

(19)



(11)

EP 2 893 126 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

21.12.2022 Bulletin 2022/51

(21) Application number: **13759255.6**

(22) Date of filing: **10.09.2013**

(51) International Patent Classification (IPC):

E21B 34/08^(2006.01) E21B 34/10^(2006.01)

(52) Cooperative Patent Classification (CPC):

E21B 34/08; E21B 34/10

(86) International application number:

PCT/EP2013/068736

(87) International publication number:

WO 2014/037584 (13.03.2014 Gazette 2014/11)

(54) **INJECTION DEVICE**

INJEKTIONSVORRICHTUNG

DISPOSITIF D'INJECTION

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **10.09.2012 GB 201216064**

(43) Date of publication of application:

15.07.2015 Bulletin 2015/29

(73) Proprietor: **TCO AS**

5888 Bergen (NO)

(72) Inventor: **WOODFORD, Keith Donald**

**Aberdeen
Aberdeenshire AB15 6WF (GB)**

(74) Representative: **Acapo AS**

**Edvard Griegs vei 1
5059 Bergen (NO)**

(56) References cited:

**EP-A1- 2 166 423 GB-A- 919 775
US-A- 3 125 113 US-A- 3 856 043**

EP 2 893 126 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

FIELD OF THE INVENTION

5 **[0001]** The present invention relates to an injection device for injecting a fluid to a target location, such as into a downhole location.

BACKGROUND TO THE INVENTION

10 **[0002]** Many industries require fluids to be delivered, or injected, from a source to a target location. For example, in the oil and gas industry many well completions include a means of injecting chemicals into the wellbore at a point in the completion for the purposes of corrosion reduction, scale reduction, hydrate reduction, well stimulation, a variety of optimisation strategies or the like. It is highly desirable to be able to control the rate of injection, and in typical applications the preference is to permit a relatively constant rate of injection to be achieved, irrespective of and pressure fluctuations within the system. Injection may also be required at other locations, such as into the wellbore, associated formation, annulus and the like. Injection could also be required at a subsea location, such as at a Christmas tree, flow line, jumper, manifold, wing line or the like. Some other examples of injection in the oil and gas industry include downhole injection of a fluid to assist production. US Patent Document 3,125,113 A discloses a valve for a gas lift system which shows some of the features of the injection valve of the invention.

20 **[0003]** A typical wellbore completion installation with injection capabilities is diagrammatically illustrated in Figure 1. The wellbore, generally identified by reference numeral 10, comprises a casing string 12 located within a drilled bore 14 which extends from surface 16 to intercept a hydrocarbon bearing formation 18. A lower annulus area 20 defined between the casing 12 and bore 14 may be filled with cement 22 for purposes of support and sealing. A production tubing string 24 extends into the casing 12 from a wellhead 26 and production tree 28. A lower end of the production tubing string 24 is sealed against the casing 12 with a production packer 30 to isolate a producing zone 32. A number of perforations 34 are established through the casing 12 and cement 22 to establish fluid communication between the casing 12 and the formation 18. Hydrocarbons may then be permitted to flow into the casing 12 at the producing zone 32 and then into the production tubing 24 via inlet 36 to be produced to surface. Artificial lift equipment, such as an electric submersible pump (ESP) 37 may optionally be installed inline with the production tubing 24 as part of the completion to assist production to surface. The production tree 28 may provide the necessary pressure barriers and provides a production outlet 38 from which produced hydrocarbons may be delivered to a production facility (not shown), for example.

30 **[0004]** A small bore injection line or conduit 40, which is often referred to as a capillary line, runs alongside the production tubing 24 from a surface located injection fluid source 42 to a downhole target location, which in the illustrated example is a lower end of the production tubing 24, below the ESP 37. The production tubing 24 may include an optional injection mandrel 44. An injection pump 46 is located at a topside location to facilitate injection of the injection fluid 42.

35 **[0005]** An injection valve 48 is located in a lower region of the injection line 40 and functions to permit fluid injection into the production tubing 24, in some cases preferentially at a constant injection rate, while preventing reverse flow back into the injection line 40. Known valves for such purposes include an injection check valve, such as illustrated in Figure 2. In this example the check valve 48 includes a housing 50 with an inlet 52 for communicating with the injection line 40 and an outlet 54 for communicating with the production tubing 24. A poppet member 56 (other similar members such as pistons and balls are also known) is mounted in the housing 50 and is biased by a spring 58 towards a closed position in which the poppet 56 sealingly engages a seat 60 to prevent flow through the housing 50. To permit injection the fluid pressure at the inlet 52 must establish a downward force on the poppet 56 which exceeds the combined force of the spring 58 and the pressure at the outlet 54, which act in the opposing direction. Accordingly, in normal flow conditions the inlet pressure will be a fixed differential above the outlet pressure by a magnitude dictated primarily by the force of the spring 58, and also by any back-pressure created at the inlet by the effect of the poppet 56 and seat defining a flow restriction. An exemplary graphical representation of the effects of varying the inlet or outlet pressures is provided in Figure 3. As shown, irrespective of pressure fluctuations at the outlet 54, the inlet pressure 62 will always be a fixed value above the outlet pressure 64 by a differential 66 which is defined primarily by the spring 58.

40 **[0006]** In chemical injection there is always a hydrostatic pressure gradient present in the injection line 40. This pressure gradient is a function of the density of the fluid and the true vertical height of the well known as the TVD (True Vertical Depth). As depth increases, the hydrostatic pressure will linearly increase, such that the maximum hydrostatic pressure will act at the inlet 52 of the injection valve 48. This hydrostatic pressure will act in a direction to open the valve poppet member 56 against the combined resistance of the spring 58 and the pressure at the valve outlet 54, which will be largely equal to the pressure within the production tubing 24 at the point of injection. There may be circumstances where the hydrostatic pressure force acting at the valve inlet 52 exceeds the resistance provided by the valve outlet pressure and the spring 58, for example where large hydrostatic pressures exist in deeper wells, and/or where relatively low wellbore

pressures exist, for example due to operation of the ESP 37. In such circumstances the result can be the undesirable flow or cascading of injection fluid into the target location. This effect may be termed "hydrostatic fall-through".

5 **[0007]** If unchecked such hydrostatic fall-through will occur until the hydrostatic pressure within the injection line 40 is in equilibrium with the target location pressure and the resistance provided by the valve spring 58. If the injection fluid is not continuously replenished, or not replenished as quickly as the injection fluid cascades through the valve 48, then the result will be the creation of low, vacuum or near vacuum pressures in the upper region of the injection line 40. Such a vacuum may present the injection line 40 to adverse mechanical forces and stresses, such as radial collapse forces. Furthermore, the established vacuum may be defined by a pressure which is lower than the vapour pressure of the injection fluid, thus causing the injection fluid to boil. This may be compounded by the effect of the increased temperatures associated with wellbore environments. The consequence of vacuum occurrence in chemical injection lines is that the original fluid may not be able to retain its intended state and the fluid carrier will boil off. This has the potential of many adverse effects, such as solid depositing, viscosity change, crystal formation, waxing, partial or full solidification, and generally changes within the fluid causing loss of effectiveness of the injection chemical, and the like.

10 **[0008]** To provide a numerical example, for an injection line which has a TVD of 1420 meters with an injection fluid having a density of 1050 kg/m³, the hydrostatic pressure (calculated by the product of fluid density, gravity and TVD) acting at the inlet 52 of the valve 48 will be in the region of 146 bar. If the pressure in the production tubing 24 at the point of injection is 95 bar, and assuming that the valve spring 58 and other flow resistance is equivalent to providing 2 bar of pressure resistance, then this creates a pressure differential across the valve of 49 bar. Accordingly, due to the tendency for the system to seek equilibrium the injection fluid within the injection line 40 will cascade through the valve 48 until the height of injection fluid establishes a hydrostatic pressure at the valve inlet 52 which is in equilibrium with the pressure in the production tubing plus other resistance, which in the present example will be 97 bar. Thus, a hydrostatic pressure of 97 bar at the valve inlet 52 will require the injection fluid to cascade to define a height of around 942 metres. This will therefore leave the upper 478 meters of the injection line 40 under vacuum conditions, which is graphically illustrated in Figure 4.

25 **[0009]** Such hydrostatic fall-through may be addressed by increasing the spring force rating of the spring 58. This will function to increase the resistance to flow through the valve 48, such that a greater pressure differential between valve inlet 52 and outlet 54 can be accommodated before the onset of hydrostatic fall-through. A graphical example of the use of a more powerful valve spring is illustrated in Figure 5. As in the previous graphical example of Figure 3, the effect of the spring is such that irrespective of pressure fluctuations at the valve outlet 54, the inlet pressure 70 will always be a fixed value above the outlet pressure 72 by the differential 68. In this exemplary case a differential of around 80 bar is established by a more powerful spring, and such a spring would prevent the occurrence of hydrostatic fall-through in the specific numerical example provided above.

30 **[0010]** However, the size of a valve spring may be limited by the size of the injection valve and available space to accommodate deployment and installation of such a valve. Further, in circumstances where very large pressure differentials exist, the required size of a valve spring may be impossible to accommodate within the valve.

35 **[0011]** In addition to establishing a desired pressure differential across a valve using a spring, it is also known in the art to utilise the effect of a flow restriction within a valve to establish a desired backpressure within the injection line 40. Also, such a flow restriction may be variable to ensure a consistent injection flow rate can be achieved irrespective of the pressure differential.

40 **[0012]** As described above, in known injection valves a fixed differential between valve inlet and outlet is provided. Thus, the expectation and desire is that the valve inlet pressure will track any variations in the outlet pressure by the fixed differential. The intention of this is to prevent hydrostatic fall-through, and to facilitate a relatively constant injection rate. However, in certain circumstances, for example where the outlet pressure should drop, for example due to activation of an ESP, it has been observed that there is an unexpected sudden rush of injection fluid through the valve. This is contrary to expectation, which is that a substantially continuous injection rate should be achieved by self-adjustment of the valve to maintain the fixed pressure differential between inlet and outlet. Further, such a sudden rush of injection fluid through the valve may cause damage to the valve.

45 **[0013]** Furthermore, in the exemplary completion system shown in Figure 1 an optional ESP 37 is provided, wherein the injection fluid is injected upstream, or on the inlet side of the ESP 37. The injection fluid may function to inhibit scale and the like within the ESP 37, to condition the production fluids to permit more efficient pumping, for example by reducing the viscosity of the production fluids, and the like. In this respect, when the ESP 37 is activated the pressure at the pump inlet, and thus at the injection location will fall. As described above, the injection valve 48 should permit this fall in pressure to be accommodated and ensure that the injection line pressure is maintained at a fixed differential above the target location pressure, and self-adjusts to ensure a consistent flow rate of injection fluid.

50 **[0014]** Expected, and indeed desired pressure profiles at the inlet and outlet of the ESP 37, and at the inlet 52 of the valve 48 is graphically illustrated in Figure 6. In this respect, as the ESP 37 is activated the pump inlet pressure 74 should fall, and the pump outlet pressure 76 should rise, until a steady state running condition is preferably achieved. In view of the fixed pressure differential provided by the valve 48, illustrated by line 78 in Figure 6, the inlet pressure 80

of the valve 48 will be maintained at a fixed value above the inlet pressure 74 of the pump 37, and will thus define a substantially equivalent pressure profile, albeit at a fixed differential higher.

5 [0015] However, despite the expectation and desire for the pump inlet and outlet pressures to reach a steady state shortly after activation of the ESP 37, the present inventor has observed that in practice this may not be the case. For example, during fluid injection, such as injection of a diluent to modify the viscosity of the production fluids, the pressure profiles observed may be more accurately depicted in Figure 7 - it should be noted that Figure 7 represents a generalisation of the observations made by the applicant. In this respect, when the ESP 37 is activated the pump inlet pressure 82 falls, and the pump outlet pressure 84 rises, with the inlet pressure 86 tracking above the pump inlet pressure 82 by the magnitude of the fixed differential 88, as expected. However, it has been observed that the pump inlet and outlet pressures 10 82, 84 may not achieve the expected and desired steady state, and as illustrated in Figure 7 these pressures may fluctuate for an extended period following activation of the ESP 37. In this respect the observation is that pump inlet pressure 82 may fall while outlet pressure 84 rises, followed by an increase in inlet pressure 82 and corresponding fall in outlet pressure 84, with the cycle repeating. Further, as the valve inlet pressure 86 tracks above the pump inlet pressure 82 by the fixed differential 88 then this also fluctuates, and as a consequence so, too, does the injection fluid pressure 15 90 at the surface. Such pressure fluctuations can cyclically load the completion equipment, such as the ESP 37, surface pump 46, injection line 40 and the like, which may have a detrimental effect, for example by fatiguing the equipment, by establishing greatly interrupted and irregular production, reducing the lifetime of the completion equipment requiring more frequent workover and servicing, requiring a greater monitoring and reducing the understanding about the effectiveness of the fluid being injected, perhaps leading to increased fluid injection in attempts to counter the effects of this observation of pressure fluctuations.

20 [0016] A greater understanding of the causes of such observations, and any solutions to address such causes, is desired.

25 SUMMARY OF THE INVENTION

[0017] The invention is defined by independent claims. Furthermore, the embodiments of the invention are those defined by the dependent claims.

30 [0018] Aspects of the present invention relate to an injection device for use in injecting a fluid into a target location. Such an injection device may include a housing having an inlet for communication with an injection line or source of injection fluid, an outlet for communication with a target injection location, and a reference pressure port for communicating with a source of reference pressure, wherein the reference pressure port is isolated from the outlet. A valve member may be mounted within the housing. The injection device may be configured such that fluid pressures at the inlet and reference pressure port act to cause said valve member to move within the housing to vary flow between the inlet and the outlet. In some embodiments the injection device may include a sealing arrangement which permits pressures at 35 the inlet and reference pressure port to move the valve member. Such a sealing arrangement may optionally function to control the effect of fluid pressure at the outlet acting on the valve member. In some embodiments the sealing arrangement may optionally function to substantially eliminate the effect of fluid pressure at the outlet acting on the valve member.

40 [0019] Aspects of the present invention also relate to a method for injecting a fluid into a target location. Such a method may comprise communicating an inlet of an injection device to a source of injection fluid, and communicating an outlet of the injection device to a target location. The method may further comprise permitting a valve member mounted within the injection device to be moved by action of pressure at the inlet of the device and by pressure acting at a reference port of the device which is isolated from the outlet. Such movement of the valve member may function to vary flow between the inlet and the outlet

45 [0020] Such an injection device and method seeks to address certain unforeseen problems and observations which are contrary to expectation in injection processes. In this respect, through diligent investigations and research the present inventor has discovered certain reasons for such observations and problems. For example, in some cases problems in known injection valves may be attributed to the fact that such valves function to modify valve inlet pressure based almost exclusively on the valve outlet pressure, which is understood to be largely equal to the pressure at the injection location, which in certain cases may be subject to large variations. Such problems may be mitigated in the present invention by permitting the valve member of the injection device to be moved by action of a fluid pressure provided at a reference pressure port which is isolated from the outlet of the housing. In certain embodiments the effect of outlet pressure may be substantially eliminated in the present invention.

50 [0021] As noted above, previously known injection valves principally operate by modifying valve inlet pressure based on valve outlet pressure. As such, in the event of a variation in outlet pressure, inlet pressure should be varied accordingly. However, in some instances an unexpected surge of flow through the valve occurs when the outlet pressure varies. The present inventor has attributed this observation to the compressibility of the fluid being injected, and in particular to the requirement for a volumetric change in a fluid to occur in the event of a pressure change.

[0022] More specifically, fluids are often considered to be incompressible. This, however, is only true to a limited extent and when high pressures are applied to fluids they do compress. Therefore if the pressure of an injection fluid at the inlet of a valve is required to fall, for example, a volume of fluid must be dissipated in order for this to occur. The valve inlet will be coupled to a source of injection fluid, and in some cases extremely long injection conduits will be utilised for this purpose, for example in downhole applications. As such, the volume of the injection fluid within an injection conduit may be significant, such that the volume of fluid to be dissipated in order to permit the pressure fall may also be significant. This fluid can only be dissipated through the injection valve. No matter how efficient the injection valve is at maintaining a differential pressure and tracking a change in outlet pressures, the valve will have to dissipate this volume of fluid to accommodate the fall in inlet pressure. It has been found the volumes of fluid that require dissipation due to pressure fall, for example, as may be found as a pump, such as an electric submersible pump (ESP), is activated to reduce pressure presented to an injection valve or device outlet, are more than is often thought.

[0023] Conversely, it has been observed that following the dissipation of fluid in the injection line, as ESP inlet pressure falls, the ESP inlet pressure may then be seen to rise. In order to facilitate a continuing delivery of chemical through the injection valve, its inlet pressure must be increased. As fluid is delivered to increase inject line pressure flow is consumed by the fluid compressibility and enlargement of the injection line, thus causing a cessation or reduction of fluid flow through the injection valve. Thus creating a fall in flow following a surge of flow. This can lead to a cyclic repetition of a rise and surge of flow followed by a fall and loss of flow.

[0024] Although a general situation has been suggested above in which pressure variations occur at a target location by use of an ESP, this may not always be the case, and such pressure variations may occur due to many reasons.

[0025] In addition to the compressibility of the fluid, any associated injection conduit may enlarge under internal pressure. This means its internal volume will increase thus requiring more fluid to be introduced in order to reach a required pressure. Therefore in order for the injection conduit to fall in pressure the volume of fluid entrained at its starting pressure must be fully dissipated in order to reach a lower pressure. This fluid volume dissipation therefore results in a significant rise, or surge of flow through the injection valve as the inlet pressure falls.

