PATENT FAMILY SPECIFICATION COMPARISONS

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’770 COMPARISON WITH U.S. PATENT 11,401,779 (’779)

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/388,716 (the “'716 Application”), filed Jul. 29, 2021, which claims the benefit of the filing date of, and priority to, U.S. ~~application~~Patent Application No. 63/189,663, filed May 17, 2021, the entire ~~disclosure~~disclosures of which ~~is~~are hereby incorporated herein by reference.

~~This application~~The '716 Application is ~~also~~ a continuation-in-part (CIP) of U.S. patent application Ser. No. 17/319,854 (the “'854 ~~application~~Application”), filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference.

The '854 ~~application~~Application is a continuation-in-part (CIP) of U.S. patent application Ser. No. 16/855,749 (the “'749 ~~application~~Application”), filed Apr. 22, 2020, the entire disclosure of which is hereby incorporated herein by reference. The '749 ~~application~~Application claims the benefit of the filing date of, and priority to, U.S. Patent Application No. 62/836,761, filed Apr. 22, 2019, the entire disclosure of which is hereby incorporated herein by reference.

The '749 ~~application~~Application is a continuation-in-part (CIP) of U.S. patent application Ser. No. 16/248,648 (the “'648 ~~application~~Application”), filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. The '648 ~~application~~Application claims the benefit of the filing date of, and priority to, U.S. Application No. 62/617,443, filed Jan. 15, 2018, the entire disclosure of which is hereby incorporated herein by reference.

The '749 ~~application~~Application is also a CIP of U.S. patent application Ser. No. 16/803,156 (the “'156 ~~application~~Application”), filed Feb. 27, 2020, the entire disclosure of which is hereby incorporated herein by reference. The '156 ~~application~~Application is a CIP of U.S. patent application Ser. No. 16/248,633 (the “'633 ~~application~~Application”), filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. The '633 ~~application~~Application claims the benefit of the filing date of, and priority to, U.S. Patent Application No. 62/617,438 (the “'438 ~~application~~Application”), filed Jan. 15, 2018, the entire disclosure of which is hereby incorporated herein by reference.

The '156 ~~application~~Application is also a CIP of U.S. patent application Ser. No. 16/436,623 (the “'623 ~~application~~Application”), filed Jun. 10, 2019, the entire disclosure of which is hereby incorporated herein by reference. The '623 ~~application~~Application claims the benefit of the filing date of, and priority to, U.S. Patent Application No. 62/755,170, filed Nov. 2, 2018, the entire disclosure of which is hereby incorporated herein by reference.

The '156 ~~application~~Application is also a CIP of U.S. patent application Ser. No. 16/100,741 (the “'741 ~~application~~Application”), filed Aug. 10, 2018, now issued as U.S. Pat. No. 10,689,938, the entire disclosure of which is hereby incorporated herein by reference. The '741 Application claims the benefit of the filing date of, and priority to, U.S. Patent Application No. 62/638,688, filed Mar. 5, 2018, U.S. Patent Application No. 62/638,681, filed Mar. 5, 2018, U.S. Patent Application No. 62/637,220, filed Mar. 1, 2018, U.S. Patent Application No. 62/637,215, filed Mar. 1, 2018, and U.S. Patent Application No. 62/598,914, filed Dec. 14, 2017, the entire disclosures of which are hereby incorporated herein by reference.

The '749 ~~application~~Application is related to U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, the entire disclosure of which is hereby incorporated herein by reference.

~~This application~~The '716 Application is also related to U.S. patent application Ser. No. 17/360,336, filed Jun. 28, 2021, the entire disclosure of which is hereby incorporated herein by reference.

BACKGROUND

This application relates generally to oil and gas hydraulic fracturing operations and, more particularly, to a hydraulic fracturing plan executable by a hydraulic fracturing system to hydraulically fracture a plurality of oil and gas wells.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.- **1**A is a diagrammatic illustration of a hydraulic fracturing system operably to execute a hydraulic fracturing plan to hydraulically fracture a plurality of oil and gas wells, according to one or more embodiments.

FIG.- **1**B is a flow diagram illustrating a method for hydraulically fracturing a plurality of wells by executing a hydraulic fracturing plan using the hydraulic fracturing system of FIG.- **1**A, according to one or more embodiments.

FIG.- **2**A schematically illustrates execution of one or more sub-step(s) of a first step of the method illustrated in FIG.- **1**B, which first step is or includes equalizing a lubricator of a frac leg associated with a first well, and opening the first well, according to one or more embodiments.

FIG.- **2**B schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **2**C schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **2**D schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **2**E schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **2**F schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **2**G schematically illustrates execution of one or more additional sub-step(s) of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **3** is a flow diagram illustrating the various sub-steps, illustrated schematically in FIGS.- **2**A and- **2**G, of the first step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **4** is a flow diagram illustrating various sub-steps of a second step of the method illustrated in FIG.- **1**B, which second step is or includes perforating a stage of the first well using a wireline perforating system, according to one or more embodiments.

FIG.- **5**A schematically illustrates execution of one or more sub-step(s) of the second step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **5**B schematically illustrates execution of one or more additional sub-step(s) of the second step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **5**C schematically illustrates execution of one or more additional sub-step(s) of the second step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.- **6** is a flow diagram illustrating various sub-steps of a third step of the method illustrated in FIG.- **1**B, which third step is or includes closing the first well using a valve apparatus, and draining a lubricator, according to one or more embodiments.

FIG.- **7**A schematically illustrates execution of one or more sub-step(s) of the third step of the method illustrated in FIG.- **1**B, according to one or more embodiments.

FIG.-7B schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7C schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7D schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7E schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7F schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7G schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7H schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-7I schematically illustrates execution of one or more additional sub-step(s) of the third step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-**8** is a flow diagram illustrating various sub-steps of a fourth step of the method illustrated in FIG.-1B, which fourth step is or includes isolating a stage of a second well in preparation for a hydraulic fracturing operation, according to one or more embodiments.
FIG.-9A schematically illustrates execution of one or more sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9B schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9C schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9D schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9E schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9F schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-9G schematically illustrates execution of one or more additional sub-step(s) of the fourth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-**10** is a flow diagram illustrating various sub-steps of a fifth step of the method illustrated in FIG.-1B, which fifth step is or includes detecting or otherwise determining that a fracturing stage of a third well has ended, according to one or more embodiments.
FIG.-**11** schematically illustrates execution of one or more subs-step(s) of the fifth step of the method illustrated in FIG.-1B, according to one or more embodiments.
FIG.-**12** is a flow diagram illustrating various sub-steps of a sixth step of the method illustrated in FIG.-1B, which sixth step is or includes determining whether to permit a regular swap or a continuous pumping swap (or "CP swap"), according to one or more embodiments.
FIG.-**13** is a flow diagram illustrating various sub-steps of a seventh step of the method illustrated in FIG.-1B, which seventh step is or includes the regular swap from hydraulically fracturing the third well to hydraulically fracturing the second well, according to one or more embodiments.

FIG.- **14**A schematically illustrates execution of one or more sub-step(s) of the seventh step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **14**B schematically illustrates execution of one or more additional sub-step(s) of the seventh step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **15** is a flow diagram illustrating various sub-steps of an eighth step of the method illustrated in FIG.- **1**B, which eighth step is or includes the CP swap from hydraulically fracturing the third well to hydraulically fracturing the second well, according to one or more embodiments.
FIG.- **16**A schematically illustrates execution of one or more sub-step(s) of the eighth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **16**B schematically illustrates execution of one or more additional sub-step(s) of the eighth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **16**C schematically illustrates execution of one or more additional sub-step(s) of the eighth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **16**D is a chart illustrating execution of one or more of the various sub-steps, schematically illustrated in FIGS.- **16**A through- **16**C, of the eighth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **16**E is another chart illustrating execution of one or more of the various sub-steps, schematically illustrated in FIGS.- **16**A through- **16**C, of the eighth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **17** is a flow diagram illustrating various sub-steps of a ninth step of the method illustrated in FIG.- **1**B, which ninth step is or includes latching, filling, and pressure testing a frac leg associated with a fourth well in preparation for perforating a stage of the fourth well using the wireline perforating system, according to one or more embodiments.
FIG.- **18**A schematically illustrates execution of one or more sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**B schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**C schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**D schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**E schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**F schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **18**G schematically illustrates execution of one or more additional sub-step(s) of the ninth step of the method illustrated in FIG.- **1**B, according to one or more embodiments.
FIG.- **19**A is a flow diagram illustrating a portion of another method for fracturing wells using the fracturing system of FIG.- **1**A, which another method includes swapping from simultaneously fracturing first and second wells to simultaneously fracturing third and fourth wells, according to one or more embodiments.
FIG.- **19**B is a flow diagram illustrating another portion of the another method of FIG.- **20**A, according to one or more embodiments.
FIG.- **20** is a diagrammatic illustration of a computing node for implementing one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

Referring to FIG.- **1**A, in an embodiment, a hydraulic fracturing system **100** for executing a hydraulic fracturing plan to hydraulically fracture wells **105**A through **105**C+n is illustrated, which hydraulic fracturing system **100** includes: a blender **110** adapted to mix fluid from a fluid source **115** with sand from a sand source **120** to produce hydraulic fracturing fluid; a suction manifold **125** adapted to receive the hydraulic fracturing fluid from the blender **110**; a discharge manifold **130**; a plurality of swap stations **135**, each adapted to communicate the hydraulic fracturing fluid from the suction manifold **125** to a corresponding pump truck **140**, and, after pressurization by the corresponding pump truck **140**, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck **140** to the discharge manifold **130**; and a zipper manifold **145** adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold **130** to a plurality of hydraulic fracturing legs (or "frac legs") **150**A through **150**C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold **145** to a corresponding one of the wells **105**A through **105**C+n. In one or more embodiments, each of the swap stations **135** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.

A grease system **155** is adapted to communicate lubricating grease to various components of the frac legs **150**A through **150**C+n, including, for example, pump-down valves **160** *a-b,*- master valves **165** *a-b,*- and zipper valves **170** *a-b* associated with each of the frac legs **150**A through **150**C+n (which components are shown in FIGS.- **2**A-G, **5**A-C, **7**A-I, **9**A-G, **11**, **14**A-B, **16**A-C, and **18**A-G). In one or more embodiments, the grease system **155** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system **155** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020~~,~~ now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system **155** is or includes one or more components shown and described in the '749 ~~application~~Application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system **155** is or includes one or more components shown and described in the '854 ~~application~~Application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.

A controller **156** is adapted to control the grease system **155**, the frac legs **150**A through **150**C+n, or both. In one or more embodiments, the controller **156** is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller **156** is located on-site at the well site. Alternatively, the controller **156** may be located remotely from the well site. In one or more embodiments, the controller **156** includes a plurality of controllers. In one or more embodiments, the controller **156** includes a plurality of controllers, with one or more controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.

Referring to FIG.- 1B, in an embodiment, a method **175** for hydraulically fracturing the wells **105**A through **105**C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system **100** of FIG.- 1A is illustrated. The method **175** generally includes: at step(s) **176** *a,*- perforating a stage of each well using, for example, a wireline perforating system **177**; at step(s) **176** *b,*- isolating the perforated stage of each well using an object dropped, for example, from a launcher **178** of the wireline perforating system **177**; and, at step(s) **176** *c,*- hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method **175** includes: at a step **225**, equalizing a lubricator **220** of the frac leg **150**A associated with the well **105**A, and opening the well **105**A; at a step **230**, perforating a stage of the well **105**A using the wireline perforating system **177**; at a step **235**, closing the well **105**A using the valve apparatus **210** and draining the lubricator **220**; at a step **238** *a,*- queuing the well **105**A (as indicated at queue position n_2) in a frac queue **239** in preparation for a hydraulic fracturing operation; at a step **238** *b,*- dequeuing the well **105**B (as indicated at queue position n_1+1) from the frac queue **239** in preparation for the hydraulic fracturing operation; at a step **240**, isolating a stage of the well **105**B in preparation for the hydraulic fracturing operation; at a step **245**, detecting or otherwise determining that a fracturing stage of the well **105**D has ended; at a step **250**, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step **262**) the well **105**D to hydraulically fracturing (at the step **262**) the well **105**B; at a step **255**, executing the regular swap from hydraulically fracturing (at the step **262**) the well **105**D to hydraulically fracturing (at the step **262**) the well **105**B, or, at a step **260**, executing the CP swap from hydraulically fracturing (at the step **262**) the well **105**D to hydraulically fracturing (at the step **262**) the well **105**B; at the step **262**, hydraulically fracturing the well **105**B; optionally, at a step **263** *a,*- queuing the well **105**D (as indicated at queue position n_1) in a wireline queue **264** in preparation for perforating a next stage of the well **105**D; optionally, at a step **238** *b,*- dequeuing the well **105**E (as indicated at queue position- **1**) from the wireline queue **264** in preparation for perforating a next stage of the well **105**E; and, at a step **265**, latching, filling, and pressure testing the frac leg **150**E associated with the well **105**E.

In one or more embodiments, the controller **156** is adapted to control the grease system **155**, the frac legs **150**A through **150**C+n, or both, in order to execute the method **175** described herein. In one or more embodiments, the frac queue **239** and the wireline queue **264** are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller **156**. In one or more embodiments, the frac queue **239** is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue **239** is associated with the wells **105**A through **105**C+n, as shown in FIG.- 1B. In addition, or instead, the frac queue **239** can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue **264** is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue **264** is associated with the wells **105**A through **105**C+n, as shown in FIG.- 1B. In addition, or instead, the wireline queue **264** can be at least partially populated by an external source, such as, for example, the wireline operator.

Referring to FIGS.- 2A through- 2G, in an embodiment, the frac leg **150**A associated with the well **105**A is illustrated, which frac leg **150**A includes: a wellhead including the master valves **165** *a-b* (such as, for example, gate valves) operably coupled to, and adapted to be in fluid

communication with, the well **105**A, each of the master valves **165** *a-b* including associated grease ports (or "GPs") **185** *a-b;* the pump-down valves **160** *a-b* (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck **190** and the well **105**A, via the master valves **165** *a-b,* each of the pump-down valves **160** *a-b* including an associated GP **195**; and the zipper valves **170** *a-b* (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold **145** and the well **105**A, via the master valves **165** *a-b,* each of the zipper valves **170** *a-b* including associated GPs **200** *a-b.* In one or more embodiments, one or both of the zipper valves **170** *a-b* of each of the frac legs **150**A through **150**C+n include(s), or is/are part of, the zipper manifold **145**. In one or more embodiments, as in FIGS. **2**A through **2**G, the frac leg **150**A associated with the well **105**A also includes a flow block **205** to which the pump-down valves **160** *a-b* and the zipper valves **170** *a-b* are operably coupled.

The frac leg **150**A associated with the well **105**A further includes a valve apparatus **210** via which both the wireline perforating system **177** and the object launched from, for example, the launcher **178**, are permitted entry to the well **105**A. The valve apparatus **210** includes: a containment area **215** *a* (labeled "WELL") adapted to be in fluid communication with the well **105**A via the master valves **165** *a-b;* a containment area **215** *b* (labeled "LUB") adapted to be in fluid communication with the lubricator **220** of the wireline perforating system **177**; and a containment area **215** *c* (labeled "LL") adapted to be in fluid communication with the containment area **215** *a* via a flow control device **221** *a* (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area **215** *b* via a flow control device **221** *b* (e.g., a flapper-type flow control device).

An equalization ("EQ") valve **222** *a* is connected between the containment areas **215** *a* and **215** *c,* which EQ valve **222** *a* is openable to permit pressure equalization between the containment areas **215** *a* and **215** *c* when the flow control device **221** *a* is closed. Likewise, an equalization valve **222** *b* is connected between the containment areas **215** *b* and **215** *c,* which EQ valve **222** *b* is openable to permit pressure equalization between the containment areas **215** *b* and **215** *c* when the flow control device **221** *b* is closed. Additionally, an EQ valve **222** *c* is connected between the lubricator **220** and atmosphere (labeled "ATM"), which EQ valve **222** *c* permits pressure equalization between the lubricator **220** and atmosphere. A drain **223** is connected between a latch **234** (via which the lubricator **220** is detachably couplable to the valve apparatus **210**) and a pump station **224** *a,* via which drain **223** fluid is communicable to and/or from the lubricator **220**, using, for example, an auto-fill/auto-drain pump of the pump station **224** *a,* when the lubricator **220** is connected to the valve apparatus **210** via the latch **234**. Finally, when the lubricator **220** is connected to the valve apparatus **210** via the latch **234**, fluid can also be communicated to the lubricator **220** (via, for example, the containment area **215** *c* and the EQ valve **222** *b*) using one or more boost pump(s) **224** *b* in order to increase a fluid pressure in the lubricator **220**, aiding in pressure equalization between the lubricator **220** and the associated wellhead. For example, the boost pump(s) **224** *b* may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment

area **215** *c,*- one or more of the boost pump(s) **224** *b* may instead be, include, or be part of the pump station **224** *a.*

In one or more embodiments, the valve apparatus **210** is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus **210** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.

In one or more embodiments, the launcher **178** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher **178** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher **178** is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.

In one or more embodiments, the frac legs **150**B through **150**C+n associated with each of the wells **105**B through **105**C+n, respectively, are substantially identical to the frac leg **150**A associated with the well **105**A; therefore, the frac legs **150**B through **150**C+n associated with each of the wells **105**B through **105**C+n will not be described in further detail. Accordingly, each of the frac legs **150**B through **150**C+n associated with the wells **105**B through **105**C+n includes features/components substantially identical to corresponding features/components of the frac leg **150**A associated with the well **105**A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.

Referring to FIG.- **3** , with continuing reference to FIGS.- **2**A through- **2**G, in an embodiment, various sub-steps **226** *a-h* of the step **225** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **225** is or includes equalizing the lubricator **220** of the frac leg **150**A associated with the well **105**A, and opening the well **105**A. In one or more embodiments, the lubricator **220** is or includes one or more components shown and described in the '749 ~~application~~Application. In addition, or instead, in one or more embodiments, the lubricator **220** is or includes one or more components shown and described in the '854 ~~application~~Application.

At the sub-step **226** *a,*- the boost pump(s) **224** *b* is/are turned on to increase a fluid pressure in the lubricator **220** of the frac leg **150**A, thereby aiding in pressure equalization between said lubricator **220** and the well **105**A, as shown in FIGS.- **2**A and- **3** (indicated by arrow **232** *a* in FIG.- **2**A). As shown in FIG.- **1**B, the step **265** of latching, filling, and pressure testing the frac leg **150**A associated with the well **105**A is executed on the frac leg **150**A just prior to the execution of the sub-step **226** *a* on the frac leg **150**A. The step **265** will be described in further detail below as executed on the frac leg **150**E; however, the description below also applies to the execution of the step **265** on the frac leg **150**A. As a result, in one or more embodiments, just prior to execution of the sub-step **226** *a* on the frac leg **150**A: the EQ valve **222** *c* is closed; the drain **223** is closed; the lubricator **220** extends within, and is latched to, the latch **234**; the flow control device **221** *b* is closed; the EQ valve **222** *b* is open; the flow

control device **221** *a* is closed; the EQ valve **222** *a* is closed; the pump-down valves **160** *a-b* closed, and grease from the grease system **155** is withheld from the corresponding GPs **195**; the zipper valves **170** *a-b* are closed, and grease from the grease system **155** is withheld from the corresponding GPs **200** *a-b;*- and the master valves **165** *a-b* are open, and grease from the grease system **155** is communicated to the corresponding GPs **185** *a-b.*- The communication of grease from the grease system **155** to the corresponding GPs **185** *a-b* is not indicated by arrows in FIG.- **2**A but is instead indicated by a lack of shading of the GPs **185** *a-b* as shown in FIG.- **2**A; the same lack of shading indication applies to the GPs **185** *a-b* as shown in FIGS.- **2**B-G, **5**A-C, **7**A-I, **9**A-G, **11**, **14**A-B, **16**A-C, and **18**A-G.

At the sub-step **226** *b,*- respective fluid pressures within the containment areas **215** *a* and **215** *c* are compared to determine whether the fluid pressure in the lubricator **220** of the frac leg **150**A has been equalized to within a threshold amount of the fluid pressure in the well **105**A. If it is determined that the fluid pressure in the lubricator **220** of the frac leg **150**A has not been equalized to within the threshold amount of the fluid pressure in the well **105**A, the EQ valve **222** *a* is opened at the sub-step **226** *c* to further encourage such pressure equalization between said lubricator **220** and the well **105**A, as shown in FIGS.- **2**B and- **3** . Alternatively, the order in which the sub-steps **226** *a* and **226** *c* are executed may be reversed, or one of the sub-steps **226** *a* and **226** *c* may be omitted altogether.

At the sub-step **226** *d,*- once it is determined that the fluid pressure in the lubricator **220** of the frac leg **150**A has been equalized to within the threshold amount of the fluid pressure in the well **105**A, the flow control device **221** *a* is opened, as shown in FIGS.- **2**C and- **3** . At the sub-step **226** *e,*- the EQ valve **222** *a* is closed, as shown in FIGS.- **2**D and- **3** . However, in those embodiments in which the sub-step **226** *c* of opening the EQ valve **222** *a* is omitted, the sub-step **226** *e* of closing the EQ valve **222** *a* is also omitted. Additionally, the sub-step **226** *e* may be executed to close the EQ valve **222** *a* at any time before, during, or after, execution of the sub-steps **226** *d,* **226** *f,*- or **226** *g.*- At the sub-step **226** *f,*- the flow control device **221** *b* is opened, as shown in FIGS.- **2**E and- **3** . At the sub-step **226** *g,*- the boost pump(s) **224** *b* is/are turned off, as shown in FIGS.- **2**F and- **3** . At the sub-step **226** *h,*- the EQ valve **222** *b* is closed, as shown in FIGS.- **2**G and- **3** . Once the sub-steps **226** *a-h* are executed, the well **105**A is ready for execution of the step **230**, namely perforating a stage of the well **105**A using the wireline perforating system **177**, as will be described in detail below in connection with FIGS.- **4**- and- **5**A through- **5**C.

Referring to FIGS.- **4**- and- **5**A through- **5**C, in an embodiment, various sub-steps **231** *a-h* of the step **230** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **230** is or includes perforating a stage of the well **105**A using the wireline perforating system **177**. In one or more embodiments, the wireline perforating system **177** is or includes the pump-down truck **190**, a wireline truck **233**, the lubricator **220**, the launcher **178**, the latch **234** (via which the lubricator **220** is detachably couplable to the valve apparatus **210**), or any combination thereof. In addition, or instead, the wireline perforating system **177** may be or include one or more components shown and described in the '749 ~~application~~Application. In addition, or instead, in one or more embodiments, the wireline perforating system **177** may be or include one or more components shown and described in the '854 ~~application~~Application.

At the sub-step **231** *a,*- a plug and perforating gun(s) are deployed from the lubricator **220**, as shown in FIGS.- **4**- and- **5**A (indicated by arrow **232** *b* in FIG.- **5**A). At the sub-step **231** *b,*- the pump-down valves **160** *a-b* are opened, as shown in FIGS.- **4**- and- **5**B. At the sub-step **231** *c,*- grease from the grease system **155** is communicated to the corresponding GPs **195** of

the pump-down valves **160** *a-b,* respectively, as shown in FIGS. **4** and **5**B (indicated by arrows **232** *c* in FIG. **5**B). At the sub-step **231** *d,* the plug and perforating gun(s) are pumped down into the well **105**A using the pump-down truck **190**, as shown in FIGS. **4** and **5**B (indicated by arrows **232** *d* and **232** *e* in FIG. **5**B). At the sub-step **231** *e,* the pump-down valves **160** *a-b* are closed, and grease from the grease system **155** is withheld from the corresponding GPs **195**, as shown in FIGS. **4** and **5**C. Additionally, the sub-step **231** *e* may be executed to close the pump-down valves **160** *a-b* at any time before, during, or after, execution of the sub-steps **231** *f,* **231** *g,* or **231** *h.* At the sub-step **231** *f,* the plug is set in the well **105**A, as shown in FIG. **4**. At the sub-step **231** *g,* the perforating gun(s) are detonated in the well **105**A, as shown in FIG. **4**. Finally, at the sub-step **231** *h,* the spent perforating gun(s) are retrieved from the well **105**A, as shown in FIGS. **4** and **5**C (indicated by arrows **232** *f* and **232** *g* in FIG. **5**C). Once the sub-steps **231** *a-h* are executed, the well **105**A is ready for execution of the step **235**, namely closing the well **105**A using the valve apparatus **210** and draining the lubricator **220**, as will be described in detail below in connection with FIGS. **6** and **7**A through **7**I.

Referring to FIGS. **6** and **7**A through **7**I, in an embodiment, various sub-steps **236** *a-n* of the step **235** of the method **175** illustrated in FIG. **1**B are shown in detail, which step **235** is or includes closing the well **105**A using the valve apparatus **210** and draining the lubricator **220**. At the sub-step **236** *a,* bump up of the retrieved spent perforating gun(s) within the lubricator **220** is determined and/or confirmed. The sub-step **236** *a* can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator **220**; receiving verbal confirmation that bump up has occurred; or any combination thereof.

At the sub-step **236** *b,* once the bump up of the retrieved spent perforating gun(s) within the lubricator **220** is determined and/or confirmed, the flow control device **221** *b* is closed, as shown in FIGS. **6** and **7**A. At the sub-step **236** *c,* the flow control device **221** *a* is closed, as shown in FIGS. **6** and **7**B. At the sub-step **236** *d,* the EQ valve **222** *c* is opened, as shown in FIGS. **6** and **7**C, to bleed down a fluid pressure in the lubricator **220** (indicated by arrow **232** *g* in FIG. **7**C). At the sub-step **236** *e,* the EQ valve **222** *b* is opened, as shown in FIGS. **6** and **7**D. At the sub-step **236** *f,* the lubricator **220** is checked to determine whether the fluid pressure in the lubricator **220** has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. **6**. At the sub-step **236** *g,* once it has been determined that the fluid pressure in the lubricator **220** has dropped to below the threshold value, the EQ valve **222** *b* is closed, as shown in FIGS. **6** and **7**E.

At the sub-step **236** *h,* the drain **223** is opened, as shown in FIGS. **6** and **7**F. At the sub-step **236** *i,* the auto-drain pump of the pump station **224** *a* is turned on to drain fluid from the lubricator **220** via the drain **223**, as shown in FIGS. **6** and **7**F (indicated by arrow **232** *h* in FIG. **7**F). At the sub-step **236** *j,* the auto-drain pump is allowed to finish auto-draining the lubricator **220** before the drain **223** is closed, as shown in FIGS. **6** and **7**G. At the sub-step **236** *k,* the latch **234** is unlatched, as shown in FIGS. **6** and **7**G. At the sub-step **236** ~~*i*~~*l*, the lubricator **220** is removed, as shown in FIGS. **6** and **7**H (indicated by arrow **232** *i* in FIG. **7**H). At the sub-step **236** *m,* the EQ valve **222** *c* is closed, as shown in FIG. **7**I. Finally, at the sub-step **236** *n,* an object drop (e.g., from the launcher **178**) and/or a

pressure test is/are enabled, as shown in FIG.- **6** . More particularly, once the sub-steps **236** *a-n* are executed, the well **105**A is ready for execution of the step **240**, namely isolating a stage of the well **105**A in preparation for a hydraulic fracturing operation. The step **240** will be described in further detail below (in connection with FIGS.- **8**- and- **9**A through- **9**G) as executed on the frac leg **150**B to isolate a stage of the well **105**B; however, the description below also applies to the execution of the step **240** on the frac leg **150**A to isolate a stage of the well **105**A.
Referring to FIGS.- **8**- and- **9**A through- **9**G, in an embodiment, various sub-steps **241** *a-o* of the step **240** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **240** is or includes isolating a stage of the well **105**B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step **240** that is or includes isolating the stage of the well **105**B includes or is part of a hydraulic fracturing operation. At the sub-step **241** *a,*- the EQ valve **222** *b* is opened to facilitate pressure equalization between the containment areas **215** *b* and **215** *c,*- as shown in FIGS.- **8**- and- **9**A. At the sub-step **241** *b,*- an object is dropped from the launcher **178**, as shown in FIGS.- **8**- and- **9**A. At the sub-step **241** *c,*- respective fluid pressures within the containment areas **215** *b* and **215** *c* are checked to determine whether the containment areas **215** *b* and **215** *c* have been pressure equalized to within a threshold amount, as shown in FIG.- **8** . At the sub-step **241** *d,*- once it is determined that the containment areas **215** *b* and **215** *c* have been pressure equalized to within the threshold amount, the flow control device **221** *b* is opened, as shown in FIGS.- **8**- and- **9**B. At the sub-step **241** *e,*- the object passes into the containment area **215** *c,*- as shown in FIGS.- **8**- and- **9**C. At the sub-step **241** *f,*- the flow control device **221** *b* is closed, as shown in FIGS.- **8**- and- **9**C. At the sub-step **241** *g,*- the EQ valve **222** *b* is closed, as shown in FIGS.- **8**- and- **9**D.
At the sub-step **241** *h,*- the boost pump(s) **224** *b* is/are turned on to increase a fluid pressure in the containment area **215** *c,*- thereby aiding in pressure equalization between the containment areas **215** *a* and **215** *c,*- as shown in FIGS.- **8**- and- **9**D (indicated by arrow **232** *j* in FIG.- **9**D). At the sub-step **241** *i,*- respective fluid pressures within the containment areas **215** *a* and **215** *c* are compared to determine whether the fluid pressure in the containment area **215** *c* has been equalized to within a threshold amount of the fluid pressure in the well **105**B. If it is determined that the fluid pressure in the containment area **215** *c* has not been equalized to within the threshold amount of the fluid pressure in the well **105**B, the EQ valve **222** *a* is opened at the sub-step **241** *j* to further encourage such pressure equalization between said containment area **215** *c* and the well **105**B, as shown in FIGS.- **8**- and- **9**E. Alternatively, the order in which the sub-steps **241** *h* and **241** *j* are executed may be reversed, or one of the sub-steps **241** *h* and **241** *j* may be omitted altogether.
At the sub-step **241** *k,*- once it is determined that the fluid pressure in the containment area **215** *c* has been equalized to within the threshold amount of the fluid pressure in the well **105**B, the flow control device **221** *a* is opened, as shown in FIGS.- **8**- and- **9**F. At the sub-step **241** *l*, the boost pump(s) **224** *b* is/are turned off, as shown in FIGS.- **8**- and- **9**F. At the sub-step **241** *m,*- the EQ valve **222** *a* is closed, as shown in FIGS.- **8**- and- **9**F. However, in those embodiments in which the sub-step **241** *j* of opening the EQ valve **222** *a* is omitted, the sub-step **241** *m* of closing the EQ valve **222** *a* is also omitted. Additionally, the sub-step **241** *m* may be executed to close the EQ valve **222** *a* at any time before, during, or after, execution of the sub-steps **241** *k* or **241** *l*. At the sub-step **241** *n,*- the object is permitted passage to the well **105**B, as shown in FIGS.- **8**- and- **9**G. Finally, at the sub-step **241** *o,*- the flow control device **221** *a* is closed, as shown in FIGS.- **8**- and- **9**G. Once the sub-steps **241** *a-o* are executed, the well **105**B is ready for execution of the step **245**, namely detecting or otherwise determining that a fracturing

stage of the well **105**D has ended, as will be described in detail below in connection with FIGS.- **10**- and- **11** .

Referring to FIGS.- **10**- and- **11** , in an embodiment, various sub-steps **246** *a-c* of the step **245** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **245** is or includes detecting or otherwise determining that a fracturing stage of the well **105**D has ended. At the sub-step **246** *a,*- the n_1 well (e.g., well **105**D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG.- **10** . At the sub-step **246** *b,*- the n_1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG.- **10** . Finally, at the sub-step **246** *c,*- the zipper valves **170** *a-b* associated with the n_1+1 well (e.g., well **105**B) are dequeued and compared against the frac order (if available). During execution of the sub-steps **246** *a-c:*- grease from the grease system **155** is communicated to the corresponding GPs **200** *a-b* of the zipper valves **170** *a-b,*- respectively, as shown in FIG.- **11** (indicated by arrows **232** *k* in FIG.- **5**B); and hydraulic fracturing fluid is communicated from the zipper manifold **145** to the well **105**D, as shown in FIG.- **11** (indicated by arrows **232** *l* and **232** *m* in FIG.- **11**~~).~~ .

Referring to FIG.- **12** , in an embodiment, various sub-steps **251** *a-c* of the step **250** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **250** is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step **262**) the well **105**D to hydraulically fracturing (at the step **262**) the well **105**B, by, for example: checking an idle rate of the hydraulic fracturing system **100** at the sub-step **251** *a;*- and detecting or otherwise determining that an idle rate of the hydraulic fracturing system **100** is below an upper threshold and above a lower threshold at the sub-step **251** *b,*- or, at the sub-step **251** *c,*- detecting or otherwise determining that the idle rate of the hydraulic fracturing system **100** is below the lower threshold. More particularly, as shown in FIG.- **12** : at the sub-step **251** *a,*- a frac rate of the n_1 well (e.g., well **105**D) is checked; and, at the sub-step **251** *b,*- if the frac rate of the n_1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n_1 well to hydraulically fracturing the n_1+1 well is permitted at step **260**, but, at the sub-step **251** *c,*- if the frac rate of the n_1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n_1 well to hydraulically fracturing the n_1+1 well is permitted at step **255**.

Referring to FIGS.- **13**- and- **14**A through- **14**B, in an embodiment, various sub-steps **256** *a-c* of the step **255** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **255** is or includes executing the regular swap from hydraulically fracturing (at the step **262**) the n_1 well (e.g., well **105**D) to hydraulically fracturing (at the step **262**) the n_1+1 well (e.g., well **105**B). At the sub-step **256** *a,*- the n_1 well's (e.g., well **105**D) zipper valves **170** *a-b* are closed, and grease from the grease system **155** is withheld from the corresponding GPs **200** *a-b,*- as shown in FIGS.- **13**- and- **14**A. At the sub-step **256** *b,*- a signal to advance is received, as shown in FIG.- **13** . For example, a user input such as a screen click may be received at the sub-step **256** *b.*- In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step **256** *b.*- In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold **145** and the fluid pressure in the n_1+1 well (e.g., well **105**B) for a threshold amount of time. At the sub-step **256** *c,*- the n_1+1 well's zipper valves **170** *a-b* are opened, as shown in FIGS.- **13**- and- **14**B, so that hydraulic fracturing fluid is communicated from the zipper

manifold **145** to the n_1+1 well (indicated by arrows **232** *n* and **232** *o* in ~~FIG.~~ FIGS. **14**B), and grease from the grease system **155** is communicated to the corresponding GPs **200** *a-b* (indicated by arrow **232** *p* in FIG.- **14**B).

Referring to FIGS.- **15**- and- **16**A through- **16**E, in an embodiment, various sub-steps **261** *a-c* of the step **260** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **260** is or includes executing the CP swap from hydraulically fracturing (at the step **262**) the n_1 well (e.g., well **105**D) to hydraulically fracturing (at the step **262**) the n_1+1 well (e.g., well **105**B). At the sub-step **261** *a,*- the n_1+1 well's (e.g., well **105**B) zipper valves **170** *a-b* are opened, as shown in FIGS.- **15**- and- **16**A, hydraulic fracturing fluid is communicated from the zipper manifold **145** to the n_1+1- well (indicated by arrows **232** *n* and **232** *o* in FIG.- **16**A), and grease from the grease system **155** is communicated to the corresponding GPs **200** *a-b* (indicated by arrow **232** *p* in FIG.- **16**A). At the sub-step **261** *b,*- both the n_1+1 well's (e.g., well **105**B) zipper valves **170** *a-b* and the n_1 well's (e.g., well D) zipper valves **170** *a-b* are allowed to fully open, as shown in FIGS.- **15**,- **16**A and- **16**B, so that: hydraulic fracturing fluid is communicated from the zipper manifold **145** to the n_1 well (indicated by arrows **232** *l* and **232** *m* in FIG.- **16**B) and the n_1+1 well (indicated by arrows **232** *n* and **232** *o* in FIG.- **14**A); and grease from the grease system **155** is communicated to the corresponding GPs **200** *a-b* (indicated by arrows **232** *p* and **232** *k* in FIGS.- **16**A and- **16**B, respectively). Finally, at the sub-step **261** *c,*- the n_1 well's (e.g., well **105**D) zipper valves **170** *a-b* are closed, as shown in FIGS.- **15**- and- **16**C, and grease from the grease system **155** is withheld from the corresponding GPs **200** *a-b.*

As shown in FIGS.- **16**D and- **16**E, executing the CP swap from hydraulically fracturing (at the step **262**) the n_1 well (e.g., well **105**D) to hydraulically fracturing (at the step **262**) the n_1+1 well (e.g., well **105**B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).

Referring to FIGS.- **17**- and- **18**A through- **18**G, in an embodiment, various sub-steps **266** *a-s* of the step **265** of the method **175** illustrated in FIG.- **1**B are shown in detail, which step **265** is or includes latching, filling, and pressure testing the frac leg **150**E associated with the well **105**E in preparation for perforating a stage of the well **105**E using the wireline perforating system **177** (in a manner similar to that described above in connection with the well **105**A and shown in FIGS.- **5**A through- **5**C). At the sub-step **266** *a,*- the lubricator **220** is stabbed into the latch **234**, as shown in FIGS.- **17**- and- **18**A (indicated by arrow **232** *q* in FIG.- **18**A). At the sub-step **266** *b,*- the EQ valve **222** *c* is closed, as shown in FIGS.- **17**- and- **18**B. At the sub-step **266** *c,*- the latch close relay is energized to close the latch **234**, thereby connecting the lubricator **220** to the valve apparatus **210**, as shown in FIGS.- **17**- and- **18**C. At the sub-step **266** *d,*- a latch close proximity switch is checked to determine whether the latch **234** has successfully latched the lubricator **220** to the valve apparatus **210**. At the sub-step **266** *e,*- once it is determined that the latch **234** has successfully latched the lubricator **220** to the valve apparatus **210**, the latch close relay is de-energized, as shown in FIG.- **17** . At the sub-step **266** *f,*- a test pressure relay is energized, as shown in FIG.- **17** . At the sub-step **266** *g,*- a determination is made as to whether the connection of the lubricator **220** to the valve apparatus **210** via the latch **234** is or is not capable of holding pressure, as shown in FIG.- **17** . At the sub-step **266** *h,*- once the determination is made that the connection of the lubricator **220** to

the valve apparatus **210** via the latch **234** is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG.- **17** .

At the sub-step **266** *i,*- the drain **223** is opened, as shown in FIGS.- **17**- and- **18**D. At the sub-step **266** *j,*- the EQ valve **222** *c* is opened, as shown in FIGS.- **17**- and- **18**E. At the sub-step **266** *k,*- the auto-fill pump of the pump station **224** *a* is turned on to fill the lubricator **220** via the open drain **223**, as shown in FIGS.- **17**- and- **18**E (indicated by arrow **232** *r* in FIG.- **18**E). At the sub-step **266** *l*, the auto-fill pump is allowed to finish auto-filling the lubricator **220**, as shown in FIG.- **17** . At the sub-step **266** *m,*- the drain **223** is closed, as shown in FIGS.- **17**- and- **18**F. At the sub-step **266** *n,*- the EQ valve **222** *c* is closed, as shown in FIGS.- **17**- and- **18**F. At the sub-step **266** *o,*- the EQ valve **222** *b* is opened, as shown in FIGS.- **17**- and- **18**F. At the sub-step **266** *p,*- the boost pump(s) **224** *b* is/are turned on to increase the fluid pressure within the lubricator **220**, as shown in FIGS.- **17**- and- **18**F (indicated by arrow **232** *s* in FIG.- **18**F). At the sub-step **266** *q,*- a determination is made as to whether the pressure in the lubricator **220** comes to within the pressure in the well **105**E by a threshold amount (e.g., 500 PSI), as shown in FIG.- **17** . Once the determination is made that the pressure in the lubricator **220** comes to within the pressure in the well **105**E by the threshold amount, the boost pump(s) **224** *b* is/are turned off at the sub-step **266** *r,*- and the EQ valve **222** *b* is closed at the sub-step **266** *s* in preparation for the next wireline swap (e.g., to the well **105**E), as shown in FIGS.- **17**- and- **18**G.

Referring to FIGS.- **19**A and- **19**B, in an embodiment, a method **270** for fracturing the wells **105**A through **105**C+n using the hydraulic fracturing system **100** of FIG.- **1**A is illustrated, which method **270** includes swapping from simultaneously fracturing the wells n_1 and n_3 (e.g., wells **105**D and **105**X) to simultaneously fracturing the wells n_1+1 and n_3+1 (e.g., wells **105**B and **105**V). More particularly, the method **270** includes steps substantially identical to corresponding steps of the method **175** described above, which steps are given the same reference numerals. In addition, the method **270** includes additional steps executable to simultaneously fracture the n_1 and n_3 wells (e.g., wells **105**D and **105**X), and to swap from simultaneously fracturing the n_1 and n_3 wells to simultaneously fracturing the n_1+1 and n_3+1 wells (e.g., wells **105**B and **105**V), which additional steps are given the same reference numerals, except that the suffix "′"″"‴" is added. Specifically, in some instances the suffix "′"″"‴" signifies that the referenced step of the method **270** is substantially identical to the corresponding step of the method **175**, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method **175** is performed (i.e., the steps **225′**, **230′**, **235′**, **238** *a′*, **239′**, **238** *b′*, **263** *a′*, **264′**, **263** *b′*, **265′**, and **268′** fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method **270** is substantially similar to the corresponding step of the method **175**, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method **175** is performed (i.e., the steps **240′**, **245′**, **250′**, **255′**, **260′**, and **262′** fall into this category). In one or more embodiments, the controller **156** is adapted to control the grease system **155**, the frac legs **150**A through **150**C+n, or both, in order to execute the method **270** described herein.

Referring to FIG.- **20** , with continuing reference to FIGS.- **1**A through- **19**B, an illustrative node **1000** for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller **156**), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system **100**), method(s) (e.g., the method **175**, the method **270**, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS.- **1**A

through- **19**B is depicted. The node **1000** includes a microprocessor **1000** *a,*- an input device **1000** *b,*- a storage device **1000** *c,*- a video controller **1000** *d,*- a system memory **1000** *e,*- a display **1000** *f,*- and a communication device **1000** *g* all interconnected by one or more buses **1000** *h.*- In one or more embodiments, the storage device **1000** *c* may include a hard drive, CD-ROM, optical drive, any other form of storage device and/or any combination thereof. In one or more embodiments, the storage device **1000** *c* may include, and/or be capable of receiving, a CD-ROM, DVD-ROM, or any other form of non-transitory computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device **1000** *g* may include a modem, network card, or any other device to enable the node **1000** to communicate with other node(s). In one or more embodiments, the node and the other node(s) represent a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS.- **1**A through- **19**B include at least the node **1000** and/or components thereof, and/or one or more nodes that are substantially similar to the node **1000** and/or components thereof. In one or more embodiments, one or more of the above-described components of the node **1000** and/or the embodiments described above and/or illustrated in FIGS.- **1**A through- **19**B include respective pluralities of same components.

In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS.- **1**A through- **19**B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.

In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD-ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment, a data structure may provide an organization of data, or an organization of executable code.

In one or more embodiments, any networks and/or one or more portions thereof may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

In one or more embodiments, a database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.

In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part one or more of the embodiments of one or more of the controller(s) (e.g., the controller **156**), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system **100**), method(s) (e.g., the method **175**, the method **270**, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS.- **1**A through- **19**B. In one or more embodiments, such a processor may include one or more of the microprocessor **1000** *a*, any processor(s) that are part of the components of the hydraulic fracturing system **100**, such as, for example, the controller **156**, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the system. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ~~ay~~may interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the

first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.

A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve

and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.

A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one

or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.

A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to

permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

In several embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some (or all) of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

Any spatial references, such as, for example, “upper,” “lower,” “above,” “below,” “between,” “bottom,” “vertical,” “horizontal,” “angular,” “upwards,” “downwards,” “side-to-side,” “left-to-right,” “right-to-left,” “top-to-bottom,” “bottom-to-top,” “top,” “bottom,” “bottom-up,” “top-down,” etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In several embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

In several embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word “means” together with an associated function.

~~779 PATENT DETAILED DESCRIPTION~~

~~DETAILED DESCRIPTION~~

Detailed Description

[0014] Referring to ~~FIG. 1A~~Figure 1, in an embodiment, a ~~hydraulic~~ fracturing system ~~100~~ for ~~executing a hydraulic~~ fracturing ~~plan to hydraulically fracture~~ wells ~~105A~~ A through ~~105C~~C+n is illustrated, which ~~hydraulic~~ fracturing system ~~100~~ includes: a blender ~~110~~ adapted to mix fluid from a fluid source ~~115~~ with sand from a sand source ~~120~~ to produce hydraulic fracturing fluid; a suction manifold ~~125~~ adapted to receive the hydraulic fracturing fluid from the blender ~~110~~; a discharge manifold ~~130~~; a plurality of swap stations ~~135~~, each adapted to communicate the hydraulic fracturing fluid from the suction manifold ~~125~~ to a corresponding pump truck ~~140~~, and, after pressurization by the corresponding pump truck ~~140~~, to ~~communicate~~communication the pressurized hydraulic fracturing fluid from the corresponding pump truck ~~140~~ to the discharge manifold ~~130;~~ ; and a zipper manifold ~~145~~ adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold ~~130~~ to a plurality of hydraulic fracturing legs (or ~~“~~"frac legs~~”) 150A through 150C+n,~~"), each ~~of which is~~ adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold ~~145~~ to a corresponding one of the wells ~~105A~~A through ~~105C~~C+n. In one or more embodiments, ~~each of~~ the swap stations ~~135 is~~each are or ~~includes~~include one or more components shown and described in U.S. ~~patent application Ser.~~ Patent Application No. 16/436,189, filed ~~Jun.~~June 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.

[0015] A grease system ~~155~~ is adapted to communicate lubricating grease to various components of the frac legs ~~150A through 150C+n~~, including, for example, first and second pump-down valves ~~160 a-b,~~, first and second master valves ~~165 a-b~~, and first and second zipper valves ~~170 a-b associated with~~ of each of the frac legs ~~150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G).~~. In one or more embodiments, the grease system ~~155~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~Patent Application No. 16/248,648, filed ~~Jan.~~ January 15, 2019 bearing Attorney Docket No. 57959.3US01, now issued as U.S. ~~Pat.~~ Patent No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system ~~155~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~Patent Application No. 16/938,341, filed ~~Jul.~~July 24, 2020 bearing Attorney Docket No. 57959.3US02, now published as U.S.

Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system ~~155~~ is or includes one or more components shown and described in U.S. Patent Application No. 16/855,749 (the ~~'749 application,~~'"749 Application"), filed ~~Apr.~~ April 22, 2020 bearing Attorney Docket No. 57959.5US01, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system ~~155~~ is or includes one or more components shown and described in ~~the '854 application,~~U.S. Patent Application No. 17/319,854 (the '"854 Application"), filed May 13, 2021 bearing Attorney Docket No. 57959.11 US01, the entire disclosure of which is hereby incorporated herein by reference in its entirety.

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing~~

~~the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.~~

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

[0016] Referring to Figure 2, in an embodiment, a method for fracturing the wells A through C+n using the fracturing system of Figure 1 is illustrated. The method generally includes: perforating a stage of each well using, for example, a wireline perforating system; isolating the perforated stage of each well using an object dropped, for example from a launcher; and hydraulically fracturing the isolated/perforated stage of each well.

[0017] Referring to ~~FIGS. 2A~~Figures 3A through ~~2G~~3K, in an embodiment, the frac leg ~~150A~~ associated with the well ~~105A~~A is illustrated, which frac leg ~~150A~~ includes: a wellhead including ~~the~~ first and second master valves ~~165 a-b~~ (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well ~~105A~~A, each of the first and second master valves ~~165 a-b~~ including ~~associated~~first and second grease ports (or ~~"~~"GPs~~") 185 a-b; the~~"); first and second pump-down valves ~~160 a-b~~ (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck ~~190~~ and the well ~~105A~~A, via the first and second master valves ~~165 a-b~~, each of the first and second pump-down valves ~~160 a-b~~ including ~~an associated~~ a grease port (or "GP ~~195;~~"); and ~~the~~first and second zipper valves ~~170 a-b~~ (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold ~~145~~ and the well ~~105A~~A, via the first and second master valves ~~165 a-b~~, each of the first and second zipper valves ~~170 a-b~~ including ~~associated~~ first and second grease ports (or "GPs ~~200 a-b.~~"). In one or more embodiments, one or both of the first and second zipper valves ~~170 a-b~~ of each of the frac legs ~~150A through 150C+n~~ include~~(s),~~ or ~~is/~~are part of~~,~~ the zipper manifold ~~145.~~ .

In one or more embodiments, as in ~~FIGS. 2A~~Figures 3A through ~~2G~~3K, the frac leg ~~150A~~ associated with
the well ~~105A~~A also includes a flow block ~~205~~ to which the first and second pump-down valves ~~160 a-b and~~, the ~~zipper valves 170 a-b are operably coupled.~~
first and second zipper valves, or both the first and second pump-down valves and the
first and second zipper valves are operably coupled.
[0018] The frac leg ~~150A~~ associated with the well ~~105A~~A further includes a valve apparatus ~~210~~(also
referred to herein as an "FSV") via which both the wireline perforating system ~~177~~ and the object launched from, for example, the launcher ~~178~~, are permitted entry to the well ~~105A~~A. The valve apparatus ~~210~~ includes: a first containment area ~~215 a (labeled "~~(also referred to herein as "WELL~~")~~ ")
adapted to be in fluid communication with the well ~~105A~~A via the first and second master valves ~~165~~; a ~~b; a~~ second containment area ~~215 b (labeled "~~(also referred to herein as "LUB~~")~~")
adapted to be in
fluid communication with the lubricator ~~220 of the wireline perforating system 177~~; and a third containment area ~~215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and~~(also referred to
herein as "LL") adapted to be in fluid communication with the first containment area ~~215 b~~ via a ~~flow control device 221 b (e.g., a flapper-type flow control device).~~
~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or~~first flow control device (also referred to herein as "WELL FLAPPER"), and adapted to be
in fluid communication with the second containment are via a second flow control device (also referred to herein as "LUB Flapper").

[0019] In one or more embodiments, the valve apparatus ~~210~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~Patent Application No. 15/487,785, filed ~~Apr.~~ April 14, 2017, now issued as U.S. ~~Pat.~~Patent No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus ~~210~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~ Patent Application No. 16/721,203, filed ~~Dec.~~December 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.

[0020] In one or more embodiments, the launcher ~~178~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~Patent Application No. 16/248,633, filed ~~Jan.~~ January 15, 2019 bearing Attorney Docket No. 57959.4US01, now issued as U.S. ~~Pat.~~ Patent No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher ~~178~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~ Patent Application No. 16/801,911, filed ~~Feb.~~ February 26, 2020 bearing Attorney Docket No. 57959.4US02, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher ~~178~~ is or includes one or more components shown and described in U.S. ~~patent application Ser.~~Patent Application No. 16/803, 156, filed ~~Feb.~~February 27, 2020 bearing Attorney Docket No. 57959.8US01, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.

[0021] In one or more embodiments, the frac legs ~~150B through 150C+n~~ associated with each of the ~~wells 105B~~wellheads B through ~~105C~~C+n~~, respectively,~~ are substantially identical to the frac leg ~~150A~~ associated with the well ~~105A;~~ A; therefore, the frac legs ~~150B through 150C+n~~ associated with each of the ~~wells 105B~~wellheads B through ~~105C~~C+n will not be described in further detail. Accordingly, each of the frac legs ~~150B through 150C+n~~ associated with the ~~wells 105B~~ wellheads B through ~~105C~~C+n includes features/components substantially identical to corresponding features/components of the frac leg ~~150A~~ associated with the well ~~105A~~A, which substantially identical features~~/~~ components ~~are given the same reference numerals and~~ will also not be described in further detail.

[0022] Referring still to ~~FIG. 3, with continuing reference to FIGS. 2A~~Figures 3A through ~~2G~~3K, in an embodiment, various sub-steps ~~226~~ of a ~~h of the~~ first step ~~225~~ of the method ~~175~~ illustrated in ~~FIG. 1B~~Figure 2 are ~~shown in detail~~illustrated, which first step ~~225~~ is or includes

equalizing ~~the~~a lubricator ~~220~~ of the frac leg ~~150A~~ associated with the well ~~105A~~A, and opening the well ~~105A.~~ A.

In one or more embodiments, the lubricator ~~220~~ is or includes one or more components shown and described in the '749 Application. In addition, or instead, in one or more embodiments, the lubricator is or includes one or more components shown and described ~~in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described~~ in the '854 ~~application~~Application.

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control device 221 b is closed; the EQ valve 222 b is open; the flow control device 221 a is closed; the EQ valve 222 a is closed; the pump-down valves 160 a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b; and the master valves 165 a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185 a-b. The communication of grease from the grease system 155 to the corresponding GPs 185 a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185 a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185 a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226 b, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222 a is opened at the sub-step 226 c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226 a and 226 c are executed may be reversed, or one of the sub-steps 226 a and 226 c may be omitted altogether.~~

~~At the sub-step 226 d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221 a is opened, as shown in FIGS. 2C and 3. At the sub-step 226 e, the EQ valve 222 a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226 c of opening the EQ valve 222 a is omitted, the sub-step 226 e of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 226 e may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 226 d, 226 f, or 226 g. At the sub-step 226 f, the flow control device 221 b is opened, as shown in FIGS. 2E and 3. At the sub-step 226 g, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226 h, the EQ valve 222 b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226 a-h are~~

~~executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

[0023] Referring to ~~FIGS. 4 and 5A~~Figures 4A through ~~5C~~4C, in an embodiment, various sub-steps ~~231 a-h~~ of ~~the~~a second step ~~230~~ of the method ~~175~~ illustrated in ~~FIG. 1B~~Figure 2 are ~~shown in detail~~illustrated, which second step ~~230~~ is or includes perforating a stage of the well ~~105A~~A using the wireline perforating system. In one or more embodiments, the wireline perforating system ~~177. In~~ is or includes one or more components shown and described in the '749 Application. In addition, or instead, in one or more embodiments, the wireline perforating system ~~177~~ is or includes ~~the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include~~ one or more ~~components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more~~ components shown and described in the '854 ~~application~~Application.

[0024] Referring to Figures 5A through 5K, in an embodiment, various sub-steps of a third step of the method illustrated in Figure 2 are illustrated, which third step is or includes closing the well A using the valve apparatus and draining the lubricator.

[0025] Referring to Figures 6A through 6H, in an embodiment, various sub-steps of a fourth step of the method illustrated in Figure 2 are illustrated, which fourth step is or includes isolating a stage of the well Bin preparation for a fracturing operation. In one or~~At the sub-step 231 a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232 b in FIG. 5A). At the sub-step 231 b, the pump-down valves 160 a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231 c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator~~

~~to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215~~

~~a and 215-c, as shown in FIGS. 8 and 9D (indicated by arrow 232-j in FIG. 9D). At the sub-step 241-i, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the containment area 215-c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215-c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222-a is opened at the sub-step 241-j to further encourage such pressure equalization between said containment area 215-c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241-h and 241-j are executed may be reversed, or one of the sub-steps 241-h and 241-j may be omitted altogether.~~

~~At the sub-step 241-k, once it is determined that the fluid pressure in the containment area 215-c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221-a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241-l, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241-m, the EQ valve 222-a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241-j of opening the EQ valve 222-a is omitted, the sub-step 241-m of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 241-m may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 241-k or 241-l. At the sub-step 241-n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241-o, the flow control device 221-a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241-a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246-a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246-a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246-b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246-c, the zipper valves 170-a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246-a-c: grease from the grease system 155 is communicated to the corresponding GPs 200-a-b of the zipper valves 170-a-b, respectively, as shown in FIG. 11 (indicated by arrows 232-k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232-l and 232-m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251-a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251-a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251-b, or, at the sub-step 251-c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251-a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251-b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing~~

~~the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes~~

~~latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l, the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.**

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and~~

~~268′ fall into this category), while, in other instances, the suffix “′” signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In one or more embodiments, the storage device 1000 c may include a hard drive, CD-ROM, optical drive, any other form of storage device and/or any combination thereof. In one or more embodiments, the storage device 1000 c may include, and/or be capable of receiving, a CD-ROM, DVD-ROM, or any other form of non-transitory computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device 1000 g may include a modem, network card, or any other device to enable the node 1000 to communicate with other node(s). In one or more embodiments, the node and the other node(s) represent a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In one or more embodiments, one or more of the above-described components of the node 1000 and/or the embodiments described above and/or illustrated in FIGS. 1A through 19B include respective pluralities of same components.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems. In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable~~

~~of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.~~

~~In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD-ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.~~

~~In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.~~

~~In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment, a data structure may provide an organization of data, or an organization of executable code.~~

~~In one or more embodiments, any networks and/or one or more portions thereof may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.~~

~~In one or more embodiments, a database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.~~

~~In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B. In one or more embodiments, such a processor may include one or more of the microprocessor 1000-a, any processor(s) that are part of the components of the hydraulic fracturing system 100, such as, for example, the controller 156, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the system. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a~~

~~virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ay interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.~~

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the~~

~~first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic~~

~~fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second~~

~~valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

more embodiments, the fourth step that is or includes isolating the stage of the well B includes or is part of the fracturing operation.

[0026] Referring to Figure 7, in an embodiment, various subs-steps of a fifth step of the method illustrated in Figure 2 are illustrated, which fifth step is or includes detecting or otherwise determining that a fracturing stage of the well D has ended.

[0027] Referring to Figure 8, in an embodiment, various sub-steps of a sixth step of the method illustrated in Figure 2 are illustrated, which sixth step is or includes permitting a regular swap, a continuous pumping swap (or "CP swap"), or both, from hydraulically fracturing the well D to hydraulically fracturing the well B by, for example, detecting or otherwise determining that an idle rate of the hydraulic fracturing system is below a threshold.

[0028] Referring to Figures 9A through 9B, in an embodiment, various sub-steps of a seventh step of the method illustrated in Figure 2 are illustrated, which seventh step is or includes the regular swap from hydraulically fracturing the well D to hydraulically fracturing the well B.

[0029] Referring to Figures 1 OA through 1 OB, in an embodiment, various sub-steps of an eighth step of the method illustrated in Figure 2 are illustrated, which eighth step is or includes the CP swap from hydraulically fracturing the well D to hydraulically fracturing the well B.

[0030] Referring to Figures 11 A through 11 F, in an embodiment, various sub-steps of a ninth step of the method illustrated in Figures 2 are illustrated, which ninth step is or includes latching, filling, and pressure testing the frac leg associated with the well E in preparation for perforating a stage of the well E using the wireline perforating system (in a manner similar to that described above in connection with well A and Figures 4A through 4C).

[0031] Referring to Figure 12, in an embodiment, another method for fracturing the wells A through C+n using the fracturing system of Figure 1 is illustrated, which another method includes swapping from simultaneously fracturing the wells D and X to simultaneously fracturing the wells B and V.

