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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 September 2012 (27.09.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/126183 A1

(51) **International Patent Classification**:
G05D 16/06 (2006.01) ***F16K 17/02*** (2006.01)

(21) **International Application Number**:
PCT/CN2011/072112

(22) **International Filing Date**:
24 March 2011 (24.03.2011)

(25) **Filing Language**: English

(26) **Publication Language**: English

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(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: FLUID REGULATING DEVICE WITH BIASED CONTROL ELEMENT

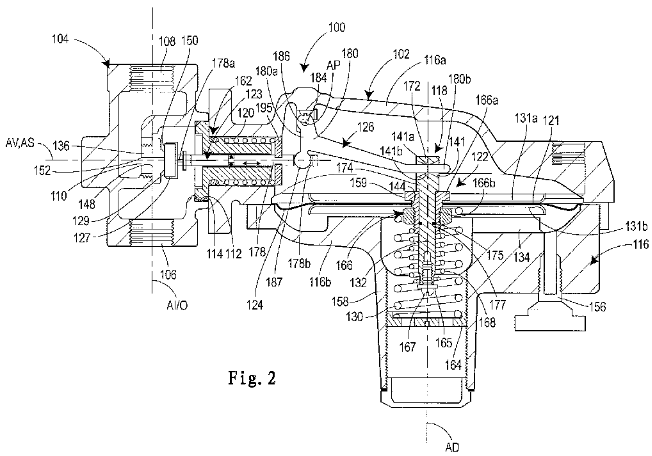

Fig. 2

(57) Abstract: A fluid regulating device includes an actuator housing (116), a control assembly (122), and a biasing member (192). The actuator housing defines a control cavity (118) and an actuator mouth (120). The control assembly is mounted within the control cavity and includes a piston (132), a stem (178), a lever (180) coupled between the piston and the stem, and a control element (127) mounted to the stem opposite the lever. The stem is disposed through the actuator mouth such that the control element is disposed outside of the control cavity. The stem is adapted for sliding displacement relative to the actuator mouth in response to sliding displacement of the piston. The biasing member is supported at least partly within the actuator mouth and biases the control element and the stem toward the control cavity.

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FLUID REGULATING DEVICE WITH BIASED CONTROL ELEMENT

FIELD OF THE DISCLOSURE

The present disclosure relates to gas regulators and, more particularly, to trim components for gas regulators.

BACKGROUND

The pressure at which typical gas distribution systems supply gas may vary according to the demands placed on the system, the climate, the source of supply, and/or other factors. However, most end-user facilities equipped with gas appliances such as furnaces, ovens, etc., require the gas to be delivered in accordance with a predetermined pressure, and at or below a maximum capacity of the gas regulator. Therefore, gas regulators are implemented into these distribution systems to ensure that the delivered gas meets the requirements of the end-user facilities. Conventional gas regulators generally include a closed-loop control actuator for sensing and controlling the pressure of the delivered gas.

Fig. 1 depicts one conventional gas regulator 10. The regulator 10 generally comprises an actuator 12 and a valve 14. The valve 14 defines an inlet 16 for receiving gas from a gas distribution system, for example, and an outlet 18 for delivering gas to an end-user facility such as a factory, a restaurant, an apartment building, etc. having one or more appliances, for example. Additionally, the valve 14 includes a throat 35 disposed between the inlet and the outlet and receiving a valve port 36. Gas must pass through the throat 35 and valve port 36 to travel between the inlet 16 and the outlet 18 of the valve 14.

The actuator 12 is coupled to the valve 14 to ensure that the pressure at the outlet 18 of the valve 14, i.e., the outlet pressure, is in accordance with a desired outlet or control pressure. The actuator 12 includes a control assembly 22 for sensing and regulating the outlet pressure of the valve 14. Specifically, the control assembly 22 includes a diaphragm 24, a piston 32 (often referred to as a "pusher post"), a lever 25, and a stem 26 having a valve disc 28 with a sealing surface 31. The lever 25, stem 26, and valve disc 28 are shown in cross-section, but without cross-hatching, for the sake clarity. The outlet pressure of the valve 14 can be delivered, via a fluid delivery line (not shown), to the diaphragm 24 through a sensing port 29 in the actuator 12. The control assembly 22 further includes a control spring 30 in engagement with a top-side of the diaphragm 24 to offset the sensed outlet pressure. Accordingly, the desired outlet pressure, which may also be referred to as the control pressure, can be set by selection or adjustment of the control spring 30.

The diaphragm 24 is operably coupled to the stem 26, and therefore the valve disc 28, via the piston 32 and the lever 25 to control the opening of the valve 14 based on the sensed outlet pressure. More specifically, as illustrated, the diaphragm 24 is operably coupled to the piston 32 via a diaphragm plate assembly 33. The piston 32 is operably coupled to the lever 25 via an hourglass-shaped recess 41 that receives a first end 25a of the lever 25. The lever 25 is operably coupled to the stem 26 via a knuckle 37 rotatably disposed within a recess 39 formed in the stem 26.

So configured, when an end user operates an appliance, such as a furnace, for example, that places a demand on the gas distribution system downstream of the regulator 10, the outlet flow increases, thereby decreasing the outlet pressure. Accordingly, the diaphragm 24 senses this decreased outlet pressure via the sensing port 29, which allows the control spring 30 to expand and move the piston 32 and the first end 25a of the lever 25 upward, relative to the orientation of Fig. 1. This displacement of the first end 25a of the lever 25 causes the knuckle 37 to pull the stem 26 and the valve disc 28 away from the throat 35 and valve port 36. This causes the sealing surface 31 to disengage from the valve port 26, which opens the throat 35 and allows the downstream appliance to draw a desired amount of gas. Once the downstream appliance is turned off, for example, the demand terminates and the pressure at the outlet 18 of the valve 14 increases and forces the diaphragm 24 downward relative to the orientation of Fig. 1, which lowers the first end 25a of the lever 25 and pushes the stem 26 and valve disc 28 back toward the throat 35 such that the sealing surface 31 sealingly engages the valve port 36 and stops the flow of gas therethrough.

