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(54) **PLUNGER LIFT LUBRICATOR**

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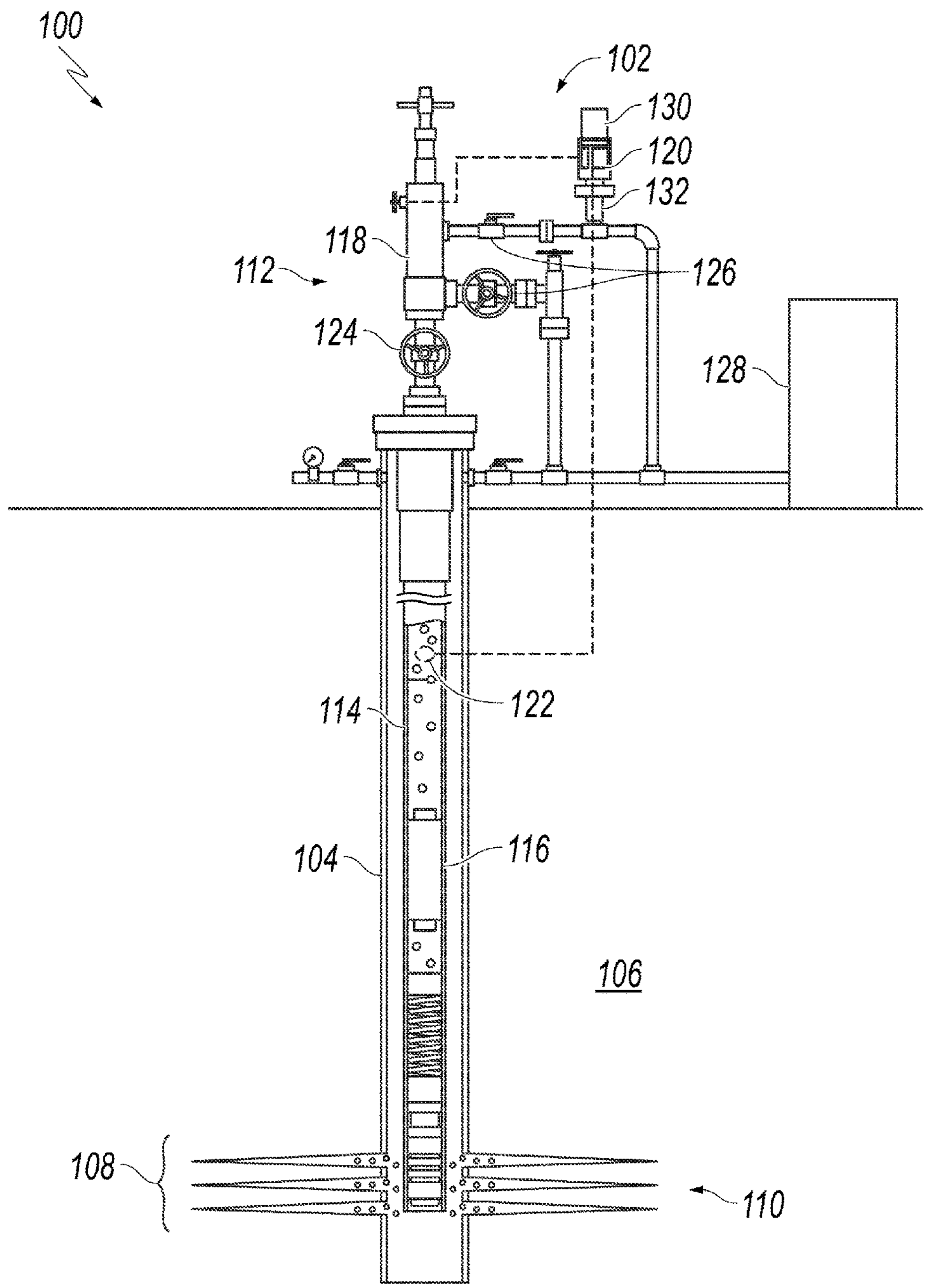
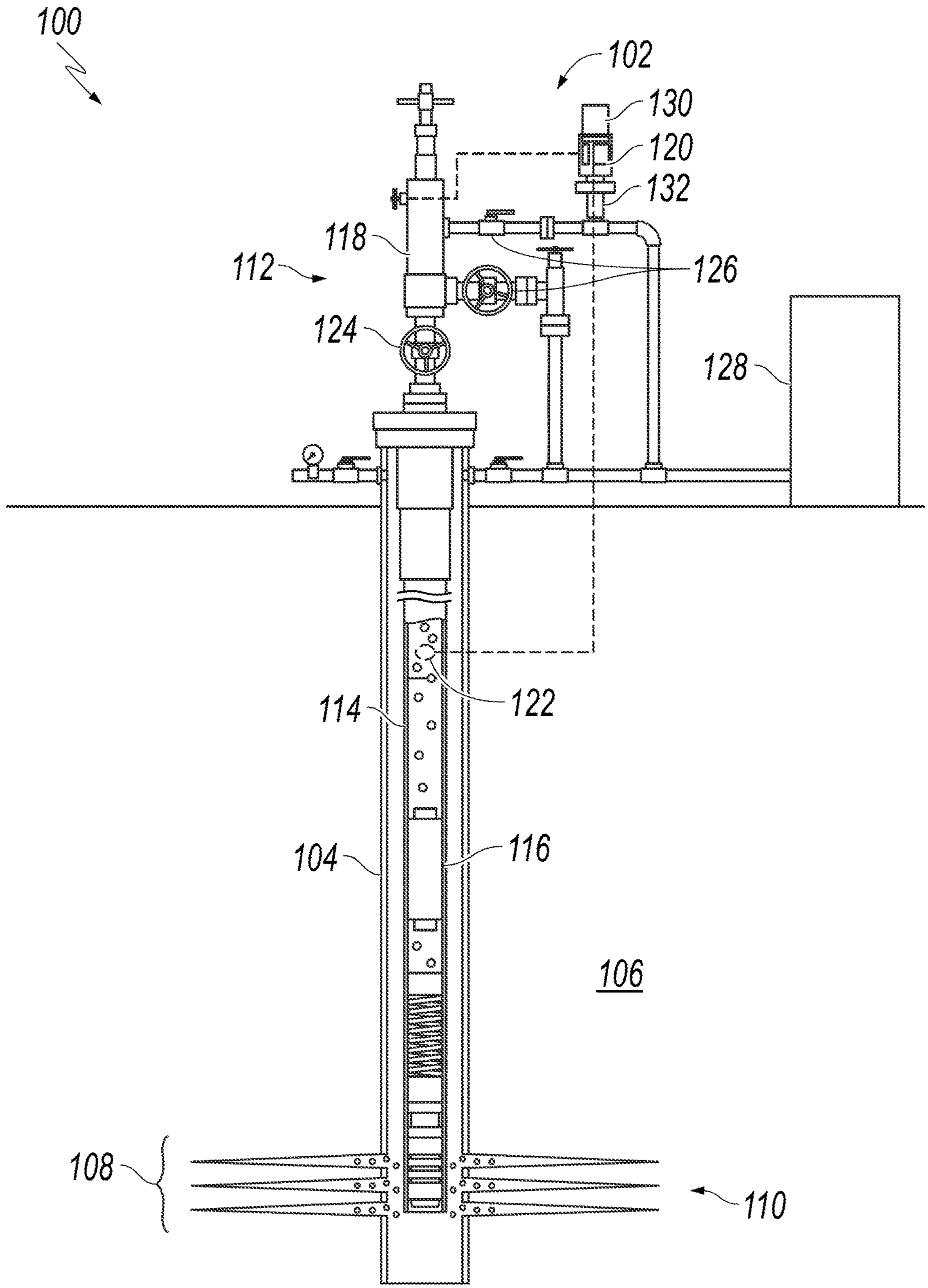
(57) **ABSTRACT**

