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- (71) Applicant (for all designated States except US): **EXXON-MOBIL UPSTREAM RESEARCH COMPANY** [US/US]; CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **KELLER, Stuart, R.** [US/US]; 5123 Indigo Street, Houston, TX 77096 (US).
- (74) Agents: **JAMES, Rick, F.** et al.; Exxonmobil Upstream Research Company, CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).
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(54) Title: SYSTEMS AND METHODS FOR STIMULATING A SUBTERRANEAN FORMATION

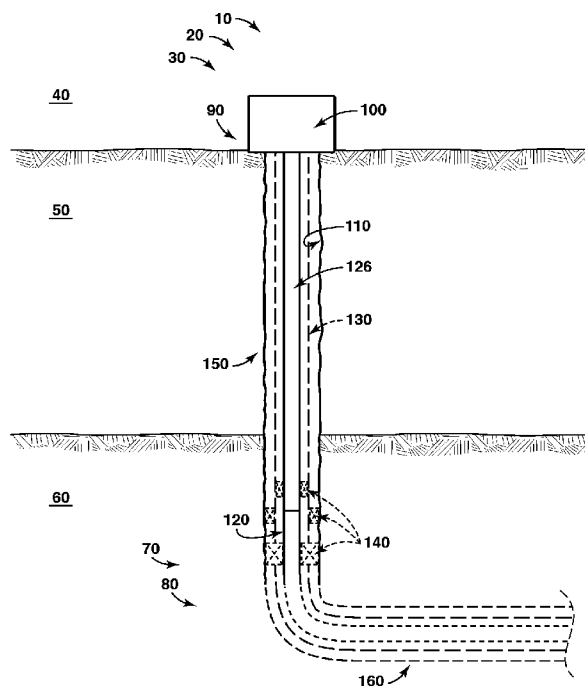


FIG. 1

(57) Abstract: Systems and methods for supplying a stimulant fluid to a subterranean formation, including apportioning a production liner assembly into a plurality of treatment zones and providing the stimulant fluid to at least an initial treatment zone of the plurality of treatment zones. Apportioning the production liner assembly into the plurality of treatment zones may include utilizing a longitudinal flow control device to fluidly isolate at least a first portion of the plurality of treatment zones from at least a second portion of the plurality of treatment zones and/or placing an outlet of a stimulant fluid supply device proximal a selected treatment zone. May include providing the stimulant fluid through one or more outflow control devices. The systems and methods also may include receiving a reservoir fluid through one or more inflow control devices.



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SYSTEMS AND METHODS FOR STIMULATING A SUBTERRANEAN FORMATION

Cross Reference To Related Applications

[0001] This application claims the benefit of U.S. Provisional Application 61/425,121, filed December 20, 2010.

Field of the Disclosure

[0002] The present disclosure is directed to systems and methods for stimulating a subterranean formation.

Background of the Disclosure

[0003] Subterranean wells, such as extended reach subterranean wells, may present unique challenges associated with construction, completion, stimulation, and/or production. This may be due to a variety of factors, including a length of the subterranean well, variations in the subterranean formation(s) that may be experienced along the length of the subterranean well, and/or variations in the reservoir fluid(s) that may be encountered along the length of the subterranean well. Because of these and other factors, construction, completion, stimulation, and/or production operations may be improved, simplified, streamlined, and/or made more efficient if a flow of fluid between the subterranean formation and the subterranean well, a flow of fluid within the subterranean formation, and/or a flow of fluid within the subterranean well itself is metered and/or otherwise controlled.

[0004] To facilitate this control, subterranean wells may include a variety of flow control devices and/or fluid flow conduits, including casing strings, production liner assemblies, packers, and/or uniformity enhancing devices. Casing strings and/or production liner assemblies may provide a conduit for the flow of fluid between the subterranean formation and a surface region. Packers, which also may be referred to herein as swell packers, may be placed within the subterranean well to stop, occlude, and/or slow a flow of fluid therethrough. Uniformity-enhancing devices (UEDs) may provide a restriction to a flow of reservoir fluid from the subterranean formation and into the subterranean well, such as into the production liner assembly of the subterranean well. This restriction may be constant or may vary with a flow rate of the reservoir fluid through the UED. As an illustrative, non-exclusive example, a pressure drop across the UED may increase significantly as a flow rate of reservoir fluid therethrough increases. This increase in pressure drop may serve to decrease variability in a flow rate of reservoir fluid into the subterranean well along the length of the subterranean well by providing a greater resistance to higher fluid flow rates through the plurality of UEDs through which reservoir fluid enters the subterranean well. The UEDs also may be designed, calibrated, configured, adapted, and/or adjusted to promote inflow from certain intervals while hindering inflow from other intervals. Illustrative, non-exclusive examples of uniformity enhancing devices are disclosed in U.S. Patent Application

Publication No. 2009/0151925, the complete disclosure of which is hereby incorporated by reference.

[0005] When stimulating a subterranean well, it may be difficult to stimulate the entire subterranean well simultaneously. This may be due to the need to provide the stimulant fluid to the subterranean well at an overall flow rate sufficient to inject the stimulant fluid into the subterranean formation surrounding the subterranean well at injection velocities and/or local flow rates that are sufficient to produce effective stimulation of the subterranean formation when the overall flow is distributed along the length of the subterranean well. This may be especially challenging when the subterranean well is an extended reach well and/or when the subterranean well includes a plurality of UEDs.

[0006] Prior methods for stimulating wells include bullheading stimulant fluid from a wellbore, using shearable ports that are opened with activation balls prior to initiating the stimulation, and using a production liner with predrilled holes through which stimulation fluid is provided with coiled tubing with an acid-jetting bottom hole assembly (BHA). Bullheading includes pumping stimulant fluid from a wellhead through UEDs in the production liner. However, this approach may only supply stimulant fluid to a portion of the subterranean formation that is near the UEDs and may fail to stimulate portions of the subterranean formation that are not near a UED. In addition, the flow rate of stimulant fluid that may be supplied through a UED that is designed and/or sized to control the inflow of reservoir fluid from the subterranean formation may be lower than, and often will be significantly lower than, a desired flow rate of stimulant fluid.

[0007] Stimulation through the use of shear ports involves providing or otherwise installing specialized shearable ports in the walls of a production liner. These ports are associated with sleeves that are designed to receive an activation ball that is dropped into the subterranean well and to open, or “shear” one or more ports in the production liner in response thereto. The opening of the one or more ports in the production liner provides a pathway for stimulant fluid to be supplied to the subterranean formation. However, the use of these specialized ports and activation balls precludes the use of uniformity-enhancing devices, since reservoir fluid may enter the production liner through the specialized ports once they have been sheared open.

[0008] Stimulation using a coiled tubing assembly with an acid-jetting bottom hole assembly requires that the production liner include predrilled holes, or ports, or the above-discussed shearable ports. The coiled tubing assembly may be used to selectively provide stimulant fluid to the respective parts.

[0009] More specifically, using coiled tubing, the location of the bottom hole assembly, and thus the acid injection location, may be moved as desired, providing location-specific stimulation. However, this approach may not be feasible for some extended reach wells due

to the challenges associated with running coiled tubing over long distances. In addition, typical coiled tubing assemblies may limit the flow rate of stimulant fluid to less than 5 barrels/minute (bbl/min), while it may be desirable to supply stimulant fluid at 50 bbl/min or more for optimal stimulation. Furthermore, the use of pre-drilled holes in the production liner assembly may preclude the use of uniformity-enhancing devices to control the production of reservoir fluid along the length of the subterranean well since reservoir fluids may enter the production liner through the pre-drilled holes.

[0010] Thus, there exists a need for improved systems and methods for stimulating a subterranean formation.

Summary of the Disclosure

[0011] The present disclosure is directed to systems and methods for providing a stimulant fluid to a subterranean formation. These systems and methods may include apportioning a production liner assembly into a plurality of treatment zones and providing a stimulant fluid to at least an initial treatment zone of the plurality of treatment zones. Apportioning the production liner assembly into the plurality of treatment zones may include utilizing a longitudinal flow control device to fluidly isolate at least a first portion of the plurality of treatment zones from at least a second portion of the plurality of treatment zones and/or placing an outlet of a stimulant fluid supply device proximal a selected treatment zone of the plurality of treatment zones. Providing the stimulant fluid may include providing the stimulant fluid through one or more outflow control devices.

[0012] In some embodiments, the longitudinal flow control devices may include ball and seat assemblies and the apportioning may include supplying a ball to a seat assembly to provide the fluid isolation. In some embodiments, the outflow control devices may include an outflow check valve adapted to facilitate fluid flow from an interior of the production liner assembly and through the outflow control device to the subterranean formation while occluding fluid flow from the subterranean formation and through the outflow control device to the interior of the production liner assembly. In some embodiments, the systems and methods may include providing the stimulant fluid to a subsequent treatment zone of the plurality of treatment zones after providing the stimulant fluid to the initial treatment zone. In some embodiments, the systems and methods also may include producing a reservoir fluid from the subterranean formation. In some embodiments, the producing may include receiving the reservoir fluid from the subterranean formation and into the production liner assembly through one or more inflow control devices. In some embodiments, the inflow control devices may include an inflow check valve adapted to facilitate fluid flow from the subterranean formation and through the inflow control device to the interior of the production liner assembly, while occluding fluid flow from the interior of the production liner assembly and through the inflow control device to the subterranean formation.

Brief Description of the Drawings

[0013] Fig. 1 provides illustrative, non-exclusive examples of a subterranean well that may be utilized with the systems and methods according to the present disclosure.

[0014] Fig. 2 provides illustrative, non-exclusive examples of a subterranean well including a plurality of inflow control devices, a plurality of outflow control devices, and a plurality of treatment zones according to the present disclosure.

[0015] Fig. 3 provides illustrative, non-exclusive examples of a portion of a subterranean well that may include longitudinal flow control devices according to the present disclosure.

[0016] Fig. 4 provides illustrative, non-exclusive schematic examples of stimulant fluid flow during treatment zone stimulation using the systems and methods according to the present disclosure.

[0017] Fig. 5 provides illustrative, non-exclusive schematic examples of reservoir fluid flow during production operations using the systems and methods according to the present disclosure.

[0018] Fig. 6 is an illustrative, non-exclusive schematic example of ball and seat assemblies that may be used to define the plurality of treatment zones according to the present disclosure.

[0019] Fig. 7 provides illustrative, non-exclusive schematic examples of localizing a supply of stimulant fluid with a stimulant fluid delivery device according to the present disclosure.

[0020] Fig. 8 provides illustrative, non-exclusive schematic examples of flow control device configurations according to the present disclosure.

[0021] Fig. 9 is a flowchart showing illustrative, non-exclusive examples of methods of using a subterranean well including a plurality of outflow control devices and a plurality of treatment zones according to the present disclosure.

Detailed Description and Best Mode of the Disclosure

[0022] Fig. 1 provides a schematic, cross-sectional view of an illustrative, non-exclusive example of a subterranean well **10** that may be utilized with the systems and methods according to the present disclosure. Subterranean well **10**, which may include, or be, a hydrocarbon well **20**, an oil well **30**, and/or a natural gas well, provides a hydraulic, or fluid, connection between a surface region **40** and a subsurface region **50**, such as between the surface region and a subterranean formation **60**. Subterranean formation **60** may include a reservoir **70** that may contain or include a reservoir fluid **80**.

[0023] Subterranean well **10** further may include a production control assembly **100** that is associated with a wellhead **90** and which is adapted or configured to control a supply of stimulant fluids from the wellhead to reservoir **70** and/or the production of reservoir fluid **80** from the reservoir to the wellhead. The subterranean well further includes a wellbore **110**

that may contain production liner assembly **120** and may optionally contain one or more other components, illustrative, non-exclusive examples of which include any suitable casing or casing string **130**, packer **140**, or any other suitable mechanical, fluid, and/or data access pathway or conduit, mechanical device, fluid flow control device, data collection device, and the like. As shown in Fig. 1, subterranean well **10** includes a vertical portion **150** and may optionally include a horizontal portion **160**. Also shown in Fig. 1 is a producing tubing **126** that extends between the wellhead and the production liner assembly. When present, producing tubing **126** may be fluidly interconnected with the production liner assembly via any suitable mechanism. In some embodiments, the production tubing may be physically interconnected with the production liner assembly, such as proximate one or more production packers and/or with a seal bore. However, a physical interconnection is not required in all embodiments in which production tubing **126** extends generally between production liner assembly **120** and wellhead **90**.

[0024] As discussed in more detail herein, subterranean well **10** may include any suitable well adapted to provide a fluid connection between surface region **40** and reservoir **70**. Reservoir **70** may include any suitable reservoir fluid **80**, including any suitable hydrocarbon, oil, and/or natural gas. It is also within the scope of the present disclosure that reservoir **70** may include or contain other fluids, illustrative, non-exclusive examples of which include water and/or stimulant fluids that may be supplied to the reservoir by subterranean well **10** and/or by another suitable subterranean well. Reservoir **70** may be referred to herein as a subterranean reservoir **70**, and additionally or alternatively may be referred to with reference to the type of fluid contained therein, such as with reservoir **70** being referred to as a hydrocarbon well, an oil well, etc.

[0025] Production control assembly **100** may include any suitable structure adapted to control the transport of fluid, information, and/or physical equipment into and/or out of subterranean well **10**. Illustrative, non-exclusive examples of production control assemblies according to the present disclosure include any suitable collection of valves, pipes, spools, blowout prevention devices, pumps, pressure relief devices, and/or fittings used to control the flow of fluid to and/or from the well. As illustrative, non-exclusive examples, production control assemblies **100** according to the present disclosure may include one or more production tree(s), mechanical access port(s) adapted to provide mechanical access to the subterranean well, chemical injection point(s) adapted to provide a fluid communication pathway for the injection of one or more chemicals into the subterranean well, and/or data access port(s) adapted to provide informational access to the subterranean well.

[0026] As shown in Fig. 1, subterranean well **10** may include one or more substantially vertical sections, or portions, **150** and also may include one or more substantially horizontal sections, or portions, **160**. By “substantially vertical” and “substantially horizontal” it is meant

that the portion, or section, of the subterranean well is approximately or nearly vertical or horizontal, such as within a threshold angle of vertical or horizontal. However, it is also within the scope of the present disclosure that the subterranean well may include sections or portions that form any suitable angle with respect to the vertical or horizontal directions. Thus, it is within the scope of the present disclosure that the subterranean well may include sections or portions that form an angle of 0-90 degrees with respect to the vertical or horizontal directions, including angles of 5, 10, 15, 30, 45, 60, 75, 80, or 85 degrees with respect to the vertical or horizontal directions.