[0032] In one or more embodiments, one or more of the embodiments of the present application are provided in whole or in part as described and illustrated in Appendix A, which forms part of the present application.

[0033] In one or more embodiments, one or more of the embodiments described and illustrated in Appendix A are combined in whole or in part with one or more of the embodiments described above and/or one or more of the other embodiments described and illustrated in Appendix A.

[0034] An apparatus has been disclosed, according to one or more embodiments.

[0035] A system has been disclosed, according to one or more embodiments.

[0036] A method has been disclosed, according to one or more embodiments of the

present disclosure.
[0037] A step has been disclosed, according to one or more embodiments.
[0038] A sub-step has been disclosed, according to one or more embodiments.
[0039] A fracturing system has been disclosed, according to one or more embodiments.
[0040] A fracturing leg has been disclosed, according to one or more embodiments.
[0041] A method for swapping from fracturing a first well to fracturing a second well while continuously pumping has been disclosed, according to one or more embodiments.
[0042] A method for swapping from fracturing first and second wells to fracturing third and fourth wells while continuously pumping has been disclosed, according to one or more embodiments.
[0043] It is understood that variations may be made in the foregoing without departing from the scope of the ~~present~~ disclosure.
[0044] In several embodiments, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some ~~(~~or all~~)~~ of the illustrative embodiments. In addition, one or more of the elements and teachings of the various illustrative embodiments may be omitted, at least in part, ~~and/~~or combined, at least in part, with one or more of the other elements and teachings of the various ~~embodiments.~~illustrative embodiments.
[0045] Any spatial references~~,~~ such as, for example, ~~“~~"upper~~,” “~~," "lower~~,” “~~," "above~~,” “~~," "below~~,” “~~," "between~~,” “~~," "bottom~~,” “~~," "vertical~~,” “~~," "horizontal~~,” “~~," "angular~~,” “~~," "upwards~~,” “~~," "downwards~~,” “~~," "side-~~to-side,” “~~toside," "left-to-right~~,” “~~," "left," "right," "right-to-left~~,” “~~," "top-to-bottom~~,” “~~," "bottom-to-top~~,” “~~," "top~~,” “~~," "bottom~~,” “~~," "bottom-up~~,” “~~," "top-down~~,”~~," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.
[0046] In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, ~~and/~~or one or more of the procedures may also be performed in different orders, simultaneously ~~and/~~or sequentially. In several embodiments, the steps, processes~~, and/~~ or procedures may be merged into one or more steps, processes ~~and/~~or procedures. In several ~~In several~~ embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the ~~above-described~~ embodiments disclosed above and~~/~~ in Appendix A, or variations thereof, may be combined in whole or in part with any one or more of the other ~~above-described~~ embodiments described above and~~/~~ in Appendix A, or variations thereof.
[0047] Although several embodiments have been ~~described~~disclosed in detail above and in Appendix A, the embodiments ~~described~~disclosed are ~~illustrative~~exemplary only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes, and~~/or~~ substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and~~/or~~ substitutions are intended to be included within the scope of this disclosure

as defined in the following claims. In the claims, ~~any~~ means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word ~~"~~"means~~"~~" together with an associated function.

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted.~~[0029]

Referring to FIG. 1, in one or more embodiments, a system generally referred to by the reference numeral 100 is diagrammatically illustrated. The system includes a manifold assembly 105 in fluid communication with a blender 110, hydraulic fracturing pumps 115 a-f, and wellheads 120 1-N. The wellheads 120 1-N serve as surface terminations for wellbores 125 1-N, respectively, with the wellheads 120 1-N being permanently, semi-permanently, or temporarily operably coupled to the wellbores 125 1-N, respectively. The system 100 includes one or more fluid sources 130 in fluid communication with the blender 110. The wellheads 120 1-N are in fluid

communication with the manifold assembly 105 via, for example, zipper modules 135 1-N and fracturing (or "frac") lines 140 1-N. The zipper modules 135 1-N are operably associated with a zipper manifold 145; for example, the zipper modules 135 1-N may be interconnected with each other via the zipper manifold 145. In one or more embodiments, the zipper modules 135 1-N are part of the zipper manifold 145 to which the manifold assembly 105 is operably coupled. In one or more embodiments, the zipper modules 135 1-N are interconnected. In one or more embodiments, at least one of the zipper modules 135 1-N is interconnected with at least one other of the zipper modules 135 1-N. The frac lines 140 1-N couple the zipper modules 135 1-N, respectively, to the wellheads 120 1-N, respectively. In one or more embodiments, the frac lines 140 1-N are part of the zipper manifold 145. The wellhead 120 1, the zipper module 135 1, and the frac line 140 1, in combination, form a frac leg 146 1. Similarly, respective sets of the wellheads 120 2-N, the zipper modules 135 2-N, and the frac line 140 2-N, in combination, form frac legs 146 2-N.

[0030]

Referring still to FIG. 1, a system for delivering and metering grease to the frac legs 146 1-N is diagrammatically illustrated and generally referred to by the reference numeral 305. In one or more embodiments, the grease 305 is, included, or is part of, the grease system described in the '648 application. For example, the frac legs 146 1-N may include process valves to which the grease system 100 delivers and meters grease, as will be described in more detail below. In one or more embodiments, such process valves are gate valves. The grease system 305 includes a delivery module 315 and metering modules 320 1-N. The metering modules 320 1-N are each operably associated with, and adapted to be in communication with, the delivery module 315. Likewise, the process valves of the frac legs 146 1-N are operably associated with, and adapted to be in communication with, the metering modules 320 1-N, respectively. In operation, to grease the process valves of the frac legs 146 1-N, the metering modules 320 1-N are adapted to force grease from the delivery module 315 into the respective process valves, as will be described in more detail below. In one or more embodiments, as in FIG. 1, a controller 180 is adapted to send control signals to the grease system 305 and the frac legs 146 1-N, as will be described in more detail below. A user interface 185 is operably coupled to the controller 180 to enable a user to monitor and control the grease system 305 and the frac legs 146 1-N, as will be described in more detail below.

[0031]

In one or more embodiments, the system 100 and/or the grease system 305 are part of a hydraulic fracturing system, which may be used to facilitate oil and gas exploration and production operations. For example, the system 100 and/or the grease system 305 may be adapted to perform a hydraulic fracturing operation on one or more of the wellbores 125 1-N. The embodiments provided herein are not, however, limited to a hydraulic fracturing system, as the system 100 may be used with, or adapted to, a mud pump system, a well treatment system, other pumping systems, one or more systems at the wellheads 120 1-N, one or more systems upstream of the wellheads 120 1-N, one or more systems downstream of the wellheads 120 1-N, and/or one or more other systems associated with the wellheads 120 1-N.

[0032]

Referring to FIG. 2, with continuing reference to FIG. 1, the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 are diagrammatically illustrated in detail. In one or more embodiments, the zipper module 135 1 includes a lower zipper valve 150 1, an upper zipper valve 150 2, and a fluid connector 155. The lower zipper valve 150 1 is operably coupled to the

zipper manifold 145. The upper zipper valve 150 2 is operably coupled to the lower zipper valve 150 1 opposite the zipper manifold 145. The fluid connector 155 is operably coupled to the upper zipper valve 150 2 opposite the lower zipper valve 150 1. An equalization valve 160 1 is in fluid communication with inlet and outlet sides of the lower zipper valve 150 1. A pressure sensor 165 1 is in fluid communication with the inlet side of the lower zipper valve 150 1. A pressure sensor 165 2 is in fluid communication with the outlet side of the lower zipper valve 150 1. Similarly, an equalization valve 160 2 is in fluid communication with inlet and outlet sides of the upper zipper valve 150 2. A pressure sensor such as, for example, the pressure sensor 165 2 is in fluid communication with the inlet side of the upper zipper valve 150 2. A pressure sensor 165 3 is in fluid communication with the outlet side of the upper zipper valve 150 2.

[0033]

In one or more embodiments, the frac line 140 1 includes frac line valves 150 3 and 150 4. The frac line valve 150 3 is operably coupled to the fluid connector 155 of the zipper module 135 1. The frac line valve 150 4 is operably coupled to the frac line valve 150 3 opposite the fluid connector 155. The frac line 140 1 is operably coupled between the zipper module 135 1 and the wellhead 120 1. An equalization valve 160 3 is in fluid communication with inlet and outlet sides of the frac line valve 150 3. A pressure sensor such as, for example, the pressure sensor 165 3 is in fluid communication with the inlet side of the frac line valve 150 3. A pressure sensor 165 4 is in fluid communication with the outlet side of the frac line valve 150 3. Similarly, an equalization valve 160 4 is in fluid communication with inlet and outlet sides of the frac line valve 150 4. A pressure sensor such as, for example, the pressure sensor 165 4 is in fluid communication with the inlet side of the frac line valve 150 4. A pressure sensor 165 5 is in fluid communication with the outlet side of the frac line valve 150 4.

[0034]

In one or more embodiments, the wellhead 120 1 includes a frac tree 170, a swab valve 150 5, and upper master valve 150 6, and a lower master valve 150 N. An inlet side of the lower master valve 150 N is in fluid communication with the wellbore 125 1. The upper master valve 150 6 is operably coupled to the lower master valve 150 N opposite the wellbore 125 1. The swab valve 150 5 is operably coupled to the upper master valve 150 6 opposite the lower master valve 150 N. The frac tree 170 is operably coupled to the swab valve 150 5 opposite the upper master valve 150 6. Alternatively, the frac tree 170 may be operably coupled to the upper master valve 150 6 opposite the lower master valve 150 N and the swab valve 150 5 may be operably coupled to the frac tree 170 opposite the upper master valve 150 6. The frac line 140 1 is operably coupled, via the frac tree 170, to the wellhead 120 1. In one or more embodiments, the frac tree 170 is or includes a goat head; in at least one such embodiment, the frac line 140 1 and one or more additional frac lines substantially similar to the frac line 140 1 are operably coupled between the zipper module 135 1 and the goat head so that fluid is communicable from the zipper module 135 1 to the wellhead 120 1 through the frac line 140 1 and the one or more additional frac lines.

[0035]

In addition, the wellhead 120 1 may include one or more other wellhead tools or components 175 such as, for example: one or more wing valves; a tree cap; a tree cap valve; the valve apparatus described in U.S. patent application Ser. No. 15/487,785 (the "'785 application"), filed Apr. 14, 2017, and published Oct. 19, 2017 as U.S. Publication No. 2017/0298708, the entire disclosure of which is hereby incorporated herein by reference; the valve apparatus described in U.S. patent application Ser. No. 16/721,203 (the "'203 application"), filed Dec. 19, 2019, the entire disclosure of which is hereby incorporated herein by reference; the object launching apparatus

described in the '633 application; or any combination thereof. One or more embodiments of the one or more other wellhead tools or components 175 are described in further detail below. Although shown as being operably coupled to the frac tree 170 opposite the swab valve 150 5, the one or more other wellhead tools or components 175 may instead be positioned at any location in the wellhead 120 1 such as, for example, between the wellbore 125 1 and the lower master valve 150 N, between the lower master valve 150 N and the upper master valve 150 6, between the upper master valve 150 6 and the swab valve 150 5, between the upper master valve 150 6 and the frac tree 170, between the frac tree 170 and the swab valve 150 5, or any combination thereof.

[0036]

An equalization valve 160 5 is in fluid communication with inlet and outlet sides of the swab valve 150 5. A pressure sensor such as, for example, the pressure sensor 165 5 is in fluid communication with the inlet side of the swab valve 150 5. A pressure sensor 165 6 is in fluid communication with the outlet side of the swab valve 150 5. Similarly, an equalization valve 160 6 is in fluid communication with inlet and outlet sides of the upper master valve 150 6. A pressure sensor such as, for example, the pressure sensor 165 6 is in fluid communication with the inlet side of the upper master valve 150 6. A pressure sensor 165 7 is in fluid communication with the outlet side of the upper master valve 150 6. Similarly, an equalization valve 160 N is in fluid communication with inlet and outlet sides of the lower master valve 150 N. A pressure sensor such as, for example, the pressure sensor 165 7 is in fluid communication with the inlet side of the lower master valve 150 N. A pressure sensor 165 N is in fluid communication with the outlet side of the lower master valve 150 N.

[0037]

In one or more embodiments, one or more of the pressure sensors 165 1-N includes a bladder or other mechanical buffer to protect the pressure sensor(s) 165 1-N from erosions/washout and/or to prevent the pressure sensor(s) 165 1-N from plugging off and trapping pressure; in such embodiments, the bladder of other mechanical buffer prevents, or at least reduces, inaccurate readings of line pressure by the pressure sensor(s) 165 1-N due to sand or grease plugging process port(s) of the pressure sensor(s) 165 1-N.

[0038]

In one or more embodiments, one or more of the equalization valves 160 1-N is designed to be resistant to washout and/or abrasive damage to the valve member(s) 215 1-N (shown in FIG. 4); accordingly, the equalization valves 160 1-N may incorporate internal materials such as, for example, Stellite, engineered ceramic, Zirconia, or the like to enhance durability and resistance to washout/erosion and to prevent, or at least reduce, sealing issues.

[0039]

Although the terms “inlet” and “outlet” used herein may imply a direction of fluid flow from the zipper manifold 145 to the zipper module 135 1, from the zipper module 135 1 to the frac line 140 1, from the frac line 140 1 to the wellhead 120 1, and/or from the wellhead 120 1 to the wellbore 125 1, it should be understood that, depending on relative fluid pressures within the system 100, fluid may instead flow in the opposite direction, that is, from the wellbore 125 1 to the wellhead 120 1, from the wellhead 120 1 to the frac line 140 1, from the frac line 140 1 to the zipper module 135 1, and/or from the zipper module to the zipper manifold 145. Accordingly, the term “inlet” may refer to an “outlet” and the term “outlet” may refer to an “inlet.”

[0040]

The controller 180 is operably coupled to, and adapted to control, the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, and the equalization valve 160 N, as will be described in more detail below. Further, the controller 180 is operably coupled to, and adapted to monitor, one or more of the pressure sensors 165 1-N, that is, the controller 180 is adapted to receive signal(s) from one or more of the pressure sensors 165 1-N, as will be described in more detail below. Further still, the controller 180 is operably coupled to, and adapted to control, the one or more other wellhead tools or components 175, as will be described in further detail below. The user interface 185 is operably coupled to the controller 180 to enable a user to monitor and control the zipper module 135 1, the frac line 140 1, and the wellhead 120 1, as will be described in more detail below.

[0041]

Referring to FIG. 3, with continuing reference to FIG. 2, the lower zipper valve 150 1 is diagrammatically illustrated in detail. In one or more embodiments, the lower zipper valve 150 1 includes a valve body 190 1 and a valve member 195 1. The valve member 195 1 extends within the valve body 190 1 and is actuable between an open configuration and a closed configuration. In the open configuration, the valve member 195 1 permits fluid flow through the valve body 190 1 from a high-pressure side (i.e., one of the inlet side or the outlet side of the of the lower zipper valve 150 1) to a low-pressure side (i.e., the other of the inlet side or the outlet side of the of the lower zipper valve 150 1) of the lower zipper valve 150 1, as shown in FIG. 3. In the closed configuration, the valve member 195 1 prevents, or at least partially restricts, fluid flow through the valve body 190 1 from the high-pressure side to the low-pressure side of the lower zipper valve 150 1. An actuator 200 1 is operably coupled to the valve member 195 1 to actuate the valve member 195 1 within the valve body 190 1 between the open configuration and the closed configuration. The controller 180 is operably coupled to, and adapted to control, the actuator 200 1. In addition to, or instead of, the actuator 200 1 being controlled by the controller 180, the actuator 200 1 may be or include a manual actuator that is manually controllable/actuable by an operator (e.g., via hydraulic, electric over hydraulic, or other mechanisms). A position sensor 205 1 is operably coupled to the actuator 200 1 to detect a position and/or an orientation of the valve member 195 1 relative to the valve body 190 1. In addition, or instead, the position sensor 205 1 may be operably coupled to the valve member 195 1 and/or the valve body 190 1. The controller 180 is operably coupled to, and adapted to monitor, the position sensor 205 1, that is, the controller 180 is adapted to receive signal(s) from the position sensor 205 1. In one or more embodiments, the feedback provided by the position sensor 205 1 is analog (i.e., continuous 0% to 100% open). In addition, or instead, the position sensor 205 1 may be or include a switch (e.g., having minimum resolutions of 0%, 50%, and 100% open).

[0042]

In one or more embodiments, the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N are substantially similar to, and operate in substantially the same manner as, the lower zipper valve 150 1; therefore, the structure and operation of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N will not be described in more detail. Moreover, the various

components of each of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the lower zipper valve 150 1 (as set forth above and shown in FIG. 3), except that, rather than the subscript "1" used to identify the components of the lower zipper valve 150 1, subscripts "2", "3", "4", "5", "6", and "N" are used to identify the corresponding components of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N, respectively.

[0043]

Referring to FIG. 4, with continuing reference to FIG. 2, the equalization valve 160 1 is diagrammatically illustrated in detail. As discussed above, the equalization valve 160 1 is in fluid communication with the inlet and outlet sides of the lower zipper valve 150 1. In one or more embodiments, the equalization valve 160 1 includes a valve body 210 1 and a valve member 215 1. The valve member 215 1 extends within the valve body 210 1 and is actuable between an open configuration and a closed configuration. In the open configuration, the valve member 215 1 permits fluid flow through the valve body 210 1 from a high-pressure side (i.e., one of the inlet side or the outlet side of the of the lower zipper valve 150 1) to a low-pressure side (i.e., the other of the inlet side or the outlet side of the lower zipper valve 150 1) of the lower zipper valve 150 1, as shown in FIG. 4. In the closed configuration, the valve member 215 1 prevents, or at least partially restricts, fluid flow through the valve body 210 1 from the high-pressure side to the low-pressure side of the lower zipper valve 150 1. An actuator 220 1 is operably coupled to the valve member 215 1 to actuate the valve member 215 1 within the valve body 210 1 between the open configuration and the closed configuration. The controller 180 is operably coupled to, and adapted to control, the actuator 220 1. In addition to, or instead of, the actuator 220 1 being controlled by the controller 180, the actuator 220 1 may be or include a manual actuator that is manually controllable/actuable by an operator (e.g., via hydraulic, electric over hydraulic, or other mechanisms). A position sensor 225 1 is operably coupled to the actuator 220 1 to detect a position and/or an orientation of the valve member 215 1 relative to the valve body 210 1. In addition, or instead, the position sensor 225 1 may be operably coupled to the valve member 215 1 and/or the valve body 210 1. The controller 180 is operably coupled to, and adapted to monitor, the position sensor 225 1, that is, the controller 180 is adapted to receive signal(s) from the position sensor 225 1. In one or more embodiments, the feedback provided by the position sensor 225 1 is analog (i.e., continuous 0% to 100% open). In addition, or instead, the position sensor 225 1 may be or include a switch (e.g., having minimum resolutions of 0%, 50%, and 100% open).

[0044]

In one or more embodiments, the equalization valves 160 2-N are substantially similar to, and operate in substantially the same manner as, the equalization valve 160 1; therefore, the structure and operation of the equalization valves 160 2-N will not be described in more detail. Moreover, the various components of each of the equalization valves 160 2-N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the equalization valve 160 1 (as set forth above and shown in FIG. 4), except that, rather than the subscript "1" used to identify the components of the equalization valve 160 1, subscripts "2", "3", "4", "5", "6", and "N" are used to identify the corresponding components of the equalization valves 160 2-N, respectively.

[0045]
Referring to FIG. 5, with continuing reference to FIGS. 2-4, a hydraulic manifold 230 operably associated with the actuators 200 1-N and 220 1-N is illustrated in detail. More particularly, the hydraulic manifold 230 is operably coupled to the actuators 200 1-N of the valves 150 1-N, respectively, and to the actuators 220 1-N of the equalization valves 160 1-N, respectively. The hydraulic manifold 230 facilitates actuation of the actuators 200 1-N and 220 1-N. A hydraulic power unit (or "HPU") 235 is operably coupled to the hydraulic manifold 230 and adapted to provide hydraulic fluid to, and to receive hydraulic fluid from, the hydraulic manifold 230. In one or more embodiments, to facilitate the communication of hydraulic fluid between the HPU 235 and the hydraulic manifold 230, the HPU 235 includes a reservoir, a hydraulic pump, and a motor. The controller 180 is operably coupled to, and adapted to control, the hydraulic manifold 230. Specifically, the controller 180 is adapted to actuate, via the hydraulic manifold 230, one or more of the actuators 200 1-N and/or 220 1-N based at least partially on data/readings received from the pressure sensors 165 1-N, the position sensors 205 1-N, and/or the position sensors 225 1-N, as will be described in more detail below. The user interface 185 is operably coupled to the controller 180 and enables a user to modify one or more parameters associated with the controller 180's actuation of the one or more of the actuators 200 1-N and/or 220 1-N via the hydraulic manifold 230. In one or more embodiments, the user interface 185 enables a user to take manual control of the controller 180's actuation of the one or more of the actuators 200 1-N and/or 220 1-N. In one or more embodiments, the controller 180 may also be operably coupled to, and adapted to control, the HPU 235.
[0046]
In one or more embodiments, the system 100 is used to perform a hydraulic fracturing operation. Prior to said hydraulic fracturing operation: the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be open; the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, and the frac line valve 150 4 may be closed; and pressure from the wellbore 125 1 may be exerted on the frac line valve 150 4. In such instances, before initiating the hydraulic fracturing operation, the wellbore pressure exerted on the frac line valve 150 4 must be equalized with a pressure of the pumped hydraulic fracturing fluid, that is, the pressure of the hydraulic fracturing fluid pumped into the manifold assembly 105 by the pumps 115 a-f (shown in FIG. 1).
[0047]
Referring to FIG. 6, a method of equalizing the wellbore pressure exerted on the frac line valve 150 4 with the pressure of the pumped hydraulic fracturing fluid is generally referred to by the reference numeral 240 and includes: at a step 245, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 4 and 165 5 is below a first predetermined threshold; if said difference is above the first predetermined threshold, at a step 250, opening the equalization valve 160 4 until said difference is below the first predetermined threshold; if said difference is below the first predetermined threshold, at a step 255, opening the frac line valve 150 4; at a step 260, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 3 and 165 4 is below a second predetermined threshold; if said difference is above the second predetermined threshold, at a step 265, opening the equalization valve 160 3 until said difference is below the second predetermined threshold; if said difference is below the second predetermined threshold, at a step 270, opening the frac line valve 150 3; at a step 275, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 2 and 165 3 is below a third predetermined threshold;

if said difference is above the third predetermined threshold, at a step 280, opening the equalization valve 160 2 until said difference is below the third predetermined threshold; if said difference is below the third predetermined threshold, at a step 285, opening the upper zipper valve 150 2; at a step 290, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 1 and 165 2 is below a fourth predetermined threshold; if said difference is above the fourth predetermined threshold, at a step 295, opening the equalization valve 160 1 until said difference is below the fourth predetermined threshold; and, if said difference is below the fourth predetermined threshold, at a step 300, opening the lower zipper valve 150 1.

[0048]

In one or more embodiments of the method 240, at least one of the first, second, third, and fourth predetermined thresholds is substantially identical to at least one other of the first, second, third, and fourth thresholds. In other embodiments of the method 240, at least one of the first, second, third, and fourth predetermined thresholds is different from at least one other of the first, second, third, and fourth predetermined thresholds. In one or more embodiments, the first, second, third, and/or fourth thresholds is/are user defined.

[0049]

In one or more embodiments, the step(s) 245, 260, 275, and/or 290 may be referred to as "intelligent lockout" steps that disallow a requested actuation of the corresponding valve(s) 160 1-4 due to excessive differential pressure(s) thereacross, as measured by corresponding pair(s) of the pressure sensors 165 1-5. In addition to, or instead of, performing the "intelligent lockout" steps of the method 240, the system 100 may include one or more mechanical interlocks designed to utilize fluid pressure from the inlet and outlet sides of a particular to-be-actuated valve 160 1, 2, 3, or 4 to block hydraulic flow (i.e., preventing said 160 1, 2, 3, or 4 valve from opening) unless the pressure differential between said inlet and outlet sides is balanced.

[0050]

In one or more embodiments, the step(s) 245, 260, 275, and/or 290 may be implemented via software stored on the controller 180 (or elsewhere) so that, when an operator desires to open one or more of the valves 160 1-4, the software only allows such opening of the valve(s) 160 1-4 if the differential pressure(s) across the valve(s) 160 1-4 are less than the corresponding predetermined threshold(s) (i.e., the first, second, third, and/or fourth thresholds). In addition, or instead, such software may include combinational logic requiring various other condition(s) to be met prior to actuation of a particular to-be-actuated valve 160 1, 2, 3, or 4, such as, for example: the pressure in the wellbore 125 1-N with which the to-be-actuated valve 160 1, 2, 3, or 4 is associated must be below a predetermined threshold, above a predetermined threshold, or within a predetermined range; the pressure in one or more of the other wellbores 125 1-N in the system 100 must be below a predetermined threshold, above a predetermined threshold, or within a predetermined range; the state of the to-be-actuated valve 160 1, 2, 3, or 4 must be open, closed, or transitioning; the state(s) of the one or more other valves 160 1, 2, 3, or 4 in the system 100 must be open, closed, or transitioning (e.g., the other valve(s) 160 1, 2, 3, or 4 must be opened/closed/transitioning prior to actuation of the to-be-actuated valve 160 1, 2, 3, or 4); one or more other conditions must be met; or any combination thereof.

[0051]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 260, step 270, step 275, step 285, step 290, and step 300.

[0052]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 260, step 270, step 290, step 300, step 275, and step 285.
[0053]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 275, step 285, step 260, step 270, step 290, and step 300.
[0054]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 275, step 285, step 290, step 300, step 260, and step 270.
[0055]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 290, step 300, step 260, step 270, step 275, and step 285.
[0056]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 290, step 300, step 275, step 285, step 260, and step 270.
[0057]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 245, step 255, step 275, step 285, step 290, and step 300.
[0058]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 245, step 255, step 290, step 300, step 275, and step 285.
[0059]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 275, step 285, step 245, step 255, step 290, and step 300.
[0060]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 275, step 285, step 290, step 300, step 245, and step 255.
[0061]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 290, step 300, step 245, step 255, step 275, and step 285.
[0062]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 290, step 300, step 275, step 285, step 245, and step 255.
[0063]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 245, step 255, step 260, step 270, step 290, and step 300.

[0064]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 245, step 255, step 290, step 300, step 260, and step 270.

[0065]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 260, step 270, step 245, step 255, step 290, and step 300.

[0066]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 260, step 270, step 290, step 300, step 245, and step 255.

[0067]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 290, step 300, step 245, step 255, step 260, and step 270.

[0068]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 290, step 300, step 260, step 270, step 245, and step 255.

[0069]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 245, step 255, step 260, step 270, step 275, and step 285.

[0070]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 245, step 255, step 275, step 285, step 260, and step 270.

[0071]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 260, step 270, step 245, step 255, step 275, and step 285.

[0072]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 260, step 270, step 275, step 285, step 245, and step 255.

[0073]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 275, step 285, step 245, step 255, step 260, and step 270.

[0074]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 275, step 285, step 260, step 270, step 245, and step 255.

[0075]

In one or more embodiments, prior to said hydraulic fracturing operation: the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be closed; and pressure from the wellbore 125 1 may be exerted on the lower master valve 150 N. In such instances, in addition to the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and 300, the method 240 may further include: an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 7 and 165 N is below a fifth predetermined threshold; if said difference is above the fifth predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 N until said difference is below the fifth predetermined threshold; if said difference is below the first predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the lower master valve 150 N; an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 6 and 165 7 is below a sixth predetermined threshold; if said difference is above the sixth predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 6 until said difference is below the sixth predetermined threshold; if said difference is below the sixth predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the upper master valve 150 6; an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 5 and 165 6 is below a seventh predetermined threshold; if said difference is above the seventh predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 5 until said difference is below the seventh predetermined threshold; and if said difference is below the seventh predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the swab valve 150 5. Similar to the sequential order in which the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and 300 may be performed, the above-described additional steps of the method 240 may be performed in any sequential order before, during, or after the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and/or 300 are performed.

[0076]

In one or more embodiments of the method 240, at least one of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds is substantially identical to at least one other of the first, second, third, fourth, fifth, sixth, and seventh thresholds. In other embodiments of the method 240, at least one of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds is different from at least one other of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds. In one or more embodiments, the first, second, third, fourth, fifth, sixth, and/or seventh thresholds is/are user defined.

[0077]

In various embodiments of the method 240, prior to said hydraulic fracturing operation, each of the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, the frac line

valve 150 4, the swab valve 150 5, the upper master valve 150 6, and/or the lower master valve 150 N may be open, closed, or transitioning; accordingly, one or more of the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, and/or one or more of the other above-described steps of the method 240 may be omitted as needed so that execution of the method 240 equalizes the wellbore pressure(s) with the pressure of the pumped hydraulic fracturing fluid.

[0078]

In one or more embodiments, the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N are substantially similar to, and operate in substantially the same manner as, the zipper module 135 1, the frac line 140 1, and the wellhead 120 1; therefore, the structure and operation of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N will not be described in more detail. Moreover, the various components of each of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 (as set forth above and shown in FIGS. 2-4).

[0079]

In one or more embodiments, the controller 180 is operably coupled to, and adapted to control, various components of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N(i.e., the frac legs 146 2-N) in a substantially similar manner as the manner in which the controller 180 is operably coupled to the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, and the equalization valve 160 N. As a result, in addition to monitoring and controlling the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 (i.e., the frac leg 146 1), the user interface 185 enables a user to monitor and control the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N(i.e., the frac legs 146 2-N). Alternatively, one or more other controllers substantially similar to the controller 180 may be operably coupled to, and adapted to control, the various components of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N. In such instances, the user interface 185 or one or more other user interfaces substantially similar to the user interface 185 may be operably coupled to the one or more other controllers to enable a user to monitor and control the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N.

[0080]

In one or more embodiments, the operation of the system 100 and/or the execution of the method 240 allows an operator to remotely control one or more of the valves 150 1-2 of the zipper modules 135 1-N, one or more of the valves 150 3-4 of the frac lines 140 1-N, and/or one or more of the valves 150 5-7 of the wellheads 120 1-N to conduct various wellbore operations on each of the wellbores 125 1-N. As a result, the operation of the system 100 and/or the execution of the method 240 eliminates the need for personnel to enter the “red zone” (i.e., a predetermined area in the vicinity of the valve(s) 150 1-N deemed to be hazardous, unsafe, or less safe) in order to actuate the valve(s) 150 1-N. As described above, during such remote control of the valve(s) 150 1-N, the corresponding position sensor(s) 205 1-N send signal(s) to the controller 180 so that the controller can verify that the valve(s) 150 1-N are in the correct state to perform the desired wellbore operation (e.g., to hydraulically fracture one or more of the wellbores 125 1-N, to perform wireline operations, to grease the valve(s) 150 1-N, to perform “flow back” on one or

more of the wellbores 125 1-N, to perform coiled tubing operations, to perform another operation, or any combination thereof). In one or more embodiments, the operation of the system 100 and/or the execution of the method 240 provides feedback to an operator so that the operator can identify leaks in the zipper manifold 145, the zipper modules 135 1-N, the frac lines 140 1-N, the wellheads 120 1-N, or elsewhere in the system 100 by monitoring the pressure sensor(s) 165 1-N and/or the position sensor(s) 205 1-N and/or 225 1-N.

[0081]

Referring to FIGS. 7A-7C, in one or more embodiments, the one or more other wellhead tools or components 175 introduced in connection with FIG. 2 include a valve 301 a, a latch 301 b, a launcher 301 c, and a lubricator 301 d. For example, the one or more other wellhead tools or components 175 may be, include, or be part of the system described in the '156 application. The valve 301 a is operably coupled to the wellhead 120 1, which wellhead 120 1 is the surface termination of the wellbore 125 1. In one or more embodiments, the valve 301 a is, includes, or is part of the valve apparatus described in the '785 application, the '203 application, or both. The valve 301 a is controlled by the controller 180. As discussed above, the user interface 185 communicates signals to, and receives signals from, the controller 180. The latch 301 b is operably coupled to the valve 301 a, opposite the wellhead 120 1. The launcher 301 c is operably coupled to the latch 301 b, opposite the valve 301 a. In one or more embodiments, the launcher 301 c is, includes, or is part of the launcher described in the '156 application. Although not shown in FIG. 1, in one or more embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 301 c, opposite the latch 301 b.

[0082]

The lubricator 301 d is extendable through the launcher 301 c (and the BOP attached thereto in certain embodiments) and, when so extended, attachable to the latch 301 b. More particularly, the controller 180 communicates signals to a hydraulic manifold, which signals cause the hydraulic manifold to communicate hydraulic fluid to, and/or receive hydraulic fluid from, the latch 301 b to thereby operate the latch 301 b. Subsequently, the lubricator 301 d is detachable from the latch 301 b in a similar manner and, when so detached, retractable from the launcher 301 c. In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of attaching/detaching the lubricator 301 d to/from the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0083]

Referring to FIG. 8, with continuing reference to FIGS. 7A-7C, in one or more embodiments, a method is generally referred to by the reference numeral 302. In one or more embodiments, the method 302 is executed using the one or more other wellhead tools or components 175. In at least one such instance, the launcher 301 c is connected to the latch 301 b. Although not shown in FIGS. 7A-7C, in one or more embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 301 c, opposite the latch 301 b. The method 302 includes, at a step 303 a, extending the lubricator 301 d through a central passageway of the launcher 301 c. More particularly, the lubricator 301 d is displaced in a direction 304 a (as shown in FIG. 7A), through the central passageway of the launcher 301 c (and the BOP attached thereto in certain embodiments), and into a central passageway of the latch 301 b (as shown in FIG. 7B). At a step 303 b, the lubricator 301 d is attached to the latch 301 b. In one or more embodiments, the step 303 b is executed after the step 303 a, and while the lubricator 301 d extends through the central passageway of the launcher 301 c. More particularly, the step 303 b is executable when the lubricator 301 d extends through the central passageway of the launcher and into the central

passageway of the latch 301 b (as shown in FIG. 7B). In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of attaching the lubricator 301 d to the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0084]

At a step 303 c, a first wellbore operation (e.g., a perforating operation such as, for example, a ball and sleeve operation) is performed while the lubricator 301 d is attached to the latch 301 b. In one or more embodiments, the step 303 c is executable by deploying a downhole tool (not shown; e.g., a plug and perforating guns) from the lubricator 301 d on a conveyance string (e.g., wireline) while the lubricator 301 d is attached to the latch 301 b. More particularly, the downhole tool passes through the central passageway of the latch 301 b, through a central passageway of the valve 301 a, through a central passageway of the wellhead 120 1, and into the wellbore 125 1. In one or more embodiments, the valve 301 a and the process of passing the downhole tool through the valve 301 a and into the wellbore 125 1 are described in the '785 application, the '203 application, or both.

[0085]

For example, the controller 180 may receive a signal from a sensor indicating that the valve 301 a is open, thereby determining that wireline is in the wellbore 125 1. After the controller 180 receives such a signal, the controller 180 may then "lock-out" actuation of one or more of the valves 150 1-N(e.g., the valves 150 5-N of the wellhead 120 1) until the controller 180 receives another signal (or ceases to receive the original signal) from the sensor indicating that the valve 301 a is closed, thereby determining that the wireline is out of the wellbore 125 1. Such a process helps to prevent users from inadvertently cutting the wireline via actuation of one or more of the valves 150 1-N, which is a common failure. A manual override of this process may be utilized just in case a user needs to intentionally cut the wireline for emergency purposes.

[0086]

In those embodiments in which the downhole tool includes the plug and perforating guns, the plug is set, the perforating guns are fired, and the spent perforating guns are retrieved from the wellbore 125 1 and back into the lubricator 301 d to complete execution of the step 303 c. At a step 303 d, the lubricator 301 d is detached from the latch 301 b. In one or more embodiments, the step 303 d is executed after the first wellbore operation is performed at the step 303 c (e.g., after the spent perforating guns are retrieved from the wellbore 125 1 and back into the lubricator 301 d). In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of detaching the lubricator 301 d from the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0087]

At a step 303 e, the lubricator 301 d is retracted from the central passageway of the launcher 301 c. In one or more embodiments, the step 303 e is executed after the step 303 d. More particularly, the lubricator 301 d is displaced in a direction 304 b (as shown in FIG. 7C) to execute the step 303 e. At a step 303 f, an object is launched from the launcher 301 c so that the object enters the wellbore 125 1. In one or more embodiments, the step 303 f is executed after the step 303 e. The execution of the step 303 f causes the object to pass through the valve 301 a before entering the wellbore 125 1. In one or more embodiments, the valve 301 a and the process of passing the object therethrough is described in the '785 application, the '203 application, or both. Finally, at a step 303 g, a second wellbore operation (e.g., a hydraulic fracturing operation) is performed. In one or more embodiments, the step 303 g is executed after the step 303 f. In those embodiments in which the second wellbore operation is a hydraulic fracturing operation, a hydraulic fracturing

fluid is pumped into the wellbore 125 1 via the frac leg 146 1 to facilitate execution of the step 303 g.

[0088]

Referring to FIG. 9, with continuing reference to FIGS. 1 and 2, in one or more embodiments, the grease system 305 is used to deliver and meter grease to process valves 310 1-N used in oil and gas operations. For example, the process valves 310 1-N to which the grease system 305 delivers and meters grease may be, include, or be part of the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, the equalization valve 160 N, or any combination thereof. As discussed above, the grease system 305 includes the delivery module 315 and the metering modules 320 1-N. The metering modules 320 1-N are each operably associated with, and adapted to be in communication with, the delivery module 315. Likewise, the process valves 310 1-N are operably associated with, and adapted to be in communication with, the metering modules 320 1-N, respectively. In operation, to grease the process valves 310 1-N, the metering modules 320 1-N are adapted to force grease from the delivery module 315 into the respective process valves 310 1-N.

[0089]

Referring to FIG. 10 with continuing reference to FIG. 9, in one or more embodiments, the delivery module 315 includes a fluid power source 325 and a grease container 330. The fluid power source 325 stores a power fluid for forcing grease from the grease container 330 into the process valves 310 1-N, as will be described in more detail below. A fluid transport device 335 is operably associated with the fluid power source 325. The fluid transport device 335 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 335 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 335 is adapted to transport the power fluid from the fluid power source 325 to the metering modules 320 1-N. A pressure sensor 340 is operably associated with the fluid transport device 335. The pressure sensor 340 is adapted to detect the pressure of the power fluid discharged from the fluid transport device 335. In addition to providing the power fluid transported to the metering modules 320 1-N, the fluid power source 325 is also adapted to receive recycled power fluid from the metering modules 320 1-N.

[0090]

The grease container 330 stores grease. A grease measuring device 345 such as, for example, a load cell (e.g., a scale) is operably associated with the grease container 330. The grease measuring device 345 may be adapted to measure a mass of the grease container 330 to keep track of the amount of grease that has been used and how much is remaining. However, although described herein as a load cell, the grease measuring device 345 may be any suitable device capable of monitoring the amount of grease in the grease container 330 such as, for example, a ranging device, a linear position transducer, an optical/laser device, or the like that measures a level of the grease within the grease container 330. A fluid transport device 350 is operably associated with the grease container 330. The fluid transport device 350 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 350 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 350 is adapted to transport grease from the grease container 330 to the metering modules 320 1-N. A pressure sensor 355 is operably associated with the fluid

transport device 350. The pressure sensor 355 is adapted to detect the pressure of the grease discharged from the fluid transport device 350. In addition to providing the grease transported to the metering modules 320 1-N, the grease container 330 is also adapted to receive recycled grease from the metering modules 320 1-N. To this end, a return valve 360 is operably associated with the grease container 330 and adapted to selectively permit communication of the recycled grease from the metering modules 320 1-N to the grease container 330.

[0091]

In one or more embodiments, as in FIG. 10, the grease system 305 also includes the controller 180. The controller 180 is adapted to send control signals to the fluid transport devices 335 and 350 and the return valve 360. In addition, the controller 180 may receive operating speed data from the fluid transport devices 335 and 350 and/or valve position data from the return valve 360. The controller 180 is also adapted to receive data/readings from the pressure sensors 340 and 355 (e.g., pressure data) and the grease measuring device 345 (e.g., grease measurement data).

[0092]

In one or more embodiments, the metering modules 320 1-N are substantially identical to each other and, therefore, in connection with FIG. 11, only the metering module 320 1 will be described in detail below; however, the description below also applies to the metering modules 320 2-N. Referring to FIG. 11, with continuing reference to FIGS. 9 and 10, in one or more embodiments, to meter the amount of grease to a particular one of the process valves 310 1, the metering module 320 1 includes a grease metering device 365 such as, for example, a grease pump. In one or more embodiments, as in FIG. 11, the grease metering device 365 includes a piston 370, a power cylinder 375, and a grease cylinder 380.

[0093]

The piston 370 includes a head portion 385 and a rod portion 390. The head portion 385 is slidably disposed in the power cylinder 375 and divides the power cylinder 375 into chambers 395 and 400. The rod portion 390 extends from the head portion 385 into the grease cylinder 380 so that, as the head portion 385 travels back and forth in the power cylinder 375, the rod portion 390 extends at least partially into, and retracts at least partially out of, the grease cylinder 380. The piston 370 may be displaced within the power cylinder 375 via hydraulic or pneumatic power; thus, in one or more embodiments, the power fluid stored by the fluid power source 325 is hydraulic or pneumatic. In addition, or instead, electric or gas power may be utilized to displace the piston 370.

[0094]

In one or more embodiments, as in FIG. 11, a control valve 405 is operably associated with the power cylinder 375. The control valve 405 is adapted to receive the power fluid from the fluid transport device 335. To stroke the piston 370 in a direction 410, the control valve 405 is adapted to communicate power fluid from the fluid transport device 335 to the chamber 395 and, at the same time, to communicate power fluid from the chamber 400 back to the fluid power source 325. Similarly, to stroke the piston 370 in a direction 415, which is opposite the direction 410, the control valve 405 is adapted to communicate power fluid from the fluid transport device 335 to the chamber 400 and, at the same time, to communicate power fluid received from the chamber 395 back to the fluid power source 325. In addition, the pressure of the grease within the grease cylinder 380 forces the piston 370 in the direction 415. In one or more embodiments, the force exerted on the piston 370 by the grease within the grease cylinder 380 is sufficient by itself to stroke the piston 370 in the direction 415. Accordingly, to ensure that the grease cylinder

380 is filled with grease before being stroked in the direction 410, the force exerted on the piston 370 by the grease within the grease cylinder 380 may itself be relied on to stroke the piston 370 in the direction 415. In one or more embodiments, the fluid power source 325, the fluid transport device 335, the pressure sensor 340, the power cylinder 375, the control valve 405, or any combination thereof, may collectively be referred to herein as an "actuator" (i.e., hydraulic- or pneumatic-powered) for stroking the piston 370 back and forth within the grease cylinder 380. However, in addition, or instead, another "actuator" may also be used to stroke the piston 370 back and forth within the grease cylinder 380 such as, for example, an electric- or gas-powered actuator.

[0095]

A cycle counter 420 is operably associated with the power cylinder 375. The cycle counter 420 may be or include limit switch(es) or other sensor(s) operably associated with the actuator to give analog or other linear position feedback. In any case, the cycle counter 420 is adapted to count the strokes of the piston 370 within the power cylinder 375. In one or more embodiments, the cycle counter 420 is capable of detecting partial strokes of the piston 370 to further enable precise greasing of the process valves 310 1. As a result, if so desired, the grease system 305 is capable of partially greasing the process valves 310 1 by allowing an operator to enter the "desired percentage" of grease required. In one or more embodiments, as in FIG. 11, the controller 180 is adapted to send control signals to the control valve 405. In addition, the controller 180 may receive valve position data from the control valve 405. The controller 180 is also adapted to receive data/readings (e.g., stroke count data) from the cycle counter 420.

[0096]

A check valve 425 is operably associated with an inlet 426 of the grease cylinder 380 and is adapted to communicate grease from the fluid transport device 350 to the grease cylinder 380 while preventing, or at least reducing, any backflow of the grease through the check valve 425. As a result, when the piston 370 is stroked in the direction 415, the rod portion 390 is retracted at least partially out of the grease cylinder 380 and the check valve 425 permits grease to be drawn into the grease cylinder 380 via the inlet 426. At the same time, a check valve 430 prevents grease from being drawn into the grease cylinder 380 via an outlet 431. The check valve 430 is operably associated with the outlet 431 of the grease cylinder 380 and is adapted to communicate grease from the grease cylinder 380 to the process valves 310 1 while preventing, or at least reducing, any backflow of the grease through the check valve 430. As a result, when the piston 370 is stroked in the direction 410, the rod portion 390 is extended at least partially into the grease cylinder 380 and the check valve 430 permits grease to be forced out of the grease cylinder 380 via the outlet 431. At the same time, the check valve 425 prevents grease from being forced out of the grease cylinder 380 via the inlet 426. In one or more embodiments, the check valve 430 is biased to the closed position with more force (e.g., tighter springs) than that of the check valve 425 in order to maintain the pressure of the grease within the grease cylinder 380. For example, springs in the check valve 430 can be tuned to a desired cracking pressure (e.g., about 1000 psi) to determine the pressure of the grease within the grease cylinder 380.

[0097]

In one or more embodiments, the grease metering device 365 is "double-acting" and includes a second grease cylinder substantially identical to the grease cylinder 380 and a second rod portion substantially identical to the rod portion 390; the second rod portion extends from the head portion 385 into the second grease cylinder so that, as the head portion 385 travels back and forth

in the power cylinder 375, the second rod portion extends at least partially into, and retracts at least partially out of, the second grease cylinder.

[0098]

Referring to FIG. 12 with continuing reference to FIGS. 9-11, in one or more embodiments, the process valves 310 1 are adapted to be in communication with the metering module 320 1 via lubricator valves 435 1-N, respectively. In one or more embodiments, the lubricator valves 435 1-N are part of the metering module 320 1. Similarly, the process valves 310 2-N may be adapted to be in communication with the metering modules 320 2-N, respectively, via lubricator valve(s) substantially identical to the lubricator valves 435 1-N. The lubricator valves 435 1-N are adapted to selectively communicate grease from the grease cylinder 380 (shown in FIG. 11) to respective ones of the process valves 310 1 (shown in FIG. 12). In one or more embodiments, as in FIG. 12, the controller 180 is adapted to send control signals to the lubricator valves 435 1-N. In addition, the controller 180 may receive valve position data from the lubricator valves 435 1-N.

[0099]

Alternatively, in one or more embodiments, the grease metering device 365 may be omitted and replaced with flow meters that are operably associated with respective ones of the process valves 310 1 (and thus respective ones of the lubricator valves 435 1-N; in such embodiments, the controller 180 receives feedback from the flow meters and actuates the lubricator valves 435 1-N to meter a desired amount of grease to the process valves 310 1 using the fluid transport device 350. In one or more embodiments, the grease system 305 further includes one or more pressure sensors located downstream from the check valve 430 (e.g., to monitor pressure within the process valves 310 1); as a result, using data/readings obtained from these one or more pressure sensors, the controller 180 can ensure that the greasing pressure is greater than the pressure within the process valves 310 1. Additional valves may also be added downstream from the check valve 430 to provide double barriers to prevent, or at least reduce, any leakage of process fluid from the process valve.

[0100]

Referring collectively to FIGS. 9-12, in operation, the fluid transport device 335 transports power fluid from the fluid power source 325 to the control valve 405 of the metering module 320 1. During the transporting of the power fluid to the control valve 405, the controller 180 communicates control signals to the fluid transport device 335 and receives data/readings from the pressure sensor 340. As a result, the controller 180 can adjust the flow of the power fluid to the control valve 405 using the fluid transport device 335 and monitor the pressure of the power fluid exiting the fluid transport device 335 using the pressure sensor 340. The control valve 405 actuates the piston 370 within the power cylinder 375. To actuate the piston 370 in the direction 410 within the power cylinder 375, the control valve 405 communicates power fluid from the 130 to the chamber 395 and, at the same time, communicates power fluid from the chamber 400 back to the fluid power source 325. Conversely, to actuate the piston 370 in the direction 415 within the power cylinder 375, the control valve 405 communicates power fluid from the fluid transport device 335 to the chamber 400 and, at the same time, communicates power fluid from the chamber 395 back to the fluid power source 325. During the actuation of the piston 370 within the power cylinder 375, the controller 180 communicates control signals to the control valve 405 and receives data/readings from the cycle counter 420. As a result, the controller 180 can stroke the piston 370 back and forth within the power cylinder 375 using the control valve 405 and count the strokes of the piston 370 back and forth within the power cylinder 375 using

the cycle counter 420. In other embodiments, in addition, or instead, electric or gas power may be utilized to actuate the piston 370.

[0101]

The fluid transport device 350 transports grease from the grease container 330 to the inlet 426 of the grease cylinder 380. During the transporting of the grease to the grease cylinder 380, the controller 180 communicates control signals to the fluid transport device 350 and receives data/readings from the pressure sensor 355. As a result, the controller 180 can adjust the flow of the grease to the grease cylinder 380 using the fluid transport device 350 and monitor the pressure of the grease exiting the fluid transport device 350 using the pressure sensor 355. As the piston 370 is actuated in the direction 415, the grease is drawn into the grease cylinder 380 through the inlet 426. The transporting of the grease to the grease cylinder 380 using the fluid transport device 350 allows the grease to be more efficiently and completely drawn into the grease cylinder 380 through the inlet 426 as the piston 370 is actuated in the direction 415. Conversely, as the piston 370 is actuated in the direction 410, the grease is forced out of the grease cylinder 380 through the outlet 431. The lubricator valves 435 1-N selectively communicate the grease forced out of the grease cylinder 380 to respective ones of the process valves 310 1. In addition, the return valve 360 selectively communicates the grease forced out of the grease cylinder 380 back to the grease container 330.

[0102]

The controller 180 communicates control signals to the return valve 360 and the lubricator valves 435 1-N. As a result, the controller 180 can selectively actuate the return valve 360 and the lubricator valves 435 1-N to determine: whether the grease forced out of the grease cylinder 380 is communicated back to the grease container 330; and/or which of the process valves 310 1 receives the grease forced out of the grease cylinder 380. For example, if the controller 180 closes the return valve 360, opens one of the lubricator valves 435 1-N, and closes the remaining lubricator valves 435 1-N, the grease forced out of the grease cylinder 380 will be communicated to the process valve 310 1 that is operably associated with the opened one of the lubricator valves 435 1-N. For another example, if the controller 180 opens the return valve 360 and closes the lubricator valves 435 1-N, the grease forced out of the grease cylinder 380 will be communicated back to the grease container 330. Alternatively, the return valve 360 could bypass the grease cylinder 380 by communicating grease back to the grease container 330 before the grease passes through the check valve 425.

[0103]

The volume of grease forced out of the grease cylinder 380 with each stroke of the piston 370 can be determined via measurement or calculation (e.g., by multiplying the cross-sectional area of the rod portion 390 by the length of the piston 370's stroke); as a result, by controlling and/or monitoring the control valve 405, the cycle counter 420, the lubricator valves 435 1-N, the return valve 360, or any combination thereof, the controller 180 meters a desired amount of grease to each of the process valves 310 1. In one or more embodiments, the desired amount of grease metered to each of the process valves 310 1 can be specifically tailored according to greasing volume and/or frequency guidelines provided, for example, by the manufacturer(s) of the process valves 310 1 and stored in a database accessible by the controller 180. In addition, or instead, the desired amount of grease metered to each of the process valves 310 1 may be provided by a user via a user interface (HMI) connected to the controller 180; if so desired, the amount of grease metered to each of the process valves 310 1 can be changed during a job. In addition, by controlling and/or monitoring the fluid transport devices 335 and 350 and the pressure sensors

340 and 355, the controller 180 regulates the flow of the power fluid and the grease within the grease system 305.

[0104]

In one or more embodiments, the controller 180 is further adapted to receive data/readings from a pressure sensor 436 (shown in FIG. 11) that detects the pressure of the grease within the grease cylinder 380; by comparing the data/reading obtained from the pressure sensor 436 with data/readings obtained from the pressure sensor 355, the controller 180 can determine whether the grease cylinder 380 is filled with grease after the piston 370 is stroked in the direction 415. As a result, the controller 180 can delay stroking the piston in the direction 410 until the grease cylinder 380 is completely filled with grease, thus improving the accuracy of greasing operations. In one or more embodiments, the controller 180 controls the metering modules 320 2-N to deliver and meter grease to the process valves 310 2-N in substantially the same manner as that described above with respect to the metering module 320 1 and the process valves 310 1; therefore, the operation of the metering modules 320 2-N to deliver and meter grease to the process valves 310 2-N will not be described in further detail. As a result, the controller 180 is capable of greasing the process valves 310 1-N at any of the following intervals: timed intervals; continuous greasing (at a rate specified by the user or the database); greasing on command from an operator via a user interface (HMI) at any time; per operational stage (e.g., fracturing stage); per N stages; scheduled greasing; scheduled partial greasing; and/or any combination thereof.

[0105]

In one or more embodiments, prior to delivering and metering grease to the process valves 310 1-N, the grease system 305 is capable of verifying that the process valves 310 1-N are actuated to the proper position for greasing. To achieve such verification, the grease system 305 includes sensor(s) (e.g., the position sensors 205 1 and 225 1 shown in FIGS. 3 and 4) associated with the process valves 310 1-N to ensure they are in the proper position prior to greasing. Such sensor(s) may include, for example, position sensor(s) and/or visual feedback devices (e.g., camera(s), image processing software, etc.) capable of detecting the position of the process valves 310 1-N. In addition, the grease system 305 may include actuator(s) adapted to receive control signals from the controller 180 to open or close the process valves 310 1-N. As a result, the controller 180 is able to automatically place the process valves 310 1-N in the proper greasing position prior to greasing.

[0106]

Referring to FIG. 13, in one or more embodiments, a method of operating the grease system 305 is generally referred to by the reference numeral 440. The method 440 is carried out by receiving, at the controller 180, data/readings from the delivery module 315 (e.g., the pressure sensors 340 and 355) and/or the metering modules 320 1-N (e.g., the cycle counter 420), and sending, from the controller 180, control signals to the delivery module 315 (e.g., the fluid transport devices 335 and 350, the return valve 360, or any combination thereof) and/or the metering modules 320 1-N(e.g., the control valve 405, the lubricator valves 435 1-N, or any combination thereof).

[0107]

The method 440 includes at a step 445 delivering grease to a first one of the metering modules 320 1-N. In one or more embodiments, the step 445 includes transporting the grease from the grease container 330 to the first one of the metering modules 320 1-N. At a step 450, the controller 180 controls the actuator of the first one of the metering modules 320 1-N so that a first amount of the delivered grease is metered to a first one of the process valves 310 1-N. In

one or more embodiments, the step 450 includes: controlling the actuator of the first one of the metering modules 320 1-N to start stroking the piston 370; determining how many strokes of the piston 370 are required to meter the first amount to the first one of the process valves 310 1-N; and controlling the actuator to stop stroking the piston 370 when the strokes counted by the cycle counter 420 equal the determined number of strokes required. In one or more embodiments of the step 450, the controller 180 determines the first amount by retrieving data relating to the first one of the process valves 310 1-N from a database.

[0108]

At a step 455, grease is delivered to a second one of the metering modules 320 1-N. In one or more embodiments, the step 455 includes transporting the grease from the grease container 330 to the second one of the metering modules 320 1-N. At a step 260, the controller 180 controls the actuator of the second one of the metering modules 320 1-N so that a second amount of the delivered grease is metered to a second one of the process valves 310 1-N. In one or more embodiments of the step 260, the controller 180 determines the second amount by retrieving data relating to the second one of the process valves 310 1-N from a database.

[0109]

In one or more embodiments, among other things, the operation of the grease system 305 and/or the execution of the method 440: ensures that an appropriate amount of grease is injected into each of the process valves 310 1-N while monitoring the amount of grease injected into each of the process valves 310 1-N; improves the flushing of debris and contaminants from the process valves 310 1-N; improves the performance of the process valves 310 1-N; decreases the risk that a less than adequate amount of grease is injected into the process valves 310 1-N; decreases the risk of malfunction and maintenance needs for the process valves 310 1-N; and/or reduces operators' exposure to oil and gas process units during operation.

[0110]

Referring to FIG. 14, with continuing reference to FIGS. 1-13, in an embodiment, the grease system 305 includes a sub-controller 465 and the frac legs 146 1-N include sub-controllers 470 1-N, respectively. A communication bus 475 connects the controller 180 to the sub-controllers 465 and 470 1-N. The controller 180 communicates with the sub-controllers 465 and 470 1-N via the communication bus 475 to coordinate operation of the grease system 305 and the frac legs 146 1-N, as will be described in further detail below.

[0111]

Referring to FIG. 15, with continuing reference to FIG. 14, in an embodiment, the sub-controller 470 1 is part of (or otherwise associated with) the valve 301 a to thereby control operation of the valve 301 a, the latch 301 b, and the launcher 301 d. The wellhead 120 1 includes a flow block 480 operably coupled between, and in fluid communication with, the upper master valve 150 6 and the lower master valve 150 7. Wing valves 485 aa and 485 ab are connected to the flow block 480. Likewise, wing valves 485 ba and 485 bb are also connected to the flow block 480, opposite the wing valves 485 aa and 485 ab. As a result, in addition to being operably coupled between, and in fluid communication with, the upper master valve 150 6 and the lower master valve 150 7, the flow block 480 is operably coupled between, and in fluid communication with, the wing valves 480 aa and 480 ba. As discussed above in connection with FIGS. 2, 3, and 5, the controller 180 is operably coupled to, and adapted to control actuation of, the lower zipper valve 150 1, the upper zipper valve 150 2, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N. Likewise, the controller 180 is operably coupled to, and adapted to control actuation of, the wing valves 185 aa, 185 ab, 185 ba, and 185 bb. The manner in which

the controller 180 controls actuation of the wing valves 185 aa, 185 ab, 185 ba, and 185 bb is similar to the manner in which the controller 180 controls actuation of the lower zipper valve 150 1, the upper zipper valve 150 2, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N, as discussed above in connection with FIGS. 2, 3, and 5; therefore, the manner in which the controller controls actuation of the wing valves 185 aa, 185 ab, 185 ba, and 185 bb will not be described in further detail. Finally, as in FIG. 15, a pump-down truck 490 may be operably coupled to, and in fluid communication with, the wing valve 485 bb.

