(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
05 March 2020 (05.03.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/041832 A1

(51) International Patent Classification:
B67D 7/36 (2010.01) *F16K 31/143* (2006.01)
F16K 31/12 (2006.01) *B60K 15/03* (2006.01)

(21) International Application Number:
PCT/AU2019/050911

(22) International Filing Date:
28 August 2019 (28.08.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2018903182 29 August 2018 (29.08.2018) AU

(71) Applicant: **WALNAB PTY LTD** [AU/AU]; 19 Metro Court, Gateshead, New South Wales 2290 (AU).

(72) Inventors: **PEATTIE, Adam**; 19 Metro Court, Gateshead, New South Wales 2290 (AU). **NORRIS, Dean**; 32 Lee Crescent, Birmingham Gardens, New South Wales 2287 (AU).

(74) Agent: **CLARK INTELLECTUAL PROPERTY PTY LTD**; Suite 102, 6-8 Clarke Street, Crows Nest, New South Wales 2065 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

(54) Title: PILOT OPERATED FLOW CONTROL VALVES

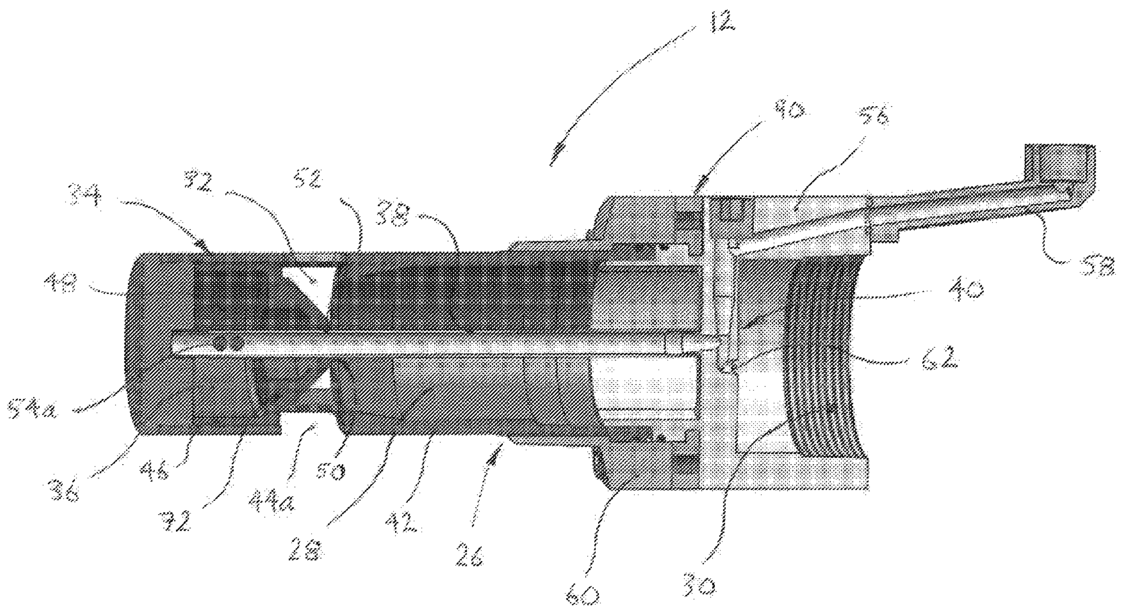

FIGURE 6

(57) Abstract: The present invention is directed broadly to a tank overfill protection system (10) generally comprising a flow control valve (12) operatively coupled to a tank level sensor via a pilot line (16). The flow control valve (12) generally comprises: 1. a valve body (26) defining a fluid passageway (28) between a fluid inlet (30) and a fluid outlet (32); 2. a piston (34) slidably mounted within the fluid passageway (28) and arranged for displacement for opening and closure of the fluid outlet (32); 3. a bleed fluid cavity (36) located within the valve body (26) and arranged to cooperate with the piston (34); 4. a bleed fluid conduit (38) operatively coupled to the bleed fluid cavity (36); 5. a venturi arrangement (40) operatively coupled to the bleed fluid conduit (38) to promote evacuation of bleed fluid from the bleed fluid cavity (36) thereby opening the fluid outlet (32) by displacement of the piston (34).

WO 2020/041832 A1

[Continued on next page]

SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

PILOT OPERATED FLOW CONTROL VALVES

Technical Field

[0001] The present invention related broadly to a flow control valve and relates particularly although not exclusively to a tank overfill protection system including a flow control valve operated by a pilot “signal” from an associated tank level sensor.

Background of Invention

[0002] In order to save time in industrial refuelling applications, flowrates over 100 litres per minute are often specified. One approach to refuel tanks is to use a pressurized tank shut off system. This system allows a tank to be refuelled at atmospheric pressure until the level of fuel inside the tank trips a level sensor, and seals off the tank venting function. The tank continues filling and pressurizes until the pressure within the tank reaches a “set point” which causes the system to shut off. Repeated refuelling cycles using this shut off system have the potential to cause tanks to fatigue. Additionally, manual override of pressurized tank shut off systems can introduce problems such as fuel spills and exacerbate the tank pressure. Further, the trend towards lower mass and lower cost fuel tanks onboard plant equipment such as mining vehicles has reduced the design pressure of such tanks, virtually mandating a “zero tank pressure” refuelling system.

[0003] In order to address these shortcomings of pressurized tank shut off systems, an alternative “zero tank pressure” system has been developed by the applicant. This “zero tank pressure” system uses a combination of a level sensor, pilot line, and flow control valve to automatically shut off flow to the tank at a safe fill level. Operation of the flow control valve is based on a flow/no-flow condition of a pilot line connected into the flow control valve itself. This pilot line is connected to one or more level sensors which are designed to allow free flow through the pilot line until the fuel level within the tank reaches a set point. Once the set point is reached the level sensors are designed to restrict flow through the pilot line, and thereby shut the flow control valve.

[0004] International patent publication No. WO2015/103341 by Cooley discloses a flow control valve for use with a float valve and associated pilot circuit. The flow control valve is designed to be automatically shut off via the float valve/pilot circuit when the fuel level reaches an adequate fill level. The flow control valve is of a normally-closed configuration relying upon a spring to bias a valve plug closed. The valve plug reciprocates outside a guide support and together they define a pressure chamber within which the spring is contained. The control valve also includes a tubular valve plug guide along which the valve plug travels in opening and closing. The valve plug guide is in fluid communication with the pilot circuit and includes fluid apertures at the pressure chamber. The pilot circuit includes an aperture which acts as a “flow limiter” at an entrance to the control valve which provides a limited flow of fluid to the pilot circuit. On reaching an adequate fill level, the flow of bleed fluid through the pilot circuit is prevented whereby the fluid pressure in the pressure chamber increases to assist the spring in closing the valve plug.

Summary of Invention

[0005] According to a first aspect of the present invention there is provided a flow control valve comprising:

a valve body defining a fluid passageway between a fluid inlet and a fluid outlet;

a piston slidably mounted within the fluid passageway and arranged for opening and closure of the fluid outlet;

a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the fluid outlet by displacement of the piston;

a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the fluid outlet by displacement of the piston.

[0006] Preferably the valve body includes a rear valve body within which the piston is slidably mounted, said rear body including one or more radial openings which at least in part define the fluid outlet. More preferably the piston includes a peripheral wall arranged to cooperate with the radial openings of the rear body for opening and closure of the fluid outlet. Still more preferably the peripheral wall of the piston internally defines a piston chamber which at least in part forms the bleed fluid cavity.

[0007] Preferably the piston includes an axial opening through which the bleed fluid conduit passes defining an annular bleed passage between the piston and the bleed fluid conduit, said bleed passage arranged to transfer bleed fluid to or from the fluid passageway and the bleed fluid cavity. More preferably the bleed fluid conduit includes one or more apertures located within the bleed fluid cavity and arranged to provide the bleed fluid communication between the bleed fluid cavity and the bleed fluid conduit.

[0008] Preferably the valve body also includes a front valve body defining at least part of the fluid passageway including the fluid inlet, said front valve body operatively coupled to a pilot line associated with the flow control valve. More preferably the valve body also includes a connector arranged to retain the rear valve body and adapted to connect to a tank with which the pilot line is associated.

[0009] Preferably the venturi arrangement is operatively coupled to the pilot line at the front valve body and located within the fluid passageway at the front valve body. More preferably the bleed fluid conduit connects the venturi arrangement within the front valve body to the bleed fluid cavity. Even more preferably the venturi arrangement is associated with a fluid sampling orifice which samples fluid at the fluid inlet for provision at the venturi arrangement which with fluid flow through the pilot line promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed fluid conduit thus reducing pressure within the bleed fluid cavity to promote displacement of the piston and opening of the fluid outlet. Still more preferably the fluid sampling orifice on restricted fluid flow through the pilot line provides sampled fluid from the fluid inlet to the bleed fluid cavity via the venturi arrangement and the bleed fluid conduit to substantially equalise fluid pressure between the fluid sampling orifice and the bleed cavity whereby the force imbalance across the piston promotes displacement of the piston and closure of the fluid outlet. In this arrangement the pilot line with which the flow control valve is associated is located outside the tank.

[0010] Alternatively the venturi arrangement is located within the bleed fluid cavity and is operatively coupled to a pilot line at the rear valve body. In this alternative embodiment the venturi arrangement is associated with a fluid sampling orifice which samples fluid at the fluid passageway for provision at the venturi arrangement which with fluid flow through the pilot line promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed conduit thus reducing pressure within said bleed cavity to promote displacement of the piston and opening of the fluid outlet. In this alternative embodiment the bleed fluid conduit is adapted to operatively couple to the pilot line located inside a tank with which the flow control valve is associated.

[0011] Preferably the piston includes a cylindrical portion defined by the peripheral wall, a seating portion connected to the cylindrical portion, and a substantially conical portion connected to the seating portion. More preferably the seating portion includes a radially extending seating face configured to seat with the rear valve body on closure of the fluid outlet via the piston. Even more preferably the fluid passageway is in a downstream flow direction tapered inwardly forming an annular shoulder including a radially extending seating face within the rear valve body configured for seating closure with the seating face of the seating portion of the piston. Still more preferably the seating face of the piston is formed by an annular rebate within the seating portion of the piston. Even still more preferably the piston is designed for staged closure of the fluid outlet where initially the annular shoulder of the rear valve body axially overlaps the annular rebate of the piston and subsequently, on complete closure of the fluid opening, the seating face of the rear body contacts the seating face in the piston. Still further more preferably the seating portion of the piston has a circumferential chamfer extending radially outward from the seating face of the piston reducing its contact area with the seating face of the rear valve body assisting with operation of the piston.

[0012] Preferably the front valve body is pivotally coupled to the connector for rotational movement relative to said connector for reorientation of the front valve body for substantial alignment with the pilot line. More preferably the valve includes a clasp assembly arranged to clasp the front valve body to the rear valve body for axial securement to one another whilst permitting pivotal movement of the front valve body relative to the connector. Even more preferably the clasp assembly includes a plurality of flange segments arranged to engage the front valve body, and a plurality of clasp fasteners arranged to engage both the connector and the plurality of flange segments for axial securement of the front and rear valve bodies to one another. Still more preferably the valve body further includes one or more locking elements arranged to engage both the front valve body and the clasp assembly to pivotally secure the front valve body relative to the connector.

[0013] According to a second aspect of the invention there is provided a flow control valve comprising:

a valve body defining a fluid passageway between opposing first and second fluid openings;

a piston slidably mounted within the fluid passageway and arranged for opening and closure of the second fluid opening;

a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the second fluid opening by displacement of the piston;

a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the second fluid opening by displacement of the piston.

[0014] Preferably the valve body is operatively coupled to a pilot line associated with the flow control valve. More preferably the venturi arrangement is associated with a fluid sampling orifice which samples fluid from either the first opening or the fluid passageway for provision at the venturi arrangement wherein: i) fluid flow from the venturi arrangement and through the pilot line in one direction promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed fluid conduit thus reducing pressure within the bleed fluid cavity to promote displacement of the piston and opening of the second fluid opening, and ii) fluid flow from the pilot line and through the venturi arrangement in an opposite direction also promotes evacuation of bleed fluid from the bleed fluid cavity to promote opening of the second fluid opening. Even more preferably the flow control valve is arranged for bi-directional flow when fluid flows through the pilot line occurs in either said one or the opposite direction.

[0015] According to a third aspect of the invention there is provided a tank overfill protection system comprising:

a flow control valve adapted to operatively couple to a tank to be filled with fluid, said flow control valve comprising:

i) a valve body defining a fluid passageway between a fluid inlet and a fluid outlet;

ii) a piston slidably mounted within the fluid passageway and arranged for opening and closure of the fluid outlet;

iii) a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the fluid outlet by displacement of the piston;

iv) a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

v) a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the fluid outlet by displacement of the piston;

a tank level sensor adapted to operatively couple to the tank, said level sensor connected to a pilot line associated with bleed fluid cavity of the flow control valve whereby the tank level sensor is arranged to detect a safe fill level within the tank and restrict bleed fluid flow through the pilot line promoting the force imbalance across the piston which is effective in displacement of the piston for closure of the fluid outlet of the flow control valve.

