



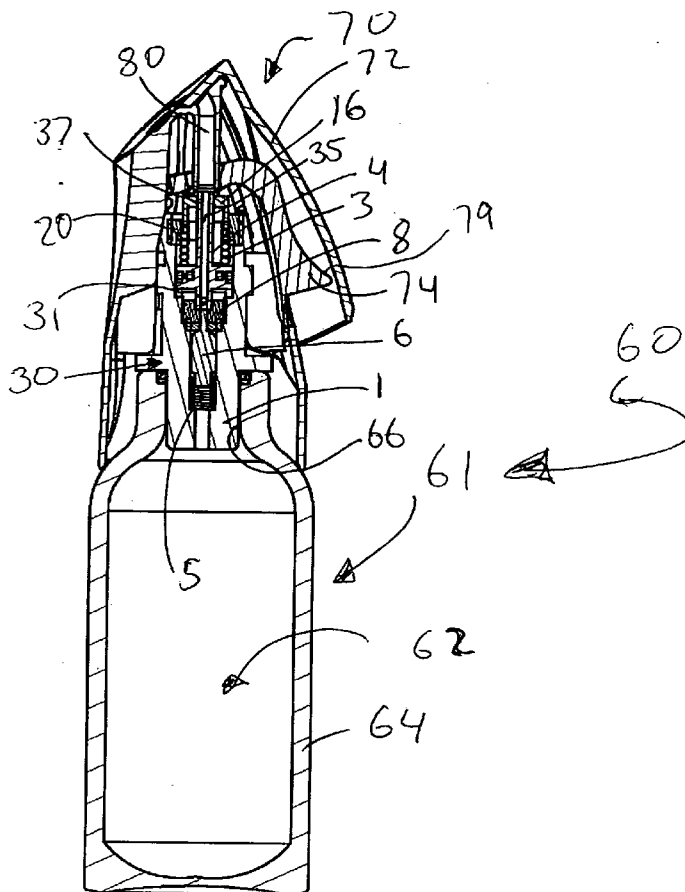
US 20050167453A1

(19) **United States**(12) **Patent Application Publication**
Brownlie(10) **Pub. No.: US 2005/0167453 A1**(43) **Pub. Date: Aug. 4, 2005**(54) **APPARATUS AND METHOD FOR
DISPENSING AND REFILLING HIGHLY
PRESSURIZED GASES**(52) **U.S. Cl. 222/399**(75) **Inventor: Joshua Lockhart Brownlie, Hong
Kong (HK)**(57) **ABSTRACT**

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(73) **Assignee: Eagle Beijing Investments Limited**(21) **Appl. No.: 11/046,460**(22) **Filed: Jan. 28, 2005****Related U.S. Application Data**(60) **Provisional application No. 60/540,740, filed on Jan.
30, 2004.****Publication Classification**(51) **Int. Cl.⁷ B65D 83/00; B65D 83/06;
B65D 83/14**

An apparatus (60) for dispensing gas stored in a highly pressurized container (61) and then refilling the container (61) with more gas. The apparatus includes a regulator (30) that in turn includes a first valve assembly (5, 6, 7, 8) on a first gas flow path to permit the flow of gas from the container (61) into the regulator (30) and to maintain a substantially constant output gas pressure or speed, regardless of the internal pressure of the highly pressurized gas container (61). The regulator (30) also includes a second valve assembly (2, 13, 17, 18, 19) on a second gas flow path to refill the container (61) with highly pressurized gas and to seal the second gas flow path at times when the container (61) needs not be refilled. The over-pressure relief mechanism (9, 10, 11, 12) of the regulator (30) releases gas from the highly pressurized container (61) in response to a condition where the internal pressure of the container (61) exceeds one and two thirds of the maximum internal pressure of the container (61).