[0112]

Referring to FIG. 16, with continuing reference to FIGS. 14 and 15, in an embodiment, a method is generally referred to by the reference numeral 500. The method 500 includes, at a step 505, performing a perforating operation (such as, for example, a ball and sleeve operation) on the wellbore 125 1. More particularly, turning briefly to FIG. 15, performing the perforating operation on the wellbore 125 1 includes: deploying a downhole tool (e.g., a plug and perforating gun(s)) on a conveyance string from the lubricator 301 d, through the wellhead 120 1, and into the wellbore 125 1; pumping the downhole tool into the wellbore 125 1 using fluid from the pump-down truck 490; perforating the wellbore 125 1 at a downhole location; and retrieving the downhole to back into the lubricator 301 d. In an alternative embodiment, the step 505 is omitted from the method 500, and the method 500 instead includes, at a step 510, performing a second operation (e.g., a hydraulic fracturing operation) on the wellbore 125 1. The method 500 further includes, at a step 515, performing the second operation on the wellbore 125 2. More particularly, turning briefly to FIG. 17, performing the second operation on the wellbore 125 2 includes pumping hydraulic fracturing fluid through the zipper module 135 2, through the frac line 140 2, through the wellhead 120 2, and into the wellbore 125 2. In an alternative embodiment, the step 515 is omitted from the method 500, and the method 500 instead includes, at a step 520, performing the perforating operation on the wellbore 125 2. Finally, the method 500 further includes, at a step 525, performing an object launching operation on the wellbore 125 N such as, for example, the wellbore 125 3. More particularly, turning briefly to FIG. 18, performing the object launching operation on the wellbore 125 3 includes: dropping an object from the launcher 301 c, through the valve 301 a, through the wellhead 120 3, and into the wellbore 125 3; and pumping the object into the wellbore 125 1 using fluid from the pump-down truck 490.

[0113]

In some embodiments, the steps 505 or 510, the steps 515 or 520, and/or the step 525 may be executed simultaneously on the wellbores 125 1-3, respectively. In some alternative embodiments, both of the steps 515 and 520 are omitted from the method 500 so that the method 500 includes only the steps 505 and 525, or the steps 510 and 525. In some alternative embodiments, the step 525 is omitted from the method 500 so that the method 500 includes only the steps 505 and 515, the steps 505 and 520, or the steps 510 and 520. In some embodiments, the controller 180 is in communication with additional wellbores such as for example, offset wellbores, wellbores located on difference well pads or different well sites, or the like. In such embodiments, the method 500 can be expanded to include execution of the steps 505 or 510, 515 or 520, and/or 525 on these additional wellbores. In some embodiments, the steps 505, 510, 515, 520, and 525 may be executed on all of the wellbores 125 1-N(and/or the additional wellbores) in order to plug, perforate, and hydraulically fracture the wellbores 125 1-N(and/or the additional wellbores) using a continuous process.

[0114]

The step 505 or, alternatively, the step 510, may be executed by communicating, using the controller 180, control signals to the frac leg 146 1 and the grease system 305. Referring back to FIG. 15, the frac leg 146 1 includes: the wellhead 120 1 operably associated with the wellbore 125 1, the wellhead 120 1 including one or more first valves (i.e., the swab valve 150 5, the upper master valve 150 6, the lower master valve 150 N, the wing valve 185 aa, the wing valve 185 ab, the wing valve 185 ba, the wing valve 185 bb, or a combination thereof); the valve 301 a operably coupled to the wellhead 120 1, opposite the wellbore 125 1; the frac line 140 1 operably coupled to the wellhead 120 1, between the wellbore 125 1 and the valve 301 a; and the zipper module 135 1 operably coupled to the frac lines 140 1, opposite the wellhead 120 1, the zipper module 135 1 including one or more third valves (i.e., the lower zipper valve 150 1, the upper zipper valve 150 2, or both). The frac leg 146 1 may further include the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 1 includes communicating at least a portion of the control signals to the sub-controller 470 1 (via, for example, the communication bus 475).

[0115]

The grease system 305 is adapted to lubricate the first valve(s) of the wellhead 120 1 and the third valve(s) of the zipper module 135 1. The grease system 305 may also include the sub-controller 465; in such embodiments, communicating, using the controller 180, the control signals to the grease system 305 includes communicating at least a portion of the control signals to the sub-controller 465 (via, for example, the communication bus 475). In an alternative embodiment, the grease system 305 is omitted, and the control signals are communicated only to the frac leg 146 1.

[0116]

Referring still to FIG. 15, with continuing reference to FIG. 16, in those embodiments of the step 505 in which the control signals are communicated to both the frac leg 146 1 and the grease system 305, the control signals enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the first valve(s) of the wellhead 120 1 to open; and the grease system 305 to lubricate the at least one of the first valve(s) of the wellhead 120 1 during and/or after the at least one of the first valve(s) open(s). In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to close; and the valve 301 a to open, allowing passage of a conveyance string carrying a downhole tool through the valve 301 a, through the wellhead 120 1, and into the wellbore 125 1. Additionally, the frac leg 146 1 may further include: the lubricator 301 d, said downhole tool being deployable from, and retrievable to, the lubricator 301 d on the conveyance string; and a latch 301 b operably coupled to the valve 301 a, opposite the wellhead 120 1, said latch 301 b being adapted to secure the lubricator 301 d for deployment and retrieval of the downhole tool. In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 1 by causing the latch 301 b to secure the lubricator 301 d for deployment and retrieval of the downhole tool.

[0117]

In some embodiments, the controller 180 locks at least one of the first valve(s) of the wellhead 120 1 in the open configuration, the valve 301 a in the open configuration (via control signals sent to the sub-controller 470 1), and/or the at least one of the third valve(s) of the zipper module 135 1 in the closed configuration when the downhole tool is deployed from the lubricator 301 d,

and until the downhole tool is retrieved. In such embodiments, this locking may be manually overridden via the user interface 185.

[0118]

Alternatively, in those embodiments of the step 505 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 1: the frac leg 146 1 further includes the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 1 comprises communicating at least a portion of the control signals to the sub-controller 470 1. In such embodiments of the step 505, the control signals enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the first valve(s) of the wellbore 120 1 to open; at least one of the third valve(s) of the zipper module 135 1 to close; and the valve 301 a to open, allowing passage of the conveyance string carrying the downhole tool through the valve 301 a, through the first one of the wellheads 120 1-N, and into the wellbore 125 1.

[0119]

In those embodiments in which the step 510 replaces the step 505 and the control signals are communicated to both the frac leg 146 1 and the grease system 305, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to open; and the grease system 305 to lubricate the at least one of the third valve(s) of the zipper module 135 1 during and/or after the at least one of the third valve(s) open(s). Additionally, the control signals may further enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0120]

Alternatively, in those embodiments of the step 510 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 1: the frac leg 146 1 further includes the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 1 comprises communicating at least a portion of the control signals to the sub-controller 470 1. In such embodiments of the step 510, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to open; and the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0121]

The step 515 or, alternatively, the step 520, may by executed by communicating, using the controller 180, control signals to the frac leg 146 2 and the grease system 305. Referring to FIG. 17, the frac leg 146 2 includes: the wellhead 120 2 operably associated with the wellbore 125 2, the wellhead 120 2 including one or more fourth valves (i.e., the swab valve 150 5, the upper master valve 150 6, the lower master valve 150 N, the wing valve 185 aa, the wing valve 185 ab, the wing valve 185 ba, the wing valve 185 bb, or a combination thereof); the valve 301 a operably coupled to the wellhead 120 2, opposite the wellbore 125 2; the frac line 140 2 operably coupled to the wellhead 120 2, between the wellbore 125 2 and the valve 301 a; and the zipper module 135 2 operably coupled to the frac line 140 2, opposite the wellhead 120 2, the zipper module 135 2 being in fluid communication with the zipper module 135 1 and including one or more sixth valves (i.e., the lower zipper valve 150 1, the upper zipper valve 150 2, or both). The frac leg 146 2 may further include the sub-controller 470 2, said sub-controller 470 2 being

associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 2 includes communicating at least a portion of the control signals to the sub-controller 470 2 (via, for example, the communication bus 475).

[0122]

The grease system 305 is adapted to lubricate the fourth valve(s) of the wellhead 120 2 and the sixth valve(s) of the zipper module 135 2. As discussed above, the grease system 305 may include the sub-controller 465; in such embodiments, communicating, using the controller 180, the control signals to the grease system 305 includes communicating at least a portion of the control signals to the sub-controller 465 (via, for example, the communication bus 475). Alternatively, the grease system 305 may be omitted, and the control signals may be communicated only to the frac leg 146 2.

[0123]

Referring still to FIG. 17, with continuing reference to FIG. 16, in those embodiments of the step 515 in which the control signals are communicated to both the frac legs 146 2 and the grease system 305, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to open; and the grease system 305 to lubricate the at least one of the sixth valve(s) of the zipper module 135 2 during and/or after the at least one of the sixth valve(s) open(s). Additionally, the control signals may further enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0124]

In some embodiments, the controller 180 locks the at least one of the fourth valve(s) of the wellhead 120 2 in the open configuration, the valve 301 a in the closed configuration (via control signals sent to the sub-controller 470 2), and/or the at least one of the sixth valve(s) of the zipper module 135 2 in the open configuration when the hydraulic fracturing fluid is pumped through the zipper module 135 2, through the frac line 140 2, through the wellhead 120 2, and into the wellbore 125 2, and until such pumping of the hydraulic fracturing fluid is complete. In such embodiments, this locking may be manually overridden via the user interface 185.

[0125]

Alternatively, in those embodiments of the step 515 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 2; the frac leg 146 2 further includes the sub-controller 470 2, said sub-controller 470 2 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 2 comprises communicating at least a portion of the control signals to the sub-controller 470 2. In such embodiments of the step 515, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to open; and the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0126]

In those embodiments in which the step 520 replaces the step 515 and the control signals are communicated to both the frac leg 146 2 and the grease system 305, the control signals enable performance of the perforating operation on the wellbore 125 2 by causing: at least one of the fourth valve(s) of the wellhead 120 2 to open; and the grease system 305 to lubricate the at least one of the fourth valve(s) of the wellhead 120 2 during and/or after the at least one of the fourth valve(s) open(s). In such embodiments, the control signals may further enable performance of

the perforating operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to close; and the valve 301 a to open, allowing passage of a conveyance string carrying a downhole tool through the valve 301 a, through the wellhead 120 2, and into the wellbore 125 2. Additionally, the frac leg 146 2 may further include: the lubricator 301 d, said downhole tool being deployable from, and retrievable to, the lubricator 301 d on the conveyance string; and the latch 301 b operably coupled to the valve 301 a, opposite the wellhead 120 2, said latch 301 b being adapted to secure the lubricator 301 d for deployment and retrieval of the downhole tool. In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 2 by causing the latch 301 b to secure the lubricator 301 d for deployment and retrieval of the downhole tool.

[0127]

Alternatively, in those embodiments of the step 520 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 2: the frac leg 146 2 further includes the sub-controller 470 2, said sub-controller 470 2 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 2 comprises communicating at least a portion of the control signals to the sub-controller 470 2. In such embodiments of the step 520, the control signals enable performance of the perforating operation on the wellbore 125 2 by causing: at least one of the fourth valve(s) of the wellhead 120 2 to open; at least one of the sixth valve(s) of the zipper module 135 2 to close; and the valve 301 a to open, allowing passage of the conveyance string carrying the downhole tool through the valve 301 a, through the second one of the wellheads 120 1-N, and into the wellbore 125 2.

[0128]

The step 525 may be executed by communicating, using the controller 180, control signals to the frac leg 146 3. Turning to FIG. 18, with continuing reference to FIG. 16, the frac leg 146 3 includes: the wellhead 120 3 operably associated with the wellbores 120 3; the valve 301 a operably coupled to the wellhead 120 3, opposite the wellbore 125 3; and the launcher 301 c operably coupled to the valve 301 a, opposite the wellhead 120 3. In such embodiments of the step 525, the control signals enable performance of the object launching operation on the wellbore 125 3 by causing: the launcher 301 c to release an object into the valve 301 a; and the valve 301 a to allow passage of the released object through the valve 301 a, through the wellhead 120 3, and into the wellbore 125 3. The frac leg 146 3 may further include the sub-controller 470 3, said sub-controller 470 3 being associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 3 includes communicating at least a portion of the control signals to the sub-controller 470 3 (via, for example, the communication bus 475).

[0129]

Referring to FIG. 19, with continuing reference to FIGS. 1-18, in one or more embodiments, a computing node 1000 for implementing one or more embodiments of one or more of the above-described elements, systems, apparatus, controllers, methods, and/or steps, or any combination thereof, is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In one or more embodiments, the microprocessor 1000 a is, includes, or is part of, the controller 180 and/or the one or more other controllers described herein. In one or more embodiments, the storage device 1000 c may include a floppy drive, hard drive, CD-ROM, optical drive, any other form of storage device ~~and/~~or any combination thereof. In one or more embodiments, the storage device 1000 c

may include, and/or be capable of receiving, a floppy disk, CD-ROM, DVD-ROM, or any other form of ~~non-transitory~~ computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device 1000 g may include a modem, network card, or any other device to enable the node 1000 to communicate with other ~~node(s).~~nodes. In one or more embodiments, ~~the~~any node ~~and the other node(s) represent~~represents a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

[0130]

In one or more embodiments, one or more of the ~~embodiments~~ components of any of the above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In one or more embodiments, one or more of the above-described components of the node 1000 and/or the ~~embodiments~~ above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include respective pluralities of same components. ~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

[0131]

In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

[0132]

In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, personal digital assistants (PDAs), or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

[0133]

In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD- ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

[0134]

In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In ~~an embodiment~~one or more embodiments, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

[0135]

In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable ~~an embodiment~~one or more embodiments of the present disclosure. In ~~an embodiment, a~~one or more embodiments, data structure may provide an organization of data, or an organization of executable code.

[0136]

In one or more embodiments, any networks and/or one or more portions thereof, may be designed to work on any specific architecture. In ~~an embodiment~~one or more embodiments, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

[0137]

In one or more embodiments, ~~a~~ database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In ~~an embodiment~~one or more embodiments, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In ~~an embodiment~~one or more embodiments, the database may exist remotely from the server, and run on a separate platform. In ~~an embodiment~~one or more embodiments, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.

[0138]

In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part ~~one or more of~~ the ~~embodiments~~above-described operation of ~~one or more~~each of the ~~controller(s) (e.g., the controller 156), element(s),~~above-described elements, systems, apparatus, ~~system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s),~~controllers, methods, and/or ~~sub-step(s),~~steps, or any combination thereof~~, described above and/or illustrated in FIGS. 1A through 19B~~. In one or more embodiments, such a processor may include one or more of the microprocessor 1000 a, the controller 180, the one or more other controllers described herein, any processor(s) that are part of the components of the ~~hydraulic fracturing system 100, such as, for example, the controller 156~~above-described systems, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the ~~system.~~above-described

systems. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ~~ay~~may interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which~~

~~second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing~~

~~queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using~~

~~hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

[0139]

A system has been disclosed. The system generally includes a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; and a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a controller that communicates first control signals to the first frac leg; wherein: (a) the first frac leg further includes a first sub-controller, said first sub-controller being associated with the second valve; and the controller communicates the first control signals to the first sub-controller to control operation of the second valve; (b) the system further includes a grease system, which grease system is adapted to lubricate the first valve(s) and/or the third valve(s); the grease system includes a second sub-controller; and the controller communicates second control signals to the second sub-controller to control lubrication of the first valve(s) and/or the third valve(s) by the grease system; or (c) both (a) and (b). In one or more embodiments, (c); the system further includes a communication bus connecting the controller to the first and second sub-controllers; and wherein the controller communicates the first and second control signals to the first and second sub-controllers, respectively, via the communication bus. In one or more embodiments, (a); and wherein the first frac leg further includes: a lubricator from which a downhole tool is deployable, and to which the downhole tool is retrievable, on a conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being controllable by the first sub-controller to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, the system further includes: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; and a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; wherein the controller communicates third control signals to the second frac leg. In one or more embodiments, (d) the second frac leg further includes a third sub-controller, said third sub-controller being associated with the fifth valve; and the controller communicates the third control signals to the third sub-controller; (e) the system further includes the grease system, which grease system is adapted to lubricate the fourth valve(s) and the sixth valve(s); the grease system includes the second sub-controller; and the controller communicates fourth control signals to the second sub-controller; or (f) both (d) and (e). In one or more embodiments, (a) and (d); the system further includes a communication bus

connecting the controller to the first and third sub-controllers; and the controller communicates the first and third control signals to the first and third sub-controllers, respectively, via the communication bus. In one or more embodiments, (d); and the second frac leg further includes: a lubricator from which a downhole tool is deployable, and to which the downhole tool is retrievable, on a conveyance string; and a latch operably coupled to the fifth valve, opposite the second wellhead, said latch being controllable by the third sub-controller to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, the system further includes: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; and a launcher operably coupled to the fifth valve, opposite the second wellhead; wherein: (d) the second frac leg further includes a third sub-controller, said third sub-controller being associated with the fifth valve and adapted to control the launcher; and the controller communicates the third control signals to the third sub-controller.

[0140]

The present disclosure also introduces a first method. The first method generally includes: communicating, using a controller, first control signals to: a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a first frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; and a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a grease system, which grease system is adapted to lubricate the first valve(s) and/or the third valve(s); wherein: (i) the first control signals enable performance of a first operation on the first wellbore by causing: at least one of the first valve(s) to open; and the grease system to lubricate the at least one of the first valve(s) during and/or after the at least one of the first valve(s) open(s); or (ii) the first control signals enable performance of a hydraulic fracturing operation on the first wellbore by causing: at least one of the third valve(s) to open; and the grease system to lubricate the at least one of the third valve(s) during and/or after the at least one of the third valve(s) open(s). In one or more embodiments, (i); the first operation is a perforating operation; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: at least one of the third valve(s) to close; and the second valve to open, allowing passage of a conveyance string carrying a downhole tool through the second valve, through the first wellhead, and into the first wellbore. In one or more embodiments, the first frac leg further includes: a lubricator, said downhole tool being deployable from, and retrievable to, the lubricator on the conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being adapted to secure the lubricator for deployment and retrieval of the downhole tool; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: the latch to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, (ii); the second operation is a hydraulic fracturing operation; and the first control signals further enable performance of the hydraulic fracturing operation on the first wellbore by causing: the second valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the second valve. In one or more embodiments, (a) the first frac leg further includes a first sub-controller, said first sub-controller being associated with the second valve; and communicating, using the controller, the first control signals to the first frac leg includes: communicating at least a first portion of the first control signals to the first sub-controller; (b) the grease system includes a second sub-controller; and

communicating, using the controller, the first control signals to the grease system includes: communicating at least a second portion of the first control signals to the second sub-controller; or (c) both (a) and (b). In one or more embodiments, (c); and the controller communicates at least the first and second portions of the first control signals to the first and second sub-controllers, respectively, via a communication bus. In one or more embodiments, the first method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; and a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; and the grease system, which grease system is further adapted to lubricate the fourth valve(s) and the sixth valve(s); wherein: (iii) the second control signals enable performance of the first operation on the second wellbore by causing: at least one of the fourth valve(s) to open; and the grease system to lubricate the at least one of the fourth valve(s) during and/or after the at least one of the fourth valve(s) open(s); or (iv) the second control signals enable performance of the hydraulic fracturing operation on the second wellbore by causing: at least one of the sixth valve(s) to open; and the grease system to lubricate the at least one of the sixth valve(s) during and/or after the at least one of the sixth valve(s) open(s). In one or more embodiments, the first method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; and a launcher operably coupled to the fifth valve, opposite the second wellhead; wherein: (iii) the second control signals enable performance of an object launching operation on the second wellbore by causing: the launcher to release an object into the fifth valve; and the fifth valve to allow passage of the released object through the fifth valve, through the second wellhead, and into the second wellbore.

[0141]

Along with the disclosed first method, an accompanying system is also disclosed, the system including a non-transitory computer readable medium and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed, one or more of the foregoing steps of the first method are executed; additionally, another accompanying system is also disclosed, the system including the controller, the first sub-controller, and the second sub-controller(s), which are used to execute one or more of the foregoing steps of the first method.

[0142]

The present disclosure also introduces a second method. The second method generally includes: communicating, using a controller, first control signals to: a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a first frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a first sub-controller, said first sub-controller being associated with the second valve; wherein communicating, using the controller, the first control signals to the first frac leg includes communicating at least a portion of the first control

signals to the first sub-controller; and wherein: (i) the first control signals enable performance of a first operation on the first wellbore by causing: at least one of the first valve(s) to open; at least one of the third valve(s) to close; and the second valve to open, allowing passage of a conveyance string carrying a downhole tool through the second valve, through the first wellhead, and into the first wellbore; or (ii) the first control signals enable performance of a hydraulic fracturing operation on the first wellbore by causing: at least one of the third valve(s) to open; and the second valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the second valve. In one or more embodiments, (i); the first operation is a perforating operation; and the first frac leg further includes: a lubricator, said downhole tool being deployable from, and retrievable to, the lubricator on the conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being adapted to secure the lubricator; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: the latch to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, (ii); and the second operation is a hydraulic fracturing operation. In one or more embodiments, the second method further includes: communicating, using a controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; and a second sub-controller, said second sub-controller being associated with the fifth valve; wherein communicating, using the controller, the second control signals to the second frac leg includes communicating at least a portion of the second control signals to the second sub-controller; and wherein: (iii) the second control signals enable performance of the first operation on the second wellbore by causing: at least one of the fourth valve(s) to open; at least one of the sixth valve(s) to close; and the fifth valve to open, allowing passage of a conveyance string carrying a downhole tool through the fifth valve, through the second wellhead, and into the second wellbore; or (iv) the second control signals enable performance of the hydraulic fracturing operation on the second wellbore by causing: at least one of the sixth valve(s) to open; and the fifth valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the fifth valve. In one or more embodiments, the second method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a launcher operably coupled to the fifth valve, opposite the second wellhead; and a second sub-controller, said second sub-controller being associated with the fifth valve; wherein communicating, using the controller, the second control signals to the second frac leg includes communicating at least a portion of the second control signals to the second sub-controller; and wherein: (iii) the second control signals enable performance of an object launching operation on the second wellbore by causing: the launcher to release an object into the fifth valve; and the fifth valve to allow passage of the released object through the fifth valve, through the second wellhead, and into the second wellbore.

[0143]

Along with the disclosed second method, an accompanying system is also disclosed, the system including a non-transitory computer readable medium and a plurality of instructions stored on

the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed, one or more of the foregoing steps of the second method are executed; additionally, another accompanying system is also disclosed, the system including the controller, the first sub-controller, and the second sub-controller(s), which are used to execute one or more of the foregoing steps of the second method.

[0144]

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

[0145]

In ~~several~~one or more embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some ~~(~~or all~~)~~ of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

[0146]

Any spatial references, such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

[0147]

In ~~several~~one or more embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In ~~several~~one or more embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

[0148]

In ~~several~~one or more embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

[0149]

Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word "means" together with an associated function.

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.**

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.**

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted.~~[0029]

Referring to FIG. 1, in one or more embodiments, a system generally referred to by the reference numeral 100 is diagrammatically illustrated. The system includes a manifold assembly 105 in fluid communication with a blender 110, hydraulic fracturing pumps 115 a-f, and wellheads 120 1-N. The wellheads 120 1-N serve as surface terminations for wellbores 125 1-N, respectively, with the wellheads 120 1-N being permanently, semi-permanently, or temporarily operably coupled to the wellbores 125 1-N, respectively. The system 100 includes one or more fluid sources 130 in fluid communication with the blender 110. The wellheads 120 1-N are in fluid

communication with the manifold assembly 105 via, for example, zipper modules 135 1-N and fracturing (or "frac") lines 140 1-N. The zipper modules 135 1-N are operably associated with a zipper manifold 145; for example, the zipper modules 135 1-N may be interconnected with each other via the zipper manifold 145. In one or more embodiments, the zipper modules 135 1-N are part of the zipper manifold 145 to which the manifold assembly 105 is operably coupled. In one or more embodiments, the zipper modules 135 1-N are interconnected. In one or more embodiments, at least one of the zipper modules 135 1-N is interconnected with at least one other of the zipper modules 135 1-N. The frac lines 140 1-N couple the zipper modules 135 1-N, respectively, to the wellheads 120 1-N, respectively. In one or more embodiments, the frac lines 140 1-N are part of the zipper manifold 145. The wellhead 120 1, the zipper module 135 1, and the frac line 140 1, in combination, form a frac leg 146 1. Similarly, respective sets of the wellheads 120 2-N, the zipper modules 135 2-N, and the frac line 140 2-N, in combination, form frac legs 146 2-N.

[0030]

Referring still to FIG. 1, a system for delivering and metering grease to the frac legs 146 1-N is diagrammatically illustrated and generally referred to by the reference numeral 305. In one or more embodiments, the grease 305 is, included, or is part of, the grease system described in the '648 application. For example, the frac legs 146 1-N may include process valves to which the grease system 100 delivers and meters grease, as will be described in more detail below. In one or more embodiments, such process valves are gate valves. The grease system 305 includes a delivery module 315 and metering modules 320 1-N. The metering modules 320 1-N are each operably associated with, and adapted to be in communication with, the delivery module 315. Likewise, the process valves of the frac legs 146 1-N are operably associated with, and adapted to be in communication with, the metering modules 320 1-N, respectively. In operation, to grease the process valves of the frac legs 146 1-N, the metering modules 320 1-N are adapted to force grease from the delivery module 315 into the respective process valves, as will be described in more detail below. In one or more embodiments, as in FIG. 1, a controller 180 is adapted to send control signals to the grease system 305 and the frac legs 146 1-N, as will be described in more detail below. A user interface 185 is operably coupled to the controller 180 to enable a user to monitor and control the grease system 305 and the frac legs 146 1-N, as will be described in more detail below.

[0031]

In one or more embodiments, the system 100 and/or the grease system 305 are part of a hydraulic fracturing system, which may be used to facilitate oil and gas exploration and production operations. For example, the system 100 and/or the grease system 305 may be adapted to perform a hydraulic fracturing operation on one or more of the wellbores 125 1-N. The embodiments provided herein are not, however, limited to a hydraulic fracturing system, as the system 100 may be used with, or adapted to, a mud pump system, a well treatment system, other pumping systems, one or more systems at the wellheads 120 1-N, one or more systems upstream of the wellheads 120 1-N, one or more systems downstream of the wellheads 120 1-N, and/or one or more other systems associated with the wellheads 120 1-N.

[0032]

Referring to FIG. 2, with continuing reference to FIG. 1, the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 are diagrammatically illustrated in detail. In one or more embodiments, the zipper module 135 1 includes a lower zipper valve 150 1, an upper zipper valve 150 2, and a fluid connector 155. The lower zipper valve 150 1 is operably coupled to the

zipper manifold 145. The upper zipper valve 150 2 is operably coupled to the lower zipper valve 150 1 opposite the zipper manifold 145. The fluid connector 155 is operably coupled to the upper zipper valve 150 2 opposite the lower zipper valve 150 1. An equalization valve 160 1 is in fluid communication with inlet and outlet sides of the lower zipper valve 150 1. A pressure sensor 165 1 is in fluid communication with the inlet side of the lower zipper valve 150 1. A pressure sensor 165 2 is in fluid communication with the outlet side of the lower zipper valve 150 1. Similarly, an equalization valve 160 2 is in fluid communication with inlet and outlet sides of the upper zipper valve 150 2. A pressure sensor such as, for example, the pressure sensor 165 2 is in fluid communication with the inlet side of the upper zipper valve 150 2. A pressure sensor 165 3 is in fluid communication with the outlet side of the upper zipper valve 150 2.

[0033]

In one or more embodiments, the frac line 140 1 includes frac line valves 150 3 and 150 4. The frac line valve 150 3 is operably coupled to the fluid connector 155 of the zipper module 135 1. The frac line valve 150 4 is operably coupled to the frac line valve 150 3 opposite the fluid connector 155. The frac line 140 1 is operably coupled between the zipper module 135 1 and the wellhead 120 1. An equalization valve 160 3 is in fluid communication with inlet and outlet sides of the frac line valve 150 3. A pressure sensor such as, for example, the pressure sensor 165 3 is in fluid communication with the inlet side of the frac line valve 150 3. A pressure sensor 165 4 is in fluid communication with the outlet side of the frac line valve 150 3. Similarly, an equalization valve 160 4 is in fluid communication with inlet and outlet sides of the frac line valve 150 4. A pressure sensor such as, for example, the pressure sensor 165 4 is in fluid communication with the inlet side of the frac line valve 150 4. A pressure sensor 165 5 is in fluid communication with the outlet side of the frac line valve 150 4.

[0034]

In one or more embodiments, the wellhead 120 1 includes a frac tree 170, a swab valve 150 5, and upper master valve 150 6, and a lower master valve 150 N. An inlet side of the lower master valve 150 N is in fluid communication with the wellbore 125 1. The upper master valve 150 6 is operably coupled to the lower master valve 150 N opposite the wellbore 125 1. The swab valve 150 5 is operably coupled to the upper master valve 150 6 opposite the lower master valve 150 N. The frac tree 170 is operably coupled to the swab valve 150 5 opposite the upper master valve 150 6. Alternatively, the frac tree 170 may be operably coupled to the upper master valve 150 6 opposite the lower master valve 150 N and the swab valve 150 5 may be operably coupled to the frac tree 170 opposite the upper master valve 150 6. The frac line 140 1 is operably coupled, via the frac tree 170, to the wellhead 120 1. In one or more embodiments, the frac tree 170 is or includes a goat head; in at least one such embodiment, the frac line 140 1 and one or more additional frac lines substantially similar to the frac line 140 1 are operably coupled between the zipper module 135 1 and the goat head so that fluid is communicable from the zipper module 135 1 to the wellhead 120 1 through the frac line 140 1 and the one or more additional frac lines.

[0035]

In addition, the wellhead 120 1 may include one or more other wellhead tools or components 175 such as, for example: one or more wing valves; a tree cap; a tree cap valve; the valve apparatus described in U.S. patent application Ser. No. 15/487,785 (the "'785 application"), filed Apr. 14, 2017, and published Oct. 19, 2017 as U.S. Publication No. 2017/0298708, the entire disclosure of which is hereby incorporated herein by reference; the valve apparatus described in U.S. patent application Ser. No. 16/721,203 (the "'203 application"), filed Dec. 19, 2019, the entire disclosure of which is hereby incorporated herein by reference; the object launching apparatus

described in the '633 application; or any combination thereof. One or more embodiments of the one or more other wellhead tools or components 175 are described in further detail below. Although shown as being operably coupled to the frac tree 170 opposite the swab valve 150 5, the one or more other wellhead tools or components 175 may instead be positioned at any location in the wellhead 120 1 such as, for example, between the wellbore 125 1 and the lower master valve 150 N, between the lower master valve 150 N and the upper master valve 150 6, between the upper master valve 150 6 and the swab valve 150 5, between the upper master valve 150 6 and the frac tree 170, between the frac tree 170 and the swab valve 150 5, or any combination thereof.

[0036]

An equalization valve 160 5 is in fluid communication with inlet and outlet sides of the swab valve 150 5. A pressure sensor such as, for example, the pressure sensor 165 5 is in fluid communication with the inlet side of the swab valve 150 5. A pressure sensor 165 6 is in fluid communication with the outlet side of the swab valve 150 5. Similarly, an equalization valve 160 6 is in fluid communication with inlet and outlet sides of the upper master valve 150 6. A pressure sensor such as, for example, the pressure sensor 165 6 is in fluid communication with the inlet side of the upper master valve 150 6. A pressure sensor 165 7 is in fluid communication with the outlet side of the upper master valve 150 6. Similarly, an equalization valve 160 N is in fluid communication with inlet and outlet sides of the lower master valve 150 N. A pressure sensor such as, for example, the pressure sensor 165 7 is in fluid communication with the inlet side of the lower master valve 150 N. A pressure sensor 165 N is in fluid communication with the outlet side of the lower master valve 150 N.

[0037]

In one or more embodiments, one or more of the pressure sensors 165 1-N includes a bladder or other mechanical buffer to protect the pressure sensor(s) 165 1-N from erosions/washout and/or to prevent the pressure sensor(s) 165 1-N from plugging off and trapping pressure; in such embodiments, the bladder of other mechanical buffer prevents, or at least reduces, inaccurate readings of line pressure by the pressure sensor(s) 165 1-N due to sand or grease plugging process port(s) of the pressure sensor(s) 165 1-N.

[0038]

In one or more embodiments, one or more of the equalization valves 160 1-N is designed to be resistant to washout and/or abrasive damage to the valve member(s) 215 1-N (shown in FIG. 4); accordingly, the equalization valves 160 1-N may incorporate internal materials such as, for example, Stellite, engineered ceramic, Zirconia, or the like to enhance durability and resistance to washout/erosion and to prevent, or at least reduce, sealing issues.

[0039]

Although the terms “inlet” and “outlet” used herein may imply a direction of fluid flow from the zipper manifold 145 to the zipper module 135 1, from the zipper module 135 1 to the frac line 140 1, from the frac line 140 1 to the wellhead 120 1, and/or from the wellhead 120 1 to the wellbore 125 1, it should be understood that, depending on relative fluid pressures within the system 100, fluid may instead flow in the opposite direction, that is, from the wellbore 125 1 to the wellhead 120 1, from the wellhead 120 1 to the frac line 140 1, from the frac line 140 1 to the zipper module 135 1, and/or from the zipper module to the zipper manifold 145. Accordingly, the term “inlet” may refer to an “outlet” and the term “outlet” may refer to an “inlet.”

[0040]

The controller 180 is operably coupled to, and adapted to control, the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, and the equalization valve 160 N, as will be described in more detail below. Further, the controller 180 is operably coupled to, and adapted to monitor, one or more of the pressure sensors 165 1-N, that is, the controller 180 is adapted to receive signal(s) from one or more of the pressure sensors 165 1-N, as will be described in more detail below. Further still, the controller 180 is operably coupled to, and adapted to control, the one or more other wellhead tools or components 175, as will be described in further detail below. The user interface 185 is operably coupled to the controller 180 to enable a user to monitor and control the zipper module 135 1, the frac line 140 1, and the wellhead 120 1, as will be described in more detail below.

[0041]

Referring to FIG. 3, with continuing reference to FIG. 2, the lower zipper valve 150 1 is diagrammatically illustrated in detail. In one or more embodiments, the lower zipper valve 150 1 includes a valve body 190 1 and a valve member 195 1. The valve member 195 1 extends within the valve body 190 1 and is actuable between an open configuration and a closed configuration. In the open configuration, the valve member 195 1 permits fluid flow through the valve body 190 1 from a high-pressure side (i.e., one of the inlet side or the outlet side of the of the lower zipper valve 150 1) to a low-pressure side (i.e., the other of the inlet side or the outlet side of the of the lower zipper valve 150 1) of the lower zipper valve 150 1, as shown in FIG. 3. In the closed configuration, the valve member 195 1 prevents, or at least partially restricts, fluid flow through the valve body 190 1 from the high-pressure side to the low-pressure side of the lower zipper valve 150 1. An actuator 200 1 is operably coupled to the valve member 195 1 to actuate the valve member 195 1 within the valve body 190 1 between the open configuration and the closed configuration. The controller 180 is operably coupled to, and adapted to control, the actuator 200 1. In addition to, or instead of, the actuator 200 1 being controlled by the controller 180, the actuator 200 1 may be or include a manual actuator that is manually controllable/actuable by an operator (e.g., via hydraulic, electric over hydraulic, or other mechanisms). A position sensor 205 1 is operably coupled to the actuator 200 1 to detect a position and/or an orientation of the valve member 195 1 relative to the valve body 190 1. In addition, or instead, the position sensor 205 1 may be operably coupled to the valve member 195 1 and/or the valve body 190 1. The controller 180 is operably coupled to, and adapted to monitor, the position sensor 205 1, that is, the controller 180 is adapted to receive signal(s) from the position sensor 205 1. In one or more embodiments, the feedback provided by the position sensor 205 1 is analog (i.e., continuous 0% to 100% open). In addition, or instead, the position sensor 205 1 may be or include a switch (e.g., having minimum resolutions of 0%, 50%, and 100% open).

[0042]

In one or more embodiments, the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N are substantially similar to, and operate in substantially the same manner as, the lower zipper valve 150 1; therefore, the structure and operation of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N will not be described in more detail. Moreover, the various

components of each of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the lower zipper valve 150 1 (as set forth above and shown in FIG. 3), except that, rather than the subscript "1" used to identify the components of the lower zipper valve 150 1, subscripts "2", "3", "4", "5", "6", and "N" are used to identify the corresponding components of the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N, respectively.

[0043]

Referring to FIG. 4, with continuing reference to FIG. 2, the equalization valve 160 1 is diagrammatically illustrated in detail. As discussed above, the equalization valve 160 1 is in fluid communication with the inlet and outlet sides of the lower zipper valve 150 1. In one or more embodiments, the equalization valve 160 1 includes a valve body 210 1 and a valve member 215 1. The valve member 215 1 extends within the valve body 210 1 and is actuable between an open configuration and a closed configuration. In the open configuration, the valve member 215 1 permits fluid flow through the valve body 210 1 from a high-pressure side (i.e., one of the inlet side or the outlet side of the of the lower zipper valve 150 1) to a low-pressure side (i.e., the other of the inlet side or the outlet side of the lower zipper valve 150 1) of the lower zipper valve 150 1, as shown in FIG. 4. In the closed configuration, the valve member 215 1 prevents, or at least partially restricts, fluid flow through the valve body 210 1 from the high-pressure side to the low-pressure side of the lower zipper valve 150 1. An actuator 220 1 is operably coupled to the valve member 215 1 to actuate the valve member 215 1 within the valve body 210 1 between the open configuration and the closed configuration. The controller 180 is operably coupled to, and adapted to control, the actuator 220 1. In addition to, or instead of, the actuator 220 1 being controlled by the controller 180, the actuator 220 1 may be or include a manual actuator that is manually controllable/actuable by an operator (e.g., via hydraulic, electric over hydraulic, or other mechanisms). A position sensor 225 1 is operably coupled to the actuator 220 1 to detect a position and/or an orientation of the valve member 215 1 relative to the valve body 210 1. In addition, or instead, the position sensor 225 1 may be operably coupled to the valve member 215 1 and/or the valve body 210 1. The controller 180 is operably coupled to, and adapted to monitor, the position sensor 225 1, that is, the controller 180 is adapted to receive signal(s) from the position sensor 225 1. In one or more embodiments, the feedback provided by the position sensor 225 1 is analog (i.e., continuous 0% to 100% open). In addition, or instead, the position sensor 225 1 may be or include a switch (e.g., having minimum resolutions of 0%, 50%, and 100% open).

[0044]

In one or more embodiments, the equalization valves 160 2-N are substantially similar to, and operate in substantially the same manner as, the equalization valve 160 1; therefore, the structure and operation of the equalization valves 160 2-N will not be described in more detail. Moreover, the various components of each of the equalization valves 160 2-N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the equalization valve 160 1 (as set forth above and shown in FIG. 4), except that, rather than the subscript "1" used to identify the components of the equalization valve 160 1, subscripts "2", "3", "4", "5", "6", and "N" are used to identify the corresponding components of the equalization valves 160 2-N, respectively.

[0045]
Referring to FIG. 5, with continuing reference to FIGS. 2-4, a hydraulic manifold 230 operably associated with the actuators 200 1-N and 220 1-N is illustrated in detail. More particularly, the hydraulic manifold 230 is operably coupled to the actuators 200 1-N of the valves 150 1-N, respectively, and to the actuators 220 1-N of the equalization valves 160 1-N, respectively. The hydraulic manifold 230 facilitates actuation of the actuators 200 1-N and 220 1-N. A hydraulic power unit (or "HPU") 235 is operably coupled to the hydraulic manifold 230 and adapted to provide hydraulic fluid to, and to receive hydraulic fluid from, the hydraulic manifold 230. In one or more embodiments, to facilitate the communication of hydraulic fluid between the HPU 235 and the hydraulic manifold 230, the HPU 235 includes a reservoir, a hydraulic pump, and a motor. The controller 180 is operably coupled to, and adapted to control, the hydraulic manifold 230. Specifically, the controller 180 is adapted to actuate, via the hydraulic manifold 230, one or more of the actuators 200 1-N and/or 220 1-N based at least partially on data/readings received from the pressure sensors 165 1-N, the position sensors 205 1-N, and/or the position sensors 225 1-N, as will be described in more detail below. The user interface 185 is operably coupled to the controller 180 and enables a user to modify one or more parameters associated with the controller 180's actuation of the one or more of the actuators 200 1-N and/or 220 1-N via the hydraulic manifold 230. In one or more embodiments, the user interface 185 enables a user to take manual control of the controller 180's actuation of the one or more of the actuators 200 1-N and/or 220 1-N. In one or more embodiments, the controller 180 may also be operably coupled to, and adapted to control, the HPU 235.
[0046]
In one or more embodiments, the system 100 is used to perform a hydraulic fracturing operation. Prior to said hydraulic fracturing operation: the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be open; the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, and the frac line valve 150 4 may be closed; and pressure from the wellbore 125 1 may be exerted on the frac line valve 150 4. In such instances, before initiating the hydraulic fracturing operation, the wellbore pressure exerted on the frac line valve 150 4 must be equalized with a pressure of the pumped hydraulic fracturing fluid, that is, the pressure of the hydraulic fracturing fluid pumped into the manifold assembly 105 by the pumps 115 a-f (shown in FIG. 1).
[0047]
Referring to FIG. 6, a method of equalizing the wellbore pressure exerted on the frac line valve 150 4 with the pressure of the pumped hydraulic fracturing fluid is generally referred to by the reference numeral 240 and includes: at a step 245, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 4 and 165 5 is below a first predetermined threshold; if said difference is above the first predetermined threshold, at a step 250, opening the equalization valve 160 4 until said difference is below the first predetermined threshold; if said difference is below the first predetermined threshold, at a step 255, opening the frac line valve 150 4; at a step 260, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 3 and 165 4 is below a second predetermined threshold; if said difference is above the second predetermined threshold, at a step 265, opening the equalization valve 160 3 until said difference is below the second predetermined threshold; if said difference is below the second predetermined threshold, at a step 270, opening the frac line valve 150 3; at a step 275, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 2 and 165 3 is below a third predetermined threshold;

if said difference is above the third predetermined threshold, at a step 280, opening the equalization valve 160 2 until said difference is below the third predetermined threshold; if said difference is below the third predetermined threshold, at a step 285, opening the upper zipper valve 150 2; at a step 290, determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 1 and 165 2 is below a fourth predetermined threshold; if said difference is above the fourth predetermined threshold, at a step 295, opening the equalization valve 160 1 until said difference is below the fourth predetermined threshold; and, if said difference is below the fourth predetermined threshold, at a step 300, opening the lower zipper valve 150 1.

[0048]

In one or more embodiments of the method 240, at least one of the first, second, third, and fourth predetermined thresholds is substantially identical to at least one other of the first, second, third, and fourth thresholds. In other embodiments of the method 240, at least one of the first, second, third, and fourth predetermined thresholds is different from at least one other of the first, second, third, and fourth predetermined thresholds. In one or more embodiments, the first, second, third, and/or fourth thresholds is/are user defined.

[0049]

In one or more embodiments, the step(s) 245, 260, 275, and/or 290 may be referred to as "intelligent lockout" steps that disallow a requested actuation of the corresponding valve(s) 160 1-4 due to excessive differential pressure(s) thereacross, as measured by corresponding pair(s) of the pressure sensors 165 1-5. In addition to, or instead of, performing the "intelligent lockout" steps of the method 240, the system 100 may include one or more mechanical interlocks designed to utilize fluid pressure from the inlet and outlet sides of a particular to-be-actuated valve 160 1, 2, 3, or 4 to block hydraulic flow (i.e., preventing said 160 1, 2, 3, or 4 valve from opening) unless the pressure differential between said inlet and outlet sides is balanced.

[0050]

In one or more embodiments, the step(s) 245, 260, 275, and/or 290 may be implemented via software stored on the controller 180 (or elsewhere) so that, when an operator desires to open one or more of the valves 160 1-4, the software only allows such opening of the valve(s) 160 1-4 if the differential pressure(s) across the valve(s) 160 1-4 are less than the corresponding predetermined threshold(s) (i.e., the first, second, third, and/or fourth thresholds). In addition, or instead, such software may include combinational logic requiring various other condition(s) to be met prior to actuation of a particular to-be-actuated valve 160 1, 2, 3, or 4, such as, for example: the pressure in the wellbore 125 1-N with which the to-be-actuated valve 160 1, 2, 3, or 4 is associated must be below a predetermined threshold, above a predetermined threshold, or within a predetermined range; the pressure in one or more of the other wellbores 125 1-N in the system 100 must be below a predetermined threshold, above a predetermined threshold, or within a predetermined range; the state of the to-be-actuated valve 160 1, 2, 3, or 4 must be open, closed, or transitioning; the state(s) of the one or more other valves 160 1, 2, 3, or 4 in the system 100 must be open, closed, or transitioning (e.g., the other valve(s) 160 1, 2, 3, or 4 must be opened/closed/transitioning prior to actuation of the to-be-actuated valve 160 1, 2, 3, or 4); one or more other conditions must be met; or any combination thereof.

[0051]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 260, step 270, step 275, step 285, step 290, and step 300.

[0052]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 260, step 270, step 290, step 300, step 275, and step 285.
[0053]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 275, step 285, step 260, step 270, step 290, and step 300.
[0054]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 275, step 285, step 290, step 300, step 260, and step 270.
[0055]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 290, step 300, step 260, step 270, step 275, and step 285.
[0056]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 245, step 255, step 290, step 300, step 275, step 285, step 260, and step 270.
[0057]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 245, step 255, step 275, step 285, step 290, and step 300.
[0058]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 245, step 255, step 290, step 300, step 275, and step 285.
[0059]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 275, step 285, step 245, step 255, step 290, and step 300.
[0060]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 275, step 285, step 290, step 300, step 245, and step 255.
[0061]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 290, step 300, step 245, step 255, step 275, and step 285.
[0062]
In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 260, step 270, step 290, step 300, step 275, step 285, step 245, and step 255.
[0063]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 245, step 255, step 260, step 270, step 290, and step 300.

[0064]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 245, step 255, step 290, step 300, step 260, and step 270.

[0065]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 260, step 270, step 245, step 255, step 290, and step 300.

[0066]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 260, step 270, step 290, step 300, step 245, and step 255.

[0067]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 290, step 300, step 245, step 255, step 260, and step 270.

[0068]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 275, step 285, step 290, step 300, step 260, step 270, step 245, and step 255.

[0069]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 245, step 255, step 260, step 270, step 275, and step 285.

[0070]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 245, step 255, step 275, step 285, step 260, and step 270.

[0071]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 260, step 270, step 245, step 255, step 275, and step 285.

[0072]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 260, step 270, step 275, step 285, step 245, and step 255.

[0073]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 275, step 285, step 245, step 255, step 260, and step 270.

[0074]

In one or more embodiments, certain steps of the method 240 are performed in the following sequential order: step 290, step 300, step 275, step 285, step 260, step 270, step 245, and step 255.

[0075]

In one or more embodiments, prior to said hydraulic fracturing operation: the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, the frac line valve 150 4, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N may be closed; and pressure from the wellbore 125 1 may be exerted on the lower master valve 150 N. In such instances, in addition to the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and 300, the method 240 may further include: an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 7 and 165 N is below a fifth predetermined threshold; if said difference is above the fifth predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 N until said difference is below the fifth predetermined threshold; if said difference is below the first predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the lower master valve 150 N; an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 6 and 165 7 is below a sixth predetermined threshold; if said difference is above the sixth predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 6 until said difference is below the sixth predetermined threshold; if said difference is below the sixth predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the upper master valve 150 6; an additional step (substantially similar to the steps 245, 260, 275, and 290) of determining, using the controller 180, if a difference between the pressures detected by pressure sensors 165 5 and 165 6 is below a seventh predetermined threshold; if said difference is above the seventh predetermined threshold, an additional step (substantially similar to the steps 250, 265, 280, and 295) of opening the equalization valve 160 5 until said difference is below the seventh predetermined threshold; and if said difference is below the seventh predetermined threshold, an additional step (substantially similar to the steps 255, 270, 285, and 300) of opening the swab valve 150 5. Similar to the sequential order in which the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and 300 may be performed, the above-described additional steps of the method 240 may be performed in any sequential order before, during, or after the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, and/or 300 are performed.

[0076]

In one or more embodiments of the method 240, at least one of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds is substantially identical to at least one other of the first, second, third, fourth, fifth, sixth, and seventh thresholds. In other embodiments of the method 240, at least one of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds is different from at least one other of the first, second, third, fourth, fifth, sixth, and seventh predetermined thresholds. In one or more embodiments, the first, second, third, fourth, fifth, sixth, and/or seventh thresholds is/are user defined.

[0077]

In various embodiments of the method 240, prior to said hydraulic fracturing operation, each of the lower zipper valve 150 1, the upper zipper valve 150 2, the frac line valve 150 3, the frac line

valve 150 4, the swab valve 150 5, the upper master valve 150 6, and/or the lower master valve 150 N may be open, closed, or transitioning; accordingly, one or more of the steps 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, and/or one or more of the other above-described steps of the method 240 may be omitted as needed so that execution of the method 240 equalizes the wellbore pressure(s) with the pressure of the pumped hydraulic fracturing fluid.

[0078]

In one or more embodiments, the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N are substantially similar to, and operate in substantially the same manner as, the zipper module 135 1, the frac line 140 1, and the wellhead 120 1; therefore, the structure and operation of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N will not be described in more detail. Moreover, the various components of each of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N may be identified hereinbelow using the same reference numerals as those associated with corresponding components of the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 (as set forth above and shown in FIGS. 2-4).

[0079]

In one or more embodiments, the controller 180 is operably coupled to, and adapted to control, various components of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N(i.e., the frac legs 146 2-N) in a substantially similar manner as the manner in which the controller 180 is operably coupled to the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, and the equalization valve 160 N. As a result, in addition to monitoring and controlling the zipper module 135 1, the frac line 140 1, and the wellhead 120 1 (i.e., the frac leg 146 1), the user interface 185 enables a user to monitor and control the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N(i.e., the frac legs 146 2-N). Alternatively, one or more other controllers substantially similar to the controller 180 may be operably coupled to, and adapted to control, the various components of the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N. In such instances, the user interface 185 or one or more other user interfaces substantially similar to the user interface 185 may be operably coupled to the one or more other controllers to enable a user to monitor and control the zipper modules 135 2-N, the frac lines 140 2-N, and the wellheads 120 2-N.

[0080]

In one or more embodiments, the operation of the system 100 and/or the execution of the method 240 allows an operator to remotely control one or more of the valves 150 1-2 of the zipper modules 135 1-N, one or more of the valves 150 3-4 of the frac lines 140 1-N, and/or one or more of the valves 150 5-7 of the wellheads 120 1-N to conduct various wellbore operations on each of the wellbores 125 1-N. As a result, the operation of the system 100 and/or the execution of the method 240 eliminates the need for personnel to enter the “red zone” (i.e., a predetermined area in the vicinity of the valve(s) 150 1-N deemed to be hazardous, unsafe, or less safe) in order to actuate the valve(s) 150 1-N. As described above, during such remote control of the valve(s) 150 1-N, the corresponding position sensor(s) 205 1-N send signal(s) to the controller 180 so that the controller can verify that the valve(s) 150 1-N are in the correct state to perform the desired wellbore operation (e.g., to hydraulically fracture one or more of the wellbores 125 1-N, to perform wireline operations, to grease the valve(s) 150 1-N, to perform “flow back” on one or

more of the wellbores 125 1-N, to perform coiled tubing operations, to perform another operation, or any combination thereof). In one or more embodiments, the operation of the system 100 and/or the execution of the method 240 provides feedback to an operator so that the operator can identify leaks in the zipper manifold 145, the zipper modules 135 1-N, the frac lines 140 1-N, the wellheads 120 1-N, or elsewhere in the system 100 by monitoring the pressure sensor(s) 165 1-N and/or the position sensor(s) 205 1-N and/or 225 1-N.

[0081]

Referring to FIGS. 7A-7C, in one or more embodiments, the one or more other wellhead tools or components 175 introduced in connection with FIG. 2 include a valve 301 a, a latch 301 b, a launcher 301 c, and a lubricator 301 d. For example, the one or more other wellhead tools or components 175 may be, include, or be part of the system described in the '156 application. The valve 301 a is operably coupled to the wellhead 120 1, which wellhead 120 1 is the surface termination of the wellbore 125 1. In one or more embodiments, the valve 301 a is, includes, or is part of the valve apparatus described in the '785 application, the '203 application, or both. The valve 301 a is controlled by the controller 180. As discussed above, the user interface 185 communicates signals to, and receives signals from, the controller 180. The latch 301 b is operably coupled to the valve 301 a, opposite the wellhead 120 1. The launcher 301 c is operably coupled to the latch 301 b, opposite the valve 301 a. In one or more embodiments, the launcher 301 c is, includes, or is part of the launcher described in the '156 application. Although not shown in FIG. 1, in one or more embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 301 c, opposite the latch 301 b.

[0082]

The lubricator 301 d is extendable through the launcher 301 c (and the BOP attached thereto in certain embodiments) and, when so extended, attachable to the latch 301 b. More particularly, the controller 180 communicates signals to a hydraulic manifold, which signals cause the hydraulic manifold to communicate hydraulic fluid to, and/or receive hydraulic fluid from, the latch 301 b to thereby operate the latch 301 b. Subsequently, the lubricator 301 d is detachable from the latch 301 b in a similar manner and, when so detached, retractable from the launcher 301 c. In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of attaching/detaching the lubricator 301 d to/from the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0083]

Referring to FIG. 8, with continuing reference to FIGS. 7A-7C, in one or more embodiments, a method is generally referred to by the reference numeral 302. In one or more embodiments, the method 302 is executed using the one or more other wellhead tools or components 175. In at least one such instance, the launcher 301 c is connected to the latch 301 b. Although not shown in FIGS. 7A-7C, in one or more embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 301 c, opposite the latch 301 b. The method 302 includes, at a step 303 a, extending the lubricator 301 d through a central passageway of the launcher 301 c. More particularly, the lubricator 301 d is displaced in a direction 304 a (as shown in FIG. 7A), through the central passageway of the launcher 301 c (and the BOP attached thereto in certain embodiments), and into a central passageway of the latch 301 b (as shown in FIG. 7B). At a step 303 b, the lubricator 301 d is attached to the latch 301 b. In one or more embodiments, the step 303 b is executed after the step 303 a, and while the lubricator 301 d extends through the central passageway of the launcher 301 c. More particularly, the step 303 b is executable when the lubricator 301 d extends through the central passageway of the launcher and into the central

passageway of the latch 301 b (as shown in FIG. 7B). In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of attaching the lubricator 301 d to the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0084]

At a step 303 c, a first wellbore operation (e.g., a perforating operation such as, for example, a ball and sleeve operation) is performed while the lubricator 301 d is attached to the latch 301 b. In one or more embodiments, the step 303 c is executable by deploying a downhole tool (not shown; e.g., a plug and perforating guns) from the lubricator 301 d on a conveyance string (e.g., wireline) while the lubricator 301 d is attached to the latch 301 b. More particularly, the downhole tool passes through the central passageway of the latch 301 b, through a central passageway of the valve 301 a, through a central passageway of the wellhead 120 1, and into the wellbore 125 1. In one or more embodiments, the valve 301 a and the process of passing the downhole tool through the valve 301 a and into the wellbore 125 1 are described in the '785 application, the '203 application, or both.

[0085]

For example, the controller 180 may receive a signal from a sensor indicating that the valve 301 a is open, thereby determining that wireline is in the wellbore 125 1. After the controller 180 receives such a signal, the controller 180 may then "lock-out" actuation of one or more of the valves 150 1-N(e.g., the valves 150 5-N of the wellhead 120 1) until the controller 180 receives another signal (or ceases to receive the original signal) from the sensor indicating that the valve 301 a is closed, thereby determining that the wireline is out of the wellbore 125 1. Such a process helps to prevent users from inadvertently cutting the wireline via actuation of one or more of the valves 150 1-N, which is a common failure. A manual override of this process may be utilized just in case a user needs to intentionally cut the wireline for emergency purposes.

[0086]

In those embodiments in which the downhole tool includes the plug and perforating guns, the plug is set, the perforating guns are fired, and the spent perforating guns are retrieved from the wellbore 125 1 and back into the lubricator 301 d to complete execution of the step 303 c. At a step 303 d, the lubricator 301 d is detached from the latch 301 b. In one or more embodiments, the step 303 d is executed after the first wellbore operation is performed at the step 303 c (e.g., after the spent perforating guns are retrieved from the wellbore 125 1 and back into the lubricator 301 d). In one or more embodiments, the latch 301 b, the lubricator 301 d, and the process of detaching the lubricator 301 d from the latch 301 b are described in the '623 application, the '741 application, or a combination thereof.

[0087]

At a step 303 e, the lubricator 301 d is retracted from the central passageway of the launcher 301 c. In one or more embodiments, the step 303 e is executed after the step 303 d. More particularly, the lubricator 301 d is displaced in a direction 304 b (as shown in FIG. 7C) to execute the step 303 e. At a step 303 f, an object is launched from the launcher 301 c so that the object enters the wellbore 125 1. In one or more embodiments, the step 303 f is executed after the step 303 e. The execution of the step 303 f causes the object to pass through the valve 301 a before entering the wellbore 125 1. In one or more embodiments, the valve 301 a and the process of passing the object therethrough is described in the '785 application, the '203 application, or both. Finally, at a step 303 g, a second wellbore operation (e.g., a hydraulic fracturing operation) is performed. In one or more embodiments, the step 303 g is executed after the step 303 f. In those embodiments in which the second wellbore operation is a hydraulic fracturing operation, a hydraulic fracturing

fluid is pumped into the wellbore 125 1 via the frac leg 146 1 to facilitate execution of the step 303 g.

[0088]

Referring to FIG. 9, with continuing reference to FIGS. 1 and 2, in one or more embodiments, the grease system 305 is used to deliver and meter grease to process valves 310 1-N used in oil and gas operations. For example, the process valves 310 1-N to which the grease system 305 delivers and meters grease may be, include, or be part of the lower zipper valve 150 1, the equalization valve 160 1, the upper zipper valve 150 2, the equalization valve 160 2, the frac line valve 150 3, the equalization valve 160 3, the frac line valve 150 4, the equalization valve 160 4, the swab valve 150 5, the equalization valve 160 5, the upper master valve 150 6, the equalization valve 160 6, the lower master valve 150 N, the equalization valve 160 N, or any combination thereof. As discussed above, the grease system 305 includes the delivery module 315 and the metering modules 320 1-N. The metering modules 320 1-N are each operably associated with, and adapted to be in communication with, the delivery module 315. Likewise, the process valves 310 1-N are operably associated with, and adapted to be in communication with, the metering modules 320 1-N, respectively. In operation, to grease the process valves 310 1-N, the metering modules 320 1-N are adapted to force grease from the delivery module 315 into the respective process valves 310 1-N.

[0089]

Referring to FIG. 10 with continuing reference to FIG. 9, in one or more embodiments, the delivery module 315 includes a fluid power source 325 and a grease container 330. The fluid power source 325 stores a power fluid for forcing grease from the grease container 330 into the process valves 310 1-N, as will be described in more detail below. A fluid transport device 335 is operably associated with the fluid power source 325. The fluid transport device 335 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 335 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 335 is adapted to transport the power fluid from the fluid power source 325 to the metering modules 320 1-N. A pressure sensor 340 is operably associated with the fluid transport device 335. The pressure sensor 340 is adapted to detect the pressure of the power fluid discharged from the fluid transport device 335. In addition to providing the power fluid transported to the metering modules 320 1-N, the fluid power source 325 is also adapted to receive recycled power fluid from the metering modules 320 1-N.