In the conventional regulator 10, when the valve 14 is opened, i.e., the stem 26 and valve disc 28 are moved away from the valve port 36, the flow of gas through the valve 14 can apply a force to the sealing surface 31 of the valve disc 28. This force can cause the valve disc 28 and stem 26 to displace relative to the knuckle 37 on the lever 25 because manufacturing tolerances and wear, for example, can create play in the form of gaps and/or spaces between the knuckle 37 and the walls of the recess 39 on the stem 26. The presence of these gaps and/or spaces can cause the stem 26 to shift relative to the knuckle 37 under the force applied to the sealing surface 31 of the valve disc 28. Additionally, this force applied to the sealing surface can cause the first end 25a of the lever 25 to shift within the hourglass-shaped recess 41 of the piston 32. These shifts can therefore cause the sealing disc 28 to move away from the valve port 36 further than desired, until the diaphragm 24 adjusts itself and corrects the position of the valve disc 28. As such, under certain circumstances, the conventional regulator can generate a temporary increase in fluid flow through the valve 14, which results in an increase or bump in outlet pressure.

SUMMARY

One aspect of the present disclosure provides a fluid regulating device including an actuator housing, a control assembly, and a biasing member. The actuator housing defines a control cavity and an actuator mouth. The control assembly is mounted within the control cavity and includes a piston, a stem, a lever coupled between the piston and the stem, and a control element mounted to the stem opposite the lever. The stem is disposed through the actuator mouth such that the control element is disposed outside of the control cavity. The stem is adapted for sliding displacement relative to the actuator mouth in response to sliding displacement of the piston. The biasing member is supported at least partly within the actuator mouth and biases the control element and the stem toward the control cavity.

In one embodiment, the fluid regulating device further comprises a valve body defining an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth. The valve mouth is coupled to the actuator mouth such that the control element is disposed in the valve body for displacement between a closed position in close proximity to the throat and an open position relatively spaced from the throat.

In one embodiment, the fluid regulating device further comprises a guide insert and a second spring seat. The guide insert is disposed within the actuator

mouth and defines a bore and a first spring seat, the bore slidably receiving the stem. The second spring seat is carried by the stem, and the biasing member is disposed between the first spring seat and the second spring seat.

In one embodiment, the second spring seat is disposed between the control cavity of the actuator housing and the guide insert.

In one embodiment, the first spring seat includes a radially outwardly extending shoulder carried by the guide insert and the second spring seat includes a circular plate fixed to the stem.

In one embodiment, the piston is slidable along a piston axis that extends along a longitudinal dimension of the piston, and the stem is slidable along a stem axis that extends along a longitudinal dimension of the stem. The piston axis is substantially perpendicular to the stem axis.

In one embodiment, the lever is pivotable about a pivot axis for transferring sliding movement between the piston and the stem.

In one embodiment, the fluid regulating device further includes a diaphragm operably coupled to the piston. The diaphragm is movable in response to pressure changes in the control cavity, and movement of the diaphragm imparts sliding movement to the piston.

In one embodiment, the fluid regulating device further includes a control spring disposed between the actuator housing and the diaphragm. The control spring biasing the piston toward the lever.

Another aspect of the present disclosure provides a fluid regulating device including an actuator, a first spring seat, a control assembly, a second spring seat, and a biasing member. The actuator housing defines a control cavity and an actuator mouth. The first spring seat fixedly mounted within the actuator mouth of the actuator housing. The control assembly is mounted within the control cavity and includes a piston, a stem, a lever coupled between the piston and the stem, and a control element mounted to the stem opposite the lever. The stem is disposed through the actuator mouth and the first spring seat such that the control element is disposed outside of the control cavity. The stem is adapted for sliding displacement relative to the actuator mouth in response to sliding displacement of the piston. The second spring seat is coupled to the stem at a location between the first spring seat and the control cavity of the actuator housing. The biasing member is disposed between the first spring seat and the second spring seat, and biases the control element and the stem toward the control cavity.

In one embodiment, the fluid regulating device further includes a valve body defining an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth. The valve mouth is coupled to the actuator mouth such that the control element is disposed in the valve body for displacement between a closed position in close proximity to the throat and an open position relatively spaced from the throat.

In one embodiment, the fluid regulating device further includes a guide insert disposed within the actuator mouth. The guide insert defines a bore and the first spring seat, and the bore slidably receives the stem.

In one embodiment, the second spring seat is disposed between the control cavity of the actuator housing and the guide insert.

In one embodiment, the first spring seat includes radially outwardly extending shoulder carried by the guide insert and the second spring seat includes a circular plate fixed to the stem.

In one embodiment, the piston is slidable along a piston axis that extends along a longitudinal dimension of the piston and the stem is slidable along a stem axis that extends along a longitudinal dimension of the stem. The stem axis is disposed substantially perpendicular to the piston axis.

In one embodiment, the lever is pivotable about a pivot axis for transferring sliding movement between the piston and the stem.

In one embodiment, the fluid regulating device further includes a diaphragm operably coupled to the piston.

In one embodiment, the fluid regulating device further includes a control spring disposed between the actuator housing and the diaphragm, the control spring biasing the piston toward the lever.

Another aspect of the present disclosure provides a fluid regulating device, including a valve body, an actuator housing, a guide insert, a control assembly, a disc, and a coil spring. The valve body defines an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth. The actuator housing defines a control cavity and an actuator mouth. The actuator mouth is coupled to the valve mouth of the valve body. The guide insert is fixedly disposed within the actuator mouth of the actuator housing, and includes a bore and a radially outwardly extending shoulder defining a first spring seat. The control assembly is mounted within the control cavity and includes a piston, a diaphragm operably coupled to the piston, a stem slidably disposed in the bore of the guide insert, a lever operably coupled between the piston and the stem, and a control element mounted to the stem opposite the lever and disposed in the valve body adjacent to the throat. The piston is slidable along a piston axis in response to pressure changes experienced by the diaphragm. The lever is pivotable about a pivot axis to transfer sliding movement of the piston along the piston axis into sliding movement of the stem along a stem axis that is perpendicular to the piston axis. The disc is coupled to the stem at a location between the first spring seat and the control cavity of the actuator housing, and defines a second spring seat. The coil spring is disposed on the stem between and in engagement with the first spring seat and the second spring seat. The coil spring biases the control element and the stem toward the control cavity and away from the throat of the valve body.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of a conventional regulator showing some of the components in cross-section, but not necessarily with cross-hatching for the sake of clarity;

Fig. 2 is a side view of a regulator constructed in accordance with one embodiment of the present disclosure showing some of the components in cross-section, but not necessarily with cross-hatching for the sake of clarity;

Fig. 3 is a detail view of the regulator of Fig. 2; and

Fig. 4 is a graphical representation of data comparing operational characteristics of a conventional regulator with operational characteristics of a regulator constructed in accordance with the principles of the present disclosure.

