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(54) **METHOD AND APPARATUS FOR STABILIZING PRESSURE IN AN INTELLIGENT REGULATOR ASSEMBLY**

(71) Applicant: **TESCOM CORPORATION**, Elk River, MN (US)

(72) Inventor: **Christian Leonard**, Hanover (DE)

(73) Assignee: **TESCOM CORPORATION**, Elk River, MN (US)

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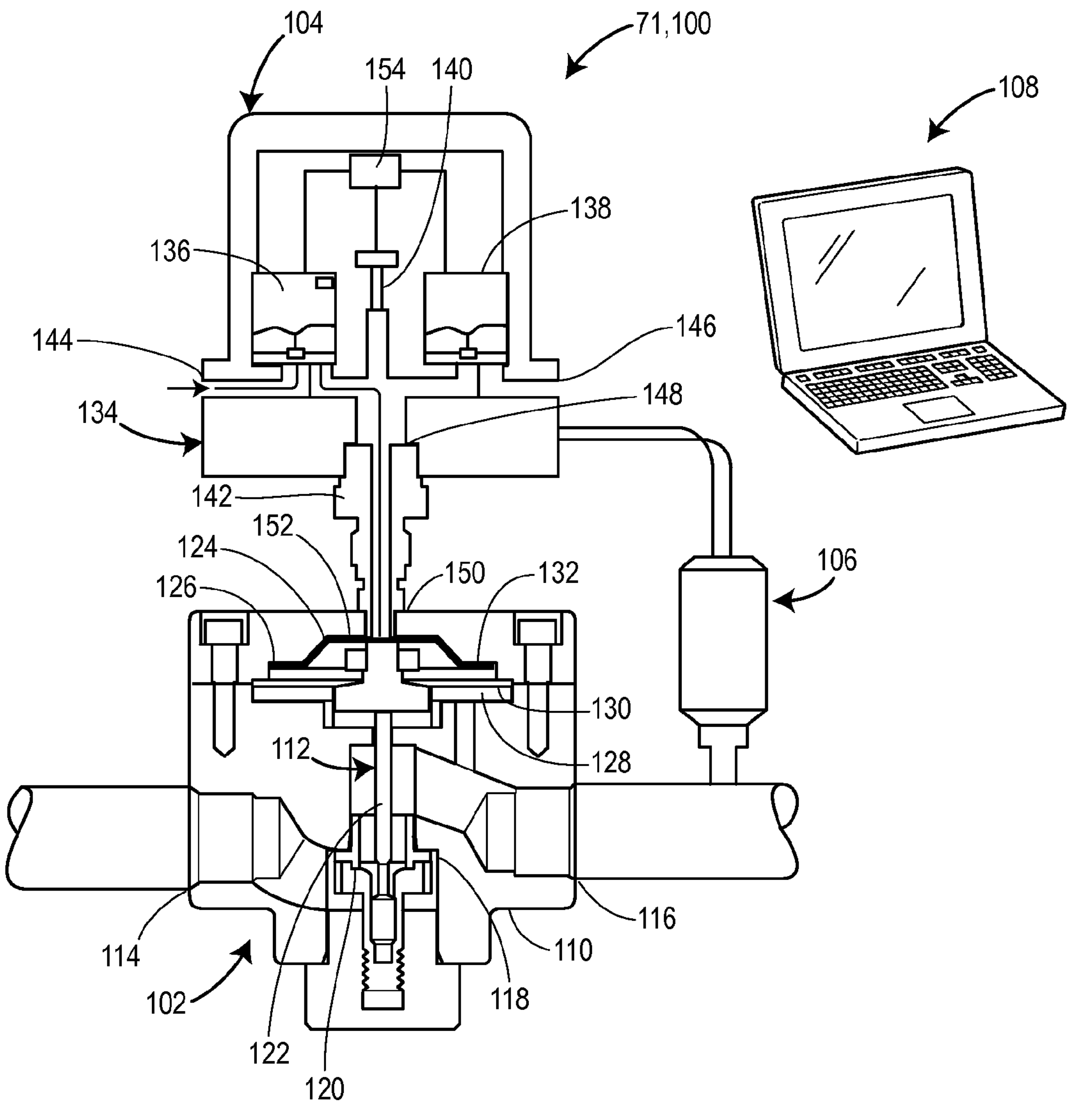
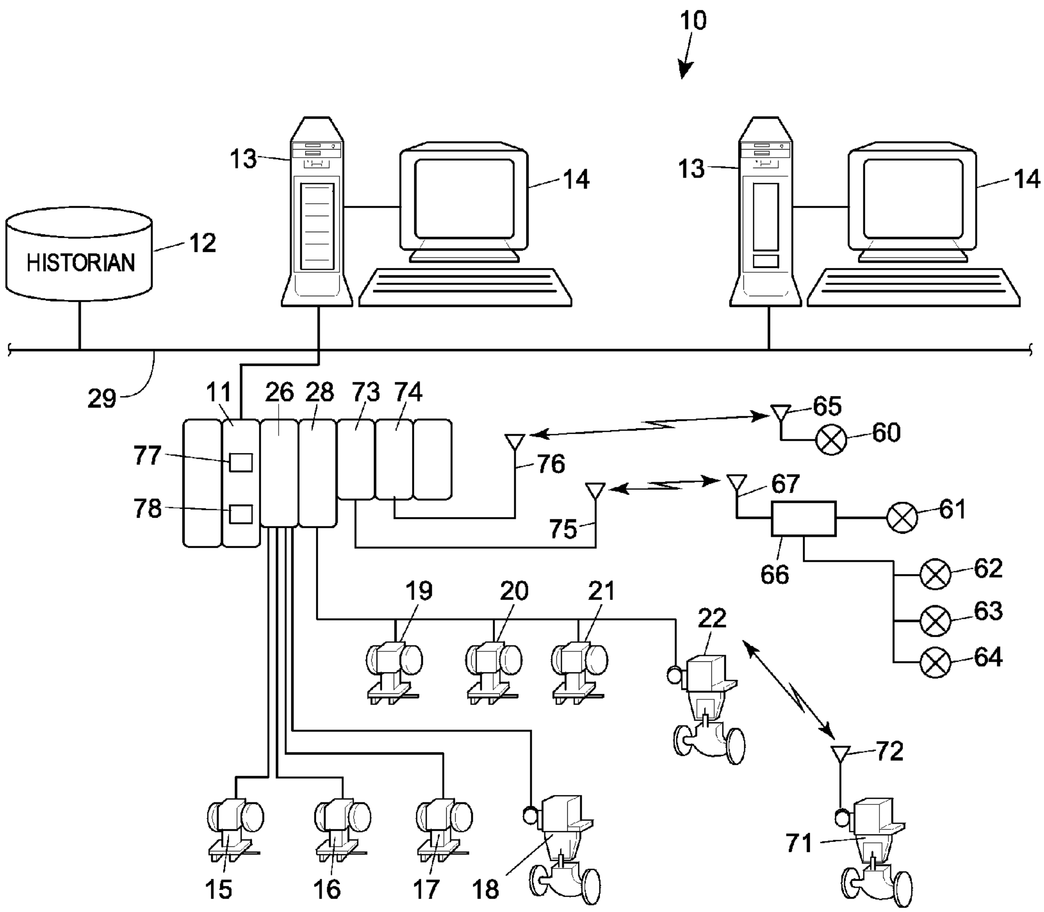
(57) **ABSTRACT**