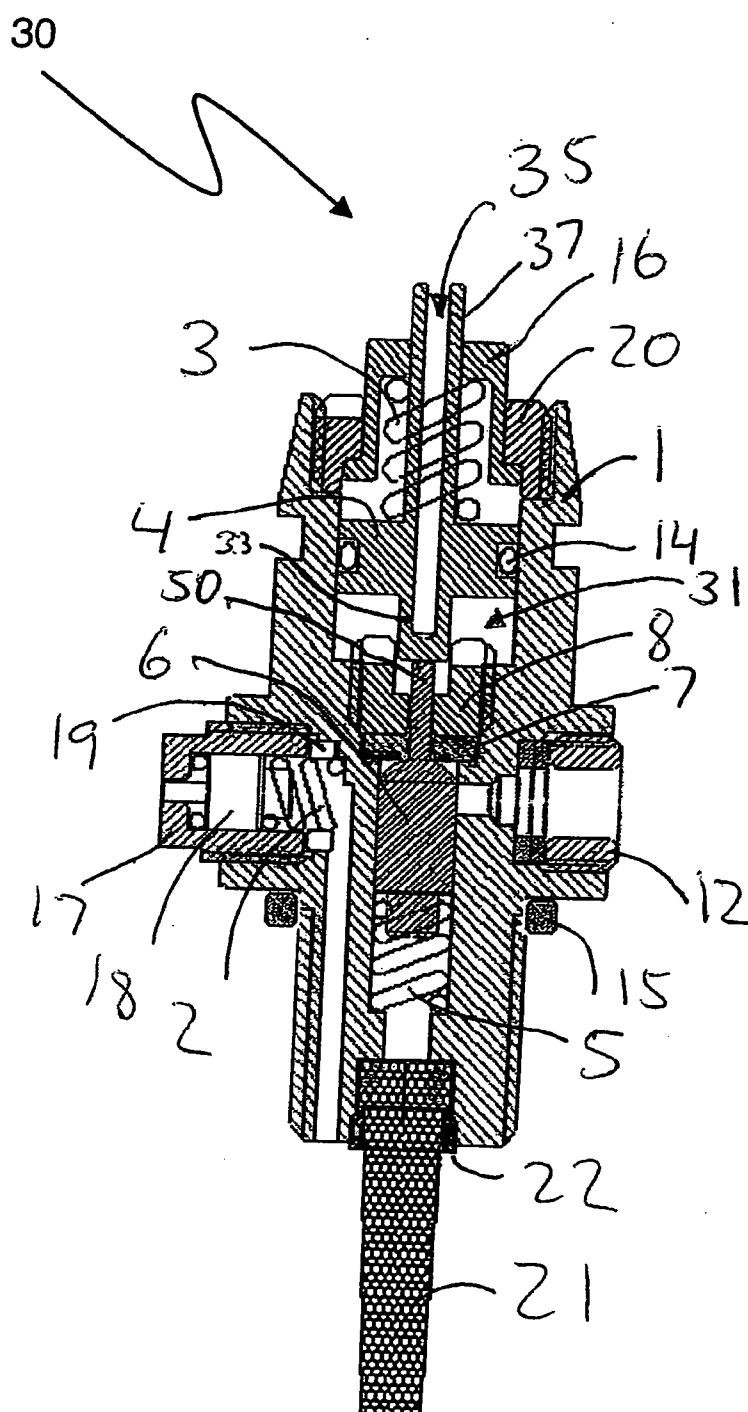


Figure 1

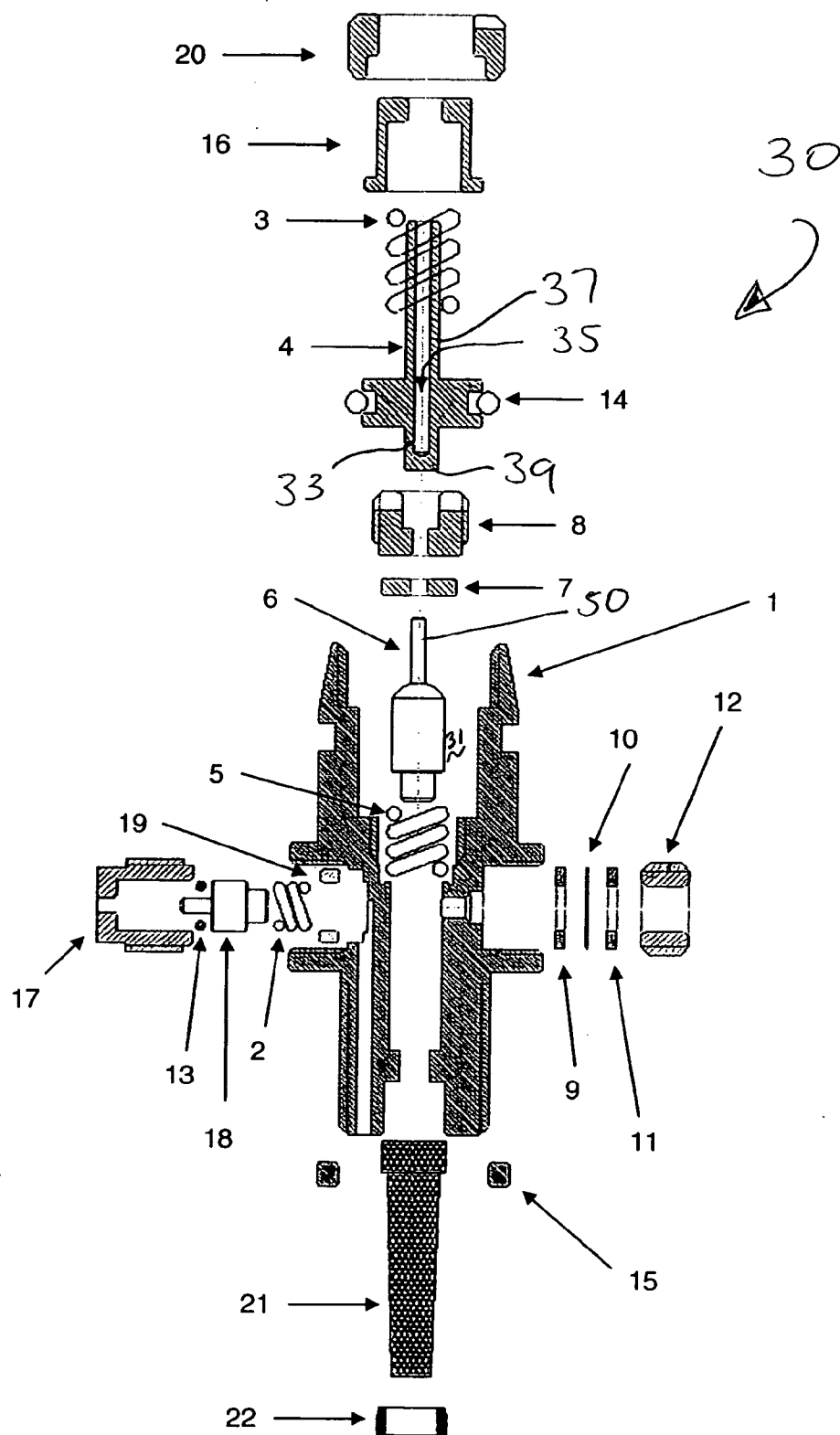


Figure 2

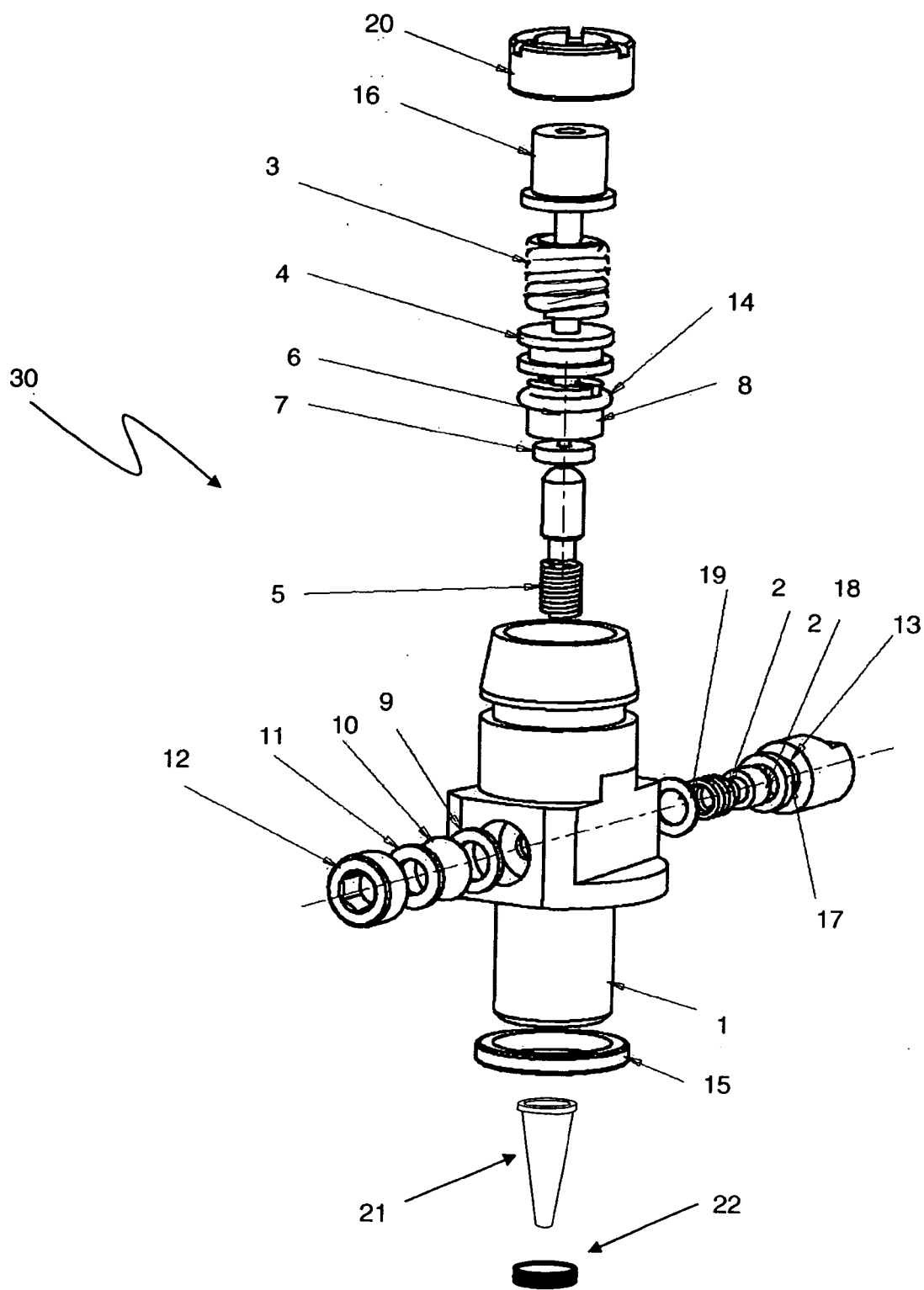


Figure 3

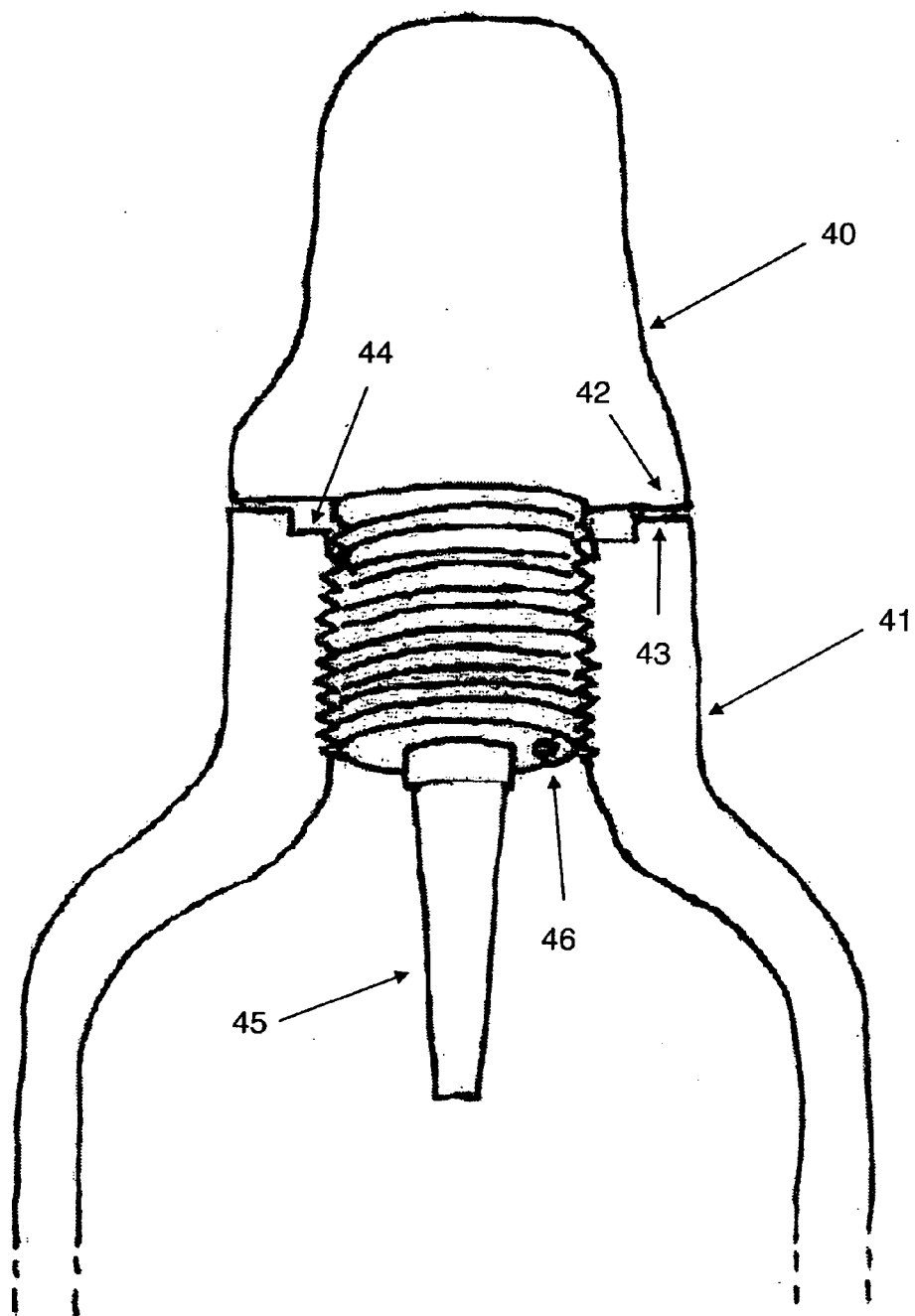


Figure 4

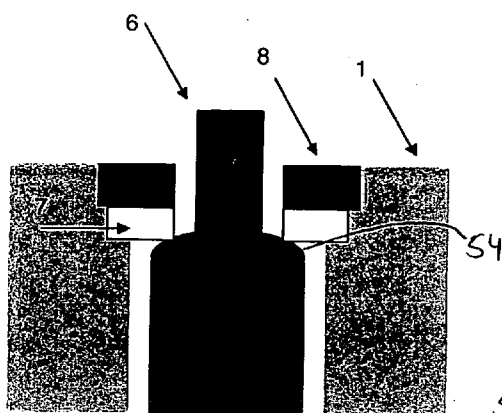


