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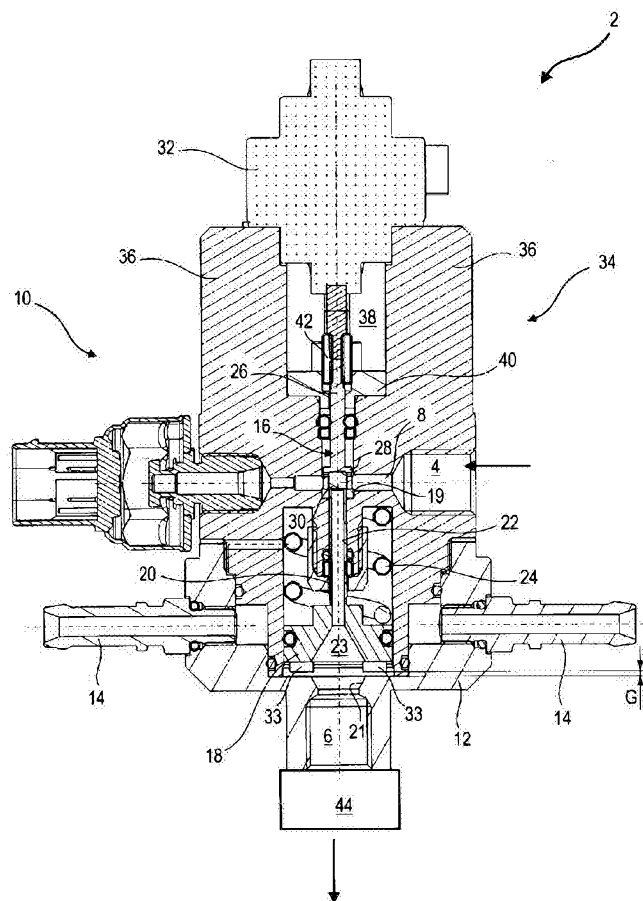
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GAS PRESSURE REDUCER WITH ADJUSTABLE SEAT.

(57)

The invention is directed to a gas pressure reducer (2) comprising a body (10) with an inlet (4) intended to be in flow communication with a high pressure gas source; an outlet (6) intended to deliver the gas at a predetermined low pressure; a passage (8) through the body (10) in flow communication with the inlet (4) and with the outlet (6). A resilient element (24) engages with a pressure reducing piston (18) with a through flow path (22) formed by a needle (20). The needle (20) cooperates with a movable seat (16). The outlet pressure acts on the piston (18) in opposite direction than the spring (24) so as to urge the path (22) against the seat (16) in order to reduce the gas flow through the path (22). Pressure setting means comprise an electric actuator (32), such as a stepper motor, which moves the seat (16) along the moving direction of the piston (18) in order to set the predetermined outlet pressure.



Description**GAS PRESSURE REDUCER WITH ADJUSTABLE SEAT****Technical field**

[0001] The invention is directed to a gas pressure reducer. More precisely, the invention relates to a gas pressure reducer with a movable element, e.g. of the piston or membrane type, that delimits an auxiliary chamber and regulates the position of a closure element cooperating with a seat.

Background art

[0002] Prior art patent document published US2004187929 A1 discloses an adjustable pressure regulator which controls the flow of a gas from a high pressure source to a low pressure device at a predetermined outlet pressure. The regulator includes a body, a piston assembly carried by the body. The assembly has a piston, a flow conduit formed in the piston and a biasing element operably connected to the piston. The flow conduit has a regulated pressure outlet end. The piston and flow conduit are movable longitudinally in the body. A retainer element is engageable with the body and is movable toward and away from the body and the piston. A seat is carried by the retainer element and is movable therewith. The seat is engaged by the flow conduit to isolate a flow path through the regulator and disengaged from the flow conduit to open a flow path through the flow conduit. The piston assembly biasing element biases the flow conduit away from the seat to open a flow path through the regulator. Gas pressure on the piston urges the flow conduit into contact with the seat to close the flow path through the regulator. The retainer element and seat are movable toward and away from the body to vary a distance of movement of the flow conduit toward and away from the seat to vary the predetermined outlet pressure.

[0003] Such an adjustable pressure regulator intends to improve the pressure adjustment of the regulator. However, said adjustment accuracy remains reduced. Further, the regulator is bulky.

Summary of invention**Technical Problem**

[0004] The invention has for technical problem to overcome at least one of the disadvantages mentioned in the prior art. More precisely, the invention has for technical problem to increase the safety of a gas pressure reducer. The invention also aims at accelerating the tuning of the predetermined outlet pressure of a known amount.

Technical solution

[0005] The invention is directed to a gas pressure reducer comprising : a body; an inlet; an outlet; a passage through the body in flow communication with the inlet and with the outlet; a seat in the passage; a closing portion cooperating with the seat for varying the cross-section of the passage and reducing the pressure; a regulating element delimiting a chamber downstream of the seat and moving the closing portion for achieving the predetermined reduced pressure at the outlet; wherein the pressure reducer further comprises: an electric actuator adapted for moving the seat along a moving direction of the closing element in order to adjust the predetermined outlet pressure.

[0006] gas pressure reducer comprising : a body; an inlet intended to be in flow communication with a high pressure gas source; an outlet intended to deliver the gas at a predetermined reduced pressure; a passage through the body in flow communication with the inlet and with the outlet; a seat; pressure setting means moving the seat; a resilient element; and a movable pressure reducing piston with a through flow path cooperating with the seat; the gas pressure regulator being configured such that the outlet pressure pushes the piston in opposite direction than the resilient element so as to close the path against the seat; wherein that the pressure setting means comprise an electric actuator which moves the movable seat along the moving direction of the piston, notably in order to set the predetermined outlet pressure .

[0007] According to a preferred embodiment, the electric actuator comprises a stepper motor.

[0008] According to a preferred embodiment, the body comprises two branches with extremities where the electric actuator is fixed.

- [0009] According to a preferred embodiment, the body comprises a cavity which is delimited by the electric actuator and which is opened outside the gas pressure reducer.
- [0010] According to a preferred embodiment, the gas pressure reducer in accordance with claim 4, wherein the cavity is a through channel, said channel possibly crossing the body perpendicularly to the inlet and/or to the outlet.
- [0011] According to a preferred embodiment, the body comprises a flow portion crossed by the gas, and an electric actuator fixing portion, said portions being separated from each other, preferably the body comprises a plate portion separating the flow portion from the fixing portion.
- [0012] According to a preferred embodiment, the electric actuator comprises a rotating electric machine and/or a leadscrew.
- [0013] According to a preferred embodiment, the electric actuator comprises a fixing element beside the body which is fixed to the seat.
- [0014] According to a preferred embodiment, the gas pressure reducer comprises a flow limiter, notably arranged at the inlet or at the outlet.
- [0015] According to a preferred embodiment, the passage comprises a flow restriction; preferentially between the inlet and the seat, and/or between the piston and the outlet.
- [0016] According to a preferred embodiment, the body comprises a flow junction between the inlet and the seat, said flow junction comprising a portion of reduced diameter forming the flow restriction.
- [0017] According to a preferred embodiment, at pressure equilibrium; the piston is at the same place with respect to the body in the open state and in the closed state.
- [0018] According to a preferred embodiment, the regulating element is a piston.
- [0019] According to a preferred embodiment, the gas pressure reducer comprises a needle forming the closing portion; said needle comprising a path crossed by the passage, preferably the closing portion is part of the regulating element.