A method of stabilizing pressure in an intelligent regulator assembly is provided. The method includes receiving, at an on-board controller of a pilot device, a request to activate a suspend control mode. The method also includes activating, via the on-board controller, the suspend control mode. The activation of the suspend control mode includes adjusting an inlet valve and an exhaust valve of the pilot device, and suspending control of the inlet valve and the exhaust valve.




10
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78
67
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75
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20
21
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71
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17
18

FIG. 1

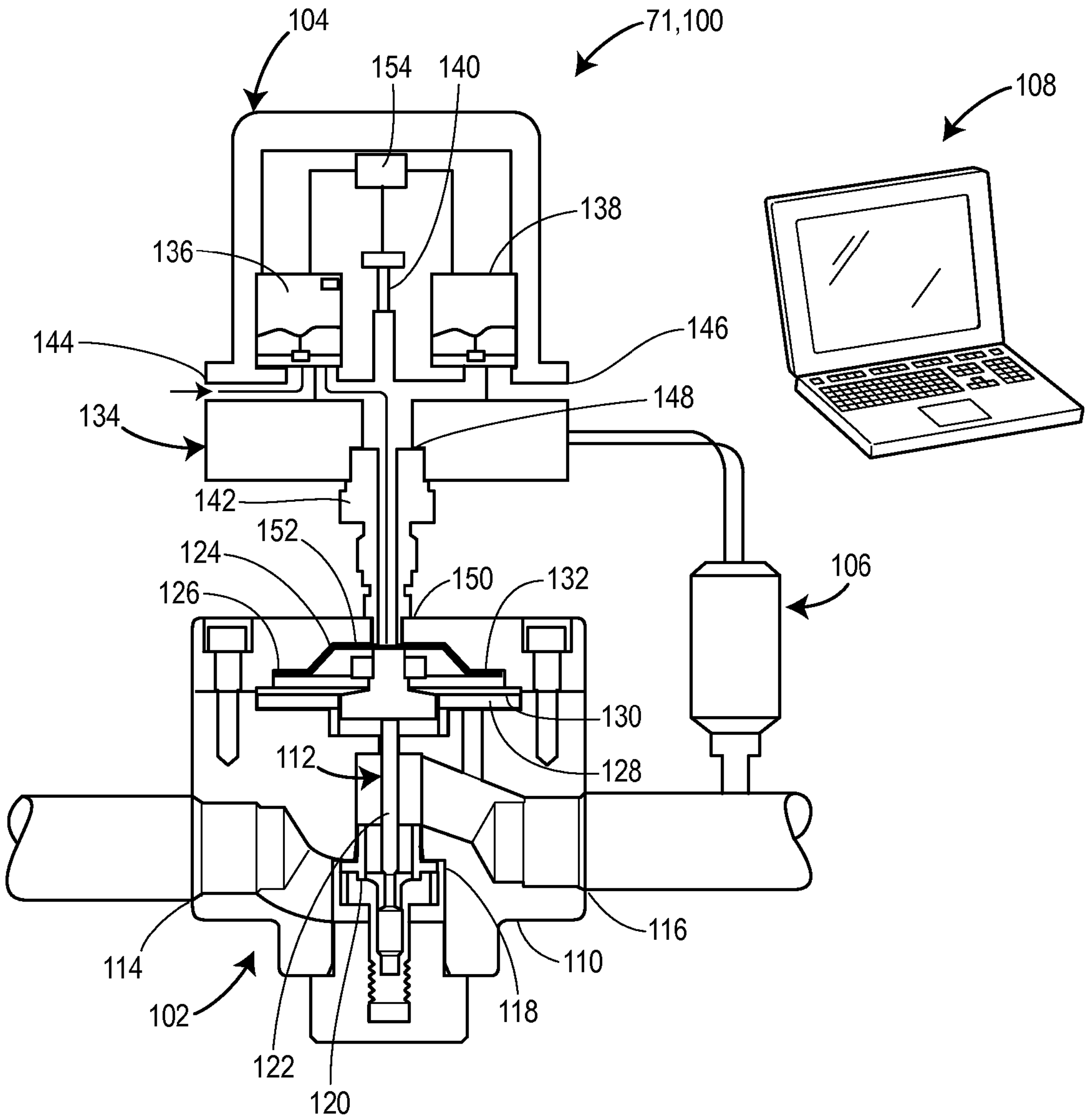
104
71,100
154
140
108
138
136
144
146
148
134
142
152
124
150
132
126
106
130
112
128
114
116
110
102
118
122
120