A housing defines a central receiving passage and internal flow passages that are fluidically connected to the central receiving passage. A receiving spring is at an uphole end of the lubricator. A plunger catcher is included as well.




100
102
130
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122
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110

FIG. 1

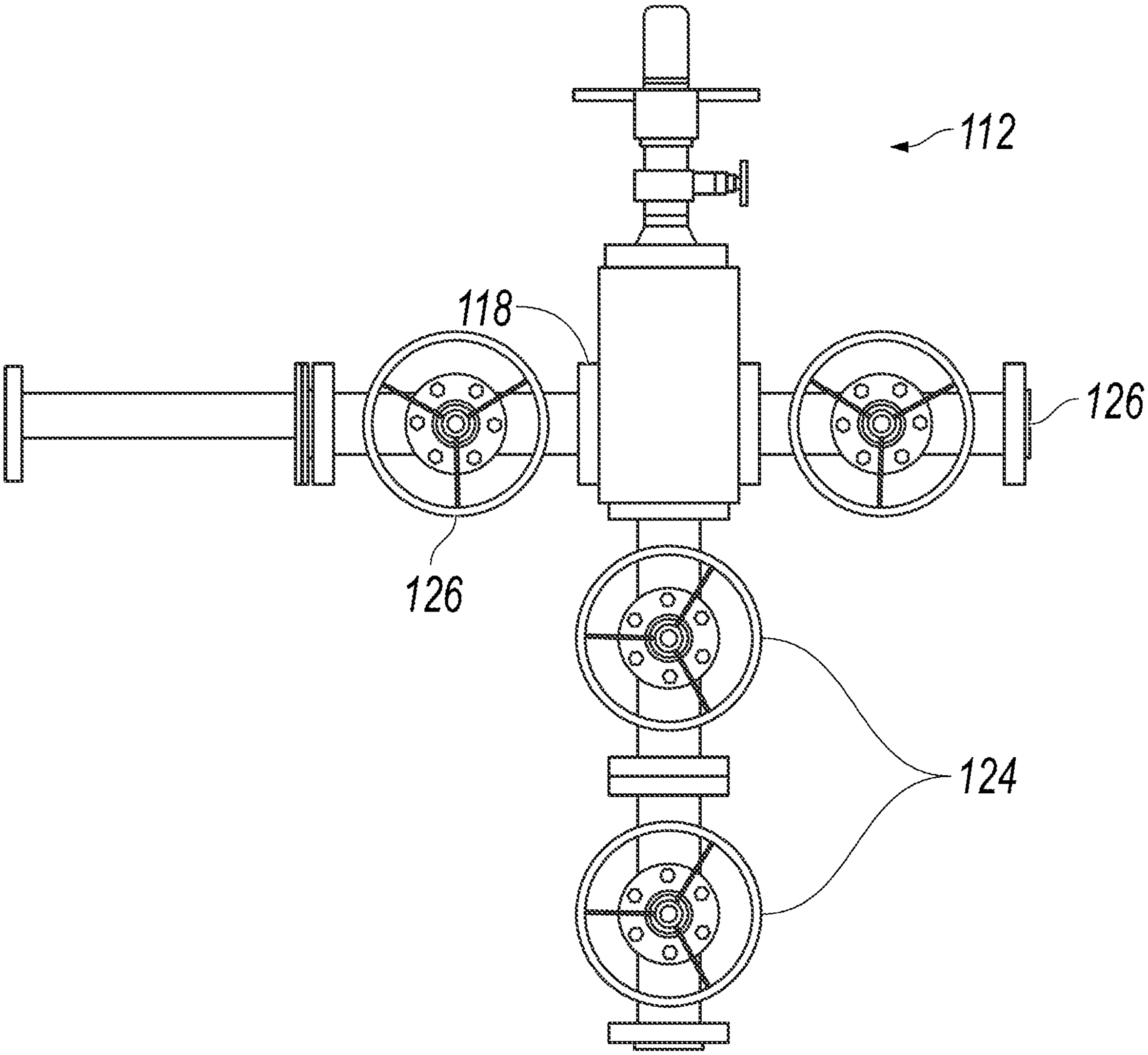

FIG. 2

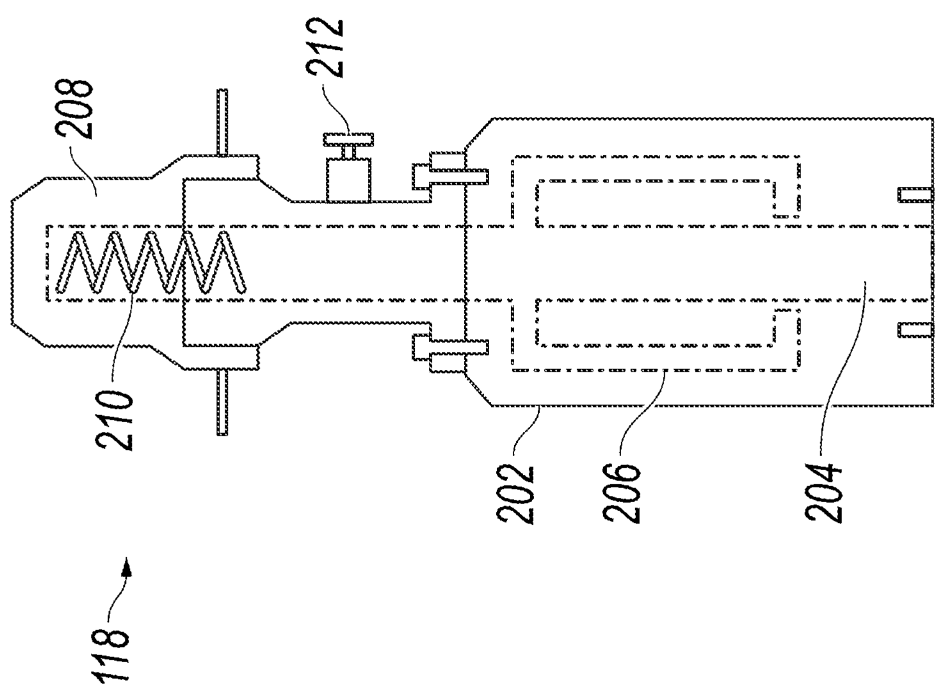

FIG. 3A

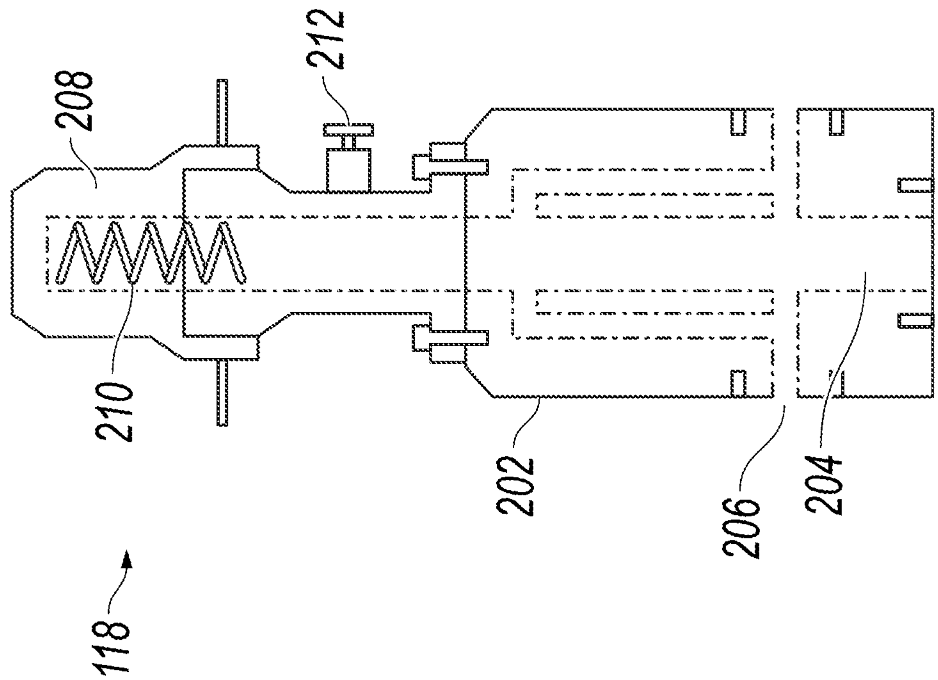

FIG. 3B

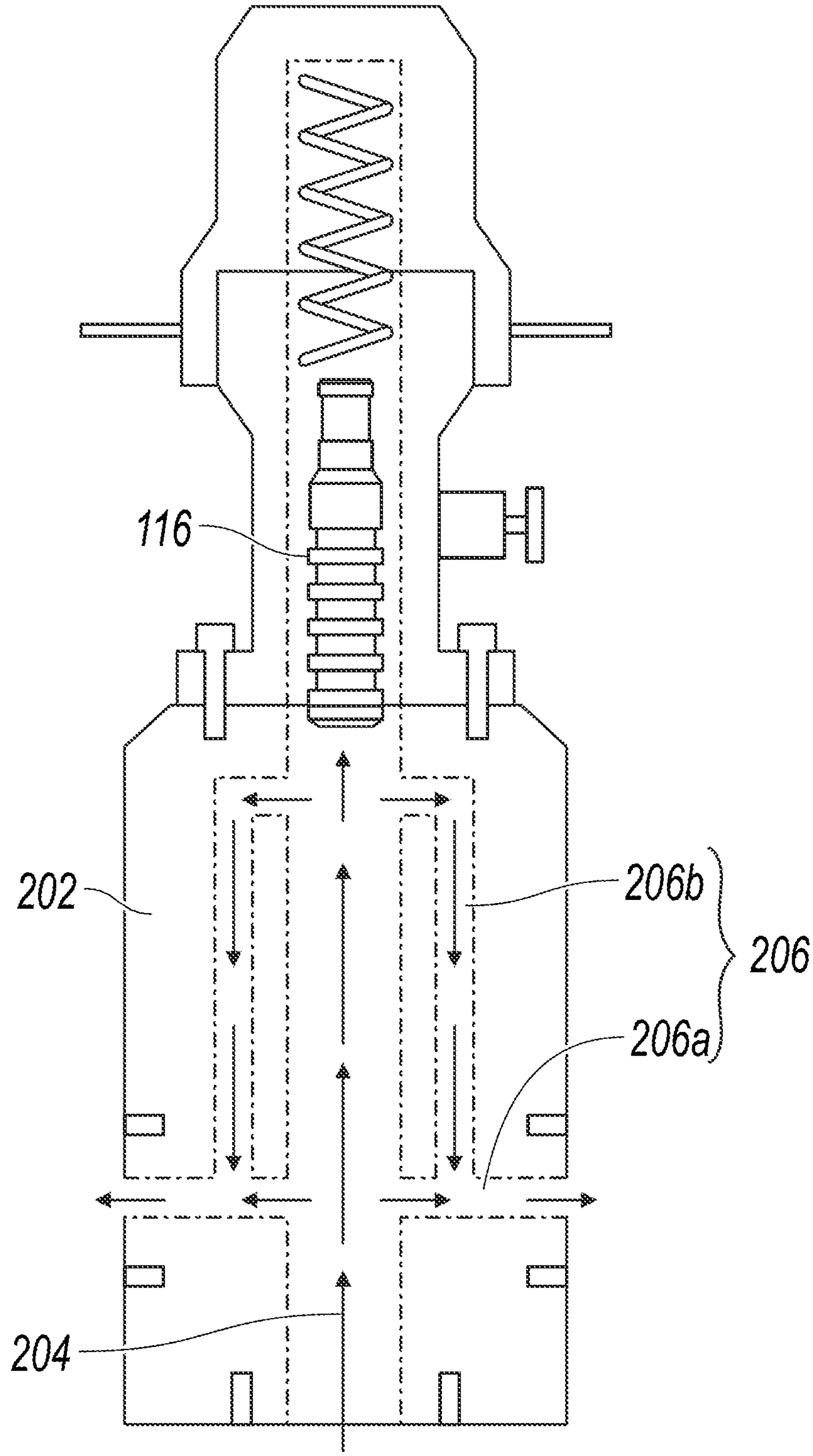

FIG. 4

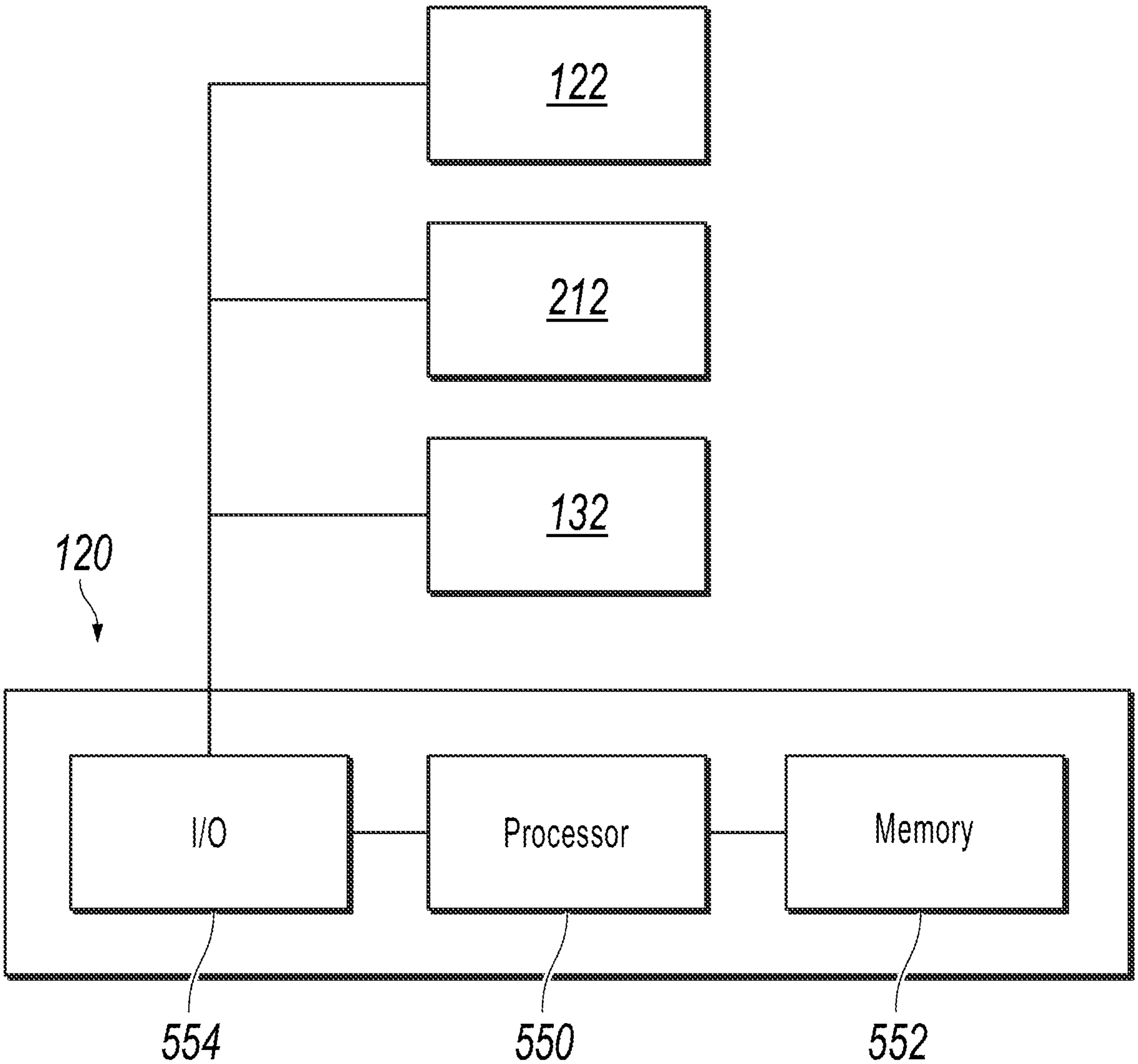

FIG. 5

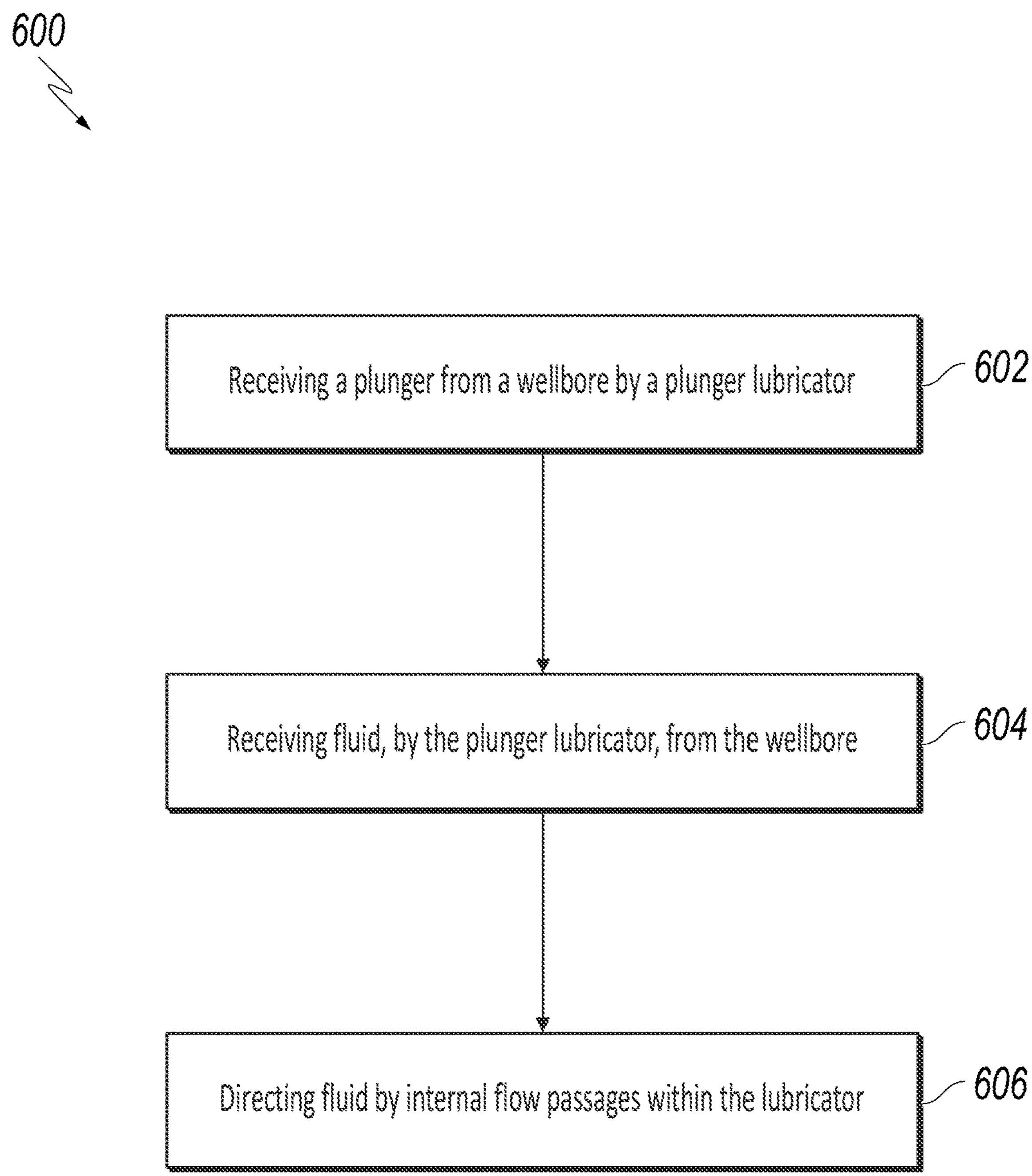
600
Receiving a plunger from a wellbore by a plunger lubricator
602
Receiving fluid, by the plunger lubricator, from the wellbore
604
Directing fluid by internal flow passages within the lubricator
606

FIG. 6

PLUNGER LIFT LUBRICATOR

TECHNICAL FIELD

[0001] This specification relates to hydrocarbon production using plunger lift systems.

BACKGROUND

[0002] A plunger lift is a widely used artificial lift mechanism for high gas liquid ratio GLR oil wells and for gas well deliquification. The plunger lift uses free traveling solid or flow through the plunger to act as an interface between the production fluids to help use the wellbore pressure to produce the wells.

