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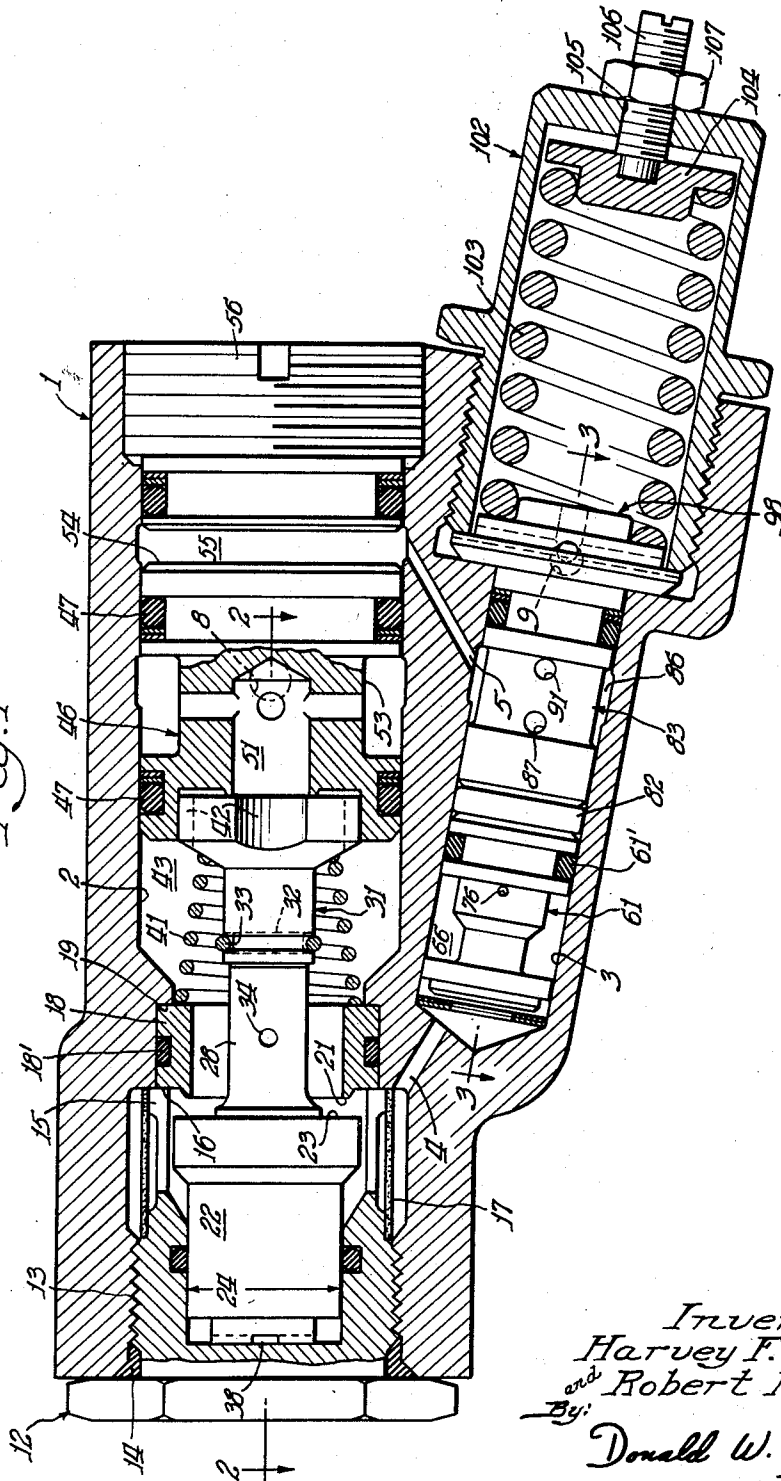
2,888,027

