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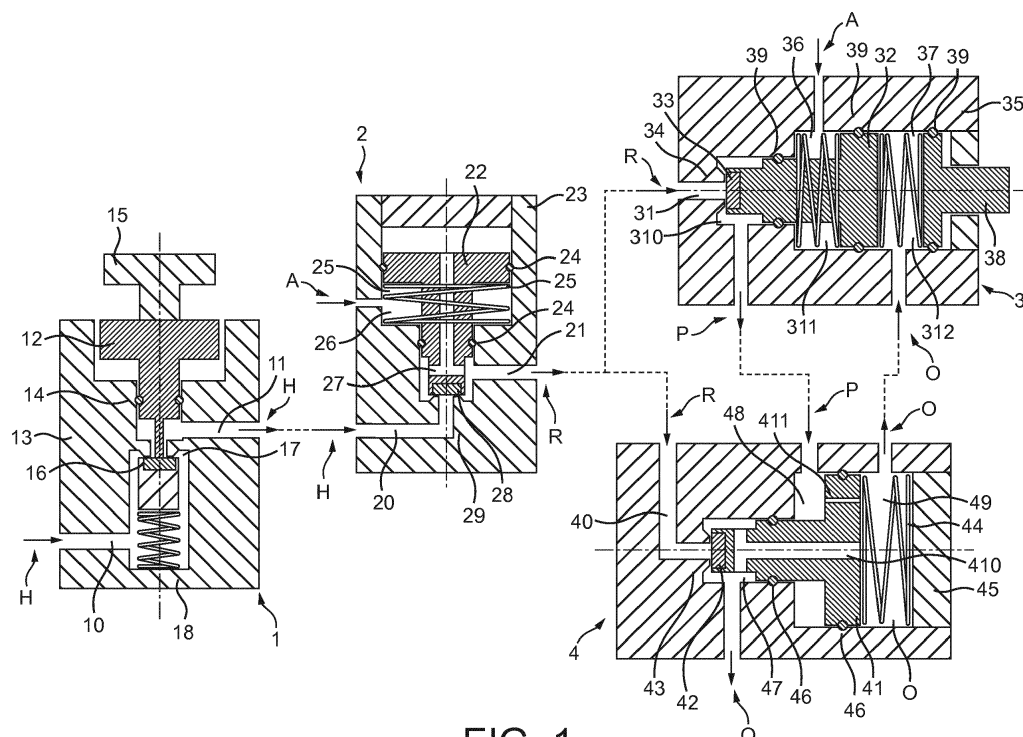
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(54) A REGULATOR ASSEMBLY FOR A PRESSURISED GAS CYLINDER

(57) The regulator assembly has a first stage regulator with a first inlet for receiving high pressure gas from the cylinder. A first regulator element reduces the pressure of the gas which exits the first stage regulator via a first outlet at a regulated pressure. A second stage regulator is provided with a second inlet for receiving the gas at the regulated pressure, and a second regulator element further reduces the pressure of the gas which

exits the second stage regulator via a second outlet at an outlet pressure which is lower than the regulated pressure. A pilot regulator receives gas at the regulated pressure from the first stage regulator. The pilot regulator is controlled by an actuator to set a pilot pressure which is communicated to the second stage regulator to set the outlet pressure delivered by the second stage regulator.

**FIG. 1****EP 3 312 494 A1**

Description

[0001] The present invention relates to a regulator assembly for a pressurised gas cylinder.

[0002] Such regulator assemblies are used to control the outlet flow of gas from a pressurised gas cylinder. Typically, a gas cylinder will be at a pressure of 300 bar or more and will be regulated by the regulator to a pressure typically below 10 bar. Such a regulator may either be provided in a separate housing which is fitted to the outlet of the gas cylinder or, following a more recent development in gas cylinder technology, may be integrated into the cylinder valve. Such valves are known in the art as VIPRs (valves with integrated pressure regulators).

[0003] Although reference is made to a "cylinder", it will be understood that the invention is applicable broadly to all portable pressurised gas containers including gases stored under pressure as liquids whether they are strictly in the form of a cylinder or not.

