United States Patent [19]

Pierce et al.

[11] **3,874,415**

[45] **Apr. 1, 1975**

[54] **VALVE APPARATUS**

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[73] Assignee: **Otis Engineering Corporation,** Dallas, Tex.

[22] Filed: **Nov. 28, 1973**

[21] Appl. No.: **419,668**

[52] **U.S. Cl.** **137/625.66**

[51] **Int. Cl.** **F16k 17/00**

[58] **Field of Search**..... 137/625.66, 825.48, 605.49, 137/625.6

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Primary Examiner—Harold W. Weakley

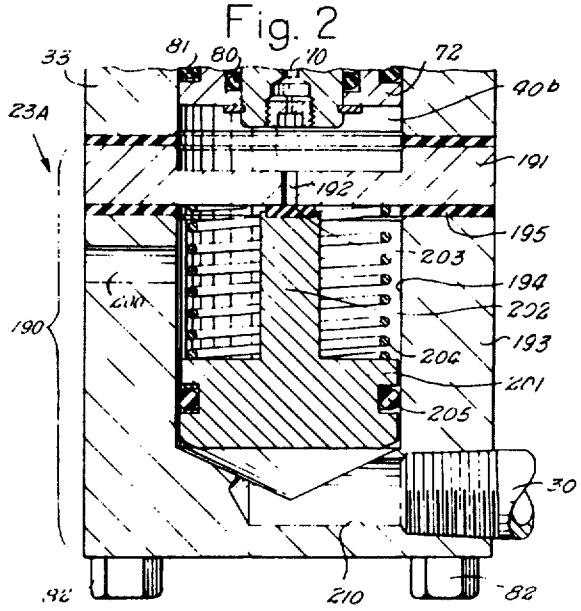
Attorney, Agent, or Firm—H. Mathews Garland

[57] **ABSTRACT**

A valve device for controlling the operation of a safety valve in a flowline responsive to a pressure sensing pilot valve activated by a predetermined high and/or low pressure. Each form of the device disclosed has a body provided with a first chamber having an exhaust port and a safety valve control fluid port, a second chamber communicating with a control fluid supply port, and a third chamber communicating with a third port which is a control fluid supply port to a pilot valve in one form and an exhaust port in another form. A valve seat and flow passage is provided between the first and second chambers. A valve stem is movably disposed in the housing provided with a valve member in the first chamber for closing the exhaust port at a first position and for opening the exhaust port while engaging the valve seat closing the passage between the first and second chambers at a second position. A pressure-responsive piston is provided on the stem dividing the second and third chambers for moving the stem from the first to the second position in response to a reduced pressure transmitted through the port to the third chamber. The first and third chambers communicate through a passage including flow rate restriction means. One alternate form of the device includes a fourth chamber and another piston for using the device with a pilot valve operated by a pressure source independent of the control fluid source to the safety valve. Another form of the device includes additional passage means and a second piston in the third chamber for resetting the valve device after it has operated to close the safety valve.