[0026] According to a first aspect of the present invention there is provided an injection device for use in injecting a fluid into a target location, comprising:

a housing defining an inlet for communicating with a source of injection fluid, an outlet for communicating with a target injection location, and a separate reference port for communicating with a reference pressure source;

a first valve member mounted within the housing;

a second valve member mounted within the housing and defining a flow path therethrough to facilitate fluid communication between the inlet and outlet of the housing; and

a sealing arrangement provided between the second valve member and the housing and configured such that fluid pressure at the housing inlet and housing reference port apply a force on the second valve member to cause said second valve member to move relative to the first valve member and vary flow between the inlet and the outlet.

[0027] In use, the effect of the reference pressure acting on the sealing arrangement may contribute to movement of the second valve member. As such, the effect of the reference pressure may function to control movement of the second valve member and thus control flow through the valve. Such an arrangement may permit the second valve member to be controlled without reliance, or with a reduced reliance, on pressure at the housing outlet, which may be substantially equivalent to pressure at the target injection location, as is the case in prior art devices.

[0028] The sealing arrangement may be configured to substantially confine any flow between the inlet and the outlet to the flow path of the second valve member. That is, the sealing arrangement may be such that flow between the inlet and outlet of the housing may only be achieved through the flow path of the second valve member.

[0029] For the purposes of clarity, pressure acting at the inlet of the housing may be defined as inlet pressure, pressure acting at the outlet of the housing may be defined as outlet pressure, and pressure acting at the reference pressure port may be defined as reference pressure.

[0030] The sealing arrangement may be directly mounted between the second valve member and the housing. For example, the sealing arrangement may directly engage the second valve member and the housing.

[0031] The sealing arrangement may be indirectly mounted between the second valve member and the housing. For example, the sealing arrangement may indirectly engage at least one of the second valve member and the housing. In one embodiment an intermediate component may be provided between the sealing arrangement and at least one of the second valve member and the housing.

[0032] A portion of the sealing arrangement may be in communication with the inlet of the housing such that inlet pressure may establish a force on the second valve member in a first direction. A portion of the sealing arrangement may be in communication with the reference pressure port of the housing such that reference pressure may establish a force on the second valve member in a second direction. The second direction may be opposite to the first direction. In such an arrangement the forces generated by the effect of pressures at the inlet and reference pressure port may

result in a net movement of the second valve member to thus vary flow between the inlet and the outlet.

[0033] The sealing arrangement may be configured such that movement of the second valve member is achieved in accordance with a pressure differential between inlet and reference pressures. The sealing arrangement may be configured to establish a preferential bias of forces applied by action of inlet and reference pressures.

[0034] The sealing arrangement may define a sealing area between the second valve member and the housing. The sealing area may determine the magnitude of a force applied on the second valve member upon exposure to various pressures.

[0035] In one embodiment the sealing arrangement may define an inlet sealing area configured to be exposed to inlet pressure, and a reference sealing area configured to be exposed to reference pressure. A ratio of the inlet and reference sealing areas may affect a net force generated on the second valve member by the inlet and reference pressures.

[0036] The inlet and reference sealing areas may be substantially equal. In such an arrangement a net force applied on the second valve member may be a function of a pressure differential between the inlet and reference pressures.

[0037] The inlet and reference sealing areas may be different. In such an arrangement a force bias on the second valve member may be applied by the sealing arrangement by action of the inlet and reference pressures. That is, a net force applied on the second valve member may be a function of both a differential of inlet and reference sealing areas and a differential between the inlet and reference pressures.

[0038] The injection device may be configured such that inlet pressure establishes a force on the valve member to cause said valve member to move in a direction to increase flow, for example initiate flow, between the inlet and the outlet of the housing. The injection device may be configured such that reference pressure establishes a force on the valve member to cause said valve member to move in a direction to decrease flow, for example to prevent flow, between the inlet and the outlet of the housing.

[0039] A portion of the sealing arrangement may be in communication with the outlet of the housing. The sealing arrangement may be configured to control the effect of the outlet pressure on the second valve member.

[0040] In one embodiment the sealing arrangement may be configured to substantially eliminate the effect of outlet pressure on the valve member. In such an embodiment the sealing arrangement may be configured such that the effect of outlet pressure does not establish or significantly minimises any net force on the second valve member. Such an arrangement may remove or eliminate any reliance on outlet pressure to control movement of the second valve member. This may contribute to addressing problems associated with prior art devices where variations in outlet pressure may have a detrimental effect on operation of the injection device.

[0041] The sealing arrangement may be configured such that outlet pressure may establish first and second substantially equal and opposite forces on the second valve member, such that any net force is substantially minimised.

[0042] The sealing arrangement may be configured such to permit the outlet pressure to provide a desired bias force on the second valve member. In such an arrangement any effect of outlet pressure may be utilised in a desired way, for example to bias the second valve member to move in a desired direction.

[0043] The sealing arrangement may define first and second outlet sealing areas between the second valve member and the housing, wherein each of the first and second outlet sealing areas is configured to be exposed to outlet pressure. The first and second sealing areas may be configured to permit outlet pressure to generate a force on the second valve member in opposite directions.

[0044] In one embodiment the first and second outlet sealing areas may be substantially equal. In such an arrangement the effect of outlet pressure acting on the first and second outlet areas may be cancelled out, such that no or minimal net force is applied on the second valve member by outlet pressure.

[0045] In one embodiment the first and second outlet sealing areas may be different. In such an arrangement the effect of the same outlet pressure acting on the first and second outlet areas may present a net force acting in one direction, and thus the outlet pressure may act to apply this bias force on the second valve member in this one direction.

[0046] The sealing arrangement may comprise one or more seal members. The sealing arrangement may comprise one or more of sliding seal members, o-rings, bellows seals, diaphragm seals piston rings or the like.

[0047] The sealing arrangement may include first and second seal assemblies which extend between the second valve member and the housing.

[0048] The first seal assembly may comprise one or more seal members.

[0049] The second seal assembly may comprise one or more seal members.

[0050] The first seal assembly may be configured to isolate the housing inlet from the housing outlet, such that fluid communication between the inlet and the outlet is permitted only through the flow path in the second valve member.

[0051] The second seal assembly may be configured to isolate the housing outlet from the housing reference port.

[0052] The first seal assembly may define an inlet sealing area configured to be exposed to inlet pressure.

[0053] The first seal assembly may define a first outlet sealing area configured to be exposed to outlet pressure.

[0054] The second seal assembly may define a reference sealing area configured to be exposed to reference pressure.

[0055] The second seal assembly may define a second outlet sealing area configured to be exposed to outlet pressure.

[0056] The inlet, reference and first and second outlet sealing areas may be as defined above.

[0057] The device may comprise a biasing arrangement configured to bias the second valve member in a desired direction. The biasing arrangement may be configured to bias the second valve member to move in a direction to decrease flow between the inlet and the outlet, for example to close the injection device. The biasing arrangement may be selected to provide a desired biasing force.

[0058] The second valve member may be configured to be actuated to move in a direction to decrease flow by a combination of biasing force from a biasing arrangement and the action of reference pressure. The second valve member may be configured to be actuated to move in a direction to increase flow by the action of inlet pressure.

[0059] The biasing arrangement may be configured to establish a force on the second valve member to permit a desired pressure differential within the injection device to be achieved. For example, the biasing arrangement may permit or require the injection pressure to be maintained at a fixed pressure differential above the reference pressure, by a magnitude associated with the force applied by the biasing arrangement.

[0060] The biasing arrangement may comprise one or more springs, such as a coil spring, wave spring, flat spring, disk spring, Belleville spring or the like. The biasing arrangement may comprise a deformable member capable of elastic recovery, such as an elastic body subject to deformation, for example compression.

[0061] The biasing arrangement may be adjustable.

[0062] The second valve member may comprise a profile to permit engagement with the biasing arrangement, such as an annular rib, one or more pins, or the like. The biasing arrangement may directly engage the second valve member. The biasing arrangement may indirectly engage the second valve member, for example via an intermediate component such as a plate member or the like.

[0063] The injection device may be configured for use in any application, such as in any application where a fluid is required to be injected into a target location, such as in the oil and gas industry, chemical processing industry, manufacturing industry or the like.

[0064] The injection device may be configured for use in injection into a wellbore target location. The target location may be associated with wellbore equipment or infrastructure. The target location may be associated with downhole tubing or equipment, such as production tubing, casing or liner tubing, drill pipe, coiled tubing or the like.

[0065] The injection device may be configured for use in injection into a separate flow line. Such a separate flowline may include a pressure varying device, such as a pump assembly, for example an electric submersible pump (ESP) assembly. In one embodiment the injection device may be configured for use in injection of a fluid into a flow line at a location which is upstream of a pressure varying device. In such an arrangement the target injection location may be located on an inlet side of such a pressure varying device, and as such the target location may be subject to pressure variations established by operation of the pressure varying device. Thus, the injection device of the present invention may assist to minimise any detrimental effect by virtue of the variations at the target injection location.

[0066] The inlet fluid pressure at the inlet of the housing may be at least partially defined by fluid pressure within an associated injection line and/or an associated source of injection fluid. The outlet fluid pressure may be at least partially defined by fluid pressure at an associated target location.

[0067] The reference pressure may be selected to be any desired pressure. In some embodiments the reference pressure may be selected to be lower than the inlet pressure.

[0068] The reference pressure may be configured to define a minimal pressure, such as atmospheric or less than atmospheric. Such an arrangement may minimise the effect of the reference pressure of applying a force on the second valve member. This arrangement may be selected when, for example, the effect of the outlet pressure is minimised or negated by the form of the sealing arrangement, such that variation in flow through the injection device is controlled largely by inlet pressure, and the presence of any associated biasing arrangement acting on the second valve member.

[0069] The reference pressure port may be configured for communication with any desired source of reference pressure. The source of reference pressure may exclude the target location. Such exclusion of the target location may minimise reliance on the outlet pressure or target location pressure on operation of the device. This may assist to minimise any effects of volumetric expansion, or even contraction, of fluid positioned on the inlet side of the housing, for example within an associated injection line.

[0070] The reference pressure port may be configured for communication with a local source of reference pressure. In one embodiment the reference pressure port may be configured for communication with a source of reference pressure which is incorporated within the injection device, for example formed within the housing of the injection device. Such a local source of reference pressure may be configured to provide a fixed reference pressure. In some embodiments a local source of reference pressure may be variable.

[0071] The reference pressure port may be configured for communication with a source of reference pressure at a remote location. In some embodiments where the injection device is utilised for injection into a downhole target location, the source of reference pressure may be provided at surface level and/or at a separate downhole location.

[0072] In one embodiment the outlet of the housing is configured to communicate with a target location which is positioned on one side of a pressure varying device, and the reference pressure port is configured to communicate with a location which is positioned on an opposite side of the pressure varying device. The pressure varying device may

comprise a pump, such as an ESP. The pressure varying device may comprise a choke.

[0073] In one embodiment the outlet of the housing is configured to communicate with an inlet of a pump assembly, and the reference pressure port is configured to communicate with an outlet of the same pump assembly. Such an arrangement may be utilised where the pump assembly is used within a wellbore, such as to provide artificial lift to produced fluid, to pressurise fluids for injection into a surrounding formation or the like. In such an arrangement, the effect of any significant pressure variation, in particular a significant pressure decrease, experienced at the reference pressure port (i.e., the pump outlet) is minimised, and as such the effect of possible volumetric expansion or the like within fluid located on the inlet side of the injection device is also minimised.

[0074] The reference pressure applied at the reference pressure port may be user variable. Such an arrangement may permit a user to tune or vary the use of the injection device to accommodate particular operation conditions, such as the density of the fluid being injected and the like.

[0075] The first and second valve members may cooperate to define a restriction to flow. This may establish a back pressure in the inlet side assisting to maintain the inlet pressure above the outlet pressure. This arrangement may assist to prevent hydrostatic fall-through of an injection fluid. The degree of separation between the first and second valve members may be adjustable to adjust the restriction to flow. The degree of separation may be adjusted automatically to maintain the inlet pressure above outlet pressure. Such automatic adjustment may be achieved by the desire for the injection device to continuously satisfy force equilibrium. In such a case force equilibrium may permit the desired pressure differential to be maintained.

[0076] The first and second valve members may be engageable. Such engagement may permit the first valve member to seal the flow path in the second valve member. The second valve member may be moveable within the housing to become separated from the first valve member, to thus permit flow through the flow path. The degree of separation between the first and second valve members may define a restriction to flow through the injection device, which may function to define a back-pressure within the inlet side of the injection device.

[0077] The first valve member may be fixed relative to the housing, such that movement of the second valve member is required to vary flow.

[0078] The first valve member may be defined by an integral part of the housing.

[0079] The first valve member may be defined by a component which is separate from the housing. The first valve member may be permitted to move within the housing. Permitting both the first and second valve members to move within the housing may provide advantages in terms of improving sealing between the first and second valve members when engaged. For example, when engaged the first valve member may be biased against the second member by inlet fluid pressure to assist sealing therebetween.

[0080] The use of inlet pressure to assist sealing may permit improved sealing to be achieved upon engagement of the first and second valve members minimising the risk of leakage therebetween. This in turn may, in some applications, minimise the possibility of an associated injection line in communication with the housing inlet being exposed to vacuum or negative pressure conditions, for example due to hydrostatic fall-through.

[0081] The second valve member may be configured to support the first valve member when engaged therewith. In such an arrangement movement of the second valve member when engaged with the first valve member will result in movement of both members. This arrangement may permit the valve members to retain the flow path in the second valve member closed in the event of such collective movement of the valve members. This may assist to regulate or minimise the effects of spurious or undesired pressure fluctuations which may otherwise cause inadvertent disengagement of the members. Such undesired pressure fluctuations may be transitory or fleeting and not intended to represent operational pressure fluctuations. For example, transitory pressure fluctuations may be created by flow surges.

[0082] The first valve member may be located on the inlet side of the second valve member.

[0083] Each valve member may define an engagement surface configured to be mutually engaged to prevent flow through the injection device. Each engagement surface may define a sealing surface.

[0084] The first and second valve members may define a seal area at the region of engagement. When the first and second valve members are engaged inlet fluid pressure may act on one side, which may be defined as an upstream side of the seal area. The bias force acting on the first valve member may therefore be a function of the seal area and the inlet pressure. Outlet fluid pressure may act on an opposite side of the seal area, which may be defined as a downstream side. The outlet pressure may define a force acting on the first valve member which is a function of the seal area and the outlet pressure. In this arrangement the first valve assembly may be biased by the effect of a pressure differential between inlet and outlet pressures.

[0085] The apparatus may comprise a limiting arrangement configured to limit or restrict movement of the first valve member. The limiting arrangement may be configured to limit movement of the first valve member during opening of the valve assembly. The limiting arrangement may be arranged to limit movement of the first valve member at a point of limitation and permit the second valve member to move beyond the point of limitation and to become disengaged from the first valve member. The limiting arrangement may be fixed relative to the housing.

[0086] The limiting arrangement may comprise a tether.

[0087] The limiting arrangement may comprise a land region configured to be engaged by the first valve member when at a point of limitation.

[0088] The limiting arrangement may comprise a no-go. The limiting arrangement may comprise a shoulder arrangement. The limiting arrangement may comprise an elongate member. The elongate member may extend through the second valve member.

[0089] The first valve member may be biased by a biasing arrangement in a desired direction. The biasing arrangement associated with the first valve member may be configured to bias said member in a direction towards engagement with the second valve member. Such a biasing arrangement may assist sealing between the valve members when engaged. The biasing arrangement associated with the first valve member may comprise one or more springs, such as a coil spring, wave spring, flat spring or the like. The biasing arrangement may comprise a deformable member capable of elastic recovery, such as an elastic body subject to deformation, for example compression.

[0090] One of the first and second valve members may define a valve seat member and the other of the first and second members may define a valve body member. The valve seat member may define a valve seat which is engaged by the valve body member.

[0091] The valve body member may comprise a pin. The valve body member may comprise a ball. The valve body member may comprise a disk, plug, plunger or the like.

[0092] The injection device may comprise a pressure rated frangible arrangement configured to rupture upon exposure to a predetermined pressure. The frangible arrangement may be located within the housing. The frangible arrangement may be located on the inlet or upstream side of the second valve member. The frangible arrangement may be configured to isolate at least the second valve member from inlet pressure until required. The frangible arrangement may comprise a burst disk arrangement, rupture cartridge or the like.

[0093] The injection device may comprise a surge protection arrangement configured to provide protection against surging flow within or through the housing. Such surging flow may be caused by a particular pump duty cycle, rupturing of a frangible arrangement or the like. The surge protection arrangement may be configured to provide protection to the valve assembly. The surge protection arrangement may be located within the housing. The surge protection arrangement may be located on the inlet or upstream side of the second valve member.

[0094] The surge protection arrangement may comprise a component defining a flow path, wherein the flow path is restricted in the event of surging flow. The flow path may be restricted by being partially or fully closed. The surge protection arrangement may be biased towards a condition in which the flow path is open, and moved against said bias during surging flow. The magnitude of the bias may define the surge rating of the surge protection arrangement. The surge protection arrangement may comprise a spring configured to bias the surge protection arrangement towards a condition in which the flow path is open.