[0003] A plunger lift system uses the reservoir's natural energy to lift up the accumulated liquids within the wellbore to help produce liquid loaded wells with no ability to utilize external power sources. A typical plunger lift operates on a cyclic basis, each cycle starting with a shut-in period to build up pressure and allow the plunger to fall from the surface to the bottom of the well, followed by an opening period to enable the plunger to travel back to the surface, lifting the accumulated liquid and producing the well for a period of time called afterflow.

[0004] The plunger lift system uses a surface lubricator that acts as a housing to the plunger when it reaches the surface and allows production fluids to flow through a production tree while the plunger is within the catcher without restricting a flow passage.

SUMMARY

[0005] This specification describes technologies relating to plunger lift lubricators.

[0006] An example implementation of the subject matter described within this disclosure is a plunger lift lubricator with the following features. A housing defines a central receiving passage and internal flow passages that are fluidically connected to the central receiving passage. A receiving spring is at an uphole end of the lubricator. A plunger catcher is included as well.

[0007] Aspects of the example plunger lift lubricator, which can be combined with the example plunger lift lubricator alone or in combination with other aspects, include the following. The internal flow passages include a first fluid passage defining a first inlet within the central passage. The first inlet is configured to receive production fluid from the central passage. A second fluid passage defines a second inlet uphole of the first inlet. The second inlet is configured to receive production fluid from the central passage. The second fluid passage converges with the first fluid passage.

[0008] Aspects of the example plunger lift lubricator, which can be combined with the example plunger lift lubricator alone or in combination with other aspects, include the following. The housing further defines an outlet configured to direct well fluid to a conditioning system from the first fluid passage and the second fluid passage.

[0009] Aspects of the example plunger lift lubricator, which can be combined with the example plunger lift lubricator alone or in combination with other aspects, include the following. The first fluid inlet and the second fluid inlet are spaced apart a distance greater than a length of a plunger to be used with the lubricator.

[0010] Aspects of the example plunger lift lubricator, which can be combined with the example plunger lift lubricator alone or in combination with other aspects, include the following. A controller is configured to receive a first signal indicative of a pressure within a wellbore. The controller is configured to determine that the pressure within the wellbore has fallen below a first specified threshold based on the first received signal. The controller is configured to send a second signal to an actuator. The second signal is configured to actuate the actuator to release a plunger into the wellbore. The controller is configured to send a third signal to a control valve. The third signal is configured to actuate the control valve to cease flow within the wellbore. After ceasing flow within the wellbore, the controller is configured to determine that the pressure within the wellbore has risen above a second specified threshold based on the first received signal. The controller is configured to send a fourth signal to the control valve. The fourth signal is configured to actuate the control valve to re-start flow within the wellbore.

