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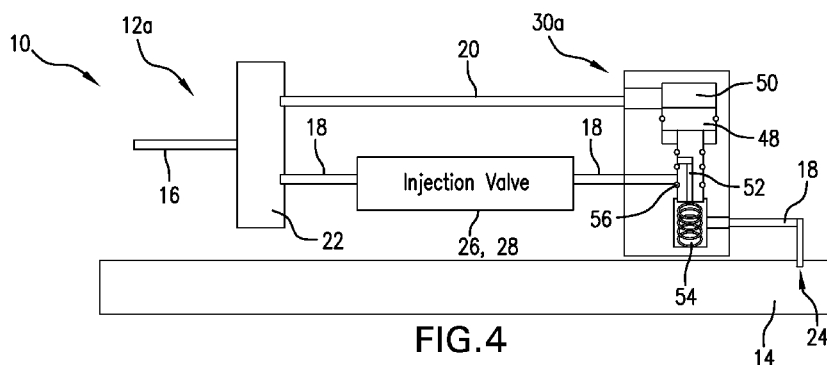


FIG. 4

(57) Abstract: A downhole valve assembly, including a line operatively arranged to carry a fluid, a splitter arranged on the line, the splitter dividing the line into a control leg and an injection leg. The injection leg terminating in an injection port, and a valve mechanism actuatable for selectively sealing the injection port, the valve mechanism controllable via a fluid pressure in the line, the fluid pressure communicated to the valve mechanism via the control leg for actuating the valve mechanism.

INJECTION LINE VALVE MECHANISM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of an earlier filing date from U.S. Provisional Application Serial No. 61/501,007 filed June 24, 2011, the entire disclosure of which is incorporated herein by reference.

BACKGROUND

[0002] Chemical injection systems are used in the downhole drilling and completions industry. Check valves are included to prevent natural gas and other fluids from undesirably migrating up through the chemical injection lines. The performance of these check valves is not always adequate to prevent all fluid migration, particularly under static conditions (no chemical being injected) or while chemicals are being injected at lower rates. Faulty differential pressure devices for the check valves may also result in some chemical fluid undesirably flowing downhole under static conditions, which can create a vacuum in the injection line, causing vaporization of the chemical carrier and formation of precipitates that tend to clog the injection line. Problems with check valves may include debris caught in the valves, wear or degradation of the valves over time, problematic installations, etc. Accordingly, advances to prevent fluid migration and improve chemical injection are always well received by the industry.

BRIEF DESCRIPTION

[0003] A downhole valve assembly, including a line operatively arranged to carry a fluid, a splitter arranged on the line, the splitter dividing the line into a control leg and an injection leg. The injection leg terminating in an injection port, and a valve mechanism actuatable for selectively sealing the injection port, the valve mechanism controllable via a fluid pressure in the line, the fluid pressure communicated to the valve mechanism via the control leg for actuating the valve mechanism.

[0004] A method of injecting fluid downhole, including pumping a fluid in a line. The line including a splitter for dividing the line into a control leg and an injection leg, the injection leg terminating in an injection port; and selectively controlling a valve mechanism to open and close the injection port based on the fluid pressure of the fluid in the line, the fluid pressure communicatable to the valve mechanism via the control leg.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0005] Figure 1 is schematic view of a shut-off assembly in an open position;

[0006] Figure 2 is a schematic view of the shut-off assembly of Figure 1 in a closed position;

[0007] Figure 3 is an enlarged view of the area encircled in Figure 2;

[0008] Figure 4 is a schematic view of an alternate embodiment shut-off assembly;

[0009] Figure 5 is a schematic view of another alternate embodiment shut-off assembly;

[0010] Figure 6 is a schematic view of a piston valve mechanism in an open position; and

[0011] Figure 7 is a schematic view of the valve mechanism of Figure 6 in a closed position.

DETAILED DESCRIPTION

[0012] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0013] Referring now to Figure 1, a downhole system 10 is shown. The system 10 includes a chemical injection assembly 12 for injecting chemical fluids into a production tube 14 located in a borehole. The production tube 14 is for directing natural gas or the like from formations downhole to a surface of the borehole where it can be harvested, collected, processed, etc. The injection assembly 12 includes a tube or line 16 that extends to the surface where the borehole is drilled, where chemicals, such as demulsifiers, clarifiers, corrosion inhibitors, scale inhibitors, dewaxers, surfactants, etc., can be pumped downhole into the production tubing 14 for assisting in the production process.