REGULATOR

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2 Sheets-Sheet 1

Fig. 1



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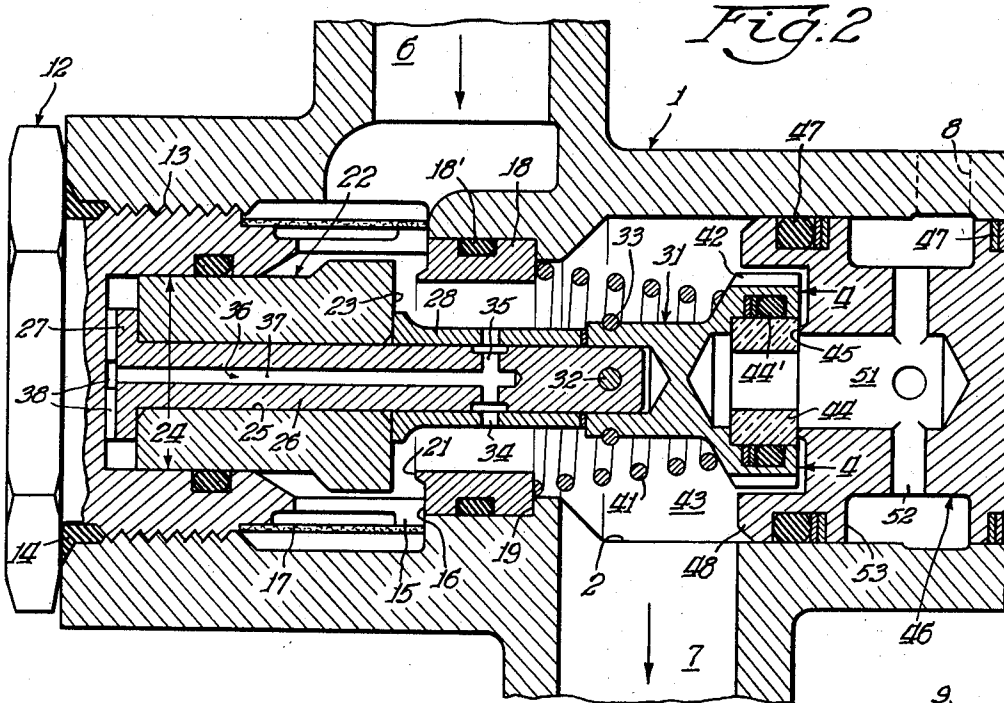
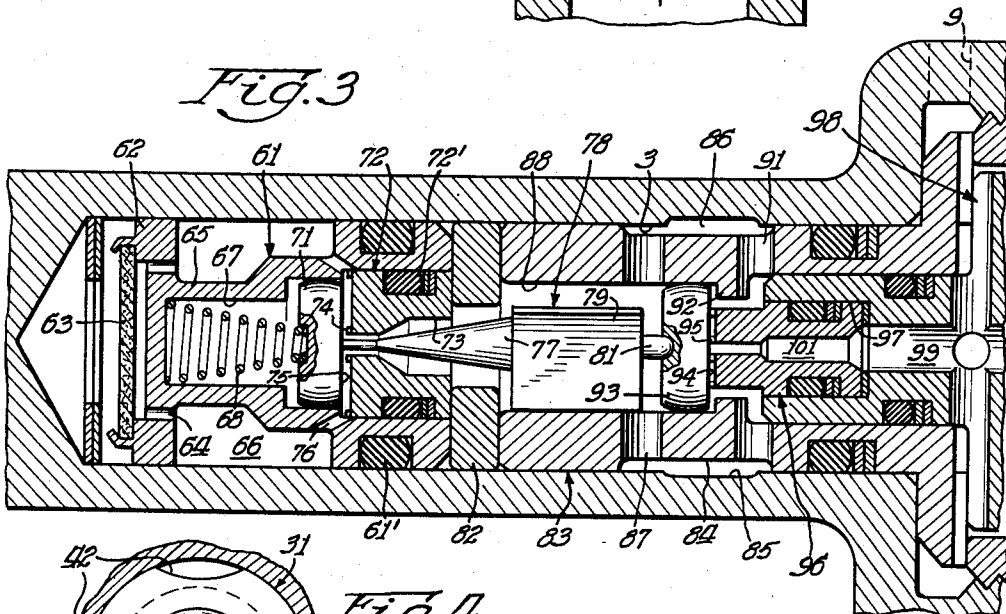
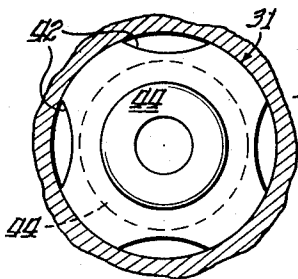
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## REGULATOR