[0004] Such cylinders are typically used to supply gas for a range of applications including welding and cutting hoses and torches, gas packaging machines and laboratory equipment.

[0005] The regulator needs to be adjustable to allow the user to vary the pressure at which the gas is supplied. The majority of regulators need to be adjusted several times a day to alter the pressure or flow rate as the cylinder pressure drops and consequently outlet pressure increases or decreases, depending upon the design of regulator.

[0006] Conventionally, in a regulator, the force required to adjust the outlet pressure is provided by manual manipulation of a hand wheel. The torque required to manipulate the hand wheel is dependent upon the outlet pressure requirements and increases as the outlet pressure increases. This torque demand can often be demanding for the user, particularly when dealing with a high outlet pressure. Also, if the regulator is intended to be operated using an electric motor controlled by an on-board power supply, the torque and therefore energy requirement of the regulator may become prohibitive in terms of the capacity required from the on-board power supply.

[0007] The present applicants have previously addressed this problem in our earlier co-pending applications PCT/EP2016/057118, PCT/EP2016/057120 and PCT/EP2016/057116. The first of these applications relates to a separate regulator while the second relates to an integrated regulator.

[0008] In each case, a pilot regulator is incorporated into the regulator. The pilot regulator is able to control the outlet pressure of the regulator. The user controls the regulator outlet pressure by adjusting the pilot regulator. Because this requires significantly lower torque than required to adjust the regulator itself, in the case of a manually activated device, it is far easier for a user to make the required adjustment and, for an electronic actuator, the demand of the on-board power supply is reduced.

[0009] The present invention relates to an improvement of this idea.

[0010] According to the present invention there is provided a regulator assembly according to claim 1.

[0011] In our previous design, the regulator receives the full cylinder pressure. However, the present invention introduces a first stage regulator in addition to the regulator controlled by the pilot regulator (now identified as the second stage regulator in the present invention). Because of this, the regulator which is controlled by the pilot regulator is not exposed to the high pressure gas from the cylinder.

[0012] This leads to a number of benefits. The whole arrangement of the second stage regulator and pilot regulator can now be designed to operate at a significantly reduced pressure range. The use of the pilot regulator already reduced considerably the force required to control the outlet flow from the valve. However, now that the second stage regulator and pilot regulator are operated over a much lower pressure range, the force required by the user or by the electric motor can be reduced dramatically.

[0013] Further, because the second stage regulator is now required to maintain a much lower differential pressure given the significant reduction in its inlet pressure, it can be made significantly smaller and is considerably more accurate. The increased accuracy of the two-stage regulator also means fewer adjustments are required due to the outlet pressure or flow deviating less as the source cylinder pressure reduces. Outlet pressure stability is also improved, due to the reduced range of inlet pressure changes and, therefore, reducing the speed and amplitude of transient changes the pilot is exposed to that can often cause instability.

[0014] A further benefit is provided by the fact that the second stage regulator is no longer exposed to any pressure surges from the high pressure cylinder gas. The first stage regulator is exposed to these, but will effectively reduce and smooth any pressure surges thereby reducing the possibility of damage to the second stage regulator and pilot regulator.

[0015] In effect, the first stage regulator can be seen as a coarse pressure reducing device which can be relatively robust and which can be responsible for a significant proportion (most likely a majority) of the pressure reduction of the high pressure cylinder gas. No control of the first stage regulator is required. This then allows the fine control to be carried out in a much more accurate manner by the second stage regulator. As this is operating at a much lower pressure range, accurate control is more readily achievable.

[0016] The shut-off valve may be a conventional shut-off valve which is separate from the regulator assembly of the present invention. However, preferably, the shut-off valve for the cylinder is incorporated into the regulator assembly. If so, it may be separate from the first stage regulator. However, preferably, the shut-off valve is integral with the first stage regulator. This reduces the size

and complexity of the regulator assembly as the shut-off valve and first stage regulator can share components.

[0017] The regulator assembly may be designed as a separate assembly which is detachable from the cylinder. In this case, the assembly preferably comprises a fixture for attachment to the cylinder. Alternatively, the regulator assembly may be integrated into the cylinder assembly.