- [0020] According to a preferred embodiment, the piston and the needle are one piece, and/or the needle comprises a tip cooperating with the seat in order to reduce the flow through its path.
- [0021] According to a preferred embodiment, the seat comprises a support portion equipped with a sealing interface able to shut off, optionally partially, the path.
- [0022] According to a preferred embodiment, the seat comprises a shaft joined to the electric actuator; preferably the body comprises a seal around said shaft.
- [0023] According to a preferred embodiment, the body comprises at least one cylindrical guiding surface, preferably two cylindrical guiding surfaces, preferably one of the two cylindrical guiding surfaces is arranged inside the other cylindrical guiding surface.
- [0024] According to a preferred embodiment, the path closes against the seat and/or opens in order to achieve a pressure reduction.
- [0025] According to a preferred embodiment, the piston is arranged in the passage.
- [0026] According to a preferred embodiment, the needle comprises an axial opening.
- [0027] According to a preferred embodiment, the path extends over the whole height of the piston.
- [0028] According to a preferred embodiment, the piston comprises an outer groove, preferably with a seal sliding in a tight fashion against the body.
- [0029] According to a preferred embodiment, the body comprises a seal, for instance an O-ring, tightly engaging with the needle.
- [0030] According to a preferred embodiment, the inlet and the outlet are remote from the setting means, and/or the outlet is axially remote from the seat, and/or the inlet axially levels the seat.
- [0031] According to a preferred embodiment, the inlet and the passage are integrally formed in the body; said body being one piece.
- [0032] According to a preferred embodiment, the gas pressure reducer comprises a lid wherein the outlet is formed; and/or the body separates the lid from the electric actuator.

- [0033] According to a preferred embodiment, with respect to flow direction, the lid comprises a converging nozzle, and/or the piston comprises a diverging nozzle, optionally said nozzles facing each other.
- [0034] According to a preferred embodiment, the channel joins two opposite faces of the body.
- [0035] According to a preferred embodiment, the piston is totally enclosed in the body.
- [0036] According to a preferred embodiment, the lead angle of the leadscrew is at most 30°, or 15° or 5°.
- [0037] According to a preferred embodiment, the flow junction comprises a downstream portion facing the seat; the inner diameter of the downstream portion is smaller than the inner diameter of the flow limiter; and/or the inner diameter of the flow limiter and the inner diameter of the downstream portion are smaller than the inner diameter of the inlet.
- [0038] According to a preferred embodiment, the flow limiter is a calibrated orifice.
- [0039] According to a preferred embodiment, the body comprises a seat chamber with a space around the seat.
- [0040] According to a preferred embodiment, the piston is separate from the seat.
- [0041] According to a preferred embodiment, the plate portion is a disc portion.
- [0042] According to a preferred embodiment, the body comprises a pressure safety line with a safety device, said line facing the seat.
- [0043] According to a preferred embodiment, the gas pressure regulator comprises a cover around the shaft.
- [0044] According to a preferred embodiment, the fixing element projects away from the external surface of the body.
- [0045] According to a preferred embodiment, the pressure setting means move the seat with respect to the body, and/or away and toward the outlet.
- [0046] According to a preferred embodiment, the resilient element biases the piston away from the seat, notably for opening the path.
- [0047] The invention is also directed to a process for leakage control in a gas supply circuit including at least one valve and a gas pressure reducer with a regulating element moving a closing portion, and an adjustable outlet

pressure to a predetermined value; wherein the gas pressure reducer includes a seat which is moved by an electric actuator, and which engages with the closing portion; the process comprising the steps of: (a) shutting off the at least one valve; then (b) detecting a gas leakage occurring in the circuit; (c) reducing the predetermined outlet pressure of the gas pressure reducer, preferably the gas pressure reducer is in accordance with the invention.

- [0048] According to a preferred embodiment, during the step (c) reducing, the predetermined outlet pressure is reduced by moving the seat of the gas pressure reducer toward the closing portion.
- [0049] According to a preferred embodiment, during the step (b) detecting, the gas leakage is measured at the inlet of the gas pressure reducer.
- [0050] According to a preferred embodiment, the gas supply circuit is a gas supply circuit of vehicle wherein the valve is upstream the gas pressure reducer, the gas supply circuit further comprising a gas storage upstream the valve, and a combustion engine of the vehicle downstream the gas pressure reducer.
- [0051] According to a preferred embodiment, the valve is a first valve, the circuit further comprising a second valve, the gas pressure reducer being arranged between said valves.

Advantages of the invention

- [0052] The invention is particularly interesting in that the tuning of the outlet pressure occurs quickly. Then in an emergency situation, the outlet pressure may be adapted correspondingly with a reduced time response. The gas pressure reducer may be integrated in a safety system with a control unit driving it automatically.
- [0053] The predetermined outlet pressure may be tuned precisely. It may be controlled dynamically, and increased or reduced of a limited amount. This may occur with a controlled acceleration, since the forces acting against the seat and the response of the electric actuator are known.
- [0054] The invention also affords to replace the electric actuator without gas lost since the passage remains isolated from the environment. The seat remains in the body and may be blocked in place during replacement or

control. Further, the position and the state of the seat may be checked from the environment.

- [0055] The seat is secured to the electric actuator. The corresponding assembly may be mounted to the body simultaneously. This solution eases the mounting step, which become safer and cost saving. Since the actuator is able to maintain the seat in place without power, energy savings are enabled. The gas pressure reducer may keep a pressure setting passively. The energising of the reducer may be reduced to the pressure setting changes.
- [0056] The invention may be involved in leakage control in a gas supply circuit. The automatic actuation of the seat

Brief description of the drawings

- [0057] Figure 1 represents a gas pressure reducer in a closed state according to a first embodiment of the invention, the seat being in a low pressure position.
- [0058] Figure 2 represents a gas pressure reducer in an open state according to the first embodiment of the invention, the seat being in a low pressure position.
- [0059] Figure 3 represents a gas pressure reducer in a closed state according to the first embodiment of the invention, the seat being in a high pressure position.
- [0060] Figure 4 represents a gas pressure reducer in an open state according to the first embodiment of the invention, the seat being set in a high pressure position.
- [0061] Figure 5 represents a vehicle including a gas supply circuit in accordance with the invention.
- [0062] Figure 6 represents a gas pressure reducer in an open state according to a second embodiment of the invention.
- [0063] Figure 7 represents a block diagram of a process for leakage control in a gas supply circuit in accordance with the invention.

Description of an embodiment

- [0064] In the following description, the word "axial" refers to the moving direction of the piston. The height is considered with respect to the moving direction of the piston. Figure 1 to 4 illustrates the gas pressure reducer according to the first embodiment of the invention.
- [0065] Figure 1 represents the gas pressure reducer 2 in the closed state. The seat is set for a low outlet pressure, for instance 3 bars. The inlet pressure may be at least 50 bars.
- [0066] The gas pressure reducer 2 comprises an inlet 4 and an outlet 6 which are in flow communication by means of a flow passage 8. The inlet 4 is plugged to a high pressure gas source (not represented). Said source may be a tank or a network supply. The inlet pressure may be at least 100 bars, or at least 200 bars. The outlet 6 may be in communication with distributing devices or a gas circuit (not represented). The outlet pressure may be at most 10 bars, or at most 3 bars. The outlet 6 is perpendicular to the inlet 4, and then an elbow is formed in the passage 8. The gas pressure reducer 2 may be used in automotive industry. It may feed a combustion engine driving a vehicle.
- [0067] The gas pressure reducer 2 comprises a body 10, for instance a main body. The passage 8 may be at least partially formed in the body 10, preferably mainly formed in the body 10. Optionally, the inlet 4 is also formed in the body 10. The outlet 6 may be formed in a lower lid 12 which may delimit the passage 8. The lid 12 is secured to the body 10 and may support several ports 14.
- [0068] The gas pressure reducer 2 comprises a seat 16 and regulating element 18 arranged in the passage 8. The seat 16 may be placed at the intersection of two elongated recesses. Their intersection may form a cavity 19 with a space around the seat 16. Said space allows a gas flow. The regulating element 18 may be a piston 18. The seat 16 is at least partially inside the passage 8. It is movable therein.
- [0069] The gas pressure reducer 2 comprises a closing portion 20 engaging with the seat 16 so as to reduce the passage 8. The adjustment of the section of the passage 8 achieves the pressure reduction. The closing portion 20

may be formed on a needle 20. The needle 20 includes a flow path 22 which is part of the passage 8. The free end of the needle 20, which is on the opposite of the regulating element's 18 main portion, faces the seat 16. The latter may be applied against the tip of the needle 20 in order to close the path 22. This limits or stops the gas flow therethrough. The closing portion 20 is driven by the regulating element 18. They may be one piece. The flow path 22 may cross the piston 18.