[0011] Aspects of the example plunger lift lubricator, which can be combined with the example plunger lift lubricator alone or in combination with other aspects, include the following. The controller is further configured to receive a fifth signal indicative of a plunger presence within the lubricator. The controller is configure to determine the presence of the plunger within the lubricator based on the received fifth signal.

[0012] An example of the subject matter described within this disclosure is a method with the following features. A plunger is received from a wellbore by a plunger lubricator. Fluid is received, by the plunger lubricator, from the wellbore. Fluid is directed by internal flow passages within the lubricator.

[0013] Aspects of the example method, which can be combined with the example method alone or in combination with other aspects, include the following. A pressure drop is detected. Fluid flow within the wellbore is ceased in response to the detected pressure drop. The plunger by the plunger lubricator releasing.

[0014] Aspects of the example method, which can be combined with the example method alone or in combination with other aspects, include the following. Receiving the plunger includes the following features. The plunger is received by an inlet of the plunger lubricator. Fluid traveling ahead of the plunger is received by a first inlet and a second inlet. Fluid, traveling behind the plunger is received by the first inlet and by the second inlet.

[0015] Aspects of the example method, which can be combined with the example method alone or in combination with other aspects, include the following. The plunger is retained by the plunger lubricator.

[0016] An example implementation of the subject matter of described within this disclosure is a plunger lift system with the following features. A production tree is at an uphole end of the production wellbore. A plunger lubricator is atop the production tree. The plunger lubricator includes the following features. A housing defines a central receiving passage and internal flow passages fluidically connected to the central receiving passage. A receiving spring is at an uphole end of the plunger lubricator. A plunger catcher is included. A plunger is configured to traverse the wellbore and be received and retained by the plunger lubricator.

[0017] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. The internal flow passages include the following features. A first fluid passage defines a first inlet within the central passage. The first inlet is configured to receive production fluid from the central passage. A second fluid passage defines a second inlet uphole of the first inlet. The second inlet is configured to receive production fluid from the central passage. The second fluid passage converges with the first fluid passage.

[0018] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. The first fluid inlet and the second fluid inlet are spaced apart a distance greater than a length of a plunger to be used with the lubricator.

[0019] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. A controller is configured to receive a first signal indicative of a pressure within the wellbore. The controller is configured to determine that the pressure within the wellbore has fallen below a first specified threshold based on the first received signal. The controller is configured to send a second signal to an actuator. The second signal is configured to actuate the actuator to release a plunger into the wellbore. The controller is configured to send a third signal to a control valve. The third signal is configured to actuate the control valve to cease flow within the wellbore. After ceasing flow within the wellbore, the controller is configured to determine that the pressure within the wellbore has risen above a second specified threshold based on the first received signal. The controller is configured to send a fourth signal to the control valve. The fourth signal is configured to actuate the control valve to re-start flow within the wellbore.

[0020] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. The controller is further configured to receive a fifth signal indicative of a plunger presence within the lubricator and determine the presence of the plunger within the lubricator based on the received fifth signal.

[0021] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. A solar panel coupled to the controller. The solar panel is configured to provide power to the controller.

[0022] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. A conditioning system is configured to condition production fluids directed by the lubricator.

[0023] Aspects of the example plunger lift system, which can be combined with the example plunger lift system alone or in combination with other aspects, include the following. The housing further defines an outlet configured to direct well fluid to a conditioning system.

[0024]]Particular embodiments of the subject matter described in this specification can be implemented so as to realize one or more of the following advantages. The subject matter described herein reduces potential leak paths as flow passages are integrated within the lubricator instead of using external piping runs.

[0025] The details of one or more embodiments of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages of the subject matter will become apparent from the description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is an example production system with a plunger lift system.

[0027] FIG. **2** is an example production tree with a plunger lift lubricator.

[0028] FIGS. **3**A and **3**B are cross-sectional views of an example plunger lift lubricator.

[0029] FIG. **4** is a cross-sectional view illustrating flow paths within the plunger lift lubricator.

[0030] FIG. **5** is a block diagram of an example controller that can be used with aspects of this disclosure.

[0031] FIG. **6** is a flowchart of an example method that can be used with aspects of this disclosure.

[0032] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0033] Typical plunger lift lubricators come with single or dual sided outlets that allow installing a flow loop with isolation valves. Such an arrangement allows for continual flow of production fluids once the plunger is caught in the lubricator by the catcher. Such an arrangement includes several leak points that can become a safety concern during operations.

[0034] This disclosure describes a plunger lubricator with integrated flow passages. The flow passages can be formed in a variety of ways, such as with machining and welding. Alternatively or in addition, additive manufacturing techniques can be used to create the lubricator with integrated passages, for example, casting or 3D printing.

[0035] FIG. **1** is an example production system **100** with a plunger lift system **102**. A production wellbore **104** is formed in a geologic formation **106**. The geologic formation **106** includes a production zone **108**. The production zone **108** contains hydrocarbons under pressure and is fluidically coupled to the production wellbore **104** by perforations **110**. A production tree **112** is installed at an uphole end of the production wellbore **104**. Production fluid flows from the production zone **108**, up through production tubing **114** to the production tree **112**.

[0036] The plunger lift system **102** includes a plunger lift lubricator **118** atop the production tree **112**. A plunger **116** is configured to traverse the production wellbore **104** through the production tubing **114** and be received and retained by the plunger life lubricator **118**. At a downhole end of the production tubing **114** is a bumper configured to cushion an impact of the plunger **116** when the plunger **116** is released from the plunger lift lubricator **118** and falls to a downhole end of the production tubing **114**.

[0037] The production system **100** includes a controller **120** configured to control the production system based on signals received by various sensors within the production system **100**, for example, from a well pressure sensor **122**. Details on the controller **120** are described later within this disclosure. In some implementations, a solar panel **130** is coupled to the controller **120**. In such implementations, the solar panel **130** is configured to provide power to the controller **120**. Alternatively or in addition, other power components are included to maintain power to the controller, for example, battery systems or links to a local power grid. The controller **120** is also coupled to a control valve **132**. The control valve **132** regulates flow from the production wellbore **104**.