[0095] The injection device may comprise a filter arrangement configured to filter injection fluid. The filter arrangement may be mounted within the housing. The filter arrangement may be located on the inlet or upstream side of the second valve member.

[0096] The injection device may comprise at least one check valve configured to prevent flow through the injection device in a direction from the outlet to the inlet. Such an arrangement may eliminate the risk of flow reversal, for example in the event of outlet pressure exceeding inlet pressure. At least one check valve may be located on an outlet or downstream side of the second valve member. At least one check valve may be located on an inlet or upstream side of the second valve member. At least one check valve may be located within the second valve member, for example within the flow path of the second valve member. At least one check valve may be mounted within the housing of the injection device. At least one check valve may be provided separately and secured to the housing of the injection device, for example via a suitable conduit or the like.

[0097] The housing may be defined by a unitary component. The housing may be defined by multiple components coupled together.

[0098] The inlet and outlets of the housing may be arranged in-line with each other.

[0099] The inlet may be arranged on one end location of the housing and the outlet may be arranged on one side of the housing.

[0100] The injection device may form part of an injection system. The injection system may comprise multiple injection devices. At least one of the multiple injection devices may be provided in accordance with any aspect of the present invention. An injection device according to any aspect of the present invention may be used in combination with any other injection device. In one embodiment the injection device may be used in series with a further injection device. For example, two or more injection devices may be arranged in series within a common injection line.

[0101] At least an injection device which is arranged to communicate directly with a target location may be provided in accordance with the present invention. Such an injection device may be considered to be a final stage injection device. Other associated injection devices which are located upstream of a final stage injection device may or may not be provided in accordance with the present invention. For example, an injection device located upstream of a final stage injection device may modify inlet pressure to said upstream injection device based on outlet pressure of said injection

device.

[0102] Where multiple injection devices are arranged in series within an injection line, the devices may operate to divide any required pressure differential between the injection line and ultimate injection location into stages. This may reduce the required pressure drop across an individual injection device, which may provide advantages. For example, in some cases an injection fluid may have behavioural problems when passed over an injection device at a high differential pressure. Such problems may include cavitation, depositing of solids or a change in the state of the injection fluid, which may lead to reduced effectiveness, such as chemical effectiveness, of the injection fluid. Accordingly, by use of multiple injection devices arranged in series, the differential pressure presented across each device may be restricted or reduced, and in particular to levels which are advantageously lower than any threshold where problems may occur within the injection fluid. Such an advantageous use of more than one injection valve in series may also be achieved while still providing the effect of avoiding low, vacuum or near vacuum pressures within the injection line.

[0103] The injection device may be configured for use in combination with one or more other injection devices arranged in parallel. In such an arrangement multiple injection devices may be arranged for injection of a fluid from a common injection fluid source into multiple different locations.

[0104] The injection device may be configured to be coupled within fluid tubing. The injection device may be configured to be located at a downhole location. The injection device may be configured to be located within downhole tubing. The injection device may be configured to be located in an annulus surrounding downhole tubing. The injection device may be configured to be located within a pocket formed in downhole tubing. The injection device may be configured to be located at a subsea location. The injection device may be configured to be located at a surface location.

[0105] The injection device may be configured to be permanently installed within an injection system. The injection device may be configured to be temporarily installed within an injection system. In one embodiment the injection device may be configured to be deployed and/or retrieved by an elongate member, such as by wireline, coiled tubing or the like.

[0106] The injection device may be for use with any suitable injection fluid. Such an injection fluid may comprise a chemical. Such an injection fluid may comprise any one of, for example, a scale inhibitor, corrosion inhibitor, pH modified, viscosity modified, diluent, water, oil, acid or the like. It will be appreciated by those of skill in the art that any injection fluid may be utilised with the injection device of the present invention.

[0107] The injection device may be configured to inject a fluid into a subterranean formation, for example for sequestration of a fluid, to assist with production of fluids from the formation, to support the surrounding subterranean geology, or the like.

[0108] The injection device may be configured for use in injecting a fluid into any location of any flow line or flow process, such as at any location of a flow line extending from a subterranean formation to a surface location.

[0109] According to a second aspect of the present invention there is provided a method for injecting a fluid into a target location, comprising:

communicating an injection fluid to an inlet of a housing of an injection device;
 communicating an outlet of the housing to a target location;
 communicating a reference port of the housing to a source of reference pressure;
 causing a second valve member to move relative to a first valve member by exposure to pressure at the inlet of the housing and pressure at the reference pressure port of the housing, wherein such movement permits flow through a flow path of the valve member to be adjusted.

[0110] According to a third aspect of the present invention there is provided a pumping system comprising:

a flow line;
 a pump associated with the flow line and defining an inlet side and an outlet side;
 an injection device according to the first aspect, wherein the outlet of the injection device housing is in communication with the flow line on an inlet side of the pump.

[0111] In one embodiment the reference pressure port of the injection device housing may be in communication with the flow line on an outlet side of the pump.

[0112] The reference pressure port may be in communication with a remote source of reference pressure.

[0113] The reference pressure port may be in communication with a local source of reference pressure, for example provided by a pressure reservoir within the housing of the injection device.

[0114] According to an example not forming part of the claimed invention there is provided an injection device for injecting a fluid into a target location, comprising:

a housing defining an inlet for communicating with a source of injection fluid, an outlet for communicating with a target injection location, and a separate reference port for communicating with a reference pressure source which

excludes the target injection location;
 a valve member mounted within the housing and defining a flow path therethrough to facilitate fluid communication between the inlet and outlet of the housing, wherein the valve member is moveable within the housing by exposure to fluid pressure at the housing inlet and fluid pressure at the housing reference pressure port to vary flow between the inlet and the outlet.

[0115] According to an example not forming part of the claimed invention there is provided an injection device for use in injecting a fluid into a target location, comprising:

a housing including an inlet chamber for communicating with an injection line, an outlet chamber for communicating with a target location, and a reference chamber for communicating with a reference pressure source;
 a valve member mounted within the housing and defining a valve flow path to facilitate fluid communication between the inlet and outlet chambers;
 a first seal assembly provided between the valve member and the housing and isolating the inlet chamber from the outlet chamber such that a pressure differential between the inlet and outlet chambers acting over the first seal assembly will establish a force on the valve member; and
 a second seal assembly provided between the valve member and the housing and isolating the reference chamber from the outlet chamber such that a pressure differential between the reference chamber and the outlet chamber acting over the second seal assembly will establish a force on the valve member,
 wherein the valve member is permitted to move within the housing in accordance with the pressure forces applied via the first and second seal assemblies to vary flow through the valve flow path between the inlet and the outlet chambers.

[0116] According to an example not forming part of the claimed invention there is provided an injection system for injecting a fluid into a target location, comprising:

an injection line in communication with a source of injection fluid;
 an injection device coupled to the injection line and comprising:

a housing defining an inlet coupled to the injection line, an outlet for communicating with a target injection location, and a separate reference port for communicating with a reference pressure source;
 a first valve member mounted within the housing;
 a second valve member mounted within the housing and defining a flow path therethrough to facilitate fluid communication between the inlet and outlet of the housing; and
 a sealing arrangement provided between the second valve member and the housing and configured such that fluid pressure at the housing inlet and housing reference port apply a force on the second valve member to cause said second valve member to move relative to the first valve member and vary flow between the inlet and the outlet.

[0117] The injection device may define a first injection device and the injection system may comprise a second injection device located upstream of the first injection device. In such an arrangement the second injection device may comprise an outlet in communication with the inlet of the first injection device.

[0118] The provision of a second injection device within the injection system may permit a pressure differential between an injection line and a target location to be divided into stages, which may be advantageous in certain circumstances.

[0119] The second injection device may be configured similarly to the first injection device. For example, the second injection device may permit movement of an associated valve member by exposure to a reference pressure which is isolated from an outlet pressure.

[0120] The second injection device may be configured differently from the first injection device.

[0121] The second injection device may comprise a housing defining an inlet coupled to the injection line and an outlet for communicating with the inlet of the first injection device. The second injection device may comprise a first valve member mounted within the housing. The second injection device may comprise a second valve member mounted within the housing and defining a flow path therethrough to facilitate fluid communication between the inlet and outlet of the housing. The first and second valve members may move relative to each other to vary flow through the flow path of the second valve member, and thus also through the second injection device.

[0122] The second injection device may comprise a sealing arrangement provided between the second valve member and the housing and configured such that fluid pressure at the housing inlet and housing outlet may apply a force on the second valve member to cause said second valve member to move relative to the first valve member and vary flow between the inlet and the outlet.

[0123] According to an example not forming part of the claimed invention there is provided a method for creating an injection system, comprising:

5 determining a required pressure differential between an injection line and a target injection location which maintains the injection line at a positive pressure;
determining an operational threshold pressure differential of an injection fluid;
determining a required number of discrete pressure reduction stages within the injection line to provide the required pressure differential between the injection line and target location while maintaining each pressure reduction stage below the operational threshold pressure differential of the injection fluid; and
10 installing a number of injection devices within an injection line to correspond to the determined number of discrete pressure reduction stages.

[0124] In such an arrangement an injection line may be created which includes a number of injection devices to provide a required number of discrete pressure differentials each below the operational threshold pressure differential of an associated injection fluid, yet which collectively maintain the injection line in a positive pressure.

[0125] The injection devices may be located at any location along the length of the injection line.

[0126] The pressure within the injection line may be associated, at least partly, with hydrostatic pressure.

[0127] At least one injection device may be provided in accordance with any other aspect.

[0128] Other aspects may relate to the use of the injection device according to any previous aspect, for example in a wellbore injection system, in a downhole pumping system, or the like.

[0129] Other aspects may relate to a completion system for a wellbore, such as a wellbore associated with the exploration and production of hydrocarbons.

[0130] It should be understood that the features defined in relation to one aspect may be applied to any other aspect.

25 BRIEF DESCRIPTION OF THE DRAWINGS

[0131] These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

30 Figure 1 is a diagrammatic illustration of a typical wellbore system which includes injection capabilities;
Figure 2 is a diagrammatic representation of a known injection valve arrangement;
Figure 3 is a diagrammatic illustration of inlet and outlet pressure profiles of the injection valve of Figure 2;
Figure 4 graphically represents the effects of hydrostatic fall-through within a capillary or injection line;
Figure 5 provides an illustration of inlet and outlet pressure profiles of the injection device of Figure 2, with the use
35 of a more powerful spring;
Figures 6 and 7 illustrate, respectively, expected and actual pressure profiles of the inlet and outlet pressures of a downhole pump, and of the inlet pressure of an associate injection valve;
Figure 8 is a cross-sectional view of an injection device in accordance with one embodiment of the present invention;
Figure 9 is a cross-sectional view of an injection device in accordance with an alternative embodiment of the present
40 invention;
Figure 10 provides an exemplary pressure plot of the use of an injection device according to the present invention, in which a reference pressure from an outlet of a downhole pump is utilised;
Figure 11 provides an exemplary pressure plot of the use of an injection device according to the present invention, in which a reference pressure from a remote location, such as a surface location, is utilised;
45 Figure 12 is a cross-sectional view of an injection device according to an alternative embodiment of the present invention;
Figure 13 is an exemplary pressure plot of the use of the injection device of Figure 12;
Figures 14 to 18 are cross-sectional views of an injection device in accordance with respective alternative embodiments of the present invention;
50 Figure 19 is a diagrammatic representation of a downhole injection system in accordance with an embodiment of the present invention; and
Figure 20 is an exemplary pressure plot of the injection system of Figure 19.

55 DETAILED DESCRIPTION OF THE DRAWINGS

[0132] The present invention relates to an injection device which may be used in multiple applications. However, for exemplary purposes some specific embodiments of an injection device have been illustrated in the drawings, and described below, with a potential application within a wellbore system, such as a wellbore system for the extraction of

oil and/or gas form a subterranean reservoir.

[0133] Figure 1, which has also been described above, provides an illustration of a wellbore completion installation, generally identified by reference numeral 10, with injection capabilities via injection valve 48. A known injection valve 48 is illustrated in Figure 2, which has already been described above. Furthermore, it has been explained above that although with the use of such a known injection valve 48 the expected pressure behaviour within an injection system, which is reflected in Figure 6, may not actually be achieved, and in fact a more accurate representation of reality is provided in Figure 7. In this particular example, which involves the use of a downhole pump, such as an ESP 37 (Figure 7), upon activation the pump 37, inlet and outlet pressures might continue to fluctuate for extended periods, and may not reach a desired steady state condition. It is believed by the present inventor that such extended periods of fluctuation is caused by unsteady rates of injection via the injection valve 48 which is initiated by a sudden rush of injection fluid through the valve shortly after initial activation of the pump 37. Through diligent investigation and research performed by the present inventor it is considered that such a rush of fluid through the valve is caused by the compressibility of the injection fluid, as described below in detail. However, in general terms, the present inventor believes that as known injection valves require the valve inlet pressure to track above valve outlet pressure, then in the event of a relatively quick pressure change at the valve outlet, for example by activation of a pump, then the fluid in the injection line acting at the valve inlet will require to undergo a volumetric change to accommodate the required change in pressure. This volumetric change will cause the rush through the valve, and destabilise the system.

[0134] A common injection or capillary control line size currently used for chemical injection is 9.5 mm (3/8") OD tube. Also, many wells are completed with "deviation" where the well may be drilled off at progressive angles to increase its reach from a central commencement location. Therefore a well may possess a true vertical depth of, for example, 2000 metres but in fact be far more in its true deviated or Measured Depth (Md).

[0135] The normal internal volume of such a control line can be summarised at varying measured depths as follows:

	Capillary Line Length - metre			
Length - m	1000	2000	3000	4000
Volume - L	39.4	78.9	118.3	157.8

[0136] Fluids are often considered to be incompressible. This is only true to a limited extent and when high pressures are applied to fluids they do compress. This is a fluid property that is a function of the compressibility of the fluid which may also change with temperature and pressure.

[0137] Therefore if the capillary line 40 (Figure 1) is at a given pressure which then is required to fall, a volume of fluid must be dissipated in order for this to occur. This fluid can only be dissipated through the injection valve 48. No matter how efficient the injection valve 48 is at maintaining a differential pressure and tracks a change in outlet pressures, the valve will have to dissipate this volume of fluid to accommodate a change in capillary line pressure. It has been found the volumes of fluid that require dissipation are more than is often thought.

[0138] In addition to the compressibility of the fluid, the capillary line 40 itself will enlarge under internal pressure. This means its internal volume will increase thus requiring more fluid to be introduced in order to reach a required pressure. Therefore, in order for the capillary line 40 to fall in pressure the volume of fluid entrained at its starting pressure must be fully dissipated in order to reach a lower pressure. This fluid volume dissipation therefore results in a significant rise, or surge of flow through the injection valve 48 as the capillary line pressure falls.

[0139] This may occur as the ESP 37 is brought online causing the ESP inlet pressure and therefore the valve outlet pressure to fall. As the injection valve 48 attempts to maintain a fixed differential from its inlet to outlet it allows the increased flow to occur through itself. This rise in flow may be very significant and constitute a flow surge through the injection valve 48. This has another detrimental effect where the injection valve 48 can be overwhelmed and once the flow surge has passed the valve may fall in its resistance pressure and struggle to retrieve a fixed value above its outlet pressure. In doing this the capillary line 40 must gain in pressure before it can reach a value to overcome the valve resistance pressure and continue to flow again.

[0140] The flow may therefore fluctuate, starting with a flow spike followed by a fall in flow, a stop in flow and then a slow recovery of flow until flow is normalised again.

[0141] A significant consequence of this is that flow of chemical to the ESP 37 is not of a fixed value and is inconsistent. In this respect certain chemicals are used, called diluents, to reduce heavy oil viscosity or density to aid in production. A surge of chemical or diluent flow may overdose the chemical or diluent resulting in a lighter fluid for the ESP 37 to pump followed by a fall in chemical flow which increases fluid weight causing a reduction in ESP 37 pumping efficiency.

[0142] The ESP 37 therefore is seen to increase flow then suffer a reduction in efficiency. This is generally illustrated in Figure 7 in which the ESP outlet pressure 84 is seen to rise as its inlet 82 falls but then suffers a decrease in efficiency where its outlet 84 falls again as the inlet 82 rises while the injection valve pressure 86 is seen to track the ESP inlet

pressure 82. This is due to firstly the surge of chemical or diluent and then the fall in chemical or diluent flow.

[0143] Another effect of this variation in pressures due to the rise and fall of valve outlet pressure is that the surface injection pressure 90 (a fixed value above the valve outlet pressure by the valve resistance pressure minus the capillary line hydrostatic pressure) will also vary which could create loading on surface injection pump equipment 42.

[0144] The consequences of this cycling of load on the ESP 37 is considered to be, as a minimum, greatly interrupted and inconstant production, greater cycle load on the ESP 37 leading to reduced lifetime requiring the well be worked over to service the ESP 37, greater monitoring and a lack of understanding about the effectiveness of the chemical or diluent input leading to increased chemical or diluent input in attempts to counter the problem.

[0145] It is also possible that the surge effect through the injection valve 48 could cause damage to its ability to provide a back pressure. This could lead to a fall in resistance ultimately allowing a vacuum to occur in the control line 40 which itself creates risk of blockage, corrosion etc.

[0146] In view of such issues identified by, the inventor as developed an injection device which seeks to address these problems. An embodiment of such an injection device will now be described with reference to Figure 8.