20 Claims, 11 Drawing Figures

Fig. 2



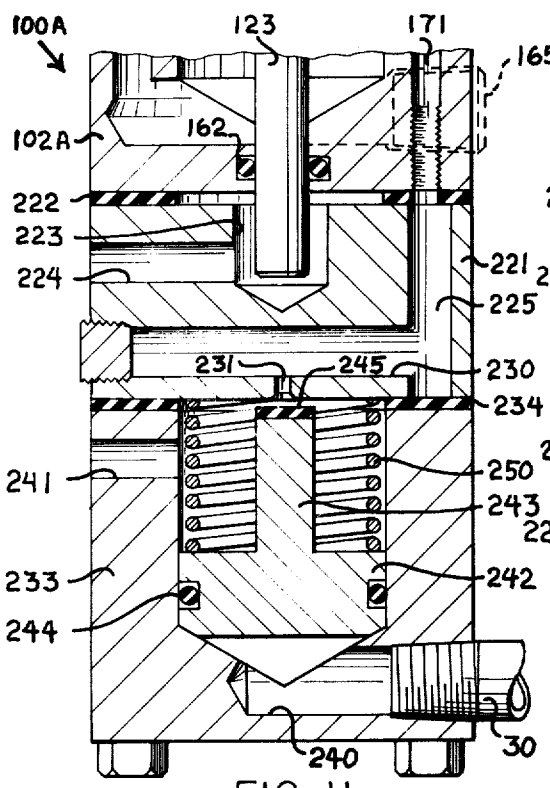


FIG. 11

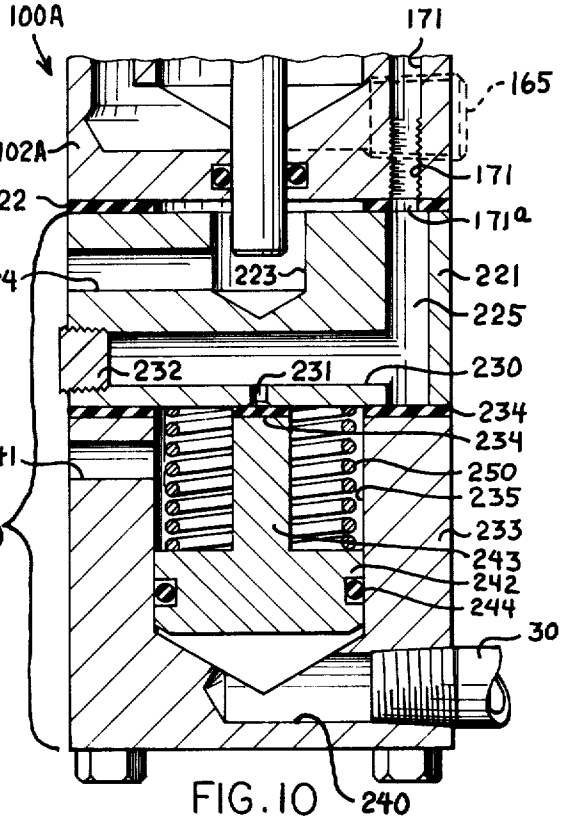


FIG. 10

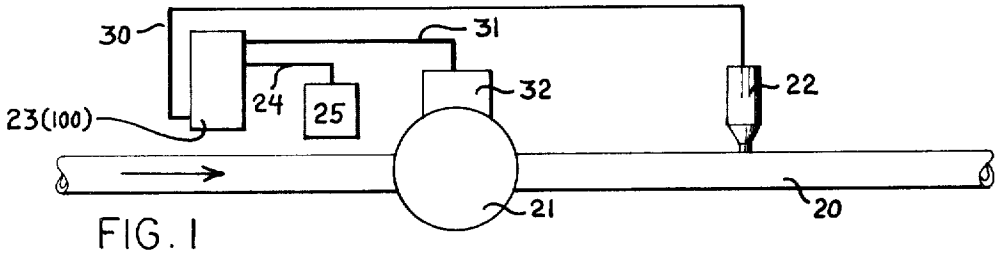


FIG. 1

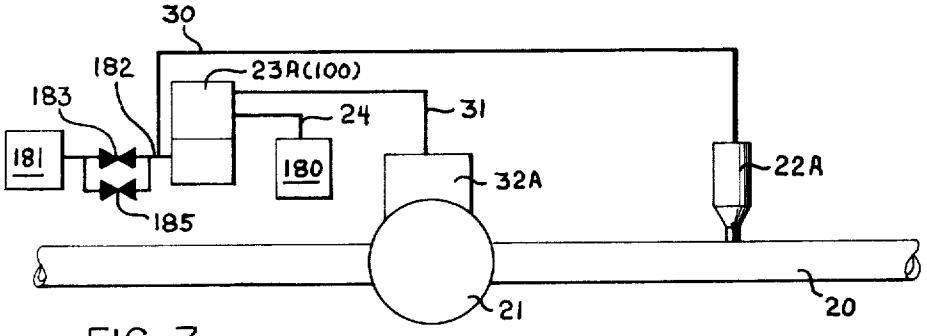


FIG. 7

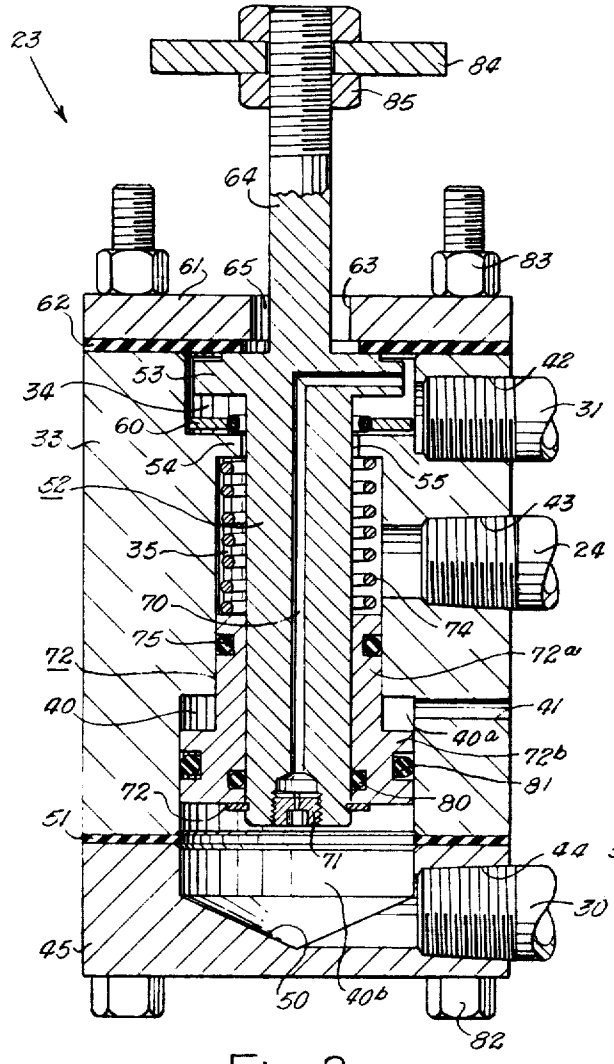


Fig. 2

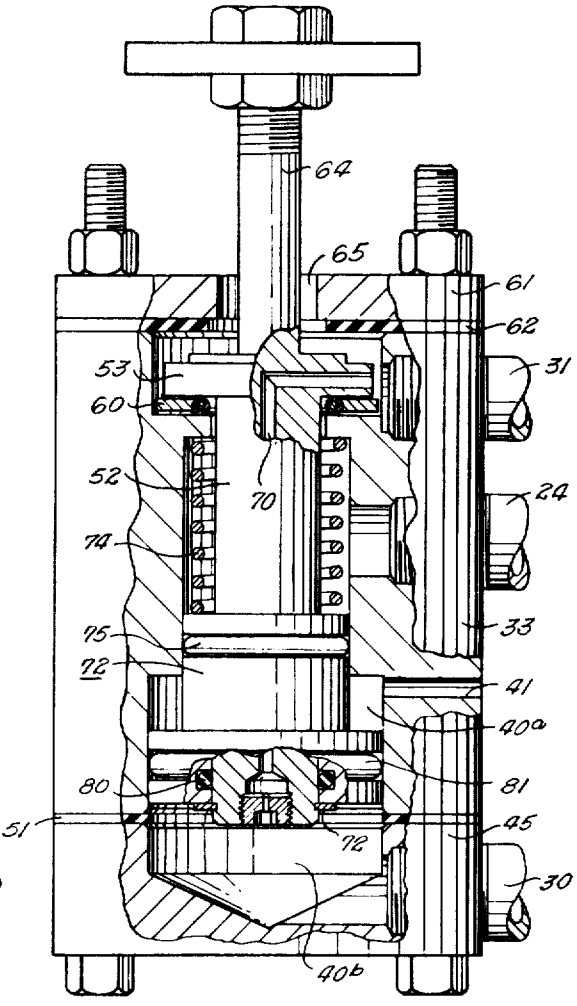


Fig. 3

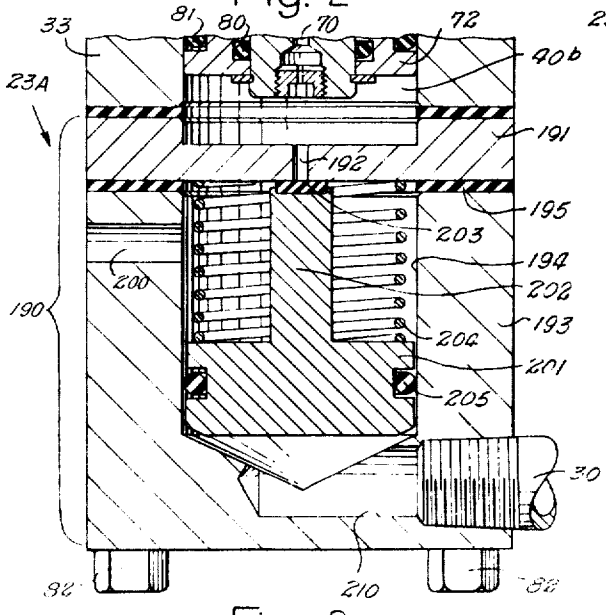


Fig. 8

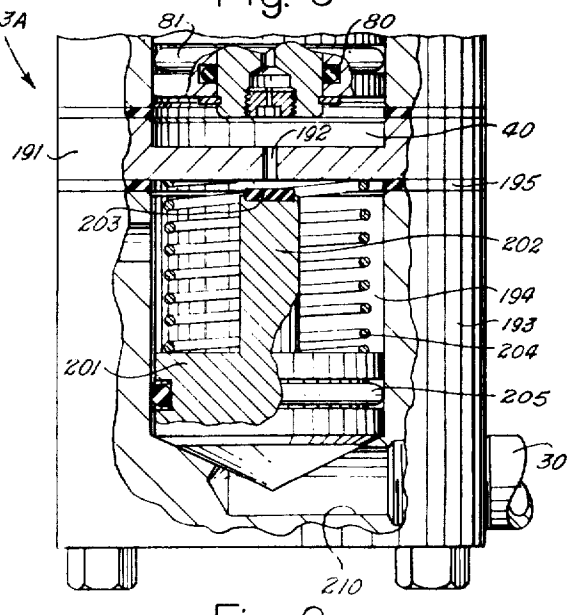


Fig. 9

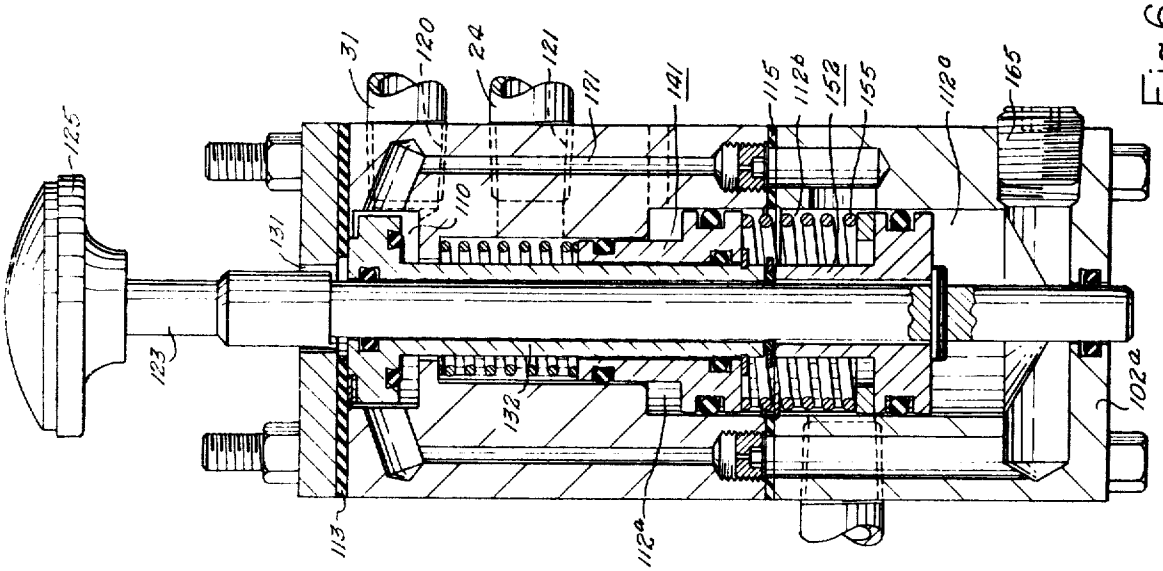


Fig. 6

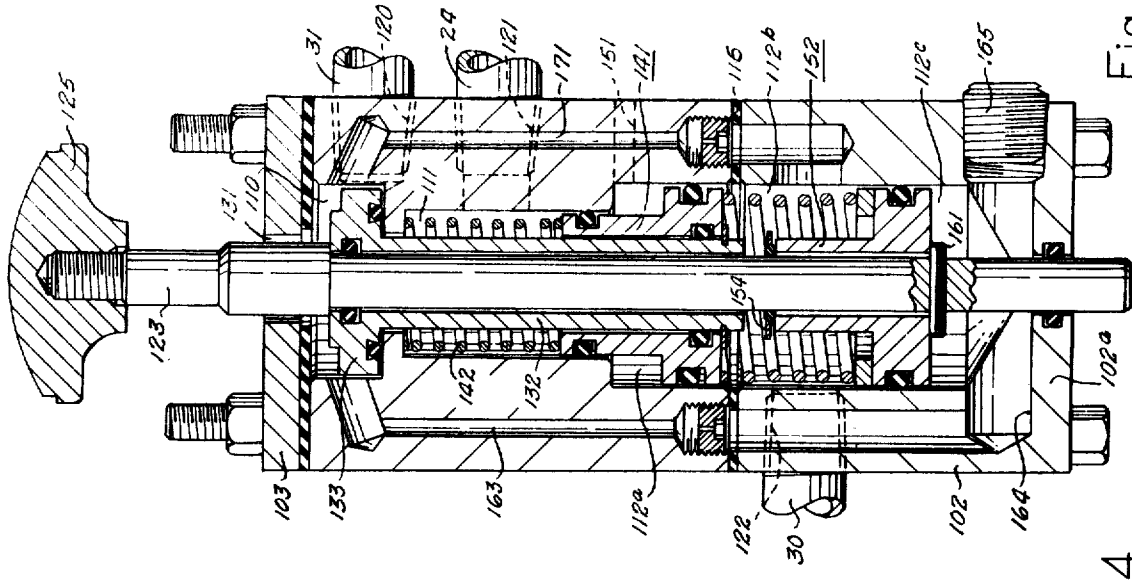


Fig. 5

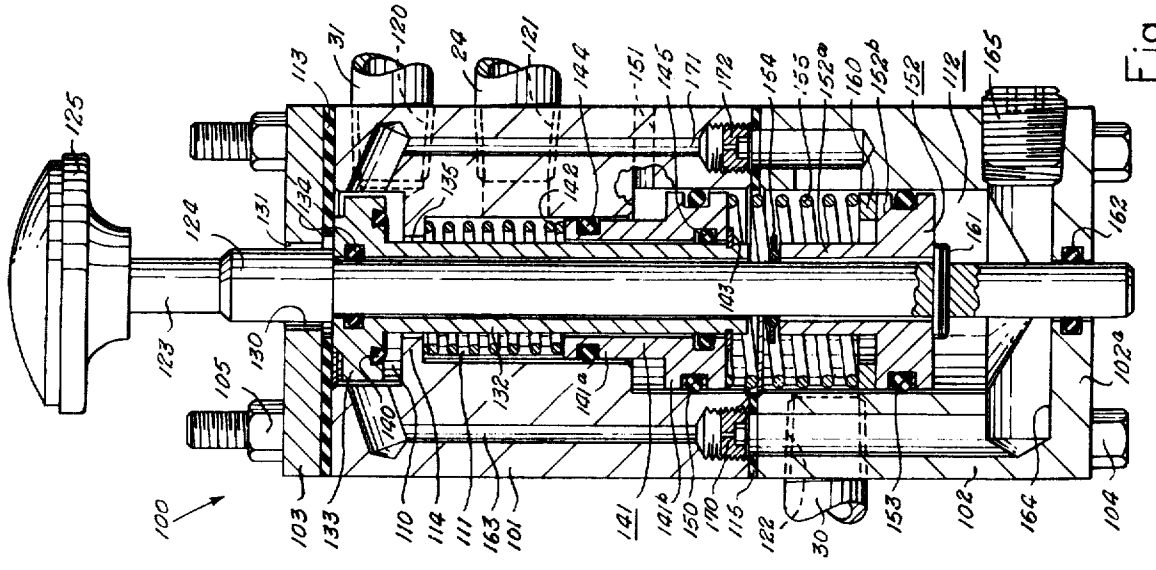


Fig. 4

VALVE APPARATUS

This invention relates to control valve devices and more particularly relates to valves of the block and bleed communication which are used for controlling communiction between one or more control fluid pressure sources and flow control devices operable in response to such pressure sources.

Control devices of the nature of the present invention are well known for interconnecting pilot and safety valves in fluid flow systems such, particularly, as found in the petroleum oil and gas industry. In such systems the pilot valve senses and responds to a predetermined pressure to close a safety valve in a flowline which may, for example, be a production line from an oil or gas well. Numerous safety and operating considerations dictate the necessity for various types of such flow control arrangements. Many of the presently available control devices of the nature of the present invention utilize a control stem or plunger which is connected with a diaphragm operable in response to a pressure controlled by a pilot valve. Such diaphragms have generally the same pressure-responsive operating area on each side and, additionally, are especially subject to wear requiring replacement, especially when the valve is cycled frequently. Another feature of the presently available block and bleed valve type flow control devices is that in resetting them after they have shut down a safety valve system, it is necessary that the operator stand at the valve and