FIG. 2

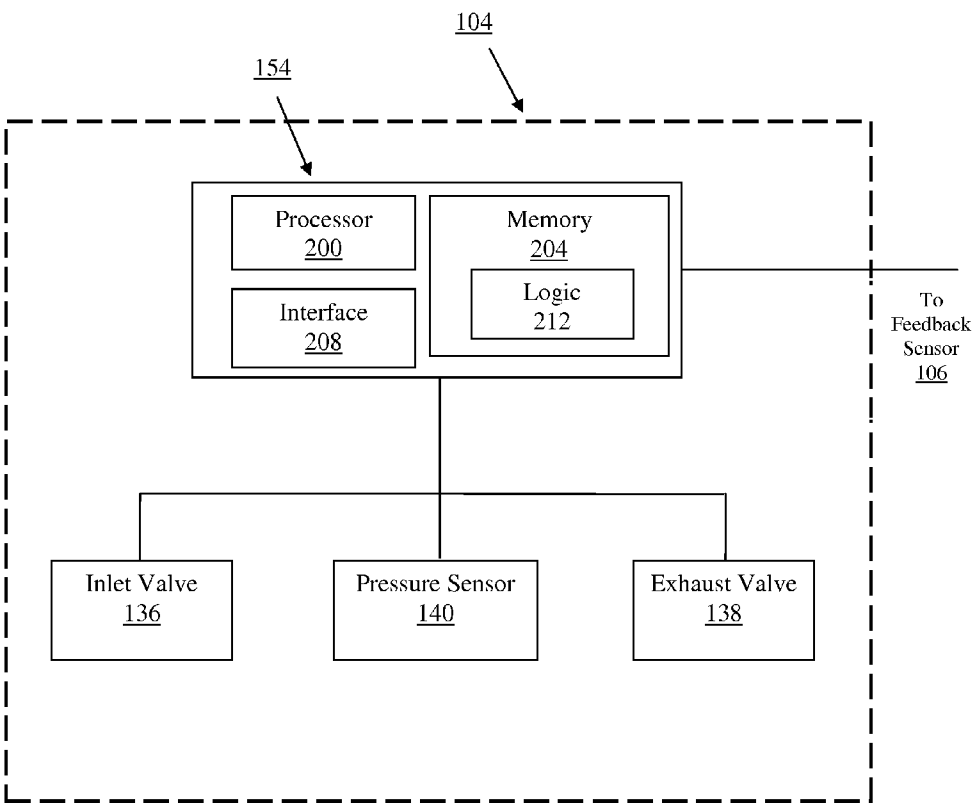
104
154
Processor
200
Memory
204
Logic
212
Interface
208
To
Feedback
Sensor
106
Inlet Valve
136
Pressure Sensor
140
Exhaust Valve
138

FIG. 3

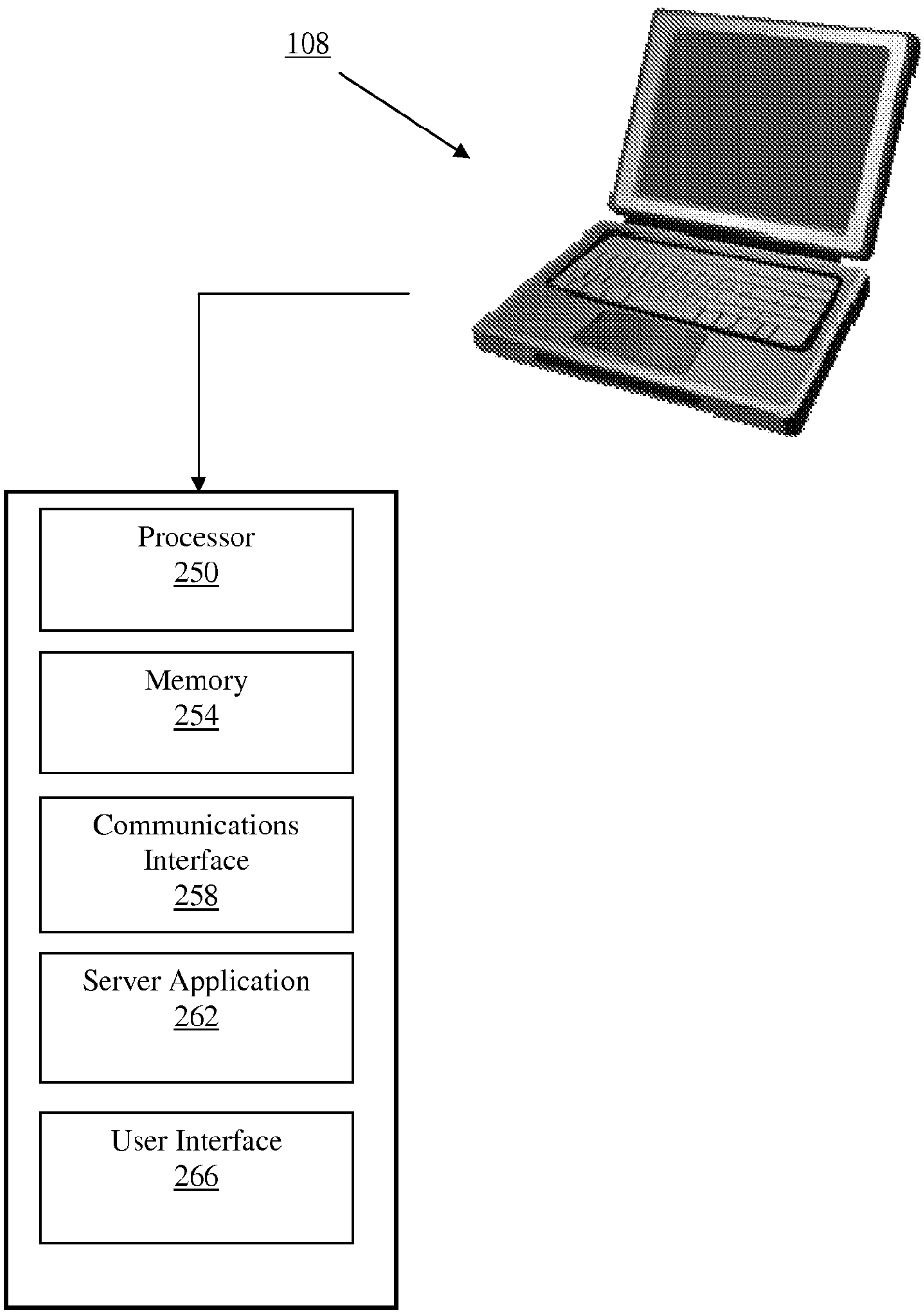
108
Processor
250
Memory
254
Communications
Interface
258
Server Application
262
User Interface
266

FIG. 4

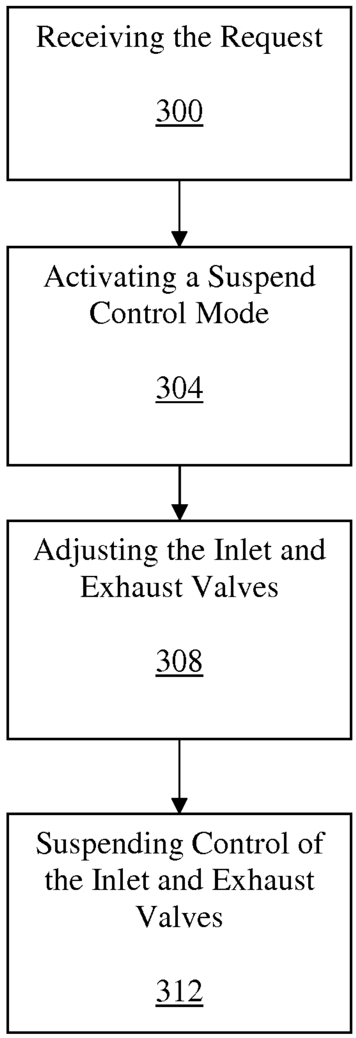
Receiving the Request
300
Activating a Suspend Control Mode
304
Adjusting the Inlet and Exhaust Valves
308
Suspending Control of the Inlet and Exhaust Valves
312

FIG. 5

METHOD AND APPARATUS FOR STABILIZING PRESSURE IN AN INTELLIGENT REGULATOR ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The priority benefit of U.S. Provisional Patent Application No. 61/830,538, filed Jun. 3, 2013, is hereby claimed and the entire contents thereof are incorporated herein by reference.