Figure 5a

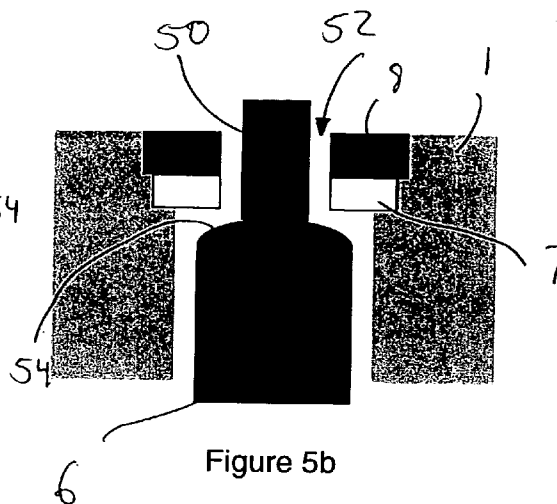


Figure 5b

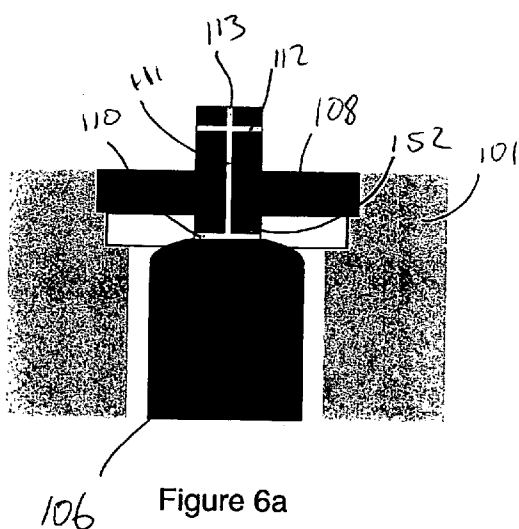


Figure 6a

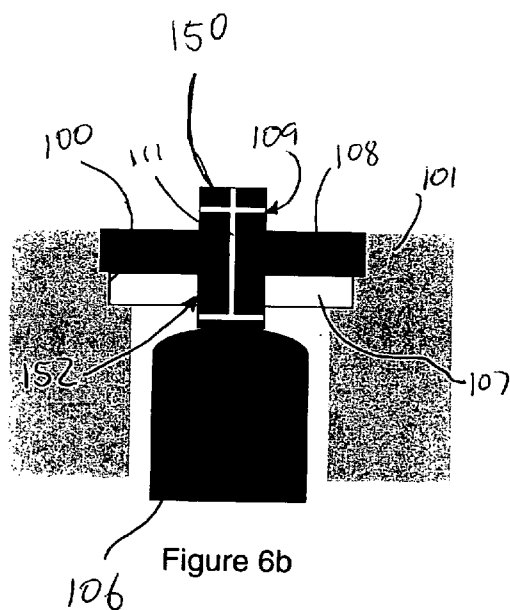
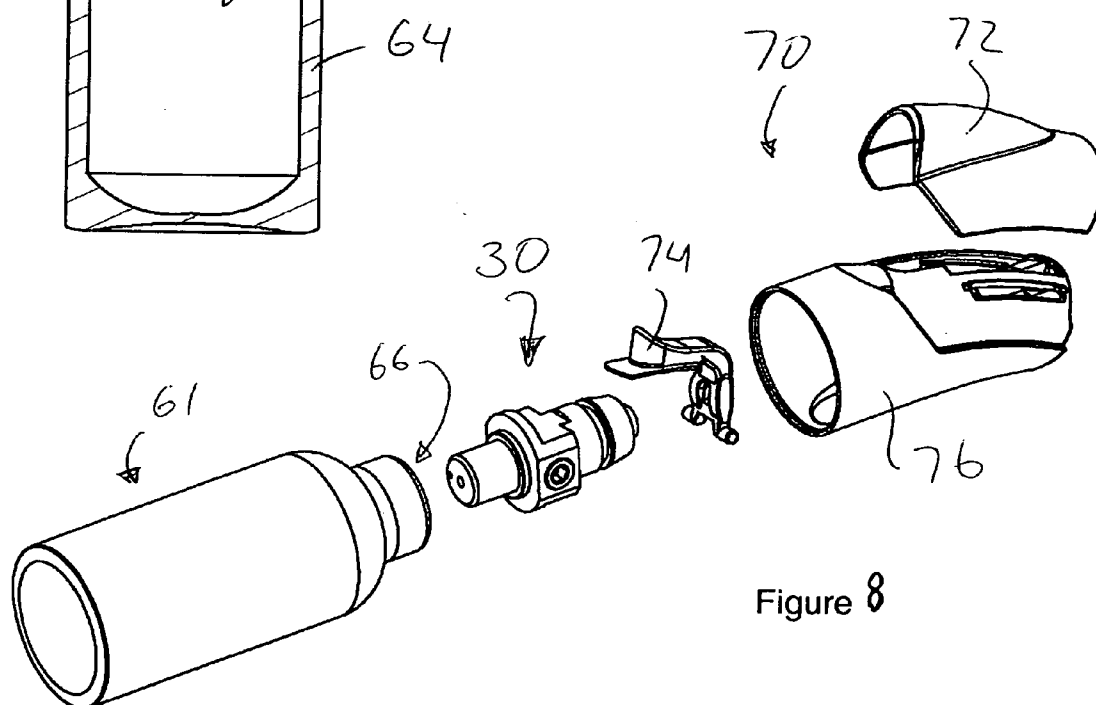
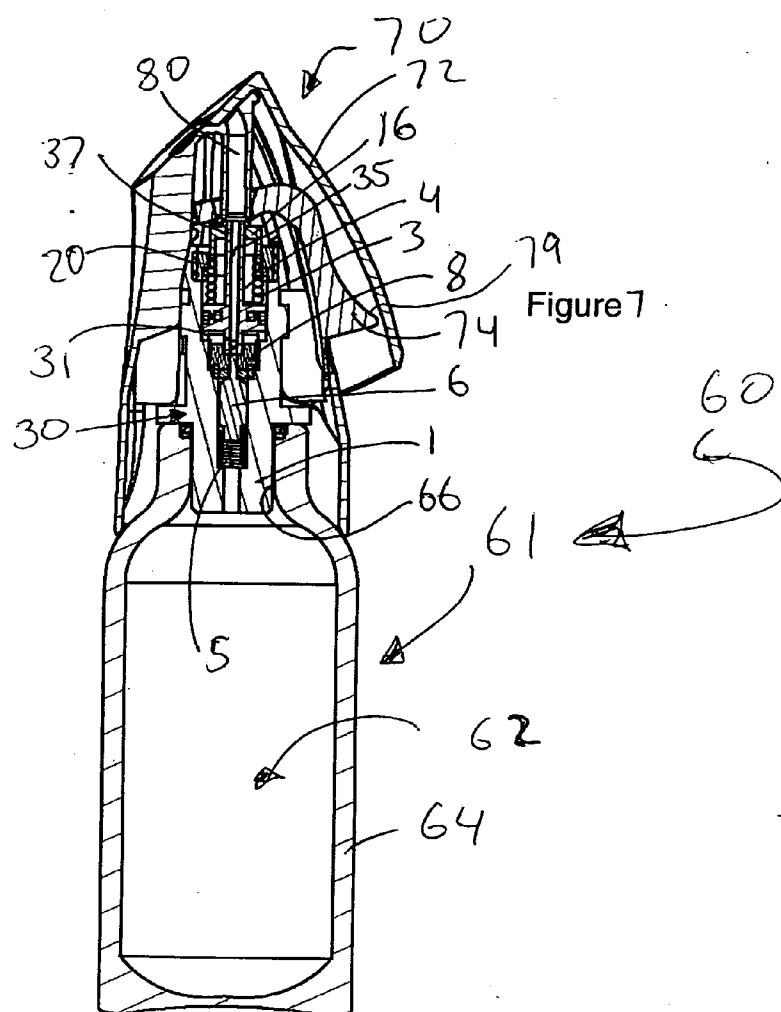