[0014] The line 16 is split into an injection leg 18 and a control leg 20 at a splitter 22. The injection leg 18 terminates at an injection port 24 into the production tubing 14. A check valve 26 is located upstream of the injection port 24 for preventing the back flow of fluids, migration of gas, etc., up the line 16 to the surface. The check valve 26 may be accompanied by a differential pressure device 28, e.g., a heavy-duty spring or other biasing feature, for

creating a pressure differential across the check valve 26 in order to keep the valve 26 closed when chemical fluids are not being pumped down the line 16 from the surface with sufficient pressure.

[0015] The check valve 26 and/or the differential pressure device 28 may leak or weep over time, such as from the buildup of debris, normal wear and tear, etc. As a result, a valve mechanism 30 is included in the injection assembly 12 of the downhole system 10 described herein. In this illustrated embodiment, the valve mechanism 30 includes a sleeve 32 slidably mounted within the production tubing 14. The sleeve 32 includes seal elements 34, 36, and 38 between the sleeve 32 and an inner surface of the production tubing 14 in order to seal the sleeve 32 to the tubing 14 as the sleeve 32 slides along the tubing 14.

[0016] The seal elements 34 and 36 define an isolation chamber 40, while the seal elements 36 and 38 define a control chamber 42, with both chambers 40 and 42 fluidly sealed from the tubing 14. Although two chambers are formed utilizing three seals in the illustrated embodiment, it will be appreciated that a single chamber could be created using only two seal elements (e.g., removing seal element 36), or that a fourth seal element could be included to seal each of the two chambers with two separate elements, etc.

[0017] The valve mechanism 30 for the assembly 12 is shown in its open position in Figure 1. In the open position, the sleeve 32 is actuated away from injection port 24 such that the injection port 24 is in fluid communication with the production tubing 14. In Figure 2, however, the valve mechanism 30 of the assembly 12 is in its closed position, with the sleeve 32 actuated toward the injection port 24, thereby positioning the injection port 24 in the chamber 40 sealed from the production tubing 14 by the seal elements 34 and 36. In the closed position, the injection port 24 and the production tubing 14 are no longer in fluid communication with each other. Thus, the valve mechanism 30 enables selective control over whether the injection port 24 is open with respect to the production tubing 14. For example, by closing the injection port 24 with the valve mechanism 30, the migration of fluids from the production tubing 14 up the injection leg 18 and into the injection line 16 can be prevented because the injection port 24 is isolated in the chamber 40 from the production tubing 14. Similarly, by closing the injection port 24 with the valve mechanism 30, the chemical injection line 16 will not readily leak, and therefore be kept full for preventing the creation of a vacuum in the line 16.

[0018] In one embodiment, a spring 44 (or some other actuation device) is utilized to urge the valve mechanism 30 into its closed position by default, i.e., by preloading the spring

44 to exert at least a minimum force on the sleeve 32, e.g., a force greater than the hydrostatic pressure of the chemical fluid in the line 16. In order to transition the valve mechanism 30 from the closed position (Figure 2) into the open position (Figure 1), a pressure in the control leg 20 must overcome the actuation force by the spring 44 or other actuation device. As shown more clearly in Figure 3, the sleeve 32 includes a profile 46 in the chamber 42 for enabling creation of a pressure differential across the sleeve 32. That is, for example, by increasing the pressure in the chamber 42, the increased surface area provided by the profile 46 results in a net force on the sleeve 32 for actuating the sleeve 32 away from the injection port 24 in order to open the injection port 24, thereby enabling chemicals or the like to be injected into the production tubing 14. It is to be appreciated that the parameters of the spring 44 and geometry of the sleeve 32 (e.g., surface area of the profile 46), can be set to predetermine a threshold pressure that overcomes the spring force.