[0018] The pilot regulator preferably has an inlet port to receive gas at the regulated pressure from the first stage regulator and a pilot valve element biased towards the inlet port by a biasing element to control the flow of gas through the inlet port, the biasing force provided by the biasing element being adjustable by an actuator to control the pressure of pilot gas passing through the inlet port to the second stage regulator. The biasing element may be a single spring positioned between the actuator and the pilot valve element. However, preferably, the biasing element is arranged to bias the pilot valve element open while a balancing biasing element is positioned between the pilot actuator and the pilot valve inlet to provide an opposing force on the pilot valve element. The presence of the balancing element allows a smaller package for the pilot regulator.

[0019] The pilot valve element may be manually operated, in which case it requires less effort from a user to adjust the regulated pressure. Alternatively, the pilot valve element is operated by a motor. In this case, the assembly may further comprise a control system to control the operation of the motor, the control system including a transmitter and receiver to receive and transmit data concerning the control of the pilot valve element.

[0020] Examples of regulator assemblies in accordance with the present invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a schematic cross-sectional view showing the regulator assembly including a shut-off valve; and

Fig. 2 is a schematic cross-section showing an integrated shut-off valve and first stage regulator in various operating positions.

[0021] The assembly shown in Fig. 1 consists of four components namely a shut-off valve 1, a first stage regulator 2, a pilot regulator 3 and a second stage regulator 4. The operation of and interaction between these four components will be described below.

[0022] There are a number of different pressures throughout the system and the following convention will be adopted:

- High pressure (H) - the high pressure received from the cylinder which passes through the shut-off valve 1 to the first stage regulator 2.
- Regulated pressure (R) - the reduced regulated pressure determined by the first stage regulator 2 and supplied to the pilot valve 3 and second stage regulator 4.

- Atmospheric pressure (A) - this is atmospheric pressure which is applied to part of the first stage regulator 2 and pilot regulator 3.
- Pilot control pressure (P) - this is the control pressure determined by the pilot valve 3 and supplied to the second stage regulator 2 to control the outlet pressure.
- Outlet pressure (O) - the outlet pressure emitted from the second stage regulator 4 for use in downstream gas processing. It is also applied to the pilot valve and second stage regulator to maintain a constant outlet pressure.

[0023] Thus, the regulator system as a whole receives high pressure H when the shut-off valve 1 is opened. This is reduced to the regulated pressure R by the first stage regulator 2 and is reduced further to the outlet pressure O by a combination of the pilot regulator 3 and second stage regulator 4 as described below.

[0024] The shut-off valve 1 comprises an inlet 10 for the high pressure cylinder gas H and an outlet 11 for the high pressure gas H. Flow through the shut-off valve 1 is controlled by a valve assembly comprising a piston 12 in a housing 13 with a seal 14 between the piston 12 and housing 13. The piston 12 is movable by a hand wheel 15 (or alternatively by a lever). The configuration shown in Fig. 1 is a reverse seat type valve in which a sealing element 16 is biased towards a seat 17 on the inlet side of the valve by a spring 18 assisted by the high pressure gas H. Alternatively, the shut-off valve may be a positive seat type valve where the seal is on the downstream side of the seat and is opened by being moved away from the seat by the high gas pressure H without a biasing member when the hand wheel 15 (or lever) is turned.

[0025] In the present case, turning of the hand wheel 15 (or lever) pushes the piston 12 downwardly to move the seal 16 from the seat 17 to create a flow of high pressure gas H through the shut-off valve 1 and to the first stage regulator 2.

[0026] The first stage regulator 2 has a high pressure inlet 20 to receive high pressure gas H from the shut-off valve 1 at an outlet 21 for gas at the regulated pressure R.

[0027] The first stage regulator 2 has a piston 22 which is sealed to a housing 23 by O-rings 24. The piston 22 is biased upwardly by a spring 25. The volume 26 beneath the piston 22 is at atmospheric pressure A while regulated pressure R is communicated to the top of the piston 22 by a bore 27 through the piston. The piston 22 has a seal 28 which seals against a seat 29.