[0027] The subterranean well **10** of Fig. 1 also may be of any suitable overall length. As an illustrative, non-exclusive example, subterranean well **10** may be an extended reach well with an overall length of at least 2,500 meters, including overall lengths of at least 3,000 meters, at least 4,000 meters, at least 5,000 meters, at least 7,500 meters, at least 10,000 meters, at least 12,500 meters, at least 15,000 meters, or at least 20,000 meters, further including overall lengths of 2,500-12,500 meters, 5,000-15,000 meters, 7,500-20,000 meters, or 10,000-15,000 meters. That being said it is also within the scope of the present disclosure to use the systems and methods disclosed herein with subterranean wells **10** having overall lengths of less than 2,500 meters. In addition, it is within the scope of the present disclosure that any suitable portion or percentage of the overall length of the subterranean well may include a horizontal portion, that any suitable portion or percentage of the overall length of the subterranean well may include a vertical portion, and/or that any suitable portion or percentage of the overall length of the subterranean well may include a portion that is at another angle with respect to the horizontal or vertical directions. Illustrative, non-exclusive examples of percentages of the subterranean well that may be horizontal, vertical, or at an angle include 0-100%, including at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, as well as 10-50%, 20-60%, 0-90%, 40-80%, or 50-90%.

[0028] Fig. 2 provides an illustrative, non-exclusive example of production region **15** of subterranean well **10** according to the present disclosure. In Fig. 2, the production region is shown including primarily horizontal portion **160**; however, and as discussed in more detail herein, it is within the scope of the present disclosure that the production region may include one or more portions or sections that include any suitable orientation. As shown in Fig. 2 and discussed in more detail herein, subterranean well **10** may include wellbore **110** that contains production liner assembly **120** that may include or comprise one or more production liner segments **122** that are operatively attached to one another along a longitudinal axis of the production liner segment at production liner joints **124** to form the production liner assembly. The lengths of the production liner segments may (but are not required to) vary within the production liner assembly, and in some embodiments may include a series of comparatively longer production liner segments as well as one or more shorter, or "sub,"

production liner segments. Wellbore **110** also may optionally include one or more casing strings **130**, as shown in dashed lines in Fig. 2, through which production liner assembly **120** may extend.

[0029] Production region **15** may include a portion of the subterranean well that is configured to receive reservoir fluid **80** from reservoir **70** and/or supply stimulant fluid to the reservoir. Production regions **15** according to the present disclosure may be divided, or apportioned, into one or more treatment zones **170**, which also may be referred to as a plurality of treatment zones **170**. In the illustrative, non-exclusive example of Fig. 2, these treatment zones include a proximal treatment zone **172**, two intermediate treatment zones **174**, and a distal treatment zone **176**. However, and as discussed herein, the number of each such treatment zone may vary. As an illustrative, non-exclusive example, production region **15** may include more than two intermediate treatment zones **174**, including more than five, more than ten, more than fifteen, more than twenty, or even more than twenty-five such treatment zones.

[0030] As used herein the terms proximal treatment zone, intermediate treatment zone, and distal treatment zone are relative terms that may refer to a relative location of a specific treatment zone with respect to another treatment zone. A proximal treatment zone is closer to the wellhead along the length of the production liner assembly than a distal treatment zone and an intermediate treatment zone is disposed in between the proximal treatment zone and the distal treatment zone. Treatment zones **170** (and/or plurality of treatment zones **170**) may additionally or alternatively be referred to as being fluidly connected and/or sequential treatment zones of a production liner assembly **120**, as fluid from a more distal treatment zone must flow through intermediate and/or proximal treatment zones prior to reaching surface region **40**, and vice versa.

[0031] Each of the plurality of treatment zones **170** may include one or more inflow control devices **180** and one or more outflow control devices **190**. In Fig. 2, these devices (and the subsequently discussed components thereof) are not illustrated and/or labeled with respect to each treatment zone simply to reduce the complexity of the drawing. It is within the scope of the present disclosure that subterranean well **10** may include isolation structures **133** that are configured to hydraulically or fluidly isolate at least a first portion of the plurality of treatment zones from at least a second portion of the plurality of treatment zones at or near treatment zone boundaries **145**. These isolation structures may include any suitable structure, illustrative, non-exclusive examples of which include packers **140**, which may form a fluid seal between an outer surface of a first fluid conduit, such as production liner assembly **120**, and an inner surface of wellbore **110** and/or a second fluid conduit, such as casing string **130**.

[0032] Inflow control devices **180** may include any suitable structure that is configured or adapted to regulate or otherwise control a flow of fluid therethrough. Illustrative, non-exclusive examples of inflow control devices according to the present disclosure include any suitable uniformity-enhancing device (UED) **182**, selective flow device, valve, or inflow check valve **184**. Uniformity-enhancing devices **182** may include any suitable structure that is adapted to increase a uniformity of (i.e., normalize and/or equalize) fluid flow from the reservoir and into the production liner assembly from the plurality of treatment zones **170** of production liner assembly **120**, including the uniformity-enhancing devices that are discussed in more detail herein.

[0033] Selective flow devices may be designed or configured to preferentially facilitate the flow of certain fluids, such as desirable fluids, therethrough, while impeding the flow of other fluids, such as undesirable fluids, therethrough. As an illustrative, non-exclusive example, selective flow devices according to the present disclosure may be designed or configured to facilitate a flow of oil therethrough, while concurrently impeding a flow of water therethrough.

[0034] Inflow check valve **184** may facilitate a flow of fluid from the reservoir into the production liner assembly but block, restrict, and/or occlude a flow of fluid from the production liner assembly into the reservoir. As an illustrative, non-exclusive example, inflow control devices **180** may be utilized to increase a uniformity of production of reservoir fluids **80** from reservoir **70** along a length of production region **15**. As another illustrative, non-exclusive example, inflow control devices **180** may be utilized to provide a controlled flow of reservoir fluid into production liner assembly **120**, while stopping, restricting, and/or occluding the flow of fluid from within the production liner assembly and into the reservoir.

[0035] Outflow control devices **190** may include any suitable structure that is adapted to regulate or otherwise control a flow of fluid therethrough; however, as used herein, the term "outflow control device" does not refer to a simple hole or orifice, such as a hole that may be drilled through a wall of the production liner assembly, but instead refers to a device that is adapted to regulate, control and/or modify a flow of fluid therethrough. Illustrative, non-exclusive examples of outflow control devices according to the present disclosure include any suitable nozzle **192**, valve, or outflow check valve **194**. Nozzle **192** may include any suitable structure adapted to provide a desired fluid velocity, fluid velocity profile and/or fluid flow distribution for a given or desired flow rate of fluid therethrough. Nozzle **192** may be configured to increase the flow rate of fluid flowing therethrough. Outflow check valve **194** may facilitate a flow of fluid from the production liner assembly into the reservoir but block, restrict, and/or occlude a flow of fluid from the reservoir into the production liner assembly. As an illustrative, non-exclusive example, outflow control device **190** may be adapted to provide a jet of fluid with at least a minimum velocity for a designed and/or desired fluid flow

rate therethrough. As another illustrative, non-exclusive example, outflow control devices **190** may be utilized to provide a controlled flow of stimulant fluid from the production liner assembly into the reservoir, while stopping, restricting, and/or occluding the flow of fluid from the reservoir into the production line assembly.

[0036] Isolation structures **133** may include any suitable structure adapted or configured to regulate or otherwise control a flow of fluid therethrough and thus at least partially isolate the fluid present on a first side of the isolation structure from the fluid present on a second side of the isolation structure. It is within the scope of the present disclosure that isolation structures **133** may include a physical isolation structure that is adapted to at least partially isolate at least a first portion of the plurality of treatment zones from at least a second portion of the plurality of treatment zones by restricting fluid flow through treatment zone boundary **145**. Illustrative, non-exclusive examples of physical isolation structures include any suitable type and/or number of valves, flappers, flow control devices, check valves, packers **140**, swell packers, and/or ball and seat assemblies. However, it is also within the scope of the present disclosure that isolation structures **133** may include a stimulant fluid supply localization device, which also may be referred to as a stimulant fluid delivery device, that is configured to focus, contain, or otherwise concentrate a supply of stimulant fluid to a specific, or desired, treatment zone or zones. As an illustrative, non-exclusive example, a stimulant fluid delivery device according to the present disclosure may include a coiled tubing assembly, drill pipe, or other stimulant fluid delivery conduit that may be selectively inserted and positioned within the subterranean well and/or into the production liner assembly and may be utilized in conjunction with a bottom hole delivery system or assembly that is adapted or configured to provide a flow of stimulant fluid to the production liner assembly in the vicinity of the bottom hole delivery system. This stimulant fluid delivery device may thus deliver the stimulant fluid to the reservoir in the vicinity of the bottom hole delivery system. As another illustrative, non-exclusive example, the bottom hole delivery system may include an acid-jetting bottom hole assembly that is adapted to supply a stream of acid stimulant to a portion of the production liner assembly and/or reservoir proximal to the acid-jetting bottom hole assembly.

[0037] It is within the scope of the present disclosure that subterranean well **10** may include any suitable number of treatment zones **170**. As an illustrative, non-exclusive example, the subterranean well may include at least two treatment zones, optionally including at least three, at least four, at least five, at least ten, at least fifteen, at least twenty, at least twenty-five, at least fifty, 10-25, 5-50, or more than fifty treatment zones. Additionally or alternatively, the plurality of treatment zones **170** may include any of the above-discussed number of treatment zones. In addition, it is within the scope of the present disclosure that each of the plurality of treatment zones may include any suitable treatment zone length.

Illustrative, non-exclusive examples of treatment zone lengths according to the present disclosure include treatment zone lengths of at least 30 meters, optionally including treatment zone lengths of at least 50 meters, at least 100 meters, at least 150 meters, at least 200 meters, at least 250 meters, at least 300 meters, at least 500 meters, at least 750 meters, at least 1000 meters, 30-50 meters, 100-200 meters, 50-300 meters, or 30-1000 meters.

[0038] Fig. 3 provides an illustrative, non-exclusive example of a portion of production region **15** of subterranean well **10**. In Fig. 3, wellbore **110** is shown including production liner assembly **120** that includes two treatment zones **170** that are contained within treatment zone boundaries **145**. Treatment zone boundaries **145** are defined by isolation structures **133**, such as longitudinal flow control devices **135**, and/or optionally by packers **140**. As discussed in more detail herein, longitudinal flow control devices **135** may include any suitable structure, such as valve **136**, flapper **137**, and/or ball and seat assembly **138**, that may be selectively actuated between at least an open configuration, in which there may be a substantially free flow of fluid therethrough, and a closed configuration, in which fluid flow therethrough may be restricted, occluded, and/or prevented. As shown in Fig. 3, each of the plurality of treatment zones **170** may include one or more inflow control devices **180** and one or more outflow control devices **190**.

[0039] Stimulating the reservoir in the vicinity of one or more of the plurality of treatment zones **170** may include supplying a suitable stimulant fluid to the treatment zone. The systems and methods disclosed herein may provide for the stimulation of a specific and/or desired treatment zone or collection of treatment zones without stimulating the remaining treatment zone or zones. Such zone-specific treatment may provide a mechanism for individualized stimulation of each of the plurality of treatment zones and/or the treatment of one or more specific, targeted, or desired treatment zones without stimulating one or more (or even all of) the remaining ones of the plurality of treatment zones, at least while stimulation of the desired treatment zone(s) is occurring.

[0040] As described in more detail herein, it is within the scope of the present disclosure that at least a portion of the plurality of outflow control devices and/or inflow control devices may include a flow trigger, which additionally or alternatively may be referred to as an activation threshold, an activation trigger, and/or a flow initiation threshold. When the flow trigger (or flow initiation threshold) has been satisfied and/or has been exceeded, the portion of the plurality of outflow control devices and/or inflow control devices may enable fluid flow therethrough, while when the flow trigger (or flow initiation threshold) has not been satisfied and/or has not been exceeded, the portion of the plurality of outflow control devices and/or inflow control devices may occlude, prevent, and/or may not enable fluid flow therethrough. It is further within the scope of the present disclosure that the portion of the plurality of

outflow control devices and/or inflow control devices that include such a flow trigger may be or may represent some but not all of the plurality of outflow control devices and/or inflow control devices. However, it is also within the scope of the present disclosure that this portion of the plurality of outflow control devices and/or inflow control devices optionally may include all of the plurality of outflow control devices and/or inflow control devices.

[0041] As an illustrative, non-exclusive example, the flow trigger may include a differential pressure across a production liner assembly wall in the vicinity of the outflow control device and/or the inflow control device. As another illustrative, non-exclusive example, the flow triggers may include treatment zone-specific flow triggers.

[0042] It is within the scope of the present disclosure that the optional flow triggers associated with the flow control devices may be selected and/or configured based upon any suitable method or criterion. As an illustrative, non-exclusive example, the flow triggers may be selected and/or configured based upon any suitable reservoir and/or subterranean well characteristic. Illustrative, non-exclusive examples of suitable reservoir and/or subterranean well characteristics according to the present disclosure include any suitable pressure, temperature, depth, reservoir fluid viscosity, stimulant fluid viscosity, reservoir fluid production rate, stimulant fluid flow rate, reservoir geology, and/or subterranean well construction parameter or value. It is also within the scope of the present disclosure that the flow triggers for the plurality of flow control devices may be selected and/or configured at least in part based on the relative position of a particular flow control device with respect to one or more others of the flow control devices, such as within the same, adjacent, and/or other treatment zone(s) of the plurality of treatment zones **170**.

[0043] Fig. 4 provides an illustrative, non-exclusive example of stimulant fluid flows that may be produced using longitudinal flow control devices **135** in combination with outflow control devices **190** that include treatment zone-specific flow triggers according to the present disclosure. In Fig. 4, and in other Figures herein that depict fluid flow, this fluid flow is schematically illustrated with arrows.

[0044] In Fig. 4, the outflow control devices **190** associated with proximal treatment zone **172** initiate, or permit, fluid flow therethrough at a higher differential pressure than the outflow control devices **190** associated with distal treatment zone **176**. As also shown in Fig. 4, open longitudinal flow control devices **200** provide a fluid communication pathway for the flow of stimulant fluid **210** from the wellhead to distal treatment zone **176**, while closed longitudinal flow control device **205** may restrict stimulant fluid flow past the distal treatment zone. Since the threshold differential pressure at which outflow control devices **190** may enable fluid flow therethrough is higher in proximal treatment zone **172** than it is in distal treatment zone **176**, stimulant fluid streams **215** may be preferentially injected into distal

treatment zone **176**, with minimal or no injection into proximal treatment zone **172**, as shown in Fig. 4.

[0045] Subsequent to supplying stimulant fluid **210** to distal treatment zone **176**, the longitudinal flow control device **135** between the distal treatment zone and the proximal treatment zone may be transitioned from the open state to the closed state and proximal treatment zone **172** may provide the stimulant fluid to the reservoir in the vicinity of the proximal treatment zone through outflow control devices **190** associated with the proximal treatment zone. It is within the scope of the present disclosure that this procedure may be repeated for each of the plurality of treatment zones that comprise the production liner assembly. However, it is also within the scope of the present disclosure that this procedure may only be repeated for specific, or desired, treatment zones of the plurality of treatment zones.