[0019] In summation, the pressure in the line 16 sets the pressure in the control leg 20, the pressure in the control leg 20 sets the pressure in the chamber 42, and the pressure in the chamber 42 is used to control the operation of the valve mechanism 30. Accordingly, it is to be understood that it is the pressure in the line 16 that ultimately controls the operation of the valve mechanism 30. Pressure will be increased in the line 16 when it is desired to pump fluid down the line 16, and advantageously, it is the very act of pumping fluid down the line 16 that also actuates the valve mechanism 30 into its open position. Thus, the valve mechanism 30 is only open when fluid is being pumped down the line 16 at a sufficiently high pressure, and then closes by default due to the spring 44 once pumping has stopped and pressure in the line 16 drops.

[0020] By pumping a chemical down the line 16 at a sufficient pressure, the chemical fluid will act on the profile 46 to force the sleeve 32 away from the injection port 24, releasing the injection port from the sealed chamber 40, and enabling fluid communication between the injection port 24 and the production tubing 14. When fluid is being pumped downhole through the line 16 with sufficient pressure to open the mechanism 30, this fluid is also at a sufficient rate to prevent the back flow or migration of fluids through the check valve 26, up the leg 18, up the line 16, etc. Then, when the fluid is no longer being pumped downhole, the pressure is relieved and the mechanism 30 closes due to the biasing force of the spring 44. Advantageously, the valve opens in response to the very act for which it is desired for the valve to be open, i.e., the act of pumping the fluid downhole, and the valve closes in response to the very act for which it is desired for the valve to be closed, i.e.,

pumping has stopped. As a result, separate control lines do not have to be run downhole, maintained, monitored, controlled, etc., the injection port 24 is closed by default to block the migration of fluids up the injection line 16 in static conditions, and the injection port 24 is opened reliably under active conditions when fluid needs to be injected into the production tubing 14.

[0021] The valve mechanism 30 takes the form of a sliding sleeve mechanism (i.e., it includes the sleeve 32) in the illustrated embodiments, but it will be appreciated that other devices could be used, such as a flapper valve, ball valve, shuttle valve, etc., in order to use the pressure in the line 16 (and the control leg 20) to selectively enable fluid communication between the injection port 24 and the production tubing 14.

[0022] It is also to be appreciated that the check valve 26 and pressure differential device 28 could play an important role even if the valve mechanism 30 prevents fluid migration up-hole. That is, the pressure differential device 28 could be set to ensure that the pressure required to open check valve 26 is greater than the pressure required to open the valve mechanism 30. If the reverse were true, then there would be little control over the rate at which fluid is pumped, as the fluid would be pressurized at the injection port 24 and ready to rush out when the port 24 is opened. For example, assume a first pressure is required to actuate the valve mechanism 30 to its open position, and a second pressure is required to overcome the pressure differential device 28 to enable flow through the check valve 26. In this example, the pressure in the line 16 can first be set to be equal to or greater than the first pressure, but less than the second pressure, at which point the valve mechanism 30 opens. Since the second pressure has not been reached, the fluid is pressurized at the check valve 26, and is not yet injected into the production tubing 14. Then, by further pressurizing to the second pressure and above, the differential device 28 can be overcome, and the flow of fluid can be more accurately controlled into the tubing 14. Since the pressure in the injection line 16 will change when the valves 30 and/or 26 are opened, a pump controller and a flowmeter could be included fluidly coupled to the line 16, for example at the surface of the borehole, for enabling more precise control of fluid rate regardless of changing pump resistance or fluid pressures. Under some conditions, a pressure differential device may not be required. For example, a pressure differential device will not be necessary if the pressure in the production tubing 14 is high enough that the pressure required to inject fluid into the production tubing 14 is greater than the pressure required to open the mechanism 30.

[0023] The system 10 is shown in Figures 4 and 5 incorporating an assembly 12a and an assembly 12b, respectively, in lieu of the assembly 12. The assembly 12a incorporates a valve mechanism 30a. The valve mechanism 30a includes a piston 48 actuatable by pressure supplied to a chamber 50 via the control leg 20. The piston 48 includes a passage 52 therethrough for selectively connecting the portions of the injection leg 18 on opposite sides of the valve mechanism 30a when properly positioned. A spring 54 is included to bias the piston 48 into a closed position, wherein the passage 52 is misaligned with the injection leg 18 so that fluid can not pass to the injection port 24. The mechanism 30a includes a plurality of seal elements 56 to seal the piston chamber 50, the passage 52, the injection leg 18, etc. from each other. Thus, it is to be appreciated that even though some degree of fluid migration may occur up the portion of the injection leg 18 downstream of the valve mechanism 30a, the valve mechanism 30a provides an alternate embodiment for selectively opening and closing the injection port 24 in order to selectively enable or disable fluid communication between the line 16 and the production tubing 14.