FIELD OF THE DISCLOSURE

[0002] The present disclosure is directed to process control systems and, more particularly, field devices such as pressure regulators and pilot loading mechanisms for pressure regulators used in process control systems.

BACKGROUND

[0003] Process control systems, such as distributed or scalable process control systems like those used in chemical, petroleum or other processes, typically include one or more process controllers communicatively coupled to one or more field devices via analog, digital or combined analog/digital buses. The field devices, which may include, for example, control valves, valve positioners, switches and transmitters (e.g., temperature, pressure and flow rate sensors), perform functions within the process such as opening or closing valves and measuring process parameters. The process controller receives signals indicative of process measurements made by the field devices and/or other information pertaining to the field devices, and uses this information to execute or implement one or more control routines to generate control signals, which are sent over the buses to the field devices to control the operation of the process. Information from each of the field devices and the controller is typically made available to one or more applications executed by one or more other hardware devices, such as host or user workstations, personal computers or computing devices, to enable an operator to perform any desired function regarding the process, such as setting parameters for the process, viewing the current state of the process, modifying the operation of the process, etc.

[0004] In some situations, such as when leak testing or sensor calibration is to be performed, pressure levels may need to be stabilized and/or reduced to zero in the process control system. Additional valves and supporting input and output lines may thus be installed in the processor control system. For example, additional valves may be installed on the end(s) of pipelines or vessels in the process control system. In turn, one or more of the field devices are no effectively longer controlled. This prevents pressure fluctuations, which would normally occur as a result of the field devices being controlled, thereby achieving the desired goal of stabilizing pressure levels, and/or reducing them to zero, in the process control system.

SUMMARY

[0005] One aspect of the present disclosure includes a method of stabilizing pressure in an intelligent regulator assembly having a pilot device and a regulator. The pilot device includes an inlet port coupled to a source of supply pressure and having an inlet valve, an exhaust port having an exhaust valve, an outlet port configured to output a controlled pressure to the regulator, and an on-board controller communicatively coupled to the inlet valve and the exhaust valve. The on-board controller is operable to control the inlet valve and the exhaust valve to control the pressure delivered to the regulator. The on-board controller includes a memory, a processor, and logic stored on the memory. The method includes receiving, at the on-board controller, a request to activate a suspend control mode. The method also includes activating, via the on-board controller, the suspend control mode, the activating including adjusting the inlet valve and the exhaust valve, and suspending control of the inlet valve and the exhaust valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a schematic representation of a process control system having one or more pilot devices constructed in accordance with the principles of the present disclosure.

[0007] FIG. **2** is a cross-sectional side view of one version of an intelligent regulator assembly constructed in accordance with the principles of the present disclosure.

[0008] FIG. **3** is a block diagram of one version of a pilot device of the intelligent regulator assembly shown in FIG. **2**.

[0009] FIG. **4** is a block diagram of one version of a personal computing device of the intelligent regulator assembly shown in FIG. **2**.

[0010] FIG. **5** is a process flow chart showing one version of a method for stabilizing pressure in an intelligent regulator assembly in accordance with the present disclosure.

DETAILED DESCRIPTION

[0011] The present disclosure is directed to an intelligent regulator assembly having an pilot device, which can be a field device of a process control system, for example. More specifically, the pilot device provides a suspend control mode that is beneficial for applications in which total pressure stability is required.

[0012] Referring now to FIG. **1**, a process control system **10** constructed in accordance with one version of the present disclosure is depicted incorporating one or more field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, **22**, and **71** in communication with a process controller **11**, which in turn, is in communication with a data historian **12** and one or more user workstations **13**, each having a display screen **14**. So configured, the controller **11** delivers signals to and receives signals from the field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, **22**, and **71** and the workstations **13** to control the process control system.

[0013] In additional detail, the process controller **11** of the process control system **10** of the version depicted in FIG. **1** is connected via hardwired communication connections to field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, and **22** via input/output (I/O) cards **26** and **28**. The data historian **12** may be any desired type of data collection unit having any desired type of memory and any desired or known software, hardware or firmware for storing data. Moreover, while the data historian **12** is illustrated as a separate device in FIG. **1**, it may instead or in addition be part of one of the workstations **13** or another computer device, such as a server. The controller **11**, which may be, by way of example, a DeltaV™ controller sold by Emerson Process Management, is communicatively connected to the workstations **13** and to the data historian **12** via a communication network **29** which may be, for example, an Ethernet connection.

[0014] As mentioned, the controller **11** is illustrated as being communicatively connected to the field devices **15**, **16**,

17, **18**, **19**, **20**, **21**, and **22** using a hardwired communication scheme which may include the use of any desired hardware, software and/or firmware to implement hardwired communications, including, for example, standard 4-20 mA communications, and/or any communications using any smart communication protocol such as the FOUNDATION® Fieldbus communication protocol, the HART® communication protocol, etc. The field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, and **22** may be any types of devices, such as sensors, control valve assemblies, transmitters, positioners, etc., while the I/O cards **26** and **28** may be any types of I/O devices conforming to any desired communication or controller protocol. In the embodiment illustrated in FIG. **1**, the field devices **15**, **16**, **17**, **18** are standard 4-20 mA devices that communicate over analog lines to the I/O card **26**, while the digital field devices **19**, **20**, **21**, **22** can be smart devices, such as HART® communicating devices and Fieldbus field devices, that communicate over a digital bus to the I/O card **28** using Fieldbus protocol communications. Of course, the field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, and **22** may conform to any other desired standard(s) or protocols, including any standards or protocols developed in the future.