DETAILED DESCRIPTION

Although the following text sets forth a detailed description of numerous different embodiments of the invention, it should be understood that the legal scope of the invention is defined by the words of the claims set forth at the end of this patent. The detailed description is to be construed as exemplary only and does not describe every possible embodiment of the invention since describing every possible embodiment would be impractical, if not impossible. Numerous alternative embodiments could be implemented, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims defining the invention.

It should also be understood that, unless a term is expressly defined in this patent using the sentence "As used herein, the term '______' is hereby defined to mean..." or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based on any statement made in any section of this patent (other than the language of the claims). To the extent that any term recited in the claims at the end of this patent is referred to in this patent in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such claim term by limited, by implication or otherwise, to that single meaning. Finally, unless a claim element is defined by reciting the word "means" and a function without the recital of any structure, express or implied, it is not intended that the scope of any claim element be interpreted based on the application of 35 U.S.C. § 112, sixth paragraph.

Referring now to Figs. 2 and 3, one embodiment of a fluid regulating device 100, e.g., a gas regulator, constructed in accordance with the principles of the present disclosure will be described.

The gas regulator 100 generally comprises an actuator 102 and a regulator valve 104. The regulator valve 104 includes an inlet 106 for receiving gas from a gas distribution system, for example, and an outlet 108 for delivering gas to a facility having one or more appliances, for example. The actuator 102 is coupled to the regulator valve 104 and includes a control assembly 122 having a control element 127. During an operational mode, the control assembly 122 is adapted to sense the pressure at the outlet 108 of the regulator valve 104, i.e., the outlet pressure, and controls a position of the control element 127 such that the outlet pressure approximately equals a predetermined control pressure.

With continued reference to FIG. 2, the regulator valve 104 defines a throat 110 and a valve mouth 112. The throat 110 is disposed between the inlet 106 and the outlet 108. A valve port 136 is disposed in the throat 110 and defines a bore 148 having an inlet 150 and an outlet 152. Gas must travel through the bore 148 in the valve port 136 to travel between the inlet 106 and the outlet 108 of the regulator valve 104. The valve port 136 is removable from the regulator valve 104 such that it may be replaced with a different valve port having a bore of a different diameter or configuration to tailor operational and flow characteristics of the regulator valve 104 to a specific application. In the disclosed embodiment, the valve mouth 112 defines an opening 114. The valve mouth 112 and the opening 114 are disposed and centered along an axis AV that is generally perpendicular to an axis AI/O of the inlet 106 and outlet 108 of the regulator valve 104.

The actuator 102 includes a housing 116 and the control assembly 122, as mentioned above. The housing 116 includes an upper housing component 116a and a lower housing component 116b secured together with a plurality of fasteners (not shown), for example. The upper housing component 116a defines a control cavity 118 and an actuator mouth 120. The actuator mouth 120 is connected to the valve mouth 112 of the regulator valve 104. In the disclosed form, the lower housing component 116b defines a relief cavity 134 and an exhaust valve 156 for performing an exhaust function as is generally understood in the art. The lower housing component 116b further defines a tower portion 158 for accommodating a portion of the control assembly 122, as will be described.

The control assembly 122 includes a diaphragm subassembly 121 and a linkage subassembly 123. The diaphragm subassembly 121 includes a diaphragm 124, a piston 132, a control spring 130, upper and lower diaphragm plates 131a, 131b, a lower spring seat 164, a combination sliding/seating component 166, and a piston spring 168. In Fig. 2, the components of the diaphragm subassembly 121 are shown in cross-section, but the diaphragm plates 131a, 131b are illustrated without cross-hatching for the sake clarity.

More particularly, the diaphragm 124 includes a disc-shaped diaphragm defining an opening 144 through a central portion thereof. The diaphragm 124 is constructed of a flexible, substantially air-tight, material and its periphery is sealingly secured between the upper and lower housing components 116a, 116b of the housing 116, as well as between the upper and lower diaphragm plates 131a, 131b, as depicted. The diaphragm 124 therefore separates the relief cavity 134 from the control cavity 118.

The combination sliding/seating component 166 includes an elongate hollow collar 166a and a seating nut 166b threaded onto the collar 166a. The collar 166a extends through the opening 144 in the diaphragm 124 and includes a shoulder portion 159 engaging the upper diaphragm plate 131a. The seating nut 166b is threaded onto the collar 166a at a location opposite the shoulder portion 159 from the diaphragm 124 and diaphragm plates 131a, 131b, and serves as a spring seat for one end of the piston spring 168. The other end of the piston spring 168 engages a washer 165 fixed to the piston 132 with a threaded fastener 167. As illustrated, the piston 132 extends through the hollow elongate collar 166a such that during an overpressure situation, i.e., when an outlet pressure of the regulator 100 is above a setpoint or lockup pressure, the piston spring 168 can compress against the washer 167, which allows the diaphragm and elongate collar 166a to displace downward relative to the piston 132, relative to the orientation of Fig. 2. Such a configuration can reduce damage to the internal components of the device in overpressure situations.

The piston 132, as illustrated, includes a generally elongated rod-shaped member having a coupler 172, a shoulder 174, and an annular recess 177 receiving an O-ring 175. The coupler 172 includes a recess 141 adapted to accommodate a portion of the disc subassembly 123 to facilitate operational coupling between the diaphragm subassembly 121 and the disc subassembly 123, as will be described. In the disclosed form, the recess 141 has an hour-glass shaped cross-section, which may also be referred to as a bow-shaped cross-section, for example, or a converging/diverging shaped cross-section. So configured, the piston 132 defines opposing top and bottom fulcrums 141a, 141b substantially centered in the recess 141, as shown. In other embodiments, the recess 141 may have generally any other shape suitable for the intended purpose of the disclosure. The shoulder 174 of the piston 132, as shown, engages the shoulder portion 159 of the elongate collar 166a of the combination sliding/seating component 166 to limit displacement of the elongate collar 166a in an upward direction relative to the piston 132, based on the orientation of Fig. 2. The O-ring 175 provides a fluid tight seal between the piston 132 and the elongate hollow collar 166a such as to enable displacement of the elongate collar 166a relative to the piston 132 during overpressure situations while also reducing and/or preventing leakage between the control and relief cavities 118, 134.