[0024] The assembly 12b includes a valve mechanism 30b. The valve mechanism 30b resembles the mechanism 30a in that it includes a piston 58 actuatable by pressure in a chamber 60 supplied by the control leg 20. Further, the mechanism 30b includes a passage 62 therethrough for selectively connecting the portions of the injection leg 18 on opposite sides of the valve mechanism 30b when the piston 58, and therefore the passage 62, is properly positioned. A spring 64 is similarly included to bias the piston 58 into a closed position, wherein the passage 62 is misaligned with the injection leg 18 so that fluid can not pass to the injection port 24. The mechanism 30b also similarly includes a plurality of seal elements 66 to seal the piston chamber 60, the passage 62, the injection leg 18, etc. from each other. The mechanism 30b differs from the mechanism 30a in that the mechanism 30b is positioned upstream from the injection valve 24. Also from mechanism 30b, it can be appreciated that the splitter 22 can be incorporated into a housing 68 for the valve mechanism 30b in order to save on the number of components that need to be manufactured or installed.

[0025] The valve mechanism 30b is shown in more detail in Figures 6 and 7, actuated between a closed and an open position, respectively. Similar to the mechanism 30, to open the injection port 24, the line 16 is pressurized, e.g., by pumping fluid down the line 16, and the fluid pressure is communicated to the valve mechanism via the control leg 20. The increased pressure actuates the piston 58 to against the force of the spring 64 in order to align the passage 62 with the injection leg 18 for enabling fluid to pass from the line 16 through the

valve mechanism 30b to the port 24 and into the production tubing 14. In order to seal off the injection port 24 from the line 16, the pressure in the line 16, control leg 20, and chamber 60 is lessened so that the spring urges the piston 58 to misalign the passage 62 and the portions of the injection leg 18. When the passage 62 is misaligned, fluid can not flow through the mechanism 30b, and therefore, can not flow between the line 16 and the port 24. It is to be understood that the mechanism 30a operates in essentially the same way as described for the mechanism 30b. Further, all three mechanisms 30, 30a, and 30b operate in generally the same way, i.e., by pressuring the fluid injection line 16. Moreover, the check valve 26 and the differential pressure device 28 can operate with either 30a or 30b as described above in order to more accurately inject chemicals or other fluids into the production tubing 14.

[0026] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

CLAIMS

What is claimed is:

1. A downhole valve assembly, comprising:
a line operatively arranged to carry a fluid;
a splitter arranged on the line, the splitter dividing the line into a control leg and an injection leg, the injection leg terminating in an injection port; and
a valve mechanism actuatable for selectively sealing the injection port, the valve mechanism controllable via a fluid pressure in the line, the fluid pressure communicated to the valve mechanism via the control leg for actuating the valve mechanism.
2. The assembly of claim 1, wherein the control leg terminates in a sealed chamber.
3. The assembly of claim 2, wherein the valve mechanism includes a slidable sleeve.
4. The assembly of claim 3, wherein the sleeve includes a profile operatively arranged in the sealed chamber to enable creation of a pressure differential across the sleeve for controlling actuation of the sleeve based on the fluid pressure in the line.
5. The assembly of claim 2, wherein the valve mechanism includes a piston at least partially located in the sealed chamber.
6. The assembly of claim 5, wherein the piston includes a passage therethrough, the passage alignable with oppositely disposed portions of the injection leg for selectively enabling fluid communication between the line and the injection port.
7. The assembly of claim 1, further comprising an actuator for urging the valve mechanism into a closed position by default, wherein the fluid pressure in the line must overcome a force exerted by the actuator to transition the valve mechanism into an open position.
8. The assembly of claim 7, wherein the actuator is a spring.
9. The assembly of claim 1, wherein the injection port is in fluid communication with production tubing when the valve mechanism is in an open position and sealed from the production tubing when the valve mechanism is in a closed position.
10. The assembly of claim 1, wherein the injection leg includes a check valve for preventing back flow of fluid through the line.
11. The assembly of claim 10, wherein the injection leg includes a pressure differential device for creating a pressure differential across the check valve.