[0016] Preferably the tank level sensor comprises:

a valve body including a pilot inlet adapted to couple to the pilot line;

at least one pilot valve mounted to the valve body and in liquid communication with the pilot inlet;

a pilot valve actuator operatively coupled to said at least one pilot valve for its opening and closure, the pilot valve actuator including a balance member arranged to cooperate with actuator biasing means, the balance member having a specific gravity relative to liquid within the tank whereby at least part submersion of the balance member provides movement of the balance member relative to the valve body, said movement of the balance member:

i) only occurring together with the influence of the actuator biasing means; and

ii) being effective in closure of said at least one pilot valve.

More preferably said at least one pilot valve includes at least one poppet valve having a poppet valve head connected to a valve stem arranged to be contacted by the balance member for opening of said at least one pilot valve. Even more preferably the actuator biasing means includes a pilot valve compression spring designed to provide sufficient biasing force to provide movement of the balance member relative to the valve body for:

i) closure of the poppet valve on at least part submersion of the balance member with the biasing force of the compression spring overcoming an apparent weight of the balance member;

ii) opening of the poppet valve when the balance member is not at least part submerged and the weight of the balance member overcomes the biasing force of the compression spring.

[0017] According to a fourth aspect of the invention there is provided a flow control valve comprising:

a valve body assembly including a rear valve body defining part of a fluid passageway including a fluid outlet, said valve body assembly including a connector arranged to retain the rear valve body;

a piston slidably mounted within the fluid passageway of the rear valve body and arranged for opening and closure of the fluid outlet;

a front valve body defining at least part of the fluid passageway including a fluid inlet, said front valve body pivotally coupled to the connector for rotational movement relative to said connector for reorientation of the front valve body.

[0018] Preferably the connector is adapted to connect to a tank, and the front valve body is operatively coupled to a pilot line associated with the flow control valve. More preferably the front valve body rotationally couples to the connector for reorientation relative to the connector for substantial alignment with the pilot line.

[0019] Preferably the flow control valve includes a clasp assembly arranged to clasp the front valve body to the rear valve body for axial securement to one another whilst permitting rotational movement of the front valve body relative to the connector. More preferably the clasp assembly includes a plurality of flange segments arranged to engage the front valve body, and a plurality of clasp fasteners arranged to engage both the connector and the flange segments for axial securement of the front and rear valve bodies to one another. Still more preferably the valve body further includes one or more locking elements arranged to engage both the front valve body and the clasp assembly to rotationally secure the front valve body relative to the connector.

Brief Description of Drawings

[0020] In order to achieve a better understanding of the nature of the present invention a preferred embodiment of a flow control valve and a tank overfill protection system will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a tank overfill protection system according to one aspect of the present invention generally comprising a flow control valve and a tank level sensor;

Figure 2 is a schematic illustration of the tank overfill protection system of figure 1 in the course of refilling the associated tank with flow through a pilot line between the flow control valve and the tank level sensor;

Figure 3 is a front perspective view of the flow control valve taken from figures 1 and 2 according to another aspect of the invention and fitted within a tank shell;

Figure 4 is a front perspective view of the flow control valve of the embodiment of figure 3;

Figure 5 is a rear perspective view of the flow control valve of figure 4;

Figure 6 is a cross-sectional view of the flow control valve of the preceding figures;

Figure 7 is an exploded rear perspective view of the flow control valve of the preceding figures;

Figure 8 is an enlarged cross-sectional view shown in perspective of an alternative venturi arrangement of a flow control valve of another embodiment of the invention;

Figure 9 is an enlarged cross-sectional view of a further venturi arrangement of a flow control valve of a further embodiment of the invention;

Figure 10 is a cross-sectional view shown in perspective of the flow control valve of the earlier embodiment depicting force imbalances;

Figures 11A to 11D are enlarged cross-sectional views of the flow control valve of the earlier embodiment showing its staged closure;

Figure 12 is a cross-sectional view of the earlier embodiment of the flow control valve showing fluid flows in its open condition;

Figure 13 is a flow diagram schematically showing flow through the flow control valve of figure 12 in its open condition;

Figure 14 is a cross-sectional view of the earlier embodiment of the flow control valve showing fluid flows in its closed condition;

Figure 15 is a flow diagram schematically illustrating flow through the flow control valve of figure 14 in its closed condition.

Detailed Description

[0021] Figures 1 and 2 illustrate a tank overfill protection system 10 according to one aspect of the invention and generally comprising a flow control valve 12 operatively coupled to a tank level sensor 14 via a pilot line 16. In this embodiment the tank level sensor 14 is substantially identical to one or more of the embodiments disclosed in the applicant's international patent publication no. WO2018/053598. The contents of the specification of this international patent application are to be considered incorporated herein by way of this reference.

[0022] In this embodiment the flow control valve 12 is connected within a tank shell 18 fitted to a tank 20. The tank 20 is unpressurised and in this example contains a liquid such as diesel. The tank 20 is filled via a nozzle 22 which connects to a receiver 24 associated with the flow control valve 12. In operation the tank level sensor 14 is designed at a safe fill level within the tank 20 to restrict flow through the pilot line 16 and automatically close the flow control valve 12 to stop filling of the tank 20 via the nozzle 22, see figure 1. On the other hand, filling of the tank 20 up to the safe fill level is permitted with flow of fluid through the pilot line 16 with the tank level sensor 14 open and the flow control valve 12 thus automatically biased in its open condition.

[0023] Figures 3 to 7 illustrates various views of the flow control valve 12 taken from the tank overfill protection system 10 of the earlier aspect of the invention. In this embodiment of the invention the flow control valve 12 generally comprises:

1. a valve body 26 defining a fluid passageway 28 between a fluid inlet 30 and a fluid outlet 32;
2. a piston 34 slidably mounted within the fluid passageway 28 and arranged for displacement for opening and closure of the fluid outlet 32;
3. a bleed fluid cavity 36 located within the valve body 26 and arranged to cooperate with the piston 34;
4. a bleed fluid conduit 38 operatively coupled to the bleed fluid cavity 36;
5. a venturi arrangement 40 operatively coupled to the bleed fluid conduit 38 to promote evacuation of bleed fluid from the bleed fluid cavity 36 thereby opening the fluid outlet 32 by displacement of the piston 34.

[0024] In this embodiment the valve body 26 includes a rear valve body 42 within which the piston 34 is slidably mounted, the rear valve body 42 including one or more radially openings such as 44a which at least in part define the fluid outlet 32. In this example the piston 34 includes a peripheral wall 46 being shaped substantially cylindrical and arranged to i) cooperate with the radial openings such as 44a of the rear body 42 for opening and closure of the fluid outlet 32, and ii) internally define a piston chamber 48 which at least in part forms the bleed fluid cavity 36.

[0025] In this embodiment the piston 34 includes an axial opening 50 through which the bleed fluid conduit 38 passes defining an annular bleed passage 52 between the piston 34 and the bleed fluid conduit 38. The annular bleed passage 52 is designed to provide bleed fluid from the fluid passageway 28 to the bleed fluid cavity 36. The bleed fluid conduit 38 includes one or more apertures such as 54a located within the bleed fluid cavity 36 and arranged to provide bleed fluid communication between the bleed fluid cavity 36 and the bleed fluid conduit 38.

[0026] The valve body 26 of this example also includes a front valve body 56 defining at least part of the fluid passageway 28 and including the fluid inlet 30. The front valve body 56 is operatively coupled to a pilot line such as 16 (see figures 1 and 2) via a pilot spigot 58 mounted to the front valve body 56. The valve body 26 also includes a connector 60 arranged to retain the rear valve body 42 and adapted to mount to a tank such as 20 with which the pilot line 16 is associated.

[0027] Importantly the venturi arrangement 40 is operatively coupled to the pilot line 16 and in this embodiment is located within the fluid passageway 28 at the front valve body 56. The bleed conduit 38 connects the bleed fluid cavity 36 within the rear valve body 42 to the venturi arrangement 40 within the front valve body 56. The venturi arrangement 40 is associated with a fluid sampling orifice 62 which samples fluid at or adjacent the fluid inlet 30 for provision to the venturi arrangement 40. With fluid flowing through the pilot line such as 16 in one direction, the venturi arrangement 40 promotes evacuation of bleed fluid from the bleed fluid cavity 36 via the bleed fluid conduit 38 thus reducing pressure within the bleed fluid cavity 36 for opening of the fluid outlet 32 by displacement of the piston 34. With restricted or no fluid flow through the pilot line 16, sampled fluid from the fluid sampling orifice 62 is provided to the bleed fluid cavity 36 at a rear of the piston 34, via the venturi arrangement 40 and the bleed fluid conduit 38, substantially equalising fluid pressure at the rear of the piston 34 relative to the stagnation pressure measured at the sampling orifice 62.

During closure of the control valve 12, the fluid pressure is substantially equalised on either side of the piston 34. This equalisation of pressure on closure of the piston 34 together with the difference in the projected area of the piston 34 at the front and the rear creates a force imbalance across the piston 34 to promote closure of the fluid outlet 32 by displacement of the piston 34.

[0028] Figure 8 illustrates an alternative embodiment of the venturi arrangement 400 operatively coupled to a pilot line (not shown) at the rear valve body 42. For ease of reference and in order to avoid repetition, corresponding components of this alternative embodiment have been designated with the same reference numeral. The venturi arrangement 400 is located within the bleed fluid cavity 36 at the rear valve body 42. The venturi arrangement 400 is associated with a fluid sampling orifice 620 which samples fluid at the fluid passageway 28 and delivers it to the venturi arrangement 400 via a fluid sampling tube 630. The venturi arrangement 400 is connected to the pilot line via bleed fluid conduit 380 which passes through end cap 650 fitted to the rear valve body 42. With fluid flow through the pilot line 160, this alternative venturi arrangement 400 promotes evacuation of bleed fluid from the bleed fluid cavity 36 via the bleed fluid conduit 380 thus reducing pressure within the bleed cavity 36 to promote opening of the fluid outlet 32 by displacement of the piston 34. The bleed fluid conduit 380 may be operatively coupled to a pilot line located either inside or outside a tank with which the flow control valve 12 is associated.

[0029] Figure 9 illustrates a further variation of the venturi arrangement 4000 located within the fluid passageway 28 at the front valve body 56 and having an internal geometry suited to fluid flow through the pilot line such as 16 in an opposite direction. In this configuration the venturi arrangement 4000 is associated with a fluid sampling orifice 6200 which samples fluid from the fluid inlet 30 for provision at the venturi arrangement 4000 wherein:

1. fluid flow from the venturi arrangement 4000 and through the pilot line in one direction promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed fluid conduit such as 38 thus reducing pressure within the bleed fluid cavity to promote displacement of the piston and opening of the fluid outlet;

2. fluid flow from the pilot line and through the venturi arrangement 4000 in an opposite direction also promotes evacuation of bleed fluid from the bleed fluid cavity to promote displacement of the piston and opening of the fluid outlet.

[0030] The flow control valve 12 can also be bi-directional and when open operates with fluid flow through the passageway 28 in either direction where fluid flows from the fluid inlet 30 to the fluid outlet 32 or *vice versa*. Fluid flow through the pilot line in the opposite direction for opening of the valve may be motivated by applying hydraulic fluid pressure to the pilot line via a pump or other device. Alternatively, fluid flow through the pilot line in said one direction for opening of the valve may be motivated by applying a vacuum to the pilot line. In either case, the pilot line is “artificially” energised by an external fluid source which promotes flow through the pilot line in either direction thereby opening the piston. This may have application in draining a tank associated with the flow control valve where flow through the pilot line opens the control valve for reverse fluid flow from the outlet to the inlet of the control valve for draining of the tank. The flow control valve can thus be activated externally via the pilot line without mechanically actuating the control valve itself.

[0031] As seen in figure 10, the piston 34 is designed so that its projected area at the front (A_{Front}) exposed to fluid pressure varies with the position of the piston 34. During operation, the major forces acting on the piston 34 result from the pressures at the front and rear of the piston 34 acting across the front projected area and its rear projected area (A_{Rear}) exposed to fluid pressure. It can be seen that during closure of the piston 34 the front projected area is smaller than the rear projected area and with substantially equal pressure on either side of the piston 34 the force on the rear of the piston (F_1) is greater than the force on the front of the piston (F_2). That is, a force imbalance is created across the piston 34 which promotes its closure.