[0147] The injection device, which is generally identified by reference numeral 100 includes a housing 102 defining an inlet 104, outlet 106 and a reference pressure port 108. The inlet 104 is configured to be in communication with a source of injection fluid 110, for example via an injection line (not shown). The outlet 106 is configured to be in communication with a target location 112, such as a downhole location. The reference pressure port 108 is configured to be in communication with a source of reference pressure 114.

[0148] The device 100 further includes a first valve member 116 which in the present embodiment is rigidly secured to the housing 102. A second valve member 118 is moveably mounted within the housing 102 and defines a flow path 120 extending therethrough to facilitate fluid communication between the inlet 104 and outlet 106. As will be described in further detail below, the second valve member 118 is permitted to move in accordance with inlet and reference pressures to vary flow between the inlet 104 and outlet 106.

[0149] The first and second valve members 116, 118 are configured to be engaged and define a sealed area 122 therebetween, such that when the first and second valve members 116, 118 are engaged flow through the flow path 120 is prevented. However, when the second valve member 118 is moved the valve members 116, 118 become disengaged such that flow is permitted. Also, when the first and second valve members 116, 118 are disengaged the gap defined therebetween may create a flow restriction and movement of the second valve member 118 may vary this flow restriction to assist to vary flow of injection fluid through the device 100.

[0150] The device 100 further comprises a biasing spring 101, in this case a coil spring, which acts on the second valve member 118 to bias this in an upward direction (relative to the orientation of Figure 8), towards engagement with the first valve member 116. Thus, spring 101 effectively operates to bias the second valve member 118 towards a closed position.

[0151] The device 100 further comprises a sealing arrangement 122 which includes first and second sealing assemblies 124, 126 extending between the second valve member 116 and the housing 102. The first sealing assembly 124 provides isolation between the inlet 104 and the outlet 106, such that flow between the inlet and outlet must be achieved via the flow path 120 in the second valve member 118. Further, the second sealing assembly 126 isolates the outlet 106 from the reference pressure port 108.

[0152] The first sealing assembly 124 is exposed to inlet fluid pressure, such that said inlet fluid pressure will establish a force on the second valve member 118 in a downward direction (relative to the orientation of Figure 8). Further, the second sealing assembly 126 is exposed to reference pressure such that said reference pressure will establish a force on the second valve member 118 in an upward direction (again, relative to the orientation of Figure 8). Accordingly, a net force will be applied on the second valve member 118 by the action of the inlet and reference pressures, and in particular in accordance with a pressure differential between the inlet and outlet pressures.

[0153] In the present embodiment the first and second sealing assemblies 124, 126 define equivalent seal areas, and as such there is no effect on any seal area differential, although in other embodiments such a seal area differential may be provided.

[0154] Furthermore, both the first and second sealing assemblies 124, 126 are exposed to outlet fluid pressure. Also, as the first and second sealing assemblies 124, 126 define equivalent seal areas then the effect of the outlet pressure will be cancelled, and no net force will be created by outlet pressure. It should be noted, however, that in other alternative embodiments a seal area differential may be provided to establish a bias force generated by outlet pressure.

[0155] Accordingly, in the present embodiment the outlet pressure, which will largely be defined by pressure at the target location 112, will not have any effect on the operation of the device 100. This may therefore avoid those problems identified above which stem from possible variations in outlet pressure resulting in a sudden surge through an injection device.

[0156] In use, for flow through the device 100 to be established, the force applied on the second valve member 118 by the inlet pressure must exceed to combined force applied by the reference pressure and the spring 101. In this way, the inlet pressure may be presented at a pressure which is greater than the reference pressure by the appropriate

equivalent pressure generated by the spring 101, in addition to any backpressure created by the restriction to flow between the first and second valve members 116, 118.

[0157] The device 100 may be used in conjunction with any desired source of reference pressure 114. In particular, the effects and advantages of the present invention may be achieved where the source of reference pressure 114 excludes the target location 112.

[0158] An alternative embodiment of an injection device, in this case generally identified by reference numeral 200, is shown in Figure 9, reference to which is now made. Device 200 is similar to device 100 of Figure 8, and as such like features share like reference numerals, incremented by 100. Further, the operation of the device 200 is largely similar to device 100, and as such only the difference in structure and operation will be described with reference to device 200.

[0159] In this respect device 200 also includes a housing 202 defining an inlet 204, outlet 206 and reference pressure port 208, with first and second valve members 216, 218 mounted within the housing 202. A sealing arrangement 222 comprising first and second sealing assemblies 224, 226 is positioned between the second valve member 218 and the housing, and functions, as before, to provide a desired force bias on the second valve member 218 by action of inlet and reference pressures.

[0160] In the present embodiment, however, the first valve member 216 is not rigidly secured to the housing 202, but is instead also permitted to move within the housing 202. In particular, the first valve member 216 is provided in the form of a pin which is mounted on a spring 130 which acts to bias said valve member 216 into engagement with the second valve member 218 to close the flow path 220 in said second valve member 218. Accordingly, when the first and second valve members 216, 218 are engaged, movement of the second valve member 218, for example by action of the various pressures and the second valve member bias spring 201, will also cause movement of the first valve member 216.

[0161] The housing 201 further comprises a limit arrangement in the form of an annular lip 132, and the second valve member 216 includes a corresponding circumferential rib 134. When the first and second valve members 216, are engaged, with the annular lip 132 and circumferential rib 134 disengaged, inlet fluid pressure will act over the seal area 222 between the engaged valve members 216, 218, which will have the effect of pressing said members together. This arrangement therefore permits inlet pressure to be utilised to improve the seal between the valve members when engaged.

[0162] However, when the appropriate pressure forces applied at the inlet is sufficient to move the second valve member downwardly, the circumferential rib 134 of the first valve member 216 will eventually engage the annular lip 132, such that continued downward movement of the second valve member 218 will cause disengagement of the valve members, thus establishing flow between the inlet 204 and outlet 206.

[0163] Also shown in the present embodiment is a check valve assembly 136 located at the outlet 206 of the housing, and which functions to prevent backflow from the target location 212 into the device. Although the check valve assembly 136 is shown mounted in an integrated part of the housing 202, a separate check valve assembly may instead be provided and secured relative to the outlet 206 of the housing 202.

[0164] As defined above, it is possible to use any desired source of reference pressure, perhaps with the exception of pressure at the target location. For example, in one exemplary use, the injection device may be used in the wellbore completion arrangement 10 first shown in Figure 1, reference to which is again made, wherein the injection valve 48 in Figure 1 may be replaced with the device according to any embodiment of the invention. In such an exemplary use the target location is on the inlet or suction side of an ESP 37. As noted above, problems have been discovered in prior art systems which also use this target location to vary the pressure within the associated injection line 40. However, in the present exemplary use the reference pressure may be provided from the outlet or delivery side of the ESP. A graphical representation of the various pressure profiles associated with such an exemplary use of the present invention is illustrated in Figure 10.

[0165] As illustrated, when a pump (where use) such as an ESP is activated the inlet pressure 140 will fall, and the outlet pressure 141 will rise. As the device utilises this outlet pressure 141 as a reference pressure, this results in the inlet pressure 143 of the device defines the same pressure profile, albeit at a differential higher provided by the effect of the spring acting against the second valve member in addition to the effect of any back pressure created by flow through the device. As illustrated also in Figure 10, the pressure differential 146 between the inlet and outlet of the device is no longer fixed, which differs from the prior art. Also, the surface pressure 146 defines a similar profile to that of the pump outlet pressure 142. As is clear from Figure 10, the pump is considered to reach a desired steady state condition, without any problems occurring due to cascading of fluid through the device.

[0166] In an alternative exemplary use, the device may be arranged such that the reference pressure is provided from a source, for example at surface level, which permits the reference pressure to be varied. The associated pressure profiles of an associated ESP and of the device is illustrated in Figure 11. In this respect, when the pump is activated the inlet pressure 150 falls. At this stage the reference pressure 151 is fixed at a first value, and as such the inlet pressure 152 of the device is initially constant at a first value, which will be a fixed differential above reference pressure 151. If at some point a change in reference pressure is required, for example due to a change in density of injection fluid, then this may be readily achieved, irrespective of the pump inlet pressure. In the exemplary embodiment the change involves an increase in reference pressure 151 (initiated around time interval 6), such that the inlet pressure 152 is seen to

increase to a second, higher level.

5 [0167] A further alternative embodiment of an injection device, in this case generally identified by reference numeral 300, is shown in Figure 12. Device 300 is similar to device 200 shown in Figure 9, and as such like features share like reference numerals, incremented by 100. For brevity, only differences between the embodiments in Figures 9 and 12 will be highlighted. In this respect, device 300 includes bellows type first and second sealing assemblies 324, 326 which form the sealing arrangement. Further, the device 300 comprises an integrated reference pressure reservoir 160 which contains an internal reference pressure which acts at the reference port 308. Thus, the second valve member 318 is affected by the pressure within this reservoir 160.

10 [0168] Further, the second valve member 318 includes a lower pin 142 which engages a plate 144, which in turn is acted on by the bias spring 301, which in this case is a disk spring, mounted within the reservoir 160.

[0169] In this present embodiment the device 300 does not necessarily require the presence of any external source of reference pressure, which may provide significant advantages in terms of permitting a simplified system to be utilised. Furthermore, in certain cases the pressure within the reservoir may define a minimal pressure, such that the effect of any active pressure is essentially negligible, such that any force applied to move the second valve member 318 upwardly is achieved primarily by the spring 301.

15 [0170] A pressure plot associated with the device 300 of Figure 12 is shown in Figure 13, in this case again assuming that the device is arranged to inject a fluid into the inlet side of an ESP, such as ESP 37 of Figure 1. Referring to Figure 13, as a pump (where used) such as an ESP is activated pump inlet pressure 162 falls. However, as the reference pressure within reservoir 160 is constant, a constant valve inlet pressure 164 and surface pressure 166 will be achieved, with the pressure differential 168 between the device inlet 304 and outlet 306 varying.

20 [0171] An injection device according to the present invention may be embodied in a number of ways, and a selection of further example embodiments are presented in Figures 14 to 18, reference to which will now be made. For brevity only particular differences between the embodiments will be identified.

25 [0172] Injection device 400 of Figure 14 is generally similar to device 200 of Figure 9, and as such like features share like reference numerals, incremented by 200. Device 400 includes bellows type sealing assemblies 424, 426 which form the sealing arrangement 422.

[0173] Injection device 500 of Figure 15 is generally similar to device 200 of Figure 9, and as such like features share like reference numerals, incremented by 300. Device 500 includes bellows sealing assemblies 524, 526 which form the sealing arrangement 522. Further, the second valve member 516 includes an extension pin 170 which is engaged by a plate 172 which in turn is engaged by bias spring 501.

30 [0174] Injection device 600 of Figure 16 is generally similar to device 200 of Figure 9, and as such like features share like reference numerals, incremented by 400. Device 600 includes bellows sealing assemblies 624, 626 which form the sealing arrangement 622. Further, the second valve member 616 includes an extension pin 174 which is engaged by a plate 176 which in turn is engaged by bias spring 601.

35 [0175] Furthermore, the second valve member 616 includes a ball member which cooperates with the second valve member 618. A support stalk 178 extends through the flow path 620 of the second valve member 618 and functions to limit movement of the ball of the first valve member 616.

40 [0176] Injection device 700 of Figure 17 is generally similar to device 300 of Figure 12, and as such like features share like reference numerals, incremented by 400. In this embodiment the first valve member 716 includes a profiled pin 180 which extends upwardly therefrom and is received within an annular chamber 182. The pin 180 and chamber 182 cooperate to limit movement of the second valve member 716 to permit disengagement from the second valve member 718.

45 [0177] Injection device 800 of Figure 18 is generally similar to device 300 of Figure 12, and as such like features share like reference numerals, incremented by 500. In device 800 the outlet 806 is provided inline with the inlet 804. This is achieved by providing a flow path 186 around the reservoir chamber 660. Further, device 800 includes a check valve assembly 190 in communication with the outlet 806.

50 [0178] In some cases the required differential resistance pressure required where an ESP is set to a very high Total Vertical Depth (TVD) and the ESP will draw to extremely low pressures may be very high. This is by way of a capillary line hydrostatic being large due to the great depth (TVD) and the ESP drawing to an exceptionally low pressure for the purposes of enhanced production, for example. In such cases the fluid being injected may have behavioural problems when passed over the injection device at a high differential pressure. Such problems may include cavitation, depositing of solids or a change in the state of the injection fluid which may lead to reduced effectiveness, such as chemical effectiveness.

55 [0179] The present inventor therefore considers it to be desirable that in some situations a differential pressure be reduced to levels that are under the thresholds where such issues may occur with the injection fluid. This reduction in differential pressure, however, may not be readily achieved in conventional prior art systems as the requirement still exists that the overall resistance within the injection device must be large enough to ensure there is no vacuum in the capillary injection line.

EP 2 893 126 B1

[0180] To address this, an injection device according to the present invention (such as in any embodiment described above) may be installed at a lower point of injection but in addition to this a second (or third etc.) injection valve may be installed at a higher point in the injection line, for example at any higher point in the injection line. Such an arrangement is illustrated in Figure 19, reference to which is now made. In this respect, Figure 19 provides a diagrammatic illustration of a wellbore system, generally identified by reference numeral 910, which includes injection capabilities and is largely similar to the system 10 of Figure 1. As such, like features share like reference numerals incremented by 900. Thus, wellbore system 910 includes a casing string 912 located within a drilled bore 914 which extends from surface 916 to intercept a hydrocarbon bearing formation 918. A lower annulus area 920 may be filled with cement 922 for purposes of support and sealing. A production tubing string 924 extends from a wellhead 926 and production tree 928. A lower end of the production tubing string 924 is sealed against the casing 912 with a production packer 930 to isolate a producing zone 932. A number of perforations 934 are established through the casing 912 and cement 922 to establish fluid communication between the casing 912 and the formation 918. Hydrocarbons may then be permitted to flow into the casing 912 at the producing zone 932 and then into the production tubing 924 via inlet 936 to be produced to surface. Artificial lift equipment, such as an ESP 937 may optionally be installed inline with the production tubing 924 as part of the completion to assist production to surface. The production tree 928 may provide the necessary pressure barriers and provides a production outlet 938 from which produced hydrocarbons may be delivered to a production facility (not shown), for example.

[0181] A small bore injection line or conduit 940, which is often referred to as a capillary line, runs alongside the production tubing 924 from a surface located injection fluid source 942 to a downhole target location, which in the illustrated example is a lower end of the production tubing 924, below the ESP 937. The production tubing 924 may include an optional injection mandrel 944. An injection pump 946 is located at a topside location to facilitate injection of the injection fluid 942.

[0182] A first injection valve 948 is located at the lower end of the injection line 940 in proximity to the location of injection. This injection valve 948 may be provided in accordance with any embodiment of the present invention. A second injection valve 949 is coupled to the injection line 940 at a location which is upstream of the first injection valve 948. The second injection valve 949 may be provided in accordance with any embodiment of the present invention. The second injection valve 949 may be provided in accordance with any known or conventional injection valve, such as a conventional backpressure injection valve which may modify its inlet pressure based on its outlet pressure.

[0183] With the example arrangement shown in Figure 19, the overall required differential pressure may be broken into two stages, thus ensuring that the differential pressure occurring at any one of the injection valves 948, 949 is reduced ensuring the injection fluid is not subjected to high shear rates through the device under high differential pressures.

[0184] This installation mode may be generally illustrated in the below example where a very high setting depth (TVD) is required for the ESP 937 which is intended to run at a very low intake pressure. The injection line 940 is installed with a conventional back pressure injection device (the second injection device 949) at approximately 50% of its TVD and an injection device (the first injection device 948) at the ESP intake depth (full TVD). If a single back pressure device is used it would be required to have a minimum back pressure resistance of 314 bar. However, if we assume in the present illustration that the injection fluid has been found to suffer degradation of properties if passed through a differential of more than 180 bar, then this required pressure differential of 314 bar will have an adverse effect on the injection fluid. Therefore two stages are employed with an upper device 949 and a lower device 948.

[0185] A process of designing or selecting the form of an appropriate injection system in the present illustration is set out in the table below:

Total Vertical Capillary Line Height (TVD) - metres	3050
<i>Determine Capillary Hydrostatic Pressure</i>	
Specific Gravity of Injected Fluid	1.050
Density of Fluid - kg/m ³	1050.00
TOTAL Capillary Line Hydrostatic pressure - bar	314.2
<i>Identify Chemical Differential Limitations</i>	
Maximum Allowable Differential - bar	180.0
Is Allowable Dp greater than required Dp ?	NO
Required Stages of Resistance	2

EP 2 893 126 B1

(continued)

5
10
15
20

<i>Determine Upper and Lower Stage Conditions</i>	
Minimum ESP Inlet Pressure - bar	86.0
Lower Device Resistance Pressure - bar	150.0
Lower Device Inlet Pressure - bar	236.0
Installation Depth of Upper Stage (TVD) - metre	1480.0
% of Overall TVD for Installation of Upper Stage - %	49%
Capillary line height from lower to upper stage (TVD) - m	1570.0
Hydrostatic Pressure in line from lower to upper Stage - bar	161.8
Upper Stage Device outlet Pressure - bar	74.2
Upper Device Resistance Pressure - bar	100.0
Upper Device Inlet Pressure - bar	174.2
Hydrostatic Pressure in line from upper Stage to Surface - bar	152.5
Surface Injection Pressure - bar	21.8

25

[0186] Although in the example above the upper device is located at approximately 50% of the TVD, this is only exemplary, and any suitable depth may be utilised. This is illustrated in the further example below, in which the upper device is located at an further example depth of 71% of TVD.