Figure 6b



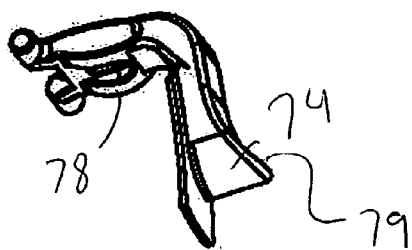
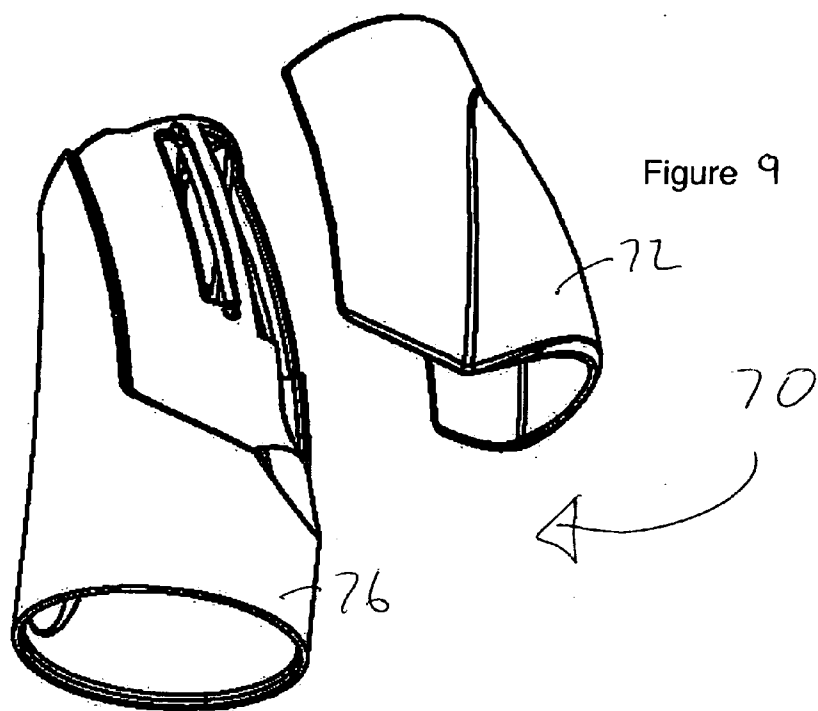
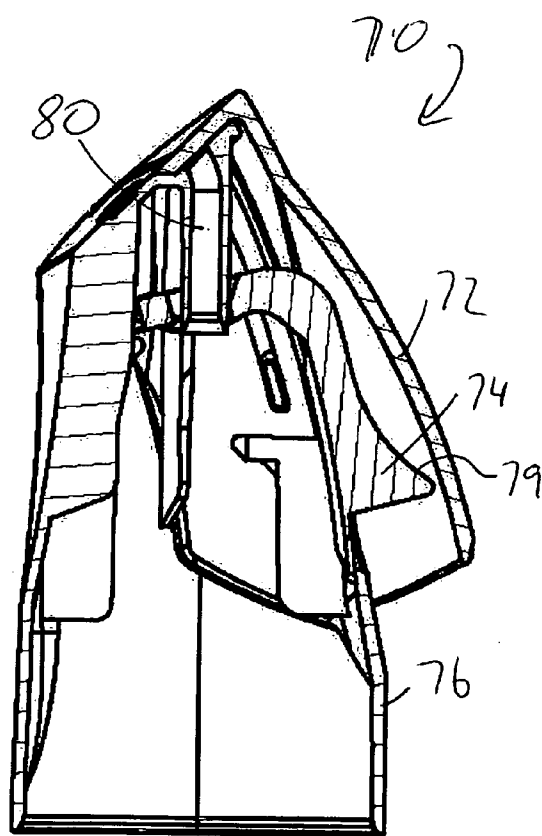


Figure 10



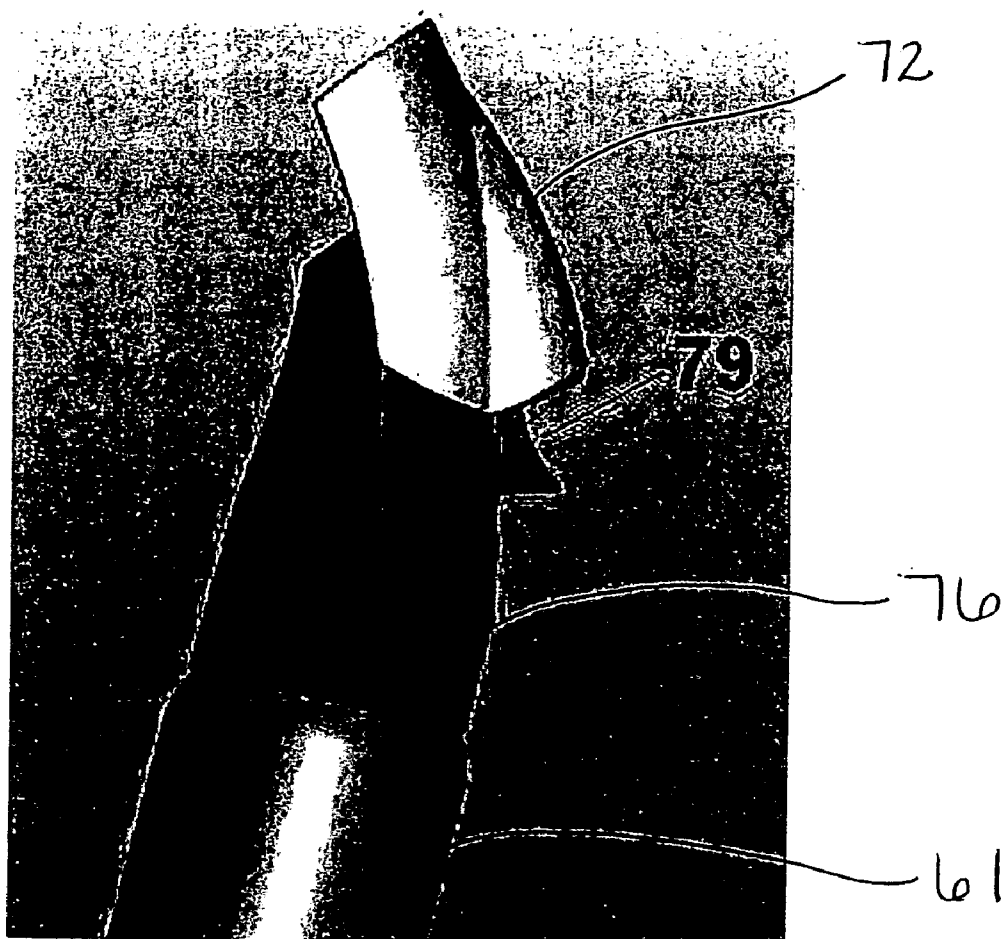


Fig. 11

APPARATUS AND METHOD FOR DISPENSING AND REFILLING HIGHLY PRESSURIZED GASES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority pursuant to 35 U.S.C. § 119(e) from provisional application No. 60/540,740 filed Jan. 30, 2004 and hereby fully incorporates the provisional application herein by reference.

TECHNICAL FIELD

[0002] The present invention generally relates to a unit for dispensing gas from a gas container and refilling the gas container, and in particular relates to an oxygen dispensing unit for use in dispensing oxygen for consumption from a high pressure container and for use in refilling the container with oxygen for consumption.

BACKGROUND

[0003] In producing a container and dispenser for gases, it is necessary to provide a dispensing unit or regulator to regulate egress of gas from a high pressure within the container to a lower pressure outside of the container. The dispensing unit or regulator must satisfy all relevant regulatory requirements including safety requirements, and at the same time preferably is lightweight, portable and inexpensive. Further, to allow re-use of the container, the dispensing unit or regulator preferably provides for convenient refilling of the container.

[0004] Where the gas is for human consumption, such as oxygen for those who are at high altitude, or otherwise desire supplemental oxygen, suitable mechanisms must be in place to ensure the oxygen is safe for human consumption. Furthermore, pure oxygen vigorously accelerates combustion and necessitates careful device design to avoid the risk of accidental ignition.

[0005] While demand exists for a highly portable oxygen dispensing device, providing a gas dispensing or regulating unit which satisfies all these requirements has proved difficult.