[0032] As seen in figures 11A to 11D the piston 34 of this embodiment includes a cylindrical portion defined by the peripheral wall 46, and a seating portion 72 connected to the cylindrical wall 46. The piston 34 also includes a substantially conical portion 74 connected to the seating portion 72 which includes an annular rebate 76. The annular rebate or step 76 defines a radially extending face 78 configured for seating closure with the rear body 42. The fluid passageway 28 within the rear body 42 is in a downstream flow direction tapered inwardly to form an annular shoulder 80. The annular shoulder 80 includes a radially extending seating face 82 with which the radially extending seating face 78 of the piston 34 seats for closure. The seating portion 78 of the piston 34 has a circumferential chamfer 84 extending radially outward from the seating face 78 of the piston 34. This circumferential chamfer 84 reduces the contact area of the piston 34 with the seating face 82 of the rear valve body 42.

[0033] As seen in figure 11A, when the piston 34 is fully opened the projected areas on the front and rear of the piston 34 that are exposed to pressure are substantially equal. When the pilot line associated with the flow control valve is exposed to restricted flow, the pressure at the front of the piston 34 is initially quite low relative to the static pressure that is developed at the rear of the piston 34 within the bleed fluid cavity 36. This is because the fluid in front of the piston 34 is freely discharging from the fluid passageway 28 via the fluid outlet 32 while the sampling orifice via the bleed fluid conduit 38 is converting most of its dynamic pressure into static pressure within the bleed fluid cavity 36.

[0034] As illustrated in figure 11B, as the piston 34 moves for closure of the fluid outlet 32 this discharge restriction from the fluid passageway 28 maintains significant discharge losses. While the projected areas to the front and rear of the piston 34 are now equal, the pressure acting on the front of the piston 34 is still reduced by the partial fluid flow from the fluid passageway 28. However, the pressure acting on the rear of the piston 34 now approaches the stagnation pressure at the sampling orifice. The stagnation pressure at the rear of the piston 34 within the bleed fluid cavity 36 is greater than the static pressure at the front of the piston 34 within the fluid passageway 28.

[0035] As depicted in figure 11C, the piston 34 moves wherein the annular shoulder 80 of the rear valve body 42 axially overlaps the annular rebate or step 76 of the piston 34. The fluid outlet 32 is thus restricted wherein the effective projected area of the front of the piston 34 is now reduced to the area of the fluid passageway 28 within the smallest diameter portion of the annular shoulder 80 i.e. the projected area of the conical portion 74 of the piston 34. At this stage of closure, discharge losses begin to increase toward the deadhead pressure of the fluid system and pressure distribution within the front and rear of the piston 34 tends to uniformly increase with a mostly even pressure distribution on the front and rear of the piston 34. The increased relative effective area of the rear of the piston 34 amplifies the force imbalance and promotes closure of the fluid outlet 32 via the piston 34. The annular rebate or step 76 in the piston 34 means the fluid passageway 28 can be maintained in a restricted flow state even with slight axial displacement of the piston. This is specifically designed to substantially eliminate “chattering” caused by piston 34 vibration whereas in this embodiment any fluid that escapes the fluid outlet 32 at this stage of closure is immediately reduced to tank pressure.

[0036] As shown in figure 11D, on complete closure of the fluid outlet 32, the radially extending seating face 78 of the piston 34 is pressed against the seating face 82 of the annular shoulder 80 of the rear body 42. The clearance fit between the piston 34 and the rear body 42 allows fluid leakage from the bleed fluid cavity 36 to the fluid outlet 32 and concurrently fluid from the fluid passageway 28 is bled into the bleed fluid cavity 36 via the annular bleed passage 52. In its fully closed condition the pressure developed on the rear of the piston 34 is equal to the pressure developed by frictional losses induced by the leakage from the bleed fluid cavity 36. The piston 34 is in this embodiment sized wherein the difference between stagnation pressure and friction leakage losses is offset by the larger effective projected area on the rear of the piston 34.

[0037] As described earlier, the chamfer 84 in the piston 34 reduces the area that the seating faces 78 and 82 contact each other thereby:

1. increasing the sealing pressure acting on these seating faces 78 and 82;
2. quickly expelling any leaked fluid between the sealing faces 78 and 82;
3. ensuring that the front face of the piston 34 which could be exposed to valve pressure will always have less projected area than the rear of the piston 34 when the piston 34 is closed.

[0038] Figure 12 illustrates fluid flows through the flow control valve 12 of the earlier embodiment in its open condition. The fluid flows through the flow control valve 12 in this open condition are schematically depicted in figure 13 where:

1. fluid from the fluid inlet 30 is sampled at the orifice 62 for entry to the venturi 40 and discharge to the associated pilot line and level sensor;
2. fluid from the inlet 30 flows through the fluid passageway 28 to the bleed fluid cavity 36 via the annular bleed passage 52 where under reduced pressure it is drawn via the venturi 40 through the bleed fluid conduit 38 for discharge to the pilot line;
3. fluid from the fluid inlet 30 flows through the fluid passageway 28 and exits the valve 12 via the fluid outlet 32 for discharge to the tank.

[0039] Figure 14 illustrates fluid flows through the flow control valve 12 of the preferred embodiment in its closed condition. The fluid flows through the flow control valve 12 in this closed condition as schematically shown in figure 15 where:

1. fluid from the fluid inlet 30 is sampled at the orifice 62 flowing to the bleed fluid cavity 36 via the venturi arrangement 40 and the bleed fluid conduit 38, escaping the bleed fluid cavity 36 to the fluid outlet 32 and tank via the clearance fit between the piston 34 and the rear valve body 42;
2. fluid from the fluid inlet 30 flows through the fluid passageway 28 and into the bleed fluid cavity 36 via the annular bleed passage 52, escaping the flow control valve 12 via the clearance fit between the piston 34 and the rear valve body 42.

[0040] In another aspect of the invention as best seen in figures 3 to 7 there is a flow control valve 12 where the front valve body 56 is rotationally coupled to the connector 60 for rotational movement relative to the connector 60. This rotational movement during installation of the flow control valve 12 permits reorientation of the front valve body 56 for substantial alignment of a pilot line such as 16 with the front valve body 56 and more particularly the pilot spigot 58. It will be understood that the connector 60 is screw threaded or otherwise connected to a tank such as 20 via an associated tank shell 18.

[0041] In this embodiment of this aspect of the invention the flow control valve 12 includes a clasp assembly 90 arranged to clasp the front valve body 56 to the rear valve body 42 for axial securement to one another whilst permitting rotational movement of the front valve body 56 relative to the connector 60. The clasp assembly 90 includes a plurality of flange segments such as 92a arranged to engage the front valve body 56 and a plurality of clasp fasteners such as 94a arranged to engage both the connector 60 and the plurality of flange segments such as 92a for axial securement of the front and rear valve bodies 56 and 42 to one another. In this example the clasp fastener 94a is one of six clasp fasteners 94a to 94f located within respective fastener openings 96a to 96f of the connector 60 and designed to threadingly engage respective of threaded fastener openings 98a to 98f formed in the clasp assembly 90. The pair of flange segments 92a and 92b are substantially identical including an internal annular flange such as 99a configured to engage a corresponding recess 100 formed in the front valve body 56.

[0042] As best seen in figure 7, the valve body 26 also includes one or more locking elements in the form of locking screws 102a and 102b arranged to engage both the front valve body 56 and the clasp assembly 90 to rotationally secure the front valve body 56 to the connector 60. The clasp assembly 90 of this example includes six threaded apertures 106a to 106f equally spaced circumferentially about the pair of flange segments 92a and 92b. The locking screws 102a/b pass through a pair of corresponding screw apertures 108a/b in the front valve body 56 and selectively align for threaded engagement with two of the six threaded apertures 106a to 106f formed in the clasp assembly 90. In this example the front valve body 56 can thus be pivoted or rotated through 60 degree increments for reorientation of the front valve body 56 depending on its required position for alignment with the associated pilot line. The front valve body 56 is then rotationally secured relative to the connector 60 and thus the associated tank via the locking screws 102a/b. Each of the front valve body 56 and rear valve body 42 include circumferential grooves 110 and 112 on their external surface designed to accommodate O-ring seals 114 and 116 respectively. These seals 114 and 116 cooperate with an internal surface of the connector 60 to prevent fluid leakage from the tank via the clearance interface between the connector 60 and the rear valve body 42 and the front valve body 56.

[0043] Returning to figure 10, it is to be understood that the static pressure at the front of the piston, P_{front} can be determined by the summation of: discharge losses which occur through the rear body, and local tank pressure (both hydrostatic and static). Similarly, the dynamic and static pressure components (stagnation pressure) measured at P_{sample} can be determined by the summation of P_{front}, the frictional losses between the sample point and rear body and the velocity pressure component of fluid flowing through the Sample Point itself. Otherwise, the pressures developed within the flow control valve are determined by a number of factors including, flowrate, tank hydrostatic pressure, tank geometry, and temperature. Notwithstanding these factors, the two key factors which control the relationship between P_{Front} and P_{Rear} are:

i) the flow condition and pressure within the pilot line; and
ii) the position of the piston.

[0044] Now that several preferred embodiments of the flow control valve and tank overfill protection system have been described it will be apparent to those skilled in the art that they have at least the following advantages:

1. the flow control valve including the venturi arrangement increases the pressure differential on opposing sides of the associated piston thereby remaining open when there is flow through the associated pilot line;
2. the flow control valve with restricted flow through the associated pilot line reverses the pressure differential across the piston promoting its displacement and closure of the valve;
3. the flow control valve and specific piston configuration of the preferred embodiment provides staged closure of the valve reducing the likelihood of "chatter" on valve closure;
4. the venturi of the flow control valve reduces the likelihood of foreign particles collecting within the piston chamber of the preferred embodiment by promoting bleed fluid flow away from said chamber;
5. the flow control valve lends itself to alignment with a pilot line during installation wherein the connector and rear valve body cooperate to permit rotational movement of the front valve body.

[0045] Those skilled in the art will appreciate that the invention as described herein is susceptible to variations and modifications other than those specifically described. For example, the piston may depart from its preferred shape provided in cooperation with the venturi arrangement it provides effective closure and opening of the fluid outlet. Similarly, the piston and bleed fluid conduit may be reconfigured without the annular bleed passage of the preferred embodiment provided bleed fluid is effectively supplied to the piston to create the force imbalance required for its displacement and resulting closure of the fluid outlet. The preferred construction of the front valve body and rear valve body in conjunction with the connector may vary where for example locking of the front valve body to the connector provides potentially an infinite number of angular dispositions for the front body for alignment with the associated pilot line. The flow control valve may be directly connected to the tank or indirectly connected in a remote installation to the tank via an intermediate coupling line. All such variations and modifications are to be considered within the scope of the present invention the nature of which is to be determined from the foregoing description.

CLAIMS

1. A flow control valve comprising:

a valve body defining a fluid passageway between a fluid inlet and a fluid outlet;

a piston slidably mounted within the fluid passageway and arranged for opening and closure of the fluid outlet;

a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the fluid outlet by displacement of the piston;

a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the fluid outlet by displacement of the piston.

2. A flow control valve as claimed in claim 1 wherein the valve body includes a rear valve body within which the piston is slidably mounted, said rear body including one or more radial openings which at least in part define the fluid outlet.

3. A flow control valve as claimed in claim 2 wherein the piston includes a peripheral wall arranged to cooperate with the radial openings of the rear body for opening and closure of the fluid outlet.

4. A flow control valve as claimed in claim 3 wherein the peripheral wall of the piston internally defines a piston chamber which at least in part forms the bleed fluid cavity.

5. A flow control valve as claimed in any one of the preceding claims wherein the piston includes an axial opening through which the bleed fluid conduit passes defining an annular bleed passage between the piston and the bleed fluid conduit, said bleed passage arranged to transfer bleed fluid to or from the fluid passageway and the bleed fluid cavity.

6. A flow control valve as claimed in claim 5 wherein the bleed fluid conduit includes one or more apertures located within the bleed fluid cavity and arranged to provide the bleed fluid communication between the bleed fluid cavity and the bleed fluid conduit.

7. A flow control valve as claimed in any one of the preceding claims wherein the valve body also includes a front valve body defining at least part of the fluid passageway including the fluid inlet, said front valve body operatively coupled to a pilot line associated with the flow control valve.

8. A flow control valve as claimed in claim 7 wherein the valve body also includes a connector arranged to retain the rear valve body and adapted to connect to a tank with which the pilot line is associated.

9. A flow control valve as claimed in claim 8 wherein the venturi arrangement is operatively coupled to the pilot line at the front valve body and located within the fluid passageway at the front valve body.

10. A flow control valve as claimed in claim 9 wherein the bleed fluid conduit connects the venturi arrangement within the front valve body to the bleed fluid cavity.

11. A flow control valve as claimed in any one of claims 8 to 10 wherein the venturi arrangement is associated with a fluid sampling orifice which samples fluid at the fluid inlet for provision at the venturi arrangement which with fluid flow through the pilot line promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed fluid conduit thus reducing pressure within the bleed fluid cavity to promote displacement of the piston and opening of the fluid outlet.