[0015] In addition, the process control system **10** depicted in FIG. **1** includes a number of wireless field devices **60**, **61**, **62**, **63**, **64** and **71** disposed in the plant to be controlled. The field devices **60**, **61**, **62**, **63**, **64** are depicted as transmitters (e.g., process variable sensors) while the field device **71** is depicted as a control valve assembly including, for example, a control valve and an actuator. Wireless communications may be established between the controller **11** and the field devices **60**, **61**, **62**, **63**, **64** and **71** using any desired wireless communication equipment, including hardware, software, firmware, or any combination thereof now known or later developed. In the version illustrated in FIG. **1**, an antenna **65** is coupled to and is dedicated to perform wireless communications for the transmitter **60**, while a wireless router or other module **66** having an antenna **67** is coupled to collectively handle wireless communications for the transmitters **61**, **62**, **63**, and **64**. Likewise, an antenna **72** is coupled to the control valve assembly **71** to perform wireless communications for the control valve assembly **71**. The field devices or associated hardware **60**, **61**, **62**, **63**, **64**, **66** and **71** may implement protocol stack operations used by an appropriate wireless communication protocol to receive, decode, route, encode and send wireless signals via the antennas **65**, **67** and **72** to implement wireless communications between the process controller **11** and the transmitters **60**, **61**, **62**, **63**, **64** and the control valve assembly **71**.

[0016] If desired, the transmitters **60**, **61**, **62**, **63**, **64** can constitute the sole link between various process sensors (transmitters) and the process controller **11** and, as such, are relied upon to send accurate signals to the controller **11** to ensure that process performance is not compromised. The transmitters **60**, **61**, **62**, **63**, **64**, often referred to as process variable transmitters (PVTs), therefore may play a significant role in the control of the overall control process. Additionally, the control valve assembly **71** may provide measurements made by sensors within the control valve assembly **71** or may provide other data generated by or computed by the control valve assembly **71** to the controller **11** as part of its operation. Of course, as is known, the control valve assembly **71** may also receive control signals from the controller **11** to effect physical parameters, e.g., flow, within the overall process.

[0017] The process controller **11** is coupled to one or more I/O devices **73** and **74**, each connected to a respective antenna **75** and **76**, and these I/O devices and antennas **73**, **74**, **75**, **76** operate as transmitters/receivers to perform wireless communications with the wireless field devices **61**, **62**, **63**, **64** and **71** via one or more wireless communication networks. The wireless communications between the field devices (e.g., the transmitters **60**, **61**, **62**, **63**, **64** and the control valve assembly **71**) may be performed using one or more known wireless communication protocols, such as the WirelessHART® protocol, the Ember protocol, a WiFi protocol, an IEEE wireless standard, etc. Still further, the I/O devices **73** and **74** may implement protocol stack operations used by these communication protocols to receive, decode, route, encode and send wireless signals via the antennas **75** and **76** to implement wireless communications between the controller **11** and the transmitters **60**, **61**, **62**, **63**, **64** and the control valve assembly **71**.

[0018] As illustrated in FIG. **1**, the controller **11** conventionally includes a processor **77** that implements or oversees one or more process control routines (or any module, block, or sub-routine thereof) stored in a memory **78**. The process control routines stored in the memory **78** may include or be associated with control loops being implemented within the process plant. Generally speaking, and as is generally known, the process controller **11** executes one or more control routines and communicates with the field devices **15**, **16**, **17**, **18**, **19**, **20**, **21**, **22**, **60**, **61**, **62**, **63**, **64**, and **71**, the user workstations **13** and the data historian **12** to control a process in any desired manner(s). Additionally, any one of the field devices **18**, **22**, and **71** in FIG. **1**, each of which is depicted as a control valve assembly, can include an intelligent control valve actuator constructed in accordance with the principles of the present disclosure for communicating with the process controller **11** in order to facilitate monitoring of the actuator's health and integrity.

[0019] Referring now to FIG. **2**, for the sake of description, field device **71** from FIG. **1** is shown as an intelligent regulator assembly **100** constructed in accordance with the principles of the present disclosure. In FIG. **2**, the intelligent regulator assembly **100** includes a regulator **102**, a pilot device **104**, and a feedback pressure sensor **106**. Additionally, FIG. **2** depicts an optional personal computing device **108** communicatively coupled to the pilot device **104** to enable user interaction with the pilot device **104**, as will be described.

[0020] The regulator **102** includes a valve body **110** and a control assembly **112**. The valve body **110** defines an inlet **114**, an outlet **116**, and a gallery **118** defining a seating surface **120**. The control assembly **112** is carried within the valve body **110** and includes a control element **122** operably connected to a diaphragm assembly **124**. The control element **122** is movable between a closed position in sealing engagement with the seating surface **120** and an open position spaced away from the seating surface **120** in response to pressure changes across the diaphragm assembly **124**. As depicted, the diaphragm assembly **124** includes a diaphragm **126** disposed within a diaphragm cavity **128** of the valve body **110** of the regulator **102**. A bottom surface **130** of the diaphragm **126** is in fluid communication with the outlet **116** of the valve body **110** and a top surface **132** of the diaphragm **126** is in fluid communication with the pilot device **104** via a pilot opening **150** in the valve body **110**.

[0021] The pilot device **104** includes a valve body **134**, an inlet valve **136**, an exhaust valve **138**, a pressure sensor **140**, and an outlet adaptor **142**. The valve body **134** defines an inlet port **144**, an exhaust port **146**, and an outlet port **148**. The inlet port **144** is adapted to be connected to a source of supply gas for loading the dome **152** of the regulator **102**, as will be described. As depicted, the inlet valve **136** is disposed adjacent to the inlet port **144**, the exhaust valve **138** is disposed adjacent to the exhaust port **146**, and the outlet adaptor **142** extends from the outlet port **148** and to the pilot opening **150** in the valve body **110**. Thus, the outlet adaptor provides **142** fluid communication between the pilot device **104** and the regulator **102**. The pressure sensor **140** is disposed in the valve body **134** of the pilot device **104** at a location between the inlet and outlet valves **136**, **138**. As such, the pressure sensor **140** is operable to sense the pressure between the inlet and outlet valves **136**, **138**, as well as in the outlet port **148**, the outlet adaptor **142**, and the diaphragm cavity **128** adjacent to the top surface **132** of the diaphragm **126**. This portion of the diaphragm cavity **128** can be referred to as the dome **152** of the regulator **102**. In one version of the pilot device **104** the inlet and exhaust valves **136**, **138** can be solenoid valves such as Pulse Width Modulation (PWM) solenoid valves and the pressure sensor **104** can be a pressure transducer. Moreover, the inlet and exhaust valves **136**, **138** and the pressure sensor **140** can be communicatively coupled to an on-board controller **154**, which can store logic and/or direct some or all of the functionality of the pilot device **104**, as will be described below.