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7 Claims. (Cl. 137—116.5)

This invention relates to a pneumatic pressure regulator and more particularly to an automatic single stage, pilot operated pneumatic regulator.

One object of the present invention is the provision of a new and improved pressure regulator which is more compact and lighter weight than those currently available, and yet which controls the outlet pressure within close limits.

Another object is the provision of a device in accordance with the preceding object in which a pilot valve is provided which determines the biasing force on the main valve, the pilot valve being constructed and arranged to minimize loss of pressurized air.

Another object is the provision of a device in accordance with the preceding objects in which the pilot valve adjustably provides pressurized air to a cavity defined in part by the main piston, the pressurized air serving as an air spring to effect a predetermined biasing force on the main piston.

Another object is the provision of a device in accordance with the preceding objects in which the device is automatically compensated to prevent variations in the inlet pressure from changing the regulated output pressure.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a longitudinal sectional view through a device constructed in accordance with the principles of the present invention;

Figure 2 is an enlarged sectional view along the plane of line 2—2 of Figure 1;

Figure 3 is an enlarged sectional view along the plane of line 3—3 of Figure 1;

Figure 4 is a sectional view along the plane of line 4—4 of Figure 2.

Turning now to the preferred form or embodiment of the present invention illustrated in the figures, there is provided a body 1 having a passage 2 extending therethrough and a passage 3, angularly disposed with respect to the passage 2, and in fluid communication with spaced portions thereof through passages 4 and 5 respectively. Integrally formed in the body 1 is an inlet port 6, in communication with the passage 2; the body 1 is also provided with an integral outlet port 7, also in communication with a spaced portion of the passage 2. The body 1 is further provided with two exhaust ports, an exhaust port 8 being provided which is in communication with the passage 2 (Figure 2), and an exhaust port 9 (Figure 1) being provided in communication with a portion of passage 3.

As illustrated in Figures 1 and 2, one end of the passage 2 is closed by an end cap 12 threadably engaged, as at 13, with an end portion of the wall defining the passage 2. Suitable means 14 are provided between the cap 12 and the body 1 to prevent air leakage therebetween. The inner portion of the cap 12 is provided with

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a plurality of spaced legs 15, which respectively abut a shoulder 16 integrally provided in the body 1. Surrounding the end of cap 12 provided with the legs 15 is a filter 17 which, as best illustrated in Figure 2, effectually filters air passing from the inlet port 6 into the passage 2. The inner ends of the legs 15 also abut against an annular main seat 18, disposed between the legs 15 and a shoulder 19 integral with the body 1, suitable sealing means 18' being disposed between the body 1 and the seat 18 to prevent air leakage therebetween.