manually hold the reset handle until the normal operating pressure has been reestablished in the flowline at the pilot valve. A still further disadvantage of at least some of the available block and bleed type valve devices is that they function in systems which use a common supply or control fluid pressure for both the safety valve and pilot valve, whereas certain operating conditions make it desirable that a pilot valve operate in response to a relatively low control fluid pressure for manipulating a safety valve operating in response to a rather high control fluid pressure.

It is, therefore, a principal object of the invention to provide a new and improved fluid flow control device in the nature of a block and bleed valve useful, particularly, in safety valve systems.

It is another object of the invention to provide a valve device of the character described which communicates a control fluid pressure source with a safety valve and a pilot valve and shuts off the pressure source while venting both the safety and pilot valves to the atmosphere in response to a desired pressure change sensed by the pilot valve.

It is another object of the invention to provide a block and bleed valve type flow control device which does not use a flexible diaphragm.

It is a further object of the invention to provide a block and bleed valve type flow control device which uses a two-stage operating piston between the control fluid supply source chamber and the chamber communicating the control fluid to the pilot valve.

It is another object of the invention to provide a valve device of the character described which is operable in response to separate pilot and safety valve control fluid sources.

It is another object of the invention to provide a valve device of the character described which includes automatic reset features to eliminate the need for an operator to manually hold the valve in reset position until all operating pressures are restored to normal.