12. A flow control valve as claimed in claim 11 wherein the fluid sampling orifice on restricted fluid flow through the pilot line provides sampled fluid from the fluid inlet to the bleed fluid cavity via the venturi arrangement and the bleed fluid conduit to substantially equalise fluid pressure between the fluid sampling orifice and the bleed cavity whereby the force imbalance across the piston promotes displacement of the piston and closure of the fluid outlet.

13. A flow control valve as claimed in any one of claims 8 to 12 wherein the pilot line with which the flow control valve is associated is located outside the tank.

14. A flow control valve as claimed in any one of claims 2 to 4 wherein the venturi arrangement is located within the bleed fluid cavity and is operatively coupled to a pilot line at the rear valve body.

15. A flow control valve as claimed in claim 14 wherein the venturi arrangement is associated with a fluid sampling orifice which samples fluid at the fluid passageway for provision at the venturi arrangement which with fluid flow through the pilot line promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed conduit thus reducing pressure within said bleed cavity to promote displacement of the piston and opening of the fluid outlet.

16. A flow control valve as claimed in either of claims 14 or 15 wherein the bleed fluid conduit is adapted to operatively couple to the pilot line located inside a tank with which the flow control valve is associated.

17. A flow control valve as claimed in either of claims 3 or 4 wherein the piston includes a cylindrical portion defined by the peripheral wall, a seating portion connected to the cylindrical portion, and a substantially conical portion connected to the seating portion.

18. A flow control valve as claimed in claim 17 wherein the seating portion includes a radially extending seating face configured to seat with the rear valve body on closure of the fluid outlet via the piston.

19. A flow control valve as claimed in claim 18 wherein the fluid passageway is in a downstream flow direction tapered inwardly forming an annular shoulder including a radially extending seating face within the rear valve body configured for seating closure with the seating face of the seating portion of the piston.

20. A flow control valve as claimed in claim 19 wherein the seating face of the piston is formed by an annular rebate within the seating portion of the piston.

21. A flow control valve as claimed in claim 20 wherein the piston is designed for staged closure of the fluid outlet where initially the annular shoulder of the rear valve body axially overlaps the annular rebate of the piston and subsequently, on complete closure of the fluid opening, the seating face of the rear body contacts the seating face in the piston.

22. A flow control valve as claimed in any one of claims 19 to 21 wherein the seating portion of the piston has a circumferential chamfer extending radially outward from the seating face of the piston reducing its contact area with the seating face of the rear valve body assisting with operation of the piston.

23. A flow control valve as claimed in any one of claims 8 to 13 wherein the front valve body is pivotally coupled to the connector for rotational movement relative to said connector for reorientation of the front valve body for substantial alignment with the pilot line.

24. A flow control valve as claimed in claim 23 wherein the valve includes a clasp assembly arranged to clasp the front valve body to the rear valve body for axial securement to one another whilst permitting pivotal movement of the front valve body relative to the connector.

25. A flow control valve as claimed in claim 24 wherein the clasp assembly includes a plurality of flange segments arranged to engage the front valve body, and a plurality of clasp fasteners arranged to engage both the connector and the plurality of flange segments for axial securement of the front and rear valve bodies to one another.

26. A flow control valve as claimed in either of claims 24 or 25 wherein the valve body further includes one or more locking elements arranged to engage both the front valve body and the clasp assembly to pivotally secure the front valve body relative to the connector.

27. A flow control valve comprising:

a valve body defining a fluid passageway between opposing first and second fluid openings;

a piston slidably mounted within the fluid passageway and arranged for opening and closure of the second fluid opening;

a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the second fluid opening by displacement of the piston;

a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the second fluid opening by displacement of the piston.

28. A flow control valve as claimed in claim 27 wherein the valve body is operatively coupled to a pilot line associated with the flow control valve.

29. A flow control valve as claimed in claim 28 wherein the venturi arrangement is associated with a fluid sampling orifice which samples fluid from either the first opening or the fluid passageway for provision at the venturi arrangement wherein: i) fluid flow from the venturi arrangement and through the pilot line in one direction promotes evacuation of bleed fluid from the bleed fluid cavity via the bleed fluid conduit thus reducing pressure within the bleed fluid cavity to promote displacement of the piston and opening of the second fluid opening, and ii) fluid flow from the pilot line and through the venturi arrangement in an opposite direction also promotes evacuation of bleed fluid from the bleed fluid cavity to promote opening of the second fluid opening.

30. A flow control valve as claimed in claim 29 wherein the flow control valve is arranged for bi-directional flow when fluid flows through the pilot line occurs in either said one or the opposite direction.

31. A tank overfill protection system comprising:

a flow control valve adapted to operatively couple to a tank to be filled with fluid, said flow control valve comprising:

i) a valve body defining a fluid passageway between a fluid inlet and a fluid outlet;

ii) a piston slidably mounted within the fluid passageway and arranged for opening and closure of the fluid outlet;

iii) a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the fluid outlet by displacement of the piston;

iv) a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit;

v) a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the fluid outlet by displacement of the piston;

a tank level sensor adapted to operatively couple to the tank, said level sensor connected to a pilot line associated with bleed fluid cavity of the flow control valve whereby the tank level sensor is arranged to detect a safe fill level within the tank and restrict bleed fluid flow through the pilot line promoting the force imbalance across the piston which is effective in displacement of the piston for closure of the fluid outlet of the flow control valve.

32. A tank overfill protection system as claimed in claim 31 wherein the tank level sensor comprises:

a valve body including a pilot inlet adapted to couple to the pilot line;

at least one pilot valve mounted to the valve body and in liquid communication with the pilot inlet;

a pilot valve actuator operatively coupled to said at least one pilot valve for its opening and closure, the pilot valve actuator including a balance member arranged to cooperate with actuator biasing means, the balance member having a specific gravity relative to liquid within the tank whereby at least part submersion of the balance member provides movement of the balance member relative to the valve body, said movement of the balance member:

i) only occurring together with the influence of the actuator biasing means; and

ii) being effective in closure of said at least one pilot valve.

33. A tank overfill protection system as claimed in claim 32 wherein said at least one pilot valve includes at least one poppet valve having a poppet valve head connected to a valve stem arranged to be contacted by the balance member for opening of said at least one pilot valve.

34. A tank overfill protection system as claimed in claim 33 wherein the actuator biasing means includes a pilot valve compression spring designed to provide sufficient biasing force to provide movement of the balance member relative to the valve body for:

i) closure of said at least one poppet valve on at least part submersion of the balance member with the biasing force of the compression spring overcoming an apparent weight of the balance member;

ii) opening of said at least one poppet valve when the balance member is not at least part submerged and the weight of the balance member overcomes the biasing force of the compression spring.

35. A flow control valve comprising:

a valve body assembly including a rear valve body defining part of a fluid passageway including a fluid outlet, said valve body assembly including a connector arranged to retain the rear valve body;

a piston slidably mounted within the fluid passageway of the rear valve body and arranged for opening and closure of the fluid outlet;

a front valve body defining at least part of the fluid passageway including a fluid inlet, said front valve body pivotally coupled to the connector for rotational movement relative to said connector for reorientation of the front valve body.

36. A flow control valve as claimed in claim 35 wherein the connector is adapted to connect to a tank, and the front valve body is operatively coupled to a pilot line associated with the flow control valve.

37. A flow control valve as claimed in claim 36 wherein the front valve body rotationally couples to the connector for reorientation relative to the front valve body for substantial alignment with the pilot line.

38. A flow control valve as claimed in any one of claims 35 to 37 wherein the valve includes a clasp assembly arranged to clasp the front valve body to the rear valve body for axial securement to one another whilst permitting rotational movement of the front valve body relative to the connector.

39. A flow control valve as claimed in claim 38 wherein the clasp assembly includes a plurality of flange segments arranged to engage the front valve body, and a plurality of clasp fasteners arranged to engage both the connector and the flange segments for axial securement of the front and rear valve bodies to one another.

40. A flow control valve as claimed in either of claims 38 or 39 wherein the valve body further includes one or more locking elements arranged to engage both the front valve body and the clasp assembly to rotationally secure the front valve body relative to the connector.

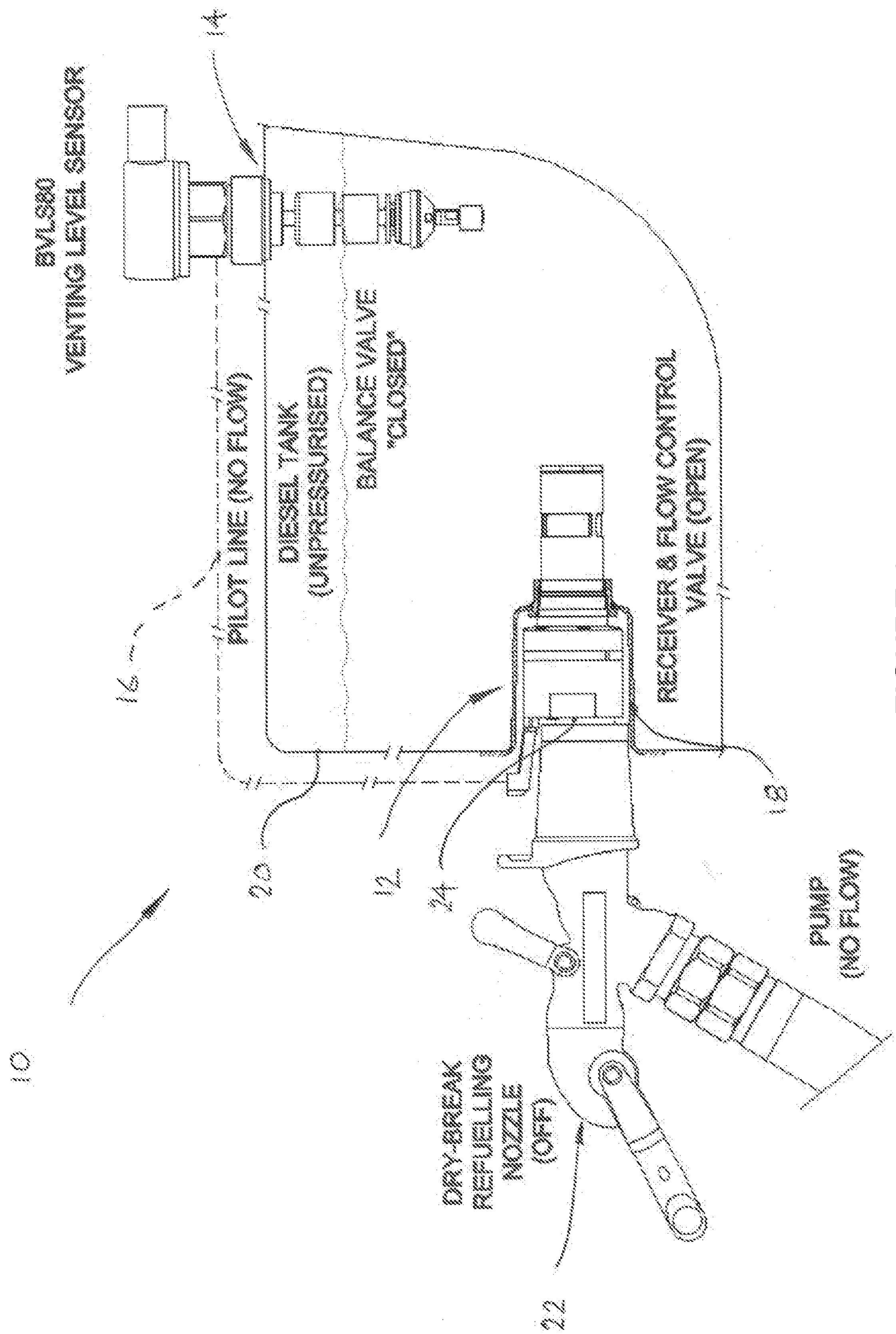
BVLS80
VENTING LEVEL SENSOR
14
PILOT LINE (NO FLOW)
DIESEL TANK
(UNPRESSURISED)
BALANCE VALVE
'CLOSED'
RECEIVER & FLOW CONTROL
VALVE (OPEN)
16
20
12
24
18
10
PUMP
(NO FLOW)
DRY-BREAK
REFUELLING
NOZZLE
(OFF)
22