[0028] When the first stage regulator 2 receives the high pressure H, this acts on the seal 28 pushing the piston 22 upwardly away from the seat 29. This pressure is then communicated to the top of the piston 22 which will act against the biasing force of the spring 26 exerting a downward force on the regulator. The pressure provided by the spring 25 is determined in advance based on the inlet pressure H and the area of the cylinder 22 in order to set the regulated pressure R at a desired level.

There is no means provided to adjust the regulated pressure R (although this could be provided if desired). The first stage regulator 2 will typically receive an inlet pressure of 300 bar and regulate this down to a pressure of around 100 bar.

[0029] When the shut-off valve 1 is initially opened, the seal 28 is exposed to a pressure surge. The piston 22 will take a finite time to open and will momentarily open to a greater extent than necessary caused by the initial momentum of the gas surge prior to the full establishment of the regulated pressure R above the piston 22. Thus, a pressure spike will be transmitted out of the first stage regulator 2. However, because of the inertial effects of the first stage regulator 2 described above, this spike will be lower and smoother than the spike of high pressure gas H from the shut-off valve 1.

[0030] The regulated pressure R is then fed to an inlet port 31 of the pilot regulator 3 and an inlet port 40 of the second stage regulator 4.

[0031] The pilot regulator 3 comprises a pilot regulator element in the form of a piston 32 which has a pilot seal 33 which seals against a seat 34 in a pilot regulator housing 35. The piston 32 is biased open by a pilot regulator spring 36 and is biased in the opposite direction by a balancing spring 37. The forced balance on the piston 32 is adjustable via an actuator stem 38 which bears against the top of the balancing spring 37.

[0032] O-ring seals 39 create three sections in the housing 35, namely a pilot section 310 which is at the pilot control pressure P, and intermediate section 311 which is at atmospheric pressure A and an outlet pressure feedback section 312 at the outlet pressure O. The position of the piston 32 and hence the magnitude of the pilot control pressure P is determined by a combination of the resultant effects of the pressures in these three sections together with the regulated pressure R acting on the seal 33 as well as the forces provided by the springs 36 and 37. Movement of the actuator stem 38 is the means by which the user adjusts the regulated pressure P. Because the pilot valve 3 is receiving as its highest pressure input the regulated pressure R rather than the high pressure H, everything about the pilot valve 3 can be scaled down proportionately as the pressure differential between the regulated pressure R and the pilot pressure P is significantly lower than previously such that the piston 32 and the spring force from the spring 36, 37 will also be proportionately reduced.

[0033] The pilot control pressure P is ultimately responsible for setting the outlet pressure O in the second stage regulator 4 as described below.

[0034] The second stage regulator 4 has a structure which is broadly similar to that of the first stage regulator 2. It has a piston 41 with a seal 42 which seals on a seat 43 in the regulated pressure inlet 40. The piston 41 is biased closed by a spring 44 which acts against the second stage regulator housing 45.

[0035] O-ring seals 46 divide the housing into three chambers, namely an outlet chamber 47 at the outlet

pressure O, a pilot chamber 48 at the pilot pressure P and a control chamber 49 containing the spring 44 at control pressure C. A through bore 410 connects the outlet chamber 47 with chamber 49, while a bleed port 411 connects the pilot chamber 48 with the outlet pressure chamber 49.

[0036] The outlet pressure O is determined by the resultant force on the piston 41. This is determined by the resultant of the regulated pressure R on the seal 43, the outlet pressure O in the pilot chamber 47 on the piston 41, the pilot control pressure P in the chamber 48 on the piston 41, the outlet feedback pressure O in the chamber 49 and the spring force from spring 44.