The main seat 18 is provided with a raised, annular seat face 21 adapted for engagement by a generally annular main poppet 22. The main poppet 22 has an annular face 23 adapted to engage the seat face 21 on the main seat 18, and is further so constructed as to have its outermost diameter portion 24 equal to the diameter of the seat face 21 so that the main poppet 22 is pressure balanced, as will further appear hereinafter. The main poppet 22 is provided with a central, longitudinally extending, annular opening 25 extending therethrough in which is disposed a portion of a circular connecting rod 26, generally T-shaped in cross section, and having a radially extending end portion 27 disposed in engagement with the outermost end of the main poppet 22. The opposite end face 23 of poppet 22, is engaged near its center portion by an adjacent, annular shoulder formed on a spacer 28 supported by the connecting rod 26, disposed between the poppet 22 and a generally annular retainer 31, which is generally T-shaped in cross section. The retainer 31 is connected to the connecting rod 26 by a pin 32, which extends through the rod 26 and the retainer 31, held in position by a retainer ring 33. As best illustrated in Figure 2, the spacer 28 has a plurality of openings 34 extending radially therethrough which are in communication with a plurality of radially openings 35 formed internally within the connecting rod 26, and which form a part of a generally T-shaped opening 36 provided in the connecting rod 26. Opening 36 further comprises a longitudinally extending opening 37 in communication with the openings 35, and also in communication with a plurality of radially extending openings 38 in the outwardmost portion 27 of the rod 26. It will therefore be seen that the outwardmost face of the main poppet 22 is in communication, through the openings 34 and the opening 36, with that portion of the passage 2 adjacent the main seat 18; as previously described, the diameter 24 of the poppet 22 is the same as the diameter of the seat 21, the net result being that the main poppet 22 is pressure balanced.

Disposed between the main seat 18 and the radially extending portion of the generally T-shaped retainer 31 is a spring 41, which serves to bias these members toward a position in which the main valve is closed. The innermost portion of the retainer 31, comprising the radially extending part thereof, is formed to have the configuration illustrated in Figure 4, a plurality of grooves 42 being formed therein which communicate the rear face of the retainer 31 with the face thereof which is engaged by the spring 41. In other words, this rearward face of the retainer 31 is in communication with a chamber designated 43 in Figure 2, in communication with the outlet port 7, which may be characterized as the regulated pressure chamber 43. The innermost end of retainer 31 is provided with an annular opening which receives an annular exhaust poppet 44, suitable sealing means 44' being provided between the poppet 44 and the retainer 31 to prevent air leakage therebetween.

The poppet 44 is normally disposed in engagement with an annular seat 45 provided on an annular main piston 46 disposed within the passage 2, suitable sealing means 47 (Figure 1) being provided therebetween to prevent the leakage of air. Piston 46 has an innermost

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portion 48, annular in configuration, having a central opening therein adapted to slidably receive the end of the retainer 31, which is movable relative thereto. Piston 46 has a longitudinally extending opening 51 in communication with the seat 45 thereon, and further in communication with a plurality of radially extending openings 52 provided therein which communicate with an annular groove 53 in piston 46 which communicates with the exhaust port 8. The main piston 46 has an annular end face 54 (Figure 1) which defines one wall of a chamber 55 formed within the passage 2, the opposite end of the chamber 55 being defined by an annular end cap 56 which threadably engages the associated end of the passage 2, suitable sealing means being provided therebetween to prevent the leakage of air. As best illustrated in Figure 1, the chamber 55 is in communication with the passage 5 previously described for a purpose to be subsequently explained.

As best illustrated in Figure 3, within the passage 3 there is provided a generally annular poppet retainer 61 having an outermost, annular portion 62 which carries a filter 63, and which is formed to have a plurality of spaced openings 64 extending longitudinally therethrough. The intermediate portion 65 of the retainer 61 is reduced in diameter, to define a chamber 66 with the adjacent side of the opening 3. This intermediate portion 65 of the retainer 61 has an annular opening 67 therein in which is disposed a light spring 68, the innermost end of which is disposed in engagement with a suitable recess provided in a poppet 71, also disposed in the opening 67. Within the opening 67 adjacent the innermost end of the retainer 61 is an annular seat 72, sealing means 72' being provided between the seat 72 and the wall defining the opening 67 to prevent air leakage therebetween. Other sealing means 61' are provided between the wall defining the opening 3 and the innermost portion of the retainer 61 to prevent air leakage. The seat 72 is provided with an annular centrally disposed opening 73 extending longitudinally therethrough, adjacent the outer end of which is formed an annular seat portion 74 adapted for engagement with an annular face 75 formed on the poppet 71. As illustrated in Figure 3, a plurality of openings 76, extending through a wall of the retainer 61, are provided which communicate the chamber 66 with the space between the face 75 on the poppet 71 and the seat-portion carrying face of the seat 72.