[0090]

The grease container 330 stores grease. A grease measuring device 345 such as, for example, a load cell (e.g., a scale) is operably associated with the grease container 330. The grease measuring device 345 may be adapted to measure a mass of the grease container 330 to keep track of the amount of grease that has been used and how much is remaining. However, although described herein as a load cell, the grease measuring device 345 may be any suitable device capable of monitoring the amount of grease in the grease container 330 such as, for example, a ranging device, a linear position transducer, an optical/laser device, or the like that measures a level of the grease within the grease container 330. A fluid transport device 350 is operably associated with the grease container 330. The fluid transport device 350 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 350 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 350 is adapted to transport grease from the grease container 330 to the metering modules 320 1-N. A pressure sensor 355 is operably associated with the fluid

transport device 350. The pressure sensor 355 is adapted to detect the pressure of the grease discharged from the fluid transport device 350. In addition to providing the grease transported to the metering modules 320 1-N, the grease container 330 is also adapted to receive recycled grease from the metering modules 320 1-N. To this end, a return valve 360 is operably associated with the grease container 330 and adapted to selectively permit communication of the recycled grease from the metering modules 320 1-N to the grease container 330.

[0091]

In one or more embodiments, as in FIG. 10, the grease system 305 also includes the controller 180. The controller 180 is adapted to send control signals to the fluid transport devices 335 and 350 and the return valve 360. In addition, the controller 180 may receive operating speed data from the fluid transport devices 335 and 350 and/or valve position data from the return valve 360. The controller 180 is also adapted to receive data/readings from the pressure sensors 340 and 355 (e.g., pressure data) and the grease measuring device 345 (e.g., grease measurement data).

[0092]

In one or more embodiments, the metering modules 320 1-N are substantially identical to each other and, therefore, in connection with FIG. 11, only the metering module 320 1 will be described in detail below; however, the description below also applies to the metering modules 320 2-N. Referring to FIG. 11, with continuing reference to FIGS. 9 and 10, in one or more embodiments, to meter the amount of grease to a particular one of the process valves 310 1, the metering module 320 1 includes a grease metering device 365 such as, for example, a grease pump. In one or more embodiments, as in FIG. 11, the grease metering device 365 includes a piston 370, a power cylinder 375, and a grease cylinder 380.

[0093]

The piston 370 includes a head portion 385 and a rod portion 390. The head portion 385 is slidably disposed in the power cylinder 375 and divides the power cylinder 375 into chambers 395 and 400. The rod portion 390 extends from the head portion 385 into the grease cylinder 380 so that, as the head portion 385 travels back and forth in the power cylinder 375, the rod portion 390 extends at least partially into, and retracts at least partially out of, the grease cylinder 380. The piston 370 may be displaced within the power cylinder 375 via hydraulic or pneumatic power; thus, in one or more embodiments, the power fluid stored by the fluid power source 325 is hydraulic or pneumatic. In addition, or instead, electric or gas power may be utilized to displace the piston 370.

[0094]

In one or more embodiments, as in FIG. 11, a control valve 405 is operably associated with the power cylinder 375. The control valve 405 is adapted to receive the power fluid from the fluid transport device 335. To stroke the piston 370 in a direction 410, the control valve 405 is adapted to communicate power fluid from the fluid transport device 335 to the chamber 395 and, at the same time, to communicate power fluid from the chamber 400 back to the fluid power source 325. Similarly, to stroke the piston 370 in a direction 415, which is opposite the direction 410, the control valve 405 is adapted to communicate power fluid from the fluid transport device 335 to the chamber 400 and, at the same time, to communicate power fluid received from the chamber 395 back to the fluid power source 325. In addition, the pressure of the grease within the grease cylinder 380 forces the piston 370 in the direction 415. In one or more embodiments, the force exerted on the piston 370 by the grease within the grease cylinder 380 is sufficient by itself to stroke the piston 370 in the direction 415. Accordingly, to ensure that the grease cylinder

380 is filled with grease before being stroked in the direction 410, the force exerted on the piston 370 by the grease within the grease cylinder 380 may itself be relied on to stroke the piston 370 in the direction 415. In one or more embodiments, the fluid power source 325, the fluid transport device 335, the pressure sensor 340, the power cylinder 375, the control valve 405, or any combination thereof, may collectively be referred to herein as an "actuator" (i.e., hydraulic- or pneumatic-powered) for stroking the piston 370 back and forth within the grease cylinder 380. However, in addition, or instead, another "actuator" may also be used to stroke the piston 370 back and forth within the grease cylinder 380 such as, for example, an electric- or gas-powered actuator.

[0095]

A cycle counter 420 is operably associated with the power cylinder 375. The cycle counter 420 may be or include limit switch(es) or other sensor(s) operably associated with the actuator to give analog or other linear position feedback. In any case, the cycle counter 420 is adapted to count the strokes of the piston 370 within the power cylinder 375. In one or more embodiments, the cycle counter 420 is capable of detecting partial strokes of the piston 370 to further enable precise greasing of the process valves 310 1. As a result, if so desired, the grease system 305 is capable of partially greasing the process valves 310 1 by allowing an operator to enter the "desired percentage" of grease required. In one or more embodiments, as in FIG. 11, the controller 180 is adapted to send control signals to the control valve 405. In addition, the controller 180 may receive valve position data from the control valve 405. The controller 180 is also adapted to receive data/readings (e.g., stroke count data) from the cycle counter 420.

[0096]

A check valve 425 is operably associated with an inlet 426 of the grease cylinder 380 and is adapted to communicate grease from the fluid transport device 350 to the grease cylinder 380 while preventing, or at least reducing, any backflow of the grease through the check valve 425. As a result, when the piston 370 is stroked in the direction 415, the rod portion 390 is retracted at least partially out of the grease cylinder 380 and the check valve 425 permits grease to be drawn into the grease cylinder 380 via the inlet 426. At the same time, a check valve 430 prevents grease from being drawn into the grease cylinder 380 via an outlet 431. The check valve 430 is operably associated with the outlet 431 of the grease cylinder 380 and is adapted to communicate grease from the grease cylinder 380 to the process valves 310 1 while preventing, or at least reducing, any backflow of the grease through the check valve 430. As a result, when the piston 370 is stroked in the direction 410, the rod portion 390 is extended at least partially into the grease cylinder 380 and the check valve 430 permits grease to be forced out of the grease cylinder 380 via the outlet 431. At the same time, the check valve 425 prevents grease from being forced out of the grease cylinder 380 via the inlet 426. In one or more embodiments, the check valve 430 is biased to the closed position with more force (e.g., tighter springs) than that of the check valve 425 in order to maintain the pressure of the grease within the grease cylinder 380. For example, springs in the check valve 430 can be tuned to a desired cracking pressure (e.g., about 1000 psi) to determine the pressure of the grease within the grease cylinder 380.

[0097]

In one or more embodiments, the grease metering device 365 is "double-acting" and includes a second grease cylinder substantially identical to the grease cylinder 380 and a second rod portion substantially identical to the rod portion 390; the second rod portion extends from the head portion 385 into the second grease cylinder so that, as the head portion 385 travels back and forth

in the power cylinder 375, the second rod portion extends at least partially into, and retracts at least partially out of, the second grease cylinder.

[0098]

Referring to FIG. 12 with continuing reference to FIGS. 9-11, in one or more embodiments, the process valves 310 1 are adapted to be in communication with the metering module 320 1 via lubricator valves 435 1-N, respectively. In one or more embodiments, the lubricator valves 435 1-N are part of the metering module 320 1. Similarly, the process valves 310 2-N may be adapted to be in communication with the metering modules 320 2-N, respectively, via lubricator valve(s) substantially identical to the lubricator valves 435 1-N. The lubricator valves 435 1-N are adapted to selectively communicate grease from the grease cylinder 380 (shown in FIG. 11) to respective ones of the process valves 310 1 (shown in FIG. 12). In one or more embodiments, as in FIG. 12, the controller 180 is adapted to send control signals to the lubricator valves 435 1-N. In addition, the controller 180 may receive valve position data from the lubricator valves 435 1-N.

[0099]

Alternatively, in one or more embodiments, the grease metering device 365 may be omitted and replaced with flow meters that are operably associated with respective ones of the process valves 310 1 (and thus respective ones of the lubricator valves 435 1-N; in such embodiments, the controller 180 receives feedback from the flow meters and actuates the lubricator valves 435 1-N to meter a desired amount of grease to the process valves 310 1 using the fluid transport device 350. In one or more embodiments, the grease system 305 further includes one or more pressure sensors located downstream from the check valve 430 (e.g., to monitor pressure within the process valves 310 1); as a result, using data/readings obtained from these one or more pressure sensors, the controller 180 can ensure that the greasing pressure is greater than the pressure within the process valves 310 1. Additional valves may also be added downstream from the check valve 430 to provide double barriers to prevent, or at least reduce, any leakage of process fluid from the process valve.

[0100]

Referring collectively to FIGS. 9-12, in operation, the fluid transport device 335 transports power fluid from the fluid power source 325 to the control valve 405 of the metering module 320 1. During the transporting of the power fluid to the control valve 405, the controller 180 communicates control signals to the fluid transport device 335 and receives data/readings from the pressure sensor 340. As a result, the controller 180 can adjust the flow of the power fluid to the control valve 405 using the fluid transport device 335 and monitor the pressure of the power fluid exiting the fluid transport device 335 using the pressure sensor 340. The control valve 405 actuates the piston 370 within the power cylinder 375. To actuate the piston 370 in the direction 410 within the power cylinder 375, the control valve 405 communicates power fluid from the 130 to the chamber 395 and, at the same time, communicates power fluid from the chamber 400 back to the fluid power source 325. Conversely, to actuate the piston 370 in the direction 415 within the power cylinder 375, the control valve 405 communicates power fluid from the fluid transport device 335 to the chamber 400 and, at the same time, communicates power fluid from the chamber 395 back to the fluid power source 325. During the actuation of the piston 370 within the power cylinder 375, the controller 180 communicates control signals to the control valve 405 and receives data/readings from the cycle counter 420. As a result, the controller 180 can stroke the piston 370 back and forth within the power cylinder 375 using the control valve 405 and count the strokes of the piston 370 back and forth within the power cylinder 375 using

the cycle counter 420. In other embodiments, in addition, or instead, electric or gas power may be utilized to actuate the piston 370.

[0101]

The fluid transport device 350 transports grease from the grease container 330 to the inlet 426 of the grease cylinder 380. During the transporting of the grease to the grease cylinder 380, the controller 180 communicates control signals to the fluid transport device 350 and receives data/readings from the pressure sensor 355. As a result, the controller 180 can adjust the flow of the grease to the grease cylinder 380 using the fluid transport device 350 and monitor the pressure of the grease exiting the fluid transport device 350 using the pressure sensor 355. As the piston 370 is actuated in the direction 415, the grease is drawn into the grease cylinder 380 through the inlet 426. The transporting of the grease to the grease cylinder 380 using the fluid transport device 350 allows the grease to be more efficiently and completely drawn into the grease cylinder 380 through the inlet 426 as the piston 370 is actuated in the direction 415. Conversely, as the piston 370 is actuated in the direction 410, the grease is forced out of the grease cylinder 380 through the outlet 431. The lubricator valves 435 1-N selectively communicate the grease forced out of the grease cylinder 380 to respective ones of the process valves 310 1. In addition, the return valve 360 selectively communicates the grease forced out of the grease cylinder 380 back to the grease container 330.

[0102]

The controller 180 communicates control signals to the return valve 360 and the lubricator valves 435 1-N. As a result, the controller 180 can selectively actuate the return valve 360 and the lubricator valves 435 1-N to determine: whether the grease forced out of the grease cylinder 380 is communicated back to the grease container 330; and/or which of the process valves 310 1 receives the grease forced out of the grease cylinder 380. For example, if the controller 180 closes the return valve 360, opens one of the lubricator valves 435 1-N, and closes the remaining lubricator valves 435 1-N, the grease forced out of the grease cylinder 380 will be communicated to the process valve 310 1 that is operably associated with the opened one of the lubricator valves 435 1-N. For another example, if the controller 180 opens the return valve 360 and closes the lubricator valves 435 1-N, the grease forced out of the grease cylinder 380 will be communicated back to the grease container 330. Alternatively, the return valve 360 could bypass the grease cylinder 380 by communicating grease back to the grease container 330 before the grease passes through the check valve 425.

[0103]

The volume of grease forced out of the grease cylinder 380 with each stroke of the piston 370 can be determined via measurement or calculation (e.g., by multiplying the cross-sectional area of the rod portion 390 by the length of the piston 370's stroke); as a result, by controlling and/or monitoring the control valve 405, the cycle counter 420, the lubricator valves 435 1-N, the return valve 360, or any combination thereof, the controller 180 meters a desired amount of grease to each of the process valves 310 1. In one or more embodiments, the desired amount of grease metered to each of the process valves 310 1 can be specifically tailored according to greasing volume and/or frequency guidelines provided, for example, by the manufacturer(s) of the process valves 310 1 and stored in a database accessible by the controller 180. In addition, or instead, the desired amount of grease metered to each of the process valves 310 1 may be provided by a user via a user interface (HMI) connected to the controller 180; if so desired, the amount of grease metered to each of the process valves 310 1 can be changed during a job. In addition, by controlling and/or monitoring the fluid transport devices 335 and 350 and the pressure sensors

340 and 355, the controller 180 regulates the flow of the power fluid and the grease within the grease system 305.

[0104]

In one or more embodiments, the controller 180 is further adapted to receive data/readings from a pressure sensor 436 (shown in FIG. 11) that detects the pressure of the grease within the grease cylinder 380; by comparing the data/reading obtained from the pressure sensor 436 with data/readings obtained from the pressure sensor 355, the controller 180 can determine whether the grease cylinder 380 is filled with grease after the piston 370 is stroked in the direction 415. As a result, the controller 180 can delay stroking the piston in the direction 410 until the grease cylinder 380 is completely filled with grease, thus improving the accuracy of greasing operations. In one or more embodiments, the controller 180 controls the metering modules 320 2-N to deliver and meter grease to the process valves 310 2-N in substantially the same manner as that described above with respect to the metering module 320 1 and the process valves 310 1; therefore, the operation of the metering modules 320 2-N to deliver and meter grease to the process valves 310 2-N will not be described in further detail. As a result, the controller 180 is capable of greasing the process valves 310 1-N at any of the following intervals: timed intervals; continuous greasing (at a rate specified by the user or the database); greasing on command from an operator via a user interface (HMI) at any time; per operational stage (e.g., fracturing stage); per N stages; scheduled greasing; scheduled partial greasing; and/or any combination thereof.

[0105]

In one or more embodiments, prior to delivering and metering grease to the process valves 310 1-N, the grease system 305 is capable of verifying that the process valves 310 1-N are actuated to the proper position for greasing. To achieve such verification, the grease system 305 includes sensor(s) (e.g., the position sensors 205 1 and 225 1 shown in FIGS. 3 and 4) associated with the process valves 310 1-N to ensure they are in the proper position prior to greasing. Such sensor(s) may include, for example, position sensor(s) and/or visual feedback devices (e.g., camera(s), image processing software, etc.) capable of detecting the position of the process valves 310 1-N. In addition, the grease system 305 may include actuator(s) adapted to receive control signals from the controller 180 to open or close the process valves 310 1-N. As a result, the controller 180 is able to automatically place the process valves 310 1-N in the proper greasing position prior to greasing.

[0106]

Referring to FIG. 13, in one or more embodiments, a method of operating the grease system 305 is generally referred to by the reference numeral 440. The method 440 is carried out by receiving, at the controller 180, data/readings from the delivery module 315 (e.g., the pressure sensors 340 and 355) and/or the metering modules 320 1-N (e.g., the cycle counter 420), and sending, from the controller 180, control signals to the delivery module 315 (e.g., the fluid transport devices 335 and 350, the return valve 360, or any combination thereof) and/or the metering modules 320 1-N(e.g., the control valve 405, the lubricator valves 435 1-N, or any combination thereof).

[0107]

The method 440 includes at a step 445 delivering grease to a first one of the metering modules 320 1-N. In one or more embodiments, the step 445 includes transporting the grease from the grease container 330 to the first one of the metering modules 320 1-N. At a step 450, the controller 180 controls the actuator of the first one of the metering modules 320 1-N so that a first amount of the delivered grease is metered to a first one of the process valves 310 1-N. In

one or more embodiments, the step 450 includes: controlling the actuator of the first one of the metering modules 320 1-N to start stroking the piston 370; determining how many strokes of the piston 370 are required to meter the first amount to the first one of the process valves 310 1-N; and controlling the actuator to stop stroking the piston 370 when the strokes counted by the cycle counter 420 equal the determined number of strokes required. In one or more embodiments of the step 450, the controller 180 determines the first amount by retrieving data relating to the first one of the process valves 310 1-N from a database.

[0108]

At a step 455, grease is delivered to a second one of the metering modules 320 1-N. In one or more embodiments, the step 455 includes transporting the grease from the grease container 330 to the second one of the metering modules 320 1-N. At a step 260, the controller 180 controls the actuator of the second one of the metering modules 320 1-N so that a second amount of the delivered grease is metered to a second one of the process valves 310 1-N. In one or more embodiments of the step 260, the controller 180 determines the second amount by retrieving data relating to the second one of the process valves 310 1-N from a database.

[0109]

In one or more embodiments, among other things, the operation of the grease system 305 and/or the execution of the method 440: ensures that an appropriate amount of grease is injected into each of the process valves 310 1-N while monitoring the amount of grease injected into each of the process valves 310 1-N; improves the flushing of debris and contaminants from the process valves 310 1-N; improves the performance of the process valves 310 1-N; decreases the risk that a less than adequate amount of grease is injected into the process valves 310 1-N; decreases the risk of malfunction and maintenance needs for the process valves 310 1-N; and/or reduces operators' exposure to oil and gas process units during operation.

[0110]

Referring to FIG. 14, with continuing reference to FIGS. 1-13, in an embodiment, the grease system 305 includes a sub-controller 465 and the frac legs 146 1-N include sub-controllers 470 1-N, respectively. A communication bus 475 connects the controller 180 to the sub-controllers 465 and 470 1-N. The controller 180 communicates with the sub-controllers 465 and 470 1-N via the communication bus 475 to coordinate operation of the grease system 305 and the frac legs 146 1-N, as will be described in further detail below.

[0111]

Referring to FIG. 15, with continuing reference to FIG. 14, in an embodiment, the sub-controller 470 1 is part of (or otherwise associated with) the valve 301 a to thereby control operation of the valve 301 a, the latch 301 b, and the launcher 301 d. The wellhead 120 1 includes a flow block 480 operably coupled between, and in fluid communication with, the upper master valve 150 6 and the lower master valve 150 7. Wing valves 485 aa and 485 ab are connected to the flow block 480. Likewise, wing valves 485 ba and 485 bb are also connected to the flow block 480, opposite the wing valves 485 aa and 485 ab. As a result, in addition to being operably coupled between, and in fluid communication with, the upper master valve 150 6 and the lower master valve 150 7, the flow block 480 is operably coupled between, and in fluid communication with, the wing valves 480 aa and 480 ba. As discussed above in connection with FIGS. 2, 3, and 5, the controller 180 is operably coupled to, and adapted to control actuation of, the lower zipper valve 150 1, the upper zipper valve 150 2, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N. Likewise, the controller 180 is operably coupled to, and adapted to control actuation of, the wing valves 185 aa, 185 ab, 185 ba, and 185 bb. The manner in which

the controller 180 controls actuation of the wing valves 185 aa, 185 ab, 185 ba, and 185 bb is similar to the manner in which the controller 180 controls actuation of the lower zipper valve 150 1, the upper zipper valve 150 2, the swab valve 150 5, the upper master valve 150 6, and the lower master valve 150 N, as discussed above in connection with FIGS. 2, 3, and 5; therefore, the manner in which the controller controls actuation of the wing valves 185 aa, 185 ab, 185 ba, and 185 bb will not be described in further detail. Finally, as in FIG. 15, a pump-down truck 490 may be operably coupled to, and in fluid communication with, the wing valve 485 bb.

[0112]

Referring to FIG. 16, with continuing reference to FIGS. 14 and 15, in an embodiment, a method is generally referred to by the reference numeral 500. The method 500 includes, at a step 505, performing a perforating operation (such as, for example, a ball and sleeve operation) on the wellbore 125 1. More particularly, turning briefly to FIG. 15, performing the perforating operation on the wellbore 125 1 includes: deploying a downhole tool (e.g., a plug and perforating gun(s)) on a conveyance string from the lubricator 301 d, through the wellhead 120 1, and into the wellbore 125 1; pumping the downhole tool into the wellbore 125 1 using fluid from the pump-down truck 490; perforating the wellbore 125 1 at a downhole location; and retrieving the downhole to back into the lubricator 301 d. In an alternative embodiment, the step 505 is omitted from the method 500, and the method 500 instead includes, at a step 510, performing a second operation (e.g., a hydraulic fracturing operation) on the wellbore 125 1. The method 500 further includes, at a step 515, performing the second operation on the wellbore 125 2. More particularly, turning briefly to FIG. 17, performing the second operation on the wellbore 125 2 includes pumping hydraulic fracturing fluid through the zipper module 135 2, through the frac line 140 2, through the wellhead 120 2, and into the wellbore 125 2. In an alternative embodiment, the step 515 is omitted from the method 500, and the method 500 instead includes, at a step 520, performing the perforating operation on the wellbore 125 2. Finally, the method 500 further includes, at a step 525, performing an object launching operation on the wellbore 125 N such as, for example, the wellbore 125 3. More particularly, turning briefly to FIG. 18, performing the object launching operation on the wellbore 125 3 includes: dropping an object from the launcher 301 c, through the valve 301 a, through the wellhead 120 3, and into the wellbore 125 3; and pumping the object into the wellbore 125 1 using fluid from the pump-down truck 490.

[0113]

In some embodiments, the steps 505 or 510, the steps 515 or 520, and/or the step 525 may be executed simultaneously on the wellbores 125 1-3, respectively. In some alternative embodiments, both of the steps 515 and 520 are omitted from the method 500 so that the method 500 includes only the steps 505 and 525, or the steps 510 and 525. In some alternative embodiments, the step 525 is omitted from the method 500 so that the method 500 includes only the steps 505 and 515, the steps 505 and 520, or the steps 510 and 520. In some embodiments, the controller 180 is in communication with additional wellbores such as for example, offset wellbores, wellbores located on difference well pads or different well sites, or the like. In such embodiments, the method 500 can be expanded to include execution of the steps 505 or 510, 515 or 520, and/or 525 on these additional wellbores. In some embodiments, the steps 505, 510, 515, 520, and 525 may be executed on all of the wellbores 125 1-N(and/or the additional wellbores) in order to plug, perforate, and hydraulically fracture the wellbores 125 1-N(and/or the additional wellbores) using a continuous process.

[0114]

The step 505 or, alternatively, the step 510, may be executed by communicating, using the controller 180, control signals to the frac leg 146 1 and the grease system 305. Referring back to FIG. 15, the frac leg 146 1 includes: the wellhead 120 1 operably associated with the wellbore 125 1, the wellhead 120 1 including one or more first valves (i.e., the swab valve 150 5, the upper master valve 150 6, the lower master valve 150 N, the wing valve 185 aa, the wing valve 185 ab, the wing valve 185 ba, the wing valve 185 bb, or a combination thereof); the valve 301 a operably coupled to the wellhead 120 1, opposite the wellbore 125 1; the frac line 140 1 operably coupled to the wellhead 120 1, between the wellbore 125 1 and the valve 301 a; and the zipper module 135 1 operably coupled to the frac lines 140 1, opposite the wellhead 120 1, the zipper module 135 1 including one or more third valves (i.e., the lower zipper valve 150 1, the upper zipper valve 150 2, or both). The frac leg 146 1 may further include the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 1 includes communicating at least a portion of the control signals to the sub-controller 470 1 (via, for example, the communication bus 475).

[0115]

The grease system 305 is adapted to lubricate the first valve(s) of the wellhead 120 1 and the third valve(s) of the zipper module 135 1. The grease system 305 may also include the sub-controller 465; in such embodiments, communicating, using the controller 180, the control signals to the grease system 305 includes communicating at least a portion of the control signals to the sub-controller 465 (via, for example, the communication bus 475). In an alternative embodiment, the grease system 305 is omitted, and the control signals are communicated only to the frac leg 146 1.

[0116]

Referring still to FIG. 15, with continuing reference to FIG. 16, in those embodiments of the step 505 in which the control signals are communicated to both the frac leg 146 1 and the grease system 305, the control signals enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the first valve(s) of the wellhead 120 1 to open; and the grease system 305 to lubricate the at least one of the first valve(s) of the wellhead 120 1 during and/or after the at least one of the first valve(s) open(s). In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to close; and the valve 301 a to open, allowing passage of a conveyance string carrying a downhole tool through the valve 301 a, through the wellhead 120 1, and into the wellbore 125 1. Additionally, the frac leg 146 1 may further include: the lubricator 301 d, said downhole tool being deployable from, and retrievable to, the lubricator 301 d on the conveyance string; and a latch 301 b operably coupled to the valve 301 a, opposite the wellhead 120 1, said latch 301 b being adapted to secure the lubricator 301 d for deployment and retrieval of the downhole tool. In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 1 by causing the latch 301 b to secure the lubricator 301 d for deployment and retrieval of the downhole tool.

[0117]

In some embodiments, the controller 180 locks at least one of the first valve(s) of the wellhead 120 1 in the open configuration, the valve 301 a in the open configuration (via control signals sent to the sub-controller 470 1), and/or the at least one of the third valve(s) of the zipper module 135 1 in the closed configuration when the downhole tool is deployed from the lubricator 301 d,

and until the downhole tool is retrieved. In such embodiments, this locking may be manually overridden via the user interface 185.

[0118]

Alternatively, in those embodiments of the step 505 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 1: the frac leg 146 1 further includes the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 1 comprises communicating at least a portion of the control signals to the sub-controller 470 1. In such embodiments of the step 505, the control signals enable performance of the perforating operation on the wellbore 125 1 by causing: at least one of the first valve(s) of the wellbore 120 1 to open; at least one of the third valve(s) of the zipper module 135 1 to close; and the valve 301 a to open, allowing passage of the conveyance string carrying the downhole tool through the valve 301 a, through the first one of the wellheads 120 1-N, and into the wellbore 125 1.

[0119]

In those embodiments in which the step 510 replaces the step 505 and the control signals are communicated to both the frac leg 146 1 and the grease system 305, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to open; and the grease system 305 to lubricate the at least one of the third valve(s) of the zipper module 135 1 during and/or after the at least one of the third valve(s) open(s). Additionally, the control signals may further enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0120]

Alternatively, in those embodiments of the step 510 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 1: the frac leg 146 1 further includes the sub-controller 470 1, said sub-controller 470 1 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 1 comprises communicating at least a portion of the control signals to the sub-controller 470 1. In such embodiments of the step 510, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 1 by causing: at least one of the third valve(s) of the zipper module 135 1 to open; and the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0121]

The step 515 or, alternatively, the step 520, may by executed by communicating, using the controller 180, control signals to the frac leg 146 2 and the grease system 305. Referring to FIG. 17, the frac leg 146 2 includes: the wellhead 120 2 operably associated with the wellbore 125 2, the wellhead 120 2 including one or more fourth valves (i.e., the swab valve 150 5, the upper master valve 150 6, the lower master valve 150 N, the wing valve 185 aa, the wing valve 185 ab, the wing valve 185 ba, the wing valve 185 bb, or a combination thereof); the valve 301 a operably coupled to the wellhead 120 2, opposite the wellbore 125 2; the frac line 140 2 operably coupled to the wellhead 120 2, between the wellbore 125 2 and the valve 301 a; and the zipper module 135 2 operably coupled to the frac line 140 2, opposite the wellhead 120 2, the zipper module 135 2 being in fluid communication with the zipper module 135 1 and including one or more sixth valves (i.e., the lower zipper valve 150 1, the upper zipper valve 150 2, or both). The frac leg 146 2 may further include the sub-controller 470 2, said sub-controller 470 2 being

associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 2 includes communicating at least a portion of the control signals to the sub-controller 470 2 (via, for example, the communication bus 475).

[0122]

The grease system 305 is adapted to lubricate the fourth valve(s) of the wellhead 120 2 and the sixth valve(s) of the zipper module 135 2. As discussed above, the grease system 305 may include the sub-controller 465; in such embodiments, communicating, using the controller 180, the control signals to the grease system 305 includes communicating at least a portion of the control signals to the sub-controller 465 (via, for example, the communication bus 475). Alternatively, the grease system 305 may be omitted, and the control signals may be communicated only to the frac leg 146 2.

[0123]

Referring still to FIG. 17, with continuing reference to FIG. 16, in those embodiments of the step 515 in which the control signals are communicated to both the frac legs 146 2 and the grease system 305, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to open; and the grease system 305 to lubricate the at least one of the sixth valve(s) of the zipper module 135 2 during and/or after the at least one of the sixth valve(s) open(s). Additionally, the control signals may further enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0124]

In some embodiments, the controller 180 locks the at least one of the fourth valve(s) of the wellhead 120 2 in the open configuration, the valve 301 a in the closed configuration (via control signals sent to the sub-controller 470 2), and/or the at least one of the sixth valve(s) of the zipper module 135 2 in the open configuration when the hydraulic fracturing fluid is pumped through the zipper module 135 2, through the frac line 140 2, through the wellhead 120 2, and into the wellbore 125 2, and until such pumping of the hydraulic fracturing fluid is complete. In such embodiments, this locking may be manually overridden via the user interface 185.

[0125]

Alternatively, in those embodiments of the step 515 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 2; the frac leg 146 2 further includes the sub-controller 470 2, said sub-controller 470 2 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 2 comprises communicating at least a portion of the control signals to the sub-controller 470 2. In such embodiments of the step 515, the control signals enable performance of the hydraulic fracturing operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to open; and the valve 301 a to close or remain closed, blocking passage of hydraulic fracturing fluid through the valve 301 a.

[0126]

In those embodiments in which the step 520 replaces the step 515 and the control signals are communicated to both the frac leg 146 2 and the grease system 305, the control signals enable performance of the perforating operation on the wellbore 125 2 by causing: at least one of the fourth valve(s) of the wellhead 120 2 to open; and the grease system 305 to lubricate the at least one of the fourth valve(s) of the wellhead 120 2 during and/or after the at least one of the fourth valve(s) open(s). In such embodiments, the control signals may further enable performance of

the perforating operation on the wellbore 125 2 by causing: at least one of the sixth valve(s) of the zipper module 135 2 to close; and the valve 301 a to open, allowing passage of a conveyance string carrying a downhole tool through the valve 301 a, through the wellhead 120 2, and into the wellbore 125 2. Additionally, the frac leg 146 2 may further include: the lubricator 301 d, said downhole tool being deployable from, and retrievable to, the lubricator 301 d on the conveyance string; and the latch 301 b operably coupled to the valve 301 a, opposite the wellhead 120 2, said latch 301 b being adapted to secure the lubricator 301 d for deployment and retrieval of the downhole tool. In such embodiments, the control signals may further enable performance of the perforating operation on the wellbore 125 2 by causing the latch 301 b to secure the lubricator 301 d for deployment and retrieval of the downhole tool.

[0127]

Alternatively, in those embodiments of the step 520 in which the grease system 305 is omitted and the control signals are communicated only to the frac leg 146 2: the frac leg 146 2 further includes the sub-controller 470 2, said sub-controller 470 2 being associated with the valve 301 a; and communicating, using the controller 180, the control signals to the frac leg 146 2 comprises communicating at least a portion of the control signals to the sub-controller 470 2. In such embodiments of the step 520, the control signals enable performance of the perforating operation on the wellbore 125 2 by causing: at least one of the fourth valve(s) of the wellhead 120 2 to open; at least one of the sixth valve(s) of the zipper module 135 2 to close; and the valve 301 a to open, allowing passage of the conveyance string carrying the downhole tool through the valve 301 a, through the second one of the wellheads 120 1-N, and into the wellbore 125 2.

[0128]

The step 525 may be executed by communicating, using the controller 180, control signals to the frac leg 146 3. Turning to FIG. 18, with continuing reference to FIG. 16, the frac leg 146 3 includes: the wellhead 120 3 operably associated with the wellbores 120 3; the valve 301 a operably coupled to the wellhead 120 3, opposite the wellbore 125 3; and the launcher 301 c operably coupled to the valve 301 a, opposite the wellhead 120 3. In such embodiments of the step 525, the control signals enable performance of the object launching operation on the wellbore 125 3 by causing: the launcher 301 c to release an object into the valve 301 a; and the valve 301 a to allow passage of the released object through the valve 301 a, through the wellhead 120 3, and into the wellbore 125 3. The frac leg 146 3 may further include the sub-controller 470 3, said sub-controller 470 3 being associated with the valve 301 a; in such embodiments, communicating, using the controller 180, the control signals to the frac leg 146 3 includes communicating at least a portion of the control signals to the sub-controller 470 3 (via, for example, the communication bus 475).

[0129]

Referring to FIG. 19, with continuing reference to FIGS. 1-18, in one or more embodiments, a computing node 1000 for implementing one or more embodiments of one or more of the above-described elements, systems, apparatus, controllers, methods, and/or steps, or any combination thereof, is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In one or more embodiments, the microprocessor 1000 a is, includes, or is part of, the controller 180 and/or the one or more other controllers described herein. In one or more embodiments, the storage device 1000 c may include a floppy drive, hard drive, CD-ROM, optical drive, any other form of storage device ~~and/~~or any combination thereof. In one or more embodiments, the storage device 1000 c

may include, and/or be capable of receiving, a floppy disk, CD-ROM, DVD-ROM, or any other form of ~~non-transitory~~ computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device 1000 g may include a modem, network card, or any other device to enable the node 1000 to communicate with other ~~node(s).~~nodes. In one or more embodiments, ~~the~~any node ~~and the other node(s) represent~~represents a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

[0130]

In one or more embodiments, one or more of the ~~embodiments~~ components of any of the above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In one or more embodiments, one or more of the above-described components of the node 1000 and/or the ~~embodiments~~ above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include respective pluralities of same components. ~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

[0131]

In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

[0132]

In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, personal digital assistants (PDAs), or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

[0133]

In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD- ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

[0134]

In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In ~~an embodiment~~one or more embodiments, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

[0135]

In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable ~~an embodiment~~one or more embodiments of the present disclosure. In ~~an embodiment, a~~one or more embodiments, data structure may provide an organization of data, or an organization of executable code.

[0136]

In one or more embodiments, any networks and/or one or more portions thereof, may be designed to work on any specific architecture. In ~~an embodiment~~one or more embodiments, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

[0137]

In one or more embodiments, ~~a~~ database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In ~~an embodiment~~one or more embodiments, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In ~~an embodiment~~one or more embodiments, the database may exist remotely from the server, and run on a separate platform. In ~~an embodiment~~one or more embodiments, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.

[0138]

In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part ~~one or more of~~ the ~~embodiments~~above-described operation of ~~one or more~~each of the ~~controller(s) (e.g., the controller 156), element(s),~~above-described elements, systems, apparatus, ~~system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s),~~controllers, methods, and/or ~~sub-step(s),~~steps, or any combination thereof~~, described above and/or illustrated in FIGS. 1A through 19B~~. In one or more embodiments, such a processor may include one or more of the microprocessor 1000 a, the controller 180, the one or more other controllers described herein, any processor(s) that are part of the components of the ~~hydraulic fracturing system 100, such as, for example, the controller 156~~above-described systems, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the ~~system.~~above-described

systems. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ~~ay~~may interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which~~

~~second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.**

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing**

~~queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using~~

~~hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

[0139]

A system has been disclosed. The system generally includes a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; and a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a controller that communicates first control signals to the first frac leg; wherein: (a) the first frac leg further includes a first sub-controller, said first sub-controller being associated with the second valve; and the controller communicates the first control signals to the first sub-controller to control operation of the second valve; (b) the system further includes a grease system, which grease system is adapted to lubricate the first valve(s) and/or the third valve(s); the grease system includes a second sub-controller; and the controller communicates second control signals to the second sub-controller to control lubrication of the first valve(s) and/or the third valve(s) by the grease system; or (c) both (a) and (b). In one or more embodiments, (c); the system further includes a communication bus connecting the controller to the first and second sub-controllers; and wherein the controller communicates the first and second control signals to the first and second sub-controllers, respectively, via the communication bus. In one or more embodiments, (a); and wherein the first frac leg further includes: a lubricator from which a downhole tool is deployable, and to which the downhole tool is retrievable, on a conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being controllable by the first sub-controller to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, the system further includes: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; and a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; wherein the controller communicates third control signals to the second frac leg. In one or more embodiments, (d) the second frac leg further includes a third sub-controller, said third sub-controller being associated with the fifth valve; and the controller communicates the third control signals to the third sub-controller; (e) the system further includes the grease system, which grease system is adapted to lubricate the fourth valve(s) and the sixth valve(s); the grease system includes the second sub-controller; and the controller communicates fourth control signals to the second sub-controller; or (f) both (d) and (e). In one or more embodiments, (a) and (d); the system further includes a communication bus

connecting the controller to the first and third sub-controllers; and the controller communicates the first and third control signals to the first and third sub-controllers, respectively, via the communication bus. In one or more embodiments, (d); and the second frac leg further includes: a lubricator from which a downhole tool is deployable, and to which the downhole tool is retrievable, on a conveyance string; and a latch operably coupled to the fifth valve, opposite the second wellhead, said latch being controllable by the third sub-controller to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, the system further includes: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; and a launcher operably coupled to the fifth valve, opposite the second wellhead; wherein: (d) the second frac leg further includes a third sub-controller, said third sub-controller being associated with the fifth valve and adapted to control the launcher; and the controller communicates the third control signals to the third sub-controller.

[0140]

The present disclosure also introduces a first method. The first method generally includes: communicating, using a controller, first control signals to: a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a first frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; and a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a grease system, which grease system is adapted to lubricate the first valve(s) and/or the third valve(s); wherein: (i) the first control signals enable performance of a first operation on the first wellbore by causing: at least one of the first valve(s) to open; and the grease system to lubricate the at least one of the first valve(s) during and/or after the at least one of the first valve(s) open(s); or (ii) the first control signals enable performance of a hydraulic fracturing operation on the first wellbore by causing: at least one of the third valve(s) to open; and the grease system to lubricate the at least one of the third valve(s) during and/or after the at least one of the third valve(s) open(s). In one or more embodiments, (i); the first operation is a perforating operation; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: at least one of the third valve(s) to close; and the second valve to open, allowing passage of a conveyance string carrying a downhole tool through the second valve, through the first wellhead, and into the first wellbore. In one or more embodiments, the first frac leg further includes: a lubricator, said downhole tool being deployable from, and retrievable to, the lubricator on the conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being adapted to secure the lubricator for deployment and retrieval of the downhole tool; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: the latch to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, (ii); the second operation is a hydraulic fracturing operation; and the first control signals further enable performance of the hydraulic fracturing operation on the first wellbore by causing: the second valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the second valve. In one or more embodiments, (a) the first frac leg further includes a first sub-controller, said first sub-controller being associated with the second valve; and communicating, using the controller, the first control signals to the first frac leg includes: communicating at least a first portion of the first control signals to the first sub-controller; (b) the grease system includes a second sub-controller; and

communicating, using the controller, the first control signals to the grease system includes: communicating at least a second portion of the first control signals to the second sub-controller; or (c) both (a) and (b). In one or more embodiments, (c); and the controller communicates at least the first and second portions of the first control signals to the first and second sub-controllers, respectively, via a communication bus. In one or more embodiments, the first method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; and a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; and the grease system, which grease system is further adapted to lubricate the fourth valve(s) and the sixth valve(s); wherein: (iii) the second control signals enable performance of the first operation on the second wellbore by causing: at least one of the fourth valve(s) to open; and the grease system to lubricate the at least one of the fourth valve(s) during and/or after the at least one of the fourth valve(s) open(s); or (iv) the second control signals enable performance of the hydraulic fracturing operation on the second wellbore by causing: at least one of the sixth valve(s) to open; and the grease system to lubricate the at least one of the sixth valve(s) during and/or after the at least one of the sixth valve(s) open(s). In one or more embodiments, the first method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; and a launcher operably coupled to the fifth valve, opposite the second wellhead; wherein: (iii) the second control signals enable performance of an object launching operation on the second wellbore by causing: the launcher to release an object into the fifth valve; and the fifth valve to allow passage of the released object through the fifth valve, through the second wellhead, and into the second wellbore.

[0141]

Along with the disclosed first method, an accompanying system is also disclosed, the system including a non-transitory computer readable medium and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed, one or more of the foregoing steps of the first method are executed; additionally, another accompanying system is also disclosed, the system including the controller, the first sub-controller, and the second sub-controller(s), which are used to execute one or more of the foregoing steps of the first method.

[0142]

The present disclosure also introduces a second method. The second method generally includes: communicating, using a controller, first control signals to: a first frac leg, the first frac leg including: a first wellhead operably associated with a first wellbore, the first wellhead including one or more first valves and a first frac tree; a second valve operably coupled to the first wellhead, opposite the first wellbore; a first frac line operably coupled to the first frac tree; a first zipper module operably coupled to the first frac line, opposite the first wellhead, the first zipper module including one or more third valves; and a first sub-controller, said first sub-controller being associated with the second valve; wherein communicating, using the controller, the first control signals to the first frac leg includes communicating at least a portion of the first control

signals to the first sub-controller; and wherein: (i) the first control signals enable performance of a first operation on the first wellbore by causing: at least one of the first valve(s) to open; at least one of the third valve(s) to close; and the second valve to open, allowing passage of a conveyance string carrying a downhole tool through the second valve, through the first wellhead, and into the first wellbore; or (ii) the first control signals enable performance of a hydraulic fracturing operation on the first wellbore by causing: at least one of the third valve(s) to open; and the second valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the second valve. In one or more embodiments, (i); the first operation is a perforating operation; and the first frac leg further includes: a lubricator, said downhole tool being deployable from, and retrievable to, the lubricator on the conveyance string; and a latch operably coupled to the second valve, opposite the first wellhead, said latch being adapted to secure the lubricator; and the first control signals further enable performance of the perforating operation of the first wellbore by causing: the latch to secure the lubricator for deployment and retrieval of the downhole tool. In one or more embodiments, (ii); and the second operation is a hydraulic fracturing operation. In one or more embodiments, the second method further includes: communicating, using a controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore, the second wellhead including one or more fourth valves and a second frac tree; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a second frac line operably coupled to the second frac tree; a second zipper module operably coupled to the second frac line, opposite the second wellhead, the second zipper module being in fluid communication with the first zipper module and including one or more sixth valves; and a second sub-controller, said second sub-controller being associated with the fifth valve; wherein communicating, using the controller, the second control signals to the second frac leg includes communicating at least a portion of the second control signals to the second sub-controller; and wherein: (iii) the second control signals enable performance of the first operation on the second wellbore by causing: at least one of the fourth valve(s) to open; at least one of the sixth valve(s) to close; and the fifth valve to open, allowing passage of a conveyance string carrying a downhole tool through the fifth valve, through the second wellhead, and into the second wellbore; or (iv) the second control signals enable performance of the hydraulic fracturing operation on the second wellbore by causing: at least one of the sixth valve(s) to open; and the fifth valve to close or remain closed, blocking passage of a hydraulic fracturing fluid through the fifth valve. In one or more embodiments, the second method further includes: communicating, using the controller, second control signals to: a second frac leg, the second frac leg including: a second wellhead operably associated with a second wellbore; a fifth valve operably coupled to the second wellhead, opposite the second wellbore; a launcher operably coupled to the fifth valve, opposite the second wellhead; and a second sub-controller, said second sub-controller being associated with the fifth valve; wherein communicating, using the controller, the second control signals to the second frac leg includes communicating at least a portion of the second control signals to the second sub-controller; and wherein: (iii) the second control signals enable performance of an object launching operation on the second wellbore by causing: the launcher to release an object into the fifth valve; and the fifth valve to allow passage of the released object through the fifth valve, through the second wellhead, and into the second wellbore.

[0143]

Along with the disclosed second method, an accompanying system is also disclosed, the system including a non-transitory computer readable medium and a plurality of instructions stored on

the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed, one or more of the foregoing steps of the second method are executed; additionally, another accompanying system is also disclosed, the system including the controller, the first sub-controller, and the second sub-controller(s), which are used to execute one or more of the foregoing steps of the second method.

[0144]

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

[0145]

In ~~several~~one or more embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some ~~(~~or all~~)~~ of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

[0146]

Any spatial references, such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

[0147]

In ~~several~~one or more embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In ~~several~~one or more embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

[0148]

In ~~several~~one or more embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

[0149]

Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word "means" together with an associated function.

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted.~~Referring to FIG. 1, in an embodiment, a system for delivering and metering grease to process valves 105 1-N used in oil and gas operations is diagrammatically illustrated and generally referred to by the reference numeral 100. For example, the process valves 105 1-N may be part of an oil and gas wellbore fracturing system. In some embodiments, the process valves 105 1-N are gate valves. The system 100 includes a delivery module 110 and metering modules 115 1-N. The metering modules 115 1-N are each operably associated with, and adapted to be in communication with, the delivery module 110. Likewise, the process valves 105 1-N are operably associated with, and adapted to be in communication with, the metering modules 115 1-

N, respectively. In operation, to grease the process valves 105 1-N, the metering modules 115 1-N are adapted to force grease from the delivery module 110 into the respective process valves 105 1-N.

Referring to FIG. 2 with continuing reference to FIG. 1, in an embodiment, the delivery module 110 includes a fluid power source 120 and a grease container 125. The fluid power source 120 stores a power fluid for forcing grease from the grease container 125 into the process valves 105 1-N, as will be described in further detail below. A fluid transport device 130 is operably associated with the fluid power source 120. The fluid transport device 130 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 130 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 130 is adapted to transport the power fluid from the fluid power source 120 to the metering modules 115 1-N. A pressure sensor 135 is operably associated with the fluid transport device 130. The pressure sensor 135 is adapted to detect the pressure of the power fluid discharged from the fluid transport device 130. In addition to providing the power fluid transported to the metering modules 115 1-N, the fluid power source 120 is also adapted to receive recycled power fluid from the metering modules 115 1-N.

The grease container 125 stores grease. A grease measuring device 140 such as, for example, a load cell (e.g., a scale) is operably associated with the grease container 125. The grease measuring device 140 may be adapted to measure a mass of the grease container 125 to keep track of the amount of grease that has been used and how much is remaining. However, although described herein as a load cell, the grease measuring device 140 may be any suitable device capable of monitoring the amount of grease in the grease container 125 such as, for example, a ranging device, a linear position transducer, an optical/laser device, or the like that measures a level of the grease within the grease container 125. A fluid transport device 145 is operably associated with the grease container 125. The fluid transport device 145 can be a pump or a compressor, depending on the nature of the power fluid being used. In addition, or instead, the fluid transport device 145 may be or include a hydraulic power unit ("HPU") accumulator. In any case, the fluid transport device 145 is adapted to transport grease from the grease container 125 to the metering modules 115 1-N. A pressure sensor 150 is operably associated with the fluid transport device 145. The pressure sensor 150 is adapted to detect the pressure of the grease discharged from the fluid transport device 145. In addition to providing the grease transported to the metering modules 115 1-N, the grease container 125 is also adapted to receive recycled grease from the metering modules 115 1-N. To this end, a return valve 155 is operably associated with the grease container 125 and adapted to selectively permit communication of the recycled grease from the metering modules 115 1-N to the grease container 125.

In some embodiments, as in FIG. 2, the system 100 also includes a control unit 160. The control unit 160 is adapted to send control signals to the fluid transport devices 130 and 145 and the return valve 155. In addition, the control unit 160 may receive operating speed data from the fluid transport devices 130 and 145 and/or valve position data from the return valve 155. The control unit 160 is also adapted to receive data/readings from the pressure sensors 135 and 150 (e.g., pressure data) and the grease measuring device 140 (e.g., grease measurement data).

In some embodiments, the metering modules 115 1-N are substantially identical to each other and, therefore, in connection with FIG. 3, only the metering module 115 1 will be described in detail below; however, the description below also applies to the metering modules 115 2-N.

Referring to FIG. 3 with continuing reference to FIGS. 1 and 2, in an embodiment, to meter the amount of grease sent to a particular one of the process valves 105 1, the metering module 115 1

includes a grease metering device 165 such as, for example, a grease pump. In some embodiments, as in FIG. 3, the grease metering device 165 includes a piston 170, a power cylinder 175, and a grease cylinder 180.

The piston 170 includes a head portion 185 and a rod portion 190. The head portion 185 is slidably disposed in the power cylinder 175 and divides the power cylinder 175 into chambers 195 and 200. The rod portion 190 extends from the head portion 185 into the grease cylinder 180 so that, as the head portion 185 travels back and forth in the power cylinder 175, the rod portion 190 extends at least partially into, and retracts at least partially out of, the grease cylinder 180. The piston 170 may be displaced within the power cylinder 175 via hydraulic or pneumatic power; thus, in some embodiments, the power fluid stored by the fluid power source 120 is hydraulic or pneumatic. In addition, or instead, electric or gas power may be utilized to displace the piston 170.

In some embodiments, as in FIG. 3, a control valve 205 is operably associated with the power cylinder 175. The control valve 205 is adapted to receive the power fluid from the fluid transport device 130. To stroke the piston 170 in a direction 210, the control valve 205 is adapted to communicate power fluid from the fluid transport device 130 to the chamber 195 and, at the same time, to communicate power fluid from the chamber 200 back to the fluid power source 120. Similarly, to stroke the piston 170 in a direction 215, which is opposite the direction 210, the control valve 205 is adapted to communicate power fluid from the fluid transport device 130 to the chamber 200 and, at the same time, to communicate power fluid received from the chamber 195 back to the fluid power source 120. In addition, the pressure of the grease within the grease cylinder 180 forces the piston 170 in the direction 215. In some embodiments, the force exerted on the piston 170 by the grease within the grease cylinder 180 is sufficient by itself to stroke the piston 170 in the direction 215. Accordingly, to ensure that the grease cylinder 180 is filled with grease before being stroked in the direction 210, the force exerted on the piston 170 by the grease within the grease cylinder 180 may itself be relied on to stroke the piston 170 in the direction 215. In some embodiments, the fluid power source 120, the fluid transport device 130, the pressure sensor 135, the power cylinder 175, the control valve 205, or any combination thereof, may collectively be referred to herein as an “actuator” (i.e., hydraulic- or pneumatic-powered) for stroking the piston 170 back and forth within the grease cylinder 180. However, in addition, or instead, another “actuator” may also be used to stroke the piston 170 back and forth within the grease cylinder 180 such as, for example, an electric- or gas-powered actuator.

A cycle counter 220 is operably associated with the power cylinder 175. The cycle counter 220 may be or include limit switch(es) or other sensor(s) operably associated with the actuator to give analog or other linear position feedback. In any case, the cycle counter 220 is adapted to count the strokes of the piston 170 within the power cylinder 175. In some embodiments, the cycle counter 220 is capable of detecting partial strokes of the piston 170 to further enable precise greasing of the process valves 105 1. As a result, if so desired, the system 100 is capable of partially greasing the process valves 105 1 by allowing an operator to enter the “desired percentage” of grease required. In some embodiments, as in FIG. 3, the control unit 160 is adapted to send control signals to the control valve 205. In addition, the control unit 160 may receive valve position data from the control valve 205. The control unit 160 is also adapted to receive data/readings (e.g., stroke count data) from the cycle counter 220.

A check valve 225 is operably associated with an inlet 226 of the grease cylinder 180 and is adapted to communicate grease from the fluid transport device 145 to the grease cylinder 180 while preventing, or at least reducing, any backflow of the grease through the check valve 225.

As a result, when the piston 170 is stroked in the direction 215, the rod portion 190 is retracted at least partially out of the grease cylinder 180 and the check valve 225 permits grease to be drawn into the grease cylinder 180 via the inlet 226. At the same time, a check valve 230 prevents grease from being drawn into the grease cylinder 180 via an outlet 231. The check valve 230 is operably associated with the outlet 231 of the grease cylinder 180 and is adapted to communicate grease from the grease cylinder 180 to the process valves 105 1 while preventing, or at least reducing, any backflow of the grease through the check valve 230. As a result, when the piston 170 is stroked in the direction 210, the rod portion 190 is extended at least partially into the grease cylinder 180 and the check valve 230 permits grease to be forced out of the grease cylinder 180 via the outlet 231. At the same time, the check valve 225 prevents grease from being forced out of the grease cylinder 180 via the inlet 226. In some embodiments, the check valve 230 is biased to the closed position with more force (e.g., tighter springs) than that of the check valve 225 in order to maintain the pressure of the grease within the grease cylinder 180. For example, springs in the check valve 230 can be tuned to a desired cracking pressure (e.g., about 1000 psi) to determine the pressure of the grease within the grease cylinder 180.

In some embodiments, the grease metering device 165 is "double-acting" and includes a second grease cylinder substantially identical to the grease cylinder 180 and a second rod portion substantially identical to the rod portion 190; the second rod portion extends from the head portion 185 into the second grease cylinder so that, as the head portion 185 travels back and forth in the power cylinder 175, the second rod portion extends at least partially into, and retracts at least partially out of, the second grease cylinder.

Turning to FIG. 4, in an alternative embodiment, the grease metering device 165 is or includes a rotary pump having one or more rotors 232 a adapted to be rotated within a casing 232 b by an actuator 232 c, as indicated by arrow 233 to drive the grease to the process valves 105 1; in such embodiments, the cycle counter 220 is adapted to count revolutions of the rotor(s) rather than strokes of the piston 170.

Referring to FIG. 5 with continuing reference to FIGS. 1-4, in an embodiment, the process valves 105 1 are adapted to be in communication with the metering module 115 1 via lubricator valves 235 1-N. In some embodiments, the lubricator valves 235 1-N are part of the metering module 115 1. Similarly, the process valves 105 2-N may be adapted to be in communication with the metering modules 115 2-N, respectively, via lubricator valve(s) substantially identical to the lubricator valves 235 1-N. The lubricator valves 235 1-N are adapted to selectively communicate grease from the grease cylinder 180 to respective ones of the process valves 105 1. In some embodiments, as in FIG. 5, the control unit 160 is adapted to send control signals to the lubricator valves 235 1-N. In addition, the control unit 160 may receive valve position data from the lubricator valves 235 1-N.

Alternatively, in some embodiments, the grease metering devices 165 may be omitted and replaced with flow meters that are operably associated with respective ones of the process valves 105 1 (and thus respective ones of the lubricator valves 235 1-N; in such embodiments, the control unit 160 receives feedback from the flow meters and actuates the lubricator valves 235 1-N to meter a desired amount of grease to the process valves 105 1 using the fluid transport device 145. In some embodiments, the system 100 further includes one or more pressure sensors located downstream from the check valve 230 (e.g., to monitor pressure within the process valves 105 1); as a result, using data/readings obtained from these one or more pressure sensors, the control unit 160 can ensure that the greasing pressure is greater than the pressure within the process valves 105 1. Additional valves may also be added downstream from the check valve 230 to

provide double barriers to prevent, or at least reduce, any leakage of process fluid from the process valve.

Referring collectively to FIGS. 1-5, in operation, the fluid transport device 130 transports power fluid from the fluid power source 120 to the control valve 205 of the metering module 115 1. During the transporting of the power fluid to the control valve 205, the control unit 160 communicates control signals to the fluid transport device 130 and receives data/readings from the pressure sensor 135. As a result, the control unit 160 can adjust the flow of the power fluid to the control valve 205 using the fluid transport device 130 and monitor the pressure of the power fluid exiting the fluid transport device 130 using the pressure sensor 135. The control valve 205 actuates the piston 170 within the power cylinder 175. To actuate the piston 170 in the direction 210 within the power cylinder 175, the control valve 205 communicates power fluid from the 130 to the chamber 195 and, at the same time, communicates power fluid from the chamber 200 back to the fluid power source 120. Conversely, to actuate the piston 170 in the direction 215 within the power cylinder 175, the control valve 205 communicates power fluid from the fluid transport device 130 to the chamber 200 and, at the same time, communicates power fluid from the chamber 195 back to the fluid power source 120. During the actuation of the piston 170 within the power cylinder 175, the control unit 160 communicates control signals to the control valve 205 and receives data/readings from the cycle counter 220. As a result, the control unit 160 can stroke the piston 170 back and forth within the power cylinder 175 using the control valve 205 and count the strokes of the piston 170 back and forth within the power cylinder 175 using the cycle counter 220. In other embodiments, in addition, or instead, electric or gas power may be utilized to actuate the piston 170.

The fluid transport device 145 transports grease from the grease container 125 to the inlet 226 of the grease cylinder 180. During the transporting of the grease to the grease cylinder 180, the control unit 160 communicates control signals to the fluid transport device 145 and receives data/readings from the pressure sensor 150. As a result, the control unit 160 can adjust the flow of the grease to the grease cylinder 180 using the fluid transport device 145 and monitor the pressure of the grease exiting the fluid transport device 145 using the pressure sensor 150. As the piston 170 is actuated in the direction 215, the grease is drawn into the grease cylinder 180 through the inlet 226. The transporting of the grease to the grease cylinder 180 using the fluid transport device 145 allows the grease to be more efficiently and completely drawn into the grease cylinder 180 through the inlet 226 as the piston 170 is actuated in the direction 215. Conversely, as the piston 170 is actuated in the direction 210, the grease is forced out of the grease cylinder 180 through the outlet 231. The lubricator valves 235 1-N selectively communicate the grease forced out of the grease cylinder 180 to respective ones of the process valves 105 1. In addition, the return valve 155 selectively communicates the grease forced out of the grease cylinder 180 back to the grease container 125.

The control unit 160 communicates control signals to the return valve 155 and the lubricator valves 235 1-N. As a result, the control unit 160 can selectively actuate the return valve 155 and the lubricator valves 235 1-N to determine: whether the grease forced out of the grease cylinder 180 is communicated back to the grease container 125; and/or which of the process valves 105 1 receives the grease forced out of the grease cylinder 180. For example, if the control unit 160 closes the return valve 155, opens one of the lubricator valves 235 1-N, and closes the remaining lubricator valves 235 1-N, the grease forced out of the grease cylinder 180 will be communicated to the process valve 105 1 that is operably associated with the opened one of the lubricator valves 235 1-N. For another example, if the control unit 160 opens the return valve 155 and

closes the lubricator valves 235 1-N, the grease forced out of the grease cylinder 180 will be communicated back to the grease container 125. Alternatively, the return valve 155 could bypass the grease cylinder 180 by communicating grease back to the grease container 125 before the grease passes through the check valve 225.

The volume of grease forced out of the grease cylinder 180 with each stroke of the piston 170 can be determined via measurement or calculation (e.g., by multiplying the cross-sectional area of the rod portion 190 by the length of the piston 170's stroke); as a result, by controlling and/or monitoring the control valve 205, the cycle counter 220, the lubricator valves 235 1-N, the return valve 155, or any combination thereof, the control unit 160 meters a desired amount of grease to each of the process valves 105 1. In some embodiments, the desired amount of grease metered to each of the process valves 105 1 can be specifically tailored according to greasing volume and/or frequency guidelines provided, for example, by the manufacturer(s) of the process valves 105 1 and stored in a database accessible by the control unit 160. In addition, or instead, the desired amount of grease metered to each of the process valves 105 1 may be provided by a user via a user interface (HMI) connected to the control unit 160; if so desired, the amount of grease metered to each of the process valves 105 1 can be changed during a job. In addition, by controlling and/or monitoring the fluid transport devices 130 and 145 and the pressure sensors 135 and 150, the control unit 160 regulates the flow of the power fluid and the grease within the system 100.