[0037] The only variables within the second regulator 4 is the pilot control pressure P. If the actuator stem 38 in the pilot valve 3 is moved to a fully closed position such that it biases the seal 33 onto the seat 34, the pilot control pressure P is reduced to 0. In turn, this causes the spring 44 in the second stage regulator 4 to urge the piston 41 to the left given the pressure reduction in the pilot chamber 48 thereby seating the seal 42 on the seat 43 and cutting off the outlet flow. In order to provide the outlet flow, the user opens the actuator stem 38 to reduce the compression of the spring 37 and hence the closing biasing force on the piston 32. The gas pressure R on the seal 33 is then able to overcome the force of the spring 37 such that the pilot flow P flows into the pilot chamber 48 in the second stage regulator 4. This gas pressure acts on the piston 46 to compress the spring 44 moving piston 41 away from the seat and generating flow at the outlet pressure O.

[0038] The pressure is maintained at a constant level because of the outlet pressure O acting on the piston 41.

[0039] In Fig. 1, the shut-off valve 1 and first stage regulator 2 are shown as separate components. However, these two may be integrated into a single component 100 as shown in Figs. 2A to 2C.

[0040] With reference to Fig. 2A, it can be seen that the lower half of the combined assembly 100 replicates the features of the shut-off valve 1 in Fig. 1 in that it has a high pressure inlet 10, piston 12 and housing 13 with a seal 14 between the piston 12 and the housing 13. A regulator spring 101 is provided between the piston 12 and a plate 102 which is acted on by the hand wheel 15 (or lever). In this example, therefore, operation of the hand wheel or lever does not simply move the piston off the seat as before, but, instead, increases the pressure on the regulator spring 101 thereby increasing the opening force on the piston 12 to lift the seal 16 from the seat 17 to cause an initial flow as shown in Fig. 2B. As the pressure downstream of the seat 17 rises, the upward force on the piston 12 increases thereby reducing the flow of the regulated pressure R at which the outlet pressure is then maintained. The regulated pressure R is then fed to the pilot regulator 3 and second stage regulator 4 in the same way as described above in relation to Fig. 1. As can be seen from a comparison of Figs. 1 and 2, combining the shut-off valve 1 and first stage regulator 2 ef-

fectively only requires the addition of a regulator spring 101 to the shut-off valve 1 thereby eliminating the separate second stage regulator. This therefore reduces the complexity of the assembly.

Claims

1. A regulator assembly for a pressured gas cylinder, the regulator assembly comprising:

a first stage regulator having a first inlet for receiving high pressure gas from the cylinder, a first regulator element for reducing the pressure of the gas in the first stage regulator and a first outlet for outputting the gas at a regulated pressure;

a second stage regulator with a second inlet for receiving gas at the regulated pressure, a second regulator element for further reducing the pressure of the gas in the second stage regulator and a second outlet for outputting gas at an outlet pressure which is lower than the regulated pressure; and

a pilot regulator that receives gas at the regulated pressure from the first stage regulator, the pilot regulator being controllable by an actuator to set a pilot pressure, the pilot pressure being communicated to the second stage regulator to set the outlet pressure delivered by the second stage regulator.

2. An assembly according to claim 1, wherein the shut-off valve for the cylinder is incorporated into the regulator assembly.

3. A regulator according to claim 2, wherein the shut-off valve is integral with the first stage regulator.

4. A regulator according to any preceding claim, further comprising a fixture for attachment to the cylinder.

5. A regulator assembly according to any one of claims 1 to 3 wherein the assembly is integrated into the cylinder.

6. A regulator assembly according to any preceding claim, wherein the pilot regulator has an inlet port to receive gas at the regulated pressure from the first stage regulator and a pilot valve element biased towards the inlet port by a biasing element to control the flow of gas through the inlet port, the biasing force provided by the biasing element being adjustable by an actuator to control the pressure of pilot gas passing through the inlet port to the second stage regulator.

7. A regulator according to claim 6, wherein the biasing

element is arranged to bias the pilot valve element open while a balancing biasing element is positioned between the pilot actuator and the pilot valve inlet to provide an opposing force on the pilot valve element.

8. A regulator assembly according to any one of the preceding claims, further comprising a motor to operate the actuator of the pilot regulator.

9. An assembly according to claim 8, further comprising a control system to control the operation of the motor, the control system including a transmitter and receiver to receive and transmit data concerning the control of the pilot valve element.