The control spring 130 is disposed below the diaphragm 124 and diaphragm plates 131a, 131b and within the tower portion 158 of the lower housing component 116b. The lower spring seat 164, which includes a threaded disc, is threaded into the tower portion 158 and, as such, compresses the control spring 130 against the lower diaphragm plate 131b. In the disclosed embodiment, the control spring 130 and the piston spring 168 include compression coil springs. Accordingly, the control spring 130 is grounded against the lower housing component 116b and applies an upward force to the diaphragm 124 and diaphragm plates 131a, 131b. In the disclosed embodiment, the force generated by the control spring 130 is adjustable by adjusting the position of the lower spring seat 164 in the tower portion 158, and therefore the control pressure of the regulator 100 is also adjustable.

The control spring 130 acts against the pressure in the control cavity 118, which is sensed by the diaphragm 124. As stated, this pressure is the same pressure as that which exists at the outlet 108 of the regulator valve 104. Accordingly, the force applied by the control spring 130 sets the outlet pressure to a desired, or control pressure for the regulator 100. The above-described diaphragm subassembly 121 is operably coupled to the disc subassembly 123, as mentioned, via the coupler 172 of the piston 132.

Specifically, the disc subassembly 123 includes a control linkage 126 and a biasing device 162. The control linkage 126 includes a stem 178, a lever 180, and the control element 127. These components are shown in cross-section without cross-hatching for the sake of clarity. The control element 127 of the disclosed embodiment includes a valve disc 128 having a circular sealing surface 129. In the disclosed embodiment, the stem 178, lever 180, and valve disc 128 are constructed separately and assembled to form the control linkage 126. Specifically, the stem 178 is a generally linear rod having a nose 178a and a recess 178b formed in an end of the stem 178 that is opposite the nose 178a. In the disclosed embodiment, the recess 178b is generally rectangular and defined between first and second opposing sidewalls 181a, 181b (shown in Fig. 3) of the stem 178. The lever 180 includes a pivot end 180a and a free end 180b. The pivot end 180a includes an aperture 184 receiving a pivot pin 186 carried by the upper housing component 116a. The pivot end 180a also includes a knuckle 187 having a round, oval, or elliptical cross-section, for example, and which is disposed within the recess 178b of the stem 178. The free end 180b of the lever 180 includes a generally linear elongate finger portion disposed within the recess 141 of the coupler 172 of the piston 132. In the present embodiment, the free end 180b extends through the recess 141. Thus, the coupler 172 operably connects the disc subassembly 123 to the diaphragm subassembly 121 and transfers movement of the piston 132 to the control linkage 126, as will be described.

The biasing device 162, as shown in more detail in Fig. 3, includes a guide insert 190 and a biasing member 192, each disposed at least partly within the actuator mouth 120 of the actuator 102 of the fluid regulating device 100 of the present disclosure. The guide insert 190 includes a generally cylindrically-shaped member including a fixation portion 190a, a seating portion 190b, and a guide portion 190c. A bore 194 extends concentrically through the entirety of the guide insert 190, as shown, and slidably receives the stem 178 of the control linkage 126 of the disc subassembly 123 previously described. As such, the stem 178 is disposed concentric with the guide insert 190 and the biasing member 192.

Still referring to Fig. 3, the guide portion 190c of the guide insert 190 includes an elongate sleeve extending along a majority of the length of the bore 194 and operates to guide and/or maintain the alignment of the stem 178. The seating portion 190b includes an annular shoulder that extends radially outwardly from the guide portion 190c of the guide insert 190 and defines an annular surface 191, as shown. In the disclosed form, the seating portion 190b is disposed within the actuator mouth 120 with the guide portion 190c and the annular surface 191 serves as a spring seat for the biasing member 192, as will be described. The fixation portion 190a of the guide insert 190 also includes an annular shoulder that extends radially outward from the guide portion 190c, but also extends radially outward from the seating portion 190b. As such, it can be said that the seating portion 190b has a maximum diameter that is larger than a maximum diameter of the guide portion 190c, and the fixation portion 190a has a maximum diameter that is larger than the maximum diameters of both the seating portion 190b and the guide portion 190c. As such, the guide insert 190 can be described as having a stepped side cross-sectional profile, for example, as illustrated. The fixation portion 190a is disposed outside of the actuator mouth 120 of the actuator 102 and inside of the valve mouth 112 of the valve 104. More specifically, the fixation portion 190a is at least partly disposed within an annular recess 112a of the valve mouth 112 and sandwiched between the valve 104 and the actuator 102, which thereby fixes the guide insert 190 into position such that the seating portion 190b and guide portion 190c are fixedly disposed within the actuator mouth 120 in the disclosed embodiment.

In addition to the guide insert 190 and the biasing member 192, the biasing device 162 of the present disclosure also includes a seating plate 195 carried by the stem 178 of the control linkage 126 of the disc subassembly 123. More specifically, the seating plate 195 can include a circular disc-shaped plate defining an orifice 196. As shown, the stem 178 extends through the orifice 196 such that the seating plate 195 can be fixed onto the stem 178 at a location between the nose 178a and the recess 178b, which receives the knuckle 187 of the lever 180. As such, the seating plate 195 is fixed to the stem 178 at a location between the control cavity 118 of the actuator 102 and the guide insert 190. The seating plate 195 can be fixed to the stem 178 in generally any foreseeable manner. For example, the seating plate 195 can include a set screw for frictionally engaging the stem 178 and which would also allow for adjustment of the position of the seating plate 195 relative to the stem 178. In another embodiment, the stem 178 could include one or more annular recesses and the seating plate 195 could include a split washer, for example, capable of residing in the one or more recesses on the stem 178 to fix its location between one or more locations in an adjustable manner. In yet other embodiments, the seating plate 195 could be welded, glued, or fixed to the stem 178 in any foreseeable manner suitable for the intended purpose.

Finally, as shown in Figs. 2 and 3, the biasing member 192 of the presently disclosed embodiment includes a coil spring disposed between and engaging the annular surface 191 of the seating portion 190b of the guide insert 162 and the seating plate 195 and, more particularly, a seating surface 198 of the seating plate 195. As such, it can be said that the guide insert 190 of the presently disclosed embodiment constitutes a first spring seat and the seating plate 195 constitutes a second spring seat. More specifically, the annular surface 191 of the seating portion 190b of the guide insert 190 constitutes a first spring seat and the seating surface 198 of the seating plate 195 constitutes a second spring seat.

