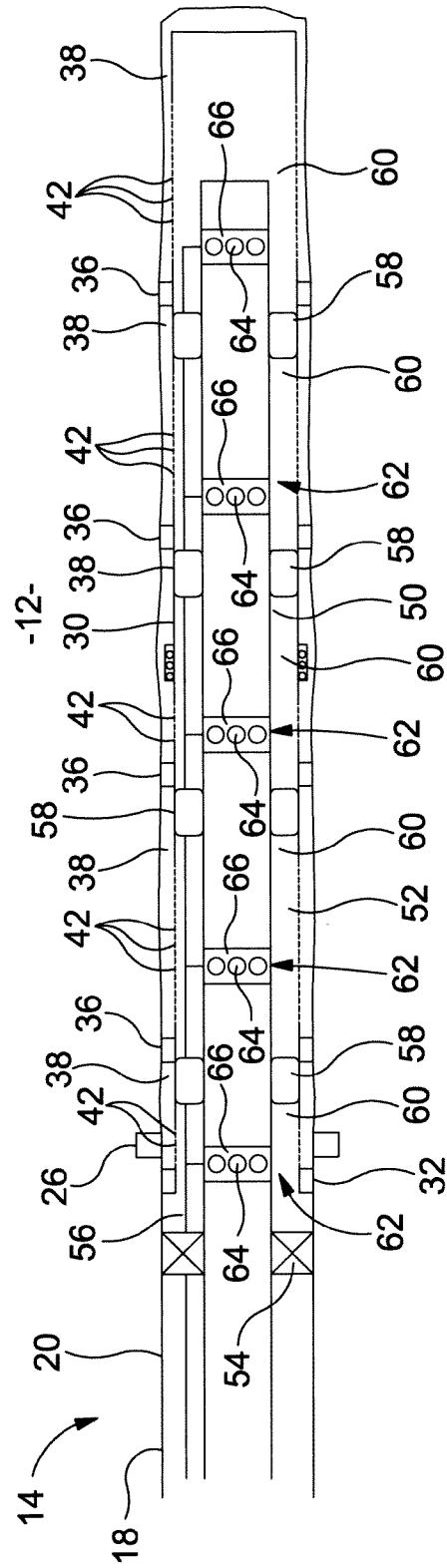
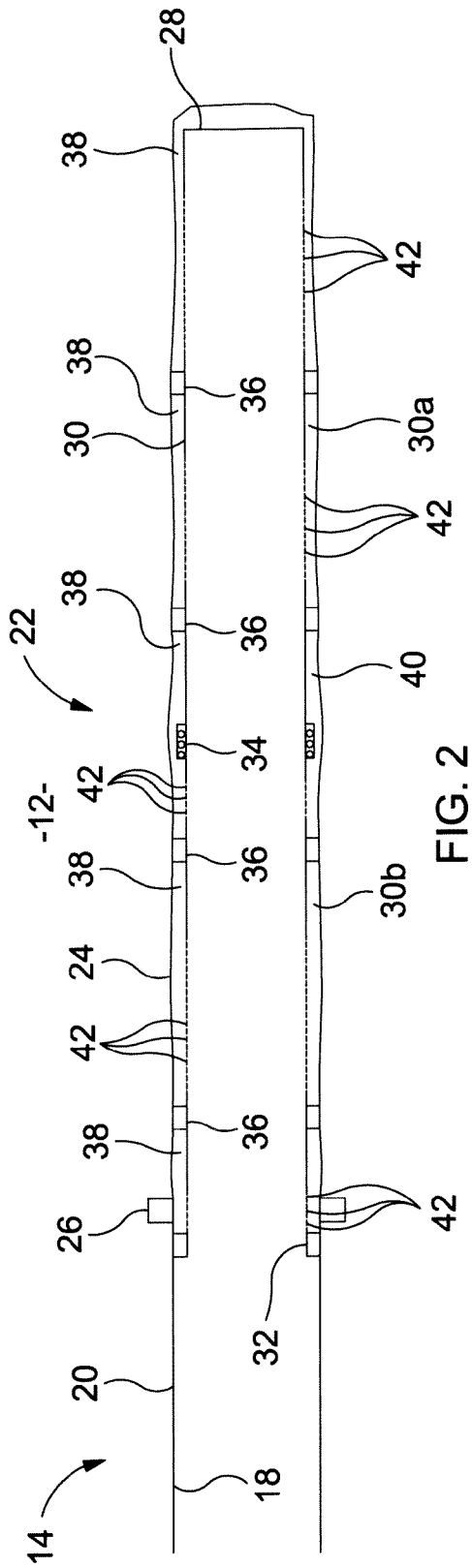