30
35
40
45

<i>Determine Upper and Lower Stage Conditions</i>	
Minimum ESP Inlet Pressure - bar	86.0
Lower Device Resistance Pressure - bar	150.0
Lower Device Inlet Pressure - bar	236.0
Installation Depth of Upper Stage (TVD) - metre	2180.0
% of Overall TVD for Installation of Upper Stage - %	71%
Capillary line height from lower to upper stage (TVD) - m	870.0
Hydrostatic Pressure in line from lower to upper Stage - bar	89.6
Upper Stage Device outlet Pressure - bar	146.4
Upper Device Resistance Pressure - bar	100.0
Upper Device Inlet Pressure - bar	246.4
Hydrostatic Pressure in line from upper Stage to Surface - bar	224.6
Surface Injection Pressure - bar	21.8

50

[0187] Therefore by using two stages (upper and lower) each with appropriate differential settings of 100 and 150 bar respectively, the overall resistance is provided and the full injection line is maintained in a positive pressure thus avoiding vacuum fall out conditions and ensuring the injection fluid is passed through differential pressures beneath its property change threshold of 180 bar.

55

[0188] The first example provided above may be further illustrated in Figure 20, which is a pressure plot along the length of the injection line showing the individual pressure drop effect of the first and second injection devices 948, 949.

[0189] It should be understood that the embodiments described herein are merely exemplary and that various modifications may be made thereto without departing from the scope of the invention. For example, various embodiments have been described above, and it should be recognised that further embodiments are possible in which the features of some of the illustrated embodiments may be applied to others. Thus, any combination of the illustrated features may be possible.

[0190] Further, in the example of Figure 19, any number of injection devices may be utilised to provide the desired

stages of pressure drop along the length of the injection line.

Claims

5

1. A downhole injection device (100) for use in injecting a fluid into a wellbore target location (112), comprising:

10

a housing (102) defining an inlet (104) for communicating with a source of injection fluid (110), an outlet (106) for communicating with a target injection location (112), and a separate reference port (108) for communicating with a reference pressure source (114);

15

a first valve member (116) mounted within the housing (102);

a second valve member (118) mounted within the housing (102) and defining a flow path (120) to facilitate fluid communication between the inlet (104) and outlet (106) of the housing (102), wherein the second valve member (118) is movably mounted within the housing (102) between an open position, wherein the first and second valve members (116, 118) are disengaged to facilitate fluid communication between the inlet (104) and the outlet (106) of the housing (102) through the flow path, and a closed position, wherein the first and second valve members (116, 118) are engaged, thereby preventing fluid communication between the inlet (104) and the outlet (106) of the housing through the flow path;

20

a biasing arrangement that acts upon the second valve member (118) to bias the second valve member (118) toward the closed position so as to decrease flow between the inlet (104) and the outlet (106); and

25

a sealing arrangement (122) provided between the second valve member (118) and the housing (102) and configured such that fluid pressure at the housing inlet (104) and housing reference port (108) apply a force on the second valve member (118) to cause said second valve member (118) to move relative to the first valve member (116) and vary flow between the inlet (104) and the outlet (106); wherein, to facilitate movement between the second valve member (118) and the first valve member (116), the fluid pressure at the housing inlet must exceed the combined force of the housing reference port pressure and the biasing arrangement, such that the position of the second valve member (118) is achieved in accordance with a pressure differential between inlet and reference pressures.

30

2. The downhole injection device (100) according to claim 1, wherein a portion of the sealing arrangement (122) is in communication with the inlet (104) of the housing (102) such that inlet pressure can establish a force on the second valve member (118) in a first direction, and a portion of the sealing arrangement (122) is in communication with the reference pressure port (108) of the housing (102) such that reference pressure can establish a force on the second valve member (118) in a second direction which is opposite to the first direction and/or wherein the sealing arrangement (122) is configured such that movement of the second valve member (118) is achieved in accordance with a pressure differential between inlet and reference pressures.

35

40

3. The downhole injection device (100) according to claim 1 or 2, wherein the sealing arrangement (122) defines an inlet sealing area configured to be exposed to inlet pressure, and a reference sealing area configured to be exposed to reference pressure, optionally wherein the inlet and reference sealing areas are substantially equal, or optionally wherein the inlet and reference sealing areas are different to establish a force bias on the second valve member by action of the inlet and reference pressures.

45

4. The downhole injection device (100) according to any preceding claim, wherein the downhole injection device (100) is configured such that inlet pressure establishes a force on the second valve member (118) to cause said second valve member (118) to move in a direction to increase flow and the reference pressure establishes a force on the second valve member (118) to cause said second valve member (118) to move in a direction to decrease flow.

50

5. The downhole injection device (100) according to any preceding claim, wherein a portion of the sealing arrangement (122) is in communication with the outlet (106) of the housing (102), optionally wherein the sealing arrangement (122) is configured to substantially eliminate the effect of outlet pressure on the second valve member (118) and/or wherein the sealing arrangement (122) is configured such that outlet pressure establishes first and second substantially equal and opposite forces on the second valve member (118), such that any net force is substantially minimised or optionally wherein the sealing arrangement (122) is configured such to permit the outlet pressure to provide a desired bias force on the second valve member (118).

55

6. The downhole injection device (100) according to any preceding claim, wherein the sealing arrangement (122) defines first and second outlet sealing areas between the second valve member (118) and the housing (102), and

each of the first and second outlet sealing areas is configured to be exposed to outlet pressure, optionally wherein the first and second sealing areas are configured to permit outlet pressure to generate a force on the second valve member (118) in opposite directions, optionally wherein the first and second outlet sealing areas are substantially equal or optionally wherein the first and second outlet sealing areas are different.

5

7. The downhole injection device (100) according to any preceding claim, wherein the sealing arrangement (122) includes first and second seal assemblies (124, 126) which extend between the second valve member (118) and the housing (102), optionally wherein each of the first and second seal assemblies (124, 126) comprise one or more seal members, optionally wherein the first seal assembly (124) isolates the housing inlet (104) from the housing outlet (106), such that fluid communication between the inlet (104) and the outlet (106) is directed through the flow path (120) in the second valve member, optionally wherein the second seal assembly (126) isolates the housing outlet (106) from the housing reference port (108) optionally wherein the first seal assembly (124) defines an inlet sealing area arranged in the device (100) to be exposed to inlet pressure, optionally wherein the first seal assembly (124) defines a first outlet sealing area arranged in the device (100) to be exposed to outlet pressure, optionally wherein the second seal assembly (126) defines a reference sealing area arranged in the device (100) to be exposed to reference pressure, optionally wherein the second seal assembly (126) defines a second outlet sealing area arranged in the device (100) to be exposed to outlet pressure.

10

15

20

8. The downhole injection device (100) according to any preceding claim, comprising a biasing arrangement configured to bias the second valve member (118) in a desired direction.

25

9. The downhole injection device (100) according to any preceding claim, wherein, in use, the inlet fluid pressure at the inlet (104) of the housing (102) is at least partially defined by fluid pressure within an associated injection line and/or an associated source of injection fluid (110), and the outlet fluid pressure is at least partially defined by fluid pressure at an associated wellbore target location (112) and/or wherein the reference pressure is atmospheric or less than atmospheric.

30

10. The downhole injection device (100) according to any preceding claim, wherein the reference pressure port (108) is configured for communication with a source of reference pressure (114), excluding reference pressure from the wellbore target location (112).

35

11. The downhole injection device (100) according to any preceding claim, wherein the outlet (106) of the housing (102) is configured to communicate with a wellbore target location (112) which is positioned on one side of a pressure varying device, and the reference pressure port (108) is configured to communicate with a location which is positioned on an opposite side of the pressure varying device, optionally wherein the pressure varying device comprises a pump.

40

12. The downhole injection device (100) according to any preceding claim, wherein the outlet (106) of the housing (102) is configured to communicate with an inlet of a pump assembly, and the reference pressure port (108) is configured to communicate with an outlet of the same pump assembly, and/or wherein reference pressure applied at the reference pressure port (108) is user variable.

45

13. The downhole injection device (100) according to any preceding claim, wherein the first valve member (116) is fixed relative to the housing (102), such that movement of the second valve member (118) is required to vary flow, or wherein the first valve member (116) is defined by a component which is separate from the housing (102), and said first valve member (116) is permitted to move within the housing (102).

14. A method for injecting a fluid into a wellbore target location (112), comprising:

50

communicating an injection fluid to an inlet (104) of a housing (102) of a downhole injection device (100) including a first valve member (116) and a second valve member (118);

biasing the second valve member (114) towards the first valve member (116);

communicating an outlet (106) of the housing (102) to a wellbore target location (112);

communicating a reference port (108) of the housing (102) to a source of reference pressure (114);

55

causing a second valve member (118) to move relative to a first valve member (116) by exposure to pressure at the inlet (104) of the housing (102), wherein such movement occurs only after overcoming a combined pressure of the biasing and pressure at the reference pressure port (108) of the housing (102), wherein such movement permits flow through a flow path (120) of the valve member (118) to be adjusted.

15. A pumping system comprising:

a flow line;
 a pump associated with the flow line and defining an inlet side and an outlet side;
 a downhole injection device (100) according to any one of claims 1 to 13,
 wherein the outlet (106) of the downhole injection device housing (102) is in communication with the flow line
 on an inlet side of the pump, wherein a reference pressure port of the injection device housing is in communication
 with the flow line on an outlet side of the pump.

Patentansprüche

1. Bohrlochinjektionsvorrichtung (100) zur Verwendung beim Injizieren eines Fluids in eine Bohrloch-Zielstelle (112),
 umfassend:

ein Gehäuse (102), das einen Einlass (104) zur Verbindung mit einer Injektionsfluidquelle (110), einen Auslass
 (106) zur Verbindung mit einer Zieleinspritzstelle (112) und einen separaten Referenzanschluss (108) zur Ver-
 bindung mit einer Referenzdruckquelle (114) festlegt;
 ein erstes Ventilelement (116), das innerhalb des Gehäuses (102) angebracht ist;
 ein zweites Ventilelement (118), das innerhalb des Gehäuses (102) angebracht ist und einen Strömungsweg
 (120) definiert, um eine Fluidverbindung zwischen dem Einlass (104) und dem Auslass (106) des Gehäuses
 (102) zu ermöglichen, wobei das zweite Ventilelement (118) innerhalb des Gehäuses (102) beweglich zwischen
 einer offenen Stellung, in der das erste und das zweite Ventilelement (116, 118) außer Eingriff sind, um eine
 Fluidverbindung zwischen dem Einlass (104) und dem Auslass (106) des Gehäuses (102) durch den Strö-
 mungsweg zu ermöglichen, und einer geschlossenen Stellung angebracht ist, in der das erste und das zweite
 Ventilelement (116, 118) in Eingriff sind, wodurch eine Fluidverbindung zwischen dem Einlass (104) und dem
 Auslass (106) des Gehäuses durch den Strömungsweg verhindert wird;
 eine Vorspannanordnung, die auf das zweite Ventilelement (118) wirkt, um das zweite Ventilelement (118) in
 Richtung der geschlossenen Stellung vorzuspannen, um einen Durchfluss zwischen dem Einlass (104) und
 dem Auslass (106) zu verringern; und
 eine Dichtungsanordnung (122), die zwischen dem zweiten Ventilelement (118) und dem Gehäuse (102) vor-
 handen und dazu eingerichtet ist, dass ein Fluiddruck am Gehäuseeinlass (104) und am Gehäusereferenzan-
 schluss (108) eine Kraft auf das zweite Ventilelement (118) ausübt, um das zweite Ventilelement (118) dazu
 zu veranlassen, sich relativ zum ersten Ventilelement (116) zu bewegen und einen Durchfluss zwischen dem
 Einlass (104) und dem Auslass (106) zu verändern, wobei zur Erleichterung einer Bewegung zwischen dem
 zweiten Ventilelement (118) und dem ersten Ventilelement (116) der Fluiddruck am Gehäuseeinlass die kom-
 binierte Kraft des Gehäusereferenzanschlusssdrucks und der Vorspannanordnung übersteigen muss, so dass
 die Stellung des zweiten Ventilelements (118) in Übereinstimmung mit einer Druckdifferenz zwischen Einlass-
 und Referenzdruck erreicht wird.

2. Bohrlochinjektionsvorrichtung (100) nach Anspruch 1, wobei ein Teil der Dichtungsanordnung (122) mit dem Einlass
 (104) des Gehäuses (102) solchermaßen in Verbindung steht, dass ein Einlassdruck eine Kraft auf das zweite
 Ventilelement (118) in einer ersten Richtung aufbauen kann, und ein Teil der Dichtungsanordnung (122) mit dem
 Referenzdruckanschluss (108) des Gehäuses (102) solchermaßen in Verbindung steht, dass ein Referenzdruck
 eine Kraft auf das zweite Ventilelement (118) in einer zweiten Richtung aufbauen kann, die der ersten Richtung
 entgegengesetzt ist, und/oder wobei die Dichtungsanordnung (122) so konfiguriert ist, dass eine Bewegung des
 zweiten Ventilelements (118) in Übereinstimmung mit einer Druckdifferenz zwischen Einlass- und Referenzdruck
 erreicht wird.

3. Bohrlochinjektionsvorrichtung (100) nach Anspruch 1 oder 2, wobei die Dichtungsanordnung (122) einen Einlass-
 dichtungsbereich, der dazu eingerichtet ist, einem Einlassdruck ausgesetzt zu sein, und einen Referenzdichtungs-
 bereich definiert, der dazu eingerichtet ist, einem Referenzdruck ausgesetzt zu sein, wobei optional der Einlass-
 und der Referenzdichtungsbereich im Wesentlichen gleich sind, oder wobei optional der Einlass- und der Referenz-
 dichtungsbereich unterschiedlich sind, um eine Kraftvorspannung auf das zweite Ventilelement durch eine Wirkung
 des Einlass- und des Referenzdrucks zu erzeugen.

4. Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei die Bohrlochinjektionsvor-
 richtung (100) dazu eingerichtet ist, dass der Einlassdruck eine Kraft auf das zweite Ventilelement (118) erzeugt,

um das zweite Ventilelement (118) dazu zu veranlassen, sich in eine Richtung zur Erhöhung des Durchflusses zu bewegen, und der Referenzdruck eine Kraft auf das zweite Ventilelement (118) erzeugt, um das zweite Ventilelement (118) dazu zu veranlassen, sich in eine Richtung zur Verringerung des Durchflusses zu bewegen.

- 5 **5.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei ein Teil der Dichtungsanordnung (122) mit dem Auslass (106) des Gehäuses (102) in Verbindung steht, wobei die Dichtungsanordnung (122) optional dazu eingerichtet ist, die Wirkung des Auslassdrucks auf das zweite Ventilelement (118) im Wesentlichen zu eliminieren, und/oder wobei die Dichtungsanordnung (122) dazu eingerichtet ist, dass der Auslassdruck eine erste und eine zweite im Wesentlichen gleichgroße und entgegengesetzte Kraft auf das zweite Ventilelement (118) ausübt, so dass jede Nettokraft im Wesentlichen minimiert ist, oder wobei optional die Dichtungsanordnung (122) dazu eingerichtet ist, dem Auslassdruck zu erlauben, eine gewünschte Vorspannkraft auf das zweite Ventilelement (118) auszuüben.
- 10
- 15 **6.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei die Dichtungsanordnung (122) erste und zweite Auslassdichtungsbereiche zwischen dem zweiten Ventilelement (118) und dem Gehäuse (102) definiert und jeder der ersten und zweiten Auslassdichtungsbereiche dazu eingerichtet ist, dem Auslassdruck ausgesetzt zu sein, wobei optional die ersten und zweiten Dichtungsbereiche dazu eingerichtet sind, dem Auslassdruck zu erlauben, eine Kraft auf das zweite Ventilelement (118) in entgegengesetzten Richtungen auszuüben, wobei optional die ersten und zweiten Auslassdichtungsbereiche im Wesentlichen gleich sind oder wobei optional die ersten und zweiten Auslassdichtungsbereiche unterschiedlich sind.
- 20
- 25 **7.** Bohrlochinjektionsgerät (100) nach einem der vorhergehenden Ansprüche, wobei die Dichtungsanordnung (122) erste und zweite Dichtungsbaugruppen (124, 126) umfasst, die sich zwischen dem zweiten Ventilelement (118) und dem Gehäuse (102) erstrecken, wobei optional jede der ersten und zweiten Dichtungsbaugruppen (124, 126) ein oder mehrere Dichtungselemente umfasst, wobei optional die erste Dichtungsbaugruppe (124) den Gehäuseeinlass (104) vom Gehäuseauslass (106) isoliert, so dass eine Fluidverbindung zwischen dem Einlass (104) und dem Auslass (106) durch den Strömungsweg (120) im zweiten Ventilelement geleitet wird, wobei optional die zweite Dichtungsbaugruppe (126) den Gehäuseauslass (106) vom Gehäusereferenzausschluss (108) isoliert, wobei optional die erste Dichtungsbaugruppe (124) einen Einlassdichtungsbereich definiert, der in der Vorrichtung (100) dazu angeordnet ist, dem Einlassdruck ausgesetzt zu sein, wobei optional die erste Dichtungsbaugruppe (124) einen ersten Auslassdichtungsbereich definiert, der in der Vorrichtung (100) dazu angeordnet ist, dem Auslassdruck ausgesetzt zu sein, wobei optional die zweite Dichtungsanordnung (126) einen Referenzdichtungsbereich definiert, der in der Vorrichtung (100) dazu angeordnet ist, einem Referenzdruck ausgesetzt zu sein, wobei optional die zweite Dichtungsanordnung (126) einen zweiten Auslassdichtungsbereich definiert, der in der Vorrichtung (100) dazu angeordnet ist, einem Auslassdruck ausgesetzt zu sein.
- 30
- 35 **8.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, umfassend eine Vorspannanordnung, die dazu eingerichtet ist, das zweite Ventilelement (118) in eine gewünschte Richtung vorzuspannen.
- 40 **9.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei im Gebrauch der Einlassfluiddruck am Einlass (104) des Gehäuses (102) zumindest teilweise durch einen Fluiddruck innerhalb einer zugehörigen Injektionsleitung und/oder einer zugehörigen Injektionsfluidquelle (110) definiert ist und der Auslassfluiddruck zumindest teilweise durch einen Fluiddruck an einem zugehörigen Bohrlochzielort (112) definiert ist und/oder wobei der Referenzdruck atmosphärisch oder geringer als atmosphärisch ist.
- 45 **10.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei der Referenzdruckanschluss (108) für eine Verbindung mit einer Referenzdruckquelle (114) konfiguriert ist, mit Ausnahme eines Referenzdrucks von der Bohrlochzielposition (112).
- 50 **11.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei der Auslass (106) des Gehäuses (102) dazu eingerichtet ist, mit einem Bohrlochzielort (112) in Verbindung zu stehen, der auf einer Seite einer Druckänderungsvorrichtung angeordnet ist, und der Referenzdruckanschluss (108) dazu eingerichtet ist, mit einem Ort in Verbindung zu stehen, der auf einer gegenüberliegenden Seite der Druckänderungsvorrichtung angeordnet ist, wobei die Druckänderungsvorrichtung optional eine Pumpe umfasst.
- 55 **12.** Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei der Auslass (106) des Gehäuses (102) dazu eingerichtet ist, mit einem Einlass einer Pumpenbaugruppe in Verbindung zu stehen, und der Referenzdruckanschluss (108) dazu eingerichtet ist, mit einem Auslass derselben Pumpenbaugruppe in Ver-

bindung zu stehen, und/oder wobei der am Referenzdruckanschluss (108) angelegte Referenzdruck vom Benutzer einstellbar ist.