[0070] The piston 16 is slidably mounted in a chamber of the passage 8. It includes two opposite faces with respect to its linear sliding direction. An upper face is toward the needle 20; and the lower face, or outlet face; is toward the outlet 6. The outlet face is subjected to the outlet pressure. The outlet pressure lifts the piston 18. It pushes the piston 18 toward the seat 16. Consequently, the needle end is pressed against the seat 16. The piston 18 includes a ring seal sliding against the body 10, which may also include another seal around the needle 20. Then, a double sealing barrier is provided between the piston 18 and the body 10. The body 10 may include a tubular portion guiding the needle 20. This portion may project within the piston receiving chamber.

[0071] A resilient element 24, such as a spring, opposes the effect of the outlet pressure. It biases on the upper face of the piston 18 and abuts against the body 10. The chamber where the resilient element 24 lies may be tightly separated from the passage 8. The resilient element 24 tends to take away the needle 20 from the seat 16 in order to allow the gas flow through the path 22. Then the piston 18 is able to reduce and to regulate the outlet pressure, since said pressure closes the path 22 when said pressure is above a predetermined pressure, and open the path 22 when said pressure is below the predetermined pressure. The resilient element 24 acts against the outlet pressure. This means that the more the resilient element 24 is compressed, the higher the predetermined outlet pressure becomes.

[0072] The seat 16 may comprise a shaft 26, a support 28 and a sealing interface 30 borne by the support 28. The body 10 may comprise a seal around the seat 16, for instance around the shaft 26. The sealing interface 30 may be

produced of a non-metallic material. It may be manufactured of a polymer, such as polytetrafluoroethylene or any equivalent. It may seal the path 22. The seat 16, and peculiarly its support 28 faces the inlet 4. The seat 16 translationally moves with respect to the body 10. This sliding direction is parallel to the one of the piston 18. Then, the seat 16 may be moved toward or away from the piston 18. Due to the resilient element 24, the position of the seat 16 infers with the threshold pressure enabling or disabling the gas flow through the path 22. In this way, the predetermined pressure may be set.

[0073] The actuation of the seat 16 is controlled by an electric actuator 32 which forms pressure setting means. In response of a power supply, the electric actuator 32 moves the seat 16 toward or away from the piston 18. The electric actuator 32 may be a linear actuator. It may comprise a rotor coupled to a leadscrew. The latter converts a rotating movement into a linear movement. The leadscrew prevents the inlet pressure to force against the electric actuator 32, and prevent the seat 16 from moving. Since this result is achieved without energising the electric actuator 32, the energy consumption is reduced. As a consequence, the accuracy of the seat position is preserved. The electric actuator 32 may comprise a stepper motor, which improves the moving precision of the seat 16. Thus, the outlet pressure may be controlled in a more accurate way. The electric actuator 32 and the outlet pressure maintain a gap G between the piston 18 and the lid 12. The gap G may be measured between the lid 12 and the projections 33 of the piston 18. Said projections 33 extend from the outlet face of the piston 18 toward the lid 12.

[0074] The body 8 exhibits a flow portion where the gas pressure is reduced, and a fixing portion 34 receiving the electric actuator 32. Said portions are remote from each other. They may be separated by a plate portion of the body. This architecture prevents heat produced by the electric actuator 32 to be communicated to the gas. This avoids bursts in case of flammable gas. The fixing portion 34 may comprise one or two branches 36 where the electric actuator 32 is screwed. These branches 36 increase the cooling of the body 10, and preserve the gas.

- [0075] The branches 36 may be parallel. They are remote from each other and delimit a cavity. The cavity may be open on the environment of the gas pressure reducer 2, and may be bordered by the electric actuator 32. The cavity may be a channel 38. Said channel 38 may be in contact of the electric actuator 32 and of a cover 40 around the shaft 26. This cover 40 may optionally embrace a fixing element 42 securing the shaft 26 of the seat 16 to the electric actuator 32. The fixing element 42 is accessible through the channel 38 which crosses the body 10 from one side to the opposite side. Hence, the servicing is eased. The position and the state of the seat 16 may be freely examined.
- [0076] Optionally, the gas pressure reducer 2 may comprise a flow limiter 44. It is arranged in order to define the maximal gas flow through the gas pressure reducer, independently from the pressures. This is achieved by a regulated orifice. Vortices devices are also considered. The flow limiter may be placed at the outlet 6, or at the inlet 4. The flow limiter 44 may comprise a calibrated orifice, or a set of calibrated orifices. These calibrated orifices may be arranged on a turning disc in order to select an orifice corresponding to a desired flow.
- [0077] Figure 2 represents the gas pressure reducer 2 in the open position with the low outlet pressure.
- [0078] The electric actuator 32 has been moved upward in order to take the seat 16 from the piston 18. The path 22 is opened. The cavity 19 is less occupied. The gap G remains constant, but a space S has appeared between the needle 20 and the sealing interface 30. The latter are remote then. The space S mainly depends on the inlet pressure and on the gas flow rate. In a pressure equilibrium state, the gap G is the same as in the closed position. A transitory phase may show variations of the gap G. The gap G mainly depends on the position of the seat 16.
- [0079] Figure 3 represents the gas pressure reducer 2 in the closed position. The seat is set for a high outlet pressure, for instance 9 bars. The inlet pressure may be at least 50 bars.

- [0080] The needle 20 abuts against the seat 16 so as to close the path 22. The gap G is wider than in figures 1 and 2. The resilient element 24 is more compressed than in the previous figures.
- [0081] Figure 4 represents the gas pressure reducer 2 in the open position with the high outlet pressure.
- [0082] The electric actuator 32 has been moved upward in order to pull away the seat 16 from the piston 18. The path 22 is opened. The gap G is the same than in figure 3. Yet, the space S similar to the configuration of figure 2.
- [0083] Figure 5 represents an automotive vehicle with a gas supply circuit 46 including a gas pressure reducer 2. The engine propels the vehicle which is represented by its driving wheels 48 and by its piston engine 50. However, the gas supply circuit 46 may equip any other installation.
- [0084] The vehicle includes at least one gas storage unit 52, such as a gas cylinder. In the present case three gas storage units 52 are represented, however any other number is considered. The vehicle is equipped with a gas supply circuit 46 wherein the gas pressure reducer 2 is arranged, said gas pressure reducer 2 being in accordance with those that are described in relation with figures 1 to 4.
- [0085] The electronic control unit 54 (ECU) actuates the gas pressure reducer 2 in order to set the outlet pressure of the gas. Then, said gas is supplied to the injectors 56 of the engine 50 at a controlled pressure. The gas supply circuit 46 includes a valve 58 between the gas storage units 52 and the gas pressure reducer 2. The valve 58 may be a check valve. The circuit 46 may comprise further valves, for instance the injectors 56 may be considered as valves.
- [0086] A pressure sensor 60 is arranged between the valve 58 and the gas pressure reducer 2 in order to measure or to estimate the pressure in the pipe joining them. Then the pressure is measured at the inlet of the gas pressure reducer 2. The pressure sensor 60 may be electrically plugged to the electronic control unit 54 in order to detect leakage. For instance, a leakage is identified when the pressure measured by the pressure sensor 60 decreases whereas the valve 58 is closed. Leakage may be measured at the valve 58, or within the gas pressure reducer 2. Leakage may also be

assessed at the injectors. Additional pressure sensors may be used and connected to the electronic control unit 54 for this purpose.