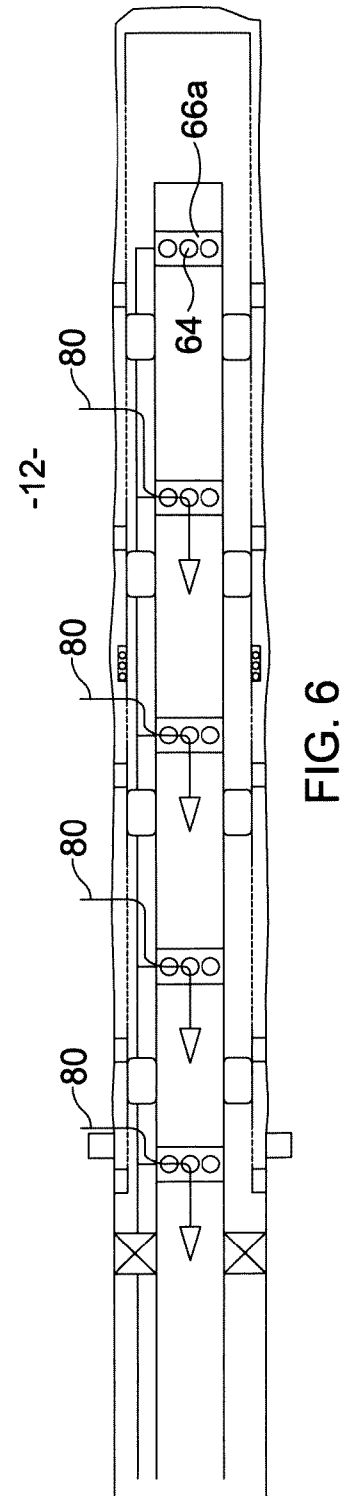