In accordance with the invention there is provided a flow control device of the block and bleed valve type for use in safety valve systems including pilot and flowline safety valves. One form of the device has a housing having a bore divided into a first chamber provided with an exhaust port and a port for connection of a control fluid line with a safety valve, a second chamber having a port for connection with a control fluid supply source, means defining a passageway and seat between the first and second chambers, a third chamber having a port for connection with a control fluid line to a pilot valve, and a stem disposed in the housing bore having a valve member in the first chamber movable between a first position closing the exhaust port while permitting communication through said passage means between said first and second chambers and a second position engaged with said seat means opening the exhaust port and closing the passage between the first and second chambers for isolating the control fluid supply source, a piston on the stem located in the third chamber, the piston being a stepped type piston having one portion exposed to the pressure in the second chamber and a second larger portion exposed to the control fluid pressure communicating with the pilot valve, and means providing restricted communication from the first chamber into the third chamber on the side of the piston communicating with the pilot valve. A pressure from the supply source is applied through the device to the safety valve control chamber and to the pilot valve when the operating stem is at a first position. When the pilot valve senses a preset high or low pressure it operates whereby the control fluid pressure leading to the pilot valve is exhausted to the atmosphere lowering the pressure in the third chamber, causing movement of the piston and control stem to a second position at which the valve means engages the seat between the first and second chambers opening the exhaust port and isolating the supply fluid source. The control fluid pressure leading to both the safety valve and the pilot valve is then exhausted, thereby shutting down the safety system.