- [0087] Figure 6 represents the gas pressure reducer 102 according to a second embodiment of the invention. Figure 6 keeps reference signs of the previous figures for identical or similar elements, said reference signs being increase of 100 however. Specific reference signs are used for the specific elements of this embodiment. The second embodiment is similar to the first embodiment; it substantially differs in that the body comprises a flow restriction 162. The gas pressure reducer 102 may be used in the gas supply circuit of figure 5.
- [0088] The electric actuator 132 has been powered in such a way that the piston 118 contacts the lid 112. The regulating element 118 is pushed by the seat 116 through the closing portion 120. This configuration corresponds to the setting of the lowest predetermined outlet pressure that the gas pressure reducer 102 may provide.
- [0089] The body 110 comprises a flow restriction 162. This flow restriction 162 may be formed in the flow passage 108. The flow restriction 162 may be arranged between the inlet 104 and the seat 116. It delimits the inlet 104, and may remain away from the seat 116. The flow restriction 162 may be a calibrated orifice. It may form a width reduction in the flow junction 164 between the inlet and the seat.
- [0090] Alternatively or complementary, the outlet 106 may comprise a flow restriction 162.
- [0091] Figure 7 represents a block diagram of a process for controlling leakage occurring in a gas supply circuit, for instance the gas supply circuit represented in figure 5.
- [0092] The process may include the following steps, preferentially carried out in the following order:
- [0093] (a) shutting off one or several valves of the gas supply circuit;
- [0094] (b) detecting a gas leakage occurring in the circuit;
- [0095] (c) reducing the predetermined outlet pressure of the gas pressure reducer. The process may be iterative, and may repeat the steps (a) to (c) continuously.

- [0096] During step (b) detecting, leakages may be continuously monitored. This is checked in spite of closed state of the valves in the circuit. Detection may be achieved by measuring pressure at several points of the gas supply circuit. It is also considered to use pressure sensors on injectors or in the injection line of the engine. Other sensors may be used to identify fluid losses.
- [0097] At step (c) reducing, the predetermined outlet pressure of the gas is reduced by means of the gas pressure reducer. Since it is equipped with an adjustable seat, the latter is activated by the electric actuator. The seat is moved toward the piston, such as reducing the biasing effect of the resilient element. Consequently, the counter effect of the outlet pressure acting on the piston may be lower in order to seal it against the seat. Then, the gas pressure reducer may also be used to automatically control gas leakage. The gas losses of a vehicle are controlled in a convenient manner.

REVENDEICATIONS

1. Réducteur de pression de gaz comprenant:

- un corps (10; 110);
- une entrée (4; 104);
- une sortie (6; 106);
- un passage (8; 108) au travers du corps (10; 110), en communication fluidique avec l'entrée (4; 104) et avec la sortie (6; 106);
- un siège (16; 116) dans le passage;
- une portion de fermeture (20; 120) coopérant avec le siège (16; 116) pour modifier la section du passage (8; 108) et pour réduire de la pression;
- un élément de régulation (18; 118) délimitant une chambre en aval du siège et déplaçant la portion de fermeture (20; 120) pour atteindre une pression réduite prédéterminée en sortie;

caractérisé en ce que le réducteur de pression comprend en outre:

- un actionneur électrique (32; 132) adapté pour déplacer le siège (16; 116) le long d'une direction de déplacement de la portion de fermeture (20; 120) afin d'ajuster la pression de sortie prédéterminée.

2. Réducteur de pression de gaz (2; 102) selon la revendication 1, caractérisé en ce que l'actionneur électrique (32; 132) comprend un moteur pas à pas.

3. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 2, caractérisé en ce que le corps (10; 110) comprend deux branches (36) avec des extrémités où l'actionneur électrique (32; 132) est fixé.

4. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 3, caractérisé en ce que le corps (10; 110) comprend une cavité qui est délimitée par l'actionneur électrique (32; 132) et qui est ouverte à l'extérieur du réducteur de pression de gaz (2; 102).

5. Réducteur de pression de gaz (2; 102) selon la revendication 4, caractérisé en ce que la cavité est un canal traversant (38), ledit canal (38) traversant éventuellement le corps (10; 110) perpendiculairement à l'entrée (4; 104) et/ou à la sortie (6; 106).

6. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 5, caractérisé en ce que le corps (10; 110) comprend une portion d'écoulement traversée par le gaz, et une portion de fixation de l'actionneur électrique (32; 132), lesdites portions étant séparées l'une de l'autre, préférentiellement le corps (10; 110) comprend une portion en forme de plaque qui sépare la portion d'écoulement de la portion de fixation.

7. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 6, caractérisé en ce que l'actionneur électrique (32; 132) comprend une machine électrique tournante et/ou une vis sans fin.

8. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 7, caractérisé en ce que l'actionneur électrique (32; 132) comprend un élément de fixation (42) à côté du corps (10; 110) et qui est fixé au siège (16; 116).

9. Réducteur de pression de gaz (2) selon l'une quelconque des revendications 1 à 8, caractérisé en ce qu'il comprend un limiteur de débit (44), notamment disposé à la sortie (6).

10. Réducteur de pression de gaz (2) selon la revendication 9, caractérisé en ce que le limiteur de débit (44) comprend un orifice calibré.

11. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 10, caractérisé en ce que l'élément de régulation est un piston (18; 118).

12. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 11, caractérisé en ce qu'il comprend une aiguille (20; 120) formant la portion de fermeture (20; 120), ladite aiguille comprenant une voie (22) traversée par le passage (8; 108), préférentiellement la portion de fermeture (20; 120) fait partie de l'élément de régulation (18; 118).

13. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 12, caractérisé en ce que le siège (16; 116) comprend une portion support (28) équipée d'une interface d'étanchéité (30) adaptée pour couper, optionnellement partiellement, la voie (22).

14. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 13, caractérisé en ce que le siège (16; 116) comprend un arbre (26) relié à l'actionneur électrique (32; 132); préférentiellement le corps (10; 110) comprend un joint d'étanchéité autour dudit arbre (26).

15. Réducteur de pression de gaz (2; 102) selon l'une quelconque des revendications 1 à 14, caractérisé en ce que le corps (10; 110) comprend au moins une surface cylindrique de guidage, préférentiellement deux surfaces de guidage cylindriques, préférentiellement l'une des deux surfaces de guidage cylindrique est disposée à l'intérieur de l'autre surface de guidage cylindrique.

16. Procédé de contrôle des fuites dans un circuit d'alimentation en gaz (46) comprenant au moins une vanne (58), et un réducteur de pression de gaz (2; 102) avec un élément de régulation (18; 118) déplaçant une portion de fermeture (20; 120), et une pression de sortie réglable à une valeur prédéterminée; caractérisé en ce que le réducteur de pression de gaz (2; 102) comprend un siège (16; 116) qui est déplacé par un actionneur électrique (32; 132), et qui coopère avec la portion de fermeture (20; 120);

le procédé comprenant les étapes :

- (a)- obturation (200) de la au moins une vanne (58); puis
- (b)- détection (202) d'une fuite de gaz se produisant dans le circuit (46);
- (c)- réduction (204) de la pression de sortie prédéterminée du réducteur de pression de gaz (2; 102), de préférence le réducteur de pression de gaz (2; 102) est selon l'une quelconque des revendications 1 à 15.

17. Procédé selon la revendication 16, caractérisé en ce que lors de l'étape (c) réduction (204), la pression de sortie prédéterminée est réduite en déplaçant le siège (16; 116) du réducteur de pression de gaz (2; 102) vers la portion de fermeture (20; 120).

18. Procédé selon l'une quelconque des revendications 16 à 17, caractérisé en ce que lors de l'étape (b) détection (202), la fuite de gaz est mesurée à l'entrée du réducteur de pression de gaz (2; 102).

19. Procédé selon l'une quelconque des revendications 16 à 18, caractérisé en ce que le circuit d'alimentation en gaz (46) est un circuit d'alimentation en gaz (46) de

véhicule, dans lequel la vanne (58) se trouve en amont du réducteur de pression de gaz (2; 102), le circuit d'alimentation en gaz (46) comprenant en outre un réservoir de gaz (52) en amont de la vanne (58), et un moteur à combustion (50) du véhicule en aval du réducteur de pression de gaz (2; 102).

20. Procédé selon l'une quelconque des revendications 16 à 19, caractérisé en ce que la vanne est une première vanne (58), le circuit comprenant en outre une deuxième vanne (56), le réducteur de pression de gaz (2; 102) étant disposé entre lesdites vannes (56; 58).