[0046] In addition, it is within the scope of the present disclosure that each of the plurality of treatment zones **170** may receive the same stimulation treatment; however, it is also within the scope of the present disclosure that at least a portion of the plurality of treatment zones may receive a different, or treatment zone-specific, stimulation treatment. As an illustrative, non-exclusive example, when one or more of the plurality of treatment zones receives the same or substantially the same stimulation treatment, this may include such one or more of the plurality of treatment zones **170** receiving at least one of a substantially similar stimulant fluid flow rate, a substantially similar stimulant fluid chemistry, a substantially similar stimulant fluid temperature, a substantially similar stimulant fluid pressure, and/or a substantially similar overall volume of stimulant fluid being supplied to each of the plurality of treatment zones and/or to each of the plurality of portions of the reservoir associated with each of the plurality of treatment zones. As another illustrative, non-exclusive example, when each of the plurality of treatment zones receives a different or substantially different treatment, this may include each of the plurality of treatment zones receiving at least one of a substantially different stimulant fluid flow rate, a substantially different stimulant fluid chemistry, a substantially different stimulant fluid temperature, a substantially different stimulant fluid pressure, and/or a substantially different overall volume of stimulant fluid than others of the plurality of treatment zones. As used herein, references to a treatment zone and/or flow outflow control device receiving a volume of fluid additionally or alternatively may refer to the corresponding portion of the reservoir receiving the volume of fluid.

[0047] Stimulation treatments according to the present disclosure may include any suitable treatment. Illustrative, non-exclusive examples of suitable stimulation treatments include fracturing, acidizing, cleaning, removing buildup from, and/or sealing at least a portion of subterranean well **10**, including wellbore **110**, production liner assembly **120**,

and/or reservoir **70**. Similarly, the stimulant fluid may include any suitable stimulant fluid, illustrative, non-exclusive examples of which include water, oil, drilling mud, an acid, hydrofluoric acid, hydrochloric acid, acetic acid, a solvent, a surfactant, and/or a sealant. In addition, a particular stimulation treatment and/or stimulant fluid may be selected based on any suitable criteria, illustrative, non-exclusive examples of which include information about the subterranean formation that is collected prior to drilling the subterranean well, information about the subterranean formation that is collected while drilling the subterranean well, information about the subterranean formation that is collected after the subterranean well is drilled, and/or information about the materials and/or construction of the subterranean well itself.

[0048] It is within the scope of the present disclosure that, as discussed in more detail herein, the treatment zone-specific flow trigger or flow initiation threshold that may be associated with each of the plurality of treatment zones may change systematically from one treatment zone to the next. As an illustrative, non-exclusive example, the treatment zone-specific flow trigger or flow initiation threshold may increase from the most distal treatment zone to the most proximal treatment zone. As another illustrative, non-exclusive example, the treatment zone-specific flow trigger or flow initiation threshold may increase monotonically from the most distal treatment zone to the most proximal treatment zone.

[0049] It is also within the scope of the present disclosure that, as discussed in more detail herein, at least a portion of the plurality of inflow control devices **180** may optionally include an inflow check valve or other device adapted to facilitate stimulant fluid flow from the reservoir to the production liner assembly, while occluding or blocking fluid flow from the production liner assembly to the reservoir. This is also shown in Fig. 4, wherein stimulant fluid **210** is provided to the reservoir through outflow control devices **190**, but the stimulant fluid is not provided to the reservoir through inflow control devices **180**. The use of an inflow check valve may provide for the use of outflow control devices that may be configured, designed, and/or sized for optimal stimulant fluid flow rates without the loss of additional stimulant fluid through the inflow control devices during stimulation operations.

[0050] Producing reservoir fluid from the reservoir may include receiving reservoir fluid through at least a portion of the inflow control devices associated with the production liner assembly and from the reservoir into the production liner assembly. This is shown schematically in Fig. 5. In Fig. 5, produced fluid **220** enters production liner assembly **120** through inflow control devices **180**, while open longitudinal flow control devices **200** provide a substantially unobstructed fluid flow pathway through the production liner assembly.

[0051] It is within the scope of the present disclosure that, as discussed in more detail herein, at least a portion of the plurality of outflow control devices **190** may optionally include an outflow check valve or other device adapted to facilitate fluid flow from the production

liner assembly to the reservoir, while occluding or blocking fluid flow from the reservoir to the production liner assembly. This is also shown in Fig. 5, wherein produced fluid **220** is received by production liner assembly **120** through inflow control devices **180**, but the produced fluid is not received through outflow control devices **190**. The use of an outflow check valve may provide for the use of inflow control devices that may be configured, designed, and/or sized for optimal production of reservoir fluids without the production of additional reservoir fluid through outflow control devices **190** present within the production liner assembly.

[0052] As discussed in more detail herein, an illustrative, non-exclusive example of longitudinal flow control devices **135** according to the present disclosure includes ball and seat assemblies **138**. An illustrative, non-exclusive example of ball and seat assemblies **138** according to the present disclosure is schematically illustrated in Fig. 6. In Fig. 6, three ball and seat assemblies are shown. Each ball and seat assembly includes a seat **230** and associated ball **240**. Ball and seat assemblies **138** provide an illustrative, non-exclusive example of a mechanism by which individual portions, sections, regions, and/or (treatment) zones of production liner assembly **120** may be hydraulically isolated from other portions, sections, regions, and/or (treatment) zones of the production liner assembly. In Fig. 6, distal ball **246** has been received by and/or is present on distal seat **236**, preventing, modifying, and/or occluding a flow of fluid therethrough. Similarly, intermediate ball **244** has been received by and/or is present on intermediate seat **234**, preventing, modifying, and/or occluding a flow of fluid therethrough. In addition, proximal ball **242** is near proximal seat **232** but has not been received by and/or is not present on the proximal seat. The presence of intermediate ball **244** on intermediate seat **234** and distal ball **246** on distal seat **236** fluidly isolates distal treatment zone **176** from the other of the plurality of treatment zones, including proximal treatment zone **172**. Similarly, when proximal ball **242** is present on proximal seat **232**, proximal treatment zone **172** may be hydraulically isolated from the other of the plurality of treatment zones.

[0053] While Fig. 6 illustrates both intermediate ball **244** and distal ball **246** being present on their respective seat assemblies, it is within the scope of the present disclosure that only one ball may be present on a particular seat assembly at a given time, even if more than one ball is present within the subterranean well. As an illustrative, non-exclusive example, and with reference to Fig. 6, it is within the scope of the present disclosure that balls **240** may be held on seats **230** by a fluid flow and/or differential pressure across the ball and seat assembly. Under these conditions, once proximal ball **242** is seated on and/or forms a seal with proximal seat **232**, a majority and/or the entire pressure drop among the plurality of treatment zones may be across the proximal ball and seat assembly. Under these conditions, there may be little or no flow of fluid from the wellhead and past the

proximal ball and seat assembly and thus little or no pressure drop across the intermediate and/or distal ball and seat assemblies. Thus, there may be little or no driving force to maintain intermediate ball **244** and/or distal ball **246** on their respective seat assemblies and only proximal ball **242** may remain on its seat assembly. Additionally or alternatively, it is within the scope of the present disclosure that the ball and seat assemblies may include a mechanism for retaining balls **240** on their respective seats **230** even if there is little or no pressure drop and/or fluid flow through the ball and seat assemblies.

[0054] It is within the scope of the present disclosure that, as shown schematically in Fig. 6, a seat that is closer, or proximal, the wellhead may include a larger seat orifice **238** when compared to a seat that is farther from, or distal, the wellhead relative to the proximal seat. Thus, a ball that is associated with and/or designed to form a seal with a given seat may pass through the seat orifice of all seats that are proximal the wellhead relative to the given seat but may not pass through the seat on which it is designed to form a seal.

[0055] Ball **240** may be supplied to its associated seat **230** using any suitable method or mechanism. As an illustrative, non-exclusive example, the ball may be placed within production liner assembly **120** in the vicinity of the wellhead and may migrate to the associated seat. It is within the scope of the present disclosure that this migration may be accomplished, at least in part, by the action of gravitational force or potential energy on the ball. However, it is also within the scope of the present disclosure that this migration may be accomplished by supplying a fluid to the production liner assembly and flowing ball **240** to its associated seat **230** with the fluid.

[0056] It is also within the scope of the present disclosure that ball **240** may be removed from production liner assembly **120**. As an illustrative, non-exclusive example, and as discussed in more detail herein, ball and seat assemblies **138** may be utilized to isolate at least a first portion of the treatment zones that are included in production liner assembly **120** from at least a second portion of the treatment zones, such as to isolate the first portion of the treatment zones during a stimulation treatment. It is within the scope of the present disclosure that, after the stimulation treatment has been completed, balls **240** may be removed from the production liner assembly to provide for unobstructed or nearly unobstructed fluid flow among the plurality of treatment zones. Balls **240** may be removed from the production liner assembly using any suitable method or mechanism. As an illustrative, non-exclusive example, reservoir fluids may be produced from the subterranean well and one or more of the balls may flow with the reservoir fluids to the wellhead. It is within the scope of the present disclosure that the wellhead may include, be associated with, and/or be proximal to a ball catcher or other suitable device that is adapted to separate balls **240** from the produced reservoir fluid.

[0057] It is also within the scope of the present disclosure that longitudinal flow control devices **135**, such as ball and seat assemblies **138**, may be designed, configured, or adapted to be temporary longitudinal flow control devices that may be selectively removed from the production liner assembly. As an illustrative, non-exclusive example, and with reference to Figs. 2-6, the longitudinal flow control devices may be designed, configured, or adapted to be sheared or otherwise removed from the production liner assembly when a differential pressure across the longitudinal flow control device exceeds a threshold differential pressure. When the longitudinal flow control devices are designed to be removed from the production liner assembly, it is within the scope of the present disclosure that a portion of the ball and seat assemblies may be pumped or otherwise removed from the production liner assembly with the reservoir fluid. However, it is also within the scope of the present disclosure that a portion of the ball and seat assemblies may be removed from their original location within the production liner assembly, such as to be pumped to a distal end of the production liner assembly.

[0058] As discussed in more detail herein, it is within the scope of the present disclosure that the systems and methods disclosed herein may additionally or alternatively include the use of a stimulant fluid supply localization device **260**, which also may be referred to as a stimulant fluid delivery device **260**, to provide stimulant fluid **210** to a stimulated region **270** of reservoir **70**, as shown in Fig. 7. As an illustrative, non-exclusive example, stimulant fluid delivery device **260** may include coiled tubing **262** and associated bottom hole assembly **264** that may supply the stimulant fluid to the stimulated region of the reservoir. Bottom hole assembly **264** may be selectively moved to different locations, regions, and/or treatment zones of production liner assembly **120** and may provide a localized supply of stimulant fluid to the treatment zone(s). As an illustrative, non-exclusive example, and as shown in solid lines in Fig. 7, bottom hole assembly **264** may initially provide stimulant fluid to proximal treatment zone **172**. In addition, and as shown in dashed lines in Fig. 7, it is within the scope of the present disclosure that bottom hole assembly **264** may be moved to distal treatment zone **176** to provide stimulant fluid **210** thereto.

[0059] As discussed in more detail herein, each of the plurality of treatment zones **170** may include one or more inflow control devices **180** and one or more outflow control devices **190**. Inflow control devices **180** and/or outflow control devices **190** may include any suitable structure, including the illustrative, non-exclusive examples discussed herein with reference to Figs. 2-5.

[0060] In Fig. 8, production liner assembly **120** includes a plurality of production liner segments **122** that are operatively attached to one another at production liner joints **124**. It is within the scope of the present disclosure that inflow control devices **180** and/or outflow control devices **190**, which also may be collectively referred to herein more generically as

flow control devices **280**, may include any suitable structure and may be operatively attached to and/or associated with production liner assembly **120** in any suitable manner. As illustrative, non-exclusive examples, and as shown in Fig. 8, it is within the scope of the present disclosure that flow control devices **280** may be associated with production liner segment **122** and/or production liner joint **124**. This may include flow control devices **280** that are associated with the production liner segment inner surface as shown schematically at **282**; flow control devices **280** that are within the production liner segment wall, as shown schematically at **284**; flow control devices **280** that are associated with the production liner segment outer surface, as shown schematically at **286**; and/or flow control devices **280** that are associated with a fitting **288** that is associated with the production liner segment, as shown schematically at **290**. As discussed, it is within the scope of the present disclosure that the flow control devices **280** may be (but are not required to be) associated with a shorter, or “sub,” length of a production liner segment, such as which may extend between a pair of production liner joints. Similarly, flow control devices **280** may be associated with production liner joint **124**, either directly, as shown schematically at **292**, or by being associated with a fitting **288** that is associated with the production liner joint, as shown schematically at **294**.

[0061] It is also within the scope of the present disclosure that production liner assembly **120** may include an optional shield, or guard, **296** that is designed to protect at least a portion of flow control devices **280** associated therewith. For example, such a shield **296** may be configured to protect a portion (such as a portion external the production liner assembly) of the flow control devices from mechanical forces or stresses without inhibiting the intended operation of the devices.

[0062] As used herein, the term “associated with” may include flow control devices and/or fittings that form a part of and/or are operatively attached to (and/or in fluid communication with) the component to which they are associated. As an illustrative, non-exclusive example, it is within the scope of the present disclosure that at least one of flow control devices **280** and/or fittings **288** may form a part of production liner segment **122** and/or production liner joint **124**. This may include flow control devices and/or fittings that are machined into the production liner segment and/or production liner joint, as well as flow control devices and/or fittings that are formed with the production liner segment and/or production liner joint. As another illustrative, non-exclusive example, when the flow control devices and/or fittings are operatively attached to the production liner segment and/or the production liner joint, they may be operatively attached in any suitable manner. This may include any suitable epoxy, adhesive, bond, weld, braze, friction fit, fastener, clip, and/or thread.

[0063] Fig. 9 is a flowchart providing illustrative, non-exclusive examples of methods **300** of operating a subterranean well according to the present disclosure that include providing a localized, or treatment zone-specific, stimulation treatment to at least a portion of the subterranean well. In the method of Fig. 9, optional steps are shown in dashed lines. It is within the scope of the present disclosure that the method steps of Fig. 9 may be completed in any suitable order. It is also within the scope of the present disclosure that steps other than those shown may be added and/or that steps listed in solid lines may be made optional without departing from the scope of the present disclosure.