The safety system is reactivated by returning the operating stem to the first position closing off the exhaust port and recommunicating the control fluid supply source with the safety and pilot valves. One embodiment of the device requires full manual resetting to reactivate the device by holding the operating stem in the first position until all of the pressures communicated to the device have returned to normal operating levels. Another embodiment of the device includes an additional piston supported on the operating stem in the third chamber and additional passage means communicating the first and third chambers for holding the operating plunger at the first reset position until normal operating pressures are restored, eliminating the need for manually holding the plunger after it is returned to a reset position.

The foregoing objects and advantages of the invention together with the specific features of preferred embodiments thereof will be better understood from the following detailed description taken in conjunction with the drawings wherein:

FIG. 1 is a schematic diagram showing a typical flowline safety system utilizing one form of flow control device embodying the invention;

FIG. 2 is a longitudinal view in section of one form of flow control device constructed in accordance with the invention, showing the operating stem at a first position at which the flow system is in operation;

FIG. 3 is a partially broken away view in section and elevation of the device of FIG. 2 showing the operating stem moved to a second position at which the flow system is shutdown;

FIG. 4 is a longitudinal view in section and elevation of another form of flow control device embodying the invention, showing the operator stem at a first position in which the flow system is in operation;

FIG. 5 is a longitudinal view similar to FIG. 4 showing the flow control device in a second operation mode in which the flow system is shutdown;

FIG. 6 is a longitudinal view in section of the device of FIGS. 4 and 5, showing an intermediate operational mode utilizing the reset features of the device;

FIG. 7 is a schematic view of a flow system utilizing the modified form of a flow control device illustrated in FIGS. 8–11;

FIG. 8 is a fragmentary view in section of a modified form of the flow control device of FIG. 2 in the operational mode illustrated in FIG. 2;

FIG. 9 is a fragmentary view in section and elevation of the modified form of the device shown in FIG. 8 operating as in FIG. 3;

FIG. 10 is a fragmentary view in section of a modified form of the flow control device illustrated in FIGS. 4–6, illustrating the device in the operational mode represented in FIG. 4; and

FIG. 11 is a fragmentary view in section similar to FIG. 10 showing the modified device of FIGS. 4–6 operating as in FIG. 5.

Referring to FIG. 1, a flowline safety system using a flow control device of the type illustrated in FIGS. 2, 3, or 4–6, includes a flowline 20 having a flow control safety valve 21 and a pressure sensing pilot valve 22. The flowline may, for example, be a production line from an oil or gas well. The safety valve 21 may be a Type U Otis Pneumatic Actuator/Gate Valve Combination, as illustrated at pages 3,520 and 3,521 of the *Composite Catalog of Oilfield Equipment and Services*, 1972–1973 *Edition*, published by World Oil, Houston, Texas. The pilot valve 22 may be any one of several suitable pilot valves such as Type P Otis Monitor Pilot, illustrated at pages 3,528 and 3,529 of the *Composite Catalog of Oilfield Equipment and Services*, supra. The safety and pilot valves are interconnected through a flow control device 23 which may be either of the forms of the present invention shown in FIGS. 2 and 3 or FIGS. 4–6. The device 23 is connected by a line 24 to a source of control fluid pressure 25 which may be a separator or any other suitable external source of control fluid pressure. The device 23 is connected by a line 30 with a pilot valve 22 for supplying control fluid pressure to the pilot valve. The device 23 is also connected by a line 31 to the control cylinder 32 of the safety valve 21 for supplying control fluid pressure to the safety valve. During normal flow control fluid pressure is supplied from the source 25 through the device 23 to both the safety and pilot valves. When either a high or low pressure of a value to which the pilot valve is adjusted to respond occurs in the line 20, the pilot valve operates to exhaust the pressure in the line 30, causing the device 23 to block the control fluid pressure source and to exhaust or bleed the control fluid pressure in the line 30 to the atmosphere permitting the operating cylinder system of the safety valve to close the safety valve, thereby shutting off flow in the flowline 20.

Referring to FIGS. 2 and 3, the control device 23 has a body 33 provided with a longitudinal bore defined by a first chamber 34, a second chamber 35, and a third chamber 40 which is larger in diameter than the chamber 35. A side vent port 41 in the body wall opens into the chamber 40. The body has an internally threaded port 42 opening into the first chamber 34 for the connection of the safety valve control line 31 and an internally threaded port 43 into the chamber 35 for the connection of the control pressure source line 24. A port 44 into the chamber 40 for the connection of the control fluid line 30 to the pilot valve is formed in an end closure 45 secured to the end of the body 33 at the chamber 40. The closure 45 has a counter bore 50 which defines a closed end of the third chamber 40. A gasket 51 seals between the body 33 and the end closure 45.

An operating stem 52 is movably disposed in the chambers defining the bore of the body for movement between a first operating position shown in FIG. 2, at which normal flow occurs in the flow system, and a second operating position of FIG. 3, at which the safety valve 21 is closed to shut off flow in the line 20. The stem 52 has a disc-shaped enlargement forming a valve member 53 located in the first chamber 34 for directing the control pressure from the source line 24 to the safety valve control line 31 at the position of FIG. 2, and for shutting off the pressure source and exhausting the safety valve control line in the position of FIG. 3. The body 33 has an internal annular flange 54 located between the first chamber 34 and the second chamber 35 sufficiently larger than the stem 52 to define an annular flow passage 55 around the stem between the first and second chambers for control fluid passage at the stem position of FIG. 2.

In the orientation of the device 23 shown in FIGS. 2 and 3, the bottom face of the flange 54 provides a downwardly facing stop shoulder at the upper end of the second chamber 35, while the top face of the flange 54 forms an upwardly facing seat surface supporting a seal assembly 60 which is engageable by the bottom of the valve member 53 when the stem is at the lower position of FIG. 3 for shutting off flow through the passage 55 between the second and first chambers. An annular cover plate 61 is secured on the end of the body 33 over the first chamber 34. A gasket 62 seals between the cover plate 61 and the end face of the body 33. The plate 61 has a central circular opening 63 for a handle 64 formed integral with the stem 52. The annular space 65 defined around the handle by the cover plate opening 63 provides an exhaust port into the first chamber 34 through which control fluid from the line 31 leading to the safety valve is exhausted when the control stem is at the lower position of FIG. 3. When the stem is at the upper position of FIG. 2, the top face of the valve member 53 seats against the gasket 62 around the exhaust port shutting off flow from the chamber 34 through the exhaust port.