12. The assembly of claim 11, wherein a first pressure is required to open the valve mechanism, a second pressure is required to overcome the pressure differential device, and the second pressure is greater than or equal to the first pressure.

13. A method of injecting fluid downhole, comprising:
pumping a fluid in a line, the line including a splitter for dividing the line into a control leg and an injection leg, the injection leg terminating in an injection port; and
selectively controlling a valve mechanism to open and close the injection port based on the fluid pressure of the fluid in the line, the fluid pressure communicatable to the valve mechanism via the control leg.

14. The method of claim 13 wherein the valve mechanism includes a slidable sleeve.

15. The method of claim 13, wherein the sleeve includes a profile in fluid communication with the line for enabling creation of a pressure differential across the sleeve for actuating the sleeve based on the fluid pressure in the line.

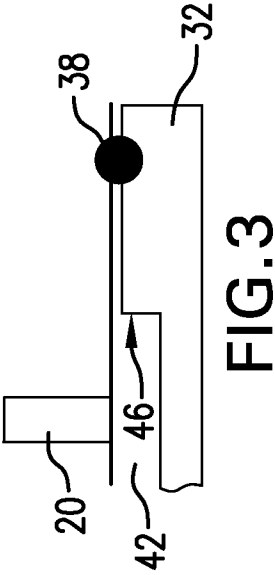
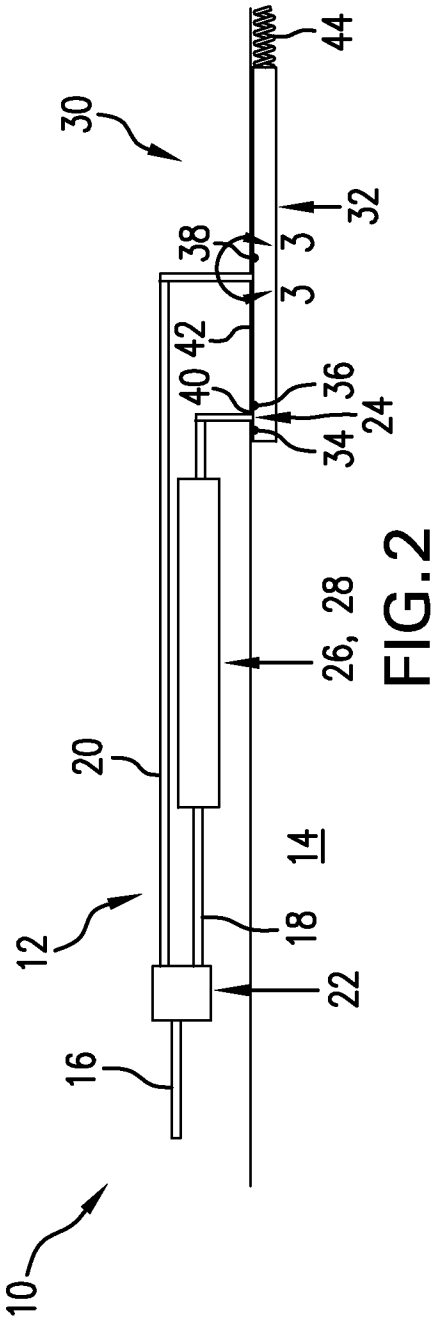
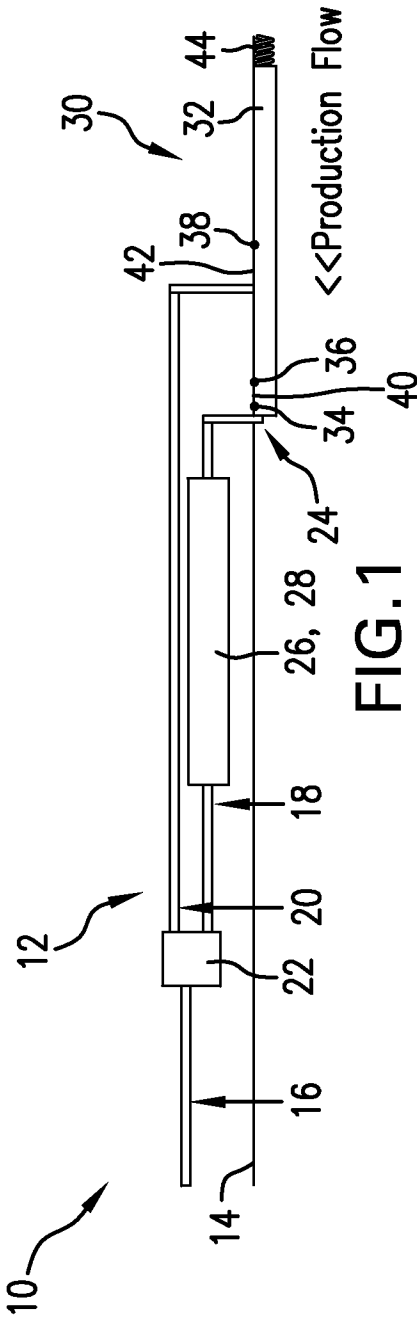
16. The method of claim 13, wherein selectively controlling the valve mechanism further comprises increasing the fluid pressure to equal or exceed a first threshold pressure for opening the injection port.