FIGURE 1

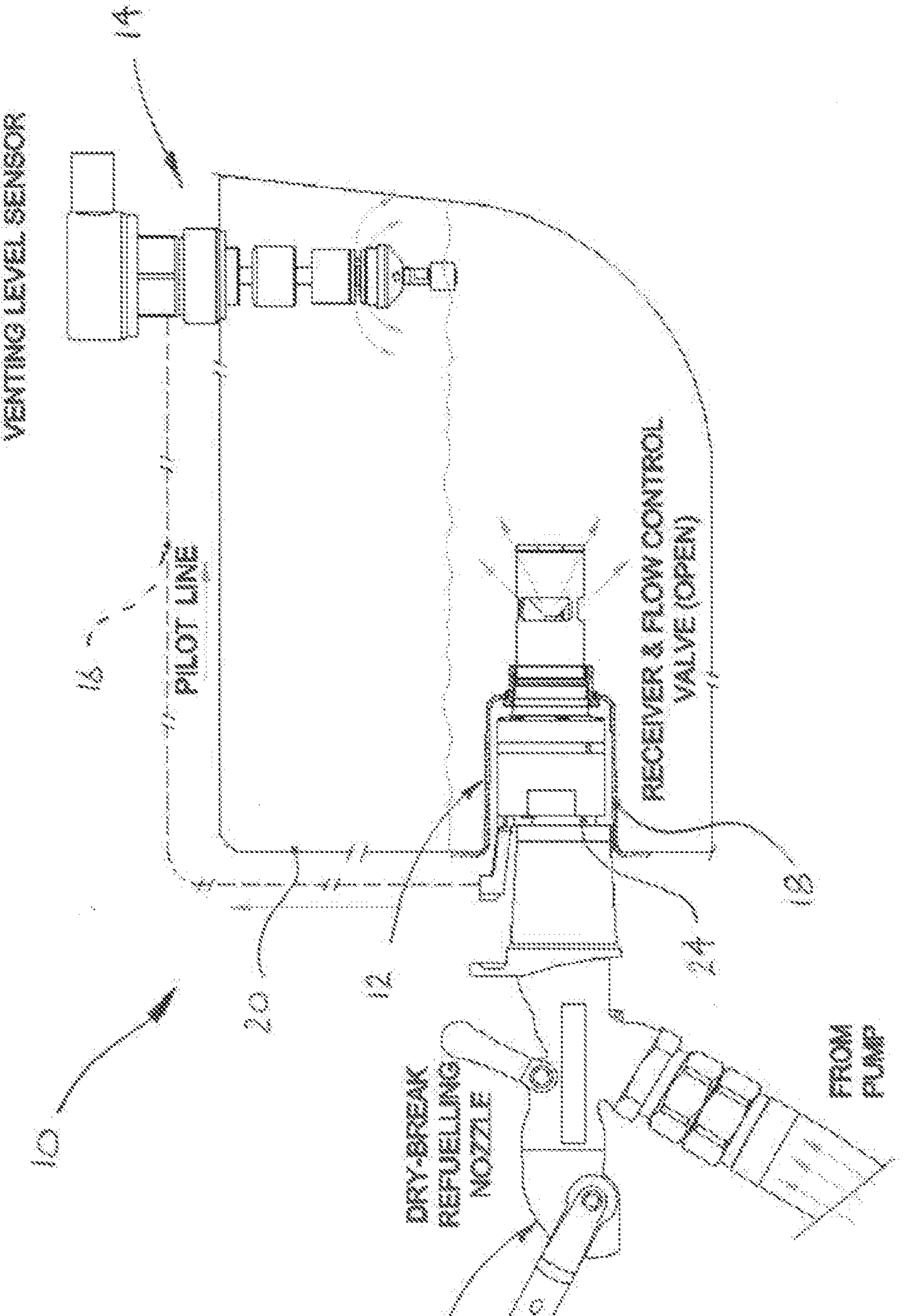
BVLS80
VENTING LEVEL SENSOR
PILOT LINE
RECEIVER & FLOW CONTROL
VALVE (OPEN)
DRY-BREAK
REFUELLING
NOZZLE
FROM
PUMP
14
16
12
18
20
24
10
22