[0064] Methods **300** may optionally include providing at least one outflow control device at **305** and providing at least one inflow control device at **310**. Methods **300** optionally also may include initializing a counter, N , at **315**, wherein the counter is utilized to select which of the plurality of treatment zones will receive a stimulation treatment at **320**. The method further optionally includes isolating the N th treatment zone from at least a portion of the plurality of treatment zones at **325** and includes supplying stimulant fluid to the N th treatment zone at **330**. At **335**, the method includes stimulating the N th portion of the subterranean reservoir.

[0065] At **340**, an outflow of fluid from the interior of the production liner assembly and through the inflow control devices to the reservoir may optionally be restricted, while at **345**, an inflow of fluid from the reservoir and through the outflow control devices to the production liner assembly is restricted. When present, and/or utilized, the counter may be incremented at **350** and compared to a maximum value of the counter, N_{max} , at **355**. If N is less than N_{max} , the “No” decision path is followed back to step **320**, and the method is repeated for the next treatment zone. If N is greater than N_{max} , the “Yes” decision path is followed to step **360**, where reservoir fluid is optionally produced from the reservoir by receiving the reservoir fluid into the production liner assembly through the inflow control devices. At **365**, a flow of reservoir fluid from the reservoir and through the outflow control devices into the production liner assembly is restricted.

[0066] Optionally providing outflow control devices at **305** and/or providing inflow control devices at **310** may include providing the flow control devices in any suitable manner, including those discussed in more detail herein. As an illustrative, non-exclusive example, the flow control devices may be attached to the production liner assembly prior to the production liner assembly being inserted into the wellbore and the flow control devices may be inserted into the wellbore with the production liner assembly. As another illustrative, non-exclusive example, the flow control devices may be formed with the production liner assembly and inserted into the wellbore with the production liner assembly. As yet another illustrative, non-exclusive example, the flow control devices may be installed on the

production liner assembly after the production liner assembly has been inserted into the wellbore.

[0067] Initializing the counter at **315**, incrementing the counter at **350**, and/or comparing the current value of the counter to a maximum value of the counter at **355** is one illustrative, non-exclusive example of a mechanism that may be utilized to select and treat a desired treatment zone. It is within the scope of the present disclosure that Nmax may refer to the total number of treatment zones associated with the production liner assembly. However, it is also within the scope of the present disclosure that Nmax may refer to fewer than the total number of treatment zones, such as to a subset of the total number of treatment zones.

[0068] Any other suitable algorithm, mechanism, procedure, and/or method may be utilized without departing from the scope of the present disclosure. As an illustrative, non-exclusive example, a user or operator may manually indicate which of the treatment zones is to be treated, such as by closing or opening a suitable longitudinal flow control device, selecting or indicating a suitable longitudinal flow control device on a control system adapted to control the operation of the subterranean well, dropping a ball of a size suitable to form a seal with a seat that isolates a desired treatment zone, and/or moving a bottom hole assembly that is associated with a stimulant fluid supply device to a desired portion, region, or zone of the production liner assembly.

[0069] As another illustrative, non-exclusive example, a control system for the subterranean well may include a predetermined list, or sequence, of treatment zones and may utilize the steps of methods **300** to stimulate a desired portion of the predetermined list of treatment zones. It is within the scope of the present disclosure that the treatment zones may be stimulated in any suitable order. As an illustrative, non-exclusive example, the treatment zones may be stimulated sequentially, such as by stimulating the most distal treatment zone and then repeating the stimulating for each of the remaining treatment zones, always stimulating a more distal treatment zone prior to stimulating a more proximal treatment zone. As another illustrative, non-exclusive example, the treatment zones may be stimulated sequentially starting with the most proximal treatment zone. As yet another illustrative, non-exclusive example, only a portion of the plurality of treatment zones may be stimulated and/or the treatment zones may be stimulated in a manner other than sequentially, such as randomly or based on any suitable criteria. As another illustrative, non-exclusive example, the treatment zones may be selected for stimulation based on a reservoir fluid production rate within the treatment zone and/or geological characteristic of the reservoir in the vicinity of the treatment zone.

[0070] Selecting the Nth treatment zone at **320** may include the use of any suitable mechanism to focus, isolate, and/or distribute stimulant fluid to the Nth treatment zone. As an illustrative, non-exclusive example, the Nth treatment zone may be isolated from at least

a portion of the plurality of treatment zones at step **325** through the use of a longitudinal flow control device, as discussed in more detail herein with reference to Figs. 3-4. As another illustrative, non-exclusive example, the supply of stimulant fluid may be localized to the Nth treatment zone, such as through the use of stimulant fluid supply device **260**, as described in more detail herein with reference to Fig. 7. The first such selected treatment zone thus may be referred to as an initial treatment zone and/or a first treatment zone. Likewise, a second such selected treatment zone may be referred to as a next, or subsequent, treatment zone and/or a second treatment zone.

[0071] Supplying stimulant fluid to the Nth treatment zone at step **330** may include supplying the stimulant fluid using any suitable mechanism or procedure. As an illustrative, non-exclusive example, supplying the stimulant fluid may include bullheading the stimulant fluid into the production liner assembly. As used herein, "bullheading" means that the fluid is pumped directly into the production liner assembly at or in the vicinity of the wellhead. It is within the scope of the present disclosure that, as discussed in more detail herein with reference to Figs. 3 and 4, when stimulant fluid is bullheaded into the production liner assembly, longitudinal flow control devices and/or outflow control devices with predetermined flow initiation thresholds may be utilized to provide the stimulant fluid to the selected or desired treatment zone. As another illustrative, non-exclusive example, the stimulant fluid may be supplied to the selected or desired treatment zone through the use of stimulant fluid supply device **260**, as discussed in more detail herein with reference to Fig. 7.

[0072] It is within the scope of the present disclosure that the stimulant fluid may be supplied to the selected treatment zone at any suitable flow rate. As an illustrative, non-exclusive example, it is within the scope of the present disclosure that the stimulant fluid may be supplied to the selected treatment zone at a flow rate of at least 5 bbl/min, optionally including stimulant fluid flow rates of at least 10 bbl/min, at least 20 bbl/min, at least 25 bbl/min, at least 40 bbl/min, at least 50 bbl/min, at least 75 bbl/min, at least 100 bbl/min, 5-100 bbl/min, 5-50 bbl/min, 20-80 bbl/min, 30-70 bbl/min, or 40-60 bbl/min. As another illustrative, non-exclusive example, it is within the scope of the present disclosure that the outflow control devices may be designed or configured to supply stimulant fluid to the selected treatment zone at a flow rate that is at least twice a flow rate at which the inflow control devices are designed or configured to produce reservoir fluid from the selected treatment zone, optionally including flow rates that are at least 5 times, at least 10 times, at least 15 times, at least 20 times, at least 25 times, or at least 50 times the designed or configured flow rate for the inflow control devices.

[0073] Stimulating the Nth portion of the reservoir at step **335** may include supplying the stimulant fluid through the outflow control devices associated with the Nth treatment zone and from an interior of the production liner assembly to the Nth portion of the reservoir. This

may include supplying a stream, jet, high-pressure jet, or flow of stimulant fluid from the production liner assembly to the reservoir using any suitable mechanism or procedure, including any of the systems and methods disclosed herein.

[0074] Restricting the outflow from the inflow control device in the Nth treatment zone may include restricting a flow of stimulant fluid through the inflow control device. It is within the scope of the present disclosure that the restricting may be concurrent with the supplying the stimulant fluid through the outflow control devices as discussed herein with reference to step **335**. As discussed in more detail herein, restricting the flow of stimulant fluid from the interior of the production liner assembly and through the inflow control devices to the subsurface formation may include the use of any suitable structure to reduce, occlude, or stop the fluid flow. As an illustrative, non-exclusive example, and as discussed in more detail herein, the inflow control devices may include an inflow check valve that is configured or adapted to facilitate a flow of fluid from the reservoir and into the production liner assembly but to restrict a flow of fluid, such as stimulant fluid, from the production liner assembly and into the reservoir.

[0075] Restricting a fluid flow through the outflow control devices at step **345** and/or step **365** may include restricting a fluid inflow from the exterior of the production liner assembly, such as from the reservoir, and through the outflow control devices to the interior of the production liner assembly. As discussed in more detail herein, this may include the use of any suitable structure to reduce, occlude, or stop the fluid inflow while facilitating fluid outflow, an illustrative, non-exclusive example of which includes an outflow check valve.

[0076] Optionally producing reservoir fluid through the inflow control devices at step **360** may include producing reservoir fluids using any suitable method. As discussed in more detail herein with reference to Fig. 5, the reservoir fluids may be provided from the reservoir and flow through the inflow control devices to the interior of the production liner assembly, where they may flow to the wellhead as produced fluid **220**.

[0077] The systems and methods disclosed herein have been discussed with reference to a production liner assembly that is divided or apportioned into a plurality of treatment zones, with each of the plurality of treatment zones including at least one inflow control device and at least one outflow control device. However, it is within the scope of the present disclosure that the systems and methods disclosed herein may be utilized with any suitable conduit that forms a portion of subterranean well **10** and/or that the systems and methods may be utilized with multiple conduits and/or distributed across multiple conduits. As an illustrative, non-exclusive example, it is within the scope of the present disclosure that the systems and methods disclosed herein may be utilized with a casing string that forms a portion of subterranean well **10**. As another illustrative, non-exclusive example, it is within the scope of the present disclosure that the systems and methods disclosed herein may be

utilized with a separate, dedicated conduit that forms a portion of subterranean well **10**. As yet another illustrative, non-exclusive example, it is within the scope of the present disclosure that a first portion of the inflow control devices, outflow control devices, longitudinal flow control devices, and/or stimulant fluid delivery devices may be associated with a first fluid conduit, while a second portion of the inflow control devices, outflow control devices, longitudinal flow control devices, and/or stimulant fluid delivery devices may be associated with a second fluid conduit.

[0078] In the present disclosure, several of the illustrative, non-exclusive examples have been discussed and/or presented in the context of flow diagrams, or flow charts, in which the methods are shown and described as a series of blocks, or steps. Unless specifically set forth in the accompanying description, it is within the scope of the present disclosure that the order of the blocks may vary from the illustrated order in the flow diagram, including with two or more of the blocks (or steps) occurring in a different order and/or concurrently. It is also within the scope of the present disclosure that the blocks, or steps, may be implemented as logic, which also may be described as implementing the blocks, or steps, as logics. In some applications, the blocks, or steps, may represent expressions and/or actions to be performed by functionally equivalent circuits or other logic devices. The illustrated blocks may, but are not required to, represent executable instructions that cause a computer, processor, and/or other logic device to respond, to perform an action, to change states, to generate an output or display, and/or to make decisions.

[0079] As used herein, the term “and/or” placed between a first entity and a second entity means one of (1) the first entity, (2) the second entity, and (3) the first entity and the second entity. Multiple entities listed with “and/or” should be construed in the same manner, i.e., “one or more” of the entities so conjoined. Other entities may optionally be present other than the entities specifically identified by the “and/or” clause, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, a reference to “A and/or B,” when used in conjunction with open-ended language such as “comprising” may refer, in one embodiment, to A only (optionally including entities other than B); in another embodiment, to B only (optionally including entities other than A); in yet another embodiment, to both A and B (optionally including other entities). These entities may refer to elements, actions, structures, steps, operations, values, and the like.

[0080] As used herein, the phrase “at least one,” in reference to a list of one or more entities should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the

phrase “at least one” refers, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, “at least one of A and B” (or, equivalently, “at least one of A or B,” or, equivalently “at least one of A and/or B”) may refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including entities other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases “at least one,” “one or more,” and “and/or” are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions “at least one of A, B and C,” “at least one of A, B, or C,” “one or more of A, B, and C,” “one or more of A, B, or C” and “A, B, and/or C” may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

[0081] In the event that any of the references that are incorporated by reference herein define a term in a manner or are otherwise inconsistent with either the non-incorporated portion of the present disclosure or with any of the other incorporated references, the non-incorporated portion of the present disclosure shall control, and the term or incorporated disclosure therein shall only control with respect to the reference in which the term is defined and/or the incorporated disclosure was originally present.

[0082] Illustrative, non-exclusive examples of systems and methods according to the present disclosure are presented in the following enumerated paragraphs. It is within the scope of the present disclosure that an individual step of a method recited herein, including in the following enumerated paragraphs, may additionally or alternatively be referred to as a “step for” performing the recited action.

[0083] A1. A method of stimulating a subterranean reservoir, the method comprising:

isolating, with a first longitudinal flow control device, a first of a plurality of treatment zones of a production liner assembly of a well that is in fluid communication with the reservoir from at least a first portion of the plurality of treatment zones of the production liner assembly;

supplying a stimulant fluid to the first of the plurality of treatment zones;

stimulating a first portion of the reservoir proximal the first of the plurality of treatment zones, wherein the stimulating includes supplying the stimulant fluid through one or more outflow control devices present in the first of the plurality of treatment zones and from an interior of the production liner assembly to the first portion of the reservoir;

isolating a second of the plurality of treatment zones from at least a second portion of the plurality of treatment zones using a second longitudinal flow control device;

supplying a stimulant fluid to the second of the plurality of treatment zones;

stimulating a second portion of the reservoir proximal the second of the plurality of treatment zones, wherein the stimulating includes supplying the stimulant fluid through the one or more outflow control devices present in the second of the plurality of treatment zones and from the interior of the production liner assembly to the second portion of the reservoir; and

repeating the isolating, supplying, and stimulating steps until all desired treatment zones have been stimulated.

[0084] A2. The method of paragraph A1, wherein at least a portion of the one or more longitudinal flow control devices includes at least one of a valve, a check valve, and a mechanical flapper.

[0085] A3. The method of any of paragraphs A1-A2, wherein at least a portion of the one or more longitudinal flow control devices includes a ball and seat assembly.

[0086] A4. The method of paragraph A3, wherein isolating the first of the plurality of treatment zones includes placing a first ball on a first seat associated with the first of the plurality of treatment zones, and further wherein isolating the second of the plurality of treatment zones includes placing a second ball on a second seat associated with the second of the plurality of treatment zones, wherein the first ball has a smaller diameter than the second ball, and further wherein the first ball will pass through the second seat assembly but not through the first seat assembly.

[0087] A5. The method of paragraph A4, wherein the method further includes producing reservoir fluid from the subterranean well, flowing the first ball and the second ball to a wellhead with the produced reservoir fluid, and capturing the first ball and the second ball using a ball catcher proximal the wellhead.

[0088] A6. The method of any of paragraphs A3-A5, wherein the seat assembly is configured to be sheared from a seat assembly mount when subjected to a differential pressure that is greater than a threshold differential pressure, and further wherein the method includes increasing the differential pressure above the threshold differential pressure to shear the seat assembly from the seat assembly mount.

[0089] A7. The method of any of paragraphs A1-A6, wherein the supplying includes bullheading the stimulant fluid into the production liner assembly.