[0022] Still referring to FIG. **2**, the feedback pressure sensor **106** of the assembly **100** includes a pressure transducer arranged to detect the pressure at the outlet **116** of the regulator **102** and transmit signals to the pilot device **104** and, more particularly, to the on-board controller **154** of the pilot device **104**. Based on the signals received by the on-board controller **154** from the feedback pressure sensor **106**, the pilot device **104** opens and/or closes the inlet and exhaust valves **136**, **138** to control the pressure in the dome **152** of the regulator **102**, which in turn, controls the position of the control element **122** and ultimately the pressure at the outlet **116** of the regulator **102**.

[0023] Specifically, during normal operation, the pressure at the outlet **116** of the regulator **102** is controlled and maintained as desired by adjusting the pressure in the dome **152** of the regulator **102**. This is achieved via operation of the pilot device **104** and feedback pressure sensor **106**. For example, in one version, the feedback pressure sensor **106** detects the pressure at the outlet **116** every 25 milliseconds and transmits a signal to the on-board controller **154** of the pilot device **104**. The on-board controller **154** compares this signal, which is indicative of the pressure at the outlet **116**, to a desired set-point pressure and determines if the outlet pressure is less than, equal to, or greater than the set-point pressure. Based on this determination, the pilot device **104** manipulates either or both of the inlet and exhaust valves **136**, **138** to adjust the pressure in the dome **152**. That is, if the sensed outlet pressure is lower than the desired set-point pressure, the on-board controller **154** activates the inlet valve **136** (e.g., instructs the inlet valve **136** to open and the exhaust valve **138** to close). In this configuration, gas enters the inlet port **144** of the pilot device **104** and increases the pressure in the dome **152**, which causes the diaphragm assembly **124** to urge the control element **122** downward relative to the orientation of FIG. **2**, which opens the regulator **102** and increases flow and ultimately pressure at the outlet **116**. In contrast, if the pressure sensed at the outlet **116** by the feedback pressure sensor **106** is determined to be higher than the desired set-point pressure, the on-board controller **154** activates the exhaust valve **138** (e.g., instructs the exhaust valve **138** to open and the inlet valve **136** to close). In this configuration, gas in the dome **152** exhausts out through the exhaust port **146** of the pilot device **104** to decrease the pressure on the top surface **132** of the diaphragm **126**. This allows the outlet pressure to urge the diaphragm assembly **124** and control element **122** upward relative to the orientation of FIG. **2**, which closes the regulator **102** and decreases flow and ultimately pressure at the outlet **116**.

[0024] Based on the foregoing description, it should be appreciated that the pilot device **104** and the feedback pressure sensor **106** operate in combination with each other to intermittently, yet frequently, monitor the pressure at the outlet **116** of the regulator **102** and adjust the pressure in the dome **152** until the pressure at the outlet **116** is equal to the set-point pressure.

[0025] With reference to FIG. **3**, the on-board controller **154** may include a processor **200**, a memory **204**, a communications interface **208**, and computing logic **212**. The processor **200** may be a general processor, a digital signal processor, ASIC, field programmable gate array, graphics processing unit, analog circuit, digital circuit, or any other known or later developed processor. The processor **200** operates pursuant to instructions in the memory **204**. The memory **204** may be a volatile memory or a non-volatile memory. The memory **204** may include one or more of a read-only memory (ROM), random-access memory (RAM), a flash memory, an electronic erasable program read-only memory (EEPROM), or other type of memory. The memory **204** may include an optical, magnetic (hard drive), or any other form of data storage device.

[0026] The communications interface **208**, which may be, for example, a universal serial bus (USB) port, an Ethernet port, or some other port or interface, is provided to enable or facilitate electronic communication between the pilot device **104** and the computing device **108**. This electronic communication may occur via any known method, including, by way of example, USB, RS-232, RS-485, WiFi, Bluetooth, or any other suitable communication connection.

[0027] The logic **212** includes one or more routines and/or one or more sub-routines, embodied as computer-readable instructions stored on the memory **204**. The pilot device **104**, particularly the processor **200**, may execute the logic **212** to cause the processor **200** to perform actions related to the configuration, management, maintenance, diagnosis, and/or operation of the pilot device **104**. The logic **212** may, when executed, cause the processor **200** to receive and/or obtain signals or requests from the personal computing device **108**, determine the contents of any received and/or obtained signals or requests, monitor the pressure detected by the pressure sensor **140**, open and/or close the inlet and/or exhaust valves **136**, **138**, suspend control of the opened and/or closed inlet and/or exhaust valves **136**, **138**, and/or perform other desired functionality.

[0028] Turning to FIG. **4**, further details of the personal computing device **108** will now be described. The personal computing device **108** may be a desktop computer, a notebook computer, a user workstation, a tablet, a hand held computing device (e.g., a smart phone), or other personal computing device. In one embodiment, the personal computing device **108** is the same as the user workstation **13** described in connection with FIG. **1**.

[0029] As shown in FIG. **4**, the personal computing device **108** includes a processor **250**, a memory **254**, a communications interface **258**, and an application **262**. The processor **250** may be a general processor, a digital signal processor, ASIC, field programmable gate array, graphics processing unit, analog circuit, digital circuit, or any other known or later developed processor. The processor **250** operates pursuant to instructions in the memory **254**. The memory **254** may be a volatile memory or a non-volatile memory. The memory **254** may include one or more of a read-only memory (ROM), random-access memory (RAM), a flash memory, an electronic erasable program read-only memory (EEPROM), or other type of memory. The memory **254** may include an optical, magnetic (hard drive), or any other form of data storage device.

[0030] The communications interface **258**, which may be, for example, a universal serial bus (USB) port, an Ethernet port, or some other port or interface, is provided to enable or facilitate electronic communication between the personal computing device **108** and the pilot device **104**. This electronic communication may occur via any known method, including, by way of example, USB, RS-232, RS-485, WiFi, Bluetooth, or any other suitable communication connection.