[0006] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

[0007] Throughout this specification the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

SUMMARY OF THE INVENTION

[0008] According to a first aspect, the present invention provides a regulator for providing a substantially constant outlet gas pressure with varying inlet gas pressure, the regulator comprising:

[0009] a pin valve and sealing disc for inter-engagement so as to releasably seal an outlet gas flow path, the pin valve having a pin portion extending through the sealing disc such that depression of the pin portion disengages the pin valve from the sealing disc and breaks the seal;

[0010] a diaphragm forming a cavity downstream of the seal and configured to depress the pin portion of the pin valve, and having an outlet port having a flow constriction;

[0011] an actuator for applying force to a diaphragm engagement spring, which in turn applies force to the diaphragm so as to engage the pin portion of the pin valve;

[0012] wherein a gas pressure within the cavity opposes the force of the diaphragm engagement spring on the diaphragm, such that the pin valve is controllably disengaged from the sealing disc and a substantially constant pressure is maintained within the cavity during actuation of the actuator, such that a substantially constant outlet pressure/gas speed is provided through said outlet port.

[0013] In one species of the invention, the pin portion of the pin valve is smaller in diameter than the aperture of the sealing disc, so that gas flows between the pin portion and the sealing disc. In another species of the invention, the pin portion slidably and sealably extends through the sealing disc, and the pin portion defines an internal passageway to allow the flow of gas when the pin valve is in an open position.

[0014] According to a second aspect the present invention provides a method of regulating gas flow to provide a substantially constant outlet gas pressure with varying inlet gas pressure, the method comprising:

[0015] providing a releasable seal of a gas flow path;

[0016] providing a cavity downstream of the releasable seal;

[0017] applying an actuation force to release said seal such that gas flows past said released seal into said cavity;

[0018] applying a gas pressure within said cavity against the actuation force, such that the seal is controllably released and a gas pressure within said cavity remains substantially constant; and

[0019] providing an outlet gas port having a constriction for egress of gas from said cavity.

[0020] According to a third aspect, the present invention provides a device for regulating the flow of pressurized gas from a pressurized container, comprising:

[0021] a first gas flow path for the flow of gas from the pressurized container; and

[0022] a second gas flow path for the flow of gas into the pressurized container.

[0023] By providing a gas flow path for the egress of gas from the container which is distinct from the gas flow path for the introduction of gas to the container, the present invention provides for the passage of gas in only one

direction through each gas flow path. Importantly, this configuration permits use of a gas filter such that particulates captured by the filter remain on an upstream side of the filter and thus cannot be passed downstream of the filter. Accordingly, in a preferred embodiment a gas filter is provided along the first gas flow path to filter gas flowing from the pressurized container.

[0024] In preferred embodiments of the invention the device further comprises means for sealing the pressurized container. Preferably, the means for sealing is operable to provide a gas tight seal for gas at high pressure. The high pressure may be substantially 3,000 psi, or may be substantially 12,000 psi.

[0025] Preferably, the second gas flow path comprises means for attachment for a high pressure gas supply. Preferably, the second gas flow path comprises a valve permitting the introduction of pressurized gas for refilling the container, and for sealing the second gas flow path at times when the container is not being refilled. The valve sealing the second gas flow path may be provided by a filler valve needle and O-ring arrangement, wherein the O-ring is positioned externally of the filler valve needle, and engagement of the filler valve shoulder with the O-ring effects a seal of the second gas flow path. The filler valve needle, being positioned internally of the O-ring along the second gas flow path, the filler valve shoulder may be pressed against and engaged with the O-ring by internal gas pressure and/or by a spring. The filler valve needle preferably further comprises a needle portion extending through the O-ring to enable manual depression of the filling valve needle. Additionally or alternatively, the refilling process may be effected simply by applying an external pressure which is greater than an internal pressure of the pressurized container and/or the pressure applied by a spring, such that the filling valve needle is forced away from the O-ring by the external pressure, thus opening the second gas flow path.

[0026] Preferred embodiments of the invention further comprise a safety failure mechanism, wherein an over-pressure condition causes the safety failure mechanism to release gas from the pressurized container. In preferred embodiments of the invention the safety failure mechanism is a reseating relief valve. Alternatively, the safety failure mechanism may comprise a sacrificial seal configured so as to fail upon occurrence of the over-pressure condition, thus releasing all pressurized gas from the container. For example, the sacrificial seal may comprise a metal sheet sealing a safety gas flow path, the metal sheet being configured to fail upon occurrence of the over-pressure condition. The metal sheet may comprise a sheet of brass having a specific thickness to meet this purpose. The over pressure condition may be selected to arise when an internal pressure of the container exceeds five thirds of the intended maximum operating internal pressure of the container but not more than 10% less than five thirds of the intended maximum internal pressure of the container.

[0027] Embodiments of the invention preferably further comprise a regulator to regulate egress of gas from the pressurized container along the first gas flow path. In particularly preferred embodiments of the invention, the regulator on the first gas flow path provides a substantially constant output gas pressure or speed, regardless of the internal pressure of the pressurized container.

[0028] The regulator is preferably effected by a pin valve engaging a sealing disc so as to selectively seal the first gas flow path. The pin valve may be held against the sealing disc by internal pressure of a pressurized container and/or a pin valve retaining spring. Preferably, the pin valve has a pin portion extending through the sealing disc and shoulder portions engaging with the sealing disc to provide said seal of said first gas flow path. Said shoulder portions may be semi-spherical, to engage in a corresponding seat of the sealing disc. In such embodiments depression of the pin portion of the pin valve against the force of the pin valve retaining spring and internal pressure allows gas to flow along the first gas flow path past the pin valve and sealing disc.

[0029] In such embodiments, actuation of the pin portion of the pin valve is preferably effected by a nose portion of a diaphragm. In such embodiments, gas flow past the pin valve and sealing disc preferably flows to a cavity between the diaphragm and the sealing disc. Such embodiments preferably further comprise an actuator for depressing a diaphragm engagement spring, which in turn applies force to the diaphragm so as to depress the pin portion of the pin valve. The flow of gas into the cavity between the diaphragm and the sealing disc applies an opposite pressure upon the diaphragm and upon the diaphragm engagement spring, thus urging the nose portion of the diaphragm away from the pin valve so as to disengage the pin portion of the pin valve and close the seal between the sealing disc and the pin valve. In such embodiments, an outlet port is provided leading from the cavity to allow the flow of gas from the cavity out of the regulator. The outlet port preferably comprises a constriction to limit the flow of gas from the cavity. The constriction may be simply effected by providing a small hole for egress of gas from the cavity, with the size of the hole being selected to provide a desired equilibrium pressure within the cavity during actuation of the actuator. For instance the constriction may comprise a small hole of substantially 0.3 mm in diameter. In particularly preferred embodiments of the invention, the outlet port is effected by a hollow shaft of the diaphragm, with one end of the hollow shaft being the nose of the diaphragm for engagement of the pin portion of the pin valve, and an opposite end of the hollow shaft being open to allow egress of gas from the hollow shaft. In such embodiments the constriction is preferably effected by a small hole passing laterally through a wall of the hollow shaft to allow constricted gas flow from the cavity to the outlet port. Thus, whenever the pressure in the cavity is greater than an external pressure, gas will flow through the small hole to the outlet port. In such embodiments, during actuation of the actuator the pressure within the cavity is primarily controlled by the balancing factors the strength of the diaphragm engagement spring and the size of the surface area of the diaphragm so as to controllably open the valve provided by the pin valve and sealing disc, with the pressure in the cavity being largely independent of the pressure within the pressurized container. Thus, the flow of gas through the small hole and through the outlet port out of the regulator is substantially constant. Embodiments of the invention in which the outlet port comprises a hollow shaft through the diaphragm are particularly advantageous in avoiding the need for an outlet port distinct from the diaphragm, such as an outlet port extending laterally from the cavity, requiring additional material and weight of the regulator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] By way of example only, preferred embodiments of the invention will be described with reference to the accompanying drawing, in which:

[0031] **FIG. 1** is an assembled cross-sectional view of an embodiment of a regulator according to the present invention;

[0032] **FIG. 2** is an exploded cross sectional view of the regulator of **FIG. 1**;

[0033] **FIG. 3** is a perspective exploded view of the regulator of **FIGS. 1 and 2**; and

[0034] **FIG. 4** is a schematic partial cross-sectional view of a regulator and cylinder in accordance with another embodiment of the invention.

[0035] **FIG. 5a** is a fragmentary schematic view of a pin valve of the regulator of **FIG. 1** showing the pin valve in a closed position;

[0036] **FIG. 5b** is a fragmentary schematic view of a pin valve of the regulator of **FIG. 1** showing the pin valve in an open position;

[0037] **FIG. 6a** is a fragmentary schematic view of another species of pin valve showing the pin valve in a closed position;

[0038] **FIG. 6a** is a fragmentary schematic view of the pin valve of **FIG. 6a** showing the pin valve in an open position;

[0039] **FIG. 7** is a cross-sectional view of a gas dispenser according to the present invention;

[0040] **FIG. 8** is a partial exploded perspective view of the gas dispenser of **FIG. 7**;

[0041] **FIG. 9** is an exploded perspective view of an actuator assembly of the gas dispenser of **FIG. 7**;

[0042] **FIG. 10** is a cross-sectional view of the actuator assembly of **FIG. 9**; and

[0043] **FIG. 11** is a side view of the gas dispenser of **FIG. 11** illustrating an open position of an actuator cover.