[0090] A8. The method of any of paragraphs A1-A7, wherein the subterranean well includes a wellbore drilled between a surface region and a subterranean formation that includes the reservoir, wherein the reservoir includes the reservoir fluid, wherein the wellbore contains the production liner assembly including a production liner and a plurality of longitudinal flow control devices that divide the production liner assembly into the plurality of treatment zones, wherein the plurality of longitudinal flow control devices selectively isolate

at least a first portion of the plurality of treatment zones from fluid communication with at least a second portion of the plurality of treatment zones along a fluid communication pathway that is internal the production liner, and further wherein each of the plurality of treatment zones includes one or more outflow control devices.

[0091] B1. A method of stimulating a subterranean well including a wellbore drilled between a surface region and a subterranean formation, the subterranean formation including a reservoir that includes a reservoir fluid, wherein the wellbore contains a production liner assembly, wherein the production liner assembly includes a plurality of treatment zones, each treatment zone including at least one inflow control devices and at least one outflow control devices, and further wherein a plurality of packers impedes fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly, the method comprising:

- placing an outlet of a stimulant fluid supply localization device proximal to a first of the plurality of treatment zones;

- supplying a stimulant fluid to the first of the plurality of treatment zones using the stimulant fluid supply localization device;

- stimulating a first portion of the reservoir proximal the first of the plurality of treatment zones, wherein the stimulating includes providing the stimulant fluid through the one or more outflow control devices present in the first of the plurality of treatment zones and from an interior of the production liner assembly to the first portion of the reservoir;

- placing the outlet of the stimulant fluid supply localization device proximal to a second of the plurality of treatment zones;

- supplying a stimulant fluid to the second of the plurality of treatment zones using the stimulant fluid supply localization device;

- stimulating a second portion of the reservoir proximal the second of the plurality of treatment zones, wherein the stimulating includes supplying the stimulant fluid through the one or more outflow control devices present in the second of the plurality of treatment zones and from the interior of the production liner assembly to the second portion of the reservoir;

- repeating the placing, supplying, and stimulating steps until all desired treatment zones have been stimulated.

[0092] B2. The method of paragraph B1, wherein the stimulant fluid supply localization device includes at least one of coiled tubing and drill pipe.

[0093] B3. The method of any of paragraphs B1-B2, wherein the stimulant fluid supply localization device is inserted within the production liner assembly.

[0094] C1. The method of any of paragraphs A1-B3, wherein at least a portion of the one or more outflow control devices includes outflow control devices adapted to facilitate fluid

flow from the production liner assembly into the reservoir but to impede fluid flow from the reservoir into the production liner assembly.

[0095] C2.The method of paragraph C1, wherein at least a portion of the one or more outflow control devices includes a check valve.

[0096] C3.The method of any of paragraphs C1-C2, wherein at least a portion of the one or more outflow control devices further includes at least a first high-velocity jet assembly adapted to increase a velocity of a fluid flowing therethrough and the method further includes accelerating the stimulant fluid through the high-velocity jet assembly.

[0097] C4.The method of any of paragraphs C2-C3, wherein the check valve opening pressure is configured based on reservoir characteristics.

[0098] C5.The method of any of paragraphs A1-C4, wherein the one or more outflow control devices are operatively attached to the production liner assembly using at least one of threads, an adhesive, and a weld.

[0099] C6.The method of any of paragraphs A1-C5, wherein the production liner assembly includes a plurality of production liner segments that are operatively attached to one another at a plurality of production liner joints, and further wherein at least a portion of the one or more outflow control devices are operatively attached to at least a portion of the production liner joints.

[0100] C7.The method of any of paragraphs A1-C6, wherein the plurality of treatment zones includes at least a proximal treatment zone and a distal treatment zone, wherein the proximal treatment zone is closer to a wellhead than the distal treatment zone, wherein each of the one or more outflow control devices includes a flow trigger, and further wherein a flow trigger for an outflow control device associated with the proximal treatment zone is different from a flow trigger for an outflow control device associated with the distal treatment zone.

[0101] C8.The method of paragraph C7, wherein the flow trigger for the outflow control device associated with the proximal treatment zone is greater than the flow trigger for the outflow control device associated with the distal treatment zone.

[0102] C9.The method of any of paragraphs C7-C8, wherein the flow trigger for the outflow control device associated with the proximal treatment zone includes a differential pressure across a production liner wall within the proximal treatment zone, and further wherein the flow trigger for the outflow control device associated with the distal treatment zone includes a differential pressure across the production liner wall within the distal treatment zone.

[0103] C10. The method of any of paragraphs C7-C9, wherein the plurality of treatment zones includes at least a first intermediate treatment zone between the proximal treatment zone and the distal treatment zone, and further wherein the flow trigger for the one

or more outflow control devices associated with each of the plurality of treatment zones increases monotonically from the distal treatment zone to the proximal treatment zone.

[0104] C11. The method of any of paragraphs A1-C10, wherein stimulating the first portion of the reservoir and stimulating the second portion of the reservoir include stimulating the portions of the reservoir in a substantially similar manner.

[0105] C12. The method of paragraph C11, wherein stimulating the portions of the reservoir in a substantially similar manner includes providing at least one of a substantially similar stimulant fluid flow rate, a substantially similar stimulant fluid chemistry, a substantially similar stimulant fluid temperature, a substantially similar stimulant fluid pressure, and a substantially similar overall volume of stimulant fluid to the portions of the reservoir.

[0106] C13. The method of any of paragraphs A1-C10, wherein stimulating the first portion of the reservoir and stimulating the second portion of the reservoir include stimulating the portions of the reservoir in a substantially different manner.

[0107] C14. The method of paragraph C13, wherein stimulating the portions of the reservoir in a substantially different manner includes providing at least one of a substantially different stimulant fluid flow rate, a substantially different stimulant fluid chemistry, a substantially different stimulant fluid temperature, a substantially different stimulant fluid pressure, and a substantially different overall volume of stimulant fluid to the portions of the reservoir.

[0108] C15. The method of any of paragraphs C11-C14, wherein a stimulant treatment for a portion of the reservoir is selected based at least in part on at least one of data collected before the subterranean well was drilled, data collected when the subterranean well was drilled, and data collected after the subterranean well was drilled.

[0109] C16. The method of any of paragraphs A1-C15, wherein at least one of stimulating the first portion of the reservoir and stimulating the second portion of the reservoir includes at least one of fracturing, acidizing, cleaning, and sealing the portion of the reservoir.

[0110] C17. The method of paragraph C16, wherein the stimulant fluid includes at least one of water; oil; drilling mud; an acid, such as hydrofluoric acid, hydrochloric acid, or acetic acid; a solvent; a surfactant; and a sealant.

[0111] C18. The method of any of paragraphs A1-C17, wherein at least a portion of the one or more inflow control device includes inflow control devices configured to increase a uniformity of a flow of reservoir fluid into the production liner assembly along a length of the production liner assembly.

[0112] C19. The method of any of paragraphs A1-C18, wherein at least a portion of the one or more inflow control device includes inflow control devices adapted to facilitate

fluid flow from the reservoir into the production liner assembly but to impede fluid flow from the production liner assembly into the reservoir.

[0113] C20. The method of paragraph C19, wherein at least a portion of the one or more inflow control device includes a check valve.

[0114] C21. The method of any of paragraphs A1-C20, wherein at least a portion of the one or more inflow control device is configured to decrease a flow rate of undesirable fluids into the subterranean well.

[0115] C22. The method of any of paragraphs A1-C21, wherein the plurality of treatment zones includes at least 2 treatment zones, optionally including at least 3 treatment zones, at least 4 treatment zones, at least 5 treatment zones, at least 10 treatment zones, at least 15 treatment zones, at least 20 treatment zones, at least 25 treatment zones, or at least 50 treatment zones, further optionally including 10-25 treatment zones, 5-50 treatment zones, or more than 50 treatment zones.

[0116] C23. The method of any of paragraphs A1-C22, wherein each of the plurality of treatment zones includes a zone length, and further wherein the zone length is at least 30 meters, optionally including zone lengths of at least 50 meters, at least 100 meters, at least 150 meters, at least 200 meters, at least 250 meters, at least 300 meters, at least 500 meters, at least 750 meters, or at least 1000 meters, further optionally including zone lengths of 30-50 meters, 100-200 meters, 50-300 meters, or 30-1000 meters.

[0117] C24. The method of any of paragraphs A1-C23, wherein the subterranean well includes an extended reach drilling well, and further wherein an overall length of the production liner assembly is at least 2,500 meters, optionally including overall lengths of at least 3,000 meters, at least 4,000 meters, at least 5,000 meters, at least 7,500 meters, at least 10,000 meters, at least 12,500 meters, at least 15,000 meters, or at least 20,000 meters.

[0118] C25. The method of any of paragraphs A1-C24, wherein, subsequent to stimulating the formation, the method further includes producing the reservoir fluid from the subterranean well, wherein the producing includes receiving the reservoir fluid into the production liner assembly through at least a portion of the one or more inflow control device.

[0119] C26. The method of any of paragraphs A1-C25, wherein the reservoir fluid includes a hydrocarbon, and further wherein the subterranean well includes a hydrocarbon well.

[0120] C27. The method of paragraph C26, wherein the hydrocarbon includes oil, and further wherein the subterranean well includes an oil well.

[0121] C28. The method of any of paragraphs C26-C27, wherein the hydrocarbon includes natural gas, and further wherein the subterranean well includes a natural gas well.

[0122] D1. A method of providing localized stimulation to a treatment zone of a subterranean well, wherein the subterranean well provides a fluid connection between a surface region and a subterranean formation including a reservoir that includes a reservoir fluid, the subterranean well including a production liner assembly that is contained within a wellbore, wherein the production liner assembly is apportioned into a plurality of treatment zones, and further wherein a plurality of packers impedes fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly, the method comprising:

- providing one or more outflow control devices in each of the plurality of treatment zones;

- providing one or more inflow control devices in each of the plurality of treatment zones;

- selecting a first of the plurality of treatment zones to receive a stimulant fluid;

- supplying the stimulant fluid to a first portion of the reservoir proximate the first of the plurality of treatment zones, wherein supplying the stimulant fluid includes supplying the stimulant fluid through at least a portion of the one or more outflow control devices present in the first of the plurality of treatment zones;

- stimulating the first portion of the reservoir;

- selecting a second of the plurality of treatments zones to receive the stimulant fluid;

- supplying the stimulant fluid to a second portion of the reservoir proximate the second of the plurality of treatment zones, wherein supplying the stimulant fluid includes supplying the stimulant fluid through at least a portion of the one or more outflow control devices present in the second of the plurality of treatment zones; and

- stimulating the second portion of the reservoir.

[0123] D2. The method of paragraph D1, wherein the production liner assembly includes one or more longitudinal flow control devices, and further wherein apportioning the production liner assembly into the plurality of treatment zones includes using the one or more longitudinal flow control devices to apportion the production liner assembly into the plurality of treatment zones.

[0124] D3. The method of any of paragraphs D1-D2, wherein apportioning the production liner assembly into the plurality of treatment zones includes utilizing a stimulant fluid supply localization device to supply the stimulant fluid to a desired one of the plurality of treatment zones.

[0125] D4. The method of any of paragraphs D1-D3 performed in combination with any of the methods of any of paragraphs A1-C28.

[0126] E1. A method of providing localized stimulation to a treatment zone of a subterranean well, wherein the subterranean well provides a fluid connection between a surface region and a subterranean formation including a reservoir that includes a reservoir fluid, the subterranean well including a production liner assembly that is contained within a wellbore, wherein the production liner assembly is apportioned into a plurality of treatment zones, and further wherein a plurality of packers impedes fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly, the method comprising:

- providing one or more outflow control devices in each of the plurality of treatment zones;

- providing one or more inflow control devices in each of the plurality of treatment zones;

- step for selecting a first of the plurality of treatment zones to receive a stimulant fluid;

- supplying the stimulant fluid to a first portion of the reservoir proximate the first of the plurality of treatment zones, wherein supplying the stimulant fluid includes supplying the stimulant fluid through at least a portion of the one or more outflow control devices present in the first of the plurality of treatment zones;

- stimulating the first portion of the reservoir;

- step for selecting a second of the plurality of treatments zones to receive the stimulant fluid;

- supplying the stimulant fluid to a second portion of the reservoir proximate the second of the plurality of treatment zones, wherein supplying the stimulant fluid includes supplying the stimulant fluid through at least a portion of the one or more outflow control devices present in the second of the plurality of treatment zones; and

- stimulating the second portion of the reservoir.

[0127] E2. The method of paragraph E1, wherein the step for selecting includes any suitable step of any of paragraphs A1-D4.

[0128] F1. A subterranean well including a wellbore drilled between a surface region and a subterranean formation, the subterranean formation including a reservoir that includes a reservoir fluid, wherein the wellbore contains a production liner assembly including a plurality of treatment zones, wherein the subterranean well further includes a plurality of packers adapted to impede fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly, the production liner assembly comprising:

- a plurality of production liner segments, wherein at least a portion of the plurality of production liner segments includes:

one or more inflow control devices, wherein at least a portion of the one or more inflow control devices includes an inflow check valve configured to facilitate fluid flow from the reservoir into the production liner segment and impede fluid flow from the production liner segment into the reservoir; and

one or more outflow control devices, wherein at least a portion of the one or more outflow control devices includes an outflow check valve configured to facilitate fluid flow from the production liner segment into the reservoir and impede fluid flow from the reservoir into the production liner segment.

[0129] F2. The subterranean well of paragraph F1, wherein the subterranean well further includes one or more longitudinal flow control devices configured to selectively apportion the production liner assembly into the plurality of treatment zones.

[0130] F3. The subterranean well of paragraph F2, wherein at least a portion of the one or more longitudinal flow control devices includes at least one of a valve, a check valve, and a mechanical flapper.

[0131] F4. The subterranean well of any of paragraphs F2-F3, wherein at least a portion of the one or more longitudinal flow control devices includes a ball and seat assembly.

[0132] F5. The subterranean well of paragraph F4, wherein the subterranean well further includes a ball catcher configured to catch the ball when it is ejected from the subterranean well.

[0133] F6. The subterranean well of any of paragraphs F4-F5, wherein the seat assembly is configured to be sheared from a seat assembly mount when subjected to a differential pressure that is greater than a threshold differential pressure.

[0134] F7. The subterranean well of any of paragraphs F1-F6, wherein the subterranean well further includes a stimulant fluid supply localization device configured to supply a stimulant fluid to at least one of the plurality of treatment zones.

[0135] F8. The subterranean well of paragraph F7, wherein the stimulant fluid supply localization device includes at least one of coiled tubing and drill pipe.

[0136] F9. The subterranean well of any of paragraphs F7-F8, wherein the stimulant fluid supply localization device is inserted into the subterranean well within the production liner assembly.