FIG. 1

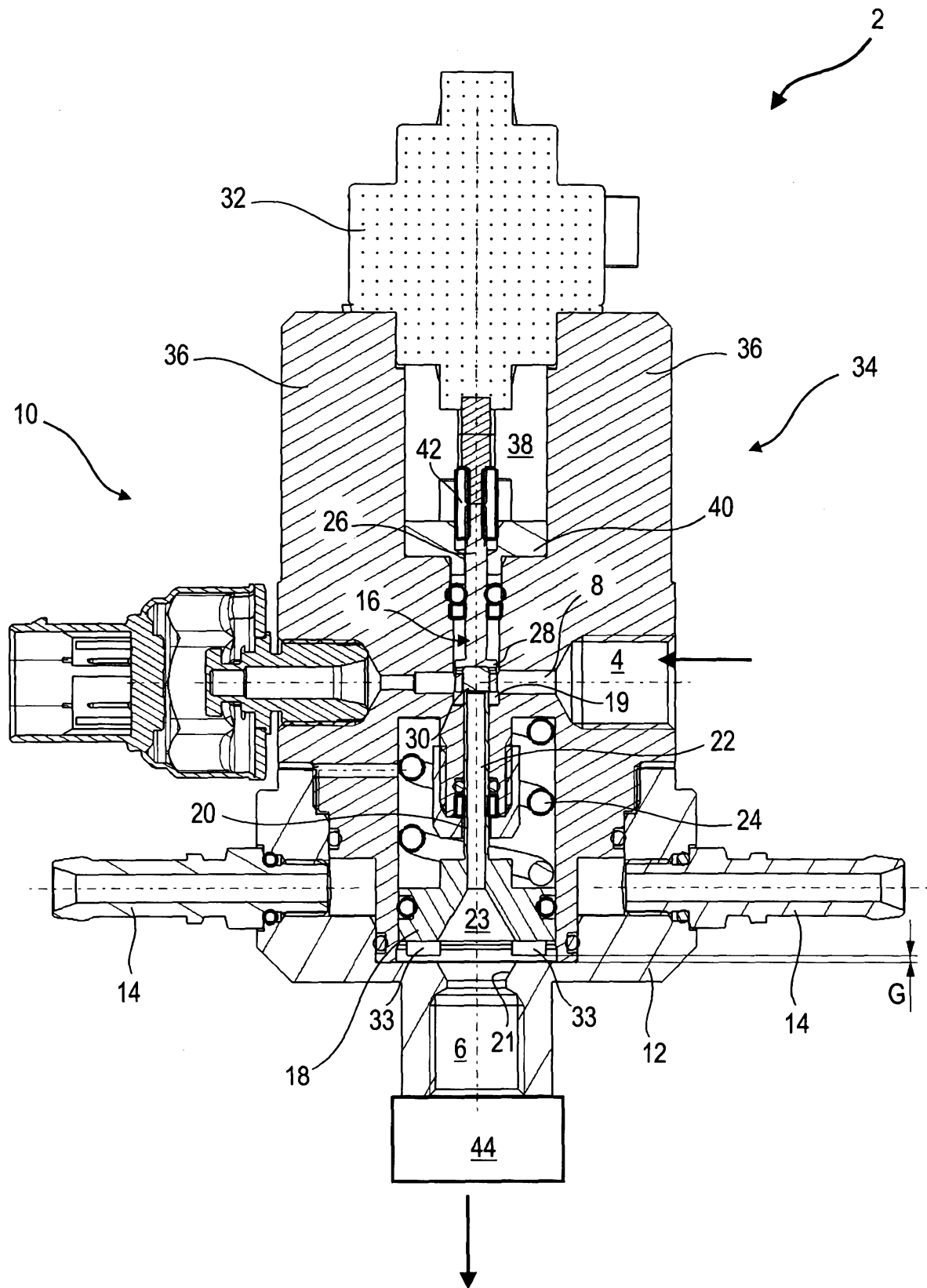


FIG. 2

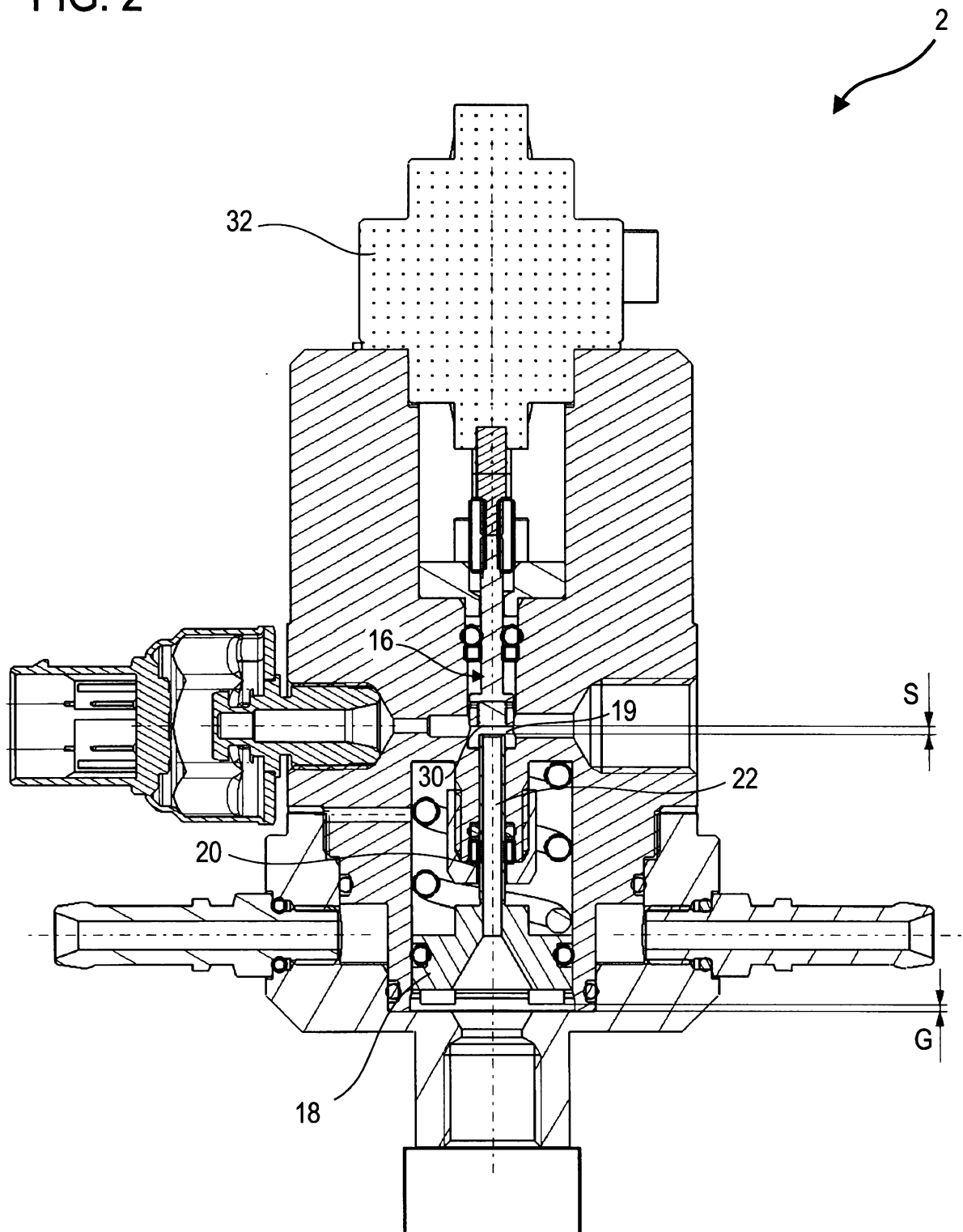


FIG. 3

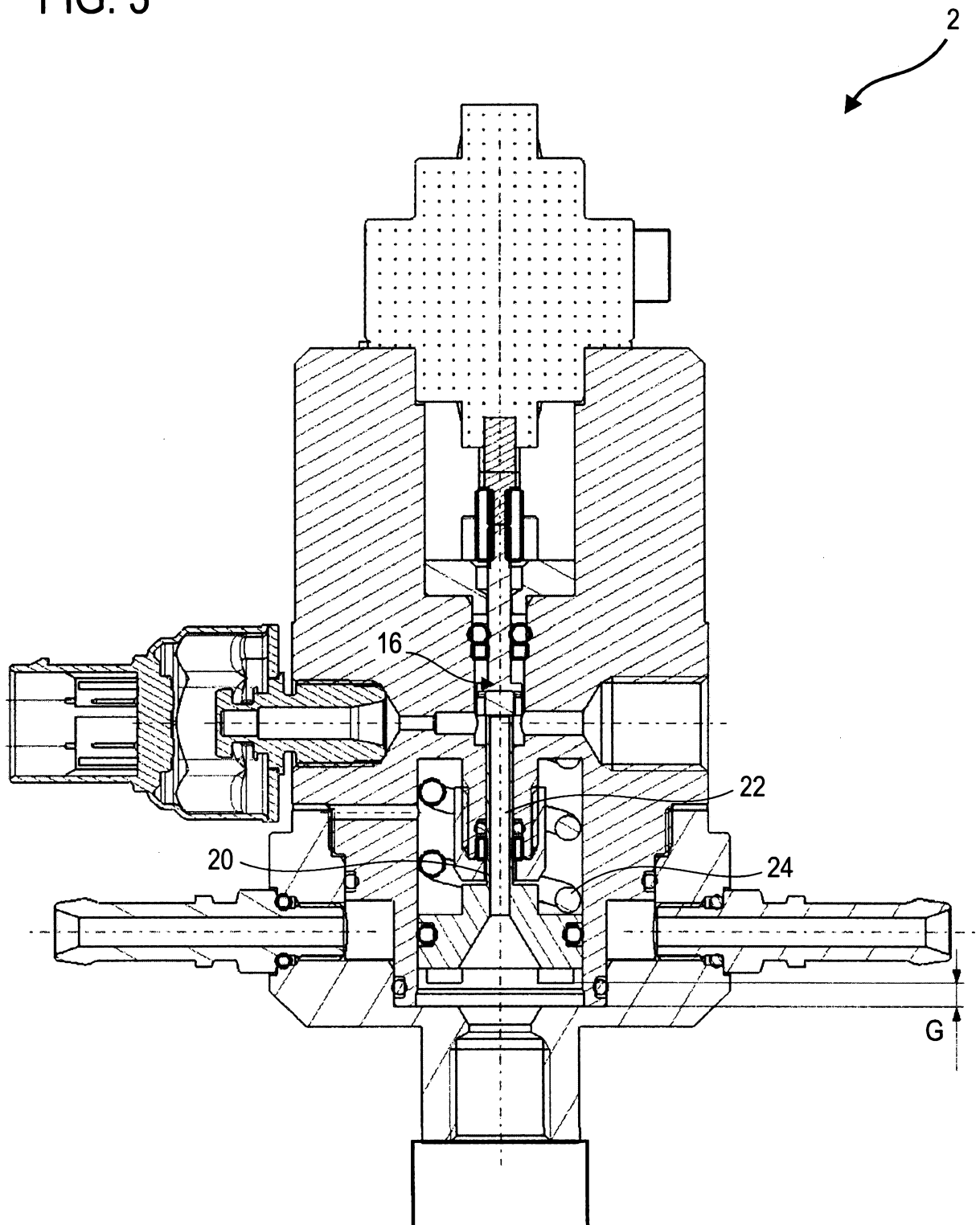


FIG. 4

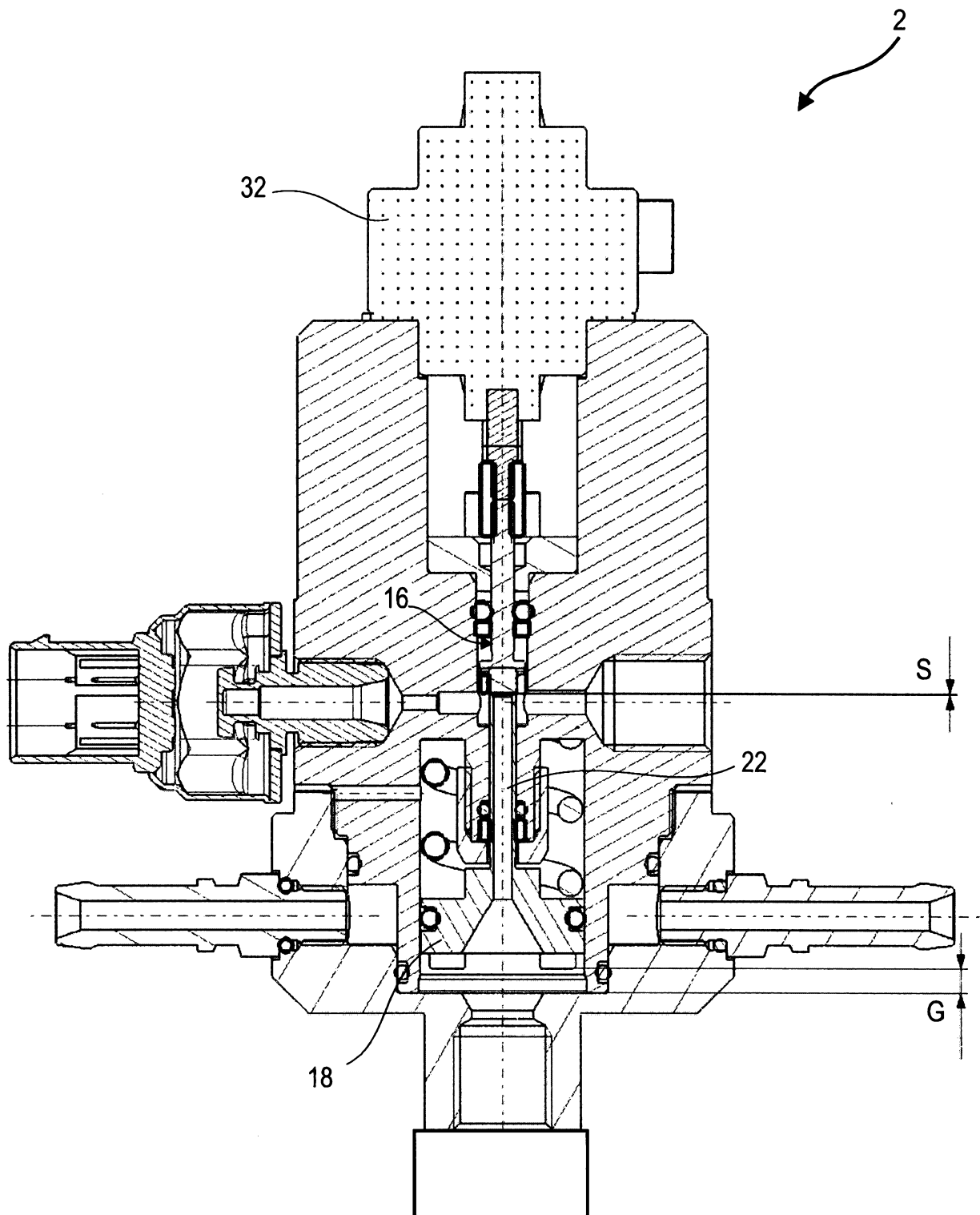


FIG. 5

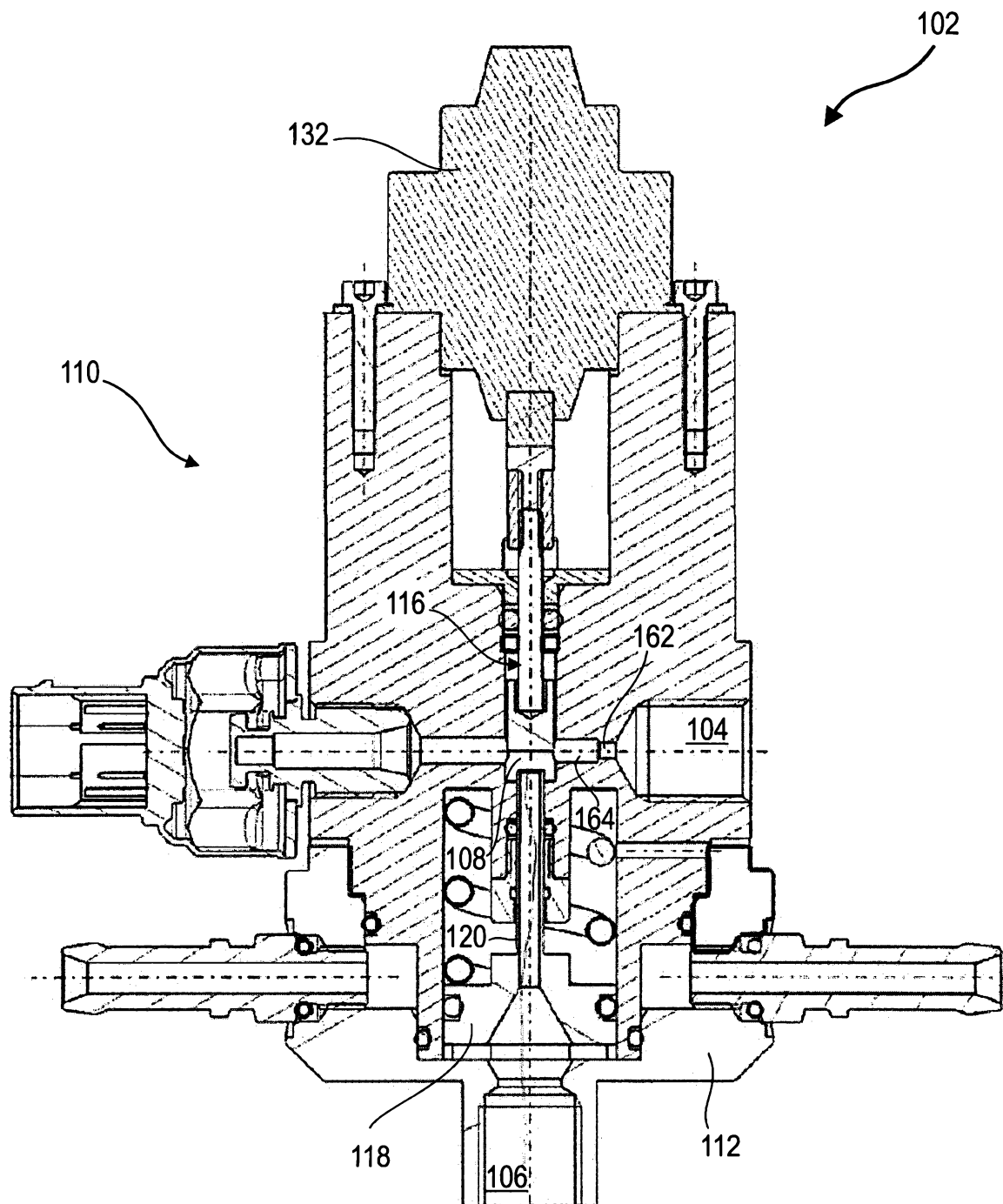


FIG. 6

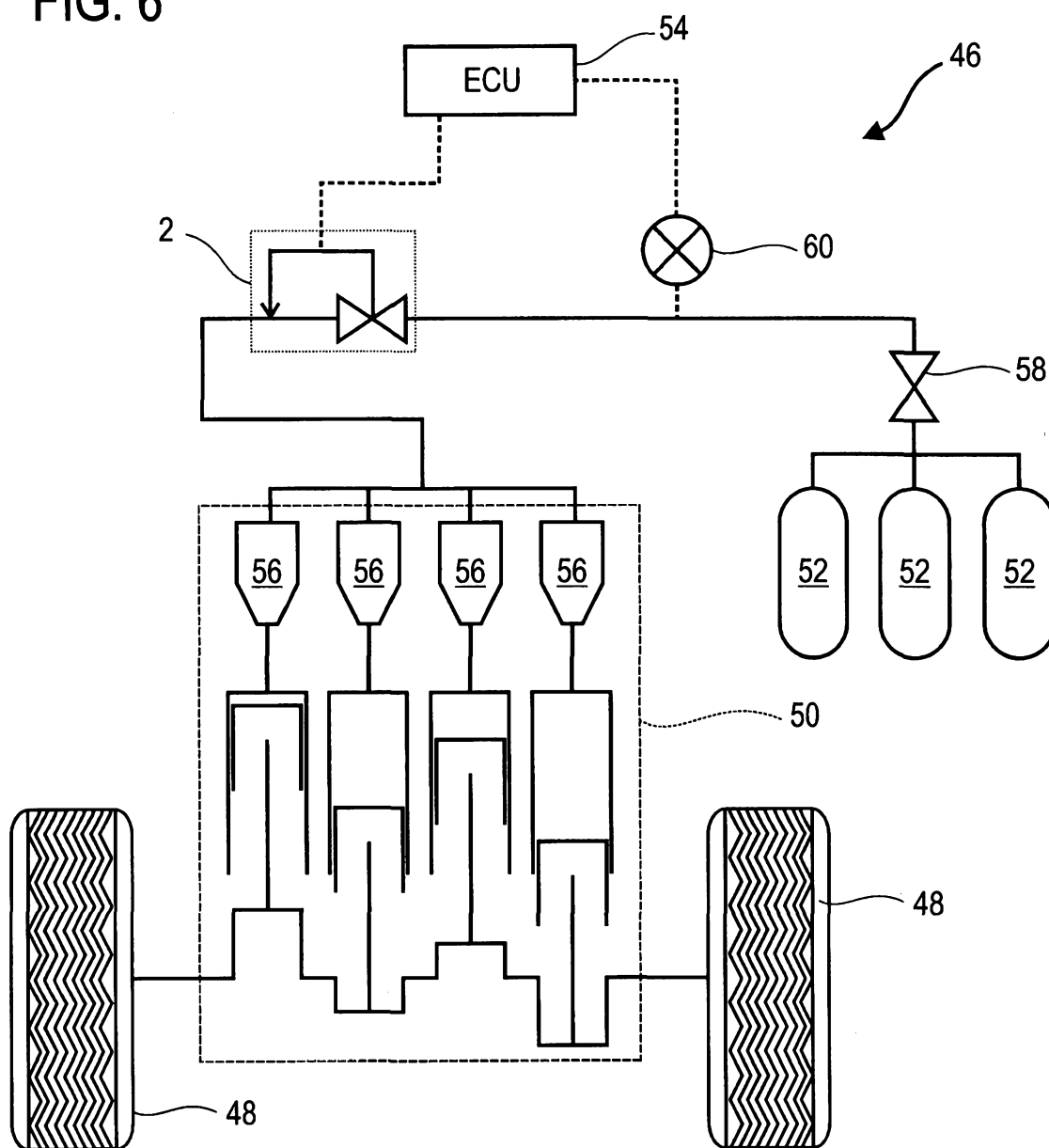
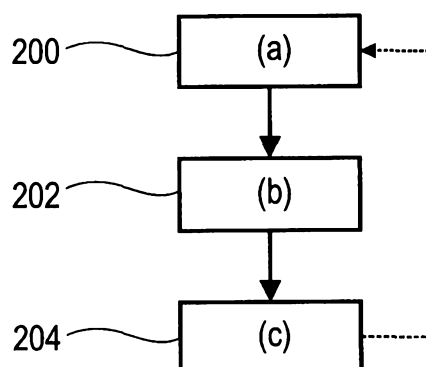


FIG. 7



Abstract**GAS PRESSURE REDUCER WITH PISTON AND ADJUSTING SEAT**

The invention is directed to a gas pressure reducer (2) comprising a body (10) with an inlet (4) intended to be in flow communication with a high pressure gas source; an outlet (6) intended to deliver the gas at a predetermined low pressure; a passage (8) through the body (10) in flow communication with the inlet (4) and with the outlet (6). A resilient element (24) engages with a pressure reducing piston (18) with a through flow path (22) formed by a needle (20). The needle (20) cooperates with a movable seat (16). The outlet pressure acts on the piston (18) in opposite direction than the spring (24) so as to urge the path (22) against the seat (16) in order to reduce the gas flow through the path (22). Pressure setting means comprise an electric actuator (32), such as a stepper motor, which moves the seat (16) along the moving direction of the piston (18) in order to set the predetermined outlet pressure.