Extending through the opening 73 in the seat 72, and engaging the face 75 on the poppet 71, is an elongated arm 77 formed integral with a push rod indicated in general by the numeral 78. The push rod 78 comprises also an intermediate, generally triangular portion 79 from which integrally extends a short stub 81 having a rounded end, as illustrated in Figure 3. The arm 77 of the push rod 78 extends through a suitable opening provided in an annular spacer 82 disposed between an end of the poppet retainer 61 and an end of a piston guide 83, annular in external configuration and generally T-shaped in cross section. The piston guide 83 has an intermediate portion thereof provided with an annular groove 84 which registers with an annular groove 85 formed in the passage 3, these grooves defining a chamber 86 therebetween which, as illustrated in Figure 1, is in communication with the passage 5 and, therefore, with the chamber 55. A plurality of radially extending, circumferentially spaced openings 87 are provided which extend through the wall of the piston guide 83 and communicate the chamber 86 with an interior opening 88 in guide 83; longitudinally spaced from the openings 87 are a plurality of circumferentially spaced, radially extending openings 91, also extending through the wall of the piston guide 83 and communicating the chamber 86 and the opening 88. Between the openings 87 and 91, the piston guide 83 is formed to have an annular, radially inwardly projecting flange 92. Also disposed between the openings 87 and 91 within the piston guide 83 is a poppet 93 having in

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one face thereof a curved opening adapted to receive the stub 81 on the push rod 78; the other, opposite face 94 thereof being adapted to engage an annular seat 95 provided on one end of a pilot exhaust seat, indicated in general by the numeral 96. This pilot exhaust seat 96 is received in a cooperating annular opening 97 in an innermost portion of a generally annular pilot piston 98 having generally cruciform shaped opening 99 therein in communication with the exhaust port 9, and in communication with an elongated opening 101 extending longitudinally through the pilot exhaust seat 96 and terminating adjacent the seat 95 thereof. As best illustrated in Figure 1, the right end of passage 3 is enlarged in diameter and receives a generally cup shaped cap 102 threadably engaged therewith, within which is disposed a spring 103. One end of the spring 103 engages the outermost side of the pilot piston 98, the other end of spring 103 being disposed in engagement with a spring guide 104 also disposed in the cap 102. The outermost end portion of cap 102 is provided with a threaded opening 105 through which projects a bolt 106, the inner end of which engages the spring guide 104, an adjusting nut 107 being provided to hold the bolt 106 in any predetermined position to provide a variable, adjustable bias on the spring 103 as desired.

Devices constructed in accordance with the principles of the present invention may—for example—be adapted for connection to an inlet supply pressure of the order of 100 to 4,000 pounds per sq. inch, and may be adjusted to provide an outlet pressure of the order of 75 to 3,800 lbs. per sq. inch. The value of the outlet pressure may be varied by adjusting the bias of the spring 103 on the pilot piston 98 which will, as will be more fully described hereinafter, adjust the pressure of the air in the chamber 55 which serves, in effect, as an air spring operating upon the main piston 46. The degree of this bias on the main piston 46 will control the pressure value in the regulated pressure chamber 43, and consequently in the outlet port 7.