5 13. Bohrlochinjektionsvorrichtung (100) nach einem der vorhergehenden Ansprüche, wobei das erste Ventilelement (116) relativ zum Gehäuse (102) fixiert ist, so dass eine Bewegung des zweiten Ventilelements (118) erforderlich ist, um den Durchfluss zu variieren, oder wobei das erste Ventilelement (116) durch ein vom Gehäuse (102) getrenntes Bauteil definiert ist und das erste Ventilelement (116) sich innerhalb des Gehäuses (102) bewegen kann.

10 14. Verfahren zum Einspritzen eines Fluids in einen Bohrlochzielort (112), umfassend:

Zuführen eines Injektionsfluids zu einem Einlass (104) eines Gehäuses (102) einer Bohrlochinjektionsvorrichtung (100), die ein erstes Ventilelement (116) und ein zweites Ventilelement (118) aufweist;
 Vorspannen des zweiten Ventilelements (118) in Richtung des ersten Ventilelements (116);
 15 Verbinden eines Auslasses (106) des Gehäuses (102) mit einem Bohrlochzielort (112);
 Verbinden eines Referenzanschlusses (108) des Gehäuses (102) mit einer Referenzdruckquelle (114);
 Veranlassen, dass sich ein zweites Ventilelement (118) relativ zu einem ersten Ventilelement (116) bewegt, indem es einem Druck am Einlass (104) des Gehäuses (102) ausgesetzt wird, wobei eine solche Bewegung nur nach Überwinden eines kombinierten Drucks der Vorspannung und des Drucks am Referenzdruckanschluss (108) des Gehäuses (102) auftritt, wobei eine solche Bewegung es ermöglicht, einen Durchfluss durch einen
 20 Strömungsweg (120) des Ventilelements (118) einzustellen.

15. Pumpsystem, umfassend:

eine Strömungsleitung;
 25 eine Pumpe, die mit der Strömungsleitung verbunden ist und eine Einlassseite und eine Auslassseite definiert;
 eine Bohrlochinjektionsvorrichtung (100) nach einem der Ansprüche 1 bis 13, wobei der Auslass (106) des Bohrlochinjektionsvorrichtungsgehäuses (102) mit der Strömungsleitung an einer Einlassseite der Pumpe in Verbindung steht, wobei ein Referenzdruckanschluss des Injektionsvorrichtungsgehäuses mit der Strömungsleitung an einer Auslassseite der Pumpe in Verbindung steht.
 30

Revendications

35 1. Dispositif d'injection de fond de trou (100) pour une utilisation dans l'injection d'un fluide dans un emplacement cible d'un puits de forage (112), comprenant :

un logement (102) définissant une entrée (104) permettant de communiquer avec une source de fluide d'injection (110), une sortie (106) permettant de communiquer avec un emplacement d'injection cible (112) et un orifice de référence séparé (108) permettant de communiquer avec une source de pression de référence (114) ;
 40 un premier élément de vanne (116) monté dans le logement (102) ;
 un deuxième élément de vanne (118) monté dans le logement (102) et définissant un chemin d'écoulement (120) pour faciliter la communication fluide entre l'entrée (104) et la sortie (106) du logement (102), dans lequel le deuxième élément de vanne (118) est monté de manière mobile dans le logement (102) entre une position ouverte, dans lequel le premier et le deuxième élément de vanne (116, 118) sont dégagés pour faciliter
 45 une communication fluide entre l'entrée (104) et la sortie (106) du logement (102) à travers le chemin d'écoulement, et une position fermée, dans laquelle le premier et le deuxième élément de vanne (116, 118) sont mis en prise, évitant ainsi la communication fluide entre l'entrée (104) et la sortie (106) du logement à travers le chemin d'écoulement ;
 un agencement de sollicitation qui agit sur le deuxième élément de vanne (118) pour solliciter le deuxième
 50 élément de vanne (118) vers la position fermée de façon à diminuer l'écoulement entre l'entrée (104) et la sortie (106) ; et
 un agencement d'étanchéité (122) ménagé entre le deuxième élément de vanne (118) et le logement (102) et configuré de sorte que la pression de fluide au niveau de l'entrée du logement (104) et de l'orifice de référence du logement (108) applique une force sur le deuxième élément de vanne (118) pour amener ledit deuxième
 55 élément de vanne (118) à se déplacer par rapport au premier élément de vanne (116) et à modifier l'écoulement entre l'entrée (104) et la sortie (106) ; dans lequel, pour faciliter le mouvement entre le deuxième élément de vanne (118) et le premier élément de vanne (116), la pression de fluide au niveau de l'entrée du logement doit dépasser la force combinée de la pression de l'orifice de référence de logement et de l'agencement de sollici-

tation, de sorte que la position du deuxième élément de vanne (118) soit atteinte conformément à un différentiel de pression entre les pressions d'entrée et de référence.

- 5 2. Dispositif d'injection de fond de trou (100) selon la revendication 1, dans lequel une partie de l'agencement d'étanchéité (122) est en communication avec l'entrée (104) du logement (102) de sorte que la pression d'entrée puisse établir une force sur le deuxième élément de vanne (118) dans un premier sens, et une partie de l'agencement d'étanchéité (122) est en communication avec l'orifice de pression de référence (108) du logement (102) de sorte que la pression de référence puisse établir une force sur le deuxième élément de vanne (118) dans un deuxième sens qui est opposé au premier sens et/ou dans lequel l'agencement d'étanchéité (122) est configuré de sorte que le mouvement du deuxième élément de vanne (118) soit atteint conformément à un différentiel de pression entre les pressions d'entrée et de référence.
- 10 3. Dispositif d'injection de fond de trou (100) selon la revendication 1 ou 2, dans lequel l'agencement d'étanchéité (122) définit une zone d'étanchéité d'entrée configurée pour être exposée à une pression d'entrée, et une zone d'étanchéité de référence configurée pour être exposée à une pression de référence, facultativement dans lequel les zones d'étanchéité d'entrée et de référence sont sensiblement identiques, ou facultativement dans lequel les zones d'étanchéité d'entrée et de référence sont différentes pour établir une sollicitation de force sur le deuxième élément de vanne par l'action des pressions d'entrée et de référence.
- 15 4. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel le dispositif d'injection de fond de trou (100) est configuré de sorte que la pression d'entrée établisse une force sur le deuxième élément de vanne (118) pour amener ledit deuxième élément de vanne (118) à se déplacer dans un sens pour augmenter le débit et la pression de référence établit une force sur le deuxième élément de vanne (118) pour amener ledit deuxième élément de vanne (118) à se déplacer dans un sens pour diminuer l'écoulement.
- 20 5. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel une partie de l'agencement d'étanchéité (122) est en communication avec la sortie (106) du logement (102), facultativement dans lequel l'agencement d'étanchéité (122) est configuré pour éliminer sensiblement l'effet de la pression de sortie sur le deuxième élément de vanne (118) et/ou dans lequel l'agencement d'étanchéité (122) est configuré de sorte qu'une pression de sortie établisse des première et deuxième forces sensiblement égales et opposées sur le deuxième élément de vanne (118), de sorte que toute force nette soit sensiblement minimisée ou facultativement dans lequel l'agencement d'étanchéité (122) est configuré de façon à permettre à la pression de sortie de fournir une force de sollicitation souhaitée sur le deuxième élément de vanne (118).
- 25 6. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel l'agencement d'étanchéité (122) définit une première et une deuxième zone d'étanchéité de sortie entre le deuxième élément de vanne (118) et le logement (102), et chacune des première et deuxième zones d'étanchéité de sortie est configurée pour être exposée à une pression de sortie, facultativement dans lequel la première et la deuxième zone d'étanchéité sont configurées pour permettre à une pression de sortie de générer une force sur le deuxième élément de vanne (118) dans des sens opposés, facultativement dans lequel la première et la deuxième zone d'étanchéité de sortie sont sensiblement égales ou facultativement dans lequel la première et la deuxième zone d'étanchéité de sortie sont différentes.
- 30 7. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel l'agencement d'étanchéité (122) inclut un premier et un deuxième ensemble d'étanchéité (124, 126), qui s'étendent entre le deuxième élément de vanne (118) et le logement (102), facultativement dans lequel chacun des premier et deuxième ensembles d'étanchéité (124, 126) comprend un ou plusieurs éléments d'étanchéité, facultativement dans lequel le premier ensemble d'étanchéité (124) isole l'entrée de logement (104) de la sortie de logement (106), de sorte qu'une communication fluïdique entre l'entrée (104) et la sortie (106) est dirigée à travers le chemin d'écoulement (120) dans le deuxième élément de vanne, facultativement dans lequel le deuxième ensemble d'étanchéité (126) isole la sortie de logement (106) de l'orifice de référence de logement (108), facultativement dans lequel le premier ensemble d'étanchéité (124) définit une zone d'étanchéité d'entrée agencée dans le dispositif (100) à exposer à une pression d'entrée, facultativement dans lequel le premier ensemble d'étanchéité (124) définit une première zone d'étanchéité de sortie agencée dans le dispositif (100) à exposer à une pression de sortie, éventuellement dans lequel le deuxième ensemble d'étanchéité (126) définit une zone d'étanchéité de référence agencée dans le dispositif (100) à exposer à une pression de référence, facultativement dans lequel le deuxième ensemble d'étanchéité (126) définit une deuxième zone d'étanchéité de sortie agencée dans le dispositif (100) à exposer à une pression de sortie.
- 35 45 50 55

8. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, comprenant un agencement de sollicitation configuré pour solliciter le deuxième élément de vanne (118) dans un sens souhaité.
- 5 9. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel, pendant l'utilisation, la pression de fluide d'entrée à l'entrée (104) du logement (102) est au moins partiellement définie par une pression de fluide dans une ligne d'injection associée et/ou une source associée de fluide d'injection (110), et la pression de fluide de sortie est au moins partiellement définie par une pression de fluide à un emplacement cible de puits de forage associé (112) et/ou dans lequel la pression de référence est atmosphérique ou inférieure à la pression atmosphérique.
- 10 10. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel l'orifice de pression de référence (108) est configuré pour communiquer avec une source de pression de référence (114), à l'exclusion de la pression de référence provenant de l'emplacement cible de puits de forage (112).
- 15 11. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel la sortie (106) du logement (102) est configurée pour communiquer avec un emplacement cible de puits de forage (112) qui est positionné sur un côté d'un dispositif de variation de pression, et l'orifice de pression de référence (108) est configuré pour communiquer avec un emplacement qui est positionné sur un côté opposé du dispositif de variation de pression, facultativement dans lequel le dispositif de variation de pression comprend une pompe.
- 20 12. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel la sortie (106) du logement (102) est configurée pour communiquer avec une entrée d'un ensemble de pompe, et l'orifice de pression de référence (108) est configuré pour communiquer avec une sortie du même ensemble de pompe, et/ou dans lequel une pression de référence appliquée à l'orifice de pression de référence (108) peut être modifiée par l'utilisateur.
- 25 13. Dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications précédentes, dans lequel le premier élément de vanne (116) est fixe par rapport au logement (102), de sorte qu'un mouvement du deuxième élément de vanne (118) est requis pour modifier l'écoulement, ou dans lequel le premier élément de vanne (116) est défini par un composant qui est séparé du logement (102), et ledit premier élément de vanne (116) est autorisé à bouger dans le logement (102).
- 30 14. Procédé permettant d'injecter un fluide dans un emplacement cible de puits de forage (112), comprenant :
- 35 la communication d'un fluide d'injection à une entrée (104) d'un logement (102) d'un dispositif d'injection de fond de trou (100) incluant un premier élément de vanne (116) et un deuxième élément de vanne (118) ;
la sollicitation du deuxième élément de vanne (114) vers le premier élément de vanne (116) ;
la communication d'une sortie (106) du logement (102) à un emplacement cible de puits de forage ;
la communication d'un orifice de référence (108) du logement (102) à une source de pression de référence (114) ;
40 le fait d'amener d'un deuxième élément de vanne (118) à se déplacer par rapport à un premier élément de vanne (116) par une exposition à une pression à l'entrée (104) du logement (102), dans lequel ce mouvement se produit uniquement après avoir surmonté une pression combinée de la sollicitation et de la pression au niveau de l'orifice de pression de référence (108) du logement (102), dans lequel ce mouvement permet l'écoulement à travers un chemin d'écoulement (120) de l'élément de vanne (118) à ajuster.
- 45 15. Système de pompage comprenant:
une conduite d'écoulement ;
une pompe associée à la conduite d'écoulement et définissant un côté entrée et un côté sortie ;
50 un dispositif d'injection de fond de trou (100) selon l'une quelconque des revendications 1 à 13, dans lequel la sortie (106) du logement de dispositif d'injection de fond de trou (102) est en communication avec la conduite d'écoulement sur un côté entrée de la pompe, dans lequel un orifice de pression de référence du logement de dispositif d'injection est en communication avec la conduite d'écoulement sur un côté sortie de la pompe.
- 55