In some embodiments, the control unit 160 is further adapted to receive data/readings from a pressure sensor 236 (shown in FIG. 3) that detects the pressure of the grease within the grease cylinder 180; by comparing the data/reading obtained from the pressure sensor 236 with data/readings obtained from the pressure sensor 150, the control unit 160 can determine whether the grease cylinder 180 is filled with grease after the piston 170 is stroked in the direction 215. As a result, the control unit 160 can delay stroking the piston in the direction 210 until the grease cylinder 180 is completely filled with grease, thus improving the accuracy of greasing operations. In some embodiments, the control unit 160 controls the metering modules 115 2-N to deliver and meter grease to the process valves 105 2-N in substantially the same manner as that described above with respect to the metering module 115 1 and the valves 105 1; therefore, the operation of the metering modules 115 2-N to deliver and meter grease to the process valves 105 2-N will not be described in further detail. As a result, the control unit 160 is capable of greasing the process valves 105 1-N at any of the following intervals: timed intervals; continuous greasing (at a rate specified by the user or the database); greasing on command from an operator via a user interface (HMI) at any time; per operational stage (e.g., fracturing stage); per N stages; schedules greasing; scheduled partial greasing; and/or any combination thereof.

In some embodiments, prior to delivering and metering grease to the process valves 105 1-N, the system 100 is capable of verifying that the process valves 105 1-N are actuated to the proper position for greasing. To achieve such verification, the system 100 includes sensor(s) associated with the process valves 105 1-N to ensure they are in the proper position prior to greasing. Such sensor(s) may include, for example, position sensor(s) and/or visual feedback devices (e.g., camera(s), image processing software, etc.) capable of detecting the position of the process valves 105 1-N. In addition, the system 100 may include actuator(s) adapted to receive control signals from the control unit 160 to open or close the process valves 105 1-N. As a result, the control unit 160 is able to automatically place the process valves 105 1-N in the proper greasing position prior to greasing.

Referring to FIG. 6, in an embodiment, a method of operating the system 100 is generally referred to by the reference numeral 240. The method 240 is carried out by receiving, at the control unit 160, data/readings from the delivery module 110 (e.g., the pressure sensors 135 and 150) and/or the metering modules 115 1-N (e.g., the cycle counter 220), and sending, from the control unit 160, control signals to the delivery module 110 (e.g., the fluid transport devices 130 and 145, the return valve 155, or any combination thereof) and/or the metering modules 115 1-N (e.g., the control valve 205, the lubricator valves 235 1-N, or any combination thereof).

The method 240 includes at a step 245 delivering grease to a first one of the metering modules 115 1-N. In some embodiments, the step 245 includes transporting the grease from the grease container 125 to the first one of the metering modules 115 1-N. At a step 250, the control unit 160 controls the actuator of the first one of the metering modules 115 1-N so that a first amount of the delivered grease is metered to a first one of the process valves 105 1-N. In some embodiments, the step 250 includes: controlling the actuator of the first one of the metering modules 115 1-N to start stroking the piston 170; determining how many strokes of the piston 170 are required to meter the first amount to the first one of the process valves 105 1-N; and controlling the actuator to stop stroking the piston 170 when the strokes counted by the cycle counter 220 equal the determined number of strokes required. In other embodiments, the step 250 includes: controlling the actuator 232 c of the first one of the metering modules 115 1-N to start rotating the rotor 232 a; determining how many rotations of the rotor 232 a are required to meter the first amount to the first one of the process valves 105 1-N; and controlling the actuator to stop rotating the rotor 232 a when the rotations by the cycle counter 220 equal the determined number of rotations required. In some embodiments of the step 250, the control unit 160 determines the first amount by retrieving data relating to the first one of the process valves 105 1-N from a database.

At a step 255, grease is delivered to a second one of the metering modules 115 1-N. In some embodiments, the step 255 includes transporting the grease from the grease container 125 to the second one of the metering modules 115 1-N. At a step 260, the control unit 160 controls the actuator of the second one of the metering modules 115 1-N so that a second amount of the delivered grease is metered to a second one of the process valves 105 1-N. In some embodiments of the step 260, the control unit 160 determines the second amount by retrieving data relating to the second one of the process valves 105 1-N from a database. At a step 265, the grease measuring device 140 measures a total amount of grease transported from the grease container 125. Finally, at a step 270, the control unit 160 compares the measured total amount to the metered first and second amounts.

In some embodiments, among other things, the operation of the system 100 and/or the execution of the method 240: ensures that an appropriate amount of grease is injected into each of the process valves 105 1-N while monitoring the amount of grease injected into each of the process valves 105 1-N; improves the flushing of debris and contaminants from the process valves 105 1-N; improves the performance of the process valves 105 1-N; decreases the risk that a less than adequate amount of grease is injected into the process valves 105 1-N; decreases the risk of malfunction and maintenance needs for the process valves 105 1-N; and/or reduces operators' exposure to oil and gas process units during operation.

Referring to FIG. 7, in an embodiment, a computing node 1000 for implementing one or more embodiments of one or more of the above-described elements, control units (e.g., 160), devices (e.g., 140 and/or 165), systems (e.g., 100), methods (e.g., 240) and/or steps (e.g., 245, 250, 255, 260, 265, and/or 270), or any combination thereof, is depicted. The node 1000 includes a

microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In ~~one or more~~several embodiments, the storage device 1000 c may include a floppy drive, hard drive, CD-ROM, optical drive, any other form of storage device ~~and/~~or any combination thereof. In ~~one or more~~several embodiments, the storage device 1000 c may include, and/or be capable of receiving, a floppy disk, CD-ROM, DVD-ROM, or any other form of ~~non-transitory~~ computer-readable medium that may contain executable instructions. In ~~one or more~~several embodiments, the communication device 1000 g may include a modem, network card, or any other device to enable the node 1000 to communicate with other ~~node(s).~~nodes. In ~~one or more~~several embodiments, ~~the~~any node ~~and the other node(s) represent~~represents a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

In ~~one or more~~several embodiments, one or more of the ~~embodiments~~ components of any of the above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In ~~one or more~~several embodiments, one or more of the above-described components of the node 1000 and/or the ~~embodiments~~ above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include respective pluralities of same components.

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more~~In several embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In ~~one or more~~several embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

In ~~one or more~~several embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, personal digital assistants (PDAs), or personal computing devices (PCDs), for example). In ~~one or more~~several embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In ~~one or more~~several embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

In ~~one or more~~several embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD~~-~~ ROM, for example). In ~~one or more~~several embodiments, software may include source or object code. In ~~one or more~~several embodiments, software encompasses any

set of instructions capable of being executed on a node such as, for example, on a client machine or server.

In ~~one or more~~several embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

In ~~one or more~~several embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In ~~one or more~~several embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment,~~ a~~ data structure may provide an organization of data, or an organization of executable code.

In ~~one or more~~several embodiments, any networks and/or one or more portions thereof, may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

In ~~one or more~~several embodiments, ~~a~~ database may be any standard or proprietary database software. In ~~one or more~~several embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In ~~one or more~~several embodiments, data may be mapped. In ~~one or more~~several embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In ~~one or more~~several embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In ~~one or more~~several embodiments, more than one database may be implemented.

In ~~one or more~~several embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part ~~one or more of~~ the ~~embodiments~~above-described operation of ~~one or more~~each of the ~~controller(s)~~above-described elements, control units (e.g., ~~the controller 156), element(s), apparatus, system(s)~~160), devices (e.g., ~~the hydraulic fracturing system 100), method(s)~~140 and/or 165), systems (e.g., ~~the method 175, the method 270,~~ 100), methods (e.g., 240) and/or steps (e.g., 245, 250, 255, 260, 265, and/or ~~both), step(s), and/or sub-step(s~~270), or any combination thereof~~, described above and/or illustrated in FIGS. 1A through 19B.~~. In ~~one or more~~several embodiments, such a processor may include one or more of the microprocessor 1000 a, any processor(s) that are part of the components of the ~~hydraulic fracturing system 100, such as, for example, the controller 156~~above-described systems, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the ~~system. In one or more~~above-described systems. In several embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In ~~one or more~~several embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ~~ay~~may interact with one or

more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e),~~

~~fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth~~

~~well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit~~

~~pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

An apparatus has been disclosed. The apparatus generally includes a first grease metering device to which grease is adapted to be delivered, the first grease metering device including either: a first grease cylinder, a first piston extending at least partially within the first grease cylinder, and a first actuator operably associated with the first piston; or a first casing, a first rotor extending at least partially within the first casing, and a second actuator operably associated with the first rotor; and a control unit adapted to either: control the first actuator to stroke the first piston back and forth within the first grease cylinder so that a first amount of the delivered grease is metered to a first process valve; or control the second actuator to rotate the first rotor within the first casing so that the first amount of the delivered grease is metered to the first process valve.

The foregoing apparatus embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:

The control unit is further adapted to determine the first amount by retrieving data relating to the first process valve from a database.

The first grease metering device further includes a first cycle counter adapted to either: count the strokes of the first piston; or count the rotations of the first rotor.

To meter the first amount to the first process valve, the control unit is further adapted to either: control the first actuator to start stroking the first piston, determine how many strokes of the first piston are required to meter the first amount to the first process valve, and control the first actuator to stop stroking the first piston when the strokes counted by the first cycle counter equal the determined number of strokes required; or control the second actuator to start rotating the first rotor, determine how many rotations of the first rotor are required to meter the first amount to the first process valve, and control the second actuator to stop rotating the first rotor when the rotations counted by the first cycle counter equal the determined number of rotations required.

The apparatus further includes: a grease container from which the grease is adapted to be transported to deliver the grease to the first grease metering device; and a grease measuring device adapted to measure a total amount of grease transported from the grease container; wherein the control unit is further adapted to compare the measured total amount to the metered first amount.

The apparatus further includes: a second grease metering device to which grease is adapted to be delivered, the second grease metering device including either: a second grease cylinder, a second piston extending at least partially within the second grease cylinder, and a third actuator operably associated with the second piston; or a second casing, a second rotor extending at least partially within the second casing, and a fourth actuator operably associated with the second rotor; wherein the control unit is further adapted to either: control the third actuator to stroke the second piston back and forth within the second grease cylinder so that a second amount of the delivered grease is metered to a second process valve; or control the fourth actuator to rotate the second rotor within the second casing so that the second amount of the delivered grease is metered to the second process valve.

The control unit is further adapted to determine the first and second amounts by retrieving data relating to the first and second process valves from a database.
The apparatus further includes: a grease container from which the grease is adapted to be transported to deliver the grease to the first and second grease metering devices; and a grease measuring device adapted to measure a total amount of grease transported from the grease container; wherein the control unit is further adapted to compare the measured total amount to the metered first and second amounts.
A method has also been disclosed. The method generally includes delivering grease to a first grease metering device, the first grease metering device including either: a first grease cylinder, a first piston extending at least partially within the first grease cylinder, and a first actuator operably associated with the first piston; or a first casing, a first rotor extending at least partially within the first casing, and a second actuator operably associated with the first rotor; and controlling, using a control unit, either: the first actuator to stroke the first piston back and forth within the first grease cylinder so that a first amount of the delivered grease is metered to a first process valve; or the second actuator to rotate the first rotor within the first casing so that the first amount of the delivered grease is metered to the first process valve.
The foregoing method embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:
The method further includes determining, using the control unit, the first amount by retrieving data relating to the first process valve from a database.
The first grease metering device further includes a first cycle counter; and the method further includes counting, using the first cycle counter, either: the strokes of the first piston; or the rotations of the first rotor.
Controlling, using the control unit, the first actuator includes: controlling the first actuator to start stroking the first piston; determining how many strokes of the first piston are required to meter the first amount to the first process valve; and controlling the first actuator to stop stroking the first piston when the strokes counted by the first cycle counter equal the determined number of strokes required; and controlling, using the control unit, the second actuator includes: controlling the second actuator to start rotating the first rotor; determining how many rotations of the first rotor are required to meter the first amount to the first process valve; and controlling the second actuator to stop rotating the first rotor when the rotations counted by the first cycle counter equal the determined number of rotations required.
Delivering the grease to the first grease metering device includes transporting the grease from a grease container to the first grease metering device; wherein the method further includes: measuring, using a grease measuring device, a total amount of grease transported from the grease container; and comparing, using the control unit, the measured total amount to the metered first amount.
The method further includes delivering grease to a second grease metering device, the second grease metering device including either: a second grease cylinder, a second piston extending at least partially within the second grease cylinder, and a third actuator operably associated with the second piston; or a second casing, a second rotor extending at least partially within the second casing, and a fourth actuator operably associated with the second rotor; and controlling, using the control unit, either: the third actuator to stroke the second piston back and forth within the second grease cylinder so that a second amount of the delivered grease is metered to a second process valve; or the fourth actuator to rotate the second rotor within the second casing so that the second amount of the delivered grease is metered to the second process valve.

The method further includes determining, using the control unit, the first and second amounts by retrieving data relating to the first and second process valves from a database.

Delivering the grease to the first grease metering device includes transporting the grease from a grease container to the first grease metering device; wherein delivering the grease to the second grease metering device includes transporting the grease from the grease container to the second grease metering device; and wherein the method further includes: measuring, using a grease measuring device, a total amount of grease transported from the grease container; and comparing, using the control unit, the measured total amount to the metered first and second amounts.

A system has also been disclosed. The system generally includes a plurality of metering modules adapted to deliver grease to a corresponding plurality of process valves, each of the metering modules including either: a first grease metering device that includes a grease cylinder, a piston extending at least partially within the grease cylinder, and a first actuator operably associated with the piston; or a second grease metering device that includes a casing, a rotor extending at least partially within the casing, and a second actuator operably associated with the rotor; a delivery module including a grease container and a fluid transport device adapted to deliver grease from the grease container to the respective grease metering modules; and a control unit adapted to control: the first actuator(s) to stroke the piston(s) back and forth within the grease cylinder(s) so that respective amounts of the delivered grease are metered to the process valves; and/or the second actuator(s) to rotate the rotor(s) within the casing(s) so that the respective amounts of the delivered grease are metered to the process valves.

The foregoing system embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:

The control unit is further adapted to determine the respective amounts by retrieving data relating to the process valves from a database.

The delivery module further includes a grease measuring device adapted to measure a total amount of grease transported from the grease container; and the control unit is further adapted to compare the measured total amount to the respective metered amounts.

The first grease metering device further includes a first cycle counter adapted to count the strokes of the piston; the second grease metering device further includes a second cycle counter adapted to count the rotations of the rotor; and, to meter the respective amounts to the process valves, the control unit is further adapted to either: control the first actuator(s) to start stroking the piston(s), determine how many strokes are required for the piston(s) to meter the respective amounts to the process valves, and control the first actuator(s) to stop stroking the piston(s) when the strokes counted by the first cycle counter(s) equal the determined number of strokes required; or control the second actuator(s) to start rotating the rotor(s), determine how many rotations are required for the rotor(s) to meter the respective amounts to the process valves, and control the second actuator(s) to stop rotating the rotor(s) when the rotations counted by the second cycle counter(s) equal the determined number of rotations required.

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

In ~~several~~some embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some ~~(~~or all~~)~~ of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

Any spatial references, such as, for example, “upper,” “lower,” “above,” “below,” “between,” “bottom,” “vertical,” “horizontal,” “angular,” “upwards,” “downwards,” “side-to-side,” “left-to-right,” “right-to-left,” “top-to-bottom,” “bottom-to-top,” “top,” “bottom,” “bottom-up,” “top-down,” etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

In ~~several~~some embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In ~~several~~some embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

In ~~several~~some embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

Although ~~several~~some embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. ~~In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word “means” together with an associated function.~~

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted.~~Referring to FIG. 1, in an embodiment, a system is generally referred to by the reference numeral 100 and includes a wellhead 105, a valve 110, a latch 115, a launcher 120, and a lubricator 125. The wellhead 105 is the surface termination of a wellbore 106 that traverses one or more subterranean formations. The valve 110 is operably coupled to the wellhead 105. In several embodiments, the valve 110 is, includes, or is part of the valve apparatus described in U.S. patent application Ser. No. 15/487,785 (the "'785 Application"), filed Apr. 14, 2017, and published Oct. 19, 2017 as U.S. Publication No. 2017/0298708, the entire disclosure of which is hereby incorporated herein by reference. The valve 110 includes a control unit 130, a digital

input/output ("I/O") 135, an analog I/O 140, and a hydraulic manifold 145. A user interface 150 communicates signals to, and receives signals from, the control unit 130. A hydraulic power unit ("HPU") 155 keeps the hydraulic manifold 145 charged with hydraulic fluid by communicating hydraulic fluid to, and receiving hydraulic fluid from, the hydraulic manifold 145. The latch 115 is operably coupled to the valve 110, opposite the wellhead 105. The launcher 120 is operably coupled to the latch 115, opposite the valve 110. Although not shown in FIG. 1, in several embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 120, opposite the latch 115.

The lubricator 125 is extendable through the launcher 120 (and the BOP attached thereto in certain embodiments) and, when so extended, attachable to the latch 115. More particularly, the control unit 130 communicates signals to the hydraulic manifold 145 via the digital I/O 135, which signals cause the hydraulic manifold 145 to communicate hydraulic fluid to, and/or receive hydraulic fluid from, the latch 115 to thereby operate the latch 115. Subsequently, the lubricator 125 is detachable from the latch 115 in a similar manner and, when so detached, retractable from the launcher 120. In several embodiments, the latch 115, the lubricator 125, and the process of attaching/detaching the lubricator 125 to/from the latch 115 are described in the '623 Application, the '741 Application, or a combination thereof.

The launcher 120 includes a hydraulic actuator 160 and position sensors 165 a-b. The position sensors 165 a-b detect the position(s) of one or more components of the launcher 120 and communicate signals to the control unit 130 via the analog I/O 140 based on the detected position(s), as will be described in further detail below. The control unit 130 communicates signals (e.g., based on the signals received from the position sensors 165 a-b) to the hydraulic manifold 145 via the digital I/O 135, which signals cause the hydraulic manifold 145 to communicate hydraulic fluid to, and/or receive hydraulic fluid from the hydraulic actuator 160 to thereby operate the launcher 120, as will be described in further detail below. In several embodiments, the hydraulic actuator 160 is omitted and replaced with an electric or pneumatic actuator.

In several embodiments, the system 100 is, includes, or is part of a hydraulic fracturing system, which hydraulic fracturing system may be used to facilitate the recovery of oil and gas from the one or more subterranean formations traversed by the wellbore 106. For example, the system 100 may be adapted to perform a hydraulic fracturing operation on the wellbore 106. In such instances, the wellhead 105 is, includes, or is part of a "frac stack" to which the launcher 120 is operably coupled. The embodiments provided herein are not, however, limited to a hydraulic fracturing system, as the system 100 may be used with, or adapted to, a mud pump system, a well treatment system, one or more other pumping systems, one or more systems at the wellhead, one or more systems upstream of the wellhead, one or more systems downstream of the wellhead, and/or one or more other systems associated with the wellhead.

Referring to FIG. 2, with continuing reference to FIG. 1, in an embodiment, the launcher 120 includes a kicker device 170 and an actuator device 175. The kicker device 170 is adapted to launch an object (e.g., a ball) into the wellbore 106, as will be described in further detail below. The actuator device 175 is adapted to actuate the kicker device 170, as will be described in further detail below.

Referring to FIGS. 3A and 3B, with continuing reference to FIG. 2, in an embodiment, the kicker device 170 includes a housing 180, which housing 180 includes a deck plate 185, an inner wall 190, an outer wall 195, an intermediate wall 200, and end walls 205 a-b. The inner wall 190, the outer wall 195, the intermediate wall 200, and the end walls 205 a-b extend transversely from the

deck plate 185. The inner wall 190 defines an exterior recess 210 in the housing 180. The end wall 205 a is connected to the inner wall 190, and the end wall 205 b is also connected to the inner wall 190, opposite the end wall 205 a. The outer wall 195 is connected to the end walls 205 a-b, opposite the inner wall 190. A kicker receptacle 215 is defined in the housing 180 proximate the end wall 205 a and between the inner wall 190 and the outer wall 195; for example, the inner wall 190, the deck plate 185, the end wall 205 a, and the outer wall 195, in combination, may define the kicker receptacle 215. A bearing hole 220 is formed transversely through the deck plate 185 from the kicker receptacle 215. Moreover, a gear hole 225 is formed transversely through the end wall 205 a from the kicker receptacle 215. A shoulder 230 extends proximate the deck plate 185 along a periphery of the kicker receptacle 215, and a surface 235 extends from the shoulder 230 to the deck plate 185; for example, the shoulder 230 and the surface 235 may be truncated so as not to obstruct the gear hole 225. Finally, an opening 236 is formed transversely through the inner wall 190 from the kicker receptacle 215, above the shoulder 230.

The intermediate wall 200 extends between the inner wall 190 and the outer wall 195. A hollow cavity 240 is defined in the housing 180 between the inner wall 190 and the intermediate wall 200, opposite the exterior recess 210; for example, the inner wall 190, the deck plate 185, and the intermediate wall 200, in combination, may define the hollow cavity 240. A magazine cavity 245 is also defined in the housing 180 between the intermediate wall 200 and the outer wall 195, opposite the hollow cavity 240; for example, the intermediate wall 200, the deck plate 185, the end wall 205 b, and the outer wall 195, in combination, may define the magazine cavity 245. The magazine cavity 245 extends arcuately from the kicker receptacle 215, opposite the gear hole 225, to the end wall 205 b. Feeder receptacles 250 a-b are formed in the housing 180 on opposing sides of the magazine cavity 245, proximate the kicker receptacle 215; for example, the feeder receptacles 250 a-b may be formed transversely into the intermediate wall 200 and the outer wall 195, respectively. Finally, a guide groove 255 is formed in the housing 180 transversely through the deck plate 185 from the magazine cavity 245; for example, the guide groove 255 may extend along the magazine cavity 245 between the intermediate wall 200 and the outer wall 195. The guide groove 255 extends arcuately from a location proximate the kicker receptacle 215 to a location proximate the end wall 205 b.

Referring to FIGS. 3C-1 and 3C-2, with continuing reference to FIGS. 3A and 3B, in an embodiment, the kicker device 170 includes a kicker 260. The kicker device 170 is shown in an exploded state in FIG. 3C-1 to illustrate the manner in which kicker 260 is received within the kicker receptacle 215 of the housing 180, and the kicker 260 is shown in an exploded state in FIG. 3C-2 to illustrate the various features and components of the kicker 260; however, in connection with FIGS. 3C-1 and 3C-2, the kicker device 170 and the kicker 260 are described below in their non-exploded states. In this regard, the kicker 260 extends within the kicker receptacle 215 of the housing 180 and includes a gear 265, a cylinder 270, a foot 275, a shim 280, and a cover plate 285. The gear 265 is fastened to the cylinder 270. The surface 235 of the housing 180 is profiled to receive the gear 265. The cylinder 270 overlaps the shoulder 230. A shaft 290 extends through the gear 265 and into a bearing 295 mounted in the bearing hole 220 of the housing 180. The cylinder 270 includes a chamber 300 and a foot receptacle 305. A shaft 310 supports the foot 275 within the foot receptacle 305, and springs 315 a-b carried on the shaft 310 bias the foot 275 into the chamber 300. In several embodiments, the springs 315 a-b are omitted and replaced with an electric, hydraulic, or pneumatic actuator adapted to move the foot 275 in and out of the chamber 300. Finally, the cover plate 285 is fastened to the cylinder 270, opposite the gear 265, to secure the shim 280 within the chamber 300. In this position, the shim

280 is adapted to guide objects (e.g., balls) into the chamber 300 while preventing jamming of the objects within the chamber 300 and/or the magazine cavity 245, as will be described in further detail below.

Referring to FIG. 3D, with continuing reference to FIGS. 3A through 3C-2, in an embodiment, the kicker device 170 further includes a feeder 320. The kicker device 170 is shown in an exploded state in FIG. 3D to illustrate the manner in which the feeder receptacles 250 a-b of the housing 180 receive the feeder 320; however, in connection with FIG. 3D, the kicker device 170 is described below in its non-exploded state. In this regard, the feeder 320 extends within the feeder receptacles 250 a-b of the housing 180 and includes a shim 325 and support members 330 a-b. More particularly, the support members 330 a-b extend within the feeder receptacles 250 a-b, respectively, and are fastened to the housing 180. The shim 325 extends from the support member 330 a into the magazine cavity 245, adjacent the kicker 260. In this position, the shim 325 is adapted to guide objects (e.g., balls) into the chamber 300 while preventing jamming of the objects within the chamber 300 and/or the magazine cavity 245, as will be described in further detail below.

Referring to FIGS. 3E-1 and 3E-2, with continuing reference to FIGS. 3A through 3D, in an embodiment, the kicker device 170 further includes a follower 335. The kicker device 170 is shown in an exploded state in FIG. 3E-1 to illustrate the manner in which the magazine cavity 245 of the housing 180 receives the follower 335, and the follower 335 is shown in an exploded state in FIG. 3E-2 to illustrate the various features and components of the follower 335; however, in connection with FIGS. 3E-1 and 3E-2, the kicker device 170 and the follower 335 are described below in their non-exploded states. In this regard, the follower 335 extends within the magazine cavity 245 of the housing 180 and includes a spool 340, a spring 345, and a pusher 350. The spool 340 includes a hollow shaft 355 extending transversely from a flange 360. The spring 345 is a spiral torsion spring. The pusher 350 includes a shaft 365, a wall 370, and a plate 375. The shaft 365 and the wall 370 are spaced apart from each other and extend transversely from the plate 375. The hollow shaft 355 of the spool 340 receives the shaft 365 of the pusher 350. The spring 345 is positioned between the hollow shaft 355 of the spool 340 and the wall 370 of the pusher 350. The spring 345 is adapted to bias the follower 335 towards the kicker receptacle 215. More particularly, the spring 345 is coiled around the pusher 350, and an end of the spring 345 is fixed to the housing 180 near the kicker receptacle 215. As the follower 335 is moved away from the kicker receptacle 215 (e.g., by the loading of objects into the magazine cavity 245), the spring 345 uncoils from the pusher 350 (e.g., along the intermediate wall 200 of the housing 180). As a result, the spring 345 exerts a biasing force on the follower 335 to return the follower 335 towards its starting point near the kicker receptacle 215. Objects loaded in the magazine cavity 245 between the follower 335 and the kicker receptacle 215 are thus urged towards the magazine cavity 245 by the spring 345.

Referring to FIG. 3F, with continuing reference to FIGS. 3A through 3E-2, in an embodiment, the kicker device 170 further includes a cover plate 380. The kicker device 170 is shown in an exploded state in FIG. 3F to illustrate the manner in which the cover plate 380 is fastened to the housing 180; however, in connection with FIG. 3F, the kicker device 170 is described below in its non-exploded state. In this regard, the cover plate 380 is fastened to the housing 180 to contain the kicker 260, the feeder 320, and the follower 335 within the housing 180. A shim 385 is fastened to the cover plate 380 and extends within the magazine cavity 245. In this position, the shim 385 is adapted to guide objects (e.g., balls) into the chamber 300 while preventing jamming of the objects within the chamber 300 and/or the magazine cavity 245, as will be

described in further detail below. The cover plate 380 includes an opening 390 formed transversely therethrough to permit access into the magazine cavity 245 proximate the kicker 260.

Referring to FIG. 3G, with continuing reference to FIGS. 3A through 3F, in an embodiment, the kicker device 170 further includes a lid 395. The kicker device 170 is shown in an exploded state in FIG. 3G to illustrate the manner in which the lid 395 is secured within the opening 390 of the cover plate 380; however, in connection with FIG. 3G, the kicker device 170 is described below in its non-exploded state. In this regard, balls 400 a-d are loaded into the magazine cavity 245 via the opening 390. During such loading, the follower 335 is displaced along the guide groove 255 and potential energy is imparted to the spring 345 so that the balls 400 a-d are biased toward the kicker 260. The lid 395 is secured within the opening 390 of the cover plate 380 to contain the balls 400 a-d within the magazine cavity 245; for example, the lid 395 may include a latching cover plate 405 and a shim 410 that extends into the magazine cavity 245. In this position, the shim 410 is adapted to guide objects (e.g., balls) into the chamber 300 while preventing jamming of the objects within the chamber 300 and/or the magazine cavity 245, as will be described in further detail below. Although shown herein with only four (4) balls 400 a-d, a lesser or greater number of balls may be loaded into the launcher 120. In addition, or instead, balls or other objects of varying shapes (e.g., cylindrical) may be loaded into the launcher 120. The shims 280, 325, 385, and 410 may be switched out for differently-sized shims (e.g., thinner or thicker) to accommodate the different sized balls or other objects. In addition to, or instead of, the shims 280, 325, 385, and 410, the launcher 120 may include flexible guide rails biased to accommodate the different sized balls or other objects. Such flexible guide rails facilitate the use of ascending- or descending-sized balls (or other objects) without the need to change out shims.

Referring to FIG. 4A, with continuing reference to FIG. 2, in an embodiment, the actuator device 175 includes a housing 415, which housing 415 includes a deck plate 420, an inner wall 425, an outer wall 430, an intermediate wall 435, and end walls 440 a-b. The inner wall 425, the outer wall 430, the intermediate wall 435, and the end walls 440 a-b extend transversely from the deck plate 420. The inner wall 425 defines an exterior recess 445 in the housing 415. The end wall 440 a is connected to the inner wall 425. The intermediate wall 435 is also connected to the inner wall 425, opposite the end wall 440 a. The end wall 440 b is connected to the intermediate wall 435 opposite the inner wall 425. The outer wall 430 is connected to the end walls 440 a-b, opposite the inner wall 425 and the intermediate wall 435. An internal cavity 450 is defined between the inner wall 425 and the outer wall 430, opposite the exterior recess 445; for example, the inner wall 425, the deck plate 420, the intermediate wall 435, the end walls 440 a-b, and the outer wall 430, in combination, may define the internal cavity 450. Bearing plate supports 455 a-d are formed on opposing sides of the internal cavity 450; for example, the bearing plate supports 455 a-b may extend transversely from the deck plate 420 adjacent the inner wall 425, and the bearing plate supports 455 c-d may extend transversely from the deck plate 420 adjacent the outer wall 430. Bearing holes 460 a-b are formed transversely through the deck plate 420.

Referring to FIG. 4B, with continuing reference to FIG. 4A, in an embodiment, a gear receptacle 465 is formed into the deck plate 420, opposite the internal cavity 450 and proximate the bearing holes 460 a-b. A bearing hole 470 and a gear hole 475 are formed transversely through the deck plate 420 from the gear receptacle 465. A shoulder 480 extends proximate the deck plate 420 along a periphery of the gear receptacle 465, and a surface 485 extends from the shoulder 480 to the deck plate 420.

Referring still to FIG. 4B, with continuing reference to FIG. 4A, in an embodiment, the actuator device 175 further includes a gear set 490. The actuator device 175 is shown in an exploded state in FIG. 4B to illustrate the manner in which the gear set 490 is received within the gear receptacle 465 of the housing 415; however, in connection with FIG. 4B, the actuator device 175 is described below in its non-exploded state. In this regard, the gear set 490 extends within the gear receptacle 465 of the housing 415 and includes gears 500 a-b and shafts 505 a-b. The surface 485 of the housing 415 is profiled to receive the gears 500 a-b. The gear 500 a is mounted on the shaft 505 a, which shaft 505 a is received within, and supported by, the bearing hole 470 of the housing 415 so that the gear 500 a overlaps the end wall 440 a of the housing 415. Similarly, the gear 500 b is mounted on the shaft 505 b, and the gear 500 b is received within, and supported by, the gear hole 475 of the housing 415.

Referring to FIG. 4C, with continuing reference to FIGS. 4A and 4B, in an embodiment, the actuator device 175 further includes a bearing plate 495. The actuator device 175 is shown in an exploded state in FIG. 4C to illustrate the manner in which the bearing plate is fastened to the shoulder 480 of the housing 415; however, in connection with FIG. 4C, the actuator device 175 is described below in its non-exploded state. In this regard, the bearing plate 495 is fastened to the shoulder 480 of the housing 415 to contain the gears 500 a-b within the gear receptacle 465. Bearing holes 510 a-b are formed in the bearing plate 495. The shafts 505 a-b extend within the bearing holes 510 a-b to support the gears 500 a-b within the gear receptacle 465.

Referring to FIG. 4D, with continuing reference to FIGS. 4A through 4C, in an embodiment, the actuator device 175 further includes the position sensor 165 a. The actuator device 175 is shown in an exploded state in FIG. 4D to illustrate the manner in which the position sensor 165 a is fastened to the end wall 440 a of the housing 415; however, in connection with FIG. 4D, the actuator device 175 is described below in its non-exploded state. In this regard, the position sensor 165 a extends within the internal cavity 450 of the housing 415 and is fastened to the end wall 440 a.

Referring to FIG. 4E, with continuing reference to FIGS. 4A through 4D, in an embodiment, the actuator device 175 further includes the hydraulic actuator 160. The actuator device 175 is shown in an exploded state in FIG. 4E to illustrate the manner in which the hydraulic actuator 160 is fastened to the deck plate 420 of the housing 415; however, in connection with FIG. 4E, the actuator device 175 is described below in its non-exploded state. In this regard, the hydraulic actuator 160 extends within the internal cavity 450 of the housing 415 and is fastened to the deck plate 420. The hydraulic actuator 160 includes a barrel 520 and a piston rod 525. The piston rod 525 extends out of the barrel 520, which barrel 520 includes a rod-end port 530 to and from which hydraulic fluid is communicable. This piston rod 525 is adapted to reciprocate into and out of the barrel 520 when hydraulic fluid is communicated to and from the rod-end port 530, as will be described in further detail below.

Referring to FIG. 4F, with continuing reference to FIGS. 4A through 4E, in an embodiment, the actuator device 175 further includes a biasing device 535. The actuator device 175 is shown in an exploded state in FIG. 4F to illustrate the manner in which the biasing device 535 is fastened to the deck plate 420 of the housing 415; however, in connection with FIG. 4F, the actuator device 175 is described below in its non-exploded state. In this regard, the biasing device 535 extends within the internal cavity 450 of the housing 415 and is fastened to the deck plate 420 proximate the hydraulic actuator 160. The position sensor 165 b is connected to the biasing device 535 to measure any change in the length (i.e., lengthening or shortening) of the biasing device 535.

Referring to FIG. 4G, with continuing reference to FIGS. 4A through 4F, in an embodiment, the actuator device 175 further includes a sprocket set 545. The actuator device 175 is shown in an exploded state in FIG. 4G to illustrate the manner in which the sprocket set 545 is received within the internal cavity 450 of the housing 415; however, in connection with FIG. 4G, the actuator device 175 is described below in its non-exploded state. In this regard, the sprocket set 545 extends within the internal cavity 450 of the housing 415 and includes a drive sprocket 550 and idler sprockets 555 a-b. The drive sprocket 550 is mounted on the shaft 505 b and is fastened to the gear 500 b (shown in FIG. 4B; not visible in FIG. 4G). The idler sprockets 555 a-b are mounted on shafts 560 a-b, respectively, which shafts 560 a-b are received within the bearing holes 460 a-b, respectively, of the housing 415 to support the idler sprockets 555 a-b.

Referring to FIG. 4H, with continuing reference to FIGS. 4A through 4G, in an embodiment, the actuator device 175 further includes a chain 565 extending within the internal cavity 450 of the housing 415. The chain 565 is connected at one end to the piston rod 525 of the hydraulic actuator 160 and, at the other end, to the biasing device 535. The chain 565 is carried by the drive sprocket 550 and the idler sprockets 555 a-b so that actuation of the hydraulic actuator 160 causes rotation of the drive sprocket 550, the idler sprockets 555 a-b, and the gears 500 a-b, as will be described in further detail below.

Referring to FIG. 4I, with continuing reference to FIGS. 4A through 4H, in an embodiment, the actuator device 175 further includes a bearing plate 570. The actuator device 175 is shown in an exploded state in FIG. 4I to illustrate the manner in which the bearing plate 570 is fastened to the bearing plate supports 455 a-d; however, in connection with FIG. 4I, the actuator device 175 is described below in its non-exploded state. In this regard, the bearing plate 570 extends within the internal cavity 450 of the housing 415 and is fastened to the bearing plate 570 supports 455 a-d. The bearing plate 570 includes bearing holes 575 a-c. The shaft 505 b extends within the bearing hole 575 a to support the gear 500 b and the drive sprocket 550. Similarly, the shafts 560 a-b extend within the bearing holes 575 b-c, respectively, to support the idler sprockets 555 a-b.

Referring to FIG. 4J, with continuing reference to FIGS. 4A through 4I, in an embodiment, the actuator device 175 further includes a cover plate 580. The actuator device 175 is shown in an exploded state in FIG. 4J to illustrate the manner in which the cover plate 580 is fastened to the housing 415; however, in connection with FIG. 4J, the actuator device 175 is described below in its non-exploded state. In this regard, the cover plate 580 is fastened to the housing 415 to contain the position sensor 165 a, the hydraulic actuator 160, the biasing device 535, the sprocket set 545, the chain 565, and the bearing plate 570 within the housing 415.

Referring to FIG. 5, with continuing reference to FIGS. 3G and 4J, in an embodiment, the launcher 120 further includes guide members 585 aa, 585 ab, 585 ba, and 585 bb, and clasp members 590 aa, 590 ab, 590 ba, and 590 bb. The launcher 120 is shown in an exploded state in FIG. 5 to illustrate the manner in which the kicker device 170 and the actuator device 175 are guided together by the guide members 585 aa, 585 ab, 585 ba, and 585 bb, and held together by the claps members 590 aa, 590 ab, 590 ba, and 590 bb; however, in connection with FIG. 5, the launcher 120 is described below in its non-exploded state. In this regard, the kicker device 170 and the actuator device 175 are guided together by the guide members 585 aa, 585 ab, 585 ba, and 585 bb, and held together by the clasp members 590 aa, 590 ab, 590 ba, and 590 bb. More particularly, the guide members 585 aa and 585 ab together guide the end walls 205 a and 440 a of the kicker device 170 and the actuator device 175, respectively, into mating engagement. Further, the clasp members 590 aa and 590 ab together secure the end walls 205 a and 440 a of the kicker device 170 and the actuator device 175, respectively, in said mating engagement.

Further still, the guide members 585 ba and 585 bb together guide the end wall 205 b of the kicker device 170 into mating engagement with the intermediate wall 435 of the actuator device 175. Finally, the clasp members 590 ba and 590 bb together secure the end walls 205 b of the kicker device 170 in said mating engagement with the intermediate wall 435 of the actuator device 175. As a result, the exterior recess 210 of the kicker device 170 adjoins the exterior recess 445 of the actuator device 175 so that, in combination, the exterior recesses 210 and 445 form a central passageway 595 (shown in FIGS. 2, 6A-1, 6B-1, and 6C-1) through the launcher 120.

Referring to FIGS. 6A-1 through 6A-3, with continuing reference to FIGS. 1 through 5, in operation, the follower 335 displaces the ball 400 a into the chamber 300 of the kicker 260, as indicated by the linear arrow 600. For example, the direction 600 may be either transverse or skew to axis 610 (shown in FIGS. 6B-1 through 6C-3). More particularly, the follower 335 applies a force against the ball 400 d, which force is generated by the spring 345 of the follower 335. The balls 400 b-c transmit the force applied against the ball 400 d to the ball 400 a. As a result, the ball 400 a overcomes the biasing force of the springs 315 a-b and pushes the foot 275 of the kicker 260 out of the chamber 300 and into the foot receptacle 305. Alternatively, the ball 400 a may be gravity-fed (e.g., via a ramped surface of the housing 180) into the chamber 300. FIGS. 6A-1 through 6A-3 illustrate an embodiment wherein the direction 600 in which the ball 400 a is loaded is transverse to the axis 610 (shown in FIGS. 6B-1 through 6C-3). Alternatively, the direction 600 in which the ball 400 a is loaded may be skew to the axis 610 and thus neither intersecting nor parallel to the axis 610. During the displacement of the ball 400 a into the chamber 300, the shims 280 and 325 guide the ball 400 a to prevent jamming of the ball 400 a as it enters the chamber 300, and the shims 325, 385, and 410 guide the balls 400 b-d to prevent jamming of the balls 400 b-d within the magazine cavity 245. The position sensor 165 a detects the presence of the foot 275 within the foot receptacle 305 and transmits signals based on such detection to the control unit 130 via the analog I/O 140 (as shown in FIG. 2). As a result, the control unit 130 is able to determine whether the ball 400 a has been properly loaded into the chamber 300. For clarity, various components of the launcher 120 have either been omitted from view or shown translucently in FIGS. 6A-1 through 6A-3.

Referring to FIGS. 6B-1 through 6B-3, with continuing reference to FIGS. 6A-1 through 6A-3, in response to the signals transmitted to the control unit 130 by the position sensor 165 a, the control unit 130 transmits signals to the hydraulic manifold 145 via the digital I/O 135, which signals cause the hydraulic manifold 145 to communicate hydraulic fluid to the hydraulic actuator 160 (as shown in FIG. 2). More particularly, the hydraulic manifold 145 communicates the hydraulic fluid to the rod-end port 530 to retract the piston rod 525 into the barrel 520. As a result, the chain 565 connected to the piston rod 525 rotates the drive sprocket 550 in a clockwise direction (as viewed in FIG. 6B-1) and lengthens the biasing device 535. The clockwise rotation of the drive sprocket 550 is transmitted to the kicker 260 via the gears 500 b, 500 a, and 265, respectively, thereby causing the kicker 260 to rotate until the chamber 300 is aligned with the opening 236, as indicated by the curvilinear arrow 605 in FIGS. 6B-1 through 6B-3. For example, the kicker 260 may rotate about the axis 610 (e.g., a vertical axis). Once the chamber 300 is so aligned with the opening 236, the springs 315 a and 315 b bias the foot 275 into the chamber 300 to eject the ball 400 a into the central passageway 595, as indicated by the linear arrow 615 in FIGS. 6B-1 through 6B-3. For example, the direction 615 may be either transverse or skew to the axis 610. Alternatively, the object may be gravity-fed (e.g., via a ramped surface of the cylinder 270) out of the chamber 300 and into the central passageway 595 of the launcher

120. FIGS. 6B-1 through 6B-3 illustrate an embodiment wherein the direction 615 in which the ball 400 a is ejected is transverse to the axis 610. Alternatively, the direction 615 in which the ball 400 a is ejected may be skew to the axis 610 and thus neither intersecting nor parallel to the axis 610. The position sensor 165 b detects the lengthening of the biasing device 535 and transmits signals based on such detection to the control unit 130 via the analog I/O 140 (as shown in FIG. 2). As a result, the control unit 130 is able to determine whether the chamber 300 has been properly aligned with the opening 236 to allow ejection of the ball 400 a into the central passageway 595. For clarity, various components of the launcher 120 have either been omitted from view or shown translucently in FIGS. 6A-1 through 6A-3.

Referring to FIGS. 6C-1 through 6C-3, with continuing reference to FIGS. 6B-1 through 6B-3, in response to the signals transmitted to the control unit 130 by the position sensor 165 b, the control unit 130 transmits signals to the hydraulic manifold 145 via the digital I/O 135, which signals cause the hydraulic manifold to cease to communicate hydraulic fluid to the hydraulic actuator 160 (as shown in FIG. 1). As a result, the biasing device 535 shortens, thereby pulling on the chain 565 to rotate the drive sprocket 550 in a counterclockwise direction (as viewed in FIG. 6C-1) and pull the piston rod 525 out of the barrel 520, which expels hydraulic fluid from the rod-end port 530. The counterclockwise rotation of the drive sprocket 550 is transmitted to the kicker 260 via the gears 500 b, 500 a, and 265, respectively, thereby causing the kicker 260 to rotate until the chamber 300 is aligned with the magazine cavity 245, as indicated by the curvilinear arrow 620 in FIGS. 6C-1 through 6C-3. For example, the kicker 260 may rotate about the axis 610 (e.g., a vertical axis). The position sensor 165 a detects the absence of the foot 275 within the foot receptacle 305 and transmits signals based on such detection to the control unit 130 via the analog I/O 140 (as shown in FIG. 2). As a result, the control unit 130 is able to determine whether the ball 400 a has been properly ejected from the chamber 300. Once the chamber 300 is so aligned with the magazine cavity 245, the follower 335 displaces the ball 400 b into the chamber 300 of the kicker 260, as indicated by the linear arrow 625. FIGS. 6C-1 through 6C-3 illustrate an embodiment wherein the direction 625 in which the ball 400 b is loaded is transverse to the axis 610. Alternatively, the direction 625 in which the ball 400 b is loaded may be skew to the axis 610 and thus neither intersecting nor parallel to the axis 610. The operation of the launcher to eject the ball 400 b into the central passageway 595 is identical to that described above with respect to the ball 400 a and, therefore, will not be described in further detail. This process may be until the remaining balls 400 b-d are ejected into the central passageway 595.

Referring to FIGS. 7 and 8A through 8C, with continuing reference to FIGS. 1 through 6C-3, in an embodiment, a method of launching an object (e.g., the ball 400 a) into the wellbore 106 is generally referred to by the reference numeral 630. In several embodiments, the method 630 is executed using the system 100. In at least one such instance, the launcher 120 is connected to the latch 115 so that housing 180 of the kicker device 170 and the housing 415 of the actuator device 175 engage the latch 115, as shown in FIGS. 8A through 8C. Although not shown in FIGS. 8A through 8C, in several embodiments, a blowout preventer (BOP) may be operably coupled to the launcher 120, opposite the latch 115. The method 630 includes, at a step 635, extending the lubricator 125 through the central passageway 595 of the launcher 120. More particularly, the lubricator 125 is displaced in a direction 636 (shown in FIG. 8A), through the central passageway 595 of the launcher 120 (and the BOP attached thereto in certain embodiments), and into a central passageway 638 of the latch 115 (shown in FIG. 8B).

At a step 640, the lubricator 125 is attached to the latch 115. In several embodiments, the step 640 is executed after the step 635, and while the lubricator 125 extends through the central passageway 595 of the launcher 120. More particularly, the step 640 is executable when the lubricator 125 extends through the central passageway 595 of the launcher and into the central passageway 638 of the latch 115 (shown in FIG. 8B). In several embodiments, the latch 115, the central passageway 638, the lubricator 125, and the process of attaching the lubricator 125 to the latch 115 are described in the '623 Application, the '741 Application, or a combination thereof.

At a step 645, a first wellbore operation (e.g., a perforating operation) is performed while the lubricator 125 is attached to the latch 115. In several embodiments, the step 645 is executable by deploying a downhole tool (not shown; e.g., a plug and perforating guns) from the lubricator 125 while the lubricator 125 is attached to the latch 115. More particularly, the downhole tool passes through the central passageway 638 of the latch 115, through a central passageway 646 of the valve 110, through a central passageway 648 of the wellhead 105, and into the wellbore 106. In several embodiments, the valve 110, the central passageway 646, and the process of passing the downhole tool through the valve 110 and into the wellbore 106 are described in the '785 Application. In several embodiments, the central passageway 648 of the wellhead 105 extends along an axis 649. In such embodiments, the axis 610 about which the kicker 260 rotates (shown in FIGS. 6B-1 through 6C-3) has a non-perpendicular (e.g., parallel) relation with the axis 649 along which the central passageway 648 of the wellhead 105 extends. In those embodiments in which the downhole tool includes the plug and perforating guns, the plug is set, the perforating guns are fired, and the spent perforating guns are retrieved from the wellbore 106 and back into the lubricator 125 to complete execution of the step 645.

At a step 650, the lubricator 125 is detached from the latch 115. In several embodiments, the step 650 is executed after the first wellbore operation is performed at the step 645 (e.g., after the spent perforating guns are retrieved from the wellbore 106 and back into the lubricator 125). In several embodiments, the latch 115, the lubricator 125, and the process of detaching the lubricator 125 from the latch 115 are described in the '623 Application, the '741 Application, or a combination thereof.

At a step 655, the lubricator 125 is retracted from the central passageway 595 of the launcher 120. In several embodiments, the step 655 is executed after the step 650. More particularly, the lubricator 125 is displaced in a direction 656 (shown in FIG. 8C) to execute the step 655.

At a step 660, an object is launched from the launcher 120 into the central passageway 595 so that the object enters the wellbore 106. In several embodiments, the step 660 is executed after the step 655. The execution of the step 660 causes the object to pass through the valve 110 before entering the wellbore 106. In several embodiments, the valve 110 and the process of passing the object therethrough is described in the '785 Application. In several embodiments, the step 660 includes: rotating the cylinder 270 of the launcher 120 about the axis 610 between first and second angular positions, the cylinder 270 defining the chamber 300, as shown and described above in connection with FIGS. 6B-1 through 6B-3 (or in connection with FIGS. 6C-1 through 6C-3); loading the object (e.g., one of the balls 400 a-d) into the chamber 300 when the cylinder 270 is in the first angular position, as shown and described above in connection with FIGS. 6A-1 through 6A-3; and launching the object from the chamber 300 when the cylinder 270 is in the second angular position, as shown and described above in connection with FIGS. 6B-1 through 6B-3. In several embodiments, the direction 615 in which the ball 400 a is ejected (shown in FIGS. 6B-1 through 6B-3) has a non-parallel (e.g., perpendicular) relation with the axis 649 along which the central passageway 648 of the wellhead 105 extends.

Finally, at a step 665, a second wellbore operation (e.g., a hydraulic fracturing operation) is performed. In several embodiments, the step 665 is executed after the step 660. In those embodiments in which the second wellbore operation is a hydraulic fracturing operation, a hydraulic fracturing fluid is pumped into the wellbore 106 via the wellhead 105 to facilitate execution of the step 665.

Referring to FIG. 9, with continuing reference to FIGS. 1-53, in an embodiment, a computing node 1000 for implementing one or more embodiments of one or more of the above-described elements, systems, controllers, control units, methods, and/or steps, or any combination thereof, is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g, all interconnected by one or more buses 1000 h. ~~In one~~In several embodiments, the microprocessor 1000 a is, includes, or ~~more~~is part of, the control unit 130. In several embodiments, the storage device 1000 c may include a floppy drive, hard drive, CD-ROM, optical drive, any other form of storage device ~~and/~~or any combination thereof. In ~~one or more~~several embodiments, the storage device 1000 c may include, and/or be capable of receiving, a floppy disk, CD-ROM, DVD-ROM, or any other form of ~~non-transitory~~ computer-readable medium that may contain executable instructions. In ~~one or more~~several embodiments, the communication device 1000 g may include a modem, network card, or any other device to enable the node 1000 to communicate with other ~~node(s).~~nodes. In ~~one or more~~several embodiments, ~~the~~any node ~~and the other node(s) represent~~represents a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

In ~~one or more~~several embodiments, one or more of the ~~embodiments~~ components of any of the above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In ~~one or more~~several embodiments, one or more of the above-described components of the node 1000 and/or the ~~embodiments~~ above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include respective pluralities of same components.

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more~~In several embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In ~~one or more~~several embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.

In ~~one or more~~several embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, personal digital assistants (PDAs), or personal computing devices (PCDs), for example). In ~~one or more~~several embodiments,

hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In ~~one or more~~several embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

In ~~one or more~~several embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD~~-~~ ROM, for example). In ~~one or more~~several embodiments, software may include source or object code. In ~~one or more~~several embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

In ~~one or more~~several embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly,~~ it should be understood that~~ combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

In ~~one or more~~several embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In ~~one or more~~several embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment,~~ a~~ data structure may provide an organization of data, or an organization of executable code.

In ~~one or more~~several embodiments, any networks and/or one or more portions thereof, may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

In ~~one or more~~several embodiments, ~~a~~ database may be any standard or proprietary database software. In ~~one or more~~several embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In ~~one or more~~several embodiments, data may be mapped. In ~~one or more~~several embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In ~~one or more~~several embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In ~~one or more~~several embodiments, more than one database may be implemented.

In ~~one or more~~several embodiments, a plurality of instructions stored on a non-transitory computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part ~~one or more of~~ the ~~embodiments~~above-described operation of ~~one or more~~each of the ~~controller(s)~~above-described elements, systems (e.g.~~., the controller 156), element(s), apparatus, system(s)~~.), controllers (e.g.~~., the hydraulic fracturing system 100), method(s)~~.), methods (e.g.~~., the method 175, the method 270, or both), step(s),~~.), and/or ~~sub-step(s),~~steps (e.g.,), or any combination thereof~~, described above and/or illustrated in FIGS. 1A through 19B.~~. In ~~one or more~~several embodiments, such a processor may

include, or be a part of, one or more of the microprocessor 1000 a, the control unit 130, any processor(s) that is/are part of the components of the ~~hydraulic fracturing system 100, such as, for example, the controller 156~~above-described systems, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the ~~system. In one or more~~above-described systems. In several embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In ~~one or more~~several embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ~~ay~~may interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the~~

~~first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments,~~

~~the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for~~

~~hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

A system has been disclosed. The system generally includes: a launcher adapted to be operably associated with a wellhead; wherein the launcher defines a first central passageway; wherein, when the launcher is operably associated with the wellhead, the launcher is adapted to launch an object into the first central passageway causing the object to pass through a second central passageway extending along a first axis and defined by the wellhead; wherein the launcher includes a cylinder rotatable about a second axis between first and second angular positions; wherein, when the launcher is operably associated with the wellhead, the second axis has a non-perpendicular relation with the first axis; wherein the cylinder defines a chamber: into which the object is adapted to be loaded when the cylinder is in the first angular position, and from which the object is adapted to be launched, in a first direction, when the cylinder is in the second angular position; and wherein, when the launcher is operably associated with the wellhead, the first direction has a non-parallel relation with the first axis. In several embodiments, the system further includes the object; wherein the object is adapted to be loaded into the chamber in a second direction when the cylinder is in the first angular position, the second direction being different from the first direction. In several embodiments, the system further includes the wellhead; wherein, when the launcher is operably associated with the wellhead, a downhole tool is deployable through the first and second central passageways and into a wellbore to perform a wellbore operation. In several embodiments, the system further includes: a latch adapted to be operably associated with the wellhead; and a lubricator, wherein the lubricator is extendable through the first central passageway of the launcher and, when so extended, attachable to the latch; wherein, when the latch is operably associated with the wellhead and the lubricator is attached to the latch, a downhole tool is deployable from the lubricator, through the second central passageway of the wellhead, and into a wellbore to perform a wellbore operation. In several embodiments, the launcher further includes: a follower movable to load the object into the chamber; and/or a foot movable to launch the object from the chamber. In several embodiments, the launcher further includes: a housing in which the cylinder is positioned, the housing defining at least a portion of the first central passageway. In several embodiments, the launcher further includes an actuator adapted to rotate the cylinder about the second axis between the first and second angular positions. In several embodiments, the launcher further includes a first housing in which the actuator is positioned, the first housing defining at least a portion of the first central passageway. In several embodiments, the launcher further includes a second

housing in which the cylinder is positioned, the second housing defining at least another portion of the first central passageway.

A method has also been disclosed. The method generally includes: launching, using a launcher operably associated with a wellhead, an object into a first central passageway defined by the launcher causing the object to pass through a second central passageway extending along a first axis and defined by the wellhead; wherein launching the object includes: rotating a cylinder of the launcher about a second axis between first and second angular positions, the second axis having a non-perpendicular relation with the first axis; loading the object into a chamber defined by the cylinder when the cylinder is in the first angular position; and launching the object from the chamber, in a first direction, when the cylinder is in the second angular position, the first direction having a non-parallel relation with the first axis. In several embodiments, loading the object into the chamber includes: loading the object into the chamber in a second direction when the cylinder is in the first angular position, the second direction being different from the first direction. In several embodiments, the method further includes: deploying a downhole tool through the first and second central passageways and into a wellbore to perform a wellbore operation. In several embodiments, the method further includes: extending a lubricator through the first central passageway of the launcher; attaching the lubricator to a latch operably associated with the wellhead; and deploying a downhole tool from the lubricator, through the second central passageway of the wellhead, and into a wellbore to perform a wellbore operation. In several embodiments, loading the object into the chamber includes: moving a follower to load the object into the chamber; and/or launching the object from the chamber includes: moving a foot to launch the object from the chamber.

An apparatus has also been disclosed. The apparatus generally includes: a first housing adapted to be operably associated with a wellhead; and a cylinder disposed within the first housing and rotatable about a first axis between first and second angular positions; wherein the first housing at least partially defines a first central passageway; wherein, when the first housing is operably associated with the wellhead, the cylinder is adapted to launch an object into the first central passageway causing the object to pass through a second central passageway extending along a second axis and defined by the wellhead; wherein, when the first housing is operably associated with the wellhead, the first axis has a non-perpendicular relation with the second axis; wherein the cylinder defines a chamber: into which the object is adapted to be loaded when the cylinder is in the first angular position, and from which the object is adapted to be launched, in a first direction, when the cylinder is in the second angular position; and wherein, when the first housing is operably associated with the wellhead, the first direction has a non-parallel relation with the second axis. In several embodiments, the apparatus further includes the object; wherein the object is loadable into the chamber in a second direction when the cylinder is in the first angular position, the second direction being different from the first direction. In several embodiments, when the first housing is operably associated with the wellhead, a downhole tool is deployable through the first and second central passageways and into a wellbore to perform a wellbore operation. In several embodiments, the apparatus further includes: a follower movable to load the object into the chamber; and/or a foot movable to launch the object from the chamber. In several embodiments, the apparatus further includes: an actuator adapted to rotate the cylinder about the first axis between the first and second angular positions. In several embodiments, the apparatus further includes: a second housing in which the actuator is positioned, the second housing defining at least another portion of the first central passageway.

Another system has also been disclosed. The another system generally includes a latch adapted to be operably associated with a wellbore; a launcher adapted to be coupled to the latch, the launcher defining a central passageway and being adapted to launch an object into the central passageway so that the object enters the wellbore; and a lubricator, wherein the lubricator is: extendable through the central passageway of the launcher and, when so extended, attachable to the latch; and detachable from the latch and, when so detached, retractable from the central passageway of the launcher. In several embodiments, the launcher includes a cylinder rotatable about an axis between first and second angular positions, the cylinder defining a chamber into which the object is loadable when the cylinder is in the first angular position, and from which the loaded object is launchable when the cylinder is in the second angular position. In several embodiments, the launcher further includes: a follower movable to load the object into the chamber; and/or a foot movable to launch the object from the chamber. In several embodiments, the launcher includes the follower and the foot. In several embodiments, the launcher further includes a housing in which the cylinder is positioned, the housing defining at least a portion of the central passageway. In several embodiments, the launcher further includes an actuator adapted to rotate the cylinder about the axis between the first and second angular positions. In several embodiments, the launcher further includes a first housing in which the actuator is positioned, the first housing defining at least a portion of the central passageway. In several embodiments, the launcher further includes a second housing in which the cylinder is positioned, the second housing defining at least another portion of the central passageway.