More specifically, when a source of highly pressurized air is connected to the inlet port 6, this air will simultaneously begin to flow through the filter 17 into the passage 2 between the face 23 on poppet 22 and seat 21 on the main seat 18 and also through passage 4, through filter 63 and into the passage 3. Discussing first the operation of the pilot valve within this passage 3, the spring 103 has previously been set, by the bolt 106, to provide a predetermined inward bias on the pilot piston 98. The innermost end of the pilot piston 98, slidably mounted in the opening 88 in the piston guide 83, will press the pilot exhaust seat 96 inwardly (to the left in Figure 3) forcing the seat 95 thereon into tight engagement with the face 94 of poppet 93. Poppet 93 will therefore be moved away from the flange 92, and will press the push rod 78 toward the left, so that the arm 77 thereof will force the poppet 71 away from the seat portion 74 formed on the seat 72, against the bias of the spring 68, and the force due to air pressure times seat area load. The pressurized air will therefore pass through the passage 4, the filter 63, the openings 64, the chamber 66, through the chamber 66, the openings 76, the open seat 74, the opening 73, the opening in the spacer 82, a portion of the opening 88, and the openings 87 into the chamber 86. Part of this pressurized air in the chamber 86 passes through the passage 5 to the chamber 55, while another part of the pressurized air in the chamber 86 flows through the openings 91 into engagement with the front face on the pilot piston 98. The effect of this pressure on the front face of the pilot piston 98 is to effect movement of this pilot piston 98 to the right, in the views of Figures 1 and 3, against the bias of the spring 103. As this occurs, the spring 68 forces the poppet 71 into engagement with the seat portion 74 to interrupt the communication between the opening 73 in the seat 72 and the chamber 66. The parts are so proportioned that the poppet 71

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will close upon the seat portion 74 before the poppet 93 engages the flange 92 whereby the poppet 93, although moved to the right in Figure 3 with the push rod 78 and the pilot piston 98, remains tightly engaged with the seat 95. It will therefore be seen that for a predetermined initial bias provided by the spring 103, that a predetermined, definite pressure is provided within the chamber 55, which will act as an air spring biasing the main piston 46 toward the left in Figure 2.

As previously indicated, simultaneously air will flow from the inlet port 6 through the space between the main poppet 22 and the main seat 18. Some of this air flows through the openings 34 in spacer 28 and the opening 36 in the connecting rod 26 to the end chamber defined by the main poppet 22 and the interior portion of the cap 12; another part of this air flows into the regulated pressure chamber 43 and into engagement with the innermost face of the main piston 46, which comprises the annular area between the outer diameter thereof and the seat 45. It will be seen that with the poppet 44 in engagement with the seat 45, however, the force on the main piston 46 tending to move it toward the right is equal to the pressure in the regulated pressure chamber 43 multiplied by the entire area of the innermost face of the main piston 46. In other words, this force is equal to the pressure in the regulated pressure chamber 43 acting on this area of the full diameter of the innermost face of the main piston 46. This force, obviously, will oppose the force on the main piston 46 due to the pressure in the chamber 55, and will tend to move the main piston 46 to the right from the position illustrated in Figure 2. The force due to the pressure times the area of the seat 45 plus the spring 41 will force the retainer 31 also toward the right, to maintain the poppet 44 in engagement with the seat 45. When the desired pressure is achieved in the regulated pressure chamber 43, and consequently in the outlet port 7, the face 23 on the poppet 22 will be in engagement with the seat face 21.

If the pressure in chamber 43 falls below that which is desired, then the force on the right end of the main piston 46, due to the pressure in chamber 55, will effect movement of the poppet 22 away from the seat face 21 so that further high pressure is admitted from the inlet port 6. When the desired pressure is once again reached in the chamber 43 and the outlet port 7, the poppet 22 will once again, in the manner previously described, engage the seat face 21 to prevent further flow into the valve from the pressure source.