DETAILED DESCRIPTION OF THE INVENTION

[0044] The embodiment of the invention set out in the figures is a regulator **30** for refillable high pressure gas containers, and for oxygen gas in particular. The regulator **30** provides for a compact, refillable personal oxygen supply, and when used in conjunction with a high pressure container, allows for more gas to be held in a smaller space. The regulator is designed and tested to International Safety and Production Standards, and importantly has been designed to be operable with one hand.

[0045] The regulator **30** provides for regulation of high pressure gas as it exits a high pressure container, and further provides a filling valve and over pressure relief, all in a compact and light weight unit. The regulator further provides for attachment of a variety of actuation mechanisms to operate the regulator, allowing for user preference and interchangeable actuation mechanisms. The regulator **30** further provides a number of anti-tampering and anti-dis-mantling features.

[0046] Referring to the Figures in more detail, the regulator **30** provides for a body-to-cylinder seal between the body **1** of the regulator **30** and a high pressure container. In the present embodiment, the body **1** is configured to screw into the neck of such a cylinder with straight threads. A counter-bore is required on the cylinder having a smaller outside diameter than the outside diameter of the body **1**. The inside diameter of the counter-bore is required to be the outside diameter of the threaded connection in the cylinder neck. When the flat lower face of the body **1** is screwed tightly against the flat top face of such a cylinder, a Teflon seal, having outside and inside diameters matched to those of the counter-bore, is trapped securely within the counter-bore.

[0047] The Teflon seal is slightly thicker than the space available between the base of the counter-bore and the lower face of the body **1**. Consequently, when the body **1** is tightened against the top of such a cylinder, the Teflon seal is crushed into the counter-bore. The Teflon seal then extrudes against the threaded connection on the base of the body **1** and all sides and imperfections in the faces of the counter-bore, ensuring a gas-tight seal up to and beyond 12,000 psi. The threaded connection provides the strength required to contain cylinder pressures up to and beyond 12,000 psi without the body **1** shearing out of the cylinder neck.

[0048] In the present embodiment it is envisaged that the operating pressure of the regulator will be between 15 psi (1 bar, or atmospheric pressure at sea level) and 3,000 psi, however for safety and design standard requirements, the system is designed to cope with up to 12,000 psi without failure.

[0049] The regulator **30** further comprises a side filling mechanism, allowing gas to be introduced to the body **1** and then into the cylinder through the side filling gas flow path. Importantly, the side filling gas flow path is distinct from a gas flow path for gas exiting the regulator. The side filling gas flow path comprises filling valve retainer **17**, O-ring **13**, filling valve needle **18**, filler spring **2** and Teflon seal **19**.

[0050] A seal of the side filling gas flow path is provided between the body **1** and the filling valve retainer **17**. The filling valve retainer **17** comprises a threaded outer which screws into the side of the body **1**. The cavity in the body **1** into which the filling valve retainer **17** is screwed is also threaded, and has a shoulder just short of the base of the hole to stop the filling valve retainer once it is screwed in to that point. The Teflon seal **19** has inside and outside diameters which match those of the filling valve retainer **17**. The Teflon seal **19** is slightly thicker than the space available between the filling valve retainer **17** and the body **1**, when the filling valve retainer **17** has been tightened against the shoulder in the body **1**. This ensures that the Teflon seal **19** is crushed and it extrudes slightly up into the threaded connection. Extrusion towards the centre of the hole is limited by the outside diameter of the filler spring **2**. Such extrusion of the Teflon seal **19** ensures a gas tight seal between the filling valve retainer **17** and the body **1**.

[0051] To allow refilling of the cylinder, a releasable seal or valve is provided by a filling hole in the filling valve retainer **17**. The filling hole in the outer end of the filling valve retainer **17** is sealed by crushing the Viton O-ring **13** between the shoulders of the filling valve needle **18** and the

flat inside face of the filling valve retainer **17**. The crushing force on the Viton O-Ring **13** is exerted in series by the flat inside face of the side filling retainer **17** crushing the o-ring against the shoulders of the filling valve needle **18**. Pressure is exerted on the filling valve needle **18** to urge it against the Viton O-ring **13** by the filler spring **2** and also by gas pressure when present. Filler spring **2** is compressed between the filling valve shoulders **18** and the body **1** as a result of having a longer free height than the space available between the filling valve needle and the body **1** when the filling valve retainer **17** is screwed in against the shoulder on the body **1**.

[0052] Filling may be achieved either by manual activation of the externally extending needle portion of the filling valve needle **18** and the introduction of gas under pressure, or by providing sufficient external gas pressure to compress filler spring **2** enough to release the seal between the filling valve needle **18** and the filling valve retainer **17**, thus allowing gas flow past the filling valve needle **18** and along the second gas flow path into a cylinder. As soon as external pressure (manual pressure or gas pressure) is removed from the filling valve needle **18**, the internal gas and spring pressure ensure that the seal between the filling valve needle **18** and the filling valve retainer **17** is re-established.

[0053] The regulator **30** further provides for over-pressure relief, so as to ensure a safe failure mode in case the cylinder and regulator become over-pressurized. In the present embodiment, over-pressurization is defined as being five thirds of a maximum cylinder/regulator operating pressure. Given that the maximum operating pressure in the present embodiment is 3,000 psi, the over pressure condition is defined as being 5,000 psi.

[0054] The failure mode can, for example, take the form of a burst disc or a reseating relief valve. The embodiment shown in FIGS. **1** to **3** incorporates a burst disc safe failure mode, however the cavity in the body that accepts the burst disc components **9-12** may alternatively be used to accept the components required for a reseating relief valve.

[0055] Referring to FIG. **1**, a cavity in the body **1** is provided with a female thread, and houses the components for the safe failure mode. A burst disc retainer **12** is provided having a thread on its outside diameter, and a hexagonal hole of a specific size for accepting a screwing tool. A brass burst disc exterior washer **11** is provided having a circular hole in it of specified size. A disc **10** for bursting under the over-pressure condition is provided, comprising a solid piece of sheet brass. The disc **10** has a specific thickness. A copper seal gasket **9** is provided and also has a circular hole in it of a specific size. When the components **9-12** are inserted into the threaded hole in the body **1** as shown, and the burst disc retainer **12** is tightened firmly in its threads, the copper seal gasket washer **9** is crushed into the body **1** by each of the parts **11** and **10** to the point of extrusion into surface imperfections. The extrusion of this gasket ensures a gas tight seal during normal operating conditions.

[0056] The specific sizes noted in components **12**, **11**, **10** and **9** are calculated to ensure that the disc **10** fails (bursts or tears) within a specific gas pressure range. In the present embodiment the range is substantially between 5,000 psi and 4,500 psi (greater than five thirds of service pressure, but not less than ninety percent of five thirds of service pressure).

[0057] With reference to FIG. **2**, the regulator **30** further ensures that within the limits of the materials, a constant gas

pressure, or gas speed, is delivered to the outlet port of part **4** regardless of the inlet pressure (or cylinder pressure) into the body **1**. The regulation of gas pressure is achieved by opening and shutting a valve comprising parts **5**, **6**, **7** and **8** to allow gas to escape to a cavity, and restricting the release of gas from the cavity by providing a constriction in the outlet port, the constriction being a small hole in the nose of the regulator piston diaphragm **4** which connects to a larger central tube through the diaphragm **4** that becomes the outlet port at its upper end. The gas speed at the outlet port is determined by the combination of gas pressure in the cavity below the diaphragm **4**, the surface area of the diaphragm within the pressure cavity, the strength of the spring **3** and the size of the hole that the gas can escape through. In the present embodiment the small hole or outlet port **33** is approximately 0.3 mm in diameter. Embodiments of the invention include a small hole in the range of approximately 0.2 mm to approximately 0.7 mm, and in other embodiments the small hole is between approximately 0.3 mm and approximately 0.5 mm.

[0058] In more detail, the brass pin valve **6** has a shoulder on its internal end which locates into a spring **5**. Brass pin valve **6** further comprises a shoulder presenting a spherical sealing surface, and a narrow pin portion protruding from its upper or external end. A Teflon (PTFE) or Neoflon (PCTFE) sealing disc **7** is provided having a central circular hole through it. The pin portion of the pin valve **6** protrudes through the hole and the spherical sealing surfaces of the pin valve shoulder mates with the sealing disc **7** around the edge of the circular hole. When sufficient pressure is exerted by the sealing surface of the pin valve **6** against the sealing disc **7**, a gas tight seal is formed due to the soft sealing disc **7** deforming onto the smooth spherical sealing surface of the pin valve **6** so that all surface imperfections are closed off, preventing any gas from escaping.

[0059] The sealing disc **7** is secured into the body **1** by a threaded retainer **8**. The outer circumference of the sealing disc **7** must also be gas tight to prevent leaking. This is achieved by an angled lower surface of the cavity in the body **1** that the sealing disc **7** is secured in, and the sealing disc **7** being slightly thicker than the space it is secured into. Accordingly, when the threaded retainer **8** is screwed down against the sealing disc **7**, the sealing disc **7** extrudes slightly into the available cavity and the angle of the lower surface ensures that a perfect seal is provided on the outer circumference so that there is no leakage through that path.