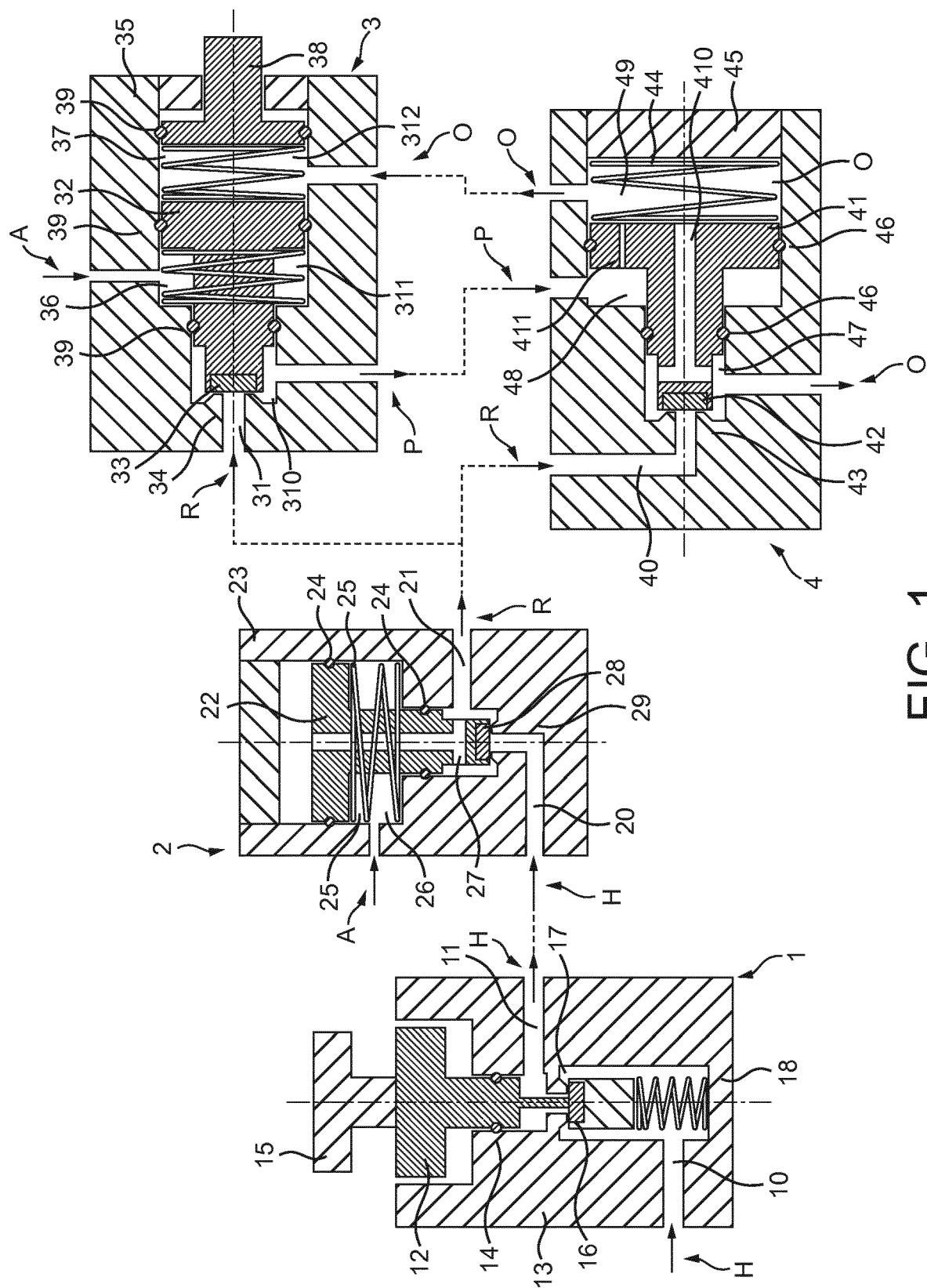


FIG. 1

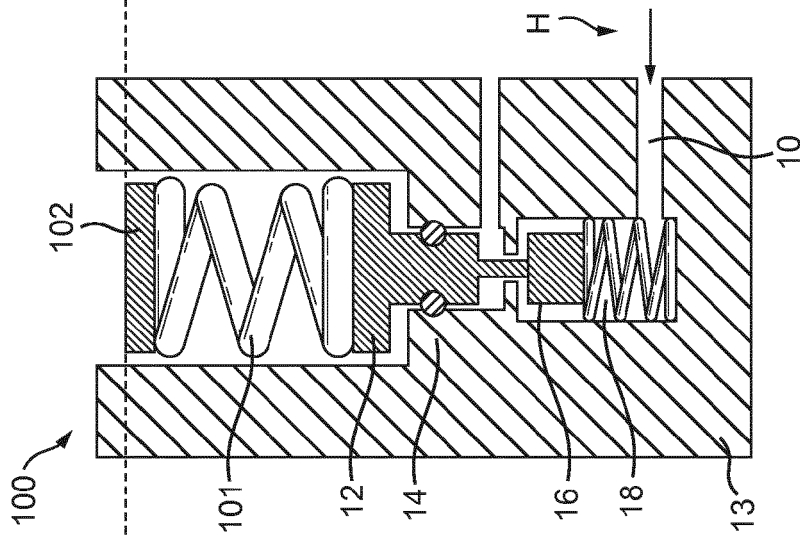


FIG. 2A

1. Spring 1 at free length with clearance, SOV seat closed

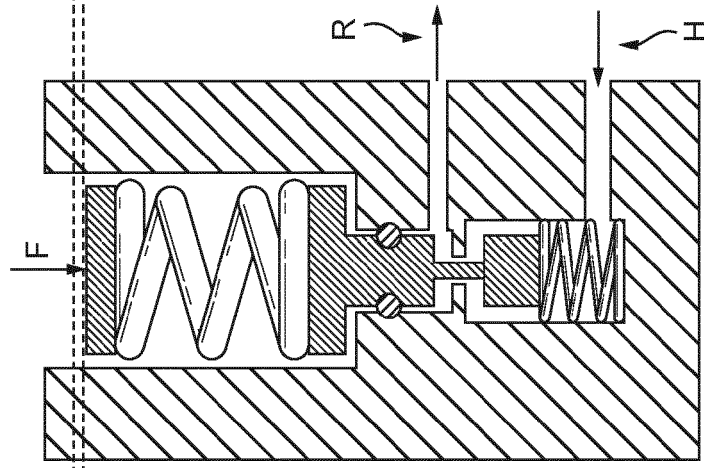


FIG. 2B

2. Spring 1 depressed, Overcomes sealing ad lower spring force to open SOV seat