FIGURE 2

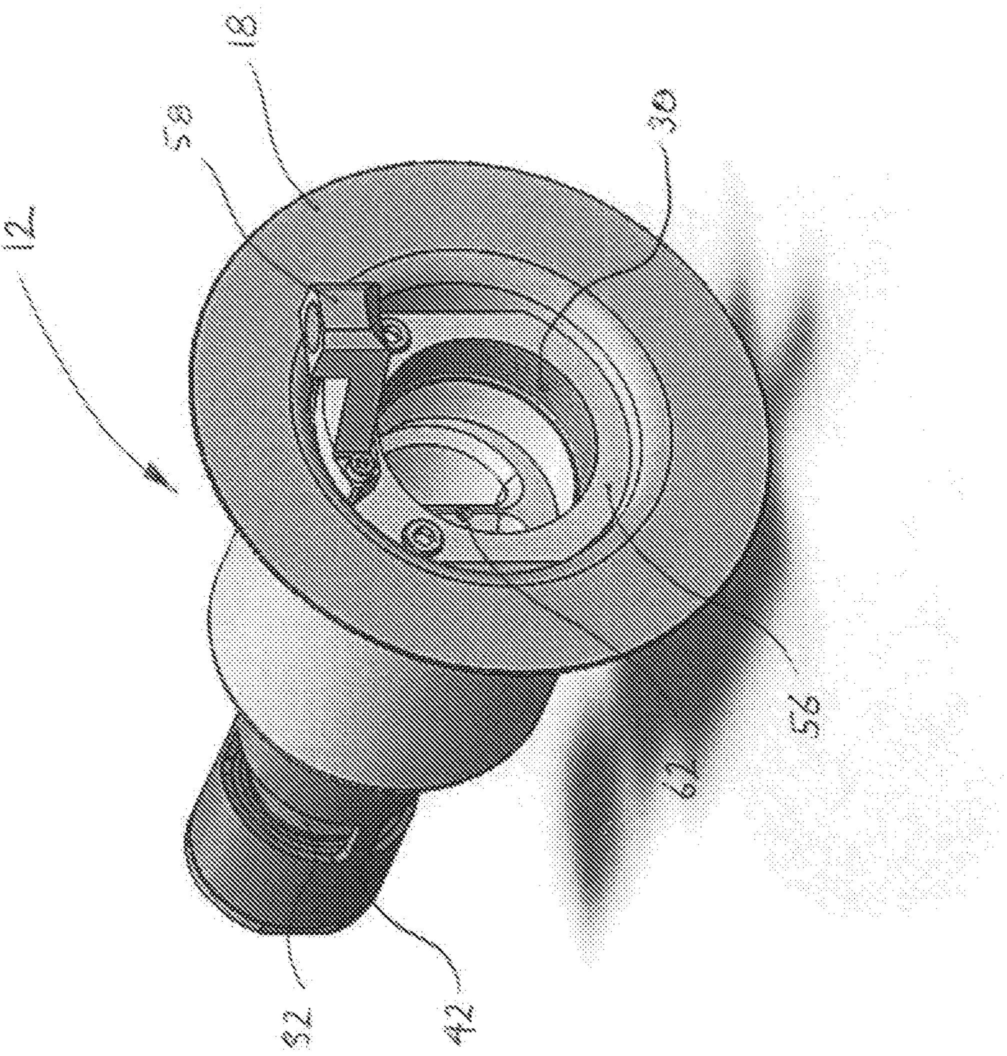

FIGURE 3

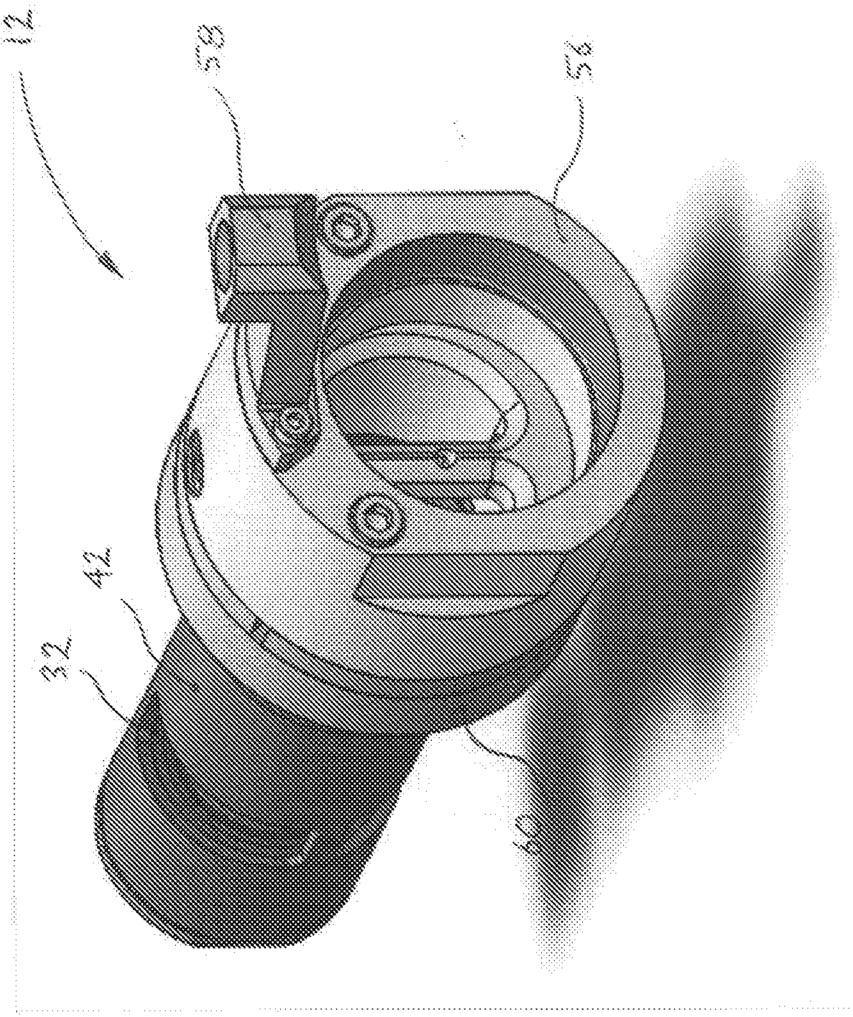

FIGURE 4

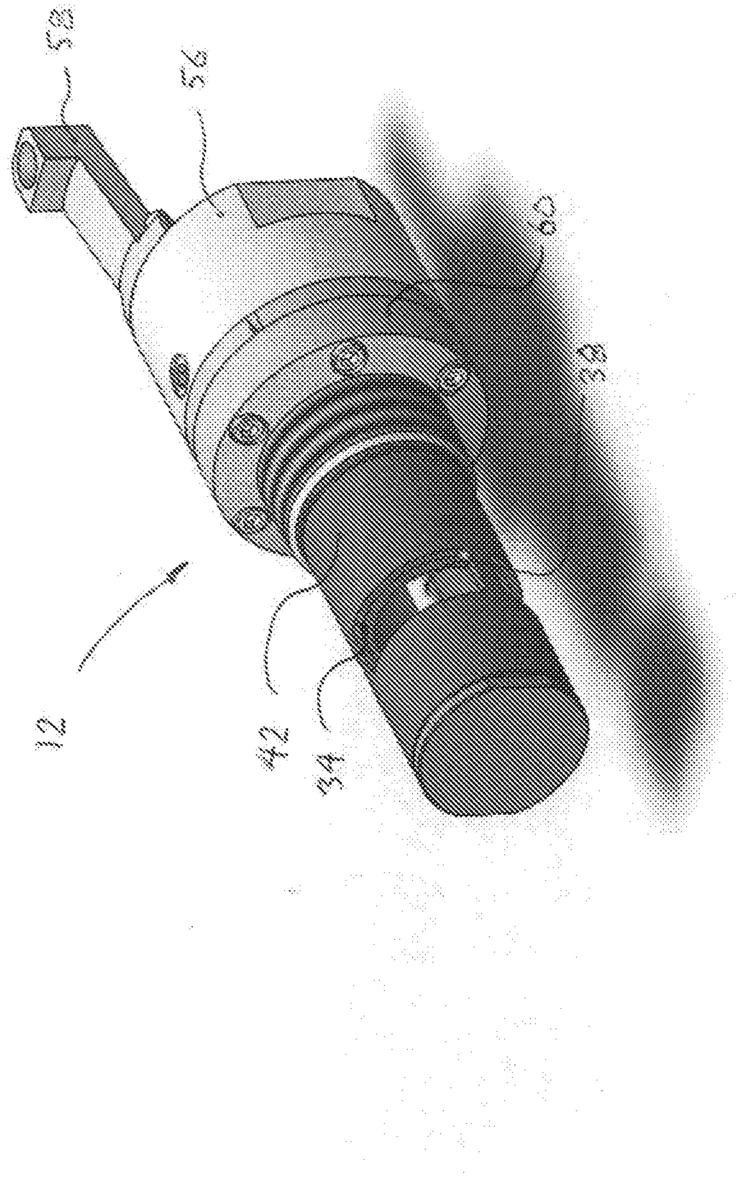

FIGURE 5

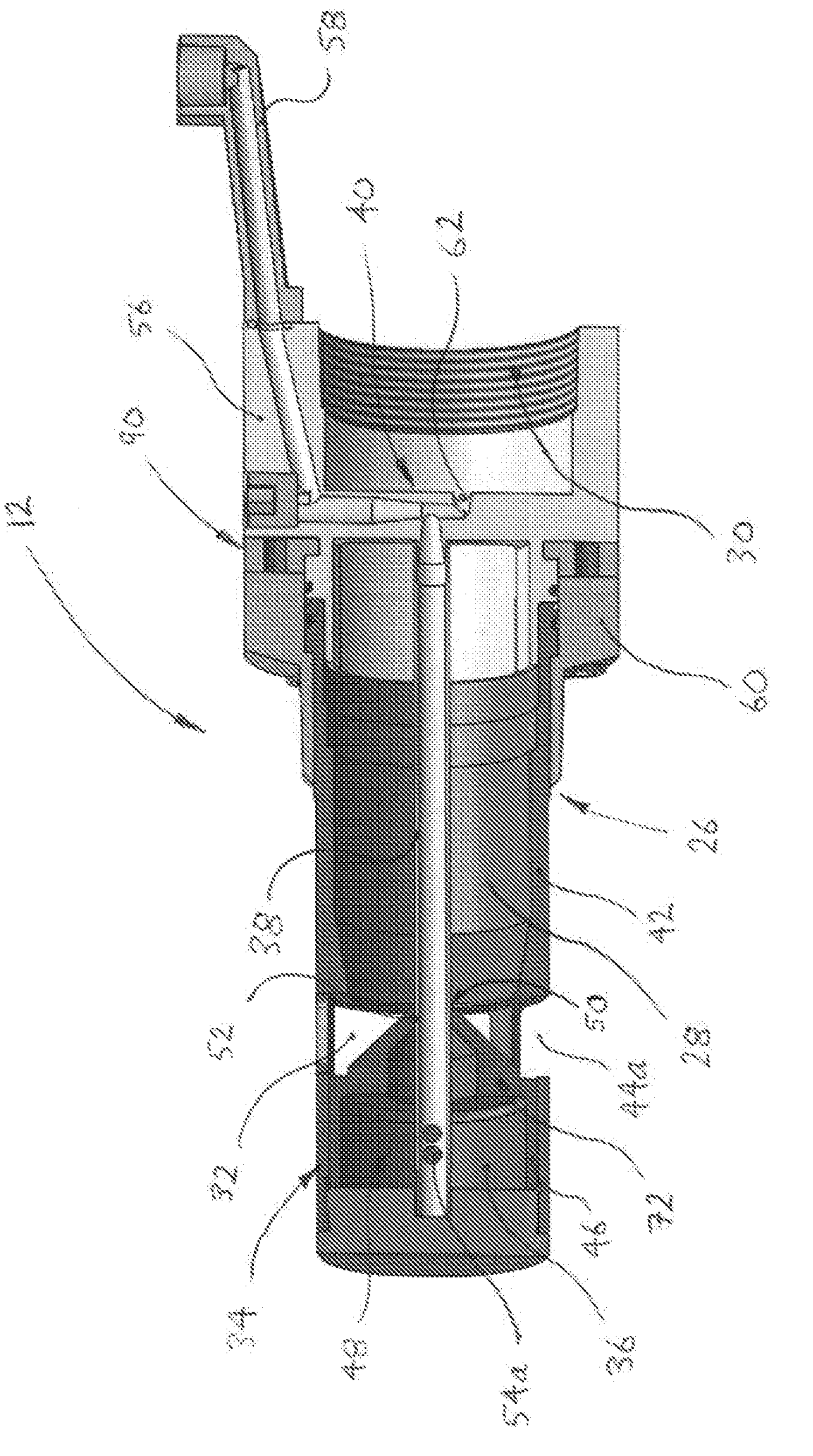

FIGURE 6

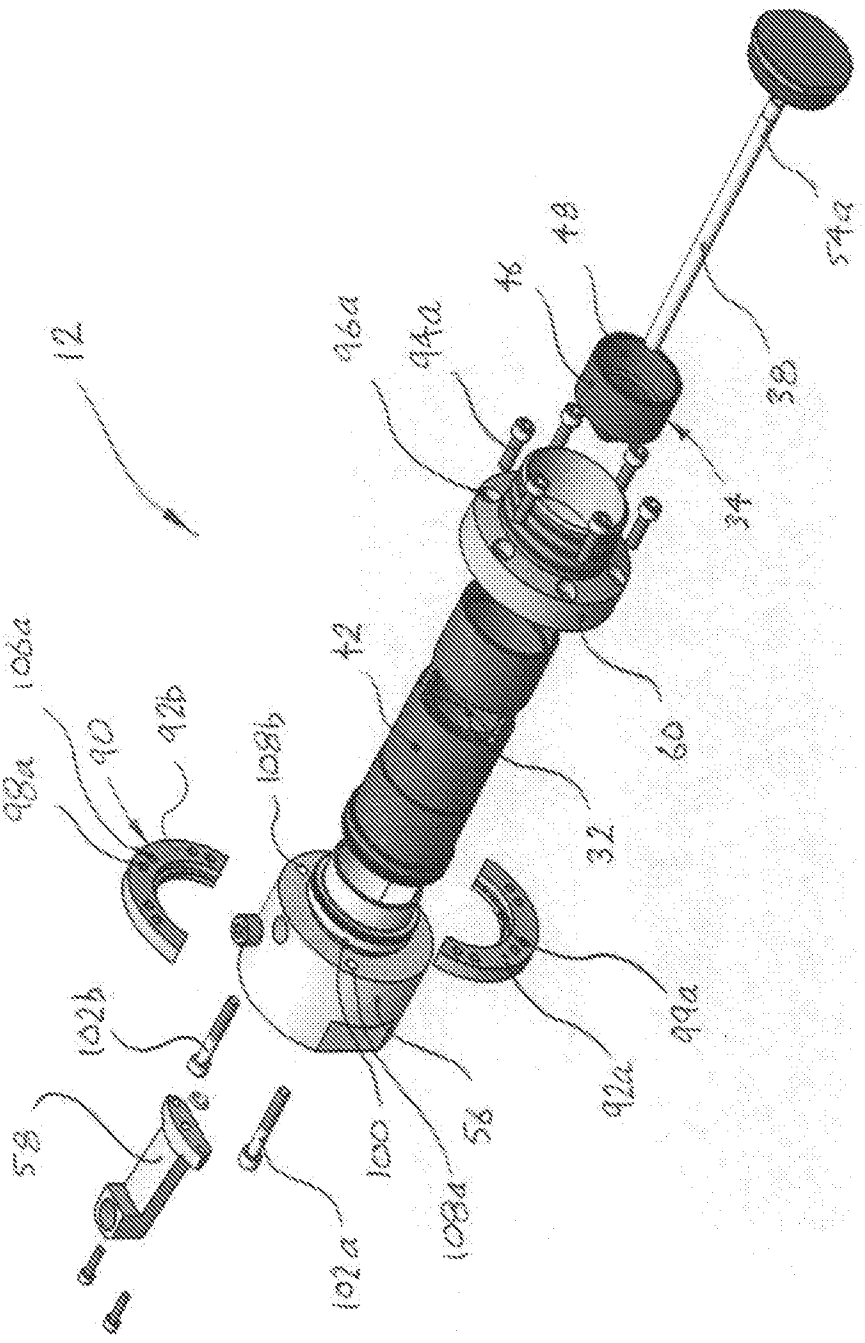
12
54a
38
48
46
94a
96a
34
60
42
32
108b
106a
90
92b
98a
102b
58
100
56
108a
102a
92a
99a