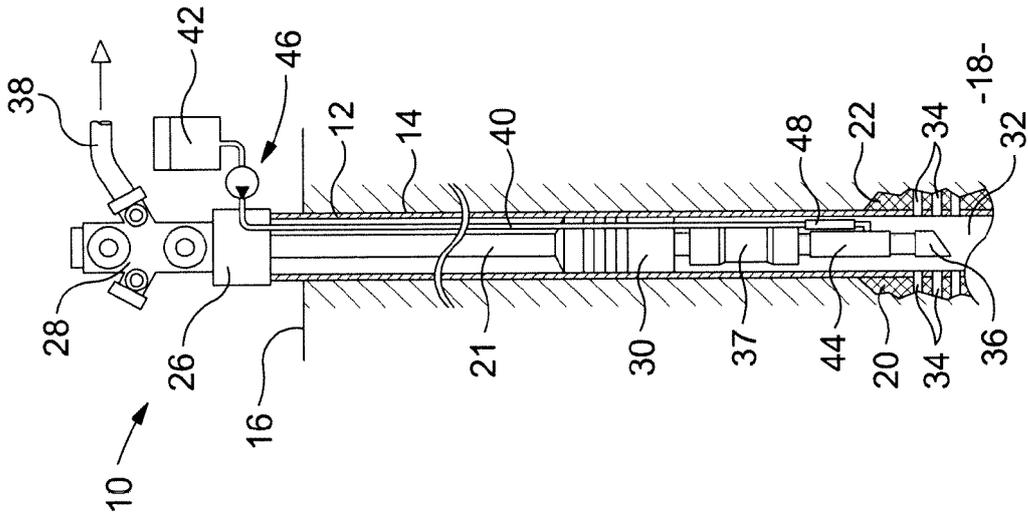


FIG. 1

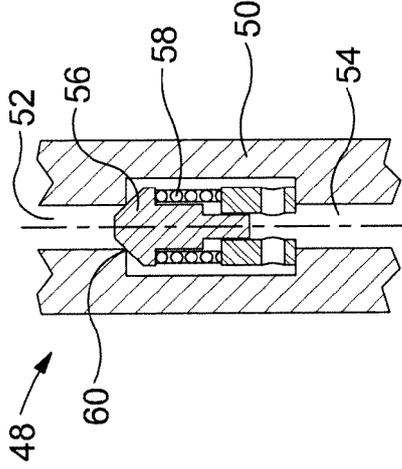


FIG. 2

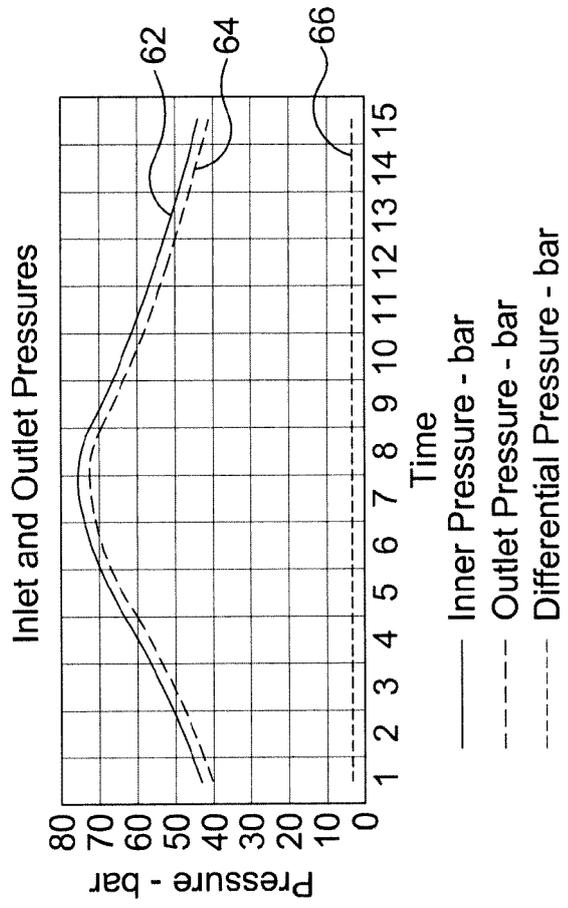


FIG. 3

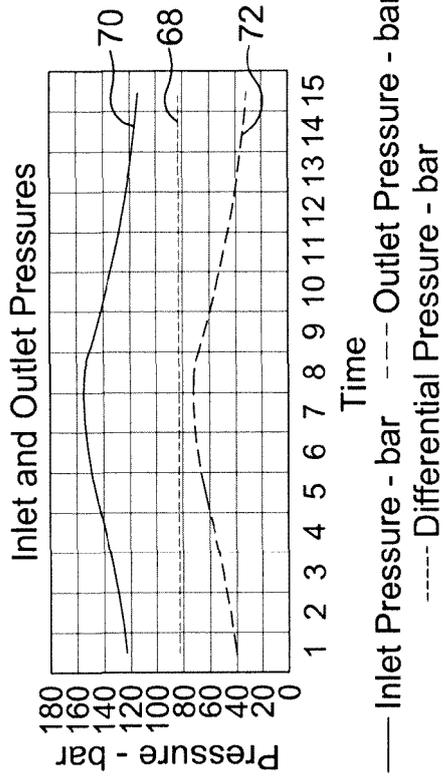


FIG. 5

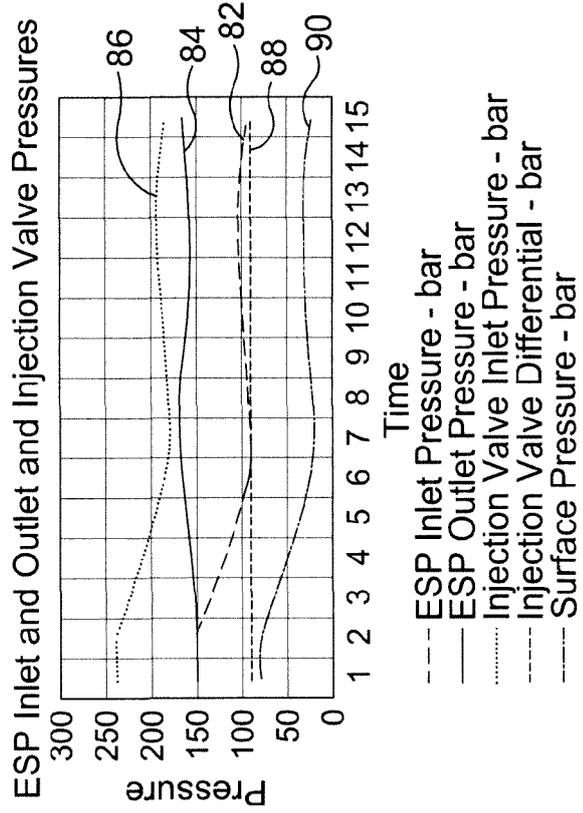


FIG. 7

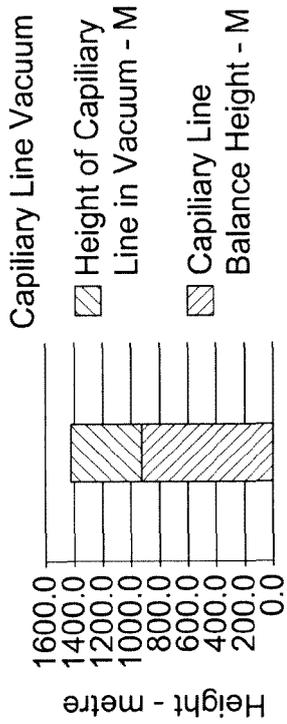


FIG. 4

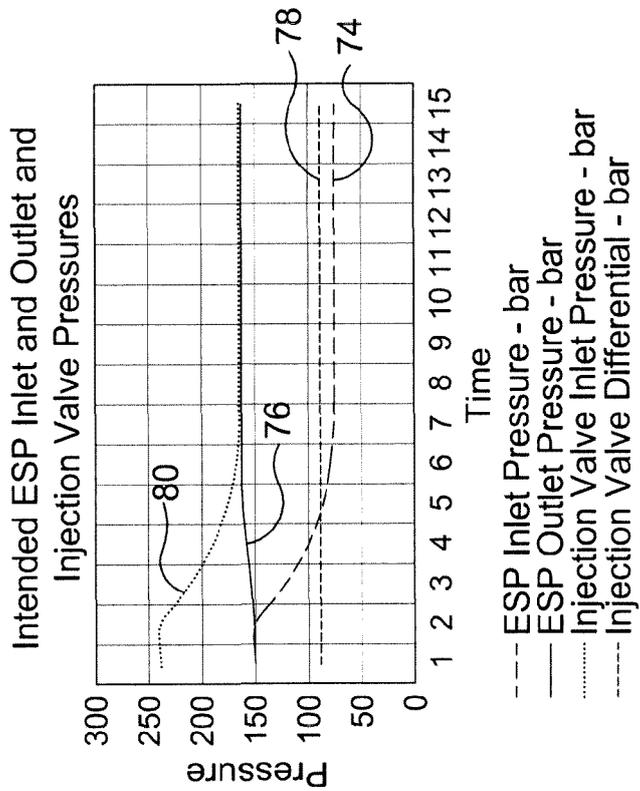


FIG. 6

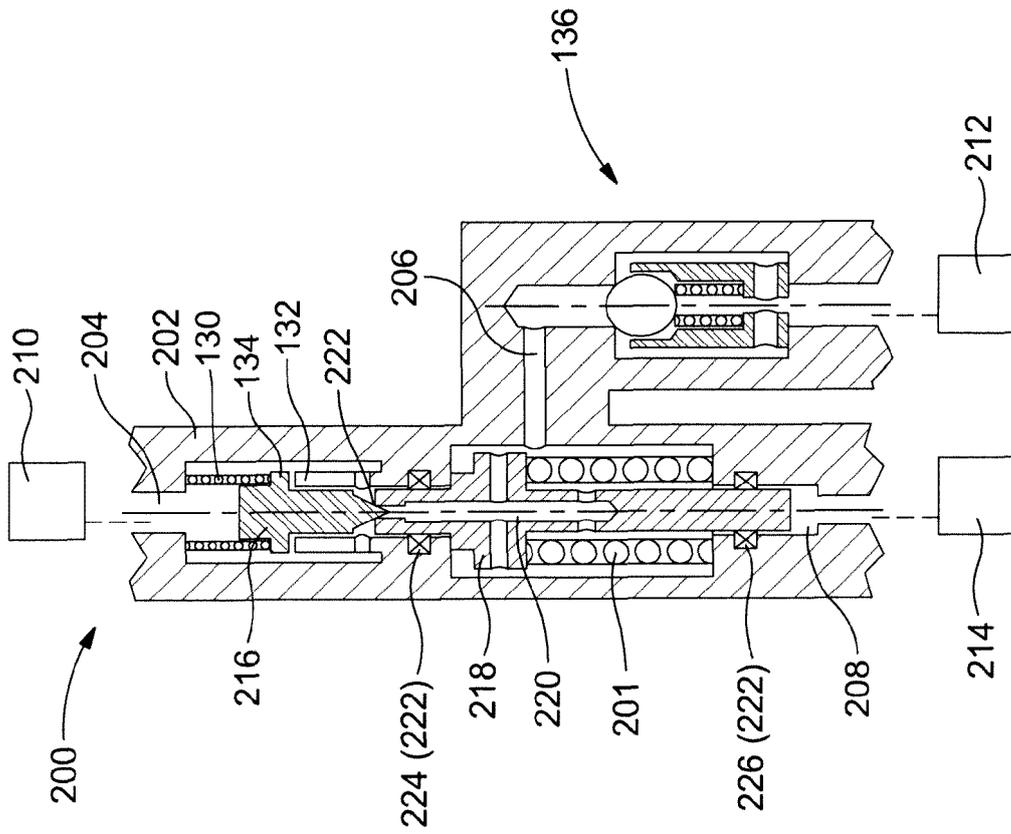


FIG. 9

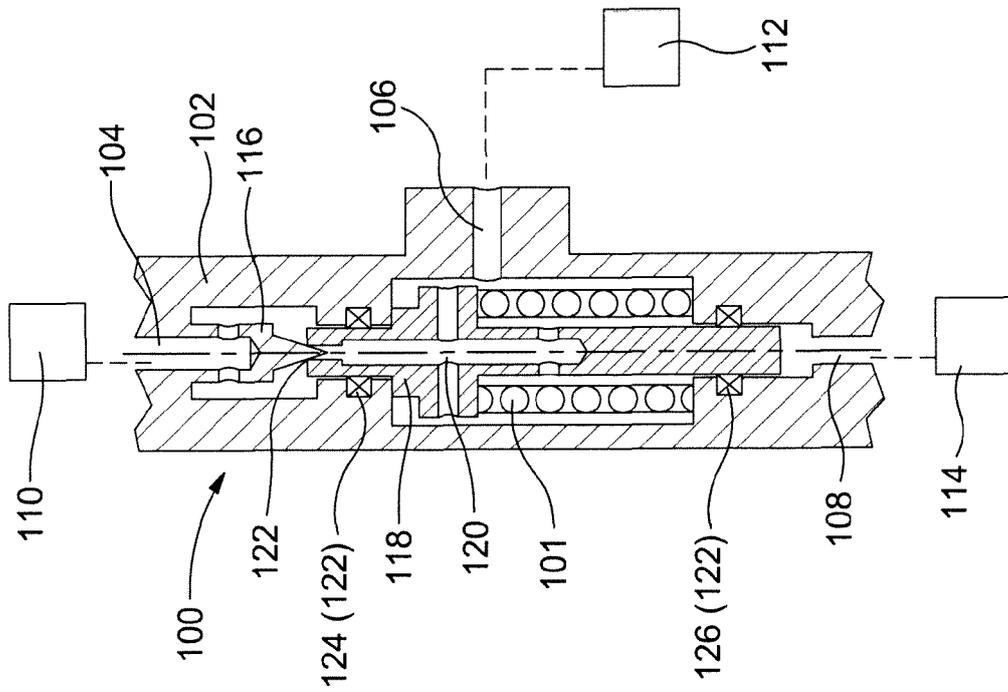


FIG. 8

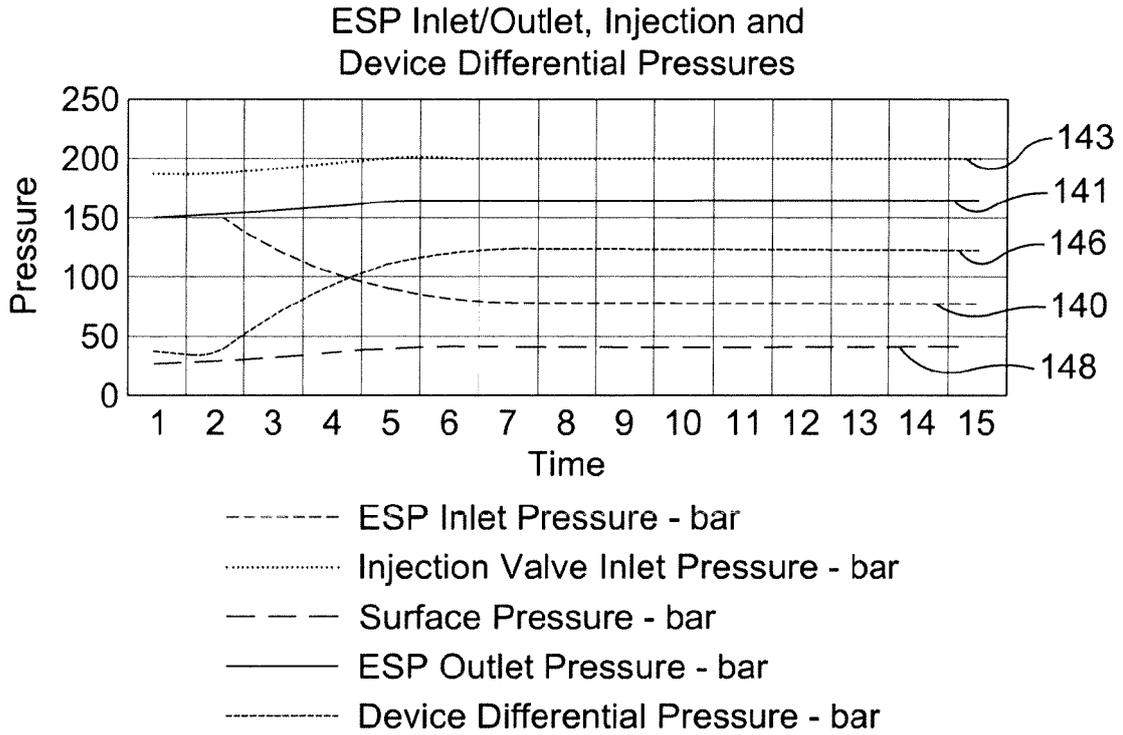


FIG. 10

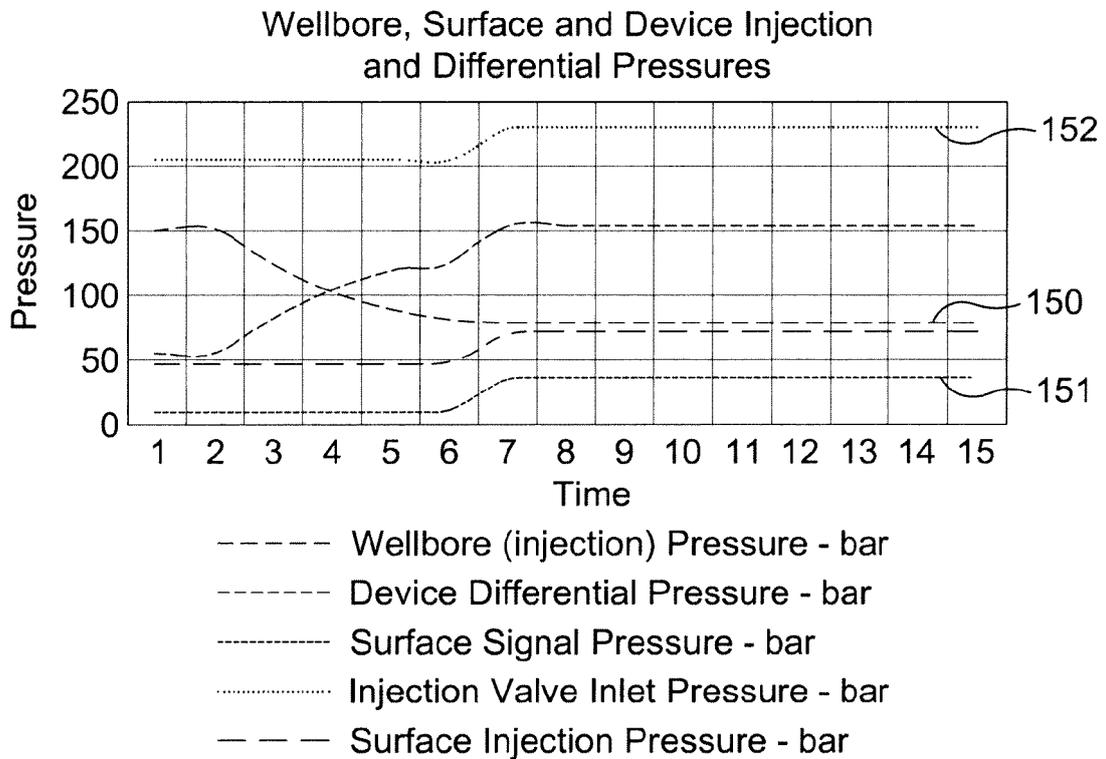