[0060] The regulation of gas flow out of the cylinder along the first gas flow path occurs as follows. When the pin valve **6** is depressed such that the seal between the pin valve **6** and the sealing disc **7** is disengaged, gas is released into the cavity between the diaphragm **4** and the sealing disc **7**. The cavity is sealed by the O-ring **14**. Thus, the release of pressurized gas into the cavity increases the gas pressure within the cavity, which pushes the diaphragm **4** upwardly against the regulator spring **3**.

[0061] Spring **3** is retained within the body **1** by the actuator **16**, which in turn is retained within the body **1** by retainer **20**. When a user of the regulator causes depression of the actuator **16**, the actuator **16** compresses spring **3** which then forces diaphragm **4** towards the pin portion of the pin valve **6**. A nose portion of the diaphragm **4** forces pin valve **6** inwardly away from the sealing disc, breaking the

seal and allowing gas to escape into the cavity between the sealing disc 7 and the diaphragm 4. Consequently, gas pressure in the cavity rises, which applies a pressure against the surface of the diaphragm within the pressure cavity urging the diaphragm 4 away from the pin valve 6, against the force of the spring 3. At a certain level of gas pressure within the cavity, the spring 3 will compress sufficiently for the diaphragm 4 to move away from the sealing disc 7, allowing the pin valve 6 to re-seat against the sealing disc 7, closing the valve.

[0062] However, gas in the cavity can escape through the constricted outlet port, and so pressure inside the cavity will tend to fall while the pin valve 6 is seated against the sealing disc 7 and the valve is closed. Should the actuator 16 still be depressed, the spring 3 will apply a force on the diaphragm 4 greater than the force applied by the reduced gas pressure in the cavity, such that the diaphragm 4 will be urged by the spring 3 to re-open the valve by depressing pin valve 6, such that the regulation cycle recommences. As the inlet (cylinder) pressure lowers, this cycle will slow down, but the outlet pressure will remain fairly constant. Typically the outlet pressure will rise slightly as the cylinder pressure lowers, as a result of the 'imbalance' in opposing spring pressures, however this variation is relatively minor.

[0063] Referring to FIGS. 1, 2, and 7, thus, the movable diaphragm 4 allows the preexhaust pressure regulating cavity 31, which forms a portion of the outlet gas flow path, to expand and contract the volume of gas in the cavity thereby slowing the pressure increase as more gas flows into the cavity 31. The pressure and volume increase at the same time at a rate determined by the force of the regulator spring 3, so that the pressure increase is slowed because volume is also increased as the regulator spring 3 is compressed. Therefore, the size of the cavity 31 varies with the pressure in the cavity, and the regulator spring 3 biases the diaphragm toward a small cavity position. This also acts to regulate the temperature change in the cavity 31 as the gas expands and would normally cool rapidly. The outlet port 33 restricts flow of the gas out of the cavity 31 building pressure in the cavity and increasing the volume of the cavity until the diaphragm and its pin engagement end 39, which abuts against the pin portion 50 of the valve pin 6, is retracted enough that the pin valve 6 closes against the sealing disc 7 to seal the cylinder. The gas in the cavity is then exhausted through the outlet port 33 and the central bore 35 of the hollow shaft 37 of the diaphragm 4. To provide oxygen to the user at the desired rate, temperature, and pressure, embodiments of the invention utilize a regulator spring having a load force of approximately 120 Newtons to approximately 200 Newtons, and in other embodiments, the load force of the regulator spring 3 is approximately 150 Newtons to approximately 170 Newtons. The working surface area of the diaphragm 4 is approximately 10 mm to approximately 15 mm in diameter, and the diameter is approximately 12.5 mm to approximately 13.5 mm in other embodiments.

[0064] The regulator 30 further provides for safety features, given that oxygen is a hazardous gas in that it can vigorously promote combustion of materials that are normally not flammable. The regulator 30 is designed so that the chance of an inadvertent release of oxygen is minimized. The regulator 30 is designed for attachment of a shroud to conceal the regulator 30 and provide an attractive product

presentable for sale, but also preferably includes a positive actuation mechanism (not shown) of the actuator 16. The positive actuation mechanism is preferably designed to engage to commence oxygen flow and disengage to ensure no inadvertent release by accidental activation of the actuator 16. During assembly of the regulator 30, all parts are "oxygen cleaned" in trichloroethylene (or similar oxygen-safe chemical solvents), which is important to safety. Further, the O-ring 14 of the diaphragm is lubricated with an oxygen compatible lubricant, again for safety purposes.

[0065] The positive actuation mechanism may comprise a spring loaded button or lever, or a threaded knob. For instance, a plastic lever may be provided to activate the actuator 16. When the user presses the button on the lever, the lower surface will engage with the actuator 16 to commence gas flow as previously described herein. When the user releases the button, the button/lever will completely disengage from the actuator 16. The disengagement preferably leaves a small space between the engagement surface of the lever and the actuator 16 by allowing excess travel in the upward movement of the lever, along with a built in spring mechanism to hold the lever away from the actuator 16. This springing mechanism may for example be provided by resilient plastic and therefore independent of the spring mechanisms of the regulator 30. The spring loaded action of the lever ensures that the user must apply 'positive' pressure to the button on the lever to commence flow.

[0066] The shroud preferably further comprises a mouthpiece. Preferably the mouthpiece is movable between a closed position and an open position, wherein the lever is accessible only when the mouthpiece is in the open position. The mouthpiece may be removably secured into the open position and the closed position by tabs moulded into the plastics. By making the lever inaccessible when the mouthpiece is in a closed position, the risk of the button being accidentally activated between usage is minimized.

[0067] As the regulator will normally be under high pressure when connected to a cylinder, it is undesirable to allow consumers to easily dismantle the regulator 30 from the cylinder due to potential safety concerns. Accordingly, the regulator 30 is screwed down to the cylinder with significant torque, so that a levered tool is required to unscrew it even when the system is un-pressurized. Furthermore, no surfaces are provided where a normal spanner can be easily connected to attempt to unscrew the regulator from the cylinder. Additionally, to ensure that users do not inadvertently unscrew the regulator 30 from the cylinder when the system is pressurized, the shroud is designed to detach from the regulator or fail before sufficient torque could be applied to unscrew the regulator. To do so will require removal of the plastics, attachment of the cylinder to a suitable holding mechanism and use of a purpose-made spanner/wrench.

[0068] A horizontal groove 21 is provided around the outer circumference of the body 1 and plastic ribs on the inside diameter of the plastic shroud parts will clip into the groove 21. The plastic is thus held in a fixed vertical location.

[0069] A shroud used in conjunction with the described regulator preferably provides safety and anti-tampering features, and further provides a substantially sealed flow path for gas from the outlet of the regulator to flow to a user's inhalation port. The plastic shroud, being interchangeable,

further provides for user customization and preference, thus providing an attractive feature to users.

[0070] Notably in the embodiment described, the propellant is the oxygen pressure itself within the container, without need for an aerosol additive or the like. Accordingly, a user receives pure oxygen from the container.

[0071] FIG. 4 is a partial cross sectional view of a regulator and cylinder in accordance with another embodiment of the invention. Regulator 40 connects to cylinder 41 by screwing into the neck of cylinder 41 with a straight threaded engagement. When the flat lower face 42 of the regulator 40 is screwed tightly against the flat top face 43 of the cylinder 41, a Teflon or Neoflon seal (not shown) is trapped securely within a counter bore 44. The Teflon or Neoflon seal is slight thicker than the space available between the base of the counter bore 44 and the lower face 42 of the regulator 40. Consequently, when the regulator 40 is tightened against the top of the cylinder 41, the Teflon or Neoflon seal is crushed within the counter bore. The Teflon or Neoflon seal then extrudes against the threaded connection on the base of the regulator 40 and against all sides of the counter bore, ensuring a gas tight seal up to and beyond 12,000 psi. The threaded connection further provides sufficient strength to contain the regulator 40 within the neck of the cylinder 41 at such pressures without the regulator 40 shearing out of the neck of the cylinder 41. FIG. 4 further illustrates a filter 45 for preventing the flow of particulate matter from the cylinder out through the regulator 40 to a user. FIG. 4 further illustrates a second gas flow path 46, for filling the cylinder in a manner which involves a gas flow through the filter 45 in one direction only.

[0072] Referring to FIGS. 5a and 5b, the pin valve 6 includes the pin portion 50, which extends through a central aperture 52 in the sealing disc 7 and the retainer 8. When the pin valve 6 is in the closed position of FIG. 5a, the rounded shoulder 54 of the pin valve seals the gas inside the cylinder. The pin valve 6 is biased into the closed position by the valve pin spring 5 (FIG. 1). When the pin valve is in the open position of FIG. 5b, the shoulder 54 is spaced away from the sealing disc, and the gas is allowed to flow through the aperture 52, which forms part of the outlet gas flow path.