In the event that the pressure in the regulated pressure chamber 43 should become too high, piston 46 will be moved to the right, against the force developed within the chamber 55. Poppet 22 is mounted for a slight degree of lost motion with respect to the connecting rod 26 so that the spring 41 can keep the poppet 44 in engagement with the seat 45 for a short distance after the poppet 22 engages the main seat 18. If, however, the pressure in the regulated pressure chamber 43 is so great that main piston 46 is moved beyond the farthest inward movement available to the poppet 44, the seat 45 will then be moved away from the poppet 44. It will be seen that air from the chamber 43 may pass through the grooves 42 in the retainer 31, and through openings 51, 52 into groove 53, from which it is exhausted through the exhaust port 8. It will be appreciated that this is substantially an instantaneous modulating action, the pressure in chamber 55 moving the piston 46 inwardly so that the seat 45 engages the poppet 44 very rapidly as soon as the connection between these members is broken, this modulating process continuing until the excessive degree of pressure in the chamber 43 is dissipated through the exhaust port 8. It will therefore be seen that the pressure in the regulated pressure chamber 43 and the outlet port 7 will be very accurately controlled.

In the previous description of the operation of the pilot valve illustrated in Figure 3, the operation was

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described in connection with the establishment of the desired pressure in the chamber 55. It will be readily apparent that should some leakage occur in the pilot valve so that the pressure in chamber 55 falls below that which is desired, the parts will be so moved that the poppet 71 will once again be disengaged from the seat portion 74 of the seat 72 to admit further highly pressurized air to the pilot valve and consequently to the chamber 55, spring 103 causing this poppet 71 to open or disengage the associated seat, and the increased pressure on the front portion of pilot piston 98 effecting closure of this poppet 71 on the associated seat when the desired pressure is obtained, as previously described. In the event that the pressure in chamber 55 increases above that which is desired, the effect of this pressure on the innermost face of the pilot piston 98 will be to move this piston to the right, from the view of Figure 3. The spring 68 will, as previously described, ensure that poppet 71 firmly engages the seat portion 74 on the associated seat 72; subsequent further movement of the pilot piston 98 to the right will effect engagement between the poppet 93 and the radial flange 92 on the piston guide 83. If the pressure in chamber 86 is sufficiently high so as to effect further movement to the right of the piston 98, the seat 95 will be carried away from the poppet 93 in view of the engagement of the face 94 thereof with the fixed flange 92. Pressure will then be bled from the chamber 55, the passage 5, the chamber 86, and the openings 91 through the opening 101 in the pilot exhaust seat 96, the opening 99 in the pilot piston 98, and to exhaust through the exhaust port 9. When the pressure on the innermost face of the pilot piston 98 decreases sufficiently, spring 103 will once again effect inward movement of the pilot piston 98 to close seat 95 against the poppet 93 and prevent further air leakage.

It will readily appear to those skilled in the art that the outlet pressure may be varied over a wide range by adjustment of the spring 103, and that the outlet pressure will be maintained at its desired level throughout a wide range of flow rates. It will furthermore be seen that the arrangement of the pilot valve is such that air from the pressurized source is not wasted by flow through the pilot valve, inasmuch as the poppet 71 is always engaged with its associated seat whenever the poppet 93 is disengaged from its associated seat to permit bleeding to the atmosphere. This is a very important consideration in installations such as those in aircraft where it is desirable to eliminate any connection between the source of pressurized air and the exhaust. It will further be seen that variations in the inlet pressure do not affect movement of the main poppet, and therefore do not affect the pressure level in the regulated pressure chamber 43, inasmuch as the main poppet 22 has the identical pressure operating on the identical area at either end thereof. It will further be seen that with the construction provided by the present invention the necessity for multiple stages is eliminated, although excellent operating characteristics are maintained, to the end that the device incorporating the present invention may be smaller, more compact and lighter in weight than regulator valves having the same operating characteristics.