[0031] The application **262** includes computing logic, such as one or more routines and/or one or more sub-routines, embodied as computer-readable instructions stored on the memory **254** or another memory. The personal computing device **108**, particularly the processor **250**, may execute the logic to cause the processor **250** to perform actions related to the configuration, management, maintenance, diagnosis, and/or operation (e.g., control or adjustment) of the components of the assembly **100** (e.g., the pilot device **104**). The application **262** may facilitate automatic interaction and/or manual interaction with the pilot device **104**. For example, the application **262** may facilitate performance of an automated tuning procedure on the pilot device **104**. The application **262** may facilitate manual interaction for a user of the personal computing device **108** with the pilot device **104**. To this end, the application may include or provide the user with a user interface **266** that facilitates user interaction with (e.g., control of) the pilot device **104**.

[0032] With or via the user interface **266**, the user may select or request activation of a suspend control mode in which control of the other components of the assembly **100** (e.g., the regulator **102**) by the pilot device **104** is suspended, as will be described in greater detail below. The user may also utilize the user interface **266** to manually tune the pilot device **104**, program a set point of the pilot device **104**, adjust proportional, derivative, and/or integral values and/or integral limits and/or dead band parameters, set control modes, perform calibration, set control limits, set diaphragm protection values, run diagnostic procedures (e.g., a solenoid leak test), and the like.

[0033] As described above, during normal operation of the assembly **100**, the pressure at the outlet port **148**, and, in turn, the pressure in the dome **152**, is controlled (e.g., adjusted) based on the set-point pressure and the determined pressure at the outlet **116** of the regulator **102**. When, for example, the on-board controller **154** determines that the set-point pressure is higher than the pressure at the outlet **116**, such that the pressure at the outlet port **148** and the pressure in the dome **152** needs to be increased, the on-board controller **154** activates the inlet valve **136**. In turn, gas enters the inlet port **144** of the pilot device **104**, the pressure at the outlet port **148** and in the dome **152** increases, and, ultimately, the pressure at the outlet **116** increases. When, however, the on-board controller **154** determines that the set-point pressure is lower than the pressure at the outlet **116**, such that the pressure at the outlet port **148** and the pressure in the dome **152** needs to be increased, the on-board controller **154** activates the exhaust valve **138**. In turn, gas in the dome **152** exhausts out through the exhaust port **146** of the pilot device **104**, decreasing the pressure at the outlet port **148** and in the dome **152**, and, ultimately, the pressure at the outlet **116** decreases. Such a process is iteratively and continuously performed.

[0034] In some situations, however, pressure stability in the assembly **100** may be desirable. In other words, in some situations, the changes or fluctuations in pressure (at the outlet port **148**, in the dome **152**, at the outlet **116**, etc.) inherent in the normal operation described above may not be desirable. Pressure stability may, for example, be desirable when an operator of the assembly **100** is conducting or performing a leak test, calibrating a sensor, or performing some other task that requires pressure stability in the assembly **100**. By, for example, stabilizing the pressure in the assembly, and monitoring the pressure levels subsequent to this stabilization, the operator can determine whether any components of the assembly **100** are leaking or otherwise faulty. If, for example, the pressure levels are stabilized, but the pressure at the outlet **116** has decreased, the operator may deduce that there are one or more leaks in the assembly **100**.

[0035] The present embodiments aim to achieve this pressure stability by providing a suspend control mode that, when activated or initiated, disrupts (e.g., suspends, freezes, or stops) the normal process described above. When the suspend control mode is activated, the control algorithm (e.g., the PID algorithm) run or employed by the pilot device **104** is suspended, frozen, or stopped. In other words, when the suspend control mode is activated, the on-board controller **154** stops controlling (e.g., adjusting) the components of the pilot device **104**, such as, for example, the inlet valve **136** and/or the exhaust valve **138**. Since the on-board controller **154** can no longer control the valves **136**, **138**, the pilot device **104** is, in essence, no longer responsive to (i.e., the pilot device **104** essentially ignores) the other components of the assembly **100** (e.g., the feedback sensor **106**), such that the feedback loop is effectively stopped and, in turn, the pressure values in the assembly **100** are frozen, locked, or maintained.

[0036] FIG. **5** depicts an exemplary method or process of stabilizing or maintaining the pressure in the assembly **100**. The on-board controller **154** of the pilot device **104** first receives a request from the personal computing device **108** via, for example, the communications interface **258** (block **300**). The request may be a request to stabilize or freeze the pressure in the assembly **100**, or, in other words, a request to activate the suspend control mode. The request may be automatically generated by the computing device **108** or may be generated by the user of the personal computing device **108** using, for example, the user interface **266** of the application **262**, and then transmitted from the computing device **108** to the on-board controller **154** of the pilot device **104**.

[0037] In other embodiments, the on-board controller **154** may receive the request from another computing device (e.g., the controller **11**) or the request may be received locally (i.e., entered directly into or on the pilot device **104**). Further yet, the on-board controller **154** may, instead of receiving the request, receive data (e.g., a signal) indicative of a leak testing, sensor calibration, or some other activity requiring pressure stabilization, from which the on-board controller **154** may infer the request.

[0038] Based on (e.g., in response to) the received request, the on-board controller **154** activates or initiates the suspend control mode (block **304**). When activated, the suspend control mode generally involves the on-board controller **154** adjusting the inlet valve **136** and the exhaust valve **138** (block **308**) and then suspending control of the adjusted inlet valve **136** and the exhaust valve **138** (block **312**).

[0039] In some embodiments, the suspend control mode involves the on-board controller **154** closing the inlet valve **136**, closing the exhaust valve **138**, and suspending control of the closed inlet valve **136** and the closed exhaust valve **138**. Since the inlet valve **136** and the exhaust valve **138** are closed, no gas can enter the inlet port **144** of the pilot device **104** and no gas in the dome **152** can be exhausted out through the exhaust port **146** of the pilot device **104**. Moreover, because the on-board controller **154** has suspended control of the closed valves **136**, **138**, the valves **136**, **138** cannot be controlled (i.e., opened). In turn, the pressure in the assembly **100**, particularly the pressure at the outlet port **148**, in the dome **152**, and at the outlet **116** of the regulator **102**, is frozen, maintained, or held constant. This happens in spite of any information or data received from other components of the assembly **100**. For example, the on-board controller **154** may continue to receive feedback information from the pressure sensor **106**. However, because the on-board controller **154** is operating in the suspend control mode, the on-board controller **154** will not respond to this feedback information as it normally would.

[0040] In other embodiments, the suspend control mode may involve the on-board controller **154** adjusting the inlet valve **136** and/or the exhaust valve **138** in some other way. For example, the on-board controller **154** may close the inlet valve **136**, open the exhaust valve **138**, and then suspend control of the closed inlet valve **136** and the open exhaust valve **138**.