Another method has also been disclosed. The another method generally includes extending a lubricator through a central passageway of a launcher; attaching the lubricator to a latch, the latch being operably associated with a wellbore; detaching the lubricator from the latch; retracting the lubricator from the central passageway of the launcher; and launching an object from the launcher into the central passageway so that the object enters the wellbore. In several embodiments, launching the object includes: rotating a cylinder of the launcher about an axis between first and second angular positions, the cylinder defining a chamber; loading the object into the chamber when the cylinder is in the first angular position; and launching the object from the chamber when the cylinder is in the second angular position. In several embodiments, loading the object into the chamber includes moving a follower to translate the object in a direction. In several embodiments, the direction is either transverse or skew to the axis. In several embodiments, launching the object from the chamber includes moving a foot to translate the object in a direction. In several embodiments, the direction is either transverse or skew to the axis.

Another apparatus has also been disclosed. The another apparatus generally includes: a cylinder rotatable about an axis between first and second angular positions, the cylinder defining a chamber into which the object is loadable when the cylinder is in the first angular position, and from which the loaded object is launchable when the cylinder is in the second angular position; wherein the another apparatus further includes: a follower movable to load the object into the chamber; and/or a foot movable to launch the object from the chamber. In several embodiments, the another apparatus includes the follower; wherein, to load the object into the chamber, the object is translatable in a first direction, the first direction being: either transverse or skew to the axis; and wherein the follower is movable to translate the object in the first direction. In several embodiments, the another apparatus includes the foot; wherein, to launch the object from the chamber, the object is translatable in a second direction, the second direction being: either transverse or skew to the axis; and wherein the foot is movable to translate the object in the

second direction. In several embodiments, the another apparatus includes the follower and the foot. In several embodiments, the another apparatus defines a central passageway into which the object is adapted to pass when the object is launched from the chamber. In several embodiments, the another apparatus further includes a housing in which the cylinder is positioned, the housing defining at least a portion of the central passageway. In several embodiments, the another apparatus further includes: an actuator adapted to rotate the cylinder about the axis between the first and second angular positions. In several embodiments, the another apparatus defines a central passageway into which the object is adapted to pass when the object is launched from the chamber; and the another apparatus further includes a first housing in which the actuator is positioned, the first housing defining at least a portion of the central passageway. In several embodiments, the another apparatus further includes: a second housing in which the cylinder is positioned, the second housing defining at least another portion of the central passageway.

Yet another apparatus has also been disclosed. The yet another apparatus generally includes: a cylinder rotatable about an axis between first and second angular positions, the cylinder defining a chamber into which the object is loadable when the cylinder is in the first angular position, and from which the loaded object is launchable when the cylinder is in the second angular position; wherein, to load the object into the chamber, the object is translatable in a first direction, the first direction being: either transverse or skew to the axis; and wherein, to launch the object from the chamber, the object is translatable in a second direction, the second direction being: either transverse or skew to the axis; and either transverse or skew to the first direction. In several embodiments, the yet another apparatus further includes: a follower movable to load the object into the chamber by translating the object in the first direction; and/or a foot movable to launch the object from the chamber by translating the object in the second direction. In several embodiments, the yet another apparatus includes the follower and the foot. In several embodiments, the yet another apparatus defines a central passageway into which the object is adapted to pass when the object is launched from the chamber; and wherein the yet another apparatus further includes a housing in which the cylinder is positioned, the housing defining at least a portion of the central passageway. In several embodiments, the yet another apparatus further includes an actuator adapted to rotate the cylinder about the axis between the first and second angular positions. In several embodiments, the yet another apparatus defines a central passageway into which the object is adapted to pass when the object is launched from the chamber; and wherein the yet another apparatus further includes a first housing in which the actuator is positioned, the first housing defining at least a portion of the central passageway. In several embodiments, the yet another apparatus further includes: a second housing in which the cylinder is positioned, the second housing defining at least another portion of the central passageway.

Yet another method has also been disclosed. The yet another method generally includes: rotating a cylinder about an axis between first and second angular positions, the cylinder defining a chamber; loading the object into the chamber when the cylinder is in the first angular position, wherein loading the object into the chamber includes translating the object in a first direction, the first direction being: either transverse or skew to the axis; and launching the object from the chamber when the cylinder is in the second angular position, wherein launching the object from the chamber includes translating the object in a second direction, the second direction being: either transverse or skew to the axis; and either transverse or skew to the first direction. In several embodiments, loading the object into the chamber includes moving a follower to translate the object in the first direction. In several embodiments, launching the object from the chamber

includes moving a foot to translate the object in the second direction. In several embodiments, launching the object from the chamber includes passing the object into a central passageway; and the cylinder is positioned within a housing, the housing defining at least a portion of the central passageway. In several embodiments, rotating the cylinder about the axis between the first and second angular positions includes moving the cylinder using an actuator. In several embodiments, launching the object from the chamber includes passing the object into a central passageway; and the actuator is positioned within a first housing, the first housing defining at least a portion of the central passageway. In several embodiments, the cylinder is positioned within a second housing, the second housing defining at least another portion of the central passageway.

It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.

In several embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some (or all) of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

Any spatial references, such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In several embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.

In several embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word "means" together with an associated function.

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.**

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted.~~Referring to FIG. 1, in an embodiment, an object launching apparatus is diagrammatically illustrated and generally referred to by the reference numeral 100. The object launching apparatus 100 is adapted to efficiently house and deliver objects into a wellbore 105 for various oilfield operations such as, for example, fracturing operations. In this regard, the object launching apparatus 100 can be designed to launch various types of objects desired to be deposited into the wellbore 105 for a particular oil and gas operation; for example, the objects can be "frac" balls or collets used in fracturing operations.

The object launching apparatus 100 includes an object container 110. In some embodiments, as in FIG. 1, the object container 110 is positioned on a bottom plate 115. A container actuator 120 is operably associated with, and adapted to displace, the object container 110. The container actuator 120 facilitates control and motivation of the object container 110 along multiple axes. The container actuator 120 may be, include, or be part of, motor(s), cylinder actuator(s), other actuators powered by electric, pneumatic, or hydraulic power, or any combination thereof. At the same time, one or more position sensors 125 are adapted to detect the position of the object container 110. The position sensor(s) 125 may be, include, or be part of encoder(s), linear position transducer(s), wire potentiometer(s), another transducer capable of translating linear motion into a mechanical or electrical signal, or any combination thereof.

A plunger 130 is operably associated with, and adapted to launch objects from, the object container 110. A plunger actuator 135 is adapted to displace the plunger 130 to launch objects from the object container 110. A release chamber 140 is adapted to receive objects launched from the object container 110. A proximity sensor 145 is adapted to detect a presence of objects within the release chamber 140 (i.e., objects launched from object container 110). In some embodiments, the proximity sensor 145 is a camera. A releasing mechanism 150 is operably associated with, and adapted to release objects from, the release chamber 140.

The object launching apparatus 100 is operably associated with a wellhead 155. The wellhead 155 serves as the surface termination of the wellbore 105. In some embodiments, as in FIG. 1, one or more oil and gas tools 160 such as, for example, the valve apparatus described in U.S. patent application Ser. No. 15/487,785, filed on Apr. 14, 2017 and published under U.S. patent application publication number US 2017/0298708 A1, the entire disclosure of which is hereby incorporated herein by reference, can be operably associated with the wellhead 155. Accordingly, objects released from the release chamber 140 travel into the wellbore 105 only after passing through the one or more oil and gas tools 160 and the wellhead 155.

A controller 165 is adapted to send control signals to the container actuator 120, the plunger actuator 135, and the releasing mechanism 150, and to receive data from the position sensor(s) 125 and the proximity sensor 145. In some embodiments, the controller 165 is embedded in the object launching apparatus 100. In some embodiments, the controller includes software that runs algorithm(s) to precisely control the position of the object container to drop each object in a pre-specified release sequence. A user interface 170 is operably associated with the controller 165. In some embodiments, the user interface 170 is a laptop or touch panel (HMI).

In some embodiments, the controller 165 is further adapted to control the one or more oil and gas tools 160 and/or other tools/components associated with the wellhead 155. To this end, the controller 165 may include input/output capabilities for controlling: one or more valve(s) operably associated with the wellhead 155 and located above or below the object launching apparatus 100; one or more bleed lines operably associated with the wellhead 155; one or more equalizing lines operably associated with the wellhead 155; one or more backside pumps operably associated with the wellhead 155; or any combination thereof. In addition, or instead, the controller 165 can be configured as a slave device that is controlled from another controller or controllers operably associated with the wellhead 155; accordingly, the controller 165 may be configured to accept commands from the controller or controllers associated with the wellhead 155 in a manner similar to the manner in which the controller 165 accepts commands from the user interface 170 (as described below). An example embodiment of such an arrangement together with the corresponding sequence for dropping an object into the wellbore 105 from the object launching apparatus 100 is illustrated in FIG. 2A. Another example embodiment of such

an arrangement together with the corresponding sequence for dropping object(s) into the wellbore 105 from the object launching apparatus 100 is illustrated in FIG. 2B.

Referring to FIGS. 3A-C with continuing reference to FIG. 1, an opening 175 is formed through the bottom plate 115 to permit the objects to pass through the bottom plate 115 and into the wellbore 105. The bottom plate 115 is positioned so that the opening 175 is generally aligned with the one or more oil and gas tools 160, the wellhead 155, and/or the wellbore 105. The bottom plate 115 defines opposing side portions 180 a and 180 b. The release chamber 140 can be at least partially defined by the space within the opening 175 between the opposing side portions 180 a and 180 b. In addition, at least a portion of the release chamber 140 can extend from the side portion 180 b of the bottom plate 115. In an embodiment, as in FIGS. 3A-C, the object launching apparatus 100 can include vertically disposed guiderails 185 supported by the bottom plate 115 to keep the object container 110 on the bottom plate 115. The guiderails 185 can extend from a perimeter portion 180 c of the bottom plate and/or from the side portion 180 a of the bottom plate 115.

The object container 110 includes compartments 190 adapted to contain objects to be launched into the wellbore 105. In some embodiments, each of the compartments 190 is adapted to contain a single object to be launched into the wellbore 105. The object container 110 is movable on the bottom plate 115 to align each of the compartments 190 with the opening 175 so that the object contained therein can be dropped through the opening 175 and into the wellbore 105. In some embodiments, the bottom plate 115 is sized and shaped so that the object container 110 is supported regardless of which compartment 190's object is being released through the opening 175 in the bottom plate 115. Once a particular one of the compartments 190 is aligned with the opening 175, the force of gravity may be sufficient to eject the object through the opening 175 and into the release chamber 140. However, if the force of gravity is not sufficient to eject the object, the plunger 130 can be employed in general alignment with the particular one of the compartments 190 and the opening 175 to push the object into the release chamber 140.

In some embodiments, as in FIGS. 3A-C, the objects are adapted to be contained in the compartments 190 by restraining devices 195. The restraining devices 195 are adapted to prevent, or at least reduce, movement of the objects within the compartment 190 during the oil and gas operation. In some embodiments, as in FIGS. 3A-C, the restraining devices 195 are feather-boards that provide frictional contact on, for example, four sides of the respective objects. In addition, or instead, other suitable restraining devices can be used to prevent, or at least reduce, movement of the objects within the compartments 190.

The compartments 190 can be laid out or oriented in a variety of configurations that allow each one of the compartments 190, and thus the object contained therein, to be aligned with the opening 175 in the bottom plate 115. For example, the layout or orientation of the compartments 190 can be a rectangular pattern, a spiral pattern, a ring pattern, multiple ring patterns, and the like. In an embodiment, the layout or orientation of the compartments 190 is based on a matrix of compartments N×N in number and movable along two primary axes of motion (e.g., x and y). For example, in the embodiment shown in FIGS. 3A-C, a 5×5 matrix of compartments is used to make up the object container, for a total of 25 compartments.

Referring to FIG. 4A with continuing reference to FIG. 1, in an embodiment, the user interface 170 provides the primary interface with the object launching apparatus 100 before and during operation. Before operation, the desired number and size of each object for a particular job can be entered into the user interface 170 and, once so entered, algorithm(s) in the user interface 170 can assign each object to a specified one of the compartments 190 in the object container 110.

This arrangement is then communicated to the operator and the desired objects for the job are loaded into the object container 110, as indicated by arrows 200. Turning to FIG. 4B with continuing reference to FIG. 1, when a desired object is to be released, an operator requests the release via the user interface 170, which request is then sent as a digital message to the controller 165. Once the digital message is received, the software on the controller 165 runs algorithm(s) to generate the appropriate control signals to be sent to the container actuator 120. Upon receiving the control signals, the container actuator 120 moves the object container 110, as indicated by arrows 205, to position the object container 110 at a precise location in which the particular one of the compartments 190 containing the desired object is centered above the opening 175. The controller 165 receives feedback from the position sensor(s) 125 to validate that the particular one of the compartments 190 containing the desired object is in the correct position. Turning to FIG. 4C with continuing reference to FIG. 1, when it is time to release the desired object, the releasing mechanism 150 is opened and, once so opened, either gravity feeds the object downward or, if required, the plunger 130 pushes the object downward, as indicated by arrow 210. The controller 165 receives feedback from the proximity sensor 145 to verify successful release of the desired object and, once so verified, the releasing mechanism 150 is closed. The controller 165 then awaits another message from the user interface 170 to release the next object; in this manner the controlled release sequence can be repeated for all subsequent ones of the compartments 190.

Referring to FIG. 5 with continuing reference to FIG. 1, in certain oil and gas operations, it may be desirable to launch a large number of objects into the wellbore 105. To facilitate the launching of large numbers of objects into the wellbore 105, the object launching apparatus 100 can include a plurality of object containers substantially similar to the object container 110, which substantially similar object containers are given the same reference numeral 110, except that a subscript 1, 2, or N is added to each as a suffix. In some embodiments, as in FIG. 5, the object container 110 1 can include restraining devices substantially similar to the retraining devices 195 while the object containers 110 2-N do not include restraining devices substantially similar to the retraining devices 195. The object containers 110 2-N each have the same number of compartments 190 as the object container 110 1; as a result, the object containers 110 2-N can be stacked or otherwise positioned above the object container 110 1 so that the respective compartments 190 of the object containers 110 2-N are substantially aligned with the respective compartments 190 of the object container 110 1. In addition, to establish or maintain such substantial alignment, the object containers 110 1-N can each be secured to adjacent one(s) of the object containers 110 1-N (or to alignment components) such that each compartment 190 of a particular one of the object containers 110 1-N is in substantial alignment with the corresponding compartment 190 of an adjacent one of the object containers 110 1-N. One or more door elements 215 are operably associated with the compartments 190 of the object containers 110 2-N. The door element(s) 215 may be mechanically, hydraulically, pneumatically, or electrically actuable. More particularly, the door element(s) 215 are openable, as indicated by arrows 220, to drop a corresponding object into an aligned one of the compartments 190 positioned below. Once the object has passed into the compartment 190 positioned below, the door element(s) 215 are closable, as indicated by arrows 225.

The door element(s) 215 can each be or include any type of door element capable of dropping objects into the compartment 190 positioned below. For example, the door element(s) 215 can each be or include a door that pivots open or slides open. For another example, the door element(s) 215 can be actuable by a single action to drop all of the loaded objects from one of

the object containers 110 2-N into the object container 110 1. Accordingly, the door element(s) 215 can include a lattice-type structure located underneath each of the object containers 110 2-N to contain the objects therein. Intersecting portions of the lattice-type structure can be centered under each object during containment. Then, when release of the objects in the one of the object containers 110 2-N is desired, the lattice-type structure is actuated using a single action in the diagonal direction to line up the intersecting portions of the lattice beneath the walls of the one of the object containers 110 2-N; this single action releases all of the objects at once into the object container 110 1.

In operation, in an embodiment, the object container 110 1 is emptied first. Once the object container 110 1 is empty, there is available space for additional objects to be launched. Thus, by actuating the door element(s) 215, the object container 110 2 above can deliver the objects contained therein to the object container 110 1 directly below. In some embodiments, the door element(s) 215 are actuable in a predetermined order to deliver objects to the compartments 190 of the object container 110 1 in a particular sequence. In some embodiments, all of the door element(s) 215 belonging to the object containers 110 2 are simultaneously actuable. In a similar manner, the object container 110 3-N can be emptied in sequence from bottom to top. More particularly, once the object container 110 1 (or at least one of the compartments 190 thereof) is empty, the door element(s) 215 are opened so that the objects contained in the object container 110 2 drop into the object container 110 1 (or into the at least one of the compartments 190 thereof). In addition, when the object containers 110 1 and 110 2 (or at least respective ones of the substantially aligned compartments 190 thereof) are empty, the door element(s) 215 are opened so that the objects contained in, for example, the object container 110 N drop into the object container 110 2 and then into the object container 110 1 (or into the at least respective ones of the substantially aligned compartments 190 thereof). In some embodiments, it is possible to leave all of the door element(s) 215 open after each drop sequence so that subsequently released objects drop directly through all of the compartments 190 positioned below; but some objects may be heavy and/or fragile, therefore a controlled drop (i.e., stopping in each of the object containers 110 1, 110 2, etc.) can be used.

Referring to FIG. 6, a method of operating the object launching apparatus 100 is diagrammatically illustrated and generally referred to by the reference numeral 230. The method 230 is carried out by receiving, at the controller 265, data from the position sensor(s) 125, the proximity sensor 145, or any combination thereof, and sending, from the controller 265, control signals to the container actuator 120, the plunger actuator 135, the releasing mechanism 150, or any combination thereof. More particularly, the method 230 includes: at a step 235 receiving from the position sensor(s) 125, using the controller 165, data relating to a detected position of the object container 110 1; at a step 240 sending, using the controller 165 and based on at least the data received from the position sensor(s) 125, control signals to the container actuator 120, said control signals causing the container actuator 120 to displace the object container 110 1 to sequentially align respective ones of the object container 110 1's compartments 190 with the opening 175 so that objects loaded into respective ones of the object container 110 1's compartments 190 are sequentially launched through the opening 175 and into the wellbore 105; at a step 245 receiving from the proximity sensor 145, using the controller 165, data relating to a detected presence of sequentially received ones of the launched objects within the release chamber 140; at a step 250 sending, using the controller 165 and based on at least the data received from the proximity sensor 145, control signals to the releasing mechanism 150, said control signals causing the releasing mechanism 150 to sequentially release objects from the

release chamber 140 and into the wellbore 105; and at a step 255 sending, using the controller 165, control signals to the door element(s) 215 of at least one of the object containers 110 2-N, said control signals causing the door element(s) 215 to sequentially release objects loaded in respective ones of the at least one of the object containers 110 2-N's compartments 190 into the respective ones of the object container 110 1's compartments 190. In some embodiments, the method 230 further includes sending, using the controller 165, control signals to the plunger actuator 135, said control signals causing the plunger actuator 135 to displace the plunger 130 to eject objects from the respective ones of the object container 110 1's compartments 190 so that the objects are launched through the opening 175 and into the wellbore 105.

In some embodiments, among other things, the operation of the object launching apparatus 100 and/or the execution of the method 230: facilitates more efficient and cost effective well fracturing strategies; provides an array of balls, collets, or other to-be-launched objects in a housing that can be automated to deliver each of these objects in a specified sequence to the wellbore 105; and maintains the array of balls, collets, or other to-be-launched objects in the housing in a dry and low-pressure environment.

Referring to FIG. 7, in an embodiment, a computing node 1000 for implementing one or more embodiments of one or more of the above-described elements, controllers (e.g., 165), user interfaces (e.g., 170), apparatus (e.g., 100), methods (e.g., 230) and/or steps (e.g., 235, 240, 245, 250, and/or 255), or any combination thereof, is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In ~~one or more~~several embodiments, the storage device 1000 c ~~may~~can include a floppy drive, hard drive, CD-ROM, optical drive, any other form of storage device ~~and/~~or any combination thereof. In ~~one or more~~several embodiments, the storage device 1000 c ~~may~~can include, and/or be capable of receiving, a floppy disk, CD-ROM, DVD-ROM, or any other form of ~~non-transitory~~ computer-readable medium that ~~may~~can contain executable instructions. In ~~one or more~~several embodiments, the communication device 1000 g ~~may~~can include a modem, network card, or any other device to enable the node 1000 to communicate with other ~~node(s).~~nodes. In ~~one or more~~several embodiments, ~~the~~any node ~~and the other node(s) represent~~represents a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.

In ~~one or more~~several embodiments, one or more of the ~~embodiments~~ components of any of the above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In ~~one or more~~several embodiments, one or more of the above-described components of the node 1000 and/or the ~~embodiments~~ above-described ~~above and/or illustrated in FIGS. 1A through 19B~~systems include respective pluralities of same components.

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more~~

~~embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more~~In several embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In ~~one or more~~several embodiments, a computer system ~~may~~can include hybrids of hardware and software, as well as computer sub-systems.

In ~~one or more~~several embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, personal digital assistants (PDAs), or personal computing devices (PCDs), for example). In ~~one or more~~several embodiments, hardware ~~may~~can include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In ~~one or more~~several embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.

In ~~one or more~~several embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD~~-~~ ROM, for example). In ~~one or more~~several embodiments, software ~~may~~can include source or object code. In ~~one or more~~several embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.

In ~~one or more~~several embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions ~~may~~can be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.

In ~~one or more~~several embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure ~~may~~can be embodied in the RAM of a computer to transform a standard computer into a new specific computing machine. In ~~one or more~~several embodiments, data structures are defined organizations of data that ~~may~~can enable an embodiment of the present disclosure. In an embodiment, ~~a~~ data structure ~~may~~can provide an organization of data, or an organization of executable code.

In ~~one or more~~several embodiments, any networks and/or one or more portions thereof ~~may~~, can be designed to work on any specific architecture. In an embodiment, one or more portions of any networks ~~may~~can be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.

In ~~one or more~~several embodiments, ~~a~~ database ~~may~~can be any standard or proprietary database software. In ~~one or more~~several embodiments, the database ~~may~~can have fields, records, data, and other database elements that ~~may~~can be associated through database specific software. In ~~one or more~~several embodiments, data ~~may~~can be mapped. In ~~one or more~~several embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In ~~one or more~~several embodiments, the physical location of the database is not limiting, and the

database ~~may~~can be distributed. In an embodiment, the database ~~may~~can exist remotely from the server, and run on a separate platform. In an embodiment, the database ~~may~~can be accessible across the Internet. In ~~one or more~~several embodiments, more than one database ~~may~~can be implemented.

In ~~one or more~~several embodiments, a plurality of instructions stored on a computer readable medium ~~may~~can be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part ~~one or more of~~ the ~~embodiments~~above-described operation of ~~one or more~~each of the ~~controller(s)~~above-described elements, controllers (e.g., ~~the controller 156), element(s~~165), user interfaces (e.g., 170), apparatus~~, system(s) (e.g., the hydraulic fracturing system 100), method(s)~~ (e.g., ~~the method 175, the method 270, or both), step(s),~~100), methods (e.g., 230) and/or ~~sub-step(s~~steps (e.g., 235, 240, 245, 250, and/or 255), or any combination thereof~~, described above and/or illustrated in FIGS. 1A through 19B.~~. In ~~one or more~~several embodiments, such a processor ~~may~~can include one or more of the microprocessor 1000 a, any processor(s) that are part of the components of the ~~hydraulic fracturing system 100, such as, for example, the controller 156~~above-described systems, and/or any combination thereof, and such a computer readable medium ~~may~~can be distributed among one or more components of the ~~system.~~above-described systems. In ~~one or more~~several embodiments, such a processor ~~may~~can execute the plurality of instructions in connection with a virtual computer system. In ~~one or more~~several embodiments, such a plurality of instructions ~~may~~can communicate directly with the one or more processors, and/or ~~ay~~can interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further~~

~~includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second~~

~~well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the~~

~~second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

An apparatus for launching objects into a wellbore has been disclosed. The apparatus generally includes a first object container including first compartments; and a container actuator adapted to displace the first object container so that respective ones of the first compartments are sequentially aligned with an opening; wherein, when the respective ones of the first compartments are sequentially aligned with the opening, objects loaded into the respective ones of the first compartments are sequentially launchable through the opening and into the wellbore.

The foregoing apparatus embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:

The first object container further includes restraining devices adapted to prevent, or at least reduce, movement of objects loaded within the first compartments.

The apparatus further includes a bottom plate into which the opening is formed, the bottom plate supporting the object container and being operably associated with a wellhead, and the wellhead serving as a surface termination of the wellbore.

The bottom plate is sized and shaped to support the first object container regardless of which one of the first compartments is aligned with the opening.

The apparatus further includes a release chamber adapted to sequentially receive the objects when the objects are sequentially launched through the opening; a proximity sensor adapted to detect a presence of each object sequentially received within the release chamber; and a releasing

mechanism adapted to sequentially release objects from the release chamber and into the wellbore.
The apparatus further includes a plunger; and a plunger actuator adapted to displace the plunger to eject loaded objects from the respective ones of the first compartments so that the loaded objects are launched through the opening and into the wellbore.
The apparatus further includes a second object container including second compartments, the second object container being positionable above the first object container so that the respective second compartments are aligned with the respective first compartments; wherein, when the respective ones of the first compartments are sequentially aligned with the opening, objects loaded into respective ones of the second compartments are sequentially launchable through the respective ones of the first compartments, through the opening, and into the wellbore.
The second object container further includes one or more door elements adapted to sequentially release the objects loaded in the respective ones of the second compartments into the respective ones of the first compartments.
A method for launching objects into a wellbore has also been disclosed. The method generally includes receiving from a position sensor, using a controller, data relating to a detected position of a first object container, the first object container including first compartments; and based on at least the data received from the position sensor, sending, using the controller, control signals to a container actuator, said control signals causing the container actuator to displace the first object container to sequentially align respective ones of the first compartments with an opening so that objects loaded into the respective ones of the first compartments are sequentially launched through the opening and into the wellbore.
The foregoing method embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:
The method further includes preventing, or at least reducing, movement of objects loaded within the first compartments using restraining devices of the first object container.
The method further includes supporting the object container with a bottom plate into which the opening is formed, the bottom plate being operably associated with a wellhead, and the wellhead serving as a surface termination of the wellbore.
The bottom plate is sized and shaped to support the first object container regardless of which one of the first compartments is aligned with the opening.
The method further includes receiving from a proximity sensor, using the controller, data relating to a detected presence of sequentially received objects within a release chamber; and based on at least the data received from the proximity sensor, sending, using the controller, control signals to a releasing mechanism, said control signals causing the releasing mechanism to sequentially release objects from the release chamber and into the wellbore.
The method further includes sending, using the controller, control signals to a plunger actuator, said control signals causing the plunger actuator to displace a plunger to eject loaded objects from the respective ones of the first compartments so that the loaded objects are launched through the opening and into the wellbore.
A second object container including second compartments is positioned above the first object container so that the respective second compartments are aligned with the respective first compartments; and, when the respective ones of the first compartments are sequentially aligned with the opening, objects loaded in respective ones of the second compartments are sequentially launchable through the respective ones of the first compartments, through the opening, and into the wellbore.

The second object container further includes one or more door elements; and the method further includes sending, using the controller, control signals to the one or more door elements, said control signals causing the one or more door elements to sequentially release the objects loaded in the respective ones of the second compartments into the respective ones of the first compartments.

Another apparatus has also been disclosed. The another apparatus generally includes a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, the plurality of instructions including: instructions that, when executed, cause the one or more processors to receive from a position sensor, using a controller, data relating to a detected position of a first object container, the first object container including first compartments; and instructions that, when executed, cause the one or more processors to send, using the controller and based on at least the data received from the position sensor, control signals to a container actuator, said control signals causing the container actuator to displace the first object container to sequentially align respective ones of the first compartments with an opening so that objects loaded into the respective ones of the first compartments are sequentially launched through the opening and into a wellbore.

The foregoing apparatus embodiment may include one or more of the following elements/limitations, either alone or in combination with one another:

The plurality of instructions further includes instructions that, when executed, cause the one or more processors to receive from a proximity sensor, using the controller, data relating to a detected presence of sequentially received objects within a release chamber; and instructions that, when executed, cause the one or more processors to send, using the controller and based on at least the data received from the proximity sensor, control signals to a releasing mechanism, said control signals causing the releasing mechanism to sequentially release objects from the release chamber and into the wellbore.

The plurality of instructions further includes instructions that, when executed, cause the one or more processors to send, using the controller, control signals to a plunger actuator, said control signals causing the plunger actuator to displace a plunger to eject loaded objects from the respective ones of the first compartments so that the loaded objects are launched through the opening and into the wellbore.

A second object container including second compartments is positioned above the first object container so that the respective second compartments are aligned with the respective first compartments, the second object container further including one or more door elements; when the respective ones of the first compartments are sequentially aligned with the opening, objects loaded in respective ones of the second compartments are sequentially launchable through the respective ones of the first compartments, through the opening, and into the wellbore; and wherein the plurality of instructions further includes instructions that, when executed, cause the one or more processors to send, using the controller, control signals to the one or more door elements, said control signals causing the one or more door elements to sequentially release the objects loaded in the respective ones of the second compartments into the respective ones of the first compartments.

It is understood that variations ~~may~~can be made in the foregoing without departing from the scope of the present disclosure.

In ~~several~~some embodiments, the elements and teachings of the various embodiments ~~may~~can be combined in whole or in part in some ~~(~~or all~~)~~ of the embodiments. In addition, one or more of the

elements and teachings of the various embodiments ~~may~~can be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.

Any spatial references, such as, for example, “upper,” “lower,” “above,” “below,” “between,” “bottom,” “vertical,” “horizontal,” “angular,” “upwards,” “downwards,” “side-to-side,” “left-to-right,” “right-to-left,” “top-to-bottom,” “bottom-to-top,” “top,” “bottom,” “bottom-up,” “top-down,” etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

In ~~several~~some embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures ~~may~~can also be performed in different orders, simultaneously and/or sequentially. In ~~several~~some embodiments, the steps, processes, and/or procedures ~~may~~can be merged into one or more steps, processes and/or procedures.

In ~~several~~some embodiments, one or more of the operational steps in each embodiment ~~may~~can be omitted. Moreover, in some instances, some features of the present disclosure ~~may~~can be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations ~~may~~can be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.

Although ~~several~~some embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. ~~In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word “means” together with an associated function.~~

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or~~

~~more embodiments, the controller 156 includes a plurality of controllers, with one or more controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.~~

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In one or more embodiments, the storage device 1000 c may include a hard drive, CD-ROM, optical drive, any other form of storage device and/or any combination thereof. In one or more embodiments, the storage device 1000 c may include, and/or be capable of receiving, a CD-ROM, DVD-ROM, or any other form of non-transitory computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device 1000 g may include a modem, network card, or~~

~~any other device to enable the node 1000 to communicate with other node(s). In one or more embodiments, the node and the other node(s) represent a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In one or more embodiments, one or more of the above-described components of the node 1000 and/or the embodiments described above and/or illustrated in FIGS. 1A through 19B include respective pluralities of same components.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.~~

~~In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.~~

~~In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD-ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.~~

~~In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.~~

~~In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a~~

~~new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment, a data structure may provide an organization of data, or an organization of executable code.~~

~~In one or more embodiments, any networks and/or one or more portions thereof may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.~~

~~In one or more embodiments, a database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.~~

~~In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B. In one or more embodiments, such a processor may include one or more of the microprocessor 1000 a, any processor(s) that are part of the components of the hydraulic fracturing system 100, such as, for example, the controller 156, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the system. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ay interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.~~

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid~~

~~communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the~~

~~following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory~~

~~computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.~~

~~In several embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some (or all) of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.~~

~~Any spatial references, such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.~~

~~In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In several embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.~~

~~In several embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.~~

~~Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word "means" together with an associated function.~~

FIG. 1 is a schematic diagram of an example well site 1 arranged for fracking. The well fracking site 1 includes tanks 2. The tanks 2 hold fracking fluids, proppants, and/or additives that are used during the fracturing process. The tanks 2 are fluidically coupled to one or more blenders 3 at the well site 1 via fluid lines (e.g., pipes, hoses, and/or other types of fluid lines). The blenders mix the fracking fluids, proppants, and/or additives being used for the fracking operation prior to being pumped into the well 4. The blenders are fluidically coupled to one or more fracking pumps 5 via lines. The fracking pumps increase the pressure of the blended fracking fluid to fracking pressure (i.e., the pressure at which the target formation fractures) for injection into the well 4. A data van 6 is electronically connected to the tanks 2, the blenders 3, the well 4, and the fracking pumps 5. The data van 6 includes a controller that controls and monitors the various components at the well site 1. While a variety of components have been described in the example well site 1, not all of the described components need be included. In some implementations, additional equipment may be included. Also, the well 4 can be an onshore or offshore well. In the case of an offshore well, including subsea wells and wells beneath lakebeds or other bodies of water, the well site 1 is on a rig or vessel or may be distributed among several rigs or vessels. During fracking operations, various components are stacked atop the well 4. FIGS. 2A-2C illustrate, at various stages of operation, an example fracturing stack 200 attached at a wellhead of the well 4. FIG. 2A shows a fracturing stack 200 with a lubricator 202 positioned at the top. The lubricator 202 carries a wireline or coiled tubing deployed tool above a tool trap of or associated with the lubricator. The tool trap has an internal flapper that is actuable in response to

a signal (e.g., hydraulic, electric, and/or other signal) to gate passage of the tool from the lubricator. The lubricator is a tool that maintains a seal around the wireline or coiled tubing while the tool is being run into the well 4. In the present example, the lubricator 202 internally carries a perforating string, including one or more perforating guns for perforating the wall of the wellbore (open hole or cased) and, often, a positioning tool, such as a casing collar locator and/or logging tool. In other examples, the lubricator 202 can carry other types of tool strings, such as logging tools, packoff tools, and other types of wireline or tubing deployed tools.

The lubricator 202 sits above a blowout preventer (BOP) 204. The BOP 204 is configured to seal off the well in the event of a kick or blowout. The BOP 204 is able to shear any tool or conveyance (e.g., tubing or wireline) that may be positioned within the well during such an event. An automated connector or latch 206 is below the BOP 204. The latch 206 operates in response to a signal (e.g., hydraulic, electric, and/or other) to grip and seal to (i.e., latch to) or open and release a mating hub. By providing the mating hub on the BOP 204, the latch 206 acts as a quick release that allows the BOP 204 and lubricator 202 to be installed and removed quickly without intervention of a worker, for example, to access and bolt/unbolt the BOP 204 from the remainder of the fracturing stack 200. In some instances, the latch 206 can be omitted from the fracturing stack 200 and the BOP bolted/unbolted from the remainder of the stack. The latch 206 can be above a valve assembly 10.

A valve assembly 10 is below the latch 206. The valve assembly 10 can include a single or dual part body. The valve assembly 10 is actuable in response to a signal (e.g., hydraulic, electric and/or other) to isolate or seal the well (i.e., seal the bore through the fracturing stack 200) from any components positioned above the valve assembly 10, such as the lubricator 202, BOP 204, or the atmosphere 208. Structural details of the valve assembly 10 are described in greater detail later within this disclosure. Below the valve assembly 10 is a fracturing manifold 210, sometimes referred to as a goat head or frac head. The fracking pumps 5 are fluidically connected by lines to the fracturing stack 200 through the frac head 210. In certain instances, a swab valve 212 can be provided above or below the frac head 210 that can be used to isolate/access the well, for example for maintenance. Below the swab valve 212 are wing valves 214. The wing valves 214 can be used for a variety of wellbore operations, such as purging the well 4. Below the wing valves are one or more main valves 216 configured to seal the well 4, including as the fracturing stack 200 is assembled, disassembled, and/or maintained. While a variety of components have been described in the fracturing stack, not all of the described components need be included. In some implementations, additional equipment, such as additional main valves 216, may be included. Also, although shown as separate components, two or more of the components of the fracturing stack 200 could be integrated. For example, in certain instances, the frac head 210 and valve assembly 10 may be integrated together, e.g., constructed with a common housing or otherwise configured to attach/detach from the fracturing stack 200 as a unit. Other combinations of components could likewise be integrated.

The valve assembly 10, when closed, seals to maintain pressure on and below the frac head 210 and any equipment fluidically connected to the frac head 210, for example the fracking equipment at the well site 1, including pumps 5, the blenders 3, and any lines fluidically connecting such equipment. Such isolation allows the BOP 204 and lubricator 202 to be removed, reinstalled, or maintained without depressurizing the well 4 or fracturing equipment on the well site 1. As explained in more detail below, such isolation also allows the top of the fracturing stack 200 to be opened and accessed at atmospheric conditions, for example, to insert a tool on wireline or tubing or a well drop (e.g., frac ball, collet, dart, or other) or other item into

the well 4. Every time the fracturing stack 200 and fracturing equipment at the well site 1 is depressurized, it needs to be re-pressure tested prior to commencing operations. In some instances, this can take several hours, and in multi-stage fracturing, cumulatively days. In multi-stage fracturing operations, where equipment is added and removed from the top of the fracturing stack 200 multiple times, maintaining pressure on the system between operations can save several days at a well site.

FIG. 2B shows a cross-sectional view of the fracturing stack 200. Once assembled, the fracturing stack has a central flow path, or main bore, extending through the center of the stack. The frac head 210 includes lateral fluid injection paths 218 where the fracking pumps 5 are fluidically connected for injecting frac fluids into the main bore and, in turn, into the well 4 during a fracturing treatment. The valve assembly 10 sits above the frac head 210 and includes two valves capable of sealing, i.e., isolating, the frac head 210 and fracturing stack 200 below from any equipment located above the valve assembly 10. For example, fracturing stack 200 can be pressurized and leak tested for perforation operations. In such a situation, the BOP 204 and lubricator 202 are installed to lower the perforating string into the wellbore. After the perforation operation is complete, a frac ball can be dropped into the well. In such an instance, the valve assembly 10 is closed and all of the components above the valve assembly are depressurized. In some instances, the BOP may remain in place. In other instances, the BOP can be removed, such as in FIG. 2C. In either instance, the fracturing stack 200 is still pressurized below the valve assembly 10.

After the well 4 is completed, or in a workover operation of the well 4, the fracturing stack 200 is used in fracturing the subterranean formation surrounding the well 4. While more details of the operation of the fracturing stack 200 will be described below, in general, in a fracturing operation, fracturing fluids containing proppant are pumped to the frac head 210 from the blenders 3 and pumps 5 at the well site 1. The fracturing stack 200 can be in either configuration of FIG. 2A or 2C and valve assembly 10 is closed, sealing the central bore of the fracturing stack 200 above the fracturing head 210. The fracturing fluids pass into the frac head 210, down the central bore of the fracturing stack 200 and the well 4, and out of a perforated or slotted interval of the well 4 into the subterranean formation. The fracturing fluids are at fracturing pressure, meaning the rate and pressure of the fracturing fluids are so high as to cause the subterranean formation at that interval to expand and fracture.

In a multi-stage fracturing operation, the well 4 is perforated and then fracked in another interval. A lubricator 202 containing a perforating string is used in conducting the perforating operation. If, upon completion of the first stage fracturing, the fracturing stack 200 is configured as in FIG. 2C without a lubricator 202, the latch 206 is operated to receive the BOP 204 with the lubricator 202 as shown in FIG. 2A. The valve assembly 10 is then used (as discussed in more detail below) to bring the BOP 204 and lubricator 202 up to pressure without needing to lower the pressure in the fracturing stack 200 below the fracturing head 210. The perforating string can then be lowered through the valve assembly 10 into the well 4, and operated to perforate the wall of the wellbore at another specified interval. The perforating string is withdrawn back to the lubricator 202 and the valve assembly 10 closed to isolate the lubricator 202 from pressure in the remaining portion of the fracturing stack 200.

The valve assembly 10 is then used (as described in more detail below) to depressurize a top portion of the fracturing stack 200 for removing the lubricator 202 from the fracturing stack 200 (resulting in the configuration of FIG. 2C) and in introducing a well drop from atmospheric conditions in the environment surrounding the fracturing stack 200 into the center bore of the

well 4 without needing to lower the pressure in the fracturing stack 200 below the valve assembly 10 or in the surface equipment (e.g., blenders, frack pumps, associated lines, and/or other surface equipment). The well drop can be released using a launcher (e.g., a single or multi ball, collet, dart launcher, and/or another type of launcher) on the fracturing stack 200 or by hand, manually inserting the well drop into the top of the stack 200 above the valve assembly 10. When released from the valve assembly 10, the well drop travels through the well 4, landing on a specified profile internal to the well 4 to isolate the fractured interval from the remaining portion of the well, for example, by shifting a frac sleeve or sealing off the central bore. Once the fractured interval is isolated, the next fracturing stage is begun.

FIGS. 3A-3B are perspective views of an example connector 302, which can be used as latch 206, shown closed/engaged (FIG. 3A) and open/disengaged (FIG. 3B). The connector 302 is actuable in response to a signal (e.g., hydraulic, electric and/or other) to secure (i.e., lock) a tool to the fracturing stack 200 as well as any tools and other stack components positioned above the connector 302, such as the lubricator 202 or BOP 204. The connector 302 includes a housing 304. The housing 304 carries a drive ring 306 that is rotatable relative to the housing 304. The housing 304 receives a first well stack tool 310 and a second well stack tool 312, such that the housing is positioned around the tools 310, 312. In certain instances, the first tool 310 is the valve assembly 10, while the second tool 312 is the BOP 204, a ball or stick launcher, the wireline lubricator 202, or another well device. As illustrated, the drive ring 306 protrudes outward from an outer perimeter of the housing 304. One or more clamps 308 (six are shown—each defining an arc segment of a circle) are within the housing to clamp to the tools 310, 312. Each clamp 308 includes an attachment end 308 a and a clamping end 308 b. The clamp 308 is moveable between an engaged position (FIG. 3A) and a disengaged position (FIG. 3B). In the engaged position, the clamp 308 engages the second well tool 312 by the clamping end 308 b. In the disengaged position, the clamp 308 allows the well tool to become unrestrained from the connector 302.

A linkage 402 is coupled to the drive ring 306, the housing 304, and the clamp 308. The linkage 402 is moveable between a first position supporting the clamp in the engaged position (FIG. 3A) and a second position supporting the clamp in the disengaged position (FIG. 3B). The linkage 402 is movable between the first position and the second position by rotating the drive ring 306.

FIGS. 4A-4B are top-views of the example connector of FIGS. 3A-3B. As illustrated, the connector has multiple linkages, one for each clamp. In some implementations, additional or fewer clamps and linkages can be used. In general, the linkages are configured to move concurrently with one another. For example, the linkages 402 are shown as all being coupled to the same drive ring 306.

Each of the linkages includes a first arm 404 with a first end 404 a and a second end 404 b. The first end 404 a of the first arm 404 is hingedly coupled to the housing 304. That is, the first end 404 a of the first arm 404 has a single degree of freedom to rotate about a pivot point fixed to the housing 304. This single degree of freedom is in the same plane as the drive ring 306. A second arm 406 has a first end 406 a and a second end 406 b. The first end 406 a of the second arm 406 is hingedly coupled to the drive ring 306. That is, the first end 406 a of the second arm 406 has a single degree of freedom to rotate about a pivot point fixed to the drive ring 306. This single degree of freedom is in the same plane as the drive ring 306. The second end 406 b of the second arm 406 is hingedly coupled to the second end 404 b of the first arm 404. The clamp 308 is coupled to the second end 404 b of the first arm 404 and the second end 406 b of the second arm

406. The attachment end 308 a of the clamp 308 is coupled to the second end 404 b of the first arm 404 and the second end 406 b of the second arm 406.

The drive ring 306 is coupled to an actuator 408 configured to operate in response to a signal. In some implementations, the actuator 408 is a rotary actuator. In such instance, the drive ring 306 can include multiple teeth on an outer circumference of the drive ring 306. The teeth can engage with a pinion gear on the rotary actuator 408, which the rotary actuator 408 rotates to drive rotation of the drive ring 306. In some implementations, the drive ring 306 can be coupled to a separate drive gear surrounding the first wellbore tool 310 or the second wellbore tool 312. The separate drive gear can then be coupled to the actuator 408. In some implementations, a chain drive can be used to connect the actuator gear to the drive ring or the drive gear. In some implementations, all or part of the gearing system may be retained and protected within the housing 304. In some implementations, the actuator 408 can be a linear actuator. In such an implementation, the actuator is attached directly to the drive ring 306 by a linkage, such that when the actuator 408 extends, linearly, it rotates the drive ring 306.

FIG. 5 is a side cross-sectional view of an example connector in the closed position. The first well tool 310, the second well tool 312, and the housing 304 are aligned on a common center axis 502, and the tool 312 has a male stab 514 that is received and sealed in a female receptacle 512 of tool 310 (or vice versa). FIG. 5 shows a pair of axially spaced apart seals 516 a, 516 b in the female receptacle 512 of the tool 310, but in other instances the seals could be provided on the tool 312. Also, the seals 516 a, 516 b need not be in the female receptacle 512 and could be provided on the male stab 514 (and on whichever tool has the male stab). A pressure test port 518 extends from the exterior of the bore through the tools 312, 310 to a location intermediate the seals 516 a, 516 b, to pressure test the sealing. In other words, fluid to supplied (e.g., pumped) into the space between the seals 516 a, 516 b and held at a test pressure for specified period of time, monitoring for leaks. In certain instances, the test pressure is above the pressures expected during the completion.

The drive ring 306 is rotatable about the common center axis 502. As illustrated, the first well tool 310 and the second well tool 312 have hubs 508 a, 508 b at their ends that form a male profile 504 when mated together and the first well tool 310 stabs into the second. The clamps 308 each have a female profile 506 shaped to receive the male profile 504. The combination of profiles allows the connector to lock the first well tool 310 and the second well tool 312 together, as the female profile 506 axially bounds the male profile 504—holding the two tools 310, 312 axially together—and the clamps 308 circumferentially enclose the male profile 504—laterally holding the two tools 310, 312 together.

In some implementations, a pressure port through a sidewall of either the first tool 310 or the second tool 312 communicates to the interior bore of the tools 310, 312. A pressure sensor connected at this pressure port can sense the pressure within the interior bore of the tools 310, 312.

As shown in FIG. 6, the latch 302 can include one or more bumpers or stops 510 to limit the motion of the clamps 308. The stops 510 are affixed to the housing 304 and are positioned relative to each clamp 308 such that when the clamp 308 is fully disengaged from the tools 310, 312 the clamp 308 abuts the stops 510. The stops 510 align the clamp 308 relative to the center axis 502, with the center of the clamp's arc segment being near or at the center axis 502. The stops 510 can be secured to the housing 304 in a variety of ways, such as being fastened to a top cover (not shown) of the housing 304. In some implementations, two soft stops 510 are used for each clamp, but additional or fewer stops can be used.

FIG. 7 illustrates a side perspective view of the connector 302 with a top mounted guide cone 602 that funnels the second tool 312 to align on the center axis 502 as it is stabbed into the guide cone 602 and then into the first tool 310.

FIG. 7 also shows a system of proximity sensors 604 to detect the open/closed/intermediate state of the connector 302. The proximity sensors 604 are mounted on the housing 304 to sense the position of a corresponding magnet 608 affixed to the drive ring 306. When the drive ring 306 is rotated to engage the clamps to the first and second tool 310, 312, the magnet 608 is adjacent to one proximity sensor 604 and when the drive ring 306 is rotated to disengage the clamps, the magnet 608 is adjacent to the opposing proximity sensor 604. As discussed below, a controller can determine the state of the latch using the proximity sensors 604 and, in turn, operate an electronic interlock.

FIG. 7 also shows a drain assembly 606 that extends through the side of the housing 304. The drain assembly 606 protrudes into the bore of the connector 302 to be in fluid communication with the bores of the first and second tools 310, 312, and can be actuated open to drain fluid from the bore or actuated closed to seal against draining fluid. In certain instances, fluid can also be supplied (e.g., pumped) through the drain assembly 606 into the bores of the first and second tools 310, 312 to provide fluid into the bores (e.g., after the bores have been drained).

FIGS. 8A-8B are a perspective view and a half cross-sectional view, respectively, of an example drain assembly 606. The example drain assembly includes a drain valve 702 and a hydraulic interlock 704. The hydraulic interlock 704 includes a push button valve 703—a type of valve with a hydraulic input 706, a hydraulic output 708 and a valve state push button 710 that, when pushed in, opens the valve to pass fluid between the input 706 and output 708 and that, when not pushed in, seals against passage of fluid between the input 706 and output 708. In use, the valve 702 is connected between the hydraulic pump or other source that would, in other circumstances, supply hydraulic pressure to power a hydraulic-driven, drive ring actuator used to operate the connector 302. Thus, the hydraulic input 706 is connected to the output of the hydraulic pump while the hydraulic output 708 is connected to return hydraulic fluid to the pump and/or to a fluid source. A hydraulic drive ring actuator (e.g., actuator 408 of FIG. 4A) is connected to the output of the hydraulic pump to receive pressure from the pump. The valve state button 710 interacts with a tab 712 on the drain valve 702. When the drain valve 702 is in a closed position, the tab 712 abuts and presses against the valve state button 710. The pressure applied by the tab 712 on the valve state button 710, pushes the button 710 in and puts the valve in an open state. In the open state, hydraulic fluid is allowed to pass from the input 706 to output 708, bypassing the drive ring actuator. In this state, the actuator for the drive ring receives no significant pressure from the pump and the connector 302 is locked out and cannot operate to open. When the drain valve 702 is in an open position, the tab 712 is moved from the valve state button. The valve state button 710 is allowed to protrude outward, and the valve 703 moves to a closed state. In the closed state, hydraulic fluid cannot pass between input 706 and output 708, thus directing all of the pump pressure onward to drive the drive ring actuator. In this state, the actuator for the drive ring is able to receive hydraulic pressure and can be operated to open. In some implementations, an electrical proximity sensor 714 can be included to signal a state of the drain valve 702, the hydraulic interlock 704, or both.

Referring to FIG. 8B, the operation of the drain valve 702 is described. An end portion of the drain valve 702 is inserted through an aperture in the sidewall of the housing 304 of connector 302, so that a plunger 758 of the valve 702 is in the bore of the housing. The outer surface of the drain valve 702 has seals 764 that seal to the inner diameter of the aperture, sealing the drain

valve 702 to the housing. The drain valve 702 is secured to the housing 304 with threads 760. When the drain valve 702 is in a closed position (as illustrated), the plunger rests on a seat 762. The seat 762 seals against passage of fluid into an interior cavity 768 of the valve 702. The seat 762 can be a metal-to-metal seat, an elastomer seat, or another type of seat. When the drain valve 702 is in an open position, the plunger 758 is moved apart from the seat 762 by the valve stem 756. Separating the plunger 758 from the seat 762 allows fluid to flow from the central bore of the housing 304, through the cavity 768 to an outlet 770. The movement of the valve stem 756 to open/close the plunger 758 is controlled by an actuator. In FIG. 8B, the actuator is a hydraulic actuator that includes a pressure inlet 750 configured to be connected to a hydraulic source, such as the hydraulic pump connected to the valve of the interlock 704 or another source, and which itself may have a control valve to gate pressure to the inlet 750. The pressure inlet 750 is fluidically connected to a spring-loaded piston 752 affixed to the valve stem 756. When pressure is applied through the inlet 750, it acts on the piston 752 driving it toward the right in FIG. 8B. The piston 752, in turn, also drives the valve stem 756 to the right, opening the valve 702 by moving the plunger 758 off the seat 762. The spring-loaded piston is biased to the left in FIG. 8B, so as to cause the valve 702 to "fail closed." That is, when there is no hydraulic pressure at the pressure inlet 750, the spring 754 of the spring-loaded piston 752 will force the drain valve 702 into the closed position shown in FIG. 8B.

Although described with the hydraulic interlock above, other configurations are possible. For example, the hydraulic interlock can be actuated when the drain valve 702 is moved to the open position. In another example, the connector 302 can be alternatively or additionally implemented with an electronic interlock. For example, a controller (e.g., controller 51) can monitor pressure in the central bore (e.g., via a pressure sensor in port 508 or elsewhere). If pressure above a threshold pressure is sensed in the bore, the controller can refuse to actuate the connector 302 to open (e.g., refuse to signal actuator 408 to operate) until the pressure drops below the threshold pressure.

Turning now to FIG. 9, FIG. 9 is an example side cross-sectional view of an example valve assembly 10. It includes a first valve body 58 coupled to a second valve body 68 by a flanged connection. However, in other instances, the valve bodies could be coupled by another type of connection or could be formed as a single, integral one piece unit. The top and bottom of the valve assembly 10 are also flanged to facilitate connecting the valve assembly 10 in-line in the fracturing stack, but other types of connections could be used.

In this example, the valve assembly 10 is a full bore valve. In other words, the main, central bore through the valve is the same diameter, without intruding obstructions, as the main, central bore through the remainder of the fracturing stack, so that tooling can pass easily through the valve assembly 10 without obstruction.

In the illustrated implementation, the first actuator rod 72 and the second actuator rod 80 are positioned outside of the center bore of the valve assembly. This arrangement enables the flappers 52, 62 and their corresponding pivot arms 54, 64 to retract into corresponding side cavities of the valve assembly 10 when the flappers are open, so as to reside completely out of the center bore when open. In this implementation, the first rod 72 and the second rod 80 are directly connected to the first pivot arm 54 and the second pivot arm 64, respectively. The direct connection further provides a compact configuration that facilitates containment of the flappers 52, 62 and pivot arms 54, 64 out of the bore. For ease of construction and maintenance, the valve assembly 10 can include side openings capped by blind flanges 902 sealed and affixed to the valve bodies 58, 68. The blind flanges 902 can be installed and removed easily to facilitate

access to the flappers 52, 62 and pivot arms 54, 64 during construction or maintenance. Pressure sensors 38 can be provided in fluid communication with the operating volumes for measuring the pressure in each operating volume, as well as the pressure differential between operating volumes. Additional or fewer sensors could be provided, as well as sensors of different types. Metal seals 904 are retained to the valve bodies 58, 68, and form a metal-to-metal seal between the valve bodies 58, 68 and their respective flappers 52, 62 when the flappers are closed. Also, in certain instances, the flappers 52, 62 are coupled to their respective pivot arms 54, 64 in a compliant manner, to allow movement between the flapper and arm. The movement facilitates the flappers 52, 62 seating on the seals 904 as they close.

The valve assembly 10 includes a first, or top, operating volume 37 a near an upper end of the assembly 10 that can be isolated from the remainder of the valve assembly 10 to enable the volume 37 a to be maintained at a lower pressure (e.g., atmospheric pressure) than the remainder of the valve assembly 10. The first operating volume 37 a can thus be in fluid communication with whatever is disposed above it via an opening at the top end of the central bore through the valve assembly 10.

The valve assembly 10 further includes a second intermediate, or load lock, operating volume 37 b disposed adjacent to the first operating volume 37 a. A third, or bottom, operating volume 37 c is disposed adjacent to a second operating volume 37 b on an opposite side of the second operating volume 37 b from the first operating volume 37 a. Each operating volume 37 a, 37 b, and/or 37 c can be sealed from the others to contain fluid at different pressures.

The valve assembly 10 is designed to use the fluid pressure in the third operating volume 37 c to pressurize the second operating volume 37 b and the pressure in the second operating volume 37 b to pressurize the first operating volume 37 a. The valve assembly 10 is also designed to reduce pressure of the second operating volume 37 b by bleeding to the atmosphere or to the first operating volume 37 a.

The valve assembly 10 further includes a first passage 40 that selectively communicates the first operating volume 37 a with the second operating volume 37 b and a second passage 42 that selectively communicates the second operating volume 37 b with the third operating volume 37 c. Each of the passages 40, 42 have an actable valve that are actuable to close to seal the passages or to open to allow the passages to pass fluid. The first operating volume 37 a can be a space that is defined by the area between the first flapper 52 and any tool disposed atop the valve assembly 10. To pass a well drop (e.g., a frac ball, collet, soap or other item to be dropped into the well) through the valve assembly 10, the pressure of the fluid in the second operating volume 37 b is adjusted to be within a specified maximum pressure differential from the fluid in the first operating volume 37 a. Adjusting the pressure of the fluid in the second operating volume 37 b allows the first flapper 52 to open up and permit the well drop disposed in the first operating volume 37 a to pass into the second operating volume 37 b. The second operating volume 37 b can be sized such that the well drop can be contained therein without affecting the operation of the first flapper 52. For example, the second operating volume 37 b could be smaller when the well drop is a frac ball and it would be larger (taller/longer) if the well drop was a collet.

When the pressure of the fluid in the second operating volume 37 b is beyond the specified maximum pressure differential from the fluid in the first operating volume 37 a, the first flapper 52 cannot be opened by operation of the valve assembly 10. In certain instances, the maximum pressure differential is implemented in the operation of system, for example, by the configuration (e.g., strength or other characteristic) of the valve actuator, hydraulic areas, by control interlocks coupled with pressure sensors on either side of first flapper 52 (to measure pressure in the first

and second operating volumes 37 a, 37 b) or in another manner, and specified to prevent unintentional opening of the first flapper 52, damage to the valve assembly 10 and other nearby equipment, and/or an otherwise unsafe condition.

To pass the well drop from the second operating volume 37 b into the third operating volume 37 c, the pressure of the fluid in the second operating volume 37 b is increased to be within a specified maximum pressure differential from the fluid in the third operating volume 37 c. Once the pressure of the fluid in the second operating volume 37 b is within the specified maximum pressure differential from the fluid in the third operating volume 37 c, the second flapper 62 will open and permit the well drop to pass from the second operating volume 37 b into the third operating volume 37 c.

Similar to operation of the first flapper 52, when the pressure of the fluid in the third operating volume 37 c is outside of the specified maximum pressure differential from the fluid in the second operating volume 37 b, the second flapper 62 cannot be opened by the operation of the valve assembly 10. As above, the specified maximum pressure differential used with the second flapper 62 can be implemented, for example, by the configuration (e.g., strength or other characteristic) of the valve actuator, hydraulic areas, by control interlocks coupled with pressure sensors measuring on either side of second flapper 62 (to measure pressure in the second and third operating volumes 37 b, 37 c) or in another manner, and specified to prevent unintentional opening of the second flapper 62, damage to the valve assembly 10 and other nearby equipment, and/or an otherwise unsafe condition. Also, the specified maximum pressure differential used with the first flapper 52 and second flapper 62 need not be the same. Logic can be built into a controller that controls the operation of the first flapper 52 and second flapper 62, which prevents the opening of the first flapper 52 and the second flapper 62 if the pressure across either flapper 52, 62 is beyond its respective specified maximum differential.

To run a tool on wireline or tubing through the valve assembly 10 during operating conditions (i.e., high-pressure conditions), the first flapper 52 and the second flapper 62 must be in an open position simultaneously. For the first flapper 52 and the second flapper 62 to be open, the pressure of the fluid in the first operating volume 37 a and the second operating volume 37 b can be adjusted to be within the specified maximum pressure differential with the pressure of the fluid in the third operating volume 37 c. This allows the first flapper 52 and the second flapper 62 to open up and permit the tool to pass through the valve assembly 10. In certain instances, the first flapper 52 and the second flapper 62 can be a type of valve that cannot shear the wireline or tubing during operation, such as flapper valves and the like. Other valves, such as plug valves, gate valves, and ball valves can be used with appropriate interlocks to prevent sheering of the wireline or tubing. That is, the first flapper 52 and the second flapper 62 can be any type of valve that can make contact with the tool or its conveyance without damaging it.