The stem 52 has an internal inverted L-shaped passage 70 which communicates the first chamber 34 with the third chamber 40. The lower end of the passage 70 is internally threaded and provided with a choke 71 to

restrict the flow rate through the passage between the first and third chambers.

A two-stage or stepped annular piston **72** is secured on the stem **52** between a retainer ring **73** secured on the stem within the chamber **40** and a spring **74** disposed in the chamber **35** between the upper end of the piston and the lower face of the internal body flange **54**. The piston has a first cylindrical upper portion **72***a* which slides in the bore chamber **35** and a lower larger flange portion **72***b* which slides in the lower third body chamber **40**. A ring seal **75** in an external annular recess of the piston portion **72***a* seals around the piston with the bore wall defining the second chamber portion **35**. Ring seals **80** and **81** positioned in internal and external recesses of the piston portion **72***b* seal, respectively, around the stem and with the bore wall defining the body chamber **40**. An upper portion **40***a* of the third body chamber **40** above the piston flange portion **72***b* communicates with the vent port **41** so that the pressure remains at atmospheric within the body bore in the chamber portion **40***a* as the piston moves in either direction. The lower portion **40***b* of the third chamber **40** below the piston **72** communicates with the side port **44** leading to the line **30** to the pilot valve **22**.

The closures **45** and **61** are held on the body **33** against the gaskets **51** and **62**, respectively, by a pluurality of bolts **82** and nuts **83**. A handle **84** is secured by a nut **85** on the stem portion **64** for manually resetting the device as discussed hereinafter.

The operation of the flow control device **23** within the safety system of FIG. **1** is as follows. The normal condition of the device prior to activation of the safety system when none of the operating pressures of the system are existent in the device is illustrated in FIG. **3**. The spring **74** acting on the upper end of the piston portion **72***a* holds the piston with the stem downwardly to the position shown in FIG. **3**. At this position the valve member **53** engages the seal **60** closing the annular passage **55** into the first chamber **34** from the second chamber **35** so that the control fluid pressure from the source **25** as applied through the line **24** and the side port **43** into the chamber **35** is shut off and cannot be communicated to either of the safety or pilot valves.

To place the device **23** in operation control fluid pressure is admitted to the line **24** and the handle **84** is manually lifted raising the stem **64** to the first position as shown in FIG. **2**, at which the top face of the valve member **53** engages the bottom face of the gasket **62** around the exhaust port **65**. The upward movement of the valve member **53** from the seal **60** opens the annular passage **55** around the stem between the first and second chambers **34** and **35** so that the control fluid pressure is communicated from the second chamber into the first chamber through which the control fluid pressure is applied in the side port **42** into the line **31** to the control cylinder **32** of the safety valve **21**. Simultaneously, the control fluid pressure is communicated from the first chamber **34** through the stem passage **70** and the choke **71** into the lower portion **40***b* of the third chamber from which the pressure is applied through the side port **44** into the line **30** to the pilot valve **22**. The stem is manually held in the first position of FIG. **2** until the pressures within the system of FIG. **1** increase to normal operating levels. Such a condition is achieved when the control fluid pressure is sufficient at the safety valve to hold the valve open and when the line pressure downstream from the safety valve at the pilot valve **22** is at a normal pressure so that the pilot valve will remain in service. When these operating conditions are reached, the operator may release the handle **84** and the stem will remain in the position of FIG. **2**. The control fluid pressures at the pilot valve in the line **30**, at the safety valve cylinder **32** as applied through the line **31**, and within the device **23** are all equal in value. The pressure within the chamber **34** around the valve member **53** as applied over the effective area sealed by the upper face of the valve member with the gasket **62** around the exhaust port **65** applies an upward force on the valve member and the stem which exceeds the downward force of the spring **74** against the top face of the piston **72** so that the stem remains at the upper first position shown in FIG. **2**.

When an abnormally high or low pressure develops in the line **20** at the pilot valve, depending upon the pressure at which the pilot responds, the pilot valve operates in the normal fashion bleeding down the pressure in the line **30** rapidly reducing the pressure in the third chamber portion **40***b* below the piston flange **72***b*. As soon as the reducing pressure within the chamber portion **40***b* below the piston flange **72***b* is reduced to a level at which the downward force of the spring **74** and the control fluid pressure in the chamber **35** acting downwardly on the piston portion **72***b* is sufficient to overcome the upward force of the control fluid pressure in the chamber **35** against the valve member **34** and the reducing pressure within the chamber **40***b* upwardly against the valve flange **72***b*, the plunger **52** moves downwardly to the position of FIG. **3**. Even though the first and third chambers communicate through the stem passage **70**, the presence of the choke **71** in the passage permits a pressure reduction in the chamber portion **40***b* at a more rapid rate than the pressure equalization through the passage **70** between the first and third chambers, so that the stem moves immediately downwardly to the lower end position when the pilot valve releases the control fluid pressure in the line **30**.

When the stem **52** is in the operating position of FIG. **2**, the downward forces on the stem are the sum of the atmospheric pressure acting on the valve member **53** and the handle **64** over an area defined by the line of sealing engagement of the top face of the valve member with the gasket **62**, the force of the spring **74**, the force of the control fluid pressure in the chamber **35** acting over the annular area of the piston portion **72***a*, and the force of atmospheric pressure in the chamber portion **40***a* acting over the annular area defined by the piston portion **72***b*. The downward forces are exceeded by the sum of the upward forces provided by the control fluid pressure in the chamber **34** acting upwardly over the effective annular area on the valve member **53** within the line of sealing engagement of the top face of the valve member with the gasket **62** and the upward force of the pressure within the chamber portion **40***b* acting over the area of the stem **52** and piston portion **72***b* within the line of sealing engagement of the ring seal **81**.