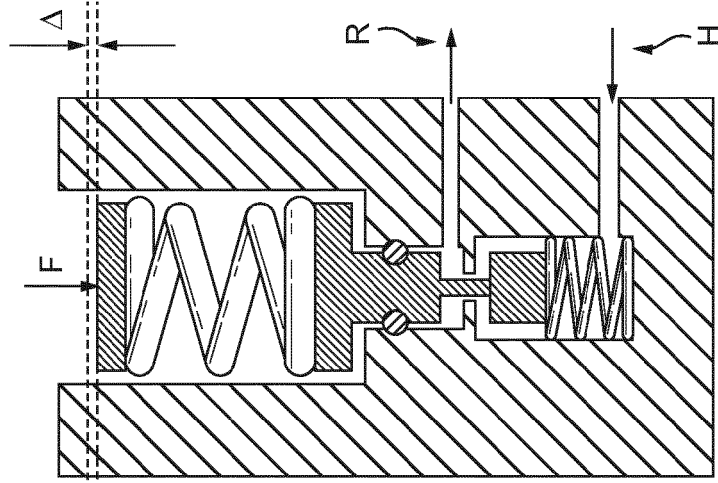


FIG. 2C

3. As downstream pressure rises, spring 1 compresses, closing seat and reducing flow



EUROPEAN SEARCH REPORT

Application Number
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