With the biasing device 162 configured as described, the biasing member 192 applies a load to the seating plate 195 carried by the stem 178 to bias the stem 178, including the control element 127, toward the control cavity 118 of the actuator 102 and away from the throat 110 and valve port 136 of the valve 104. In some embodiments, the force generated by the biasing member 192 can be generally constant throughout the operational range of the control element 127 within acceptable tolerances. This force maintains a compression on the components of the control linkage 126 of the present regulator 100, thereby advantageously reducing slop or play between the individual components, which slop or play can be a result of manufacturing tolerances and/or system wear.

During operation, when an end user operates an appliance that places a downstream demand on the regulator 100, the outlet flow increases, thereby decreasing the outlet pressure. Accordingly, the diaphragm 124 senses this decreased outlet pressure and allows the control spring 130 to displace the diaphragm 124, diaphragm plates 131a, 131b, and the piston 132 upward relative to the orientation of Fig. 2. As shown in Fig. 2, the piston 132 moves along a piston axis AD that constitutes a central axis extending along a longitudinal dimension of the piston 132. This displacement of the piston 132 displaces the free end 180b of the lever 180 upward, which causes the lever 180 to pivot about a pivot axis AP defined by the pivot pin 186, to which the lever 180 is mounted.

This further causes the knuckle 187 to rotate within the recess 178b formed on the stem 178 and to displace to the right relative to the orientation of Fig. 2. This positional displacement of the knuckle 187 pulls the stem 178 and control element 127 away from the throat 110 and valve port 136 of the valve 104, thereby opening the valve 104 and allowing for increased fluid supply. The stem 178 slides along a stem axis AS that constitutes a central axis extending along a longitudinal dimension of the stem 178. In the disclosed embodiment, the stem axis AS is the same as the axis AV along which the valve mouth 112 and actuator mouth 120 extend and are centered. As such, the stem axis AS is also substantially perpendicular to the axis AI/O along which the inlet 106 and outlet 108 of the valve 104 extend and are centered. Finally, in the disclosed embodiment, the stem axis AS is also substantially perpendicular to the piston axis AD. In alternative embodiments, the stem axis AS can be oriented differently.

With the foregoing construct, the biasing device 162 generates a generally continuous force such that the knuckle 187 of the lever 180 is always positioned in the same location in the recess 178b of the stem 178, and the free end 180b of the lever 180 is always positioned in the same location in the recess 141 of the piston 132, regardless of the forces generated by any gas flow through the valve 104. More specifically, the biasing member 192 of the biasing device 162 applies a continuous force to the seating plate 195 fixed to the stem 178 in a direction toward the lever 180, thereby biasing the stem 178 toward the control cavity 118. This force ensures that the first sidewall 181a of the recess 178b is in generally continuous engagement with the knuckle 187, and the free end 180b of the lever is in generally continuous engagement with the top fulcrum 141a of the piston 132, regardless of the position of the stem 178 and control element 127 or the amount of force generated by gas flowing through the valve 104. This biasing force reduces and/or eliminates the effect of any mechanical play or slop in the system, thereby also reducing and/or eliminating undesired fluctuations in fluid flow and pressure such as those present in the conventional regulator 10 described above with reference t o Fig. 1.

For example, Fig. 4 presents a graph illustrating the improvement achieved by implementation of the biasing device 162 of the present disclosure. The solid line in Fig. 4 represents a plot of the outlet pressure versus the fluid flow through the conventional regulator, and the dashed line represents a plot of the outlet pressure versus the fluid flow through the regulator 100 disclosed with reference to Figs. 2 and 3. As illustrated by the solid line, in one test, the conventional regulator 10 generates an abrupt increase or bump in the outlet pressure at approximately 2800 Scfh (standard cubic foot per hour) of fluid flow through the valve 104. Specifically, the outlet pressure abruptly increases from approximately 4 in. w.c. (inches of water column) to approximately 5 in w.c., before the regulator makes the necessary adjustment and the pressure settles back to approximately 4.5 in. w.c. By comparison, the dashed line in the graph of Fig. 4 illustrates that the biasing device 162 assists in ensuring a generally constant outlet pressure across fluid flows from approximately 0 Scfh to approximately 6500 Scfh.

Based on the foregoing, the biasing device 162 of the present disclosure compensates for any mechanical slop or play in the control linkage 126 of the fluid regulating device 100, thereby advantageously ensuring the provision of a desired fluid flow through the regulating device 100, absent sudden increases, bumps, or other fluctuations.

While the disclosure has described a specific embodiment, the present invention is not limited by the example provided, but rather, is intended to include that which is defined by the scope and spirit of the following claims.

WHAT IS CLAIMED:

1. A fluid regulating device, comprising:

an actuator housing defining a control cavity and an actuator mouth;

a control assembly mounted within the control cavity, the control assembly including a piston, a stem, a lever coupled between the piston and the stem, and a control element mounted to the stem opposite the lever, the stem disposed through the actuator mouth such that the control element is disposed outside of the control cavity, the stem adapted for sliding displacement relative to the actuator mouth in response to sliding displacement of the piston; and

a biasing member supported at least partly within the actuator mouth, the biasing member biasing the control element and the stem toward the control cavity.

2. The device of claim 1, further comprising a valve body defining an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth, the valve mouth coupled to the actuator mouth such that the control element is disposed in the valve body for displacement between a closed position in close proximity to the throat and an open position relatively spaced from the throat.

3. The device of claim 1, further comprising:

a guide insert disposed within the actuator mouth, the guide insert defining a bore and a first spring seat, the bore slidably receiving the stem; and

a second spring seat carried by the stem, wherein the biasing member is disposed between the first spring seat and the second spring seat.

4. The device of claim 3, wherein the second spring seat is disposed between the control cavity of the actuator housing and the guide insert.

5. The device of claim 3, wherein the first spring seat includes a radially outwardly extending shoulder carried by the guide insert and the second spring seat includes a circular plate fixed to the stem.

6. The device of claim 1, wherein the piston is slidable along a piston axis that extends along a longitudinal dimension of the piston, and the stem is slidable along a stem axis that extends along a longitudinal dimension of the stem, the piston axis being substantially perpendicular to the stem axis.