[0137] F10. The subterranean well of any of paragraphs F1-F9, wherein at least a portion of the one or more outflow control devices further include a high-velocity jet assembly adapted to increase a velocity of a fluid flowing therethrough.

[0138] F11. The subterranean well of any of paragraphs F1-F10, wherein the outflow check valve opening pressure is configured based on reservoir characteristics.

[0139] F12. The subterranean well of any of paragraphs F1-F11, wherein the outflow control devices are operatively attached to the production liner assembly using at least one of threads, an adhesive, and a weld.

[0140] F13. The subterranean well of any of paragraphs F1-F12, wherein the plurality of production liner segments are operatively attached to one another at a plurality of production liner joints, and further wherein at least a portion of the one or more outflow control devices are operatively attached to at least a portion of the production liner joints.

[0141] F14. The subterranean well of any of paragraphs F1-F13, wherein the plurality of treatment zones includes at least a proximal treatment zone and a distal treatment zone, wherein the proximal treatment zone is closer to a wellhead than the distal treatment zone, and further wherein each of the one or more outflow check valves includes a differential pressure flow trigger, and further wherein a differential pressure flow trigger associated with the proximal treatment zone is different from a differential pressure flow trigger associated with the distal treatment zone.

[0142] F15. The subterranean well of paragraph F14, wherein the differential pressure flow trigger associated with the proximal treatment zone is higher than the differential pressure flow trigger associated with the distal treatment zone.

[0143] F16. The subterranean well of any of paragraphs F14-F15, wherein the plurality of treatment zones includes at least a first intermediate treatment zone between the proximal treatment zone and the distal treatment zone, and further wherein the differential pressure flow trigger for the one or more outflow control devices associated with each of the plurality of treatment zones increases monotonically from the distal treatment zone to the proximal treatment zone.

[0144] F17. The subterranean well of any of paragraphs F1-F16, wherein at least a portion of the one or more inflow control devices is configured to increase a uniformity of a flow of reservoir fluid into the production liner assembly along a length of the production liner assembly.

[0145] F18. The subterranean well of any of paragraphs F1-F17, wherein at least a portion of the one or more inflow control devices is configured to decrease a flow rate of undesirable fluids into the subterranean well.

[0146] F19. The subterranean well of any of paragraphs F1-F18, wherein the plurality of treatment zones includes at least 2 treatment zones, optionally including at least 3 treatment zones, at least 4 treatment zones, at least 5 treatment zones, at least 10 treatment zones, at least 15 treatment zones, at least 20 treatment zones, at least 25 treatment zones, or at least 50 treatment zones, further optionally including 10-25 treatment zones, 5-50 treatment zones, or more than 50 treatment zones.

[0147] F20. The subterranean well of any of paragraphs F1-F19, wherein each of the plurality of treatment zones includes a zone length, and further wherein the zone length is at least 30 meters, optionally including zone lengths of at least 50 meters, at least 100 meters, at least 150 meters, at least 200 meters, at least 250 meters, at least 300 meters, at least 500 meters, at least 750 meters, or at least 1000 meters, further optionally including zone lengths of 30-50 meters, 100-200 meters, 50-300 meters, or 30-1000 meters.

[0148] F21. The subterranean well of any of paragraphs F1-F20, wherein the subterranean well includes an extended reach drilling well, and further wherein an overall length of the production liner assembly is at least 2,500 meters, optionally including overall lengths of at least 3,000 meters, at least 4,000 meters, at least 5,000 meters, at least 7,500 meters, at least 10,000 meters, at least 12,500 meters, at least 15,000 meters, or at least 20,000 meters.

[0149] F22. The subterranean well of any of paragraphs F1-F21, wherein the reservoir fluid includes a hydrocarbon, and further wherein the subterranean well includes a hydrocarbon well.

[0150] F23. The subterranean well of paragraph F22, wherein the hydrocarbon includes oil, and further wherein the subterranean well includes an oil well.

[0151] F24. The subterranean well of any of paragraphs F22-F23, wherein the hydrocarbon includes natural gas, and further wherein the subterranean well includes a natural gas well.

[0152] F25. The subterranean well of any of paragraphs F1-F24, wherein the subterranean well includes a horizontal well.

[0153] F26. The subterranean well of any of paragraphs F1-F25, wherein the subterranean well includes a vertical well.

[0154] G1. The use of the systems of any of paragraphs F1-F26 with the methods of any of paragraphs A1-E2.

[0155] G2. The use of the methods of any of paragraphs A1-E2 with the systems of any of paragraphs F1-F26.

[0156] G3. The use of the systems of any of paragraphs F1-F26 to produce oil.

[0157] G4. The use of the methods of any of paragraphs A1-E2 to produce oil.

[0158] G5. The use of the systems of any of paragraphs F1-F26 to stimulate a subterranean well.

[0159] G6. The use of the methods of any of paragraphs A1-E2 to stimulate a subterranean well.

[0160] Still further illustrative, non-exclusive examples of systems and methods according to the present disclosure include:

[0161] H1.A method of stimulating a reservoir including a subterranean well, the method comprising:

isolating a treatment zone from at least a portion of a plurality of treatment zones using a longitudinal flow control device;

supplying a stimulant fluid to the treatment zone;

stimulating a portion of the reservoir proximal the treatment zone, wherein the stimulating includes providing the stimulant fluid from an interior of a production liner assembly to the portion of the reservoir through one or more outflow control devices associated with the treatment zone; and

restricting a flow of fluid through the one or more outflow control devices associated with the treatment zone and from the portion of the reservoir to the interior of the production liner assembly.

[0162] H2.The method of paragraph H1, wherein the treatment zone is an initial treatment zone, the portion of the plurality of treatment zones is an initial portion of the plurality of treatment zones, the longitudinal flow control device is an initial longitudinal flow control device, and the portion of the reservoir is an initial portion of the reservoir, the method further including:

isolating a subsequent treatment zone from at least a subsequent portion of the plurality of treatment zones using a subsequent longitudinal flow control device;

supplying the stimulant fluid to the subsequent treatment zone;

stimulating a subsequent portion of the reservoir proximal the subsequent treatment zone, wherein the stimulating includes providing the stimulant fluid from the interior of the production liner assembly to the subsequent portion of the reservoir through one or more outflow control devices associated with the subsequent treatment zone; and

restricting a flow of fluid through the one or more outflow control devices associated with the subsequent treatment zone and from the subsequent portion of the reservoir to the interior of the production liner assembly.

[0163] H3.The method of paragraph H2, wherein stimulating the initial portion of the reservoir and stimulating the subsequent portion of the reservoir include providing a substantially similar stimulation treatment to the initial portion of the reservoir and the subsequent portion of the reservoir, and further wherein providing a substantially similar stimulation treatment includes providing at least one of a substantially similar stimulant fluid flow rate, a substantially similar stimulant fluid chemistry, a substantially similar stimulant fluid temperature, a substantially similar stimulant fluid pressure, and a substantially similar overall volume of stimulant fluid.

[0164] H4.The method of paragraph H2, wherein stimulating the initial portion of the reservoir and stimulating the subsequent portion of the reservoir include providing a

substantially different stimulation treatment to the initial portion of the reservoir than to the subsequent portion of the reservoir, and further wherein providing a substantially different stimulation treatment includes at least one of providing a substantially different stimulant fluid flow rate, a substantially different stimulant fluid chemistry, a substantially different stimulant fluid temperature, a substantially different stimulant fluid pressure, and a substantially different overall volume of stimulant fluid.

[0165] H5. The method of any of paragraphs H2-H4, wherein at least one of the initial longitudinal flow control device and the subsequent longitudinal flow control device includes a ball and seat assembly including a ball and a seat adapted to selectively receive the ball to obstruct fluid flow past the ball and seat assembly, and further wherein the method further includes selectively obstructing fluid flow through the ball and seat assembly when the ball is seated on the seat and selectively permitting fluid flow through the ball and seat assembly when the ball is not seated on the seat.

[0166] H6. The method of paragraph H5, wherein isolating the initial treatment zone includes seating a first ball on a first seat associated with the initial treatment zone, and further wherein isolating the subsequent treatment zone includes seating a second ball on a second seat associated with the subsequent treatment zone, wherein the first ball has a smaller diameter than the second ball, and further wherein the first ball will pass through the second seat assembly but not through the first seat assembly.

[0167] H7. The method of any of claims H1-H6, wherein the supplying includes bullheading the stimulant fluid into the production liner assembly.

[0168] H8. The method of any of paragraphs H1-H7, wherein at least a portion of the one or more outflow control devices includes a check valve adapted to facilitate fluid flow from the production liner assembly into the reservoir but to impede fluid flow from the reservoir into the production liner assembly, wherein the restricting includes restricting with the check valve, and optionally wherein at least a portion of the one or more outflow control devices further includes at least a first jet assembly adapted to increase a velocity of a fluid flowing therethrough, and further wherein the supplying includes accelerating the supplied stimulant fluid with the jet assembly.

[0169] H9. The method of any of paragraphs H1-H8, wherein the plurality of treatment zones includes at least a proximal treatment zone and a distal treatment zone, wherein the proximal treatment zone is closer to a wellhead than the distal treatment zone, wherein each of the proximal treatment zone and the distal treatment zone includes one or more outflow control devices, wherein each of the one or more outflow control devices includes a flow initiation threshold, wherein a flow initiation threshold for an outflow control device associated with the proximal treatment zone is greater than a flow initiation threshold for an outflow control device associated with the distal treatment zone, and further wherein the

stimulating includes preferentially providing the stimulant fluid through the one or more outflow control devices associated with the distal treatment zone prior to providing the stimulant fluid through the one or more outflow control devices associated with the proximal treatment zone.

[0170] H10. The method of paragraph H9, wherein the flow initiation threshold includes a threshold differential pressure across the outflow control device, and optionally wherein the plurality of treatment zones includes at least a first intermediate treatment zone between the proximal treatment zone and the distal treatment zone, wherein the at least a first intermediate treatment zone includes one or more outflow control devices, and further wherein the flow initiation threshold for the one or more outflow control devices associated with each of the plurality of treatment zones increases from the distal treatment zone to the proximal treatment zone.

[0171] H11. The method of any of paragraphs H1-H10, wherein stimulating the portion of the reservoir includes at least one of fracturing, acidizing, cleaning, removing buildup from, and sealing the portion of the reservoir, and optionally wherein the stimulant fluid includes at least one of water, oil, drilling mud, an acid, hydrofluoric acid, hydrochloric acid, acetic acid, a solvent, a surfactant, and a sealant.

[0172] H12. The method of any of paragraphs H1-H11, wherein each of the plurality of treatment zones further includes one or more inflow control devices, and further wherein the method includes producing reservoir fluid from the subterranean well by receiving the reservoir fluid from the reservoir and into the production liner assembly through the one or more inflow control devices, and optionally wherein the supplying includes supplying the stimulant fluid through the one or more outflow control devices at a flow rate that is at least five times larger than a flow rate of the reservoir fluid through the one or more inflow control devices during the producing.

[0173] H13. The method of paragraph H12, wherein at least a portion of the one or more inflow control devices includes inflow control devices configured to increase a uniformity of a flow of reservoir fluid into the production liner assembly along a length of the production liner assembly and the method further includes increasing the uniformity of the flow of reservoir fluid into the production liner assembly along the length of the production liner assembly.

[0174] H14. The method of paragraph H12 or H13, wherein at least a portion of the one or more inflow control devices includes inflow control devices adapted to facilitate fluid flow from the reservoir into the production liner assembly but to impede fluid flow from internal the production liner assembly into the reservoir and the method further includes restricting a flow of fluid through the inflow control device and from the production liner assembly into the reservoir.

[0175] H15. The method of paragraph H14, wherein at least a portion of the one or more inflow control devices includes a check valve.

[0176] H16. The method of any of paragraphs H1-H15, wherein the subterranean well includes a wellbore drilled between a surface region and a subterranean formation that includes the reservoir, wherein the reservoir includes reservoir fluid, wherein the wellbore contains the production liner assembly including a production liner and a plurality of longitudinal flow control devices that divide the production liner assembly into the plurality of treatment zones, wherein the plurality of longitudinal flow control devices selectively isolate at least a first portion of the plurality of treatment zones from fluid communication with at least a second portion of the plurality of treatment zones along a fluid communication pathway that is internal the production liner, wherein each of the plurality of treatment zones includes one or more outflow control devices, optionally wherein the reservoir fluid includes oil and the subterranean well includes an oil well, and further optionally wherein the subterranean well includes a plurality of packers and the method further includes impeding fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly using at least a portion of the plurality of packers.

Industrial Applicability

[0177] The systems and methods disclosed herein are applicable to the oil and gas industry.

[0178] It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

[0179] It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower, or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

Claims

1. A method of stimulating a subterranean reservoir, the method comprising:
 - isolating, with a first longitudinal flow control device, a treatment zone of a production liner assembly of a well that is in fluid communication with the reservoir from at least a portion of a plurality of treatment zones of the production liner assembly;
 - supplying a stimulant fluid to the treatment zone;
 - stimulating a portion of the reservoir proximal the treatment zone, wherein the stimulating includes providing the stimulant fluid from an interior of the production liner assembly to the portion of the reservoir through one or more outflow control devices associated with the treatment zone; and
 - restricting a flow of fluid through the one or more outflow control devices associated with the treatment zone and from the portion of the reservoir to the interior of the production liner assembly.
2. The method of claim 1, wherein the treatment zone is an initial treatment zone, the portion of the plurality of treatment zones is an initial portion of the plurality of treatment zones, the longitudinal flow control device is an initial longitudinal flow control device, and the portion of the reservoir is an initial portion of the reservoir, the method further including:
 - isolating a subsequent treatment zone from at least a subsequent portion of the plurality of treatment zones using a subsequent longitudinal flow control device;
 - supplying the stimulant fluid to the subsequent treatment zone;
 - stimulating a subsequent portion of the reservoir proximal the subsequent treatment zone, wherein the stimulating includes providing the stimulant fluid from the interior of the production liner assembly to the subsequent portion of the reservoir through one or more outflow control devices associated with the subsequent treatment zone; and
 - restricting a flow of fluid through the one or more outflow control devices associated with the subsequent treatment zone and from the subsequent portion of the reservoir to the interior of the production liner assembly.
3. The method of claim 2, wherein stimulating the initial portion of the reservoir and stimulating the subsequent portion of the reservoir include providing a substantially similar stimulation treatment to the initial portion of the reservoir and the subsequent portion of the reservoir, and further wherein providing a substantially similar stimulation treatment includes providing at least one of a substantially similar stimulant fluid flow rate, a substantially similar stimulant fluid chemistry, a substantially similar stimulant fluid temperature, a substantially similar stimulant fluid pressure, and a substantially similar overall volume of stimulant fluid.