[0073] Referring to the alternate pin valve 106 in FIGS. 6a and 6b, the body 101 again houses and slidably guides the pin valve 106, and the sealing disc 107 and retainer 108 are held in position by the concentric counter bore 100 of the body 101. The pin portion 150 again extends through the central aperture 152 defined by the sealing disc 107 and the retainer 108. However, the outer surface of the pin portion 150 seals in the aperture of the sealing disc. To transmit gas past the sealing disc, the pin portion 150 defines a pin portion passageway 109, which forms part of the outlet gas flow path when the pin valve 106 is in the open position of FIG. 6b. The pin portion passageway 109 includes a lower passage 110, a centrally and axially located through passage 111, and a plurality of outlet passages 112, 113. Each of the passages 110, 111, 112, 113 is in fluid communication, and are sized to restrict the flow of gas from the cylinder. When the pin valve 106 is in the closed position of FIG. 6a, the lower passage 110 is within and sealed by the sealing disc 107, and when the pin valve 106 is in the open position of FIG. 6b, the lower passage is outside of the sealing disc so gas flows into the lower passage 110, up through the through

passage 111, and out the outlet passages 112, 113 into the preexhaust pressure regulating cavity.

[0074] Referring to FIGS. 7 and 8, the gas dispensing apparatus 60 includes a pressure vessel 61 defining and internal chamber 62 closed by a pressure bearing wall 64, which defines an opening 66 for receiving the regulator 30, specifically the body 1 of the regulator, and permitting gas to move in and out of the internal chamber as controlled by the regulator. Referring additionally to FIGS. 9 and 10, the gas dispenser 60 also includes an actuator assembly 70 which engages the diaphragm hollow shaft 37, so that an operator can depress actuator button 79 of the actuator lever 74. To prevent accidental actuation, the lever and button are covered by an actuator cover 72. The actuator cover 72 slides into an open position illustrated in FIG. 11. In one embodiment the cover 72 clips into both its open and closed positions. The actuator lever 74 engages the actuator 16 which moves the diaphragm 4 to move the pin valve 6 to the open position illustrated in FIG. 5b. The actuator button is movably mounted on the actuator housing 76, and the actuator lever 74 is, in one embodiment, pivotally mounted in the actuator housing 76. An actuator surface 78 of the lever 74, extends around the hollow shaft 37 of the diaphragm 4 and engages the actuator 16. The hollow shaft is in fluid communication with an actuator passage 80 that also forms part of the outlet gas flow path. Thus, a user may release gas with a single step of pressing the lever 74 on the button surface 79. Alternate actuation mechanisms may include a button or a threaded knob, incorporated into a similar actuator housing clipped on the groove of the regulator body 1.

[0075] It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

What is claimed is:

1. A regulator for providing a substantially constant outlet gas pressure with varying inlet gas pressure, the regulator comprising:

a pin valve and sealing disc for inter-engagement so as to releasably seal an outlet gas flow path, the pin valve having a pin portion extending through the sealing disc such that depression of the pin portion disengages the pin valve from the sealing disc and breaks the seal;

a diaphragm forming a cavity downstream of the seal and configured to depress the pin portion of the pin valve, and having an outlet port having a flow constriction;

an actuator for applying force to a diaphragm engagement spring, which in turn applies force to the diaphragm so as to engage the pin portion of the pin valve;

wherein a gas pressure within the cavity opposes the force of the diaphragm engagement spring on the diaphragm, such that the pin valve is controllably disengaged from the sealing disc and a substantially constant pressure is maintained within the cavity during actuation of the actuator, such that a substantially constant outlet pressure/gas speed is provided through said outlet port.

2. A method of regulating gas flow to provide a substantially constant outlet gas pressure with varying inlet gas pressure, the method comprising:

providing a releasable seal of a gas flow path;

providing a cavity downstream of the releasable seal;

applying an actuation force to release said seal such that gas flows past said released seal into said cavity;

applying a gas pressure within said cavity against the actuation force, such that the seal is controllably released and a gas pressure within said cavity remains substantially constant; and

providing an outlet gas port having a constriction for egress of gas from said cavity.

3. A device for regulating the flow of pressurized gas into and out of a pressurized container, comprising:

a first gas flow path for the flow of gas from the pressurized container; and

a second gas flow path for the flow of gas into the pressurized container.

4. The device according to claim 3 further comprising a third gas flow path for the flow of gas from the pressurized container when the pressurized container is over-pressurized.

5. An apparatus capable of dispensing gas stored in a highly pressurized container and then refilling the container with more gas, comprising:

a regulator, the regulator including a first valve assembly on a first gas flow path permitting the flow of gas from the container into the regulator and maintaining a substantially constant output gas pressure or speed, regardless of the internal pressure of the highly pressurized gas container; and a second valve assembly on a second gas flow path for refilling the container with highly pressurized gas and sealing the second gas flow path when the container is not being refilled.

6. The apparatus of claim 5 wherein the first valve assembly includes a pin valve and a sealing disc the pin valve engaging the sealing disc to releasably seal the outlet gas flow path.

7. The apparatus of claim 6 wherein a pin portion of the pin valve extends through the sealing disc such that depression of the pin portion disengages the pin valve from the sealing disc and breaks the seal.

8. The apparatus of claim 7 wherein the first valve assembly also includes a diaphragm forming a cavity downstream of the seal and configured to depress the pin portion of the pin valve, and having an outlet port providing flow constriction.

9. The apparatus of claim 8 wherein the first valve assembly further includes an actuator for applying force to a diaphragm engagement spring, which in turn applies force to the diaphragm so that a pin engagement end of the diaphragm engages the pin portion of the pin valve.

10. The apparatus of claim 8 wherein a gas pressure within the cavity opposes the force of the diaphragm engagement spring on the diaphragm, such that the pin valve is controllably disengaged from the sealing disc and a substantially constant pressure is maintained within the

cavity during actuation of the actuator, such that a substantially constant outlet pressure/gas speed is provided through said outlet port.

11. The apparatus of claim 5 wherein a gas filter is present along the first gas flow path to capture particulates in the gas flowing from the highly pressurized container.

12. The apparatus of claim 1 wherein the second valve assembly includes a filler valve needle and an O-ring.

13. The apparatus of claim 12 wherein the O-ring is positioned externally of the filler valve needle and an engagement of the filler valve needle with the O-ring forms a seal of the second gas flow path.

14. The apparatus according to claim 12 wherein the refilling process may be effected by applying an external pressure greater than an internal pressure of the pressurized container and/or the pressure applied by a spring, such that the filling valve needle is forced away from the O-ring by the external pressure, thereby opening the second gas flow path.

15. The apparatus of claim 1 further including an over-pressure relief mechanism to release gas from the highly pressurized container in response to a condition where the internal pressure of the container exceeds one and two thirds of the maximum internal pressure of the container.

16. The apparatus of claim 15, wherein the over-pressure relief mechanism includes a burst disc which will burst or tear when the internal pressure of the container is between one and two thirds of the maximum internal pressure of the container and greater than or equal to 90% of one and two thirds of the maximum internal pressure.

17. A gas dispensing apparatus comprising:

a pressure vessel including a pressure bearing wall defining an internal chamber for housing a gas and an opening through the pressure bearing wall to the internal chamber;

a regulator including a valve assembly for dispensing gas from the internal chamber through an outlet gas flow path, the valve assembly defining a preexhaust pressure regulating cavity in the outlet gas flow path;

an actuator assembly for operating the valve assembly to release gas from the pressure vessel.

18. The gas dispensing apparatus according to claim 17 wherein the valve assembly further includes a pin valve, a pin valve spring biasing the pin valve into a closed position against a sealing disc.

19. The gas dispensing apparatus according to claim 18 where in the pin valve includes a pin portion smaller than an aperture of the sealing disc.

20. The gas dispensing apparatus according to claim 18 where in the pin valve includes a pin portion slidably and sealably received in an aperture of the sealing disc, and the pin portion defining a gas passageway bypassing the seal between the pin portion and the sealing disc when the pin valve is in an open position, and thereby forming a portion of the outlet gas flow path.

21. The gas dispensing apparatus according to claim 17 wherein the preexhaust pressure regulating cavity varies in size depending on the pressure in the preexhaust cavity.

22. A gas dispensing apparatus comprising:

a pressure vessel including a pressure bearing wall defining an internal chamber for housing a gas and an opening through the pressure bearing wall to the internal chamber;

a regulator including a valve assembly for dispensing gas from the internal chamber through an outlet gas flow path, the valve assembly including a diaphragm defining an internal passageway forming a portion of the outlet gas flow path;

an actuator assembly for operating the valve assembly to release gas from the pressure vessel.

23. A gas dispensing apparatus comprising:

a pressure vessel including a pressure bearing wall defining an internal chamber for housing a gas and an opening through the pressure bearing wall to the internal chamber;

a regulator including a valve assembly for dispensing gas from the internal chamber through an outlet gas flow path, the valve assembly including a movable diaphragm defining a preexhaust pressure regulating cavity, and the diaphragm being biased by a regulator spring toward a small cavity position; and

an actuator assembly for operating the valve assembly to release gas from the pressure vessel.

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