When the pilot valve suddenly reduces the pressure in the chamber portion **40***b*, the downward forces on the plunger and piston exceed the upward forces, moving the plunger and piston to the lower second position of FIG. **3** at which the bottom face of the valve member **53** seats on the seal **60** shutting off the control fluid

pressure at the passage **55** and opening the exhaust port **65** so that the control fluid pressure in the line **31** to the safety valve is suddenly exhausted to the atmosphere, permitting the safety valve to close. The pressures in the chambers **34** and **40** bleed down to atmospheric while the control fluid pressure from the source **25** is confined to the middle chamber **35** by the seating of the valve member **53** on the seal **60.** At the stem and piston positions of FIG. **3,** the downward forces on the plunger and piston comprising the force of the spring **74** and the control fluid pressure in the chamber **35** acting over the area sealed by the ring seal **75** on the piston portion **72***a* exceed the upward forces which include the control fluid pressure in the chamber **35** acting upwardly on the valve member within the area of the member **53** sealed by the seal assembly **60.** Atmospheric pressure exists in the chamber portions **40***a* and **40***b* and within the chamber **34** above the valve member **53.** Thus, the control fluid pressure is confined to the chamber **35** while the lines to both the pilot and safety valves are vented to the atmosphere.

The safety system of FIG. **1** may be reactivated and fluid flow reestablished through the line **20** by manually lifting the stem **52** by means of the handle **84** back to the first upper position of FIG. **2.** At this position the control fluid pressure is again communicated from the chamber **35** into the chamber **34** through the annular passage **55.** From the chamber **34** the control fluid pressure flows to the safety valve **21** through the line **31** and through the passage **70** and the lower chamber portion **40***b* of the third chamber into the line **30** to the pilot valve. The stem is held at the upper position manually until normal operating pressure is reestablished in the line **20** at the pilot valve, at which time the pilot valve is reset automatically so that the line **30** is no longer vented to the atmosphere and normal control fluid pressure is reestablished in the chamber portion **40***b*. The upward forces on the piston and stem from the pressure of the control fluid now exceeds the downward forces so that the device **23** remains in service as illustrated in FIG. **2** until once again the pilot valve **22** senses a pressure change sufficient to operate the safety system and again close the safety valve **21** as previously discussed.

FIGS. **4–6** illustrate another form of flow control device **100** incorporating features of the invention including reset means which eliminates the need for an operator to manually hold the operating stem in the reset position until the pressures have been reestablished in the system. The device **100** serves the same control valve functions as the device **23** and thus may be substituted in the fluid flow system of FIG. **1** in place of the device **23.**

The device **100** has a body which includes a first member **101,** a second member **102,** and an end closure plate **103** secured together by a plurality of bolts and nuts **104** and **105,** respectively. The body has a central longitudinal bore formed by a first chamber **110,** a second chamber **111,** and a third chamber **112.** The bore through the housing is partially closed at one end by the end plate **103** which is secured to the housing member **101** over a gasket **113** which also serves a valve seat function in connection with the exhaust port of the device. The first and second chambers **110** and **111** are separated by an internal annular flange **114.** In the orientation of the device shown in FIGS. **4–6,** the top face of the flange **114** forms a valve seat while the bottom face of the flange is an upper spring stop shoulder. The third chamber **112** is substantially larger in diameter than the second chamber **111** to accommodate the two-stage piston arrangement shown. A gasket **115** is secured between the abutting faces of the body members **101** and **102.** The body has a side port **120** leading to the first chamber **110** for connection of the control fluid line **31** to the safety valve. A port **121** is provided in the body leading to the second chamber **111** for connection of the control fluid pressure source through the line **24.** A side port **122** is provided in the body opening into the third chamber **112** for connection of the line **30** from the pilot valve **22.**

A stem **123** is positioned for movement in the bore of the body of the device **100.** The stem has an integral external flange **124** and is provided with a handle **125** for manual manipulation of the stem. The flange **124** of the stem is disposed through a circular opening **130** in the end plate **103** which is larger than the outside diameter of the flange **124** defining an annular exhaust port **131** through the end plate around the stem from the first chamber **110.** Within the bore of the body a sleeve **132** is slidably disposed on the stem and provided with an integral annular valve member **133.** A ring seal **134** within an internal annular recess in the valve member **133** seals between the valve member and the stem. The internal annular flange **114** of the body member **101** is spaced concentrically around the sleeve **132** defining an annular flow passage **135** between the flange and the sleeve for communication between the upper chamber **110** and the middle chamber **111** for the flow of control fluid in the operating mode of FIG. **4.** A ring seal **140** within a circular recess in the bottom face of the valve member **133** seats against the top face of the flange **114** when the valve member is at a lower position, as in FIG. **5,** to close the passageway **135** between the chambers **110** and **111.** An annular two-stage main piston **141** is slidable on the sleeve **132.** The piston **141** has a first cylindrical portion **141***a* which telescopes into the middle chamber **111** and an enlarged flange portion **141***b* which slides within the third chamber **112.** A spring **142** is confined within the chamber **111** between the upper end edge of the piston **141** and the bottom face of the flange **114** biasing the piston downwardly on the sleeve **132.** A lock ring **143** in an external annular recess along the lower end portion of the sleeve **132** limits the downward movement of the piston **141** on the sleeve. A ring seal **144** in an external annular recess of the main piston portion **141***a* seals between the piston and the housing bore wall surface defining the chamber **111.** An internal ring seal **145** within the piston flange **141***b* seals between the piston and the sleeve **132.** An external seal **150** in an external annular recess of the piston flange **141***b* seals between the piston and the wall surface of the body defining the chamber **112.** A side port **151** in the body wall at the upper end of the chamber **112** vents the portion **112***a* of the chamber between the piston flange **141***b* and the upper end of the chamber to the atmosphere so that the pressure remains at atmospheric within that portion of the chamber regardless of the position of the main piston.

A reset piston **152** is slidable on the stem **123** below the main piston **141** for movement between a first position, as shown in FIGS. **4** and **5,** spaced from the lower end of the sleeve and a second position, as shown in FIG. **6,** abutting the lower end of the sleeve. The reset piston has an upper sleeve portion **152***a* and a lower

flange or piston portion **152***b*. An external ring seal **153** in an external annular recess of the piston portion **152***b* seals between the piston and the housing wall surface defining the chamber **112.** The bore through the piston **152** is larger than the stem **123** so that fluid flow may occur along the stem through the piston bore between the chamber portions **112***b* and 112*c*. A seal assembly **154** is slidably positioned around the stem between the top edge of the reset piston portion **152***a* and the bottom end of the sleeve **132** below the main piston. The assembly **154** seals between the top edge of the piston portion **152***a* and the bottom end edge of the sleeve **132** but does not form a seal with the outer surface of the stem **123.** A spring **155** is positioned within the chamber portion **122***b* between the main and the reset pistons. The spring engages the bottom face of the piston portion **141***b* and rests on a spacer **160** supported on the top face of the reset piston portion **152***b* biasing the main and reset pistons in opposite directions on the stem. A cross pin **161** through the stem below the reset piston limits the downward movement of the reset piston away from the main piston. The main piston flange **141***b* and the reset piston flange **152***b* effectively divide the third housing chamber **112***b* into the upper portion **112***a* above the flange **141***b*, the central portion **112***b* between the piston flanges and the lower end portion **112***c* below the reset piston flange at the lower end of the device. The lower end portion of the stem **123** extends through the end plate **102***a* of the body which has an internal annular recess holding a ring seal **162** which seals between the end plate and the stem.