FIGURE 7

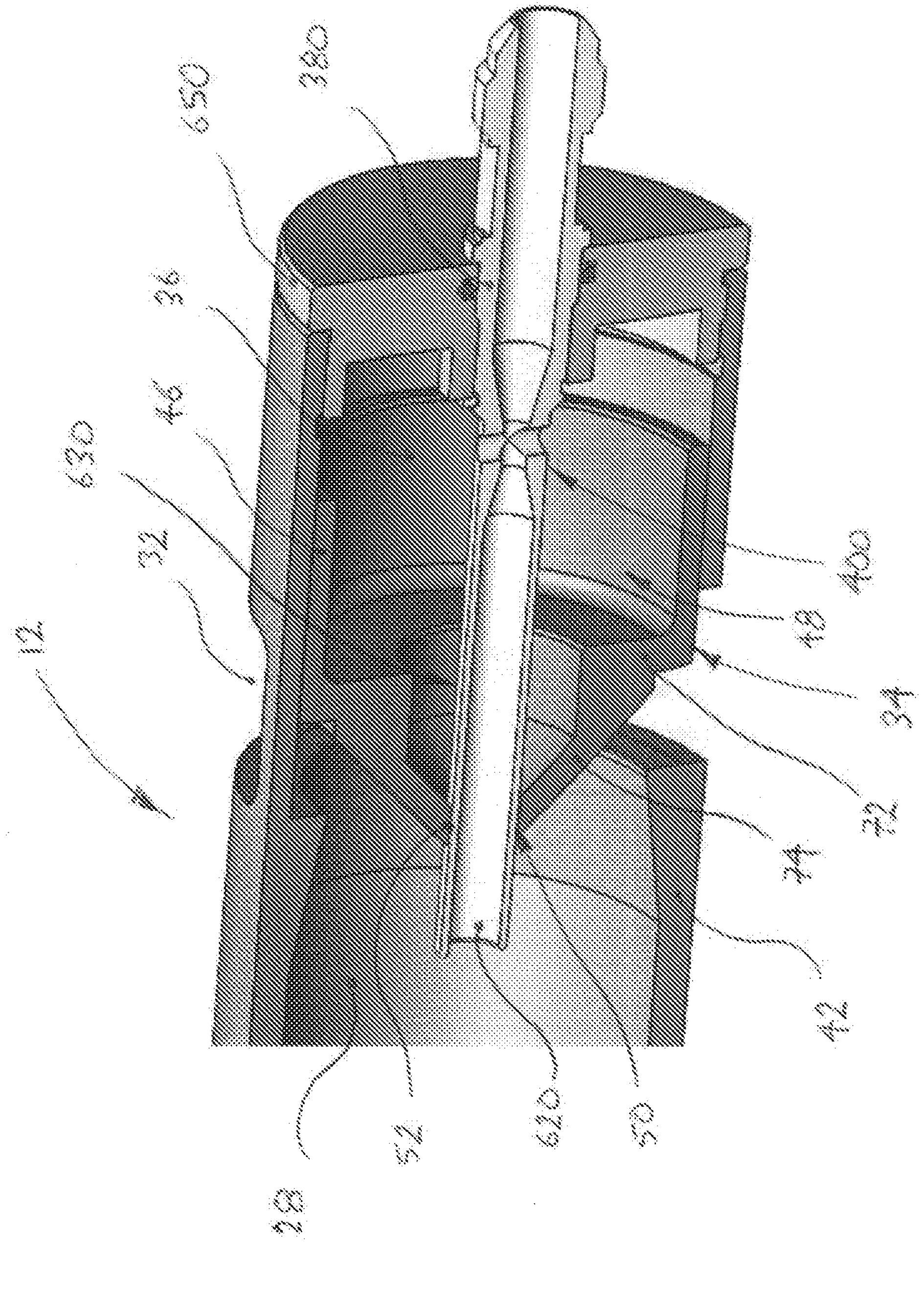

FIGURE 8

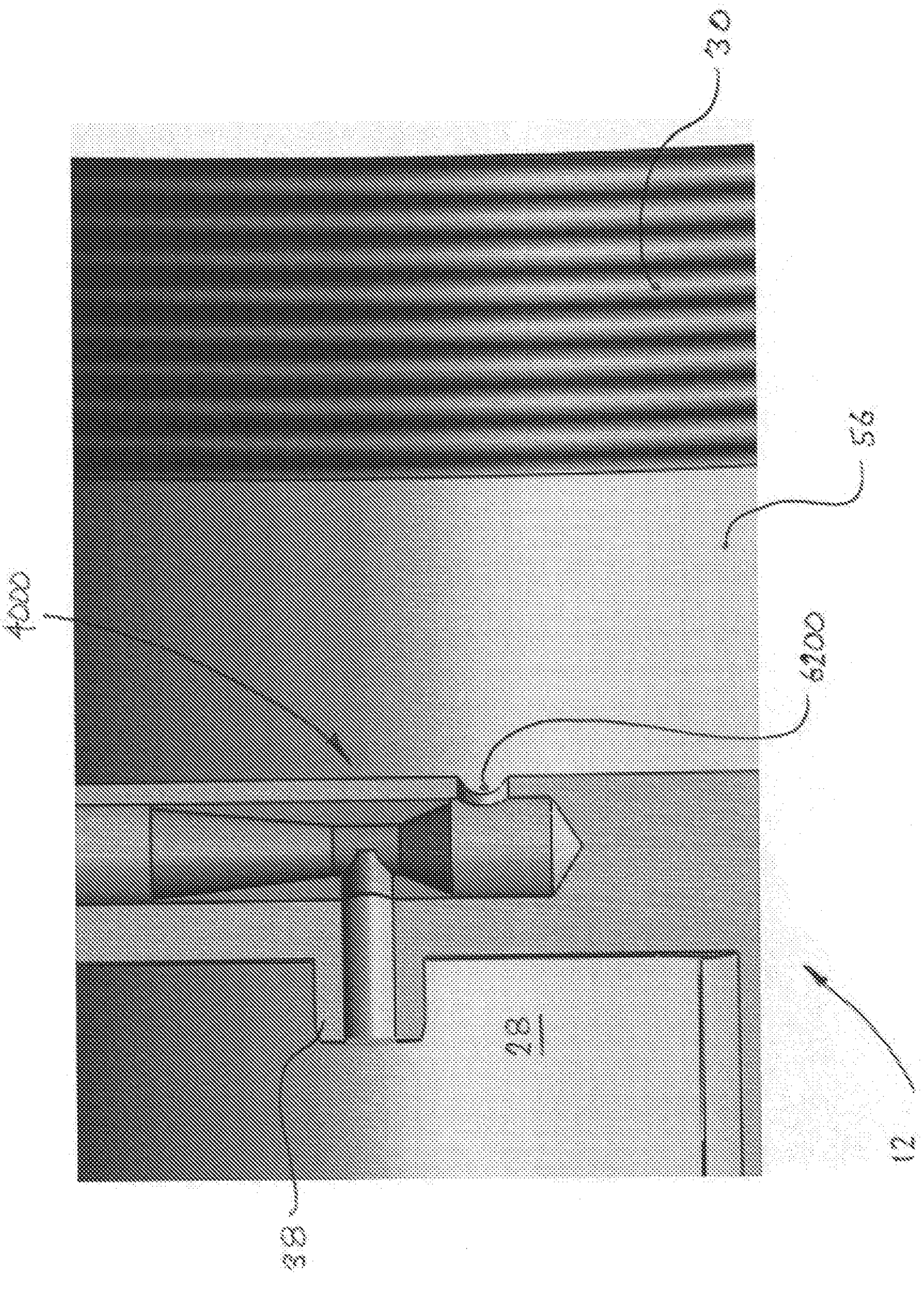

FIGURE 9

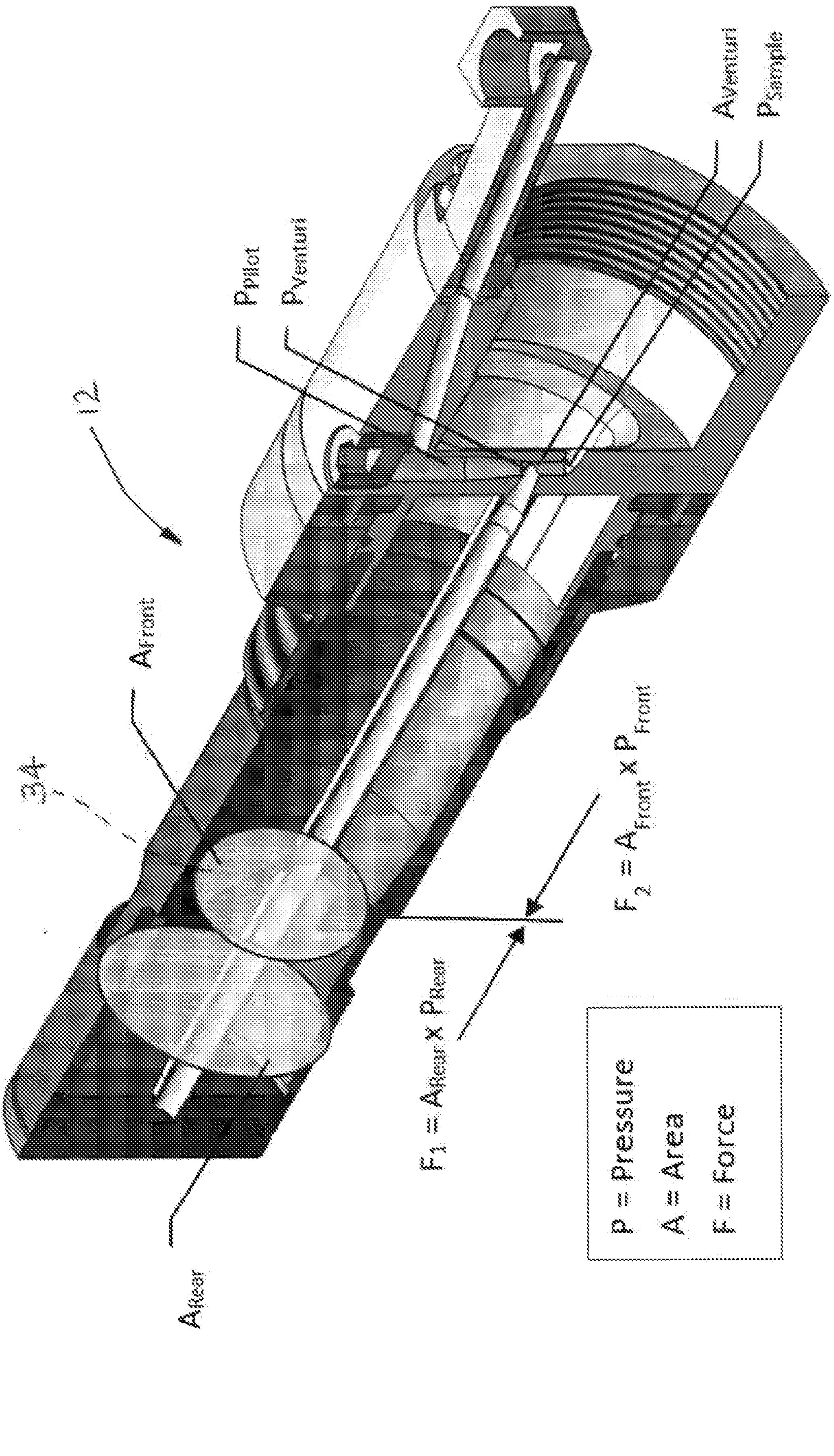
12
34
AFront
PPilot
PVenturi
AVenturi
PSample
F1 = ARear x PRear
F2 = AFront x PFront
ARear
P = Pressure
A = Area
F = Force