7. The device of claim 6, wherein the lever is pivotable about a pivot axis for transferring sliding movement between the piston and the stem.

8. The device of claim 1, further comprising a diaphragm operably coupled to the piston, the diaphragm movable in response to pressure changes in the control cavity, wherein movement of the diaphragm imparts sliding movement to the piston.

9. The device of claim 8, further comprising a control spring disposed between the actuator housing and the diaphragm, the control spring biasing the piston toward the lever.

10. A fluid regulating device, comprising:

an actuator housing defining a control cavity and an actuator mouth;

a first spring seat fixedly mounted within the actuator mouth of the actuator housing;

a control assembly mounted within the control cavity, the control assembly including a piston, a stem, a lever coupled between the piston and the stem, and a control element mounted to the stem opposite the lever, the stem disposed through the actuator mouth and the first spring seat such that the control element is disposed outside of the control cavity, the stem adapted for sliding displacement relative to the actuator mouth in response to sliding displacement of the piston;

a second spring seat coupled to the stem at a location between the first spring seat and the control cavity of the actuator housing; and

a biasing member disposed between the first spring seat and the second spring seat, the biasing member biasing the control element and the stem toward the control cavity.

11. The device of claim 10, further comprising a valve body defining an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth, the valve mouth coupled to the actuator mouth such that the control element is disposed in the valve body for displacement between a closed position in close proximity to the throat and an open position relatively spaced from the throat.

12. The device of claim 11, further comprising:

a guide insert disposed within the actuator mouth, the guide insert defining a bore and the first spring seat, the bore slidably receiving the stem.

13. The device of claim 12, wherein the second spring seat is disposed between the control cavity of the actuator housing and the guide insert.

14. The device of claim 12, wherein the first spring seat includes radially outwardly extending shoulder carried by the guide insert and the second spring seat includes a circular plate fixed to the stem.

15. The device of claim 10, wherein the piston is slidable along a piston axis that extends along a longitudinal dimension of the piston and the stem is slidable along a stem axis that extends along a longitudinal dimension of the stem, the stem axis disposed substantially perpendicular to the piston axis.

16. The device of claim 15, wherein the lever is pivotable about a pivot axis for transferring sliding movement between the piston and the stem.

17. The device of claim 10, further comprising a diaphragm operably coupled to the piston.

18. The device of claim 17, further comprising a control spring disposed between the actuator housing and the diaphragm, the control spring biasing the piston toward the lever.

19. A fluid regulating device, comprising:

a valve body defining an inlet, an outlet, a throat disposed between the inlet and the outlet, and a valve mouth;

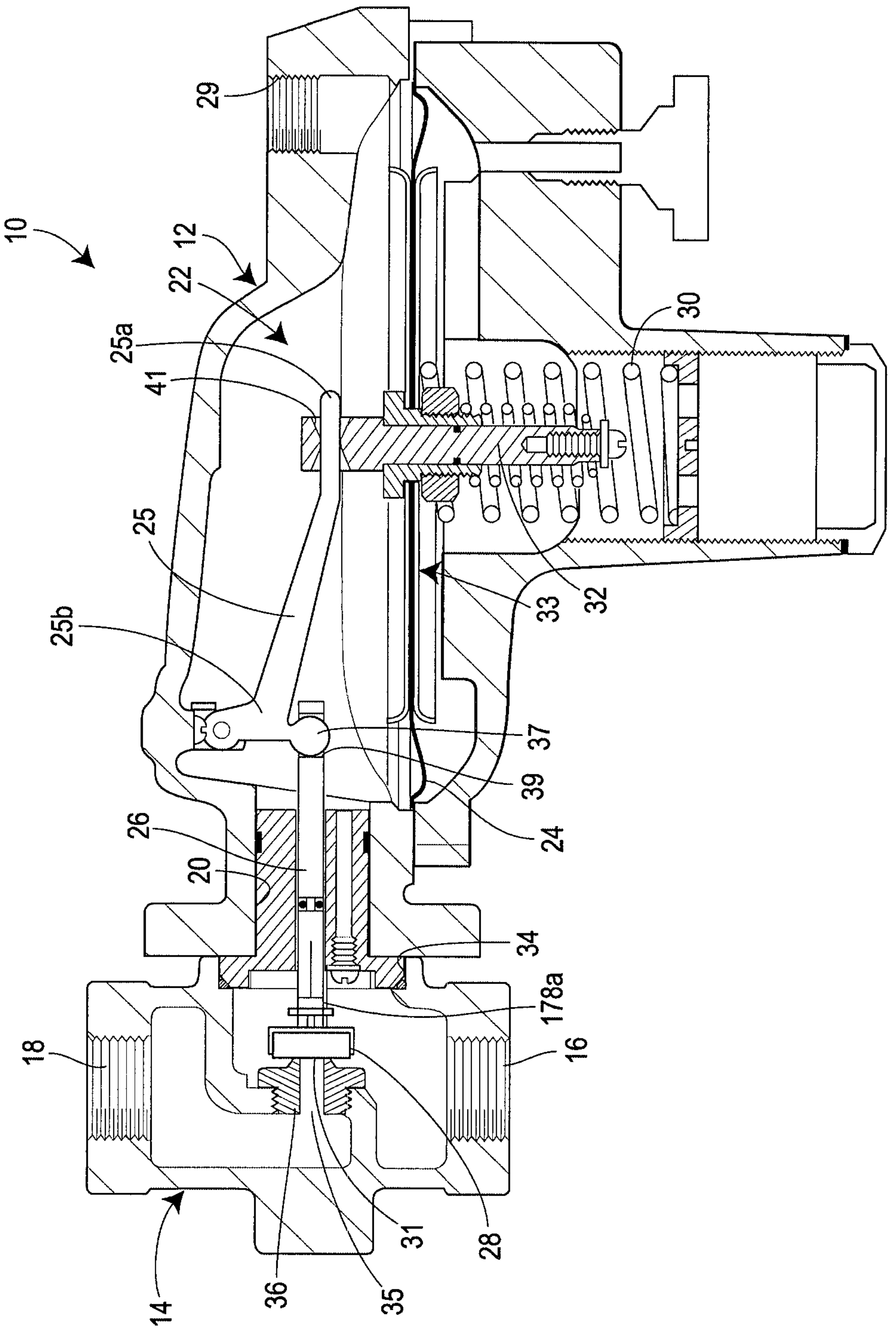
an actuator housing defining a control cavity and an actuator mouth, the actuator mouth coupled to the valve mouth of the valve body;

a guide insert fixedly disposed within the actuator mouth of the actuator housing, the guide insert including a bore and a radially outwardly extending shoulder defining a first spring seat;