[0038] Downstream of the production tree **112** is a conditioning system **128** configured to condition production fluids. The conditioning system **128** includes separators, heaters, and any other conditioning systems needed to condition the production fluids to meet a production spec. In some implementations, the conditioning system **128** is located nearby or adjacent to the production tree **112** (for example, within the same facility). In some implementations, the conditioning system **128** can be located at a great distance from the production tree **112**, for example, at a separate facility miles away from the production tree **112**.

[0039] While the implementation illustrated in FIG. **1** shows a vertical wellbore for simplicity, the subject matter described herein is applicable to other wellbore configurations, for example, a deviated wellbore.

[0040] FIG. **2** is an example production tree **112** with a plunger lift lubricator **118**. The production tree **112** includes one or more isolation valves **124** and one or more wing valves **126**. The isolation valves **124** are arranged to isolate the plunger lift lubricator **118** from the production tubing **114** (FIG. **1**). The wing valves **126** are arranged to isolate the plunger lift lubricator **118** from any downstream systems, such as the conditioning system **128**. In some implementations, an upper end of the plunger lift lubricator **118** is accessible to an operator. In such instances, walkways, ladders, and/or stairs can be used to ensure accessibility.

[0041] FIGS. **3**A and **3**B are cross-sectional views of the plunger lift lubricator **118**. The plunger lift lubricator **118** includes a housing **202** defining a central receiving passage **204** and internal flow passages **206** fluidically connected to the central receiving passage **204**. At an uphole end of the plunger lift lubricator **118** is a cap **208**. The cap **208** is removable to allow access to the central receiving passage **204** to, for example, insert or remove a plunger from the uphole end of the plunger lift lubricator **118**. The cap **208** can be coupled to the lubricator in a variety of ways, for example, a threaded connection, a bayoneted connection, or a latched connection. Regardless of the connection used, the cap **208** is configured to substantially seal and retain pressure (per regulatory requirements for pressure and leakage testing) within the plunger lift lubricator **118**. Within the cap **208** is a receiving spring **210**. The receiving spring **210** cushions an impact of the plunger **116** (FIG. **1**) when it is returned to the plunger lift lubricator **118** from the production wellbore **104**. Just below the cap **208** is a plunger catcher **212**. The plunger catcher **212** mechanically retains and releases the plunger **116**. In some implementations, the plunger catcher is controlled by the controller **120** (FIG. **1**).

[0042] FIG. **4** is a cross-sectional view illustrating flow paths within the plunger lift lubricator **118**. The internal flow passages **206** include a first fluid passage **206*a*** and a second fluid passage **206*b*** defining a first inlet and a second inlet respectively. The internal flow passages **206** described herein are integrated within the lubricator housing **202**. In some implementations, the flow passages **206** include an annular flow passage. The first inlet and the second inlet are arranged and configured to receive production fluid from the central receiving passage **204**. The second inlet is uphole of the first inlet, and the second fluid passage **206*b*** converges with the first flow passage **206*a***. In some implementations, the first fluid inlet and the second fluid inlet are spaced apart a distance greater than a length of a plunger **116** to be used with the plunger lift lubricator **118**. The spacing allows for continuous fluid flow from the wellbore to the conditioning system. Downstream of the convergence, the housing **202** further defines an outlet configured to direct production fluid to the conditioning system **128** from the first flow passage **206*a*** and the second fluid passage **206*b***. In some implementations, a second outlet is defined by the housing **202**. In some implementations, the housing is manufactured by additive manufacturing techniques, such as 3D printing or casting.

[0043] FIG. **5** is a block diagram of an example controller **120** that can be used with aspects of this disclosure. The controller **120** can, among other things, monitor parameters of the system **100** and send signals to actuate and/or adjust various operating parameters of the system **100**. As shown in FIG. **5**, the controller **120**, in certain instances, includes a processor **550** (e.g., implemented as one processor or multiple processors) and a memory **552** (e.g., implemented as one memory or multiple memories) containing instructions that cause the processors **550** to perform operations described herein. The processors **550** are coupled to an input/output (I/O) interface **554** for sending and receiving communications with components in the system, including, for example, the plunger catcher **212**. In certain instances, the controller **120** can additionally communicate status with and send actuation and/or control signals to one or more of the various system components (including an actuable system, such as the control valve **132**) of the system, as well as other sensors (e.g., the well pressure sensor **122**, position sensors, and other types of sensors) provided with the system **100**. In certain instances, the controller **120** can communicate status and send actuation and control signals to one or more of the components within the system **100**, such as with a status light or with a heads-up display. The communications can be hard-wired, pneumatic, hydraulic, wireless, or a combination. In some implementations, the controller **120** can be a distributed controller with different portions located throughout the system **100**. Additional controllers can be used throughout the system **100** as stand-alone controllers or networked controllers without departing from this disclosure.

[0044] The controller **120** can have varying levels of autonomy for controlling the system **100**. For example, the controller **120** can begin sensing a system parameter, such as a wellbore pressure, and an operator actuates system, by the controller, in response. Alternatively, the controller **120** can begin sensing the vehicle parameter and actuate various components, such as the control valve, plunger catcher, or both, with no input from an operator.

[0045] In operation, the controller **120** receives a first signal, for example, from the well pressure sensor **122**, indicative of a pressure within the wellbore. The controller **120** then determines that the pressure within the wellbore has fallen below a first specified threshold based on the first received signal. Next, the controller **120** sends a second signal to an actuator. The second signal is configured to actuate the actuator to release a plunger into the wellbore. In some implementations, the actuator is the plunger catcher. A third signal is sent by the controller **120** to a control valve

132. The third signal is configured to actuate the control valve **132** to cease flow within the production wellbore **104**. The third signal can be sent before the second signal, after the second signal, or at substantially the same time (within a few seconds) as the second signal without departing from this disclosure. After ceasing flow within the wellbore, the controller **120** determines that the pressure within the wellbore has risen above a second specified threshold based on the first received signal. The controller **120** then sends a fourth signal to the control valve **132**. The fourth signal is configured to actuate the control valve **132** to re-start flow within the production wellbore **104**.

[0046] Once the plunger has returned, the controller **120** receives a fifth signal indicative of a plunger presence within the lubricator. The controller **120** then determines the presence of the plunger within the lubricator based on the received fifth signal.