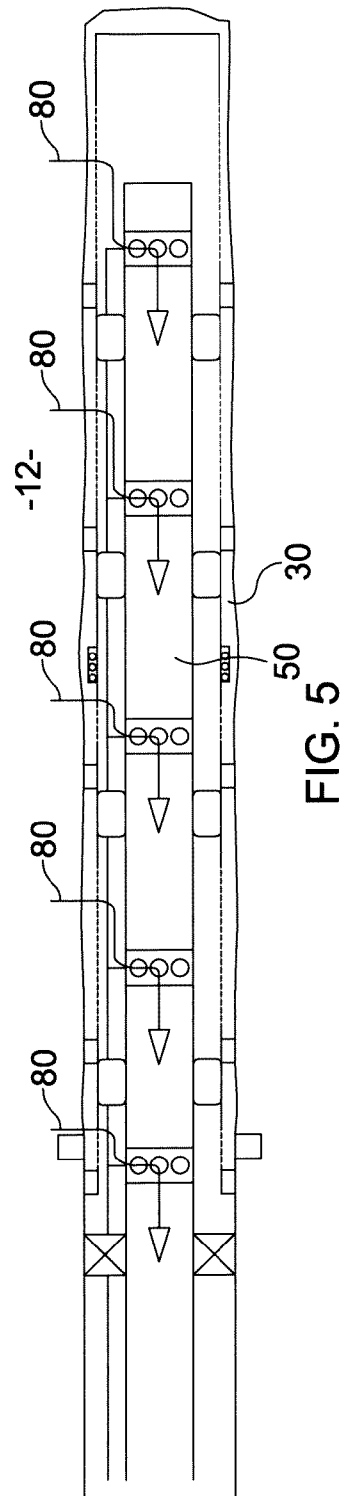
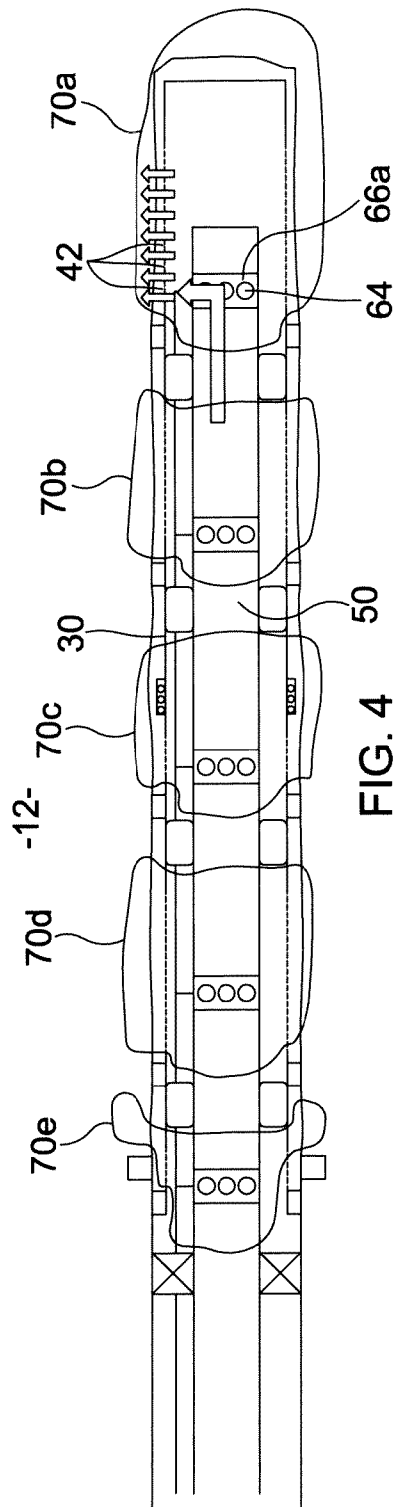