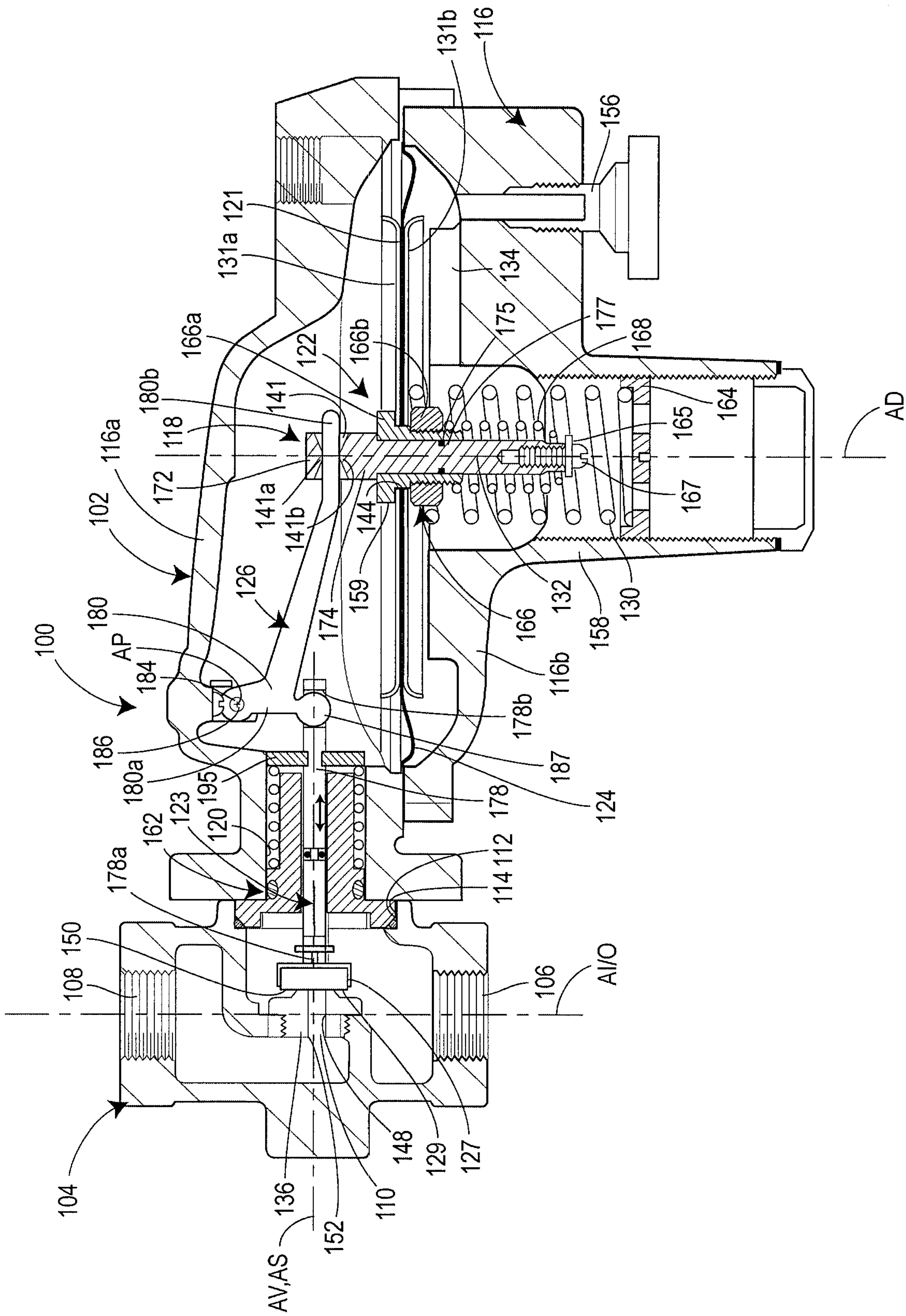
a control assembly mounted within the control cavity, the control assembly including a piston, a diaphragm operably coupled to the piston, a stem slidably disposed in the bore of the guide insert, a lever operably coupled between the piston and the stem, and a control element mounted to the stem opposite the lever and disposed in the valve body adjacent to the throat, the piston being slidable along a piston axis in response to pressure changes experienced by the diaphragm, the lever being pivotable about a pivot axis to transfer sliding movement of the piston along the piston axis into sliding movement of the stem along a stem axis that is perpendicular to the piston axis;

a disc coupled to the stem at a location between the first spring seat and the control cavity of the actuator housing, the disc defining a second spring seat; and

a coil spring disposed on the stem between and in engagement with the first spring seat and the second spring seat, the coil spring biasing the control element and the stem toward the control cavity and away from the throat of the valve body.