4. The method of claim 2, wherein stimulating the initial portion of the reservoir and stimulating the subsequent portion of the reservoir include providing a substantially different stimulation treatment to the initial portion of the reservoir than to the subsequent portion of the reservoir, and further wherein providing a substantially different stimulation treatment includes at least one of providing a substantially different stimulant fluid flow rate, a substantially different stimulant fluid chemistry, a substantially different stimulant fluid temperature, a substantially different stimulant fluid pressure, and a substantially different overall volume of stimulant fluid.

5. The method of claim 2, wherein at least one of the initial longitudinal flow control device and the subsequent longitudinal flow control device includes a ball and seat assembly including a ball and a seat adapted to selectively receive the ball to obstruct fluid flow past the ball and seat assembly, and further wherein the method further includes selectively obstructing fluid flow through the ball and seat assembly when the ball is seated on the seat and selectively permitting fluid flow through the ball and seat assembly when the ball is not seated on the seat.

6. The method of claim 5, wherein isolating the initial treatment zone includes seating a first ball on a first seat associated with the initial treatment zone, and further wherein isolating the subsequent treatment zone includes seating a second ball on a second seat associated with the subsequent treatment zone, wherein the first ball has a smaller diameter than the second ball, and further wherein the first ball will pass through the second seat assembly but not through the first seat assembly.

7. The method of claim 1, wherein the supplying includes bullheading the stimulant fluid into the production liner assembly.

8. The method of claim 1, wherein at least a portion of the one or more outflow control devices includes a check valve adapted to facilitate fluid flow from the production liner assembly into the reservoir but to impede fluid flow from the reservoir into the production liner assembly, and further wherein the restricting includes restricting with the check valve.

9. The method of claim 8, wherein at least a portion of the one or more outflow control devices further includes at least a first jet assembly adapted to increase a velocity of a fluid flowing therethrough, and further wherein the supplying includes accelerating the supplied stimulant fluid with the jet assembly.

10. The method of claim 1, wherein the production liner assembly includes a plurality of production liner segments that are operatively attached along a longitudinal axis at a plurality

of production liner joints to form an internal fluid passage, wherein at least a portion of the one or more outflow control devices is operatively attached to at least a portion of the production liner joints, and further wherein the stimulating includes providing the stimulant fluid through the one or more outflow control devices that are operatively attached to the portion of the production liner joints.

11. The method of claim 1, wherein the plurality of treatment zones includes at least a proximal treatment zone and a distal treatment zone, wherein the proximal treatment zone is closer to a wellhead than the distal treatment zone, wherein each of the proximal treatment zone and the distal treatment zone includes one or more outflow control devices, wherein each of the one or more outflow control devices includes a flow initiation threshold, wherein a flow initiation threshold for an outflow control device associated with the proximal treatment zone is greater than a flow initiation threshold for an outflow control device associated with the distal treatment zone, and further wherein the stimulating includes preferentially providing the stimulant fluid through the one or more outflow control devices associated with the distal treatment zone prior to providing the stimulant fluid through the one or more outflow control devices associated with the proximal treatment zone.

12. The method of claim 11, wherein the flow initiation threshold includes a threshold differential pressure across the outflow control device.

13. The method of claim 11, wherein the plurality of treatment zones includes at least a first intermediate treatment zone between the proximal treatment zone and the distal treatment zone, wherein the at least a first intermediate treatment zone includes one or more outflow control devices, and further wherein the flow initiation threshold for the one or more outflow control devices associated with each of the plurality of treatment zones increases from the distal treatment zone to the proximal treatment zone.

14. The method of claim 1, wherein stimulating the portion of the reservoir includes at least one of fracturing, acidizing, cleaning, removing buildup from, and sealing the portion of the reservoir.

15. The method of claim 1, wherein the stimulant fluid includes at least one of water, oil, drilling mud, an acid, hydrofluoric acid, hydrochloric acid, acetic acid, a solvent, a surfactant, and a sealant.

16. The method of claim 1, wherein each of the plurality of treatment zones further includes one or more inflow control devices, and further wherein the method includes producing reservoir fluid from the subterranean reservoir by receiving the reservoir fluid from

the reservoir and into the production liner assembly through the one or more inflow control devices.

17. The method of claim 16, wherein at least a portion of the one or more inflow control devices includes inflow control devices configured to increase a uniformity of a flow of reservoir fluid into the production liner assembly along a length of the production liner assembly and the method further includes increasing the uniformity of the flow of reservoir fluid into the production liner assembly along the length of the production liner assembly.

18. The method of claim 16, wherein at least a portion of the one or more inflow control devices includes inflow control devices adapted to facilitate fluid flow from the reservoir into the production liner assembly but to impede fluid flow from internal the production liner assembly into the reservoir and the method further includes restricting a flow of fluid through the inflow control device and from the production liner assembly into the reservoir.

19. The method of claim 18, wherein at least a portion of the one or more inflow control devices includes a check valve.

20. The method of claim 16, wherein the supplying includes supplying the stimulant fluid through the one or more outflow control devices at a flow rate that is at least five times larger than a flow rate of the reservoir fluid through the one or more inflow control devices during the producing.

21. The method of claim 1, wherein the subterranean reservoir includes a plurality of packers and the method further includes impeding fluid communication among the plurality of treatment zones by a fluid pathway that is external to the production liner assembly using at least a portion of the plurality of packers.

22. The method of claim 1, wherein the subterranean reservoir includes a wellbore drilled between a surface region and a subterranean formation that includes the reservoir, wherein the reservoir includes a reservoir fluid, wherein the wellbore contains the production liner assembly including a production liner and a plurality of longitudinal flow control devices that divide the production liner assembly into the plurality of treatment zones, wherein the plurality of longitudinal flow control devices selectively isolate at least a first portion of the plurality of treatment zones from fluid communication with at least a second portion of the plurality of treatment zones along a fluid communication pathway that is internal the production liner, wherein each of the plurality of treatment zones includes one or more outflow control devices, and further wherein the reservoir fluid includes oil and the well includes an oil well.

23. A subterranean well including a wellbore drilled between a surface region and a subterranean formation, wherein the subterranean formation includes a reservoir that includes a reservoir fluid, the subterranean well comprising:

a production liner assembly contained within the wellbore, the production liner assembly comprising:

one or more longitudinal flow control devices configured to selectively divide the production liner assembly into a plurality of treatment zones, wherein each of the plurality of treatment zones comprises:

one or more inflow control devices, wherein at least a portion of the one or more inflow control devices includes an inflow check valve configured to facilitate fluid flow from the reservoir into the production liner assembly and to impede fluid flow from the production liner assembly into the reservoir; and

one or more outflow control devices, wherein at least a portion of the one or more outflow control devices includes an outflow check valve configured to facilitate fluid flow from the production liner assembly into the reservoir and to impede fluid flow from the reservoir into the production liner assembly.

24. The subterranean well of claim 23, wherein at least a portion of the one or more longitudinal flow control devices includes a ball and seat assembly.

25. The subterranean well of claim 23, wherein at least a portion of the one or more outflow control devices further includes a jet assembly adapted to increase a velocity of a fluid flowing therethrough.

26. The subterranean well of claim 23, wherein the plurality of treatment zones includes at least a proximal treatment zone and a distal treatment zone, wherein the proximal treatment zone is closer to a wellhead than the distal treatment zone, wherein each of the one or more outflow check valves includes a differential pressure flow initiation threshold, and further wherein a differential pressure flow initiation threshold associated with the proximal treatment zone is greater than a differential pressure flow initiation threshold associated with the distal treatment zone.

27. The subterranean well of claim 26, wherein the plurality of treatment zones includes at least a first intermediate treatment zone between the proximal treatment zone and the distal treatment zone, and further wherein the differential pressure flow initiation threshold for the one or more outflow control devices associated with each of the plurality of treatment zones increases from the distal treatment zone to the proximal treatment zone.

28. The subterranean well of claim 23, wherein at least a portion of the one or more inflow control devices is configured to increase a uniformity of a flow of reservoir fluid into the production liner along a length of the production liner.

29. The subterranean well of claim 23, wherein the plurality of treatment zones includes at least 10 treatment zones.

30. The subterranean well of claim 23, wherein each of the plurality of treatment zones includes a zone length, and further wherein the zone length is at least 100 meters.

31. The subterranean well of claim 23, wherein the subterranean well includes an extended reach drilling well, and further wherein an overall length of the production liner is at least 5000 meters.

32. The subterranean well of claim 23, wherein the production liner assembly includes a plurality of production liner segments that are operatively attached along a longitudinal axis at a plurality of production liner joints to form an internal fluid passage, and further wherein at least a portion of the one or more outflow control devices are operatively attached to at least a portion of the plurality of production liner joints.

33. The subterranean well of claim 23, wherein the reservoir fluid includes oil, and further wherein the subterranean well includes an oil well.

34. A method of stimulating a subterranean well including a wellbore drilled between a surface region and a subterranean formation, the subterranean formation including a reservoir that includes a reservoir fluid, wherein the wellbore contains a production liner assembly that includes a production liner and defines a plurality of treatment zones, and further wherein each of the plurality of treatment zones includes one or more outflow control devices, the method comprising:

placing an outlet of a stimulant fluid delivery device proximal to an initial treatment zone, wherein the initial treatment zone includes a first treatment zone of the plurality of treatment zones;

supplying a stimulant fluid to the initial treatment zone using the stimulant fluid delivery device;

stimulating a first portion of the reservoir proximal the initial treatment zone, wherein the stimulating includes providing the stimulant fluid from an interior of the production liner to the first portion of the reservoir through the one or more outflow control devices of the initial treatment zone;

restricting a flow of fluid through the one or more outflow control devices of the initial treatment zone and from the first portion of the reservoir to the interior of the production liner;

placing the outlet of the stimulant fluid delivery device proximal to a subsequent treatment zone, wherein the subsequent treatment zone includes a second treatment zone of the plurality of treatment zones;

supplying the stimulant fluid to the subsequent treatment zone using the stimulant fluid delivery device;

stimulating a second portion of the reservoir proximal the subsequent treatment zone, wherein the stimulating includes providing the stimulant fluid from the interior of the production liner to the second portion of the reservoir through the one or more outflow control devices of the subsequent treatment zone; and

restricting a flow of fluid through the one or more outflow control devices of the subsequent treatment zone and from the second portion of the reservoir to the interior of the production liner.

35. The method of claim 34, wherein the stimulant fluid delivery device includes at least one of coiled tubing and drill pipe.

36. The method of claim 34, the method further including inserting the stimulant fluid delivery device within the production liner.

37. The method of claim 34, the method further including repeating the placing, supplying, stimulating, and restricting steps until all desired treatment zones have been stimulated.

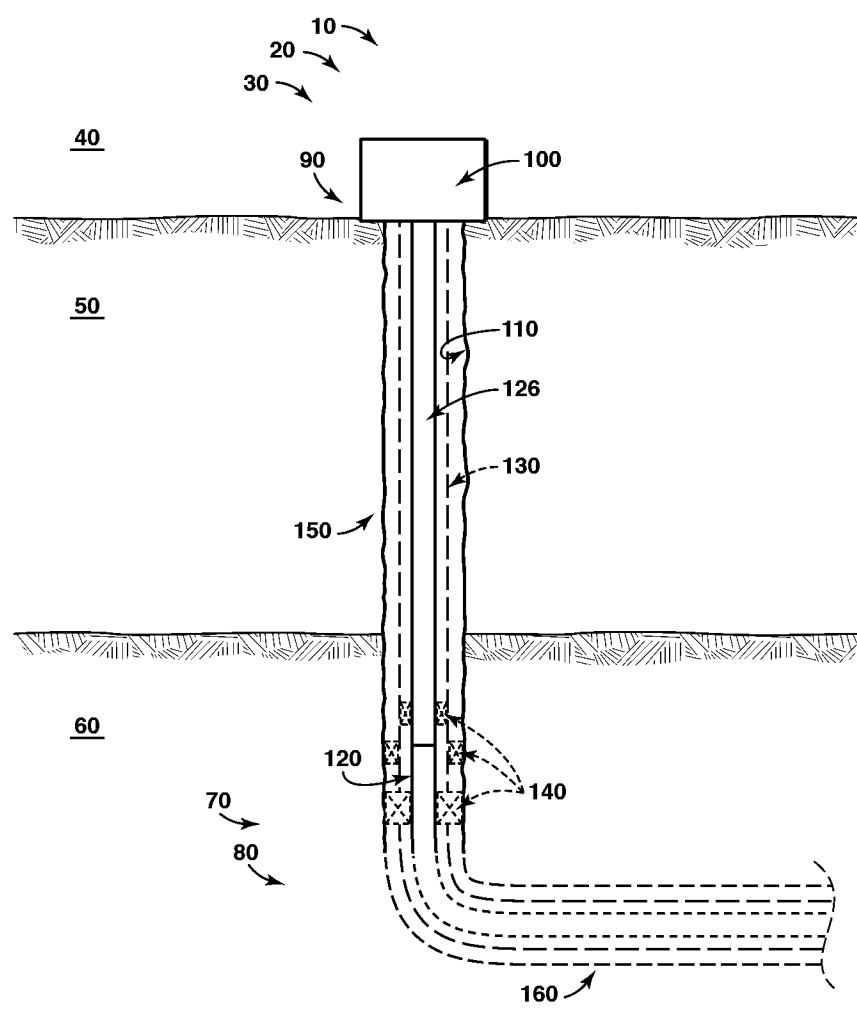
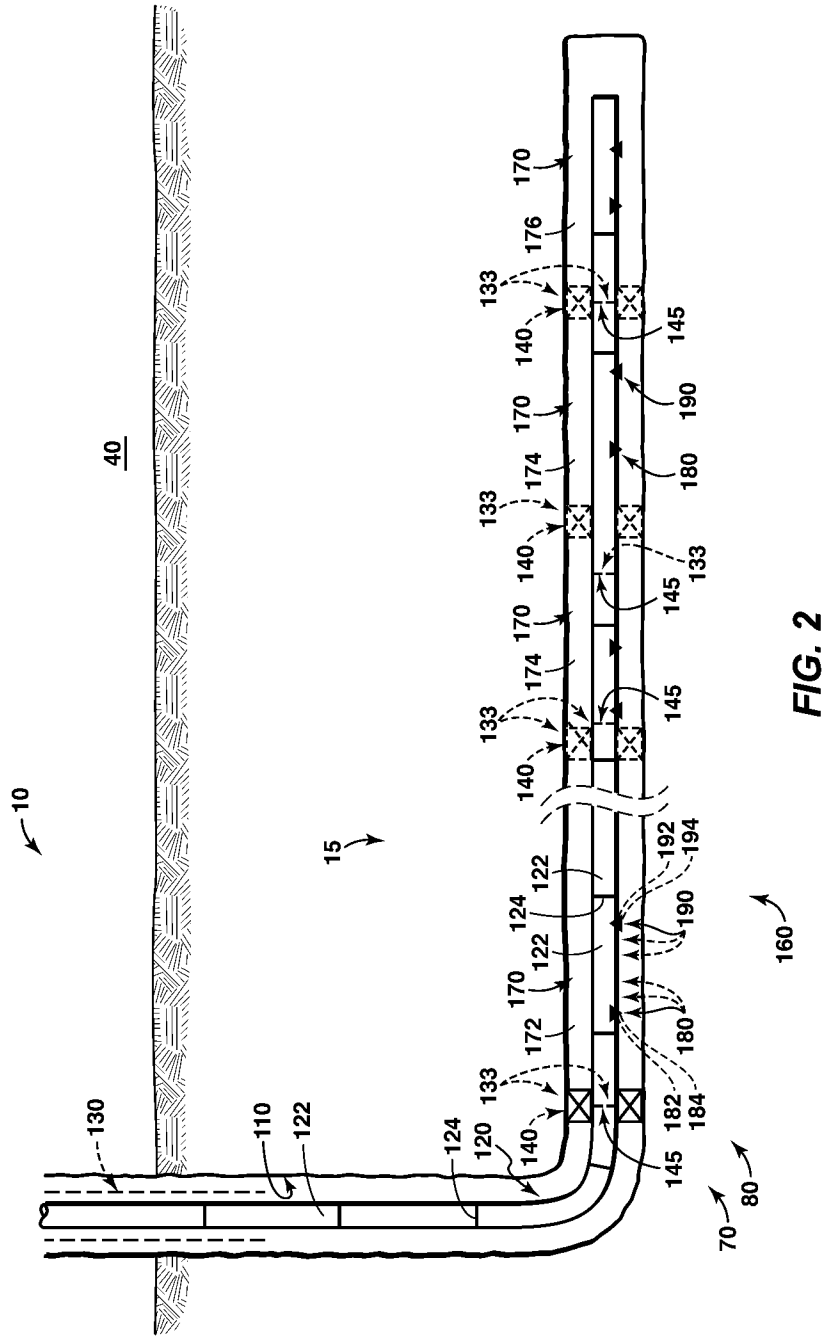