In some implementations, when wanting to pass a tool through the valve assembly 10, the first flapper 52 is in a closed position and the pressure of the fluid in the second operating volume 37 b can be increased to be within the specified maximum pressure differential with the fluid in the third operating volume 37 c, so the second flapper 62 can open. In this scenario, the pressure of the fluid in the first operating volume 37 a will then be increased to be within the specified maximum pressure differential with the fluid in the second operating volume 37 b, so the first flapper 52 can open. The pressure of the fluid in the first operating volume 37 a will dictate the pressure in the fracturing stack above, since the two are in fluid communication. Once the first flapper 52 and the second flapper 62 are open, the tool is permitted to pass all of the operating volumes and into the well.

In some instances, the first flapper 52 is in an open position and the second flapper 62 is in a closed position when it is desirable for the valve assembly 10 to be used in passing a tool. The fluid in the first operating volume 37 a and the second operating volume 37 b is increased within the specified maximum pressure differential with the fluid in the third operating volume 37 c, the second flapper 62 can open, which would permit the tool to be extended into and through the valve assembly 10. Conversely, the second flapper 62 can be in an open position and the first flapper 52 is in a closed position when it is desirable for the valve assembly 10 to be used in passing a tool. In this instance, the fluid in the first operating volume 37 a is increased within the specified maximum pressure differential with the fluid in the second operating volume 37 b, and the third operating volume 37 c, the first flapper 52 can open, which permits the tool to be extended into and through the valve assembly 10. It should be understood and appreciated that each operating volume 37 a, 37 b, and/or 37 c can be pressured up or down in numerous ways. In certain situations, the pressure of the fluid in the third operating volume 37 c, because it is exposed to well conditions, is dynamic and may be fluctuating in such a manner whereby the fluid pressure in the second operating volume 37 b cannot reach the substantially same pressure as the dynamic pressure of the fluid in the third operating volume 37 c for a sufficient amount of time to open the second flapper 62. In some implementations, to combat this dynamic fluid pressure issue, the valve assembly 10 can include an external pump in fluid communication with the second operating volume 37 b to increase the pressure of the fluid in the second operating volume 37 b to a sufficient pressure to overcome the dynamic pressure of the fluid in the third operating volume 37 c for a sufficient amount of time and permit the second flapper 62 to open. The external pump 48 can be any type of pump capable of achieving the required fluid pressures, for example, a triplex plunger pump or a diaphragm pump.

The valve assembly 10 can include a first port disposed in the body of the valve assembly 10 that fluidically connects the third operating volume 37 c with a first end of a first equalizing passage 42. The first passage 42 extends from the first port to a second port disposed in the body of the valve assembly 10 that fluidically connects the second operating volume 37 b to a second end of the first passage 42. The valve assembly 10 can also include a third port disposed in the body of the valve assembly 10 that fluidically connects the second operating volume 37 b with a first end of a second equalizing passage 42. The second passage 40 extends from the third port to a fourth port disposed in the body of the valve assembly 10 that fluidically connects the first operating volume 37 a to a second end of the second passage 40. In some implementations, the valve assembly 10 can include a third conduit that fluidically connects the third operating volume 37 c to the first operating volume 37 a. The first operating volume 37 a and third operating volume 37 c can include additional ports to facilitate this fluid connection or the third conduit can be tied into the first passage 42 on one end, where the first passage 42 comes out of the third operating volume 37 c and ties into the second passage 40 on the other end, where the second passage 40 comes out of the first operating volume 37 a. Equalizing valves (e.g., sealing valve, flow diverters, and/or other fluid flow control devices) can be incorporated into or in fluid communication with the conduits direct fluid to flow to the appropriate conduits to accomplish the desired operation of the valve assembly 10. The equalizing valves can be actuable types, actuable to open/close in response to a signal (e.g., hydraulic, electric and/or other) and can include multiple devices for redundancy and safety.

To manage the pressure of the fluid in the second operating volume 37 b, the first passage 42 that fluidically connects the second operating volume 37 b to the third operating volume 37 c can be used to increase the pressure of the fluid in the second operating volume 37 b. The associated

valve can be activated to permit the fluid at a higher pressure in the third operating volume 37 c to flow into the second operating volume 37 b in order to increase the pressure of the fluid in the second operating volume 37 b via the first passage 42. The second passage 40 that fluidically connects the second operating volume 37 b to the first containment can be used to increase the pressure of the fluid in the first operating volume 37 a or decrease the pressure of the fluid in the second operating volume 37 b. In some implementations, the associated valve can be activated to permit the fluid at a higher pressure in the second operating volume 37 b to flow into the first operating volume 37 a in order to increase the pressure of the fluid in the first operating volume 37 a. In some implementations, the associated valve can be activated to permit the fluid at a higher pressure in the second operating volume 37 b to flow into the first operating volume 37 a in order to decrease the pressure of the fluid in the second operating volume 37 b via the first passage 42.

The valve assembly 10 can also include a first vent fluidically connected to the first operating volume 37 a to bleed pressure from the first operating volume 37 a when it is desirable to decrease the pressure of the fluid therein. The valve assembly 10 can also include a second vent fluidically connected to the second operating volume 37 b to bleed pressure from the second operating volume 37 b. The first vent can be a separate port in fluid communication with the first operating volume 37 a. In another implementation, the first vent can use the fourth port disposed in the body of the valve assembly 10, the second passage 40 or third conduit, and any appropriate valves, flow diverters, fluid flow control devices, and the like to bleed pressure from the first operating volume 37 a. The second vent can be a separate port in fluid communication with the second operating volume 37 b. In another implementation, the second vent can use the second port or the third port disposed in the body of the valve assembly 10, the first passage 42 or second passage 40, and any appropriate valves, flow diverters, fluid flow control devices, and the like to bleed pressure from the second operating volume 37 b.

In one implementation, the second operating volume 37 b can be positioned below the first operating volume 37 a and the third operating volume 37 c can be positioned below the second operating volume 37 b. This orientation allows the well drop being passed through the valve assembly 10 or the tool to pass downward through the valve assembly 10.

In one implementation, the first flapper 52 and second flapper 62 can be flapper valves, oriented to open into the second and third operating volumes 37 b, 37 c, so the higher pressure of the fluid in the second operating volume 37 b over the pressure of the fluid in the first operating volume 37 a acts on the flapper to maintain the closure of the first flapper 52 and the higher pressure of the fluid in the third operating volume 37 c over the pressure of the fluid in the second operating volume 37 b acts on the flapper to maintain the closure of the second flapper 62. Further, the first flapper 52 and second flapper 62 can be opened and closed by an actuator, one on each flapper, that is responsive to signals (e.g., electric, hydraulic or other). The actuator 50 can be any type of actuator 50 known in the art. Examples include, but are not limited to, a pneumatic actuator, a hydraulic actuator, an electrical actuator, an air-over hydraulic actuator, a manual screw actuator, or manual lever actuator. The first flapper 52 and the second flapper 62 can be driven by a single actuator or multiple actuators. The actuators can be controlled by the controller 51.

In some implementations, the valve assembly 10 is designed to not destroy the wireline or tubing that are in the valve assembly 10 during operation, even by an accidental activation of the first flapper 52 and/or the second flapper 62. The valve assembly 10 is designed so that the first flapper 52 must fully close before the second flapper 62 will close. If the first flapper 52 does not fully close, then the second flapper 62 will not close. The first flapper 52 can be designed such

that it will close at a predetermined speed or force and will continue to close unless the first flapper 52 meets some form of resistance before the first flapper 52 is completely closed. If the tool string is running through the valve assembly 10, then the first flapper 52 will contact it, which provides resistance to the first flapper 52 prior to the first flapper 52 being fully closed, but not contact it with such force that the wireline or tubing is destroyed or damaged (e.g., severed). The operation above can be implemented via control logic in the controller 51 and/or by physical configuration of the valve assembly 10 (e.g., by sizing of the valve actuators and hydraulic areas or by providing a slip clutch between each valve and its actuator). In some implementations, the controller 51 can receive signals from various sensors and create an interlock if an object is detected by the sensors. Such an interlock prevents the actuators from moving and potentially damaging the wireline, tubing or tool string. Sensors can include optical sensors, position sensors, current sensors, torque sensors, or any other type of sensor that can be used to determine the presence of an obstruction, such as the wireline, tubing or tool string. For example, in some implementations, current sensors can be provided on the actuators. A larger than normal current draw during actuation (i.e., above a specified threshold current) can indicate that there is an object within the valve assembly 10. The actuator 50 can then feed that data back to the controller 51, which can deactivate the actuator 50 in response to the data. In other examples, similar results can be achieved with torque sensors on the actuators (e.g., when torque to move the flappers is above a specified threshold torque) or pressure sensors on hydraulic lines of the actuators (e.g., pressure to move flappers with a hydraulic actuator is above a specified threshold pressure).

In some implementations, the position of the actuator 50 for the first flapper 52 and/or second flapper 62 can be monitored to determine where resistance begins for the first flapper 52 and/or second flapper 62. The actuator 50 for the first flapper 52 and/or second flapper 62 can also have a lower force to close the valves so that if resistance occurs before the first flapper 52 and/or second flapper 62 is completely closed, the actuator 50 will stop forcing the first flapper 52 and/or the second flapper 62 to close. The valve assembly 10 may also be equipped with an indicator to notify an operator that the first flapper 52 and/or second flapper 62 could not close, which alerts the operator that the tool string is in the valve assembly 10. This also prevents the other valve from closing and damaging the tool string. Feedback from the first flapper 52 and/or the second flapper 62 or the actuator 50 controlling the first flapper 52 and/or the second flapper 62 can be connected mechanically or electronically.

When it is desirable to pass the well drop through the valve assembly 10, the well drop is delivered into the first operating volume 37 a. To pass the well drop from the first operating volume 37 a to the second operating volume 37 b, pressure of the fluid in the second operating volume 37 b has to be decreased (or potentially increased in certain circumstances) to essentially the same pressure as the pressure of the fluid in the first operating volume 37 a (the low pressure area). To facilitate this, the equalizing valve is manipulated to permit fluid from the second operating volume 37 b to flow through the second passage 40 and into the first operating volume 37 a. Permitting fluid to flow through the second passage 40 from the second operating volume 37 b into the first operating volume 37 a results in the pressure of the fluid in the second operating volume 37 b being decreased to substantially the same pressure as the pressure of the fluid in the first operating volume 37 a. During the operation, permitting the well drop to flow from the first operating volume 37 a into the second operating volume 37 b, the second flapper 62 is in the closed position.

When it is desirable for the well drop to flow from the second operating volume 37 b to the third operating volume 37 c, pressure of the fluid in the second operating volume 37 b has to be increased to essentially the same pressure as the pressure in the fluid in the third operating volume 37 c (the high-pressure system). To facilitate this, the appropriate equalizing valve is manipulated to permit fluid from the third operating volume 37 c to flow through the first passage 42 and to the second operating volume 37 b. Permitting fluid to flow through the first passage 42 from the third operating volume 37 c into the second operating volume 37 b results in the pressure of the fluid in the second operating volume 37 b being increased to substantially the same pressure as the pressure of the fluid in the third operating volume 37 c. During the operation, permitting the well drop to flow from the second operating volume 37 b into the third operating volume 37 c, the first flapper 52 is in the closed position.

As shown in FIG. 10, the valve assembly 10 can include a controller 51 to, among other things, monitor pressures of the operating volumes and send signals to actuate the equalizing valves 44 and the actuators 50. As shown in FIG. 10, the controller 51 can include a processor 1102 (implemented as one or more local or distributed processors) and non-transitory storage media (e.g., memory 1104—implemented as one or more local or distributed memories) containing instructions that cause the processor 1102 to perform the methods described herein. The processor 1102 is coupled to an input/output (I/O) interface 1106 for sending and receiving communications with other equipment of the well fracking site 1 (FIG. 1), including, for example, the actuator 408 and/or other actuators (e.g., valve actuators). In certain instances, the controller 51 can additionally communicate status with and send actuation and control signals to one or more of the automated latch 206 (for example, connector 302), the other valves (including main valves 216 and swab valve 212) of the fracturing stack 200, the BOP 204, the lubricator 202 (and its tool trap), any well drop launcher, as well as other sensors (e.g., pressure sensors, temperature sensors and other types of sensors) provided in the fracturing stack 200. In certain instances, the controller 51 can communicate status and send actuation and control signals to one or more of the systems on the well site 1, including the blenders 3, fracking pumps 5 and other equipment on the well site 1. The communications can be hard-wired, wireless or a combination of wired and wireless. In some implementations, the controller 51 can be located on the valve assembly 10. In some implementations, the controller 51 can be located elsewhere, such as in the data van 6, elsewhere on the well site 1 or even remote from the well site 1. In some implementations, the controller can be a distributed controller with different portions located about the well site 1 or off site. For example, in certain instances, a portion of the controller 51 can be located at the valve assembly 10, while another portion of the controller 51 can be located at the data van 6 (FIG. 1).

The controller 51 can operate in monitoring, controlling, and using the valve assembly 10 for introducing a well drop and for allowing the passage of a tool through the valve assembly 10 to the high pressure area. To monitor and control the valve assembly 10, the controller 51 is used in conjunction with transducers (sensors) to measure the pressure of fluid at various positions in the valve assembly 10 and to measure the position of various parts of the valve assembly 10. Input and output signals, including the data from the transducers, controlled and monitored by the controller 51, can be logged continuously by the controller 51.

Once the valve assembly 10 is powered up, a determination is made whether a wireline deployed tool sequence is desired or a well drop sequence is desired. The wireline deployed tool sequence would be used when a tool on wireline, such as perforating string or logging string supported on wireline, is passed through the fracking stack 200 into the well 4. A well dropping sequence

would be used when a well drop (e.g., frac ball, collet, soap bar or other) is to be dropped through the fracking stack 200 into the well 4. FIG. 11 shows an example logic sequence 1100 that is used by the controller to set which operation to perform. The determination is made based on user input to the controller, for example, through a terminal in communication with the controller. In the event that a wireline deployed tool sequence is desired, then logic sequence 1200 is selected. Notably, the wireline sequence can also be used for running tubing deployed tools. If a well drop sequence is desired, then a logic sequence 1300 is selected. Details of each logic sequence are provided below. The logic sequences 1100, 1200 and 1300 can be stored as executable instructions in the memory 1004 of controller 51.

FIG. 12 is a block diagram of an example logic sequence 1200 that can be used by the controller 51 (FIG. 51) when executing wireline operations. In performing the wireline sequence, a lubricator containing the wireline tool string typically has previously been attached above the valve assembly (FIG. 2A). The sequence 1200 can be performed autonomously, without human intervention other than to indicate to the controller 51 that certain actions performed apart from controller 51 (e.g., stabbing/retrieving the lubricator) have been completed. At operation 1201, a check of the lubricator is performed. That is, the controller 51 makes a determination if the lubricator is present. Such a check can be performed using the sensing port 508. If the lubricator is not present, the controller 51 can issue an alert and/or an interlock to prevent the sequence from continuing until the lubricator is present. The lubricator can be lifted onto the well stack 200 and secured to the stack with the latch 206 (e.g., connector 302, discussed above). In such an instance, the controller 51 can actuate the latch 206 to transition to the disengaged position so that it may accept the lubricator. Once the lubricator is on the stack, the controller can actuate the latch 206 to the engaged position to secure the lubricator to the well stack 200.

If the lubricator needs to be installed or removed, for example to change or repair the tool carried in the lubricator, operation 1202 is performed. In operation 1202, the pressure of the fluid in the first operating volume 37 a (FIG. 9) is brought to atmospheric pressure (e.g., absolute atmospheric pressure, actual pressure of the surrounding atmosphere, or to within a specified maximum pressure differential to either). The pressure of the fluid in the first operating volume 37 a can be determined via a pressure sensor in fluid communication with the first operating volume 37 a and coupled to the controller 51. The pressure of the fluid in the first operating volume 37 a can be reduced by venting the first operating volume 37 a (e.g., by actuating an equalizing valve, as described above (i.e., Open EQU LUB/ATM)) to bleed off pressure. Once it is verified that the pressure of the fluid in the first operating volume 37 a is equalized with the atmosphere (i.e., LUB/ATM Equalized), the latch 206 can be actuated to disengage the lubricator form the well stack 200. The lubricator can then be changed or accessed, and the lubricator reinstalled to the fracking stack 200 by securing the lubricator with the latch 206. Actuating the latch 206 can be done autonomously via control logic within the controller 51 and/or manually by an operator. Notably, the pressure in the well 4 and the fracking stack 200 below the valve assembly 10 need not be affected, and can remain at fracturing pressure or near to fracturing pressure.

In operation 1204, the second flapper 62 is operated. First, the pressure of fluid in the second operating volume 37 b (referred to as the “load lock area” in the accompanying diagram) can be determined via a pressure sensor in fluid communication with the second operating volume 37 b. To open the second flapper 62 that separates the second operating volume 37 b and the third operating volume 37 c, the pressure of the fluid in the second operating volume 37 b has to be within the specified maximum pressure differential to the third operating volume 37 c, which

essentially equalizes the second operating volume 37 b and third operating volume 37 c. The third operating volume 37 c is open to the well 4, and thus is at well pressure. If the pressure differential is greater than the specified maximum pressure differential, the pressure of the fluid in the second operating volume 37 b has to be increased to be essentially equal (i.e., within the specified maximum pressure differential wherein the second flapper 62 will open) to the pressure of the fluid in the third operating volume 37 c.

To increase the pressure of the fluid in the second operating volume 37 b, the equalizing valve associated with the first passage 42 connecting the second operating volume 37 b and the third operating volume 37 c can be opened, i.e., actuated, and the pressure of the fluid in the third operating volume 37 c flows into the second operating volume 37 b and increases the pressure of the fluid in the second operating volume 37 b to the specified maximum pressure differential of the fluid in the third operating volume 37 c (i.e., Open EQU Well/LL). Once the pressure of the fluids in the second operating volume 37 b and the third operating volume 37 c are equalized (i.e., Well/LL Equalized?), the second flapper 62 separating these two operating volumes can be opened (i.e., Open Bottom Flapper). Once actuated, the system can check to confirm the flapper 62 is opened (i.e., Flapper OPEN?)

Once the second flapper 62 separating the second operating volume 37 b and the third operating volume 37 c is opened, the first flapper 52 will need to be opened to allow the tool string to be extended through the valve assembly 10 (operation 1206). To open the first flapper 52, the pressure of the fluid in the first operating volume 37 a and the second operating volume 37 b is brought to within the specified maximum pressure differential wherein the first flapper 52 is capable of opening. If the pressure of the fluid in the second operating volume 37 b is greater than the pressure of the fluid in the first operating volume 37 a, the pressure of the fluid in the first operating volume 37 a has to be increased to be essentially equal (or within a certain range wherein the first flapper 52 will open) to the pressure of the fluid in the second operating volume 37 b. In another implementation, the pressure of the fluid in first operating volume 37 a, the second operating volume 37 b, and the third operating volume 37 c can be brought to within a certain range and the first flapper 52 and second flapper 62 can then be opened. The first and second flapper 52 and 62 can be opened at the same time, or near the same time, to permit the tool string to extend through the valve assembly 10 and into the well.

To increase the pressure of the fluid in the first operating volume 37 a, the equalizing valve associated with the second passage 40 connecting the first operating volume 37 a and the second operating volume 37 b can be opened, i.e., actuated, and the pressure of the fluid in the second operating volume 37 b flows into the first operating volume 37 a and increases the pressure of the fluid in the first operating volume 37 a to be essentially equal to the pressure of the fluid in the second operating volume 37 b (i.e., Open EQU LUB/LL). Once the pressure of the fluids in the first operating volume and the second operating volume 37 b are equalized (i.e., LUB/LL Equalized?), the first flapper 52 separating the first operating volume 37 a and the second operating volume 37 b can be opened (i.e., Open Top Flapper). Once actuated, the system can check to confirm the flapper 52 is opened (i.e., Flapper OPEN?) In certain implementations, a third conduit fluidically connecting the first operating volume 37 a and the third operating volume 37 c, and a corresponding equalizing valve could be used to permit the fluid in the third operating volume 37 c be used to increase the pressure of the fluid in the first operating volume 37 a.

It should be understood that for wireline sequences, the second flapper 62 separating the second operating volume 37 b and the third operating volume 37 c can be started out as open and left

open for the duration of the operation to equalize the pressure of the fluid in the valve assembly 10.

Once the second flapper 62 separating the second operating volume 37 b and the third operating volume 37 c and the first flapper 52 are opened, the fluid in the valve assembly 10 is equalized and the lubricator can feed the tool string into and through the valve assembly 10 to perform any desired operation in the well (operation 1208). After the conclusion of the operation being performed via the tool string (i.e., Wait For Completion of Perforation Operation), the tool string can be withdrawn from the well and the valve assembly 10 (i.e., Gun Out of Well?). In operation 1210, the first flapper 52 can then be closed (i.e., Close Top Flapper, Flapper Closed?) and the equalizing valve associated with the second or third conduit, depending on which conduit was used to equalize the first operating volume 37 a, can be closed (i.e., Close EQU LUB/LL). The second flapper 62 separating the second operating volume 37 b and the third operating volume 37 c can then be closed (i.e., Close Bottom Flapper, Flapper Closed?). The equalizing valve associated with the first equalizing passage 42 can be closed after the second flapper 62 is closed (i.e., Close EQU Well/LL).

The opening and closing of the first flapper 52 that separates the first operating volume 37 a and second operating volume 37 b and the second flapper 62 that separates the second operating volume 37 b and third operating volume 37 c can be verified via a valve position sensor (can be the same valve position sensor or separate valve position sensors) in communication with the controller.

The process can be repeated. If no other operations are to be performed, the wireline sequence is terminated (i.e., Last Zone?). If the wireline sequence is terminated, the pressure of the fluid in the first operating volume 37 a can be decreased to atmospheric pressure venting the first operating volume 37 a to bleed pressure from the first containment.

FIG. 13 is a block diagram of an example logic sequence 1300 that can be used by the controller 51 to execute well drop operations, for example, dropping a frac ball or collet down the well. As with sequence 1200, sequence 1300 can be performed autonomously, without human intervention other than to indicate to the controller 51 that certain actions performed apart from controller 51 (e.g., placing the well drop) have been completed. In general, if logic sequence 1300 is used, operation 1301 is performed. That is, a check of the launcher, such as a ball or collet launcher, is performed. The controller 51 makes a determination if the launcher is present. Such a determination can be made using sensing port 508. If the launcher is not present, the controller 51 can issue an alert and/or an interlock to prevent the sequence from continuing until the launcher is present. The launcher can be lifted onto the well stack 200 and secured to the stack with the latch 206 (e.g., connector 302). In such an instance, the controller 51 can actuate the latch 206 to transition to the disengaged position so that it may accept the launcher. Once the launcher is on the stack, the controller can actuate the latch 206 to the engaged position to secure the launcher to the well stack 200.

Once it is determined the launcher is secured to the well stack, the valve assembly 10 is given the command via the controller to continue the logic sequence 1300. When it is desirable to conduct the logic sequence 1300, the well drop to be released will be positioned in the first operating volume 37 a and operation 1302 performed. To open the first flapper 52, the pressure of the fluid in the second operating volume 37 b has to be within a certain range of the pressure of the fluid in the first operating volume 37 a, which essentially equalizes the first and second operating volumes 37 a and 37 b. The pressure of the fluid in the first operating volume 37 a can be determined via a pressure sensor if the pressure of the fluid is not known to be atmospheric.

Pressure of the fluid in the second operating volume 37 b can be determined via a pressure sensor coupled to the second operating volume 37 b.
The pressure of the fluid in the second operating volume 37 b can be reduced by opening the corresponding equalizing valve to the second passage 40 that fluidically connects the second operating volume 37 b and the first operating volume 37 a. Once the pressure of the fluid in the first operating volume 37 a and the second operating volume 37 b equalizes, the first flapper 52 can then be opened by the controller 51. The controller 51 will not send the signal to open the first flapper 52 until the equalization occurs between the first operating volume 37 a and the second operating volume 37 b. The equalizing valve can remain open until the equalization occurs and then be closed before or during the opening of the first flapper 52 or the vent port or second passage 40 can remain open during the opening and closing of the first flapper 52.
The well drop will fall from the first operating volume 37 a into the second operating volume 37 b once the first flapper 52 is opened. Confirmation of the well drop having fallen into the second operating volume 37 b can be verified by a well drop detection sensor that can confirm the presence of the well drop in the second operating volume 37 b. After a specified amount of time (delay) or detection of the well drop in the second operating volume 37 b, the first flapper 52 will close. The closure of the first flapper 52 can be verified via a valve position sensor in communication with the controller 51. Once it has been verified that the first flapper 52 has been closed, the vent port or the second passage 40 can be closed if the vent port or the second passage 40 was left open during the operation of the first flapper 52.
The well drop to be released is then passed into the third operating volume 37 c (operation 1304). Pressure of fluid in the third operating volume 37 c can be determined via a pressure sensor coupled to the third operating volume 37 c. To open the second flapper 62, the pressure of the fluid in the third operating volume 37 c has to be within a certain range of the pressure of the fluid in the second operating volume 37 b, which essentially equalizes the second operating volume 37 b and the third operating volume 37 c. The pressure of the fluid in the second operating volume 37 b can be determined via the pressure sensor used to determine the pressure of the fluid in the second operating volume 37 b.
The pressure of the fluid in the second operating volume 37 b can be increased by opening the first passage 42 via the equalizing valve associated with the first passage 42. The first passage 42, when opened, allows the pressure of the fluid in the third operating volume 37 c to flow there through and increase the pressure of the fluid in the second operating volume 37 b. Once the pressure of the fluid in the second and third operating volumes 37 b and equalizes, the second flapper 62 can then be opened by the controller. The controller will not send the signal to open the second flapper 62 until the equalization occurs between the second operating volume 37 b and the third operating volume 37 c. The first passage 42 can remain open until the equalization occurs and then be closed before or during the opening of the second flapper 62 or the first passage 42 can remain open during the opening and closing of the second flapper 62.
The well drop will fall from the second operating volume 37 b into the third operating volume 37 c once the second flapper 62 is opened. Confirmation of the well drop having fallen into the third operating volume 37 c can be verified by the well drop detection sensor disclosed herein or a separate well drop detection sensor that can determine the location of the well drop in the third operating volume 37 c. After a certain amount of time or detection of the well drop in the third operating volume 37 c, the second flapper 62 will close. The closure of the second flapper 62 can be verified via a valve position sensor (can be the same valve position sensor disclosed herein or a separate valve position sensor) in communication with the controller 51. Once it has been

verified that the second flapper 62 has been closed, the first passage 42 can be closed if the first passage 42 was left open during the operation of the second flapper 62.

After the well drop is passed into the third operating volume 37 c (or well), a determination of whether another well drop will be passed into the third operating volume 37 c is made. If no further well drop is to be passed into the third operating volume 37 c, the logic sequence 1300 is terminated. If an additional well drop is to be passed into the third operating volume 37 c, another well drop is positioned in the first operating volume 37 a and the logic sequence 1300 is recommenced.

A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. Accordingly, other implementations are within the scope of the following claims.

DETAILED DESCRIPTION

~~Referring to FIG. 1A, in an embodiment, a hydraulic fracturing system 100 for executing a hydraulic fracturing plan to hydraulically fracture wells 105A through 105C+n is illustrated, which hydraulic fracturing system 100 includes: a blender 110 adapted to mix fluid from a fluid source 115 with sand from a sand source 120 to produce hydraulic fracturing fluid; a suction manifold 125 adapted to receive the hydraulic fracturing fluid from the blender 110; a discharge manifold 130; a plurality of swap stations 135, each adapted to communicate the hydraulic fracturing fluid from the suction manifold 125 to a corresponding pump truck 140, and, after pressurization by the corresponding pump truck 140, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck 140 to the discharge manifold 130; and a zipper manifold 145 adapted to communicate the pressurized hydraulic fracturing fluid from the discharge manifold 130 to a plurality of hydraulic fracturing legs (or “frac legs”) 150A through 150C+n, each of which is adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold 145 to a corresponding one of the wells 105A through 105C+n. In one or more embodiments, each of the swap stations 135 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/436,189, filed Jun. 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.~~

~~A grease system 155 is adapted to communicate lubricating grease to various components of the frac legs 150A through 150C+n, including, for example, pump-down valves 160 a-b, master valves 165 a-b, and zipper valves 170 a-b associated with each of the frac legs 150A through 150C+n (which components are shown in FIGS. 2A-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G). In one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,648, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/938,341, filed Jul. 24, 2020, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '749 application, filed Apr. 22, 2020, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system 155 is or includes one or more components shown and described in the '854 application, filed May 13, 2021, the entire disclosure of which is hereby incorporated herein by reference in its entirety.~~

~~A controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both. In one or more embodiments, the controller 156 is or includes a non-transitory computer readable medium and one or more processors adapted to execute instructions stored on the non-transitory computer readable medium. In one or more embodiments, the controller 156 is located on-site at the well site. Alternatively, the controller 156 may be located remotely from the well site. In one or more embodiments, the controller 156 includes a plurality of controllers. In one or more embodiments, the controller 156 includes a plurality of controllers, with one or more~~

~~controllers located on-site at the well site and/or one or more other controllers located remotely from the well site.~~

~~Referring to FIG. 1B, in an embodiment, a method 175 for hydraulically fracturing the wells 105A through 105C+n by executing a hydraulic fracturing plan using the hydraulic fracturing system 100 of FIG. 1A is illustrated. The method 175 generally includes: at step(s) 176 a, perforating a stage of each well using, for example, a wireline perforating system 177; at step(s) 176 b, isolating the perforated stage of each well using an object dropped, for example, from a launcher 178 of the wireline perforating system 177; and, at step(s) 176 c, hydraulically fracturing the isolated/perforated stage of each well. More particularly, as will be described in further detail below, the method 175 includes: at a step 225, equalizing a lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A; at a step 230, perforating a stage of the well 105A using the wireline perforating system 177; at a step 235, closing the well 105A using the valve apparatus 210 and draining the lubricator 220; at a step 238 a, queuing the well 105A (as indicated at queue position n2) in a frac queue 239 in preparation for a hydraulic fracturing operation; at a step 238 b, dequeuing the well 105B (as indicated at queue position n1+1) from the frac queue 239 in preparation for the hydraulic fracturing operation; at a step 240, isolating a stage of the well 105B in preparation for the hydraulic fracturing operation; at a step 245, detecting or otherwise determining that a fracturing stage of the well 105D has ended; at a step 250, determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at a step 255, executing the regular swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, or, at a step 260, executing the CP swap from hydraulically fracturing (at the step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B; at the step 262, hydraulically fracturing the well 105B; optionally, at a step 263 a, queuing the well 105D (as indicated at queue position n1) in a wireline queue 264 in preparation for perforating a next stage of the well 105D; optionally, at a step 238 b, dequeuing the well 105E (as indicated at queue position 1) from the wireline queue 264 in preparation for perforating a next stage of the well 105E; and, at a step 265, latching, filling, and pressure testing the frac leg 150E associated with the well 105E.**

~~In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 175 described herein. In one or more embodiments, the frac queue 239 and the wireline queue 264 are stored on a non-transitory computer readable medium that includes or is part of, for example, the controller 156. In one or more embodiments, the frac queue 239 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the frac queue 239 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the frac queue 239 can be at least partially populated by an external source, such as, for example, the frac operator. Likewise, in one or more embodiments, the wireline queue 264 is or includes a list of data items, commands, etc., stored on the computer readable medium so as to be retrievable by one or more processors in a definite order (but not necessarily in the order stored), and the wireline queue 264 is associated with the wells 105A through 105C+n, as shown in FIG. 1B. In addition, or instead, the wireline queue 264 can be at least partially populated by an external source, such as, for example, the wireline operator.~~

~~Referring to FIGS. 2A through 2G, in an embodiment, the frac leg 150A associated with the well 105A is illustrated, which frac leg 150A includes: a wellhead including the master valves 165 a-b (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well 105A, each of the master valves 165 a-b including associated grease ports (or "GPs") 185 a-b; the pump-down valves 160 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck 190 and the well 105A, via the master valves 165 a-b, each of the pump-down valves 160 a-b including an associated GP 195; and the zipper valves 170 a-b (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold 145 and the well 105A, via the master valves 165 a-b, each of the zipper valves 170 a-b including associated GPs 200 a-b. In one or more embodiments, one or both of the zipper valves 170 a-b of each of the frac legs 150A through 150C+n include(s), or is/are part of, the zipper manifold 145. In one or more embodiments, as in FIGS. 2A through 2G, the frac leg 150A associated with the well 105A also includes a flow block 205 to which the pump-down valves 160 a-b and the zipper valves 170 a-b are operably coupled.~~

~~The frac leg 150A associated with the well 105A further includes a valve apparatus 210 via which both the wireline perforating system 177 and the object launched from, for example, the launcher 178, are permitted entry to the well 105A. The valve apparatus 210 includes: a containment area 215 a (labeled "WELL") adapted to be in fluid communication with the well 105A via the master valves 165 a-b; a containment area 215 b (labeled "LUB") adapted to be in fluid communication with the lubricator 220 of the wireline perforating system 177; and a containment area 215 c (labeled "LL") adapted to be in fluid communication with the containment area 215 a via a flow control device 221 a (e.g., a flapper-type flow control device), and adapted to be in fluid communication with the containment area 215 b via a flow control device 221 b (e.g., a flapper-type flow control device).~~

~~An equalization ("EQ") valve 222 a is connected between the containment areas 215 a and 215 c, which EQ valve 222 a is openable to permit pressure equalization between the containment areas 215 a and 215 c when the flow control device 221 a is closed. Likewise, an equalization valve 222 b is connected between the containment areas 215 b and 215 c, which EQ valve 222 b is openable to permit pressure equalization between the containment areas 215 b and 215 c when the flow control device 221 b is closed. Additionally, an EQ valve 222 c is connected between the lubricator 220 and atmosphere (labeled "ATM"), which EQ valve 222 c permits pressure equalization between the lubricator 220 and atmosphere. A drain 223 is connected between a latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210) and a pump station 224 a, via which drain 223 fluid is communicable to and/or from the lubricator 220, using, for example, an auto-fill/auto-drain pump of the pump station 224 a, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234. Finally, when the lubricator 220 is connected to the valve apparatus 210 via the latch 234, fluid can also be communicated to the lubricator 220 (via, for example, the containment area 215 c and the EQ valve 222 b) using one or more boost pump(s) 224 b in order to increase a fluid pressure in the lubricator 220, aiding in pressure equalization between the lubricator 220 and the associated wellhead. For example, the boost pump(s) 224 b may include: a first boost pump capable of pumping at relatively higher volumes and relatively lower pressures; and a second boost pump capable of pumping at relatively lower volumes and relatively higher pressures. The first and second boost pumps are used in combination to achieve combined pumping at relatively higher volumes and relatively higher pressures. In addition, or instead, a third boost pump capable of pumping at relatively~~

~~higher volumes and relatively higher pressures may be used. Moreover, although shown as being connected to, and in fluid communication with, the containment area 215 c, one or more of the boost pump(s) 224 b may instead be, include, or be part of the pump station 224 a.~~

~~In one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 15/487,785, filed Apr. 14, 2017, now issued as U.S. Pat. No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus 210 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/721,203, filed Dec. 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/248,633, filed Jan. 15, 2019, now issued as U.S. Pat. No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/801,911, filed Feb. 26, 2020, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher 178 is or includes one or more components shown and described in U.S. patent application Ser. No. 16/803,156, filed Feb. 27, 2020, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.~~

~~In one or more embodiments, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n, respectively, are substantially identical to the frac leg 150A associated with the well 105A; therefore, the frac legs 150B through 150C+n associated with each of the wells 105B through 105C+n will not be described in further detail. Accordingly, each of the frac legs 150B through 150C+n associated with the wells 105B through 105C+n includes features/components substantially identical to corresponding features/components of the frac leg 150A associated with the well 105A, which substantially identical features/components are given the same reference numerals and will also not be described in further detail.~~

~~Referring to FIG. 3, with continuing reference to FIGS. 2A through 2G, in an embodiment, various sub-steps 226 a-h of the step 225 of the method 175 illustrated in FIG. 1B are shown in detail, which step 225 is or includes equalizing the lubricator 220 of the frac leg 150A associated with the well 105A, and opening the well 105A. In one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the lubricator 220 is or includes one or more components shown and described in the '854 application.~~

~~At the sub-step 226 a, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the lubricator 220 of the frac leg 150A, thereby aiding in pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2A and 3 (indicated by arrow 232 a in FIG. 2A). As shown in FIG. 1B, the step 265 of latching, filling, and pressure testing the frac leg 150A associated with the well 105A is executed on the frac leg 150A just prior to the execution of the sub-step 226 a on the frac leg 150A. The step 265 will be described in further detail below as executed on the frac leg 150E; however, the description below also applies to the execution of the step 265 on the frac leg 150A. As a result, in one or more embodiments, just prior to execution of the sub-step 226 a on the frac leg 150A: the EQ valve 222 c is closed; the drain 223 is closed; the lubricator 220 extends within, and is latched to, the latch 234; the flow control~~

~~device 221-b is closed; the EQ valve 222-b is open; the flow control device 221-a is closed; the EQ valve 222-a is closed; the pump-down valves 160-a-b closed, and grease from the grease system 155 is withheld from the corresponding GPs 195; the zipper valves 170-a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200-a-b; and the master valves 165-a-b are open, and grease from the grease system 155 is communicated to the corresponding GPs 185-a-b. The communication of grease from the grease system 155 to the corresponding GPs 185-a-b is not indicated by arrows in FIG. 2A but is instead indicated by a lack of shading of the GPs 185-a-b as shown in FIG. 2A; the same lack of shading indication applies to the GPs 185-a-b as shown in FIGS. 2B-G, 5A-C, 7A-I, 9A-G, 11, 14A-B, 16A-C, and 18A-G.~~

~~At the sub-step 226-b, respective fluid pressures within the containment areas 215-a and 215-c are compared to determine whether the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within a threshold amount of the fluid pressure in the well 105A. If it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has not been equalized to within the threshold amount of the fluid pressure in the well 105A, the EQ valve 222-a is opened at the sub-step 226-c to further encourage such pressure equalization between said lubricator 220 and the well 105A, as shown in FIGS. 2B and 3. Alternatively, the order in which the sub-steps 226-a and 226-c are executed may be reversed, or one of the sub-steps 226-a and 226-c may be omitted altogether.~~

~~At the sub-step 226-d, once it is determined that the fluid pressure in the lubricator 220 of the frac leg 150A has been equalized to within the threshold amount of the fluid pressure in the well 105A, the flow control device 221-a is opened, as shown in FIGS. 2C and 3. At the sub-step 226-e, the EQ valve 222-a is closed, as shown in FIGS. 2D and 3. However, in those embodiments in which the sub-step 226-c of opening the EQ valve 222-a is omitted, the sub-step 226-e of closing the EQ valve 222-a is also omitted. Additionally, the sub-step 226-e may be executed to close the EQ valve 222-a at any time before, during, or after, execution of the sub-steps 226-d, 226-f, or 226-g. At the sub-step 226-f, the flow control device 221-b is opened, as shown in FIGS. 2E and 3. At the sub-step 226-g, the boost pump(s) 224-b is/are turned off, as shown in FIGS. 2F and 3. At the sub-step 226-h, the EQ valve 222-b is closed, as shown in FIGS. 2G and 3. Once the sub-steps 226-a-h are executed, the well 105A is ready for execution of the step 230, namely perforating a stage of the well 105A using the wireline perforating system 177, as will be described in detail below in connection with FIGS. 4 and 5A through 5C.~~

~~Referring to FIGS. 4 and 5A through 5C, in an embodiment, various sub-steps 231-a-h of the step 230 of the method 175 illustrated in FIG. 1B are shown in detail, which step 230 is or includes perforating a stage of the well 105A using the wireline perforating system 177. In one or more embodiments, the wireline perforating system 177 is or includes the pump-down truck 190, a wireline truck 233, the lubricator 220, the launcher 178, the latch 234 (via which the lubricator 220 is detachably couplable to the valve apparatus 210), or any combination thereof. In addition, or instead, the wireline perforating system 177 may be or include one or more components shown and described in the '749 application. In addition, or instead, in one or more embodiments, the wireline perforating system 177 may be or include one or more components shown and described in the '854 application.~~

~~At the sub-step 231-a, a plug and perforating gun(s) are deployed from the lubricator 220, as shown in FIGS. 4 and 5A (indicated by arrow 232-b in FIG. 5A). At the sub-step 231-b, the pump-down valves 160-a-b are opened, as shown in FIGS. 4 and 5B. At the sub-step 231-c, grease from the grease system 155 is communicated to the corresponding GPs 195 of the pump-~~

~~down valves 160 a-b, respectively, as shown in FIGS. 4 and 5B (indicated by arrows 232 c in FIG. 5B). At the sub-step 231 d, the plug and perforating gun(s) are pumped down into the well 105A using the pump-down truck 190, as shown in FIGS. 4 and 5B (indicated by arrows 232 d and 232 e in FIG. 5B). At the sub-step 231 e, the pump-down valves 160 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 195, as shown in FIGS. 4 and 5C. Additionally, the sub-step 231 e may be executed to close the pump-down valves 160 a-b at any time before, during, or after, execution of the sub-steps 231 f, 231 g, or 231 h. At the sub-step 231 f, the plug is set in the well 105A, as shown in FIG. 4. At the sub-step 231 g, the perforating gun(s) are detonated in the well 105A, as shown in FIG. 4. Finally, at the sub-step 231 h, the spent perforating gun(s) are retrieved from the well 105A, as shown in FIGS. 4 and 5C (indicated by arrows 232 f and 232 g in FIG. 5C). Once the sub-steps 231 a-h are executed, the well 105A is ready for execution of the step 235, namely closing the well 105A using the valve apparatus 210 and draining the lubricator 220, as will be described in detail below in connection with FIGS. 6 and 7A through 7I.~~

~~Referring to FIGS. 6 and 7A through 7I, in an embodiment, various sub-steps 236 a-n of the step 235 of the method 175 illustrated in FIG. 1B are shown in detail, which step 235 is or includes closing the well 105A using the valve apparatus 210 and draining the lubricator 220. At the sub-step 236 a, bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed. The sub-step 236 a can be achieved in several ways, including, but not limited to: prompting the wireline operation for bump up; checking with the wireline operator to determine whether bump up has occurred; detecting bump up using a switch (e.g., a proximity switch) and/or another sensor (e.g., an accelerometer, a wireline speed sensor, a wireline tension sensor, a wireline length sensor, a wireline direction sensor, the like, or any combination thereof) associated with the lubricator 220; receiving verbal confirmation that bump up has occurred; or any combination thereof.~~

~~At the sub-step 236 b, once the bump up of the retrieved spent perforating gun(s) within the lubricator 220 is determined and/or confirmed, the flow control device 221 b is closed, as shown in FIGS. 6 and 7A. At the sub-step 236 c, the flow control device 221 a is closed, as shown in FIGS. 6 and 7B. At the sub-step 236 d, the EQ valve 222 c is opened, as shown in FIGS. 6 and 7C, to bleed down a fluid pressure in the lubricator 220 (indicated by arrow 232 g in FIG. 7C). At the sub-step 236 e, the EQ valve 222 b is opened, as shown in FIGS. 6 and 7D. At the sub-step 236 f, the lubricator 220 is checked to determine whether the fluid pressure in the lubricator 220 has dropped (or "bled down") to below a threshold value (e.g., a bleed PSI limit), as shown in FIG. 6. At the sub-step 236 g, once it has been determined that the fluid pressure in the lubricator 220 has dropped to below the threshold value, the EQ valve 222 b is closed, as shown in FIGS. 6 and 7E.~~

~~At the sub-step 236 h, the drain 223 is opened, as shown in FIGS. 6 and 7F. At the sub-step 236 i, the auto-drain pump of the pump station 224 a is turned on to drain fluid from the lubricator 220 via the drain 223, as shown in FIGS. 6 and 7F (indicated by arrow 232 h in FIG. 7F). At the sub-step 236 j, the auto-drain pump is allowed to finish auto-draining the lubricator 220 before the drain 223 is closed, as shown in FIGS. 6 and 7G. At the sub-step 236 k, the latch 234 is unlatched, as shown in FIGS. 6 and 7G. At the sub-step 236 i, the lubricator 220 is removed, as shown in FIGS. 6 and 7H (indicated by arrow 232 i in FIG. 7H). At the sub-step 236 m, the EQ valve 222 c is closed, as shown in FIG. 7I. Finally, at the sub-step 236 n, an object drop (e.g., from the launcher 178) and/or a pressure test is/are enabled, as shown in FIG. 6. More particularly, once the sub-steps 236 a-n are executed, the well 105A is ready for execution of the~~

~~step 240, namely isolating a stage of the well 105A in preparation for a hydraulic fracturing operation. The step 240 will be described in further detail below (in connection with FIGS. 8 and 9A through 9G) as executed on the frac leg 150B to isolate a stage of the well 105B; however, the description below also applies to the execution of the step 240 on the frac leg 150A to isolate a stage of the well 105A.~~

~~Referring to FIGS. 8 and 9A through 9G, in an embodiment, various sub-steps 241 a-o of the step 240 of the method 175 illustrated in FIG. 1B are shown in detail, which step 240 is or includes isolating a stage of the well 105B in preparation for a hydraulic fracturing operation. In one or more embodiments, the step 240 that is or includes isolating the stage of the well 105B includes or is part of a hydraulic fracturing operation. At the sub-step 241 a, the EQ valve 222 b is opened to facilitate pressure equalization between the containment areas 215 b and 215 c, as shown in FIGS. 8 and 9A. At the sub-step 241 b, an object is dropped from the launcher 178, as shown in FIGS. 8 and 9A. At the sub-step 241 c, respective fluid pressures within the containment areas 215 b and 215 c are checked to determine whether the containment areas 215 b and 215 c have been pressure equalized to within a threshold amount, as shown in FIG. 8. At the sub-step 241 d, once it is determined that the containment areas 215 b and 215 c have been pressure equalized to within the threshold amount, the flow control device 221 b is opened, as shown in FIGS. 8 and 9B. At the sub-step 241 e, the object passes into the containment area 215 c, as shown in FIGS. 8 and 9C. At the sub-step 241 f, the flow control device 221 b is closed, as shown in FIGS. 8 and 9C. At the sub-step 241 g, the EQ valve 222 b is closed, as shown in FIGS. 8 and 9D.~~

~~At the sub-step 241 h, the boost pump(s) 224 b is/are turned on to increase a fluid pressure in the containment area 215 c, thereby aiding in pressure equalization between the containment areas 215 a and 215 c, as shown in FIGS. 8 and 9D (indicated by arrow 232 j in FIG. 9D). At the sub-step 241 i, respective fluid pressures within the containment areas 215 a and 215 c are compared to determine whether the fluid pressure in the containment area 215 c has been equalized to within a threshold amount of the fluid pressure in the well 105B. If it is determined that the fluid pressure in the containment area 215 c has not been equalized to within the threshold amount of the fluid pressure in the well 105B, the EQ valve 222 a is opened at the sub-step 241 j to further encourage such pressure equalization between said containment area 215 c and the well 105B, as shown in FIGS. 8 and 9E. Alternatively, the order in which the sub-steps 241 h and 241 j are executed may be reversed, or one of the sub-steps 241 h and 241 j may be omitted altogether.~~

~~At the sub-step 241 k, once it is determined that the fluid pressure in the containment area 215 c has been equalized to within the threshold amount of the fluid pressure in the well 105B, the flow control device 221 a is opened, as shown in FIGS. 8 and 9F. At the sub-step 241 l, the boost pump(s) 224 b is/are turned off, as shown in FIGS. 8 and 9F. At the sub-step 241 m, the EQ valve 222 a is closed, as shown in FIGS. 8 and 9F. However, in those embodiments in which the sub-step 241 j of opening the EQ valve 222 a is omitted, the sub-step 241 m of closing the EQ valve 222 a is also omitted. Additionally, the sub-step 241 m may be executed to close the EQ valve 222 a at any time before, during, or after, execution of the sub-steps 241 k or 241 l. At the sub-step 241 n, the object is permitted passage to the well 105B, as shown in FIGS. 8 and 9G. Finally, at the sub-step 241 o, the flow control device 221 a is closed, as shown in FIGS. 8 and 9G. Once the sub-steps 241 a-o are executed, the well 105B is ready for execution of the step 245, namely detecting or otherwise determining that a fracturing stage of the well 105D has ended, as will be described in detail below in connection with FIGS. 10 and 11.~~

~~Referring to FIGS. 10 and 11, in an embodiment, various sub-steps 246 a-c of the step 245 of the method 175 illustrated in FIG. 1B are shown in detail, which step 245 is or includes detecting or otherwise determining that a fracturing stage of the well 105D has ended. At the sub-step 246 a, the n1 well (e.g., well 105D) is monitored for an external signal indicating the fracturing stage has ended, as shown in FIG. 10. At the sub-step 246 b, the n1 well's frac data is monitored to determine whether the fracturing stage has ended, as shown in FIG. 10. Finally, at the sub-step 246 c, the zipper valves 170 a-b associated with the n1+1 well (e.g., well 105B) are dequeued and compared against the frac order (if available). During execution of the sub-steps 246 a-c: grease from the grease system 155 is communicated to the corresponding GPs 200 a-b of the zipper valves 170 a-b, respectively, as shown in FIG. 11 (indicated by arrows 232 k in FIG. 5B); and hydraulic fracturing fluid is communicated from the zipper manifold 145 to the well 105D, as shown in FIG. 11 (indicated by arrows 232 l and 232 m in FIG. 11).~~

~~Referring to FIG. 12, in an embodiment, various sub-steps 251 a-c of the step 250 of the method 175 illustrated in FIG. 1B are shown in detail, which step 250 is or includes determining whether to permit a regular swap or a CP swap from hydraulically fracturing (at a step 262) the well 105D to hydraulically fracturing (at the step 262) the well 105B, by, for example: checking an idle rate of the hydraulic fracturing system 100 at the sub-step 251 a; and detecting or otherwise determining that an idle rate of the hydraulic fracturing system 100 is below an upper threshold and above a lower threshold at the sub-step 251 b, or, at the sub-step 251 c, detecting or otherwise determining that the idle rate of the hydraulic fracturing system 100 is below the lower threshold. More particularly, as shown in FIG. 12: at the sub-step 251 a, a frac rate of the n1 well (e.g., well 105D) is checked; and, at the sub-step 251 b, if the frac rate of the n1 well is below the upper threshold rate (e.g., 10 bbl) and above the lower threshold rate (e.g., 0 bbl) for a threshold amount of time (e.g., 10 s), a CP swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 260, but, at the sub-step 251 c, if the frac rate of the n1 well is below the lower threshold rate for a threshold amount of time, only a regular swap from hydraulically fracturing the n1 well to hydraulically fracturing the n1+1 well is permitted at step 255.~~

~~Referring to FIGS. 13 and 14A through 14B, in an embodiment, various sub-steps 256 a-c of the step 255 of the method 175 illustrated in FIG. 1B are shown in detail, which step 255 is or includes executing the regular swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 256 a, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b, as shown in FIGS. 13 and 14A. At the sub-step 256 b, a signal to advance is received, as shown in FIG. 13. For example, a user input such as a screen click may be received at the sub-step 256 b. In addition, or instead, an external signal, such as an external signal from the frac operator, may be received at the sub-step 256 b. In addition, or instead, a signal to advance may be generated by detecting or otherwise determining that pressure equalization has been achieved to within a threshold amount between the hydraulic fracturing pressure in the zipper manifold 145 and the fluid pressure in the n1+1 well (e.g., well 105B) for a threshold amount of time. At the sub-step 256 c, the n1+1 well's zipper valves 170 a-b are opened, as shown in FIGS. 13 and 14B, so that hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14B), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 14B).~~

~~Referring to FIGS. 15 and 16A through 16E, in an embodiment, various sub-steps 261 a-c of the step 260 of the method 175 illustrated in FIG. 1B are shown in detail, which step 260 is or includes executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B). At the sub-step 261 a, the n1+1 well's (e.g., well 105B) zipper valves 170 a-b are opened, as shown in FIGS. 15 and 16A, hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 16A), and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrow 232 p in FIG. 16A). At the sub-step 261 b, both the n1+1 well's (e.g., well 105B) zipper valves 170 a-b and the n1 well's (e.g., well D) zipper valves 170 a-b are allowed to fully open, as shown in FIGS. 15, 16A and 16B, so that: hydraulic fracturing fluid is communicated from the zipper manifold 145 to the n1 well (indicated by arrows 232 l and 232 m in FIG. 16B) and the n1+1 well (indicated by arrows 232 n and 232 o in FIG. 14A); and grease from the grease system 155 is communicated to the corresponding GPs 200 a-b (indicated by arrows 232 p and 232 k in FIGS. 16A and 16B, respectively). Finally, at the sub-step 261 c, the n1 well's (e.g., well 105D) zipper valves 170 a-b are closed, as shown in FIGS. 15 and 16C, and grease from the grease system 155 is withheld from the corresponding GPs 200 a-b.~~

~~As shown in FIGS. 16D and 16E, executing the CP swap from hydraulically fracturing (at the step 262) the n1 well (e.g., well 105D) to hydraulically fracturing (at the step 262) the n1+1 well (e.g., well 105B) transitions the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is less than 20 seconds (as fast as 19 seconds in some instances).~~

~~Referring to FIGS. 17 and 18A through 18G, in an embodiment, various sub-steps 266 a-s of the step 265 of the method 175 illustrated in FIG. 1B are shown in detail, which step 265 is or includes latching, filling, and pressure testing the frac leg 150E associated with the well 105E in preparation for perforating a stage of the well 105E using the wireline perforating system 177 (in a manner similar to that described above in connection with the well 105A and shown in FIGS. 5A through 5C). At the sub-step 266 a, the lubricator 220 is stabbed into the latch 234, as shown in FIGS. 17 and 18A (indicated by arrow 232 q in FIG. 18A). At the sub-step 266 b, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18B. At the sub-step 266 c, the latch close relay is energized to close the latch 234, thereby connecting the lubricator 220 to the valve apparatus 210, as shown in FIGS. 17 and 18C. At the sub-step 266 d, a latch close proximity switch is checked to determine whether the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210. At the sub-step 266 e, once it is determined that the latch 234 has successfully latched the lubricator 220 to the valve apparatus 210, the latch close relay is de-energized, as shown in FIG. 17. At the sub-step 266 f, a test pressure relay is energized, as shown in FIG. 17. At the sub-step 266 g, a determination is made as to whether the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is or is not capable of holding pressure, as shown in FIG. 17. At the sub-step 266 h, once the determination is made that the connection of the lubricator 220 to the valve apparatus 210 via the latch 234 is capable of holding pressure, the test pressure relay is de-energized, as shown in FIG. 17.~~

~~At the sub-step 266 i, the drain 223 is opened, as shown in FIGS. 17 and 18D. At the sub-step 266 j, the EQ valve 222 c is opened, as shown in FIGS. 17 and 18E. At the sub-step 266 k, the auto-fill pump of the pump station 224 a is turned on to fill the lubricator 220 via the open drain 223, as shown in FIGS. 17 and 18E (indicated by arrow 232 r in FIG. 18E). At the sub-step 266 l,~~

~~the auto-fill pump is allowed to finish auto-filling the lubricator 220, as shown in FIG. 17. At the sub-step 266 m, the drain 223 is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 n, the EQ valve 222 c is closed, as shown in FIGS. 17 and 18F. At the sub-step 266 o, the EQ valve 222 b is opened, as shown in FIGS. 17 and 18F. At the sub-step 266 p, the boost pump(s) 224 b is/are turned on to increase the fluid pressure within the lubricator 220, as shown in FIGS. 17 and 18F (indicated by arrow 232 s in FIG. 18F). At the sub-step 266 q, a determination is made as to whether the pressure in the lubricator 220 comes to within the pressure in the well 105E by a threshold amount (e.g., 500 PSI), as shown in FIG. 17. Once the determination is made that the pressure in the lubricator 220 comes to within the pressure in the well 105E by the threshold amount, the boost pump(s) 224 b is/are turned off at the sub-step 266 r, and the EQ valve 222 b is closed at the sub-step 266 s in preparation for the next wireline swap (e.g., to the well 105E), as shown in FIGS. 17 and 18G.~~

~~Referring to FIGS. 19A and 19B, in an embodiment, a method 270 for fracturing the wells 105A through 105C+n using the hydraulic fracturing system 100 of FIG. 1A is illustrated, which method 270 includes swapping from simultaneously fracturing the wells n1 and n3 (e.g., wells 105D and 105X) to simultaneously fracturing the wells n1+1 and n3+1 (e.g., wells 105B and 105V). More particularly, the method 270 includes steps substantially identical to corresponding steps of the method 175 described above, which steps are given the same reference numerals. In addition, the method 270 includes additional steps executable to simultaneously fracture the n1 and n3 wells (e.g., wells 105D and 105X), and to swap from simultaneously fracturing the n1 and n3 wells to simultaneously fracturing the n1+1 and n3+1 wells (e.g., wells 105B and 105V), which additional steps are given the same reference numerals, except that the suffix "′" is added. Specifically, in some instances the suffix "′" signifies that the referenced step of the method 270 is substantially identical to the corresponding step of the method 175, except that the referenced step is instead performed on a different one of the wells than that on which the corresponding step of the method 175 is performed (i.e., the steps 225′, 230′, 235′, 238 a′, 239′, 238 b′, 263 a′, 264′, 263 b′, 265′, and 268′ fall into this category), while, in other instances, the suffix "′" signifies that the referenced step of the method 270 is substantially similar to the corresponding step of the method 175, except that the referenced step is simultaneously performed on another one of the wells other than that on which the corresponding step of the method 175 is performed (i.e., the steps 240′, 245′, 250′, 255′, 260′, and 262′ fall into this category). In one or more embodiments, the controller 156 is adapted to control the grease system 155, the frac legs 150A through 150C+n, or both, in order to execute the method 270 described herein.~~

~~Referring to FIG. 20, with continuing reference to FIGS. 1A through 19B, an illustrative node 1000 for implementing one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B is depicted. The node 1000 includes a microprocessor 1000 a, an input device 1000 b, a storage device 1000 c, a video controller 1000 d, a system memory 1000 e, a display 1000 f, and a communication device 1000 g all interconnected by one or more buses 1000 h. In one or more embodiments, the storage device 1000 c may include a hard drive, CD-ROM, optical drive, any other form of storage device and/or any combination thereof. In one or more embodiments, the storage device 1000 c may include, and/or be capable of receiving, a CD-ROM, DVD-ROM, or any other form of non-transitory computer-readable medium that may contain executable instructions. In one or more embodiments, the communication device 1000 g may include a modem, network card, or~~

~~any other device to enable the node 1000 to communicate with other node(s). In one or more embodiments, the node and the other node(s) represent a plurality of interconnected (whether by intranet or Internet) computer systems, including without limitation, personal computers, mainframes, PDAs, smartphones and cell phones.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include at least the node 1000 and/or components thereof, and/or one or more nodes that are substantially similar to the node 1000 and/or components thereof. In one or more embodiments, one or more of the above-described components of the node 1000 and/or the embodiments described above and/or illustrated in FIGS. 1A through 19B include respective pluralities of same components.~~