Prior Art
Fig. 1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166a
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180b
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186
187
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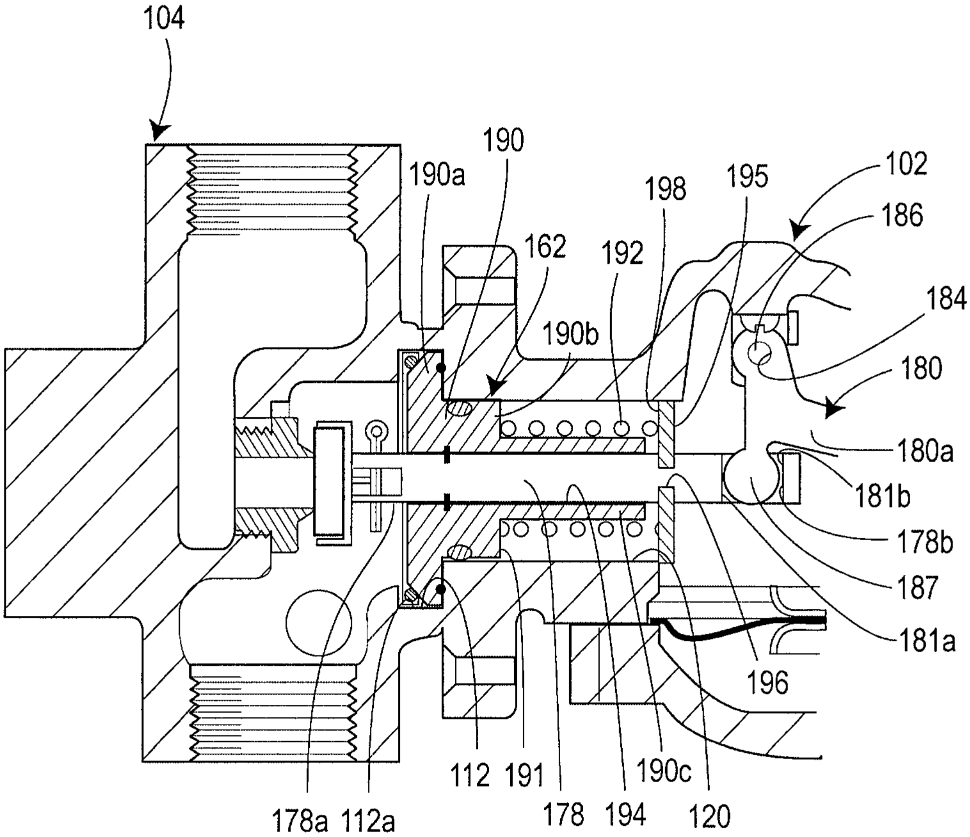
AP
AD
AI/O
AV,AS

Fig. 2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190a
162
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195
102
186
192
190b
184
180
180a
181b
178b
187
181a
196
112
191
178
194
190c
120
178a
112a

Fig. 3

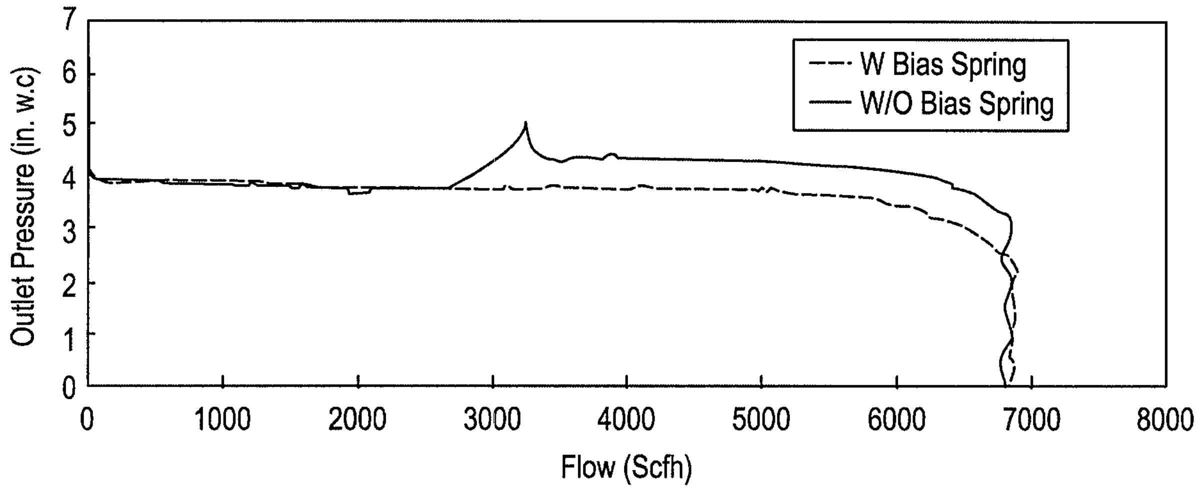
W Bias Spring
W/O Bias Spring
Outlet Pressure (in. w.c)
7
6
5
4
3
2
1
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Flow (Scfh)

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/072112

A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet

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)

IPC：G05D, F16K, F15B

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)

WPI, EPODOC, CNPAT: fluid, air, gas, flow, regulate, control, manipulate, piston, stem, bias, spring, flexible, cavity, chamber, room, space, inlet, outlet, rod, guide, seat, slide

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US4503883A (SINGER CO) 12 Mar. 1985 (12.03.1985) see column 1, line 58 - column 5, line 21 of the description, figures 1-4	1-17
X	US3623506A (ROCKWELL MFG CO) 30 Nov. 1971 (30.11.1971) see column 1, line 62 - column 5, line 17 of the description, figures 1-3	1-17
Y	US5697398A (FISHER CONTROLS INT) 16 Dec. 1997 (16.12.1997) see column 2, line 32 - column 4, line 36 of the description, figures 1-3	1-17
Y	US2619983A (FISHER GOVERNOR CO) 02 Dec. 1952 (02.12.1952) see column 2, line 19 - column 4, line 23 of the description, figures 1-2	1-17

☒ Further documents are listed in the continuation of Box C. ☒ 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

"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
10 Dec. 2011 (10.12.2011)	**05 Jan. 2012 (05.01.2012)**

Name and mailing address of the ISA/CN	Authorized officer
The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	LIU, Jingyi Telephone No. (86-10)62085239

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/072112

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US2669071A (WEATHERHEAD CO) 16 Feb. 1954 (16.02.1954) see column 2, line 4 - column 6, line 2 of the description, figures 1-4	1-17
Y	US4491149A (SHERWOOD SELPAC CORP) 01 Jan. 1985 (01.01.1985) see column 2, line 55 - column 8, line 11 of the description, figures 1-8	1-17
A	US3580271A (BRYAN DONKIN CO LTD) 25 May 1971 (25.05.1971) see the whole document	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/072112

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US4503883A	12.03.1985	DK604784A	16.12.1985
		AU3651684A	19.12.1985
		AU563251B2	02.07.1987
		EP0165339A1	27.12.1985
		JP61003918A	09.01.1986
		DE165339T1	10.04.1986
		CA1219190A1	17.03.1987
US3623506A	30.11.1971	NONE	
US5697398A	16.12.1997	CA2182844A1	09.02.1997
US2619983A	02.12.1952	NONE	
US2669071A	16.02.1954	NONE	
US4491149A	01.01.1985	NONE	
US3580271A	25.05.1971	NONE	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/072112

Continuation of: second sheet

A. CLASSIFICATION OF SUBJECT MATTER

G05D 16/06 (2006.01) i

F16K 17/02 (2006.01) i