FIG. 1



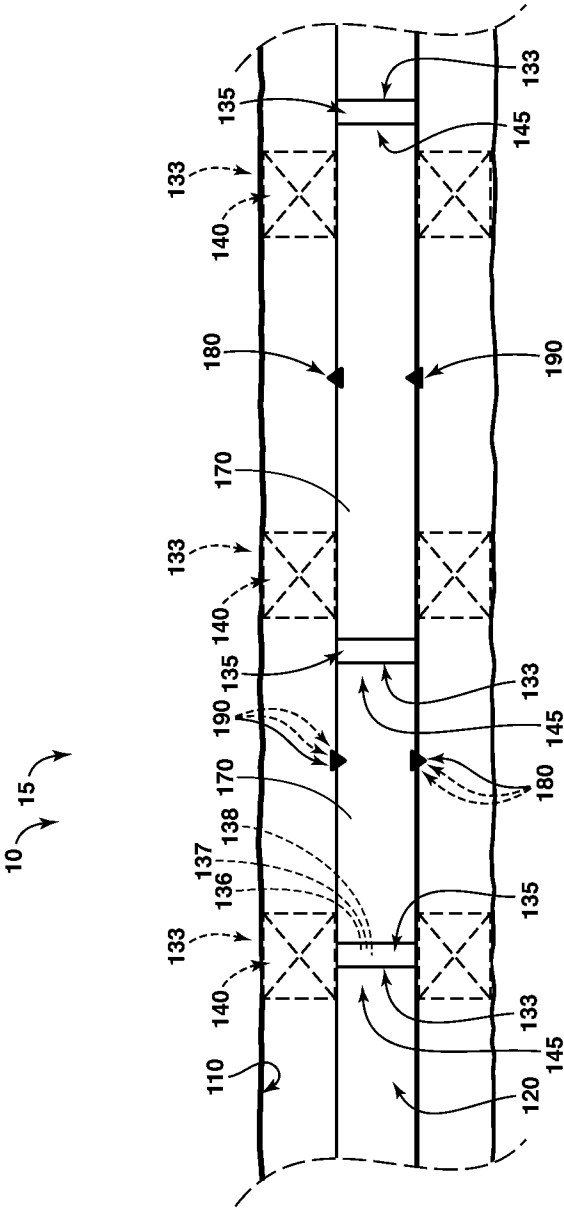


FIG. 3

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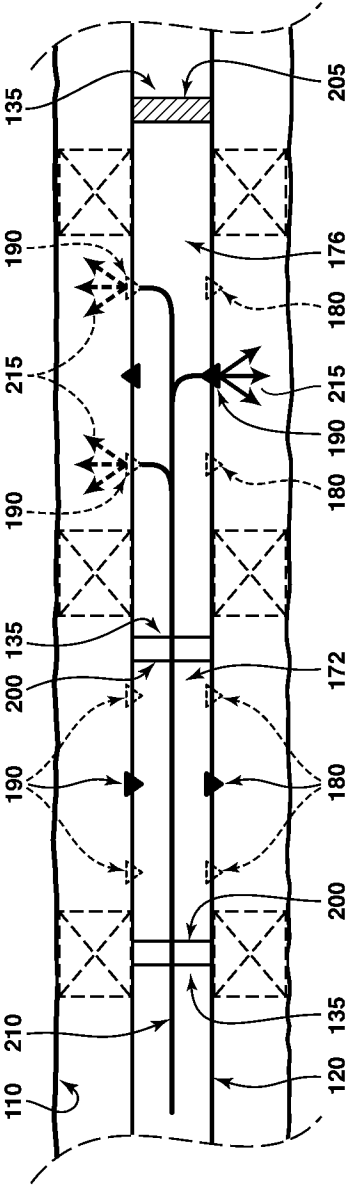


FIG. 4

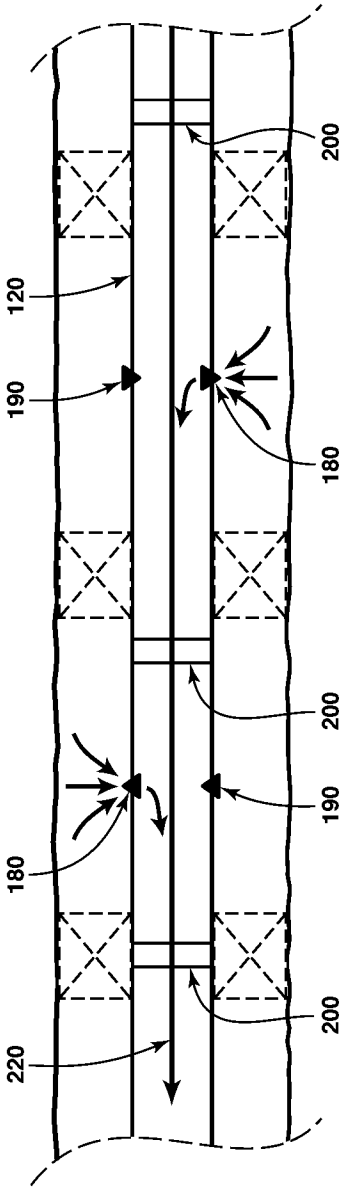


FIG. 5

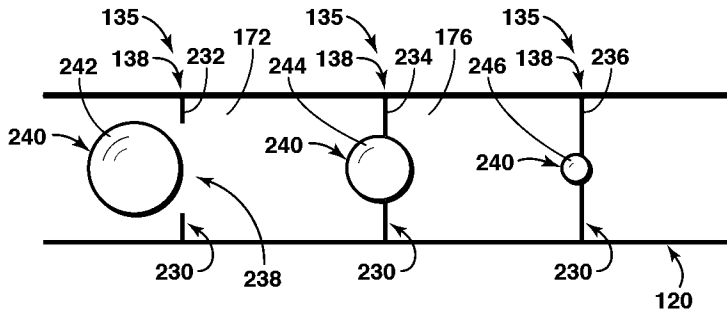


FIG. 6

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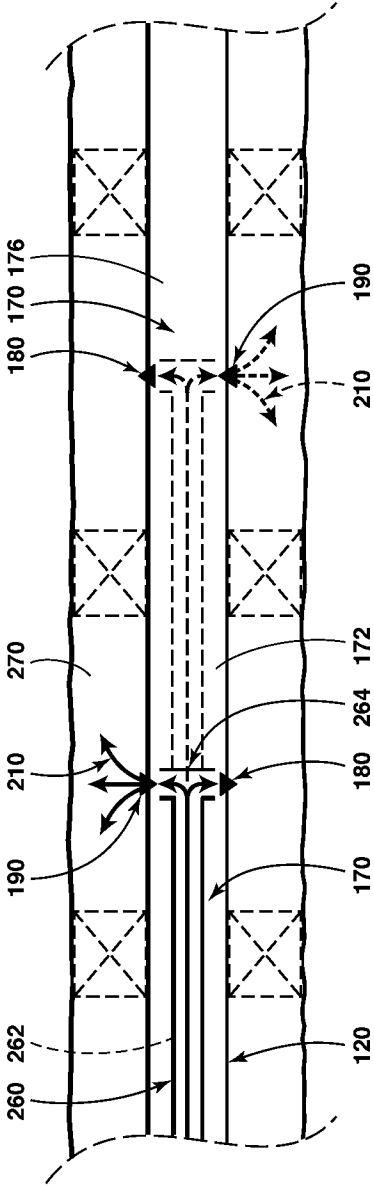


FIG. 7

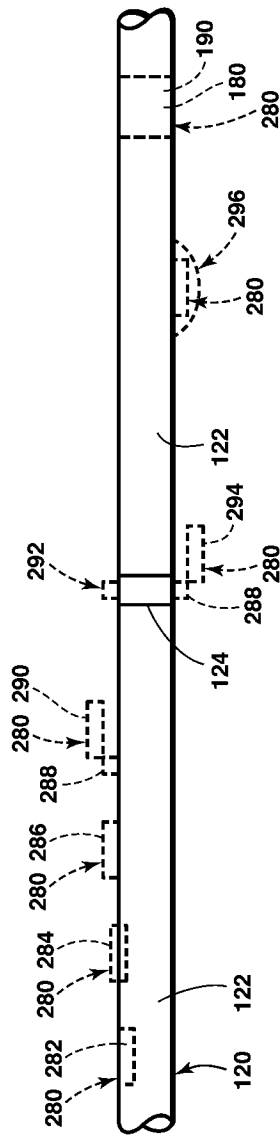


FIG. 8

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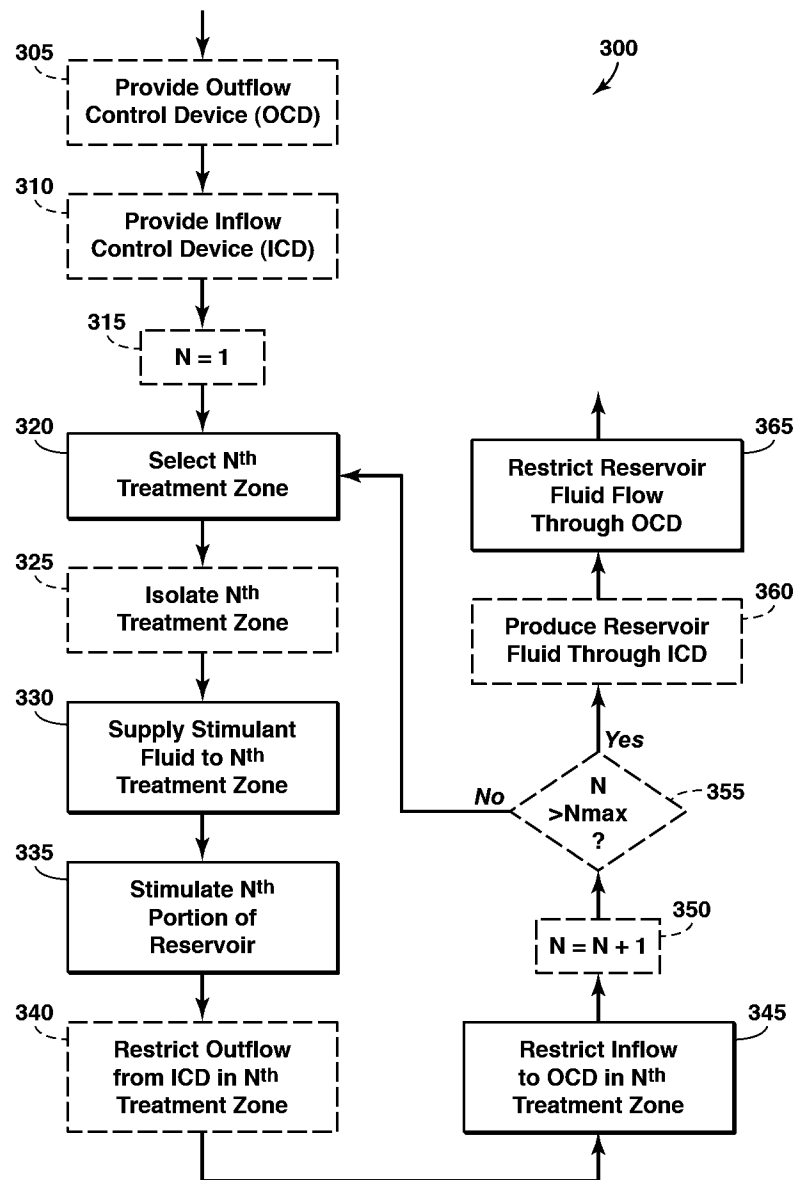


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/058989

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 43/26 (2012.01)

USPC - 166/308.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - E21B 34/00, 43/26 (2012.01)

USPC - 166/177.5, 227, 308.1, 329, 376

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0260815 A1 (MALONE) 22 October 2009 (22.10.2009) entire document	1-7, 14-22
Y		8-13, 23-37
Y	US 2008/0179060 A1 (SURJAATMADJA et al) 31 July 2008 (31.07.2008) entire document	8, 9, 23-37
Y	US 2010/0000727 A1 (WEBB et al) 07 January 2010 (07.01.2010) entire document	10, 32
Y	US 2003/0188871 A1 (DUSTERHOFT et al) 09 October 2003 (09.10.2003) entire document	11-13, 26, 27
A	US 2008/0041588 A1 (RICHARDS et al) 21 February 2008 (21.02.2008) entire document	1-37
A	US 2005/0263284 A1 (JUSTUS) 01 December 2005 (01.12.2005) entire document	1-37
A	US 4,934,460 A (CORONADO) 19 June 1990 (19.06.1990) entire document	1-37

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* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

07 March 2012

Date of mailing of the international search report

16 MAR 2012

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Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

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