~~In one or more embodiments, one or more of the embodiments described above and/or illustrated in FIGS. 1A through 19B include a computer program that includes a plurality of instructions, data, and/or any combination thereof; an application written in, for example, Arena, HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Extensible Markup Language (XML), asynchronous JavaScript and XML (Ajax), and/or any combination thereof; a web-based application written in, for example, Java or Adobe Flex, which in one or more embodiments pulls real-time information from one or more servers, automatically refreshing with latest information at a predetermined time increment; or any combination thereof.~~

~~In one or more embodiments, a computer system typically includes at least hardware capable of executing machine readable instructions, as well as the software for executing acts (typically machine-readable instructions) that produce a desired result. In one or more embodiments, a computer system may include hybrids of hardware and software, as well as computer sub-systems.~~

~~In one or more embodiments, hardware generally includes at least processor-capable platforms, such as client-machines (also known as personal computers or servers), and hand-held processing devices (such as smart phones, tablet computers, or personal computing devices (PCDs), for example). In one or more embodiments, hardware may include any physical device that is capable of storing machine-readable instructions, such as memory or other data storage devices. In one or more embodiments, other forms of hardware include hardware sub-systems, including transfer devices such as modems, modem cards, ports, and port cards, for example.~~

~~In one or more embodiments, software includes any machine code stored in any memory medium, such as RAM or ROM, and machine code stored on other devices (such as floppy disks, flash memory, or a CD-ROM, for example). In one or more embodiments, software may include source or object code. In one or more embodiments, software encompasses any set of instructions capable of being executed on a node such as, for example, on a client machine or server.~~

~~In one or more embodiments, combinations of software and hardware could also be used for providing enhanced functionality and performance for certain embodiments of the present disclosure. In an embodiment, software functions may be directly manufactured into a silicon chip. Accordingly, it should be understood that combinations of hardware and software are also included within the definition of a computer system and are thus envisioned by the present disclosure as possible equivalent structures and equivalent methods.~~

~~In one or more embodiments, computer readable mediums include, for example, passive data storage, such as a random-access memory (RAM) as well as semi-permanent data storage such as a compact disk read only memory (CD-ROM). One or more embodiments of the present disclosure may be embodied in the RAM of a computer to transform a standard computer into a~~

~~new specific computing machine. In one or more embodiments, data structures are defined organizations of data that may enable an embodiment of the present disclosure. In an embodiment, a data structure may provide an organization of data, or an organization of executable code.~~

~~In one or more embodiments, any networks and/or one or more portions thereof may be designed to work on any specific architecture. In an embodiment, one or more portions of any networks may be executed on a single computer, local area networks, client-server networks, wide area networks, internets, hand-held and other portable and wireless devices and networks.~~

~~In one or more embodiments, a database may be any standard or proprietary database software. In one or more embodiments, the database may have fields, records, data, and other database elements that may be associated through database specific software. In one or more embodiments, data may be mapped. In one or more embodiments, mapping is the process of associating one data entry with another data entry. In an embodiment, the data contained in the location of a character file can be mapped to a field in a second table. In one or more embodiments, the physical location of the database is not limiting, and the database may be distributed. In an embodiment, the database may exist remotely from the server, and run on a separate platform. In an embodiment, the database may be accessible across the Internet. In one or more embodiments, more than one database may be implemented.~~

~~In one or more embodiments, a plurality of instructions stored on a computer readable medium may be executed by one or more processors to cause the one or more processors to carry out or implement in whole or in part one or more of the embodiments of one or more of the controller(s) (e.g., the controller 156), element(s), apparatus, system(s) (e.g., the hydraulic fracturing system 100), method(s) (e.g., the method 175, the method 270, or both), step(s), and/or sub-step(s), or any combination thereof, described above and/or illustrated in FIGS. 1A through 19B. In one or more embodiments, such a processor may include one or more of the microprocessor 1000 a, any processor(s) that are part of the components of the hydraulic fracturing system 100, such as, for example, the controller 156, and/or any combination thereof, and such a computer readable medium may be distributed among one or more components of the system. In one or more embodiments, such a processor may execute the plurality of instructions in connection with a virtual computer system. In one or more embodiments, such a plurality of instructions may communicate directly with the one or more processors, and/or ay interact with one or more operating systems, middleware, firmware, other applications, and/or any combination thereof, to cause the one or more processors to execute the instructions.~~

~~A first method has been disclosed. The first method generally includes: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid~~

~~communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and the method further includes withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and the method further includes: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and the method further includes: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A first apparatus has also been disclosed. The first apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation includes pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time; (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation includes pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve. In one or more embodiments, the second valve is opened after step (b). In one or more embodiments, the first valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: withholding grease from the grease port after step (e). In one or more embodiments, the second valve includes a grease port; and, when the instructions are executed by the one or more processors, the following step is also executed: during and/or after opening the second valve, communicating grease to the grease port of the second valve. In one or more embodiments, each of the first and second valves is a zipper valve. In one or more embodiments, step (d): further includes measuring a flow rate of the fluid being pumped into the second well; and is, or is part of, a hydraulic fracturing stage of the second well; and, when the instructions are executed by the one or more processors, the~~

~~following steps are also executed: determining that the hydraulic fracturing stage of the second well has ended; determining that the flow rate of the fluid being pumped into the second well is above the flow rate threshold; closing the second valve associated with the second well; withholding grease from a grease port of the second valve; receiving a signal to advance; opening a third valve associated with a third well; and during and/or after opening the third valve, communicating grease to a grease port of the third valve.~~

~~A second method has also been disclosed. The second method generally includes: (a) queuing, using a controller, a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue is associated with a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing, using the controller, the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing, using the controller, the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, the step (e) further includes, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, the method further includes: (f) queuing, using the controller, a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue is associated with a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing, using the controller, the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing, using the controller, the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~A second apparatus has also been disclosed. The second apparatus generally includes: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory~~

~~computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) queuing a first well in a first hydraulic fracturing queue, which first hydraulic fracturing queue includes a first plurality of wells standing by for hydraulic fracturing, including at least the first well and a second well; (b) dequeuing the second well from the first hydraulic fracturing queue; (c) permitting hydraulic fracturing of the second well; (d) dequeuing the first well from the first hydraulic fracturing queue; and (e) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well. In one or more embodiments, step (c) further includes measuring a flow rate of the fluid being pumped into the second well. In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time, the first valve associated with the first well is opened at step (e) before the second valve associated with the second well is closed at step (e). In one or more embodiments, in response to determining that the flow rate of the fluid being pumped into the second well is above a flow rate threshold, the first valve associated with the first well is opened at step (e) after the second valve associated with the second well is closed at step (e). In one or more embodiments, when the instructions are executed by the one or more processors, the following steps are also executed: (f) queuing a third well in a second hydraulic fracturing queue, which second hydraulic fracturing queue includes a second plurality of wells standing by for hydraulic fracturing, including at least the third well and a fourth well; (g) dequeuing the fourth well from the second hydraulic fracturing queue; (h) permitting hydraulic fracturing of the fourth well; (i) dequeuing the third well from the second hydraulic fracturing queue; and (j) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well. In one or more embodiments, steps (c) and (h) are executed simultaneously using hydraulic fracturing fluid from a hydraulic manifold; and steps (e) and (j) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold. In one or more embodiments, step (c) includes opening a second valve associated with the second well to permit pumping of fluid into the second well via the second valve; step (e) includes: opening a first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; step (h) includes opening a fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and step (j) includes: opening a third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and closing the fourth valve associated with the fourth well.~~

~~It is understood that variations may be made in the foregoing without departing from the scope of the present disclosure.~~

~~In several embodiments, the elements and teachings of the various embodiments may be combined in whole or in part in some (or all) of the embodiments. In addition, one or more of the elements and teachings of the various embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various embodiments.~~

~~Any spatial references, such as, for example, "upper," "lower," "above," "below," "between," "bottom," "vertical," "horizontal," "angular," "upwards," "downwards," "side-to-side," "left-to-right," "right-to-left," "top-to-bottom," "bottom-to-top," "top," "bottom," "bottom-up," "top-down," etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.~~

~~In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, and/or one or more of the procedures may also be performed in different orders, simultaneously and/or sequentially. In several embodiments, the steps, processes, and/or procedures may be merged into one or more steps, processes and/or procedures.~~

~~In several embodiments, one or more of the operational steps in each embodiment may be omitted. Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the above-described embodiments and/or variations may be combined in whole or in part with any one or more of the other above-described embodiments and/or variations.~~

~~Although several embodiments have been described in detail above, the embodiments described are illustrative only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes and/or substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and/or substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, any means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word "means" together with an associated function.~~

FIG. 1 is a schematic diagram of an example well site 1 arranged for fracking. The well fracking site 1 includes tanks 2. The tanks 2 hold fracking fluids, proppants, and/or additives that are used during the fracturing process. The tanks 2 are fluidically coupled to one or more blenders 3 at the well site 1 via fluid lines (e.g., pipes, hoses, and/or other types of fluid lines). The blenders mix the fracking fluids, proppants, and/or additives being used for the fracking operation prior to being pumped into the well 4. The blenders are fluidically coupled to one or more fracking pumps 5 via lines. The fracking pumps increase the pressure of the blended fracking fluid to fracking pressure (i.e., the pressure at which the target formation fractures) for injection into the well 4. A data van 6 is electronically connected to the tanks 2, the blenders 3, the well 4, and the fracking pumps 5. The data van 6 includes a controller that controls and monitors the various components at the well site 1. While a variety of components have been described in the example well site 1, not all of the described components need be included. In some implementations, additional equipment may be included. Also, the well 4 can be an onshore or offshore well. In the case of an offshore well, including subsea wells and wells beneath lakebeds or other bodies of water, the well site 1 is on a rig or vessel or may be distributed among several rigs or vessels. During fracking operations, various components are stacked atop the well 4. FIGS. 2A-2C illustrate, at various stages of operation, an example fracturing stack 200 attached at a wellhead of the well 4. FIG. 2A shows a fracturing stack 200 with a lubricator 202 positioned at the top. The lubricator 202 carries a wireline or coiled tubing deployed tool above a tool trap of or associated with the lubricator. The tool trap is actuable in response to a signal (e.g., hydraulic,

electric, and/or other signal) to gate passage of the tool from the lubricator. The lubricator is a tool that maintains a seal around the wireline or coiled tubing while the tool is being run into the well 4. In the present example, the lubricator 202 internally carries a perforating string 220, including one or more perforating guns for perforating the wall of the wellbore and, often, a positioning tool, such as a casing collar locator and/or logging tool. In other examples, the lubricator 202 can carry other types of tool strings, such as logging tools, packoff tools, and other types of wireline or tubing deployed tools.

The lubricator 202 sits above a blowout preventer (BOP) 204. The BOP 204 is configured to seal off the well in the event of a kick or blowout. The BOP 204 is able to shear any tool or conveyance that may be positioned within the well during such an event. An automated latch 206 is below the BOP 204. The latch 206 operates in response to a signal (e.g., hydraulic, electric, and/or other) to grip and seal to (i.e., latch to) or open and release a mating hub. By providing the mating hub on the BOP 204, the latch 206 acts as a quick release that allows the BOP 204 and lubricator 202 to be installed and removed quickly without intervention of a worker, for example, to access and bolt/unbolt the BOP 204 from the remainder of the fracturing stack 200. In some instances, the latch 206 can be omitted from the fracturing stack 200 and the BOP bolted/unbolted from the remainder of the stack.

A valve assembly 10 is below the latch 206. The valve assembly 10 can include a single or dual part body. The valve assembly 10 is actuable in response to a signal (e.g., hydraulic, electric and/or other) to isolate or seal the well (i.e., seal the bore through the fracturing stack 200) from any components positioned above the valve assembly 10, such as the lubricator 202, BOP 204, or the atmosphere 208. Structural details of the valve assembly 10 are described in greater detail later within this disclosure. Below the valve assembly 10 is a fracturing manifold 210, sometimes referred to as a goat head or frac head. The fracking pumps 5 are fluidically connected by lines to the fracturing stack 200 through the frac head 210. In certain instances, a swab valve 212 can be provided above or below the frac head 210 that can be used to isolate/access the well, for example for maintenance. Below the swab valve 212 are wing valves 214. The wing valves 214 can be used for a variety of wellbore operations, such as purging the well 4. Below the wing valves are one or more main valves 216 configured to seal the well 4, including as the fracturing stack 200 is assembled, disassembled, and/or maintained. While a variety of components have been described in the fracturing stack, not all of the described components need be included. In some implementations, additional equipment, such as additional main valves 216, may be included. Also, although shown as separate components, two or more of the components of the fracturing stack 200 could be integrated. For example, in certain instances, the frac head 210 and valve assembly 10 may be integrated together, e.g., constructed with a common housing or otherwise configured to attach/detach from the fracturing stack 200 as a unit. Other combinations of components could likewise be integrated.

The valve assembly 10, when closed, seals to maintain pressure on and below the frac head 210 and any equipment fluidically connected to the frac head 210, for example the fracking equipment at the well site 1, including pumps 5, the blenders 3, any lines fluidically connecting such equipment. Such isolation allows the BOP 204 and lubricator 202 to be removed, reinstalled, or maintained without depressurizing the well 4 or fracturing equipment on well site 1. As explained in more detail below, such isolation also allows the top of the fracturing stack 200 to be opened and accessed at atmospheric conditions, for example, to insert a tool on wireline or tubing or a well drop (e.g., frac ball, collet, dart, or other) or other item into the well 4. Every time the fracturing stack 200 and fracturing equipment at the well site 1 is

depressurized, it needs to be re-pressure tested prior to commencing operations. In some instances, this can take several hours, and in multi-stage fracturing, cumulatively days In multi-stage fracturing operations, where equipment is added and removed from the top of the fracturing stack 200 multiple times, maintaining pressure on the system between operations can save several days at a well site.

FIG. 2B shows a cross-sectional view of the fracturing stack 200. Once assembled, the fracturing stack has a central flow path, or main bore, extending through the center of the stack. The frac head 210 includes lateral fluid injection paths 218 where the fracking pumps 5 are fluidically connected for injecting frac fluids into the main bore and, in turn, into the well 4 during a fracturing treatment. The valve assembly 10 sits above the frac head 210 and includes two valves capable of isolating the frac head 210 and fracturing stack 200 below from any equipment located above the valve assembly 10. For example, fracturing stack 200 can be pressurized and tested for perforation operations. In such a situation, the BOP 204 and lubricator 202 are installed to lower the perforating string 220 into the wellbore. After the perforation operation is complete, a frac ball can be dropped into the well. In such an instance, the valve assembly 10 is closed and all of the components above the valve assembly are depressurized. In some instances, the BOP may remain in place. In other instances, the BOP can be removed, such as in FIG. 2C. In either instance, the fracturing stack 200 is still pressurized below the valve assembly 10.

After the well 4 is completed, or in a workover operation of the well 4, the fracturing stack 200 is used in fracturing the subterranean formation surrounding the well 4. While more details of the operation of the fracturing stack 200 will be described below, in general, in a fracturing operation, fracturing fluids containing proppant are pumped to the frac head 210 from the blenders and pumps at the well site 1. The fracturing stack 200 can be in either configuration of FIG. 2A or 2C and valve assembly 10 is closed, sealing the central bore of the fracturing stack 200 above the fracturing head 210. The fracturing fluids pass into the frac head 210, down the central bore of the fracturing stack 200 and the well 4, and out of a perforated or slotted interval of the well 4 into the subterranean formation. The fracturing fluids are at fracturing pressure, meaning the rate and pressure of the fracturing fluids cause the subterranean formation at that interval to expand and fracture.

In a multi-stage fracturing operation, the well 4 is perforated and then fracked in another interval. A lubricator 202 containing a perforating string 220 is used in conducting the perforating operation. If, upon completion of the first stage fracturing, the fracturing stack 200 is configured as in FIG. 2C without a lubricator 202, the latch 206 is operated to receive the BOP 204 with the lubricator 202 as shown in FIG. 2A. The valve assembly 10 is then used (as discussed in more detail below) to bring the BOP 204 and lubricator 202 up to pressure without needing to lower the pressure in the fracturing stack 200 below the fracturing head 210. The perforating string 220 can then be lowered through the valve assembly 10 into the well 4, and operated to perforate the wall of the wellbore at another specified interval. The perforating string 220 is withdrawn back to the lubricator 202 and the valve assembly 10 closed to isolate the lubricator 202 from pressure in the remaining portion of the fracturing stack 200.

The valve assembly 10 is then used (as described in more detail below) to depressurize a top portion of the fracturing stack 200 for removing the lubricator 202 from the fracturing stack 200 (resulting in the configuration of FIG. 2C) and in introducing a well drop from atmospheric conditions in the environment surrounding the fracturing stack 200 into the center bore of the well 4 without needing to lower the pressure in the fracturing stack 200 below the valve assembly 10 or in the surface equipment (e.g., blenders, frack pumps, associated lines, and/or

other surface equipment). The well drop can be released using a launcher (e.g., a single or multi ball, collet, dart launcher, and/or another type of launcher) on the fracturing stack 200 or by hand, manually inserting the well drop into the top of the stack 200 above the valve assembly 10. When release from the valve assembly 10, the well drop travels through the well 4, landing on a specified profile internal to the well 4 to isolate the fractured interval from the remaining portion of the well, for example, by shifting a frac sleeve or sealing off the central bore. Once the fractured interval is isolated, the next fracturing stage is begun.

FIG. 3 shows one example of a valve assembly 10. The valve assembly 10 includes connectors (e.g., flange or other type of connector), top and bottom, for connecting to other components of the fracturing stack. The valve assembly 10 can also include a first, or top, operating volume 14 near an upper end of the assembly 10 that can be isolated from the remainder of the valve assembly 10 to enable the area 14 to be maintained at a lower pressure (e.g., atmospheric pressure) than the remainder of the valve assembly 10. The first operating volume 14 can thus be in fluid communication with whatever is disposed above it via an opening at the top end of the central bore through the valve assembly 10.

The valve assembly 10 further includes a second intermediate, or load lock, operating volume 16 disposed adjacent to the first operating volume 14. A third, or bottom, operating volume 18 is disposed adjacent to a second operating volume 16 on an opposite side of the second operating volume 16 from the first operating volume 14. Each operating volume 14, 16, and/or 18 can be sealed from the others to contain fluid at different pressures.

FIG. 4 is a side half cross-sectional view of the example valve assembly 10. The first operating volume 14, the second operating volume 16, and/or the third operating volume 18 can each include a downwardly oriented frustoconical funnel that works to direct a well drop 12, such as a well drop or well tool, being passed therethrough to the center bore in each respective operating volume. A first funnel 20 is disposed in an upper part of the first operating volume 14. A second funnel 22 is disposed in an upper part of the second operating volume 16. A third funnel element is disposed in an upper part of the third operating volume 18.

The valve assembly 10 is designed to use the fluid pressure in the third operating volume 18 to pressurize the second operating volume 16 and the pressure in the second operating volume 16 to pressurize the first operating volume 14. The valve assembly 10 is also designed to reduce pressure of the second operating volume 16 by bleeding to the atmosphere or to the first operating volume 14.

The valve assembly 10 further includes a first valve 36 that separates the first operating volume 14 from the second operating volume 16 and a second valve 38 that separates the second operating volume 16 from the third operating volume 18. The first operating volume 14 can be a space that is defined by the area between the first valve 36 and any apparatus disposed atop the valve assembly 10. To pass the well drop 12 through the valve assembly 10, the pressure of the fluid in the second operating volume 16 is adjusted to be within a specified maximum pressure differential from the fluid in the first operating volume 14. Adjusting the pressure of the fluid in the second operating volume 16 allows the first valve 36 to open up and permit the well drop 12 disposed in the first operating volume 14 to pass into the second operating volume 16. The second operating volume 16 can be sized such that the well drop 12 can be contained therein without affecting the operation of the first valve 36. For example, the second operating volume 16 could be smaller when the well drop 12 is a frac ball and it would be larger (taller/longer) if the well drop 12 was a collet.

When the pressure of the fluid in the second operating volume 16 is beyond the specified maximum pressure differential from the fluid in the first operating volume 14, the first valve 36 cannot be opened by operation of the valve assembly 10. In certain instances, the maximum pressure differential is implemented in the operation of system, for example, by the configuration (e.g., strength or other characteristic) of the valve actuator, hydraulic areas, by control interlocks coupled with pressure sensors on either side of first valve 36 (to measure pressure in the first and second operating volumes 14, 16) or in another manner, and specified to prevent unintentional opening of the first valve 36, damage to the valve assembly 10 and other nearby equipment, and/or an otherwise unsafe condition.

To pass the well drop 12 from the second operating volume 16 into the third operating volume 18, the pressure of the fluid in the second operating volume 16 is increased to be within a specified maximum pressure differential from the fluid in the third operating volume 18. Once the pressure of the fluid in the second operating volume 16 is within the specified maximum pressure differential from the fluid in the third operating volume 18, the second valve 38 will open and permit the well drop 12 to pass from the second operating volume 16 into the third operating volume 18.

Similar to operation of the first valve 36, when the pressure of the fluid in the third operating volume 18 is outside of the specified maximum pressure differential from the fluid in the second operating volume 16, the second valve 38 cannot be opened by the operation of the valve assembly 10. As above, the specified maximum pressure differential used with the second valve 38 can be implemented, for example, by the configuration (e.g., strength or other characteristic) of the valve actuator, hydraulic areas, by control interlocks coupled with pressure sensors measuring on either side of second valve 38 (to measure pressure in the second and third operating volumes 16, 18) or in another manner, and specified to prevent unintentional opening of the second valve 38, damage to the valve assembly 10 and other nearby equipment, and/or an otherwise unsafe condition. Also, the specified maximum pressure differential used with the first valve 36 and second valve 38 need not be the same. Logic can be built into a controller that controls the operation of the first valve 36 and second valve 38, which prevents the opening of the first valve 36 and the second valve 38 if the pressure across either valve 36, 38 is beyond its respective specified maximum differential.

To run a tool on wireline or tubing through the valve assembly 10 during operating conditions (i.e., high-pressure conditions), the first valve 36 and the second valve 38 must be in an open position simultaneously. For the first valve 36 and the second valve 38 to be open, the pressure of the fluid in the first operating volume 14 and the second operating volume 16 can be adjusted to be within the specified maximum pressure differential with the pressure of the fluid in the third operating volume 18. This allows the first valve 36 and the second valve 38 to open up and permit the tool to pass through the valve assembly 10. In certain instances, the first valve 36 and the second valve 38 can be a type of valve that cannot shear the wireline or tubing during operation, such as flapper valves and the like. Other valves, such as plug valves, gate valves, and ball valves can be used with appropriate interlocks to prevent sheering of the wireline or tubing. That is, the first valve 36 and the second valve 38 can be any type of valve that can make contact with the tool or its conveyance without damaging it.

In some implementations, when wanting to pass a tool through the valve assembly 10, the first valve 36 is in a closed position and the pressure of the fluid in the second operating volume 16 can be increased to be within the specified maximum pressure differential with the fluid in the third operating volume 18, so the second valve 38 can open. In this scenario, the pressure of the

fluid in the first operating volume 14 will then be increased to be within the specified maximum pressure differential with the fluid in the second operating volume 16, so the first valve 36 can open. The pressure of the fluid in the first operating volume 14 will dictate the pressure in the fracturing stack above, since the two are in fluid communication. Once the first valve 36 and the second valve 38 are open, the tool is permitted to pass all of the operating volumes and into the well.

In some instances, the first valve 36 is in an open position and the second valve 38 is in a closed position when it is desirable for the valve assembly 10 to be used in passing a tool. The fluid in the first operating volume 14 and the second operating volume 16 is increased within the specified maximum pressure differential with the fluid in the third operating volume 18, the second valve 38 can open, which would permit the tool to be extended into and through the valve assembly 10. Conversely, the second valve 38 can be in an open position and the first valve 36 is in a closed position when it is desirable for the valve assembly 10 to be used in passing a tool. In this instance, the fluid in the first operating volume 14 is increased within the specified maximum pressure differential with the fluid in the second operating volume 16, and the third operating volume 18, the first valve 36 can open, which permits the tool to be extended into and through the valve assembly 10. It should be understood and appreciated that each operating volume 14, 16, and/or 18 can be pressured up or down in numerous ways.

In certain situations, the pressure of the fluid in the third operating volume 18, because it is exposed to well conditions, is dynamic and may be fluctuating in such a manner whereby the fluid pressure in the second operating volume 16 cannot reach the substantially same pressure as the dynamic pressure of the fluid in the third operating volume 18 for a sufficient amount of time to open the second valve 38. In some implementations, to combat this dynamic fluid pressure issue, the valve assembly 10 can include an external pump 48 (FIG. 3) in fluid communication with the second operating volume 16 to increase the pressure of the fluid in the second operating volume 16 to a sufficient pressure to overcome the dynamic pressure of the fluid in the third operating volume 18 for a sufficient amount of time and permit the second valve 38 to open. The external pump 48 can be any type of pump capable of achieving the required fluid pressures, for example, a triplex plunger pump or a diaphragm pump.

The valve assembly 10 can include a first port disposed in the body of the valve assembly 10 that fluidically connects the third operating volume 18 with a first end of a first equalizing conduit 42. The first conduit 42 extends from the first port to a second port disposed in the body of the valve assembly 10 that fluidically connects the second operating volume 16 to a second end of the first conduit 42. The valve assembly 10 can also include a third port disposed in the body of the valve assembly 10 that fluidically connects the second operating volume 16 with a first end of a second equalizing conduit 40. The second conduit 40 extends from the third port to a fourth port disposed in the body of the valve assembly 10 that fluidically connects the first operating volume 14 to a second end of the second conduit 40. In some implementations, the valve assembly 10 can include a third conduit that fluidically connects the third operating volume 18 to the first operating volume 14. The first operating volume 14 and third operating volume 18 can include additional ports to facilitate this fluid connection or the third conduit can be tied into the first conduit 42 on one end, where the first conduit 42 comes out of the third operating volume 18 and ties into the second conduit 40 on the other end, where the second conduit 40 comes out of the first operating volume 14. Equalizing valves 44 (e.g., sealing valve, flow diverters, and/or other fluid flow control devices) can be incorporated into or in fluid communication with the conduits direct fluid to flow to the appropriate conduits to accomplish the desired operation of

the valve assembly 10. The equalizing valves 44 can be actuable types, actuable to open/close in response to a signal (e.g., hydraulic, electric and/or other) and can include multiple devices for redundancy and safety.

To manage the pressure of the fluid in the second operating volume 16, the first conduit 42 that fluidically connects the second operating volume 16 to the third operating volume 18 can be used to increase the pressure of the fluid in the second operating volume 16. The associated valve can be activated to permit the fluid at a higher pressure in the third operating volume 18 to flow into the second operating volume 16 in order to increase the pressure of the fluid in the second operating volume 16 via the first conduit 42. The second conduit 40 that fluidically connects the second operating volume 16 to the first containment can be used to increase the pressure of the fluid in the first operating volume 14 or decrease the pressure of the fluid in the second operating volume 16. In some implementations, the associated valve can be activated to permit the fluid at a higher pressure in the second operating volume 16 to flow into the first operating volume 14 in order to increase the pressure of the fluid in the first operating volume 14. In some implementations, the associated valve can be activated to permit the fluid at a higher pressure in the second operating volume 16 to flow into the first operating volume 14 in order to decrease the pressure of the fluid in the second operating volume 16 via the first conduit 42.

The valve assembly 10 can also include a first vent fluidically connected to the first operating volume 14 to bleed pressure from the first operating volume 14 when it is desirable to decrease the pressure of the fluid therein. The valve assembly 10 can also include a second vent fluidically connected to the second operating volume 16 to bleed pressure from the second operating volume 16. The first vent can be a separate port in fluid communication with the first operating volume 14. In another implementation, the first vent can use the fourth port disposed in the body of the valve assembly 10, the second conduit 40 or third conduit, and any appropriate valves, flow diverters, fluid flow control devices, and the like to bleed pressure from the first operating volume 14. The second vent can be a separate port in fluid communication with the second operating volume 16. In another implementation, the second vent can use the second port or the third port disposed in the body of the valve assembly 10, the first conduit 42 or second conduit 40, and any appropriate valves, flow diverters, fluid flow control devices, and the like to bleed pressure from the second operating volume 16.

In one implementation, the second operating volume 16 can be positioned below the first operating volume 14 and the third operating volume 18 can be positioned below the second operating volume 16. This orientation allows the well drop 12 being passed through the valve assembly 10 or the tool to pass downward through the valve assembly 10.

A first opening 28 is disposed in the bottom of the first end 24 of the first operating volume 14 (or at the upper end 32 of the second operating volume 16 or between the first operating volume 14 and the second operating volume 16) so that the well drop 12 being passed through the valve assembly 10 or the downhole tool passed into the first operating volume 14 can pass into the second operating volume 16. Similarly, a second opening 30 is disposed in the lower end 26 of the second operating volume 16 (or at the upper end 34 of the third operating volume 18, or between the second operating volume 16 and the third operating volume 18) so that the well drop 12 being passed through the valve assembly 10 or the downhole tool passed into the second operating volume 16 from the first operating volume 14 can pass into the third operating volume 18.

In one implementation, the first valve 36 and second valve 38 can be flapper valves, oriented to open into the second and third operating volumes 16, 18, so the higher pressure of the fluid in the

second operating volume 16 over the pressure of the fluid in the first operating volume 14 acts on the flapper to maintain the closure of the first valve 36 and the higher pressure of the fluid in the third operating volume 18 over the pressure of the fluid in the second operating volume 16 acts on the flapper to maintain the closure of the second valve 38. Further, the first valve 36 and second valve 38 can be opened and closed by an actuator 50. The actuator 50 can be any type of actuator 50 known in the art. Examples include, but are not limited to, a pneumatic actuator, a hydraulic actuator, an electrical actuator, an air-over hydraulic actuator, a manual screw actuator, or manual lever actuator. The first valve 36 and the second valve 38 can be driven by a single actuator or multiple actuators. The actuators can be controlled by the controller 51.

In some implementations, the valve assembly 10 is designed to not destroy the wireline or tubing that are in the valve assembly 10 during operation, even by an accidental activation of the first valve 36 and/or the second valve 38. The valve assembly 10 is designed so that the first valve 36 must fully close before the second valve 38 will close. If the first valve 36 does not fully close, then the second valve 38 will not close. The first valve 36 can be designed such that it will close at a predetermined speed or force and will continue to close unless the first valve 36 meets some form of resistance before the first valve 36 is completely closed. If the tool string is running through the valve assembly 10, then the first valve 36 will contact it, which provides resistance to the first valve 36 prior to the first valve 36 being fully closed, but not contact it with such force that the wireline or tubing is destroyed or damaged (e.g., severed). The operation above can be implemented via control logic in the controller 51 and/or by physical configuration of the valve assembly 10 (e.g., by sizing of the valve actuators and hydraulic areas or by providing a slip clutch between each valve and its actuator). In some implementations, the controller 51 can receive signals from various sensors and create an interlock if an object is detected by the sensors. Such an interlock prevents the actuators from moving and potentially damaging the wireline, tubing or tool string. Sensors can include optical sensors, position sensors, current sensors, torque sensors, or any other type of sensor that can be used to determine the presence of an obstruction, such as the wireline, tubing or tool string. For example, in some implementations, current sensors can be provided on the actuators. A larger than normal current draw during actuation (i.e., above a specified threshold current) can indicate that there is an object within the valve assembly 10. The actuator 50 can then feed that data back to the controller 51, which can deactivate the actuator 50 in response to the data. In other examples, similar results can be achieved with torque sensors on the actuators (e.g., when torque to move the flappers is above a specified threshold torque) or pressure sensors on hydraulic lines of the actuators (e.g., pressure to move flappers with a hydraulic actuator is above a specified threshold pressure).

In some implementations, the position of the actuator 50 for the first valve 36 and/or second valve 38 can be monitored to determine where resistance begins for the first valve 36 and/or second valve 38. The actuator 50 for the first valve 36 and/or second valve 38 can also have a lower force to close the valves so that if resistance occurs before the first valve 36 and/or second valve 38 is completely closed, the actuator 50 will stop forcing the first valve 36 and/or the second valve 38 to close. The valve assembly 10 may also be equipped with an indicator to notify an operator that the first valve 36 and/or second valve 38 could not close, which alerts the operator that the tool string is in the valve assembly 10. This also prevents the other valve from closing and damaging the tool string. Feedback from the first valve 36 and/or the second valve 38 or the actuator 50 controlling the first valve 36 and/or the second valve 38 can be connected mechanically or electronically.

FIG. 5 is a side half cross-sectional view of the example valve assembly 10 with the first flapper 52 in the open position. When it is desirable to pass the well drop 12 through the valve assembly 10, the well drop 12 is delivered into the first operating volume 14. To pass the well drop 12 from the first operating volume 14 to the second operating volume 16, pressure of the fluid in the second operating volume 16 has to be decreased (or potentially increased in certain circumstances) to essentially the same pressure as the pressure of the fluid in the first operating volume 14 (the low pressure area). To facilitate this, the equalizing valve is manipulated to permit fluid from the second operating volume 16 to flow through the second conduit 40 and into the first operating volume 14. Permitting fluid to flow through the second conduit 40 from the second operating volume 16 into the first operating volume 14 results in the pressure of the fluid in the second operating volume 16 being decreased to substantially the same pressure as the pressure of the fluid in the first operating volume 14. During the operation, permitting the well drop 12 to flow from the first operating volume 14 into the second operating volume 16, the second valve 38 is in the closed position.

FIG. 6 is a side half cross-sectional view of the example valve assembly 10 with the second flapper 62 in the open position. When it is desirable for the well drop 12 to flow from the second operating volume 16 to the third operating volume 18, pressure of the fluid in the second operating volume 16 has to be increased to essentially the same pressure as the pressure in the fluid in the third operating volume 18 (the high-pressure system). To facilitate this, the appropriate equalizing valve is manipulated to permit fluid from the third operating volume 18 to flow through the first conduit 42 and to the second operating volume 16. Permitting fluid to flow through the first conduit 42 from the third operating volume 18 into the second operating volume 16 results in the pressure of the fluid in the second operating volume 16 being increased to substantially the same pressure as the pressure of the fluid in the third operating volume 18. During the operation, permitting the well drop 12 to flow from the second operating volume 16 into the third operating volume 18, the first valve 36 is in the closed position.

In some implementations, the first valve 36 includes a flapper 52, and a pivot arm 54 supported on one end to a rod 72 (FIG. 7A) that is rotationally disposed in the valve body and extends through the valve body. The operation of the actuator 50 is transferred to rotate the rod 72, which causes the opening and closing of the flapper 52 over the opening separating the first operating volume 14 and the second operating volume 16. When closed, the flapper 52 of the first valve 36 sits against a seat that is disposed on the bottom end of the directing passageway disposed in the first operating volume 14. The second operating volume 16 includes a first flapper 52 cavity that permits the flapper 52 and pivot arm 54 to be maintained therein when the flapper 52 of the first valve 36 is in an open position. The first flapper 52 cavity is designed and shaped such that the flapper 52 and pivot arm 54 of the first valve 36 are completely withdrawn from a total directing passageway, which is the combination of the directing passageways disposing the operating volumes and valve cavities disposed in the second and third operating volume 18 to provide space for the operation of the flappers 52 and 62.

FIGS. 7A-7C are side cross-sectional views of the example valve assembly 10. The linkage assembly 60 includes a rod 72 rotationally disposed in a portion of a valve body 58 of the second operating volume 16 and extending through the valve body 58 to engage with the actuator 50. A planar element 74 is attached to the rod 72 on one end 76 and rotatably attached to an extension assembly 78 on a second end 79 of the planar element 74. The extension assembly 78 is rotatably attached to the flapper 52 on the other end. The extension assembly 78 is designed such that when the planar element 74 is rotated via the rod 72, the extension assembly 78 can extend when

the flapper 52 is open and the extension assembly 78 can provide selective compressive force to the flapper 52. In one implementation, the extension assembly 78 can be attached to the rod 72 without the use of the planar element 74.

In some implementations, such as FIG. 8A, the linkage assembly 70 includes a rod 80 rotationally disposed in a portion of a second valve body 68 (if a dual valve design is used) of the third operating volume 18 and extending through the second valve body 68 to engage with the actuator 50. A planar element 82 is attached to the rod 80 on one end 84 and rotatably attached to an extension assembly 86 on a second end 87 of the planar element 82. The extension assembly 86 is rotatably attached to the flapper 62 on the other end. The extension assembly 86 is designed such that when the planar element 82 is rotated via the rod 80, the extension assembly 86 can extend when the flapper 62 is open and the extension assembly 86 can provide selective compressive force to the flapper 62. In one implementation, the extension assembly 86 can be attached to the rod 80 without the use of the planar element 82.

The extension assemblies 78 and 86 also function to lock the valves 36 and 38 into place when the extension assemblies are rotated to a certain position and the valves 36 and 38 are in the closed position. It is not the rotational force supplied by the actuators 50 that holds the valves 36 and 38 closed. It should be understood and appreciated that the extension assemblies 78 and 86 also experience a tensional force when the actuators 50 cause the opening of the valves 36 and 38 in the manner disclosed herein.

The planar elements 74 and 82 can be any shape and size such that when the actuator 50 rotates the rods 72 and 80 in one direction, the extension assemblies 78 and 86 and the planar elements 74 and 82 cooperate to pull the flappers 52 and 62 open. Conversely, the planar elements 74 and 82 can be any shape and size such that when the actuator 50 rotates the rods 72 and 80 in the other direction, the extension assemblies 78 and 86 and the planar elements 74 and 82 cooperate to push the flappers 52 and 62 closed. In one implementation shown in FIG. 8A, the planar element 82 has an arch shape such that when the valve 38 is opened there is more access to the center portion of the valve assembly 10. It should be understood and appreciated that the planar element 74 can be arched shape as well.

As shown in FIGS. 8B-8C, the second valve 38 includes a flapper 62, and a pivot arm 64 supported on one end to a second rod 80 that is rotationally disposed in the valve body and extends through the valve body. The operation of the actuator 50 is transferred to rotate the second rod 80, which causes the opening and closing of the flapper 62 over the opening separating the second operating volume 16 and the third operating volume 18. When closed, the flapper 62 of the second valve 38 sits against a seat that is disposed on the bottom end of the directing passageway disposed in the second operating volume 16. The third operating volume 18 includes a second flapper 62 cavity that permits the flapper 62 and pivot arm 64 of the second valve 38 to be maintained therein when the flapper 62 of the second valve 38 is in an open position. The second flapper 62 cavity is designed and shaped such that the flapper 62 and pivot arm 64 of the second valve 38 are completely withdrawn from the total directing passageway.

As a safety measure, the selective compressive forces of the extension assemblies 78 and 86 allow the flappers 52 and 62 to open during situations when the pressure of the fluid in the first operating volume 14 and the second operating volume 16, respectively, increases above a certain threshold. The extension assemblies 78 and 86 can be extendable and retractable under certain forces such that the flappers 52 and 62 could be opened in specific scenarios wherein the pressure of the fluid in the first and second operating volumes 14 and 16 increases a certain

predetermined amount over the pressure of the fluid in the second and third operating volumes 16 and 18.

In some implementations, as in FIG. 7C, the extension assembly 78 includes a first end portion 88 rotatably attachable to the flapper 52 or the pivot arm 54, a second end portion 90 rotatably attachable to the planar element 74 and a rod 92 slidably disposed within a passageway 94 disposed in the first end portion 88 on one end and slidably disposed within a passageway 96 disposed in the second end portion 90 on the other end of the rod 92. The first end portion 88 has a sleeve portion 98 extending therefrom to receive the rod 92 and the second end portion 90 has a sleeve portion 100 to receive the rod 92. The passageway 94 disposed in the first end portion 88 is in alignment with an internal portion 102 of the sleeve portion 98, and the passageway 96 disposed in the second end portion 90 is in alignment with an internal portion 104 of the sleeve portion 100 to allow the first and second end portions 88 and 90 to slide on the rod 92.

Similarly, as in FIG. 8A, the extension assembly 86 includes a first end portion 106 rotatably attachable to the flapper 62 or the pivot arm 64, a second end portion 108 rotatably attachable to the planar element 82 and a rod 110 slidably disposed within a passageway 112 disposed in the first end portion 106 on one end and slidably disposed within a passageway 114 disposed in the second end portion 108 on the other end of the rod 110. The first end portion 106 has a sleeve portion 116 extending therefrom to receive the rod 110, and the second end portion 108 has a sleeve portion 118 to receive the rod 110. The passageway 112 disposed in the first end portion 106 is in alignment with an internal portion 120 of the sleeve portion 116 and the passageway 114 disposed in the second end portion 108 is in alignment with an internal portion 122 of the sleeve portion 118 to allow the first and second end portions 106 and 108 to slide on the rod 110.

In some implementations, the extension assembly 78 includes a spring 124 disposed around the rod 92, the sleeve portion 98 of the first end portion 88, and the sleeve portion 100 of the second end portion 90. The spring 124 is also disposed between a shoulder 126 disposed on the first end portion 88 and a shoulder 128 disposed on the second end portion 90 of the extension assembly 78. Similarly, the extension assembly 86 includes a spring 130 disposed around the rod 110, the sleeve portion 116 of the first end portion 106 and the sleeve portion 118 of the second end portion 108. The spring 130 is also disposed between a shoulder 132, disposed on the first end portion 106 and a shoulder 134, disposed on the second end portion 108 of the extension assembly 86. The springs 124 and 130 provide additional control of the flappers 52 and 62 when pressure of the fluid above it is increased a certain amount above the fluid disposed below the flapper. In some implementations, the springs 124 and 130 are coil springs.

In some implementations, the rods 72 and 80 of the linkage assemblies can be comprised of more than one component and multiple actuators 50 to permit more efficient rotational force to be applied to planar elements 74 and 82.

In certain instances, the valve assembly 10 can only include a first operating volume 14 and the third operating volume 18 and only one valve 36 or 38 disposed there between. Thus, when used with tethered tools, the valve assembly 10 only requires a single valve 36 or 38. It should be understood that if only the first valve 36 is implemented, then the second and third operating volumes 16 and 18 merge to form a single operating volume. Similarly, if only the second valve 38 is implemented, then the first and second operating volumes 14 and 16 merge to create a single operating volume.

The pressure of the fluid above the first valve 36 and the second valve 38 can spike in certain circumstances. Should this situation occur, the respective actuators are equipped to let the first

flapper 52 and/or the second flapper 62 open if the pressure of the fluid above the first flapper 52 and/or the second flapper 62 exceeds some predetermined threshold.

The valve assembly 10 can also include a first access port and a second access port disposed in the valve body adjacent to the first flapper 52 and second flapper 62 cavities, respectively. The first access port and the second access port provide access to the first valve 36 and the second valve 38, respectively, in the case any repairs need to be made.

FIG. 9 is an example side cross-sectional view of an alternate example valve assembly 10. The illustrated example is similar to the valve assembly 10 described above in function and features, except as noted below. It includes a first valve body 58 coupled to a second valve body 68 by a flanged connection. However, in other instances, the valve bodies could be coupled by another type of connection or could be formed as a single, integral one piece unit. The top and bottom of the valve assembly 10 are also flanged to facilitate connecting the valve assembly 10 in-line in the fracturing stack, but other types of connections could be used.

In this example, the valve assembly 10 is a full bore valve. In other words, the main, central bore through the valve is the same dimeter, without intruding obstructions, as the main, central bore through the remainder of the fracturing stack, so that tooling can pass easily through the valve assembly 10 without obstruction.

In the illustrated implementation, the first actuator rod 72 and the second actuator rod 80 are positioned outside of the center bore of the valve assembly. This arrangement enables the flappers 52, 62 and their corresponding pivot arms 54, 64 to retract into corresponding side cavities of the valve assembly 10 when the flappers are open, so as reside completely out of the center bore when open. In this implementation, the first rod 72 and the second rod 80 are directly connected to the first pivot arm 54 and the second pivot arm 64, respectively. The direct connection further provides a compact configuration that facilitates containment of the flappers 52, 62 and pivot arms 54, 64 out of the bore. For ease of construction and maintenance, the valve assembly 10 can include side openings capped by blind flanges 902 sealed and affixed to the valve bodies 58, 68. The blind flanges 902 can be installed and removed easily to facilitate access to the flappers 52, 62 and pivot arms 54, 64 during construction or maintenance. Pressure sensors 37 a, 37 b and 37 c are shown in fluid communication with the operating volumes for measuring the pressure in each operating volume, as well as the pressure differential between operating volumes. Additional or fewer sensors could be provided, as well as sensors of different types.

Metal seals 904 are retained to the valve bodies 58, 68, and form a metal-to-metal seal between the valve bodies 58, 68 and their respective flappers 52, 62 when the flappers are closed. Also, in certain instances, the flappers 52, 62 are coupled to their respective pivot arms 54, 64 in a compliant manner, to allow movement between the flapper and arm. The movement facilitates the flappers 52, 62 seating on the seals 904 as they close.

As shown in FIG. 10, the valve assembly 10 can include a controller 51 to, among other things, monitor pressures of the operating volumes and send signals to actuate the equalizing valves 44 and the actuators 50. As shown in FIG. 10, the controller 51 can include one or more processors 1102 and non-transitory storage media (e.g., memory 1104) containing instructions that cause the processors 1102 to perform the methods described herein. The processors 1102 are coupled to an input/output (I/O) interface 1106 for sending and receiving communications with other equipment of the well fracking site 1 (FIG. 1), including, for example, the actuators 50 via communication links 53 (FIG. 3). In certain instances, the controller 51 can additionally communicate status with and send actuation and control signals to one or more of the automated

latch 206, the other valves (including main valves 216 and swab valve 212) of the fracturing stack 200, the BOP 204, the lubricator 202 (and its tool trap), any well drop launcher, as well as other sensors (e.g., pressure sensors, temperature sensors and other types of sensors) provided in the fracturing stack 200. In certain instances, the controller 51 can communicate status and send actuation and control signals to one or more of the systems on the well site 1, including the blenders 3, fracking pumps 5 and other equipment on the well site 1. The communications can be hard-wired, wireless or a combination of wired and wireless. In some implementations, the controller 51 can be located on the valve assembly 10. In some implementations, the controller 51 can be located elsewhere, such as in the data van 6, elsewhere on the well site 1 or even remote from the well site 1. In some implementations, the controller can be a distributed controller with different portions located about the well site 1 or off site. For example, in certain instances, a portion of the controller 51 can be located at the valve assembly 10, while another portion of the controller 51 can be located at the data van 6 (FIG. 1).

The controller 51 can operate in monitoring, controlling, and using the valve assembly 10 for introducing a well drop and for allowing the passage of a tool through the valve assembly 10 to the high pressure area. To monitor and control the valve assembly 10, the controller 51 is used in conjunction with transducers (sensors) to measure the pressure of fluid at various positions in the valve assembly 10 and to measure the position of various parts of the valve assembly 10. Input and output signals, including the data from the transducers, controlled and monitored by the controller 51, can be logged continuously by the controller 51.

Once the valve assembly 10 is powered up, a determination is made whether a wireline deployed tool sequence is desired or a well drop sequence is desired. The wireline deployed tool sequence would be used when a tool on wireline, such as perforating string or logging string supported on wireline, is passed through the fracking stack 200 into the well 4. A well dropping sequence would be used when a well drop (e.g., frac ball, collet, soap bar or other) is to be dropped through the fracking stack 200 into the well 4. FIG. 11 shows an example logic sequence 1100 that is used by the controller to set which operation to perform. The determination is made based on user input to the controller, for example, through a terminal in communication with the controller. In the event that a wireline deployed tool sequence is desired, then logic sequence 1200 is selected. Notably, the wireline sequence can also be used for running tubing deployed tools. If a well drop sequence is desired, then a logic sequence 1300 is selected. Details of each logic sequence are provided below. The logic sequences 1100, 1200 and 1300 can be stored as executable instructions in the memory 1104 of controller 51.

FIG. 12 is a block diagram of an example logic sequence 1200 that can be used by the controller 51 (FIG. 10) when executing wireline operations. In performing the wireline sequence, a lubricator containing the wireline tool string typically has previously been attached above the valve assembly (FIG. 2A). The sequence 1200 can be performed autonomously, without human invention other than to indicate to the controller 51 that certain actions performed apart from controller 51 (e.g., stabbing/retrieving the lubricator) have been completed. If the lubricator needs to be removed, for example to change or repair the tool carried in the lubricator, operation 1202 is performed. In operation 1202, the pressure of the fluid in the first operating volume 14 (FIG. 3) is brought to atmospheric pressure (e.g., absolute atmospheric pressure, actual pressure of the surrounding atmosphere, or to within a specified maximum pressure differential to either). In this context, and in the accompanying diagram, the first operating volume 14 is referred to as an “atmospheric pressure area.” The pressure of the fluid in the first operating volume 14 can be determined via a pressure sensor in fluid communication with the first operating volume 14 and

coupled to the controller 51. The pressure of the fluid in the first operating volume 14 can be reduced by venting the first operating volume 14 (e.g., by actuating a equalizing valve, as described above) to bleed off pressure. Once it is verified that the pressure of the fluid in the first operating volume 14 is equalized with the atmosphere, the lubricator can be removed, the tool changed or accessed, and the lubricator reinstalled to the fracking stack 200 above the first operating volume 14. Notably, the pressure in the well 4 and the fracking stack 200 below the valve assembly 10 need not be affected, and can remain at fracturing pressure or near to fracturing pressure.

In operation 1204, the second valve 38 is operated. First, the pressure of fluid in the second operating volume 16 (referred to as the "load lock area" in the accompanying diagram) can be determined via a pressure sensor in fluid communication with the second operating volume 16. To open the second valve 38 that separates the second operating volume 16 and the third operating volume 18, the pressure of the fluid in the second operating volume 16 has to be within the specified maximum pressure differential to the third operating volume 18, which essentially equalizes the second operating volume 16 and third operating volume 18. The third operating volume 18 is open to the well 4, and thus is at well pressure. If the pressure differential is greater than the specified maximum pressure differential, the pressure of the fluid in the second operating volume 16 has to be increased to be essentially equal (i.e., within the specified maximum pressure differential wherein the second valve 38 will open) to the pressure of the fluid in the third operating volume 18.

To increase the pressure of the fluid in the second operating volume 16, the equalizing valve associated with the first conduit 42 connecting the second operating volume 16 and the third operating volume 18 can be opened and the pressure of the fluid in the third operating volume 18 flows into the second operating volume 16 and increases the pressure of the fluid in the second operating volume 16 to the specified maximum pressure differential of the fluid in the third operating volume 18. Once the pressure of the fluids in the second operating volume 16 and the third operating volume 18 are equalized, the second valve 38 separating these two operating volumes can be opened.

Once the second valve 38 separating the second operating volume 16 and the third operating volume 18 is opened, the first valve 36 will need to be opened to allow the tool string to be extended through the valve assembly 10 (operation 1206). To open the first valve 36, the pressure of the fluid in the first operating volume 14 and the second operating volume 16 is brought to within the specified maximum pressure differential wherein the first valve 36 is capable of opening. If the pressure of the fluid in the second operating volume 16 is greater than the pressure of the fluid in the first operating volume 14, the pressure of the fluid in the first operating volume 14 has to be increased to be essentially equal (or within a certain range wherein the first valve 36 will open) to the pressure of the fluid in the second operating volume 16. In another implementation, the pressure of the fluid in first operating volume 14, the second operating volume 16, and the third operating volume 18 can be brought to within a certain range and the first valve 36 and second valve 38 can then be opened. The first and second valve 36 and 38 can be opened at the same time, or near the same time, to permit the tool string to extend through the valve assembly 10 and into the well.

To increase the pressure of the fluid in the first operating volume 14, the equalizing valve associated with the second conduit 40 connecting the first operating volume 14 and the second operating volume 16 can be opened and the pressure of the fluid in the second operating volume 16 flows into the first operating volume 14 and increases the pressure of the fluid in the first

operating volume 14 to be essentially equal to the pressure of the fluid in the second operating volume 16. Once the pressure of the fluids in the first operating volume and the second operating volume 16 are equalized, the first valve 36 separating the first operating volume 14 and the second operating volume 16 can be opened. In another implementation, a third conduit fluidically connecting the first operating volume 14 and the third operating volume 18, and a corresponding equalizing valve could be used to permit the fluid in the third operating volume 18 be used to increase the pressure of the fluid in the first operating volume 14.

It should be understood that for wireline sequences, the second valve 38 separating the second operating volume 16 and the third operating volume 18 can be started out as open and left open for the duration of the operation to equalize the pressure of the fluid in the valve assembly 10. Once the second valve 38 separating the second operating volume 16 and the third operating volume 18 and the first valve 36 are opened, the fluid in the valve assembly 10 is equalized and the lubricator can feed the tool string into and through the valve assembly 10 to perform any desired operation in the well (operation 1208). After the conclusion of the operation being performed via the tool string, the tool string can be withdrawn from the well and the valve assembly 10. In operation 1210, the first valve 36 can then be closed and the equalizing valve associated with the second or third conduit, depending on which conduit was used to equalize the first operating volume 14, can be closed. The second valve 38 separating the second operating volume 16 and the third operating volume 18 can then be closed. The equalizing valve associated with the first equalizing conduit 42 can be closed after the second valve 38 is closed.

The opening and closing of the first valve 36 that separates the first operating volume 14 and second operating volume 16 and the second valve 38 that separates the second operating volume 16 and third operating volume 18 can be verified via a valve position sensor (can be the same valve position sensor or separate valve position sensors) in communication with the controller. The process can be repeated. If no other operations are to be performed, the wireline sequence is terminated. If the wireline sequence is terminated, the pressure of the fluid in the first operating volume 14 can be decreased to atmospheric pressure venting the first operating volume 14 to bleed pressure from the first containment.

FIG. 13 is a block diagram of an example logic sequence 1300 that can be used by the controller 51 to execute well drop operations, for example, dropping a frac ball or collet down the well. As with sequence 1200, sequence 1300 can be performed autonomously, without human intervention other than to indicate to the controller 51 that certain actions performed apart from controller 51 (e.g., placing the well drop) have been completed. If it is determined the logic sequence 1300 is desired, the valve assembly 10 is given the command via the controller to perform the logic sequence 1300. When it is desirable to conduct the logic sequence 1300, the well drop 12 to be released will be positioned in the first operating volume 14 and operation 1302 performed. To open the first valve 36, the pressure of the fluid in the second operating volume 16 has to be within a certain range of the pressure of the fluid in the first operating volume 14, which essentially equalizes the first and second operating volumes 14 and 16. The pressure of the fluid in the first operating volume 14 can be determined via a pressure sensor if the pressure of the fluid is not known to be atmospheric. Pressure of fluid in the second operating volume 16 can be determined via a pressure sensor coupled to the second operating volume 16. The pressure of the fluid in the second operating volume 16 can be reduced by opening the corresponding equalizing valve to the second conduit 40 that fluidically connects the second operating volume 16 and the first operating volume 14. Once the pressure of the fluid in the first operating volume 14 and the second operating volume 16 equalizes, the first valve 36 can then

be opened by the controller 51. The controller 51 will not send the signal to open the first valve 36 until the equalization occurs between the first operating volume 14 and the second operating volume 16. The equalizing valve can remain open until the equalization occurs and then be closed before or during the opening of the first valve 36 or the vent port or second conduit 40 can remain open during the opening and closing of the first valve 36.

The well drop 12 will fall from the first operating volume 14 into the second operating volume 16 once the first valve 36 is opened. Confirmation of the well drop 12 having fallen into the second operating volume 16 can be verified by an well drop 12 detection sensor that can confirm the presence of the well drop 12 in the second operating volume 16. After a specified amount of time (delay) or detection of the well drop 12 in the second operating volume 16, the first valve 36 will close. The closure of the first valve 36 can be verified via a valve position sensor in communication with the controller 51. Once it has been verified that the first valve 36 has been closed, the vent port or the second conduit 40 can be closed if the vent port or the second conduit 40 was left open during the operation of the first valve 36.

The well drop 12 to be released is then passed into the third operating volume 18 (operation 1304). Pressure of fluid in the third operating volume 18 can be determined via a pressure sensor coupled to the third operating volume 18. To open the second valve 38, the pressure of the fluid in the third operating volume 18 has to be within a certain range of the pressure of the fluid in the second operating volume 16, which essentially equalizes the second operating volume 16 and the third operating volume 18. The pressure of the fluid in the second operating volume 16 can be determined via the pressure sensor used to determine the pressure of the fluid in the second operating volume 16.

The pressure of the fluid in the second operating volume 16 can be increased by opening the first conduit 42 via the equalizing valve associated with the first conduit 42. The first conduit 42, when opened, allows the pressure of the fluid in the third operating volume 18 to flow there through and increase the pressure of the fluid in the second operating volume 16. Once the pressure of the fluid in the second and third operating volumes 16 and 18 equalizes, the second valve 38 can then be opened by the controller. The controller will not send the signal to open the second valve 38 until the equalization occurs between the second operating volume 16 and the third operating volume 18. The first conduit 42 can remain open until the equalization occurs and then be closed before or during the opening of the second valve 38 or the first conduit 42 can remain open during the opening and closing of the second valve 38.

The well drop 12 will fall from the second operating volume 16 into the third operating volume 18 once the second valve 38 is opened. Confirmation of the well drop 12 having fallen into the third operating volume 18 can be verified by the well drop 12 detection sensor disclosed herein or a separate well drop 12 detection sensor that can determine the location of the well drop 12 in the third operating volume 18. After a certain amount of time or detection of the well drop 12 in the third operating volume 18, the second valve 38 will close. The closure of the second valve 38 can be verified via a valve position sensor (can be the same valve position sensor disclosed herein or a separate valve position sensor) in communication with the controller 51. Once it has been verified that the second valve 38 has been closed, the first conduit 42 can be closed if the first conduit 42 was left open during the operation of the second valve 38.

After the well drop 12 is passed into the third operating volume 18 (or well), a determination of whether another well drop 12 will be passed into the third operating volume 18 is made. If no further well drop 12 is to be passed into the third operating volume 18, the logic sequence 1300 is terminated. If an additional well drop 12 is to be passed into the third operating volume 18,

another well drop 12 is positioned in the first operating volume 14 and the logic sequence 1300 is recommenced.

The concepts described herein can, in certain instances, yield a number of advantages. For example, due to the valve assembly's ability to prevent damage to the tool strings and their associated wireline or tubing (e.g., the perforating string), there should be no downtime fishing for lost tools. The operations can manifest a significant time, and thus cost, savings because, in multistage fracking operations, the majority of the fracking stack and the surface equipment, including the fracking equipment on the well site, need not be pressured up and down with each fracturing stage to enable interchanging the perforating string and well drop. Furthermore, pressure testing between fracturing stages can be reduced or eliminated. Cost savings can be had in fuel/energy, operator and equipment costs that would otherwise have been incurred in pumping the well and such a large volume of the fracking stack and surface equipment up to pressure, both for pressure testing and pressurizing back up to fracturing pressure in performing the next fracturing stage. Savings due to wear on equipment can also be realized, as the maintenance (e.g., repair of worn parts and greasing) on the valves below the valve assembly and within the surface equipment is reduced, since these valves can be operated fewer times during the fracturing operations. Finally, savings can be realized in reduction of non-productive operator time associated with repairing leaks that can occur from pressurizing/depressurizing multiple valves and lines of the surface equipment with each fracturing stage.

A number of implementations of the invention have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. For example, valves other than flappers may be used without departing from this disclosure. Accordingly, other implementations are within the scope of the following claims.