[0041] So long as it is desirable to maintain or freeze the pressure in the assembly **100**, particularly the pressure at the outlet port **148**, in the dome **152**, and at the outlet **116** of the regulator **102**, the pilot device **104**, particularly the on-board controller **154**, may continue running or operating in the suspend control mode. The pilot device **104** may operate in the suspend control mode for any length of time (e.g., 30 minutes, 1 day, etc.), depending on the task that is being performed (e.g., sensor calibration, leak testing).

[0042] When it is no longer necessary or desirable to maintain or freeze the pressure in the assembly **100**, the suspend control mode may be deactivated. The suspend control mode may be deactivated in a manner similar to how the suspend control mode was activated. In turn, the assembly **100**, particularly the pilot device **104**, may return to a normal operation.

[0043] Based on the foregoing description, it should be appreciated that the devices and methods described herein provide for a suspend control feature that is highly advantageous for applications, such as leak detection or sensor calibration, in which total stability, particularly pressure stability, is critical. By providing such a feature without requiring the installation of additional valves and supporting input and output lines for those valves, the disclosed devices and methods are simpler to install and utilize, more reliable, and may have a longer useful life than known process control systems.

1. A pilot device for use with a fluid regulator assembly comprising a fluid regulator and a feedback pressure sensor, the pilot device comprising:
- an inlet port coupled to a source of supply pressure and having an inlet valve;
- an exhaust port having an exhaust valve;
- an outlet port configured to output a controlled pressure to the fluid regulator; and
- an on-board controller communicatively coupled to the inlet valve and the exhaust valve and operable to control the inlet valve and the exhaust valve to control the pressure delivered to the fluid regulator, the on-board controller including a memory, a processor, and logic stored on the memory, wherein the logic stored on the memory of the controller is executable by the processor to receive a request to activate a suspend control mode, and, based on the request, activate the suspend control mode, the suspend control mode including adjusting the inlet valve and the exhaust valve, and suspending control of the inlet valve and the exhaust valve.

2. (canceled)

3. The pilot device of claim **1**, wherein the request is received when a leak test is to be performed or a sensor of the fluid regulator assembly is to be calibrated.

4. The pilot device of claim **1**, wherein the on-board controller is configured to activate the suspend control mode, the suspend control mode including closing the inlet valve and the exhaust valve and suspending control of the closed inlet valve and the closed exhaust valve.

5. The pilot device of claim **1**, wherein the on-board controller is configured to activate the suspend control mode, the suspend control mode including closing the inlet valve and opening the exhaust valve and suspending control of the closed inlet valve and the opened exhaust valve.

6. The pilot device of claim **1**, wherein, when the on-board controller suspends control of the inlet valve and the exhaust valve, a value of the controlled pressure output by the outlet port remains constant.

7. The pilot device of claim **6**, wherein the on-board controller is operable to maintain the value of the controlled pressure output by the outlet port without the installation of any additional valves.

8-10. (canceled)

11. A fluid flow device comprising:
- a regulator;
- a pilot device comprising:
  - an inlet port coupled to a source of supply pressure and having an inlet valve;
  - an exhaust port having an exhaust valve;
  - an outlet port configured to output a controlled pressure to the regulator; and
  - an on-board controller communicatively coupled to the inlet valve and the exhaust valve and operable to control the inlet valve and the exhaust valve to control the pressure delivered to the regulator, the on-board controller including a memory, a processor, and logic stored on the memory; and
- a computing device in communication with the pilot device, the computing device configured to generate a request to active a suspend control mode and transmit the request to the pilot device,

wherein the on-board controller is configured to receive the request and activate the suspend control mode based on the request, the suspend control mode comprising adjusting the inlet valve and the exhaust valve, and suspending control of the inlet valve and the exhaust valve.

12-14. (canceled)

15. The fluid flow device of claim **11**, wherein the request is received when a leak test is to be performed for the fluid flow device or a sensor of the fluid flow device is to be calibrated.

16. The fluid flow device of claim **11**, wherein the on-board controller is configured to activate the suspend control mode, the suspend control mode comprising closing the inlet valve and the exhaust valve, and suspending control of the closed inlet valve and the closed exhaust valve.

17. The fluid flow device of claim **11**, wherein the on-board controller is configured to activate the suspend control mode, the suspend control mode comprising closing the inlet valve and opening the exhaust valve, and suspending control of the closed inlet valve and the open exhaust valve.

18. The fluid flow device of claim **11**, wherein, when the on-board controller suspends control of the inlet valve and the exhaust valve, a value of the pressure output by the outlet port remains locked.

19. The fluid flow device of claim **18**, wherein the on-board controller is configured to maintain the locked value of the pressure output by the outlet port without the installation of any additional valves.

20. The fluid flow device of claim **11**, further comprising a feedback pressure sensor configured to periodically sense a pressure at an outlet of the regulator and send a feedback control signal to the on-board controller, the feedback control signal being indicative of the magnitude of the detected pressure, wherein the on-board controller is configured to receive but not respond to the feedback control signal when the suspend control mode is activated.

21. A method of stabilizing pressure in an intelligent regulator assembly comprising a pilot device and a regulator, the pilot device comprising an inlet port coupled to a source of supply pressure and having an inlet valve, an exhaust port having an exhaust valve, an outlet port configured to output a controlled pressure to the regulator, and an on-board controller communicatively coupled to the inlet valve and the exhaust valve, the on-board controller operable to control the inlet valve and the exhaust valve to control the pressure delivered to the regulator, the on-board controller including a memory, a processor, and logic stored on the memory, the method comprising:

receiving, at the on-board controller, a request to activate a suspend control mode; and

activating, via the on-board controller, the suspend control mode, the activating comprising adjusting the inlet valve and the exhaust valve, and suspending control of the inlet valve and the exhaust valve.

22. The method of claim **21**, wherein receiving the request comprises receiving the request from a computing device in communication with the pilot device.

23. (canceled)

24. The method of claim **21**, wherein the request is received when a leak test is to be performed or a sensor is to be calibrated.

25. The method of claim **21**, wherein adjusting the inlet valve and the exhaust valve comprises closing the inlet valve and the exhaust valve.

26. The method of claim **21**, wherein adjusting the inlet valve and the exhaust valve comprises closing the inlet valve and opening the exhaust valve.

27. The method of claim **21**, wherein the activating comprises activating without installing any additional valves.

28. The method of claim **21**, further comprising performing a leak detection test or calibrating a sensor while the suspend control mode is activated.

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