(Figure 1)



SEARCH REPORT
in accordance with Article 35.1 a)
of the Luxembourg law on patents
dated 20 July 1992

LO 1285
LU 92967

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
	LACK OF UNITY OF INVENTION see sheet B -----		INV. G05D16/10 G05D16/20
Y	US 2004/200531 A1 (ZUCK JAMES C [US]) 14 October 2004 (2004-10-14) * the whole document *	1-15	

Y	DE 34 05 954 A1 (KLOECKNER HUMBOLDT DEUTZ AG [DE]) 17 October 1985 (1985-10-17) * the whole document *	1-15	

Y	US 2004/221894 A1 (HENLEY JASON S [US] ET AL) 11 November 2004 (2004-11-11) * paragraphs [0024] - [0030]; figure 4 *	1-15	

Y	WO 2015/128690 A1 (ZODIAC AEROTECHNICS [FR]) 3 September 2015 (2015-09-03) * page 1, line 1 - page 4, line 26 * * page 6, line 13 - page 9, line 31; figures 1a,1b *	1-15	

			TECHNICAL FIELDS SEARCHED (IPC)
			G05D
The present search report has been drawn up for all claims			
Date of completion of the search		Examiner	
25 October 2016		Vaño Gea, Joaquín	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

LACK OF UNITY OF INVENTION
SHEET B

Application Number

LO 1285
LU 92967

The Search Division considers that the present patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-15

Gas pressure reducer comprising an adjustable seat, as disclosed in D1 (see paragraphs [0023] and [0025]-[0027] and figure 1), characterised in the use of an electric actuator for the adjustment.

2. claims: 16-20

Process for leakage control in a gas supply circuit comprising the steps of shutting off a valve, detecting a gas leakage and reducing the predetermined outlet pressure of a gas pressure reducer. Such an adjustable gas pressure reducer is commonly known in the art, for example from D1. The feature that said pressure reducer is in accordance with any of claims 1 to 15 is merely optional ("preferably").

The search has been limited to the first subject.

**ANNEX TO THE SEARCH REPORT
ON LUXEMBOURG PATENT APPLICATION NO.**

LO 1285
LU 92967

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-10-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004200531 A1	14-10-2004	NONE	
DE 3405954 A1	17-10-1985	NONE	
US 2004221894 A1	11-11-2004	NONE	
WO 2015128690 A1	03-09-2015	CA 2938738 A1	03-09-2015
		CN 106029177 A	12-10-2016
		WO 2015128690 A1	03-09-2015



WRITTEN OPINION

File No. LO1285	Filing date (day/month/year) 02.02.2016	Priority date (day/month/year)	Application No. LU92967
International Patent Classification (IPC) INV. G05D16/10 G05D16/20			
Applicant LUXEMBOURG PATENT COMPANY S.A.			

This report contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☒ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

Form LU237A (Cover Sheet) (January 2007)	Examiner Vaño Gea, Joaquín
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WRITTEN OPINION

Application No.

LU92967

Box No. I Basis of the opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the application as filed.
 - ☐ filed together with the application in electronic form.
 - ☐ furnished subsequently.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

WRITTEN OPINION

Application No.

LU92967

Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step, or to be industrially applicable have not been examined in respect of

☐ the entire application

☒ claims Nos. 16-20

because:

☐ the said application, or the said claims Nos. relate to the following subject matter which does not require a search (*specify*):

☐ the claims, the description or the drawings or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed (*specify*):

☒ no search report has been established for the whole application or for said claims Nos. 16-20

☐ a meaningful opinion could not be formed as the sequence listing was either not available, or was not furnished in the international format (WIPO ST25).

☐ a meaningful opinion could not be formed without the tables related to the sequence listings; or such tables were not available in electronic form compliant with the international norm (WIPO ST.25).

☐ See Supplemental Box for further details

Box No. IV Lack of unity of invention

1. The requirement of unity of invention is not complied with for the following reasons:

see separate sheet

2. This opinion has been established in respect of the following parts of the application:

☐ all parts.

☒ the parts relating to claims Nos. (see Search Report)

WRITTEN OPINION

Application No.

LU92967

Box No. V Reasoned statement with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-15
	No: Claims	
Inventive step	Yes: Claims	
	No: Claims	1-15
Industrial applicability	Yes: Claims	1-15
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the application

The following defects in the form or contents of the application have been noted:

see separate sheet

Re Item IV

Lack of unity of invention

- 1 Reference is made to the following documents:

D1 US 2004/200531 A1 (ZUCK JAMES C [US]) 14 October 2004

D2 DE 34 05 954 A1 (KLOECKNER H DEUTZ AG [DE]) 17 October 1985
- 2 It is considered that there are 2 inventions covered by the claims indicated as follows:

Claims: 1-15

Define a gas pressure reducer comprising an adjustable seat, as disclosed in D1 (see item V below), characterised in the use of an electric actuator for the adjustment.

Claims: 16-20

Define a process for leakage control in a gas supply circuit comprising the steps of shutting off a valve, detecting a gas leakage and reducing the predetermined outlet pressure of a gas pressure reducer. Such an adjustable gas pressure reducer is commonly known in the art, for example from D1. The feature that said pressure reducer is in accordance with any of claims 1 to 15 is merely optional ("preferably").
- 3 In view of the prior art according to document D1, the mentioned inventions lack a **posteriori** a single technical feature in common that would define a contribution over the prior art. The two inventions provide different solutions to the two different technical **problems** of providing automatic adjustment of a gas pressure reducer and of controlling leakage in a gas supply circuit, respectively. Therefore, the two inventions lack a single general inventive concept that would link them.

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1 The present application does not meet the criteria of patentability, because the subject-matter of claims **1-15** does not involve an **inventive step**.

- 2 Document **D1**, which is considered to represent the most relevant state of the art for independent claim **1**, discloses a gas pressure reducer 10 comprising (D1, figure 1):
- a. a body 12;
 - b. an inlet 40;
 - c. an outlet 84;
 - d. a passage 38 through the body in flow communication with the inlet and with the outlet;
 - e. a seat 96 in the passage;
 - f. a closing portion 56 cooperating with the seat for varying the cross-section of the passage and reducing the pressure;
 - g. a regulating element 50 delimiting a chamber downstream of the seat and moving the closing portion for achieving the predetermined reduced pressure at the outlet (D1, paragraph [0023]); [and]
 - h. an ... actuator 120 adapted for moving the seat along a moving direction of the closing element in order to adjust the predetermined outlet pressure (D1, paragraphs [0025]-[0027]).

from which the subject-matter of claim 1 only **differs** in that:

the actuator is an electric actuator.

The **problem** to be solved by the present invention may therefore be regarded as to:

allow automatic adjustment of the predetermined outlet pressure

However, document **D2** discloses a similar gas pressure regulator comprising an electric actuator for automatic adjustment of the predetermined pressure, see abstract and figure 1.

It would be **obvious** to the person skilled in the art, namely when the same result is to be achieved, to use the electric actuator of D2 to automatically adjust the predetermined outlet pressure in the gas pressure reducer according to document D1, thereby arriving at the subject-matter of claim 1.

The subject-matter of claim 1 does therefore not involve an **inventive step**.

- 3 The additional features of dependent claims **2-8** are already known from document D2, see the passages cited above. Likewise, the additional features of dependent claims **11-15** are already known from document D1,

see the passages cited above. Consequently, the subject-matter of said claims lacks an **inventive step** for the same reasons as already set out with respect to claim 1.

- 4 The additional features of dependent claims **9-10** define only slight constructional changes which come within the scope of the customary practice followed by persons skilled in the art, especially as the advantages thus achieved can readily be foreseen.

Re Item VII

Certain defects in the application

- 1 The relevant background art disclosed in the documents **D1 and D2** is not mentioned in the description, nor are these documents identified therein.
- 2 Paragraph [0083] of the description refers to figure 5 instead of to figure 6 apparently by mistake, whereas paragraph [0087] of the description refers to figure 6 instead of to figure 5 also apparently by mistake