FIG. 11

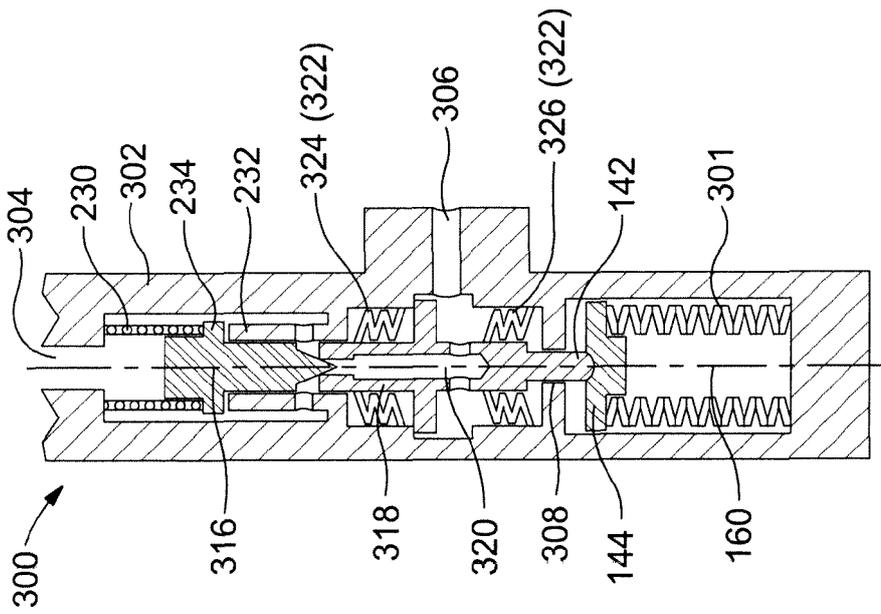


FIG. 12

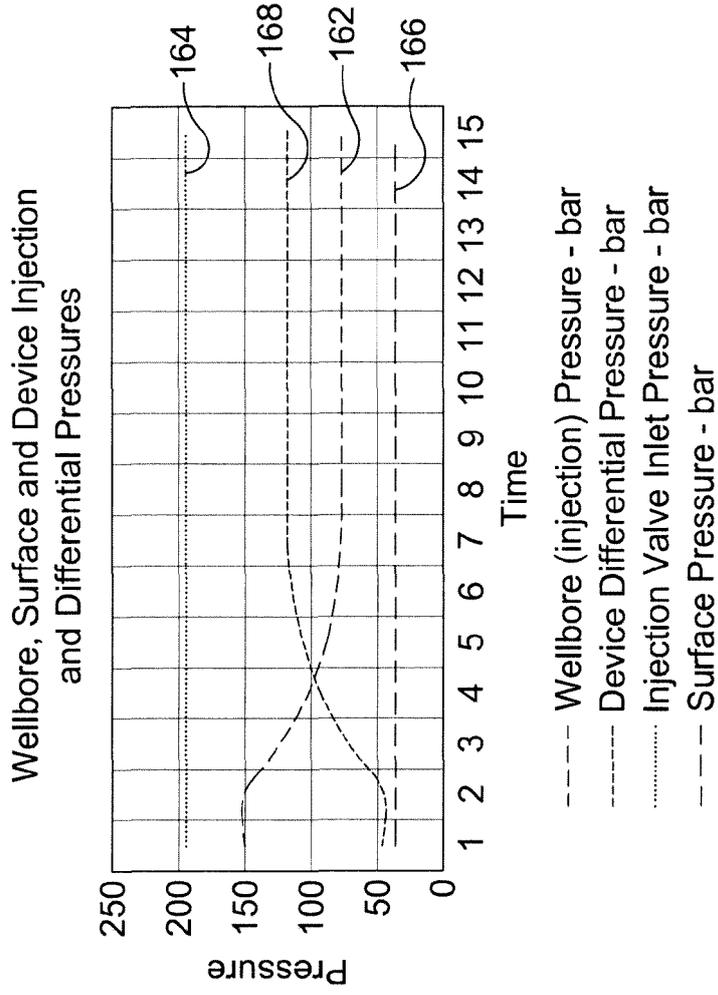


FIG. 13

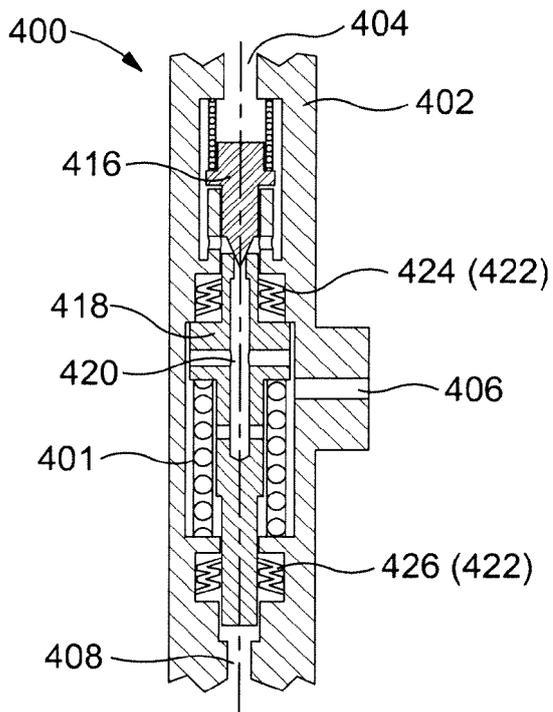


FIG. 14

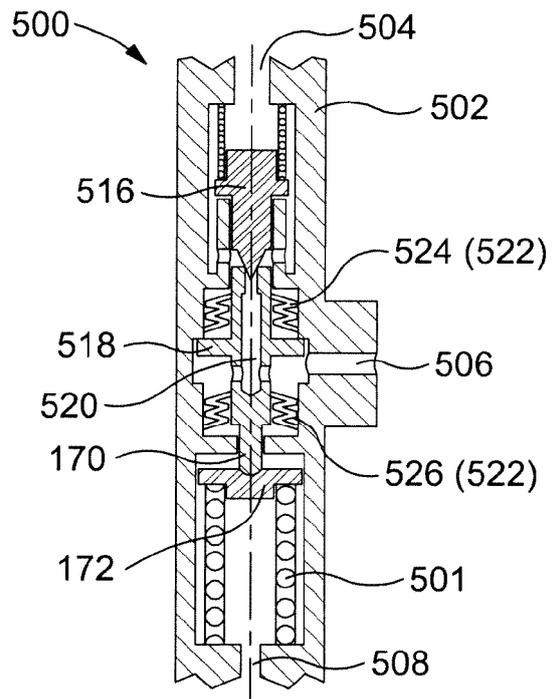


FIG. 15

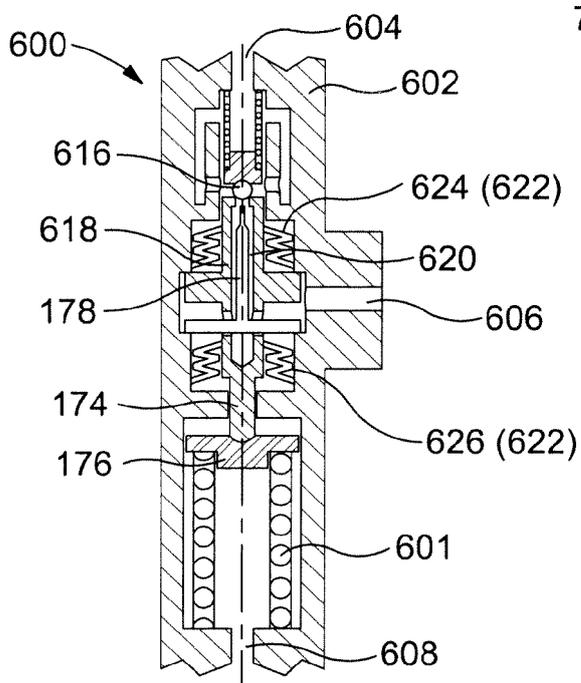


FIG. 16

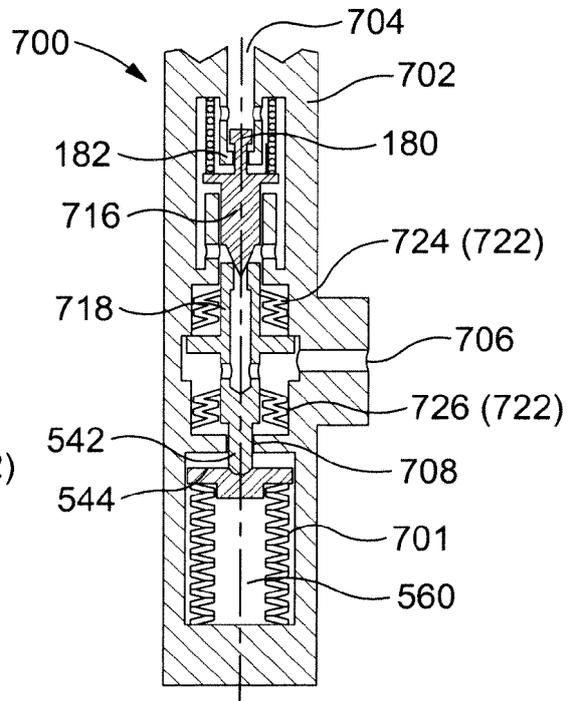


FIG. 17

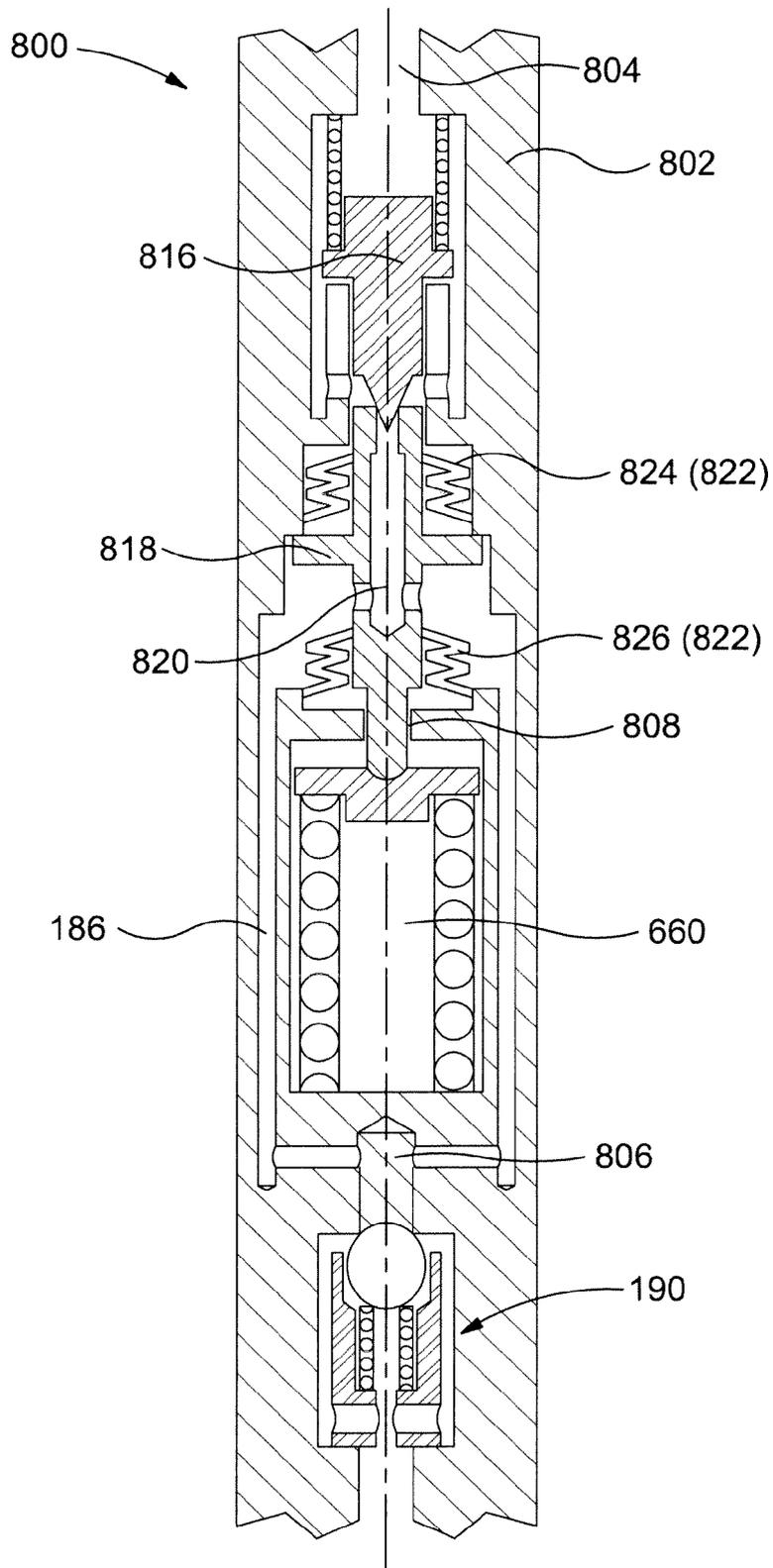


FIG. 18

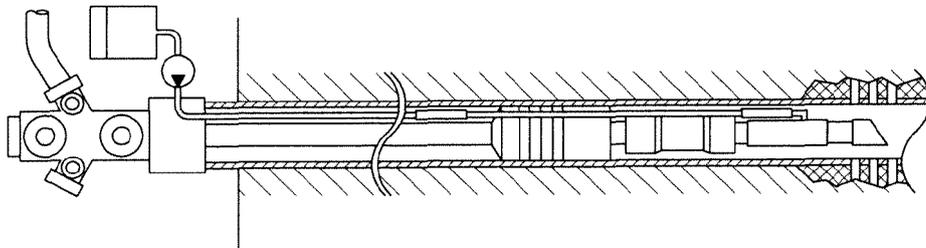


FIG. 19

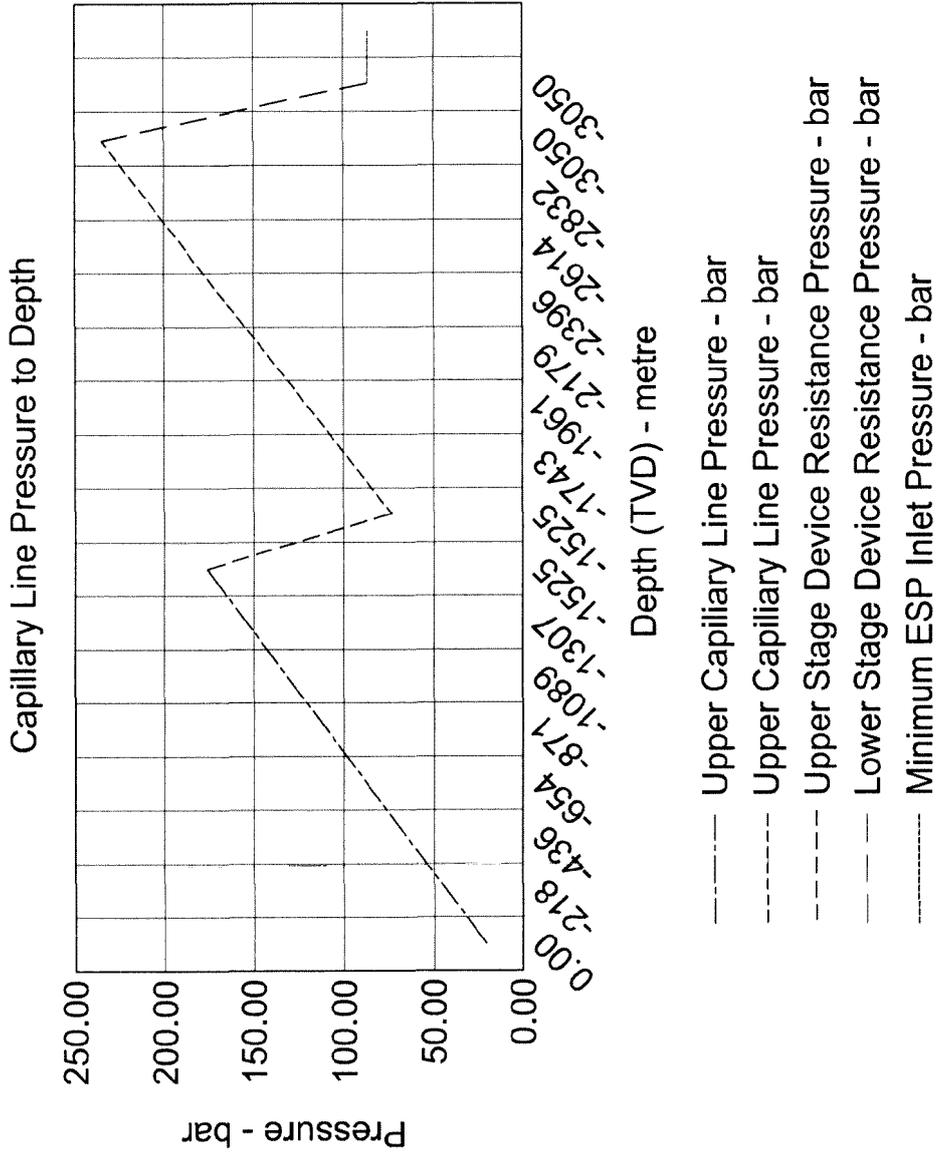


FIG. 20

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 3125113 A [0002]