FIG. 1





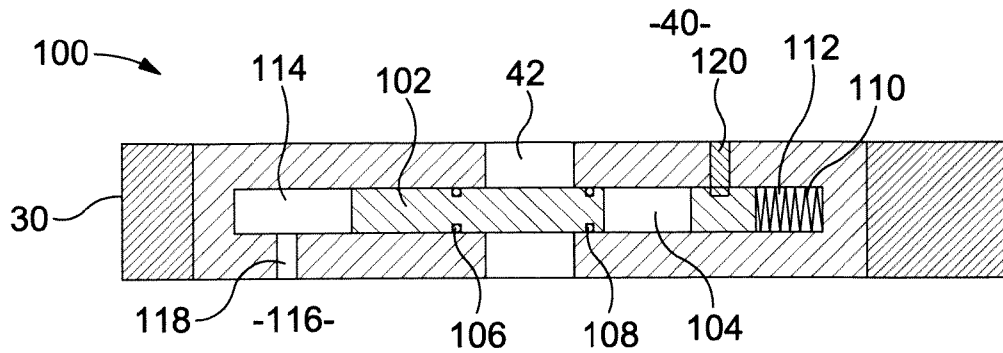


FIG. 7A

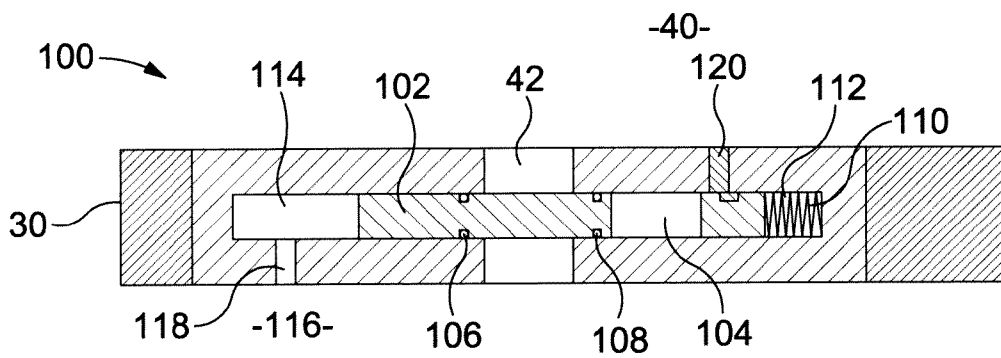


FIG. 7B

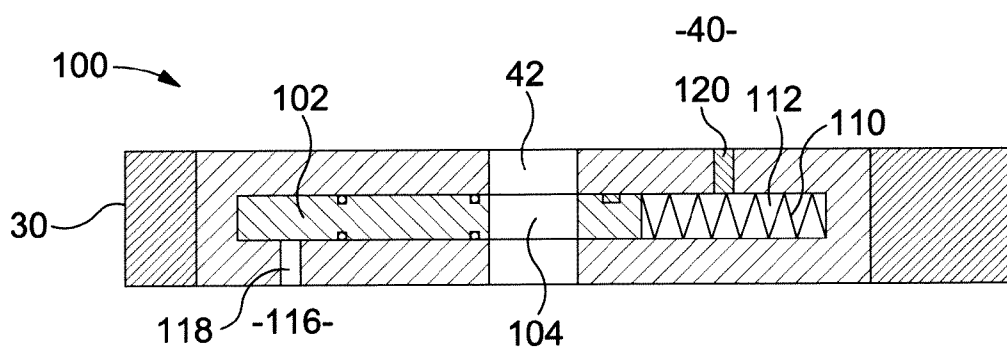


FIG. 7C

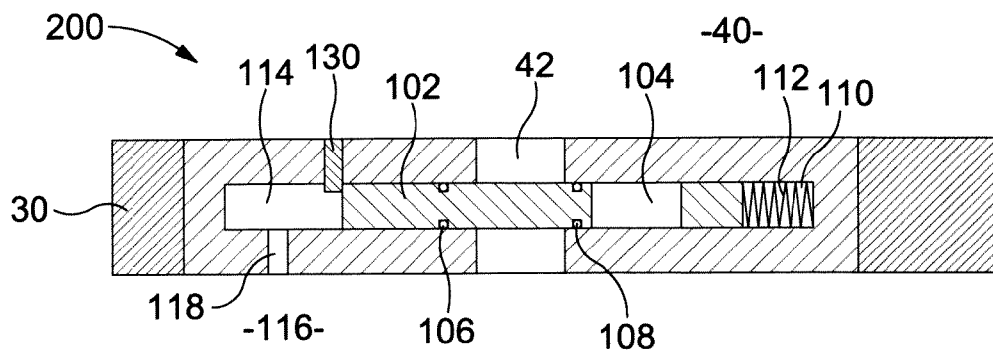


FIG. 8A

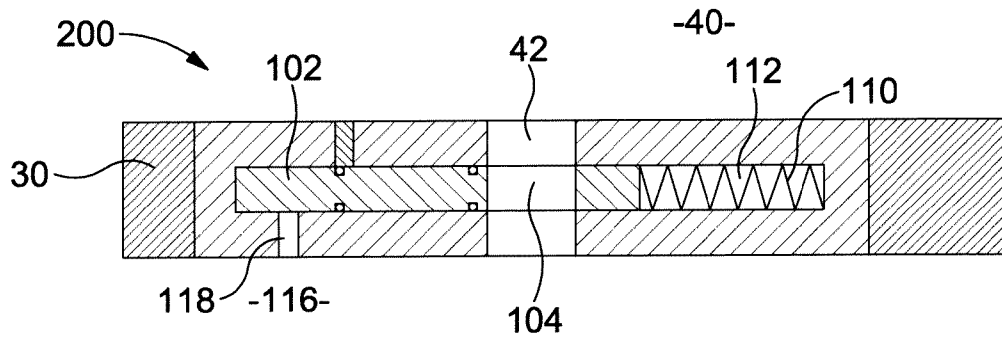


FIG. 8B