[0047] FIG. **6** is a flowchart of an example method **600** that can be used with aspects of this disclosure. In some implementations, some or all of the method is performed by the controller **120**. Prior to the method **600**, a pressure drop is detected within the wellbore. As previously discussed, fluid flow is ceased within the production wellbore **104** in response to the detected pressure drop. The plunger **116** is also released from the plunger lift lubricator **118** into the production wellbore **104** in response to the detected pressure drop. Once pressure has built back up sufficiently, flow from the production wellbore **104** is once more started, sending the plunger **116** and a slug of liquid uphole towards the production tree.

[0048] At **602**, the plunger **116** is received from the production wellbore **104** by the plunger lift lubricator **118**. More specifically, the plunger is received by the inlet of the plunger lift lubricator **118**. The plunger **116** is retained by the plunger lift lubricator **118** for example. At **604**, fluid is received by the plunger lift lubricator **118** from the production wellbore **104**. It should be noted that the fluid can be received before and/or after the plunger **116**. That is, in some implementations, the first inlet and the second inlet receive fluid traveling ahead of the plunger **116**, and the first inlet and the second inlet receive fluid traveling behind the plunger. At **606**, fluid is directed by internal flow passages **206** within the plunger lift lubricator **118**.

[0049] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any inventions or of what may be claimed, but rather as descriptions of features specific to particular embodiments of particular inventions. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

[0050] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[0051] Thus, particular embodiments of the subject matter have been described. Other embodiments are within the scope of the following claims. In some cases, the actions recited in the claims can be performed in a different order and still achieve desirable results. In addition, the processes depicted in the accompanying figures do not necessarily require the particular order shown, or sequential order, to achieve desirable results. In certain implementations, multitasking and parallel processing may be advantageous.

What is claimed is:

1. A plunger lift lubricator comprising:

a housing defining a central receiving passage and internal flow passages fluidically connected to the central receiving passage;

a receiving spring at an uphole end of the lubricator; and

a plunger catcher.

2. The plunger lubricator of claim **1**, wherein the internal flow passages comprise:

a first fluid passage defining an first inlet within the central passage, the first inlet configured to receive production fluid from the central passage; and

a second fluid passage defining a second inlet uphole of the first inlet, the second inlet configured to receive production fluid from the central passage, the second fluid passage converging with the first fluid passage.

3. The plunger lubricator of claim **2**, wherein the housing further defines an outlet configured to direct well fluid to a conditioning system from the first fluid passage and the second fluid passage.

4. The plunger lubricator of claim **2**, wherein the first fluid inlet and the second fluid inlet are spaced apart a distance greater than a length of a plunger to be used with the lubricator.

5. The plunger lubricator of claim **1**, further comprising a controller configured to:

receive a first signal indicative of a pressure within a wellbore;

determine that the pressure within the wellbore has fallen below a first specified threshold based on the first received signal;

send a second signal to an actuator, the second signal configured to actuate the actuator to release a plunger into the wellbore;

send a third signal to a control valve, the third signal configured to actuate the control valve to cease flow within the wellbore;

after ceasing flow within the wellbore, determine that the pressure within the wellbore has risen above a second specified threshold based on the first received signal; and

send a fourth signal to the control valve, the fourth signal configured to actuate the control valve to re-start flow within the wellbore.

6. The plunger lubricator of claim **5**, wherein the controller is further configured to:

receive a fifth signal indicative of a plunger presence within the lubricator; and
determine the presence of the plunger within the lubricator based on the received fifth signal.

7. A method comprising:
receiving a plunger from a wellbore by a plunger lubricator;
receiving fluid, by the plunger lubricator, from the wellbore; and
directing fluid by internal flow passages within the lubricator.

8. The method of claim **7**, further comprising:
detecting a pressure drop;
ceasing fluid flow within the wellbore in response to the detected pressure drop; and
releasing the plunger by the plunger lubricator.

9. The method of claim **7**, wherein receiving the plunger comprises:
receiving the plunger by an inlet of the plunger lubricator;
receiving fluid, traveling ahead of the plunger, by a first inlet and a second inlet; and
receiving fluid, traveling behind the plunger, by the first inlet and by the second inlet.

10. The method of claim **7**, further comprising:
retaining the plunger by the plunger lubricator.

11. A plunger lift system comprising:
a production wellbore;
a production tree at an uphole end of the production wellbore;
a plunger lubricator atop the production tree, the plunger lubricator comprising:
a housing defining a central receiving passage and internal flow passages fluidically connected to the central receiving passage;
a receiving spring at an uphole end of the plunger lubricator;
a plunger catcher; and
a plunger configured to traverse the wellbore and be received and retained by the plunger lubricator.

12. The plunger lift system of claim **11**, wherein the internal flow passages comprise:
a first fluid passage defining an first inlet within the central passage, the first inlet configured to receive production fluid from the central passage; and
a second fluid passage defining a second inlet uphole of the first inlet, the second inlet configured to receive production fluid from the central passage, the second fluid passage converging with the first fluid passage.

13. The plunger lift system of claim **12**, wherein the first fluid inlet and the second fluid inlet are spaced apart a distance greater than a length of a plunger to be used with the lubricator.

14. The plunger lift system of claim **12**, further comprising a controller configured to:
receive a first signal indicative of a pressure within the wellbore;
determine that the pressure within the wellbore has fallen below a first specified threshold based on the first received signal;
send a second signal to an actuator, the second signal configured to actuate the actuator to release a plunger into the wellbore;
send a third signal to a control valve, the third signal configured to actuate the control valve to cease flow within the wellbore;
after ceasing flow within the wellbore, determine that the pressure within the wellbore has risen above a second specified threshold based on the first received signal; and
send a fourth signal to the control valve, the fourth signal configured to actuate the control valve to re-start flow within the wellbore.

15. The plunger lift system of claim **14**, wherein the controller is further configured to:
receive a fifth signal indicative of a plunger presence within the lubricator; and
determine the presence of the plunger within the lubricator based on the received fifth signal.

16. The plunger lift system of claim **14**, further comprising a solar panel coupled to the controller, the solar panel configured to provide power to the controller.

17. The plunger lift system of claim **11**, further comprising a conditioning system configured to condition production fluids directed by the lubricator.

18. The plunger lift system of claim **17**, wherein the housing further defines an outlet configured to direct well fluid to a conditioning system.

* * * * *