17. The method of claim 16, further comprising automatically returning the valve mechanism to a closed position when the fluid pressure falls below the first threshold pressure.

18. The method of claim 17, wherein a spring biases the valve mechanism to automatically return to the closed position.

19. The method of claim 16, further comprising increasing the fluid pressure in the line to a second threshold pressure, the second threshold pressure greater than the first threshold pressure and required to open a check valve included along the injection leg upstream of the injection port.

20. The method of claim 13, wherein the valve mechanism includes a piston.



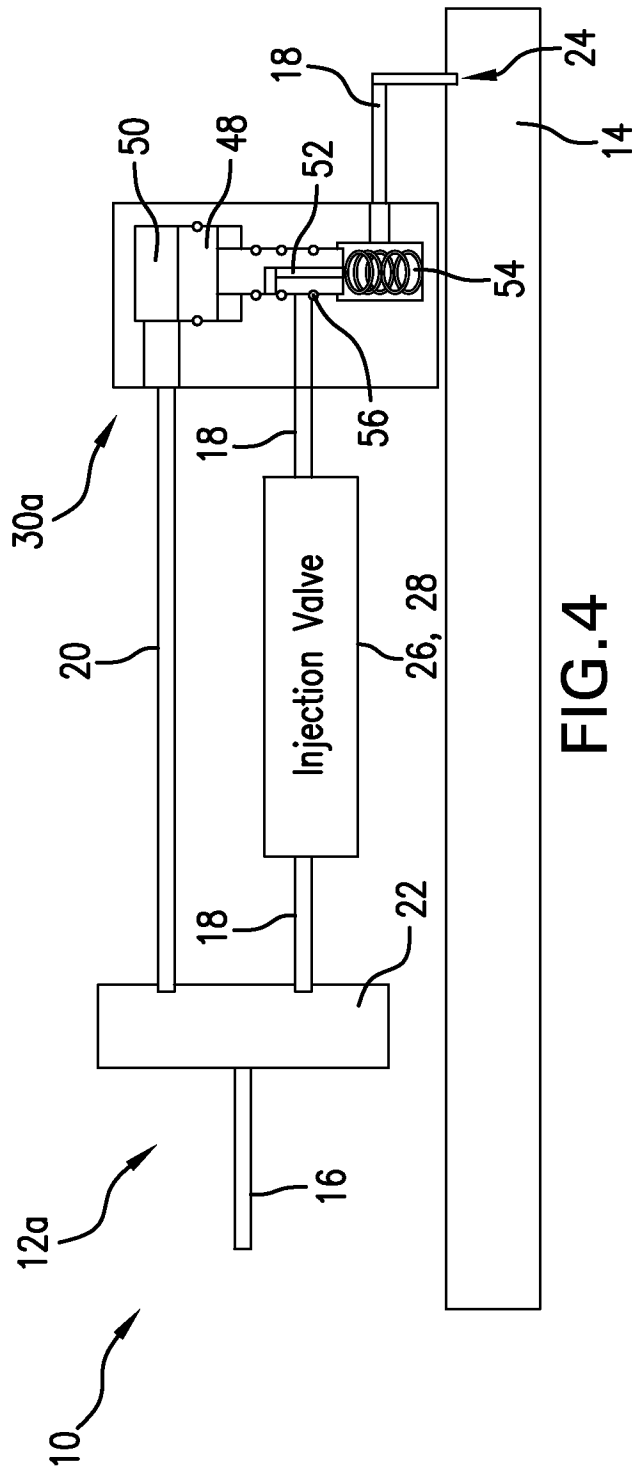


FIG. 4

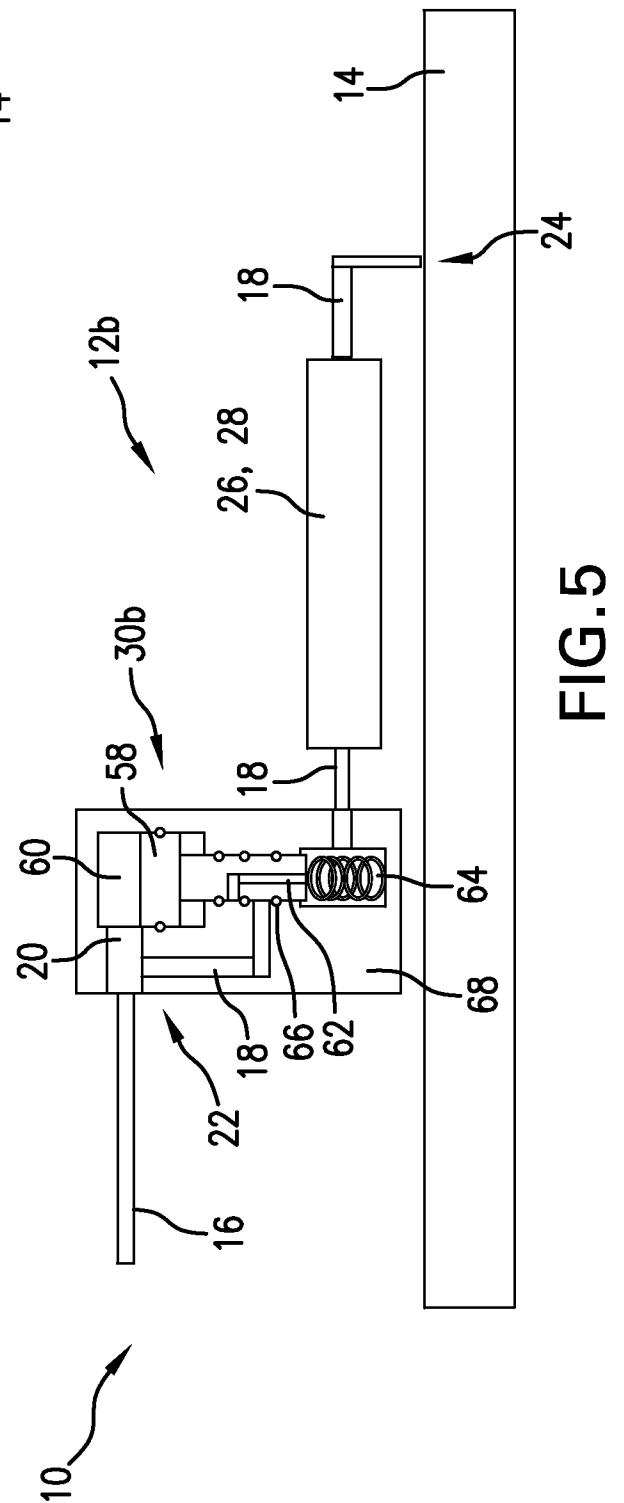


FIG. 5

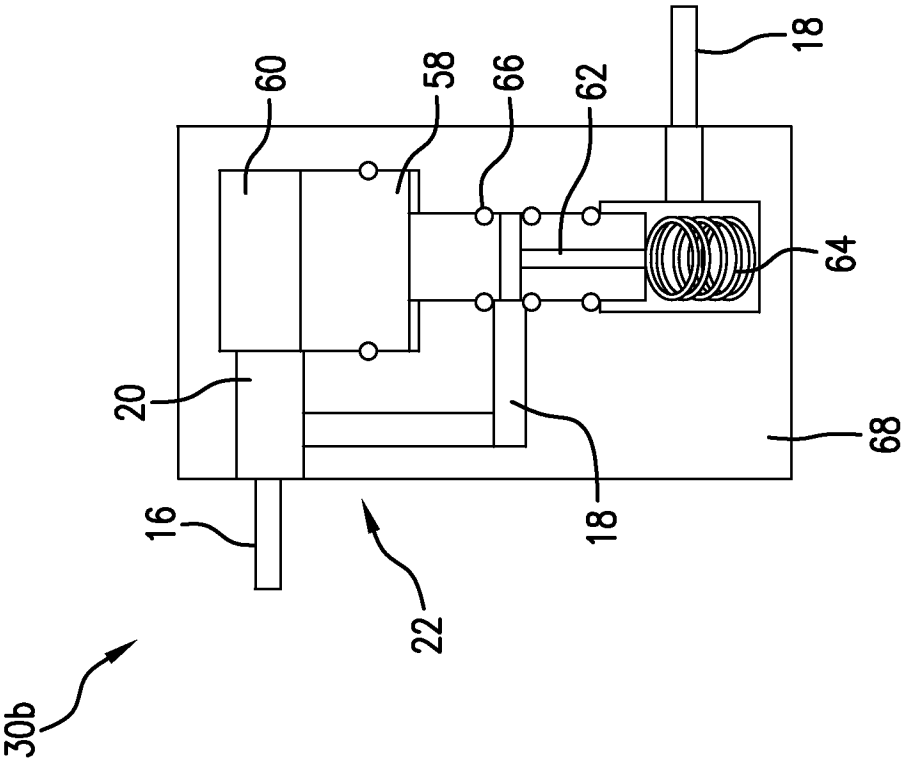


FIG. 6

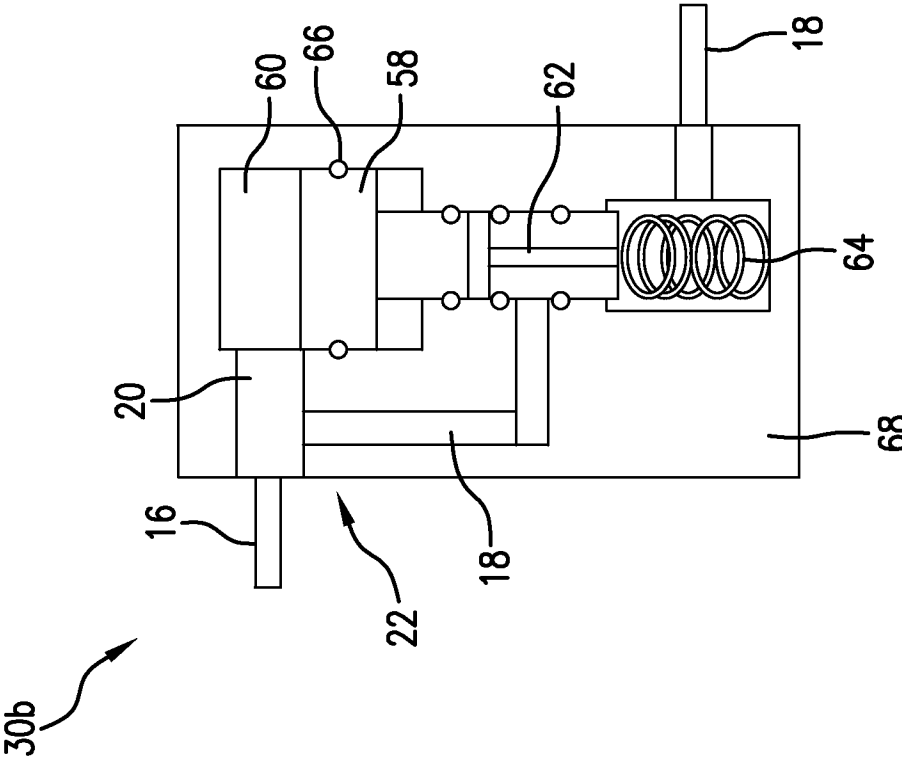


FIG. 7