FIGURE 10

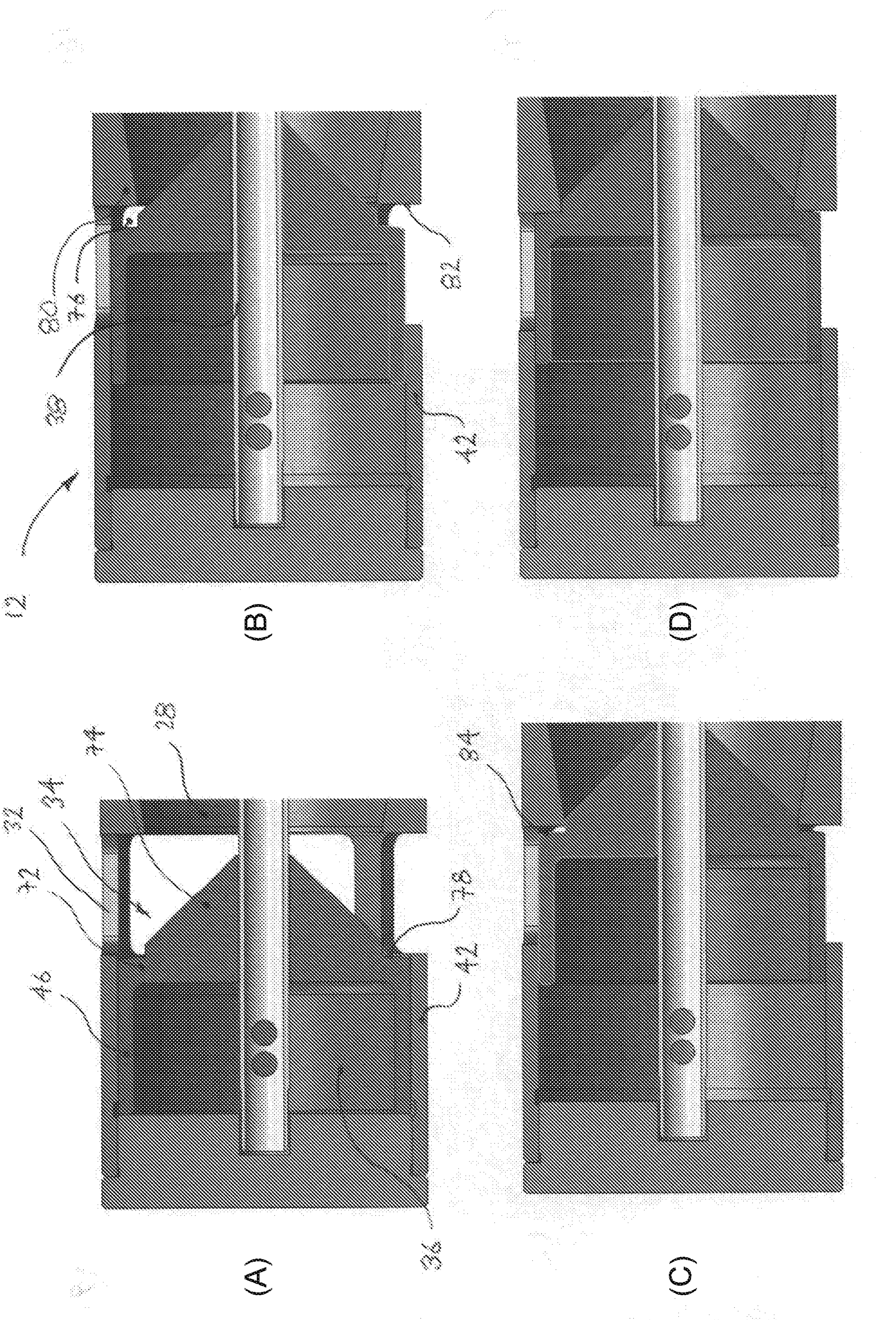

FIGURE 11

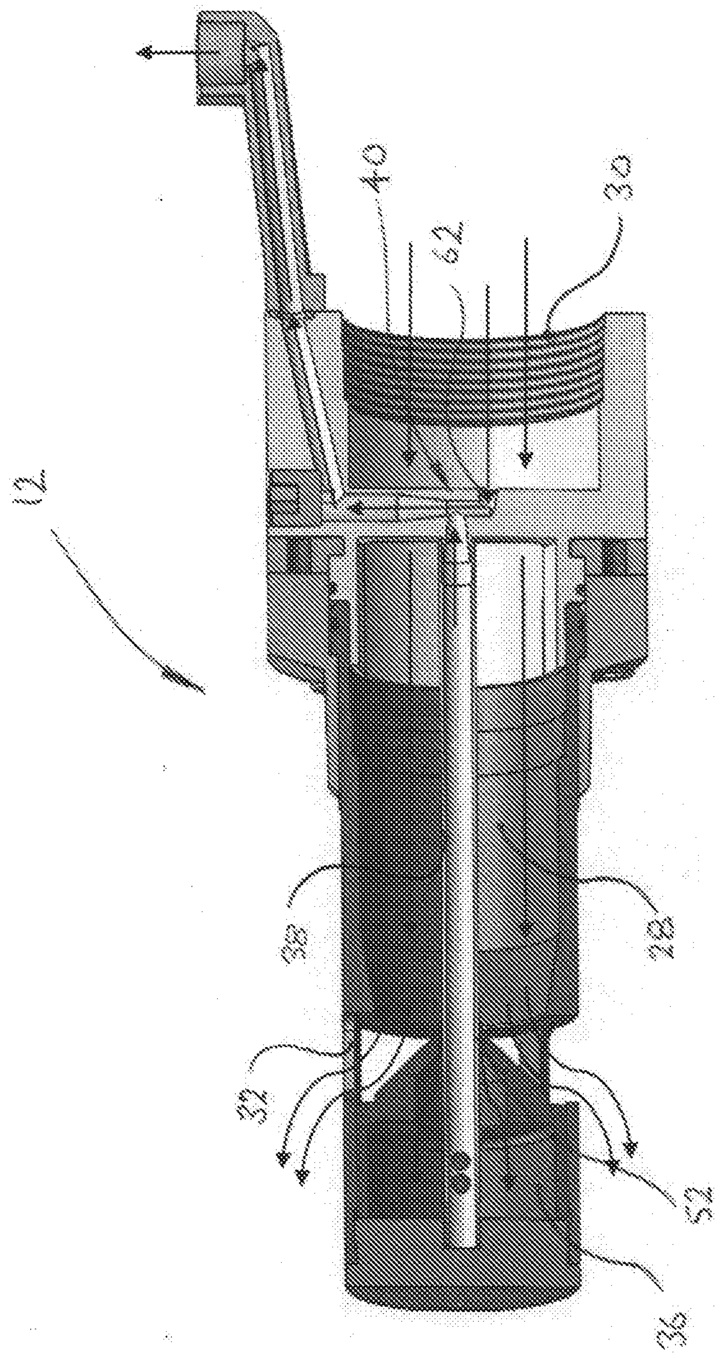

FIGURE 12

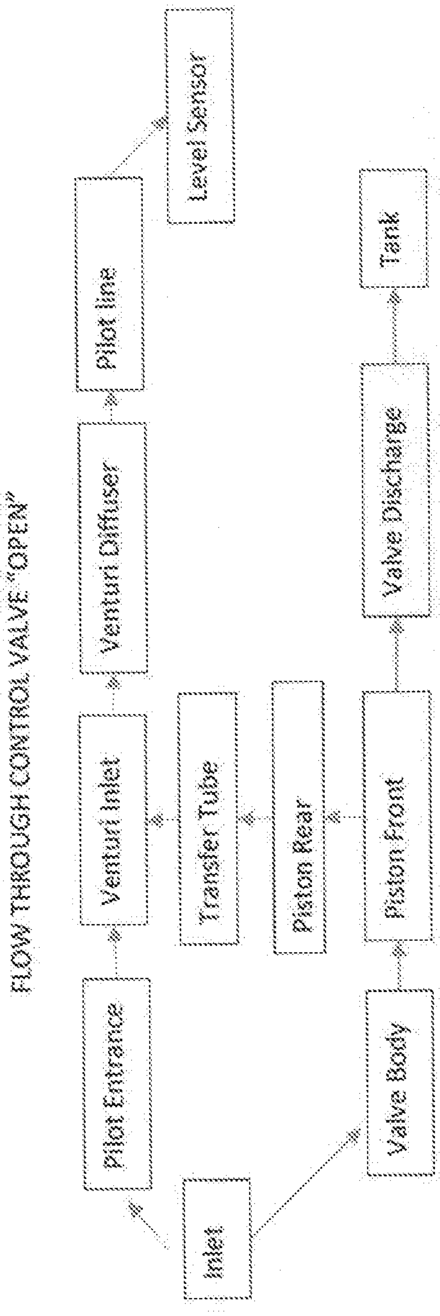
FLOW THROUGH CONTROL VALVE "OPEN"
Inlet
Pilot Entrance
Venturi Inlet
Venturi Diffuser
Pilot line
Level Sensor
Valve Body
Piston Front
Piston Rear
Transfer Tube
Valve Discharge
Tank

FIGURE 13

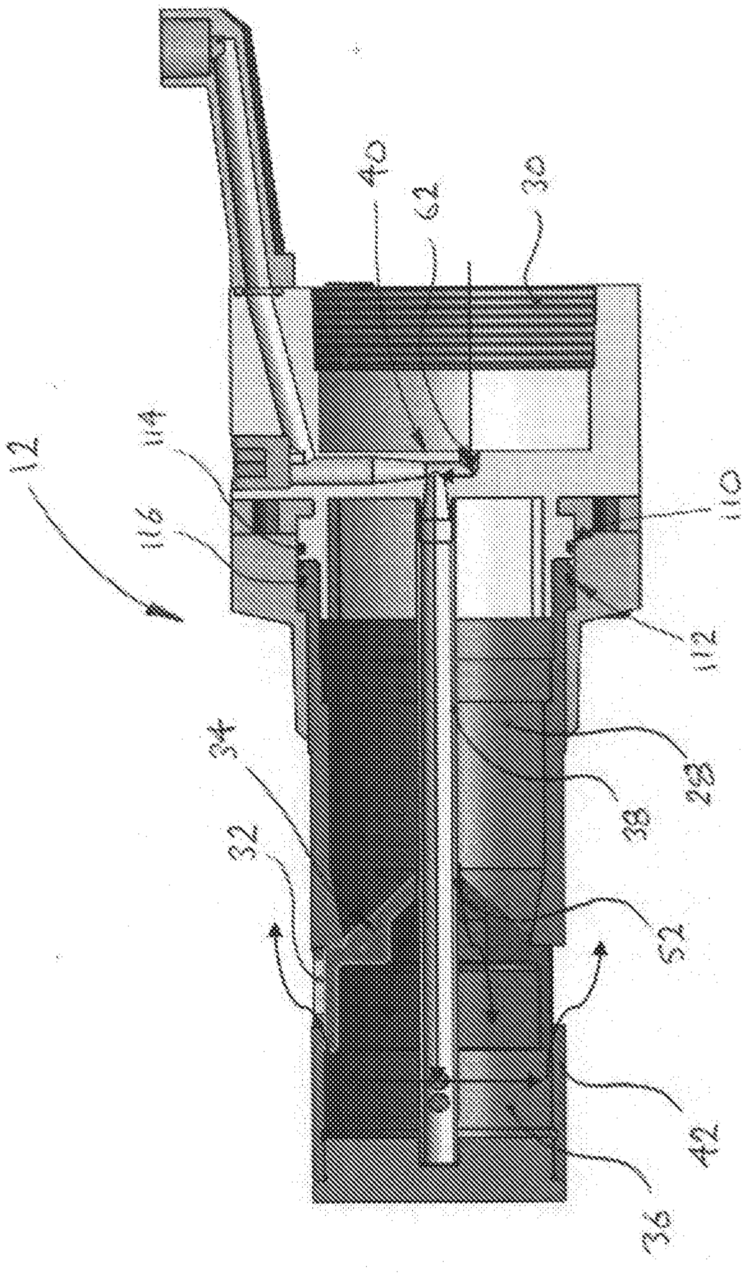

FIGURE 14

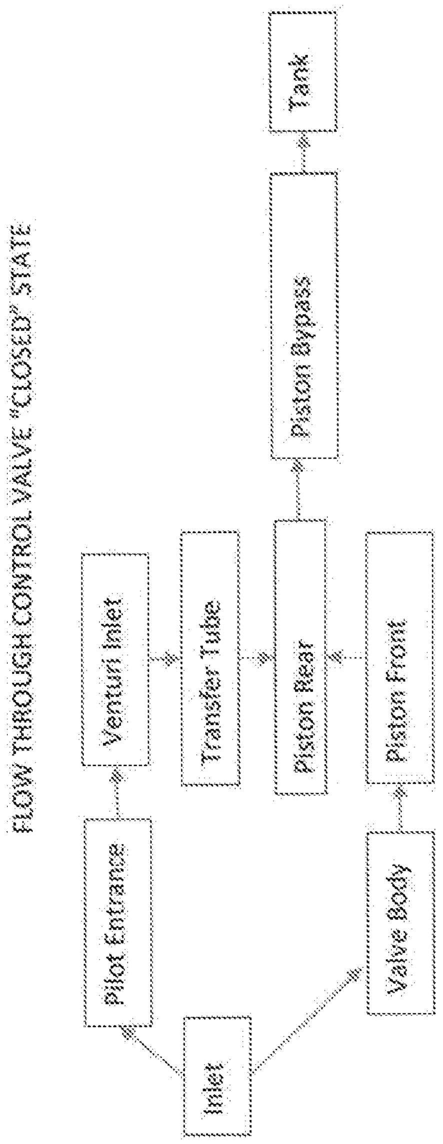
FLOW THROUGH CONTROL VALVE "CLOSED" STATE
Inlet
Pilot Entrance
Valve Body
Venturi Inlet
Transfer Tube
Piston Rear
Piston Front
Piston Bypass
Tank

FIGURE 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2019/050911

A. CLASSIFICATION OF SUBJECT MATTER

B67D 7/36 (2010.01) F16K 31/12 (2006.01) F16K 31/143 (2006.01) B60K 15/03 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, PATENW: B67D7/36, F16K31/12, F16K31/383, B67D7/46, B67D7/52, B60K2015/03368, B60K15/03519, F16K21/-, F16K31/- & keywords (bleed, liquid, fuel, venturi, piston, orifice, hole, area, differ, pressure_drop, pilot, by_pass, line, circuit, float_valve, sense, actuate, close, plug, tank) & like terms; Citing and Cited document; **Espacenet**: B67D7/362 & keywords (venturi, tank, fuel, flow, bleed, valve); **Google Patents**: keywords (over fill, venturi, tank) & like terms; Applicant/inventor name search conducted on Espacenet, AusPat, and internal databases provided by IP Australia.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2019	21 October 2019

Name and mailing address of the ISA/AU	Authorised officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Chris Hang AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262832657

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

   because they relate to subject matter not required to be searched by this Authority, namely:

   the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:

   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:

   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT	International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT	**PCT/AU2019/050911**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	WO 2018053598 A2 (WALNAB PTY LTD) 29 March 2018	
X	Figures 4A-4C; para [0034], [0036]	35-40
A	Abstract; figures 1-9; para [0015]-[0036]	1-34
	WO 2015103341 A1 (COOLEY, ROBERT CHARLES et al.) 09 July 2015	
A	Whole document	1-40
	US 20050166966 A1 (CORTEZ) 04 August 2005	
A	Whole document	1-40
	US 20080202600 A1 (PEATTIE et al.) 28 August 2008	
A	Whole document	1-40
	US 20140261884 A1 (ADEL WIGGINS GROUP) 18 September 2014	
A	Whole document	1-40
	US 6311723 B1 (SHIPP et al.) 06 November 2001	
A	Whole document	1-40
	WO 2016094952 A1 (WALNAB PTY LTD) 23 June 2016	
A	Whole document	1-40

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-34 are directed to a flow control valve. The features of a bleed fluid cavity at least in part located within the valve body and arranged to cooperate with the piston to, under the influence of bleed fluid pressure within the bleed fluid cavity, create a force imbalance across the piston to promote closure of the fluid outlet by displacement of the piston; a bleed fluid conduit operatively coupled to the bleed fluid cavity for bleed fluid communication between said cavity and the bleed fluid conduit; a venturi arrangement operatively coupled to the bleed fluid conduit to reduce pressure within the bleed fluid cavity to promote evacuation of the bleed fluid from said cavity thereby opening the fluid outlet by displacement of the piston are specific to this group of claims.
- Claims 35-40 are directed to a flow control valve. The features of said valve body assembly including a connector arranged to retain the rear valve body; and said front valve body pivotally coupled to the connector for rotational movement relative to said connector for reorientation of the front valve body are specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2019/050911**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
WO 2018053598 A2	29 March 2018	WO 2018053598 A2	29 Mar 2018
		AU 2017329247 A1	16 May 2019
		CA 3036098 A1	29 Mar 2018
		CL 2019000767 A1	24 May 2019
		CN 109790940 A	21 May 2019
WO 2015103341 A1	09 July 2015	WO 2015103341 A1	09 Jul 2015
US 20050166966 A1	04 August 2005	US 2005166966 A1	04 Aug 2005
		US 7258130 B2	21 Aug 2007
		AU 2002360778 A1	30 Jul 2003
		AU 2002360778 B2	09 Aug 2007
		AU 2006204085 A1	13 Jul 2006
		AU 2006204085 B2	02 Jul 2009
		CA 2472616 A1	24 Jul 2003
		CA 2592110 A1	13 Jul 2006
		EP 1465831 A1	13 Oct 2004
		EP 1465831 B1	06 Dec 2006
		US 2003131888 A1	17 Jul 2003
		US 6837262 B2	04 Jan 2005
		US 2008011359 A1	17 Jan 2008
		US 7757709 B2	20 Jul 2010
		WO 03059802 A1	24 Jul 2003
		WO 2006074220 A2	13 Jul 2006
US 20080202600 A1	28 August 2008	US 2008202600 A1	28 Aug 2008
		AU 2003248297 A1	07 Apr 2005
		WO 2005028935 A1	31 Mar 2005
US 20140261884 A1	18 September 2014	US 2014261884 A1	18 Sep 2014
		US 9458006 B2	04 Oct 2016
		AU 2014235305 A1	01 Oct 2015
		AU 2014235305 B2	24 Aug 2017
		AU 2017210599 A1	24 Aug 2017
		AU 2017210599 B2	15 Nov 2018
		CA 2907054 A1	25 Sep 2014
		CN 105377609 A	02 Mar 2016
		CN 105377609 B	06 Apr 2018

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2019/050911**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		EP 2969627 A2	20 Jan 2016
		EP 2969627 B1	20 Jun 2018
		JP 2016519016 A	30 Jun 2016
		JP 6178490 B2	09 Aug 2017
		WO 2014151131 A2	25 Sep 2014
US 6311723 B1	06 November 2001	US 6311723 B1	06 Nov 2001
		AU 3635200 A	30 Nov 2000
		AU 767110 B2	30 Oct 2003
		CA 2309521 A1	27 Nov 2000
		GB 2350446 A	29 Nov 2000
		GB 2350446 B	16 Jul 2003
		NZ 504740 A	30 Mar 2001
		TW 405068 B	11 Sep 2000
WO 2016094952 A1	23 June 2016	WO 2016094952 A1	23 Jun 2016
		AU 2015367297 A1	03 Aug 2017
		CA 2970885 A1	23 Jun 2016
		CL 2017001573 A1	26 Jan 2018
		CN 107231809 A	03 Oct 2017
		CN 107231809 B	20 Sep 2019
		RU 2017125040 A	17 Jan 2019
		US 2017349428 A1	07 Dec 2017
		US 10155654 B2	18 Dec 2018

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.