While a certain preferred embodiment of the invention has been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims:

What is claimed is:

1. A pneumatic pressure regulator valve comprising a body having a main opening therein, air pressure inlet and outlet means in said body communicating with spaced portions of said main opening, a second opening in said body spaced from said main opening, a first passage communicating a portion of said main opening with a portion of said second opening, a second passage communi-

cating a different portion of said second opening with said inlet means, pressure regulator means in said second opening between said first and second passages comprising relatively movable valve means and biasing means therefor constructed and arranged to supply air to said first passage at a pressure which is a predetermined fractional part of the pressure in said second passage, a piston in said main opening having a first portion in communication with said outlet means and a second portion adjacent the point of communication of said main opening with said first passage whereby said piston defines in part a chamber adapted to receive pressurized air from said first passage, main valve means in said main opening including relatively movable means constructed and arranged to control air flow between said inlet and outlet means, and means between said main valve means and said piston adapted to effect movement of said main valve means as said piston is moved in response to variations in the ratio between the air pressure acting upon said first piston portion and the air pressure in said chamber acting upon said second piston portion.

2. The pressure regulator valve defined in claim 1 in which said pressure regulating means in said second opening comprises; plunger means movable longitudinally in said second opening, spring means engaging one part of said plunger means applying a bias thereto in a first direction, means effecting communication between a second part of said plunger means and said first passage whereby a pneumatic force is applied to said plunger means which opposes the bias of said spring means when said first passage contains pressurized air, a pair of spaced seats and a pair of spaced poppets respectively associated therewith adapted for relative movement between each seat and associated poppet in response to plunger movement, said poppets and seats being constructed and arranged to ensure engagement between one poppet and its associated seat prior to disengagement of the other poppet from its associated seat and vice versa.

3. The pressure regulator valve defined in claim 1 in which said body is provided with an exhaust port communicating with said main opening adjacent said piston, and in which said piston has opening defining means therein communicating with said exhaust port, a valve seat on said first piston portion surrounding one end of the piston opening, an exhaust poppet on said means between said main valve means and said piston normally engaging said valve seat preventing air flow therethrough, and means limiting movement of said exhaust poppet in at least one direction whereby said piston may move said valve seat thereon away from said exhaust poppet under the influence of excessive pressures in said outlet means to connect said outlet means to said exhaust port.

4. The pressure regulator valve defined in claim 1 in which said main valve means comprises; a seat fixedly

mounted within said main opening between said inlet and outlet means, a main poppet in said main opening adjacent said inlet means movable relative to said seat to control air flow therebetween having a face on one end thereof adapted to engage said main seat and a face of equal area at the opposite end thereof, and opening defining means extending through said main poppet adapted to communicate said faces at opposite ends of said main poppet whereby said main poppet is pressure balanced.

5. The pressure regulator valve defined in claim 2 in which said body is provided with an exhaust port communicating with said main opening adjacent said piston, and in which said piston has opening defining means therein communicating with said exhaust port, a valve seat on said first piston portion surrounding one end of the piston opening, an exhaust poppet on said means between said main valve means and said piston normally engaging said valve seat preventing air flow therethrough, and means limiting movement of said exhaust poppet in at least one direction whereby said piston may move said valve seat thereon away from said exhaust poppet under the influence of excessive pressures in said outlet means to connect said outlet means to said exhaust port.

6. The pressure regulator valve defined in claim 3 in which said main valve means comprises; a seat fixedly mounted within said main opening between said inlet and outlet means, a main poppet in said main opening adjacent said inlet means movable relative to said seat to control air flow therebetween having a face on one end thereof adapted to engage said main seat and a face of equal area at the opposite end thereof, and opening defining means extending through said main poppet adapted to communicate said faces at opposite ends of said main poppet whereby said main poppet is pressure balanced.

7. The pressure regulator valve defined in claim 5 in which said main valve means comprises; a seat fixedly mounted within said main opening between said inlet and outlet means, a main poppet in said main opening adjacent said inlet means movable relative to said seat to control air flow therebetween having a face on one end thereof adapted to engage said main seat and a face of equal area at the opposite end thereof, and opening defining means extending through said main poppet adapted to communicate said faces at opposite ends of said main poppet whereby said main poppet is pressure balanced.

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