The body wall of the device **100** has a first longitudinal passage **163** which connects into the upper chamber **110** and into a lateral bore **164** at the lower end of the housing intersecting the lower chamber portion **112***c* communicating the upper chamber **110** with the lower chamber portion **112***c* below the reset piston **152.** The bore **164** is formed by drilling into the side of the body member **102** and closing the outer end of the bore with a solid plug **165.** A flow restriction member **170** is secured in a threaded lower end portion of the section of the passage **163** in the body member **102.** A second longitudinal passage **171** is formed in the body wall opening at an upper end into the upper chamber **110** and at a lower end laterally into the central position **112***b* of the lower chamber **112** between the main and reset pistons. A flow restriction member **172** is secured in a threaded portion of the section of the passage **171** in the lower end of the body member **102** to restrict the flow rate through the passage. The passage **163** communicates the upper chamber **110** with the chamber **112** below the reset piston flange while the passage **171** communicates the upper chamber with the chamber **112** between the main piston flange and reset piston flange which also is in communication with the side port **122** leading to the line **30** connected with the pilot valve.

The valve device **100** is normally closed, as shown in FIG. **5.** The downward force of the spring **142** on the main piston **141** is transferred to the sleeve **132** through the retainer ring **143** holding the valve member **133** seated on the top face of the annular flange **114.** The valve member **133** thus closes off flow through the passage **135** from the central chamber **111** into the upper chamber **110.** The reset piston **152** is biased downwardly on the stem apart from the main piston by the spring **155.** The spring force against the reset piston urges the piston against the pin **161** through the stem so that the stem is biased to the position of FIG. **5** at which the bottom edge of the stem flange **124** engages the top face of the valve member **133.**

To activate the flow system of FIG. **1** using the device **100,** the stem **123** is manually pulled upwardly by the handle **125** to the position of FIG. **6.** Control fluid pressure is applied through the line **24** to activate the safety valve **32.** When the stem is pulled to the position of FIG. **6,** the pin **161** forces the reset piston **152** toward the main piston squeezing the seal **154** between the reset and main pistons so that there is no communication along the stem through the reset piston between the chamber portions **112***b* and **112***c* above and below the reset piston. At the same time the top face of the valve member **133** engages the gasket **113** around the exhaust passage **131** in the top place **103** closing off the exhaust passage from the first chamber **110.**

With the valve device **100** operating as in FIG. **6,** the control fluid pressure is applied through the line **24** and the side port **121** into the middle chamber **111** from which it is communicated through the annular passage **135** into the first chamber **110.** The control fluid pressure is applied from the first chamber to the side port **120** connected with the safety valve line **31** and also into both of the housing side wall passages **163** and **171.** The passage **171** connects into the center portion **112***b* of the third housing chamber **112** so that the control fluid pressure applied through the passage **171** is communicated from the device through the side port **122** and the line **30** to the pilot valve. The control fluid pressure supplied through the housing passage **163** is applied into the lower portion **112***c* of the third housing chamber below the reset piston. It will be recognized that during the initial stages of placing the flow system in operation, although control fluid is being directed to all of the chambers of the valve device **100** and through the device to both the safety valve control cylinder **32A** and the pilot valve **22A**, until the pressure has built up to a normal level downstream in the flowline **20** at the pilot valve, the pilot valve will be operating to bleed down the line **30.** It is only when the pilot valve senses normal full line pressure that it will close off and quit venting the line **30** to the atmosphere. Thus, during the initial phases of supplying control fluid to the system, the safety valve control line **31** is quickly filled, and also normal control fluid pressure is built up in the third chamber portion **112***c* below the reset piston while in the chamber **112***b* the pressure is atmospheric so that the reset piston is held upwardly compressing the spring **155** squeezing the seal **154** to seal between the reset and main pistons and holding the sleeve **132** and the valve member **133** at the upper position shown, keeping the exhaust passage **131** closed. The pressure of the control fluid in the first chamber **110** below the valve member **133** aids in holding the valve member at the closed position. At this time the pilot valve is continuing to bleed down the line **30** so that the pressure within the chamber portion **122***b* remains at a level which may exceed atmospheric but will be substantially below normal control fluid pressure. When the pressure in the line **20** at the pilot valve reaches a normal operating level, the pilot valve ceases to bleed down the line **30.** The pressure within the central chamber portion **112***b* then increases to the full value of the control fluid pressure being admitted to the housing chambers in the line **24.** As the control fluid pressure approaches

the normal value, the pressure differential across the reset piston **152** diminishes so that the spring **155** expands moving the reset piston downwardly apart from the main piston and carrying the stem **123** to the position shown in FIG. **4.** The seal **154** is no longer suqeezed between the reset and main pistons allowing the pressures to fully equalize on the opposite sides of the reset piston through the enlarged bore of the piston along the stem. Thus, full normal control fluid pressure is established in the chamber portion **112***b* and **112***c*. With control fluid pressure in the upper chamber **110** below the valve member **133** and in the chamber portion **112***b* below the main piston, and atmospheric pressure applied through the side port **151** into the chamber portion **112***a* and to the upper face of the valve member **133** through the exhaust port **131**, the valve member **133** and the sleeve **132** are held closed over the exhaust port and the main piston is held to the first upper position shown in FIG. **4.** So long as normal operating pressure is in the line **20**, the valve device remains as illustrated in FIG. **4.**

When the pressure in the line **20** changes to a value at which the pilot valve is set to operate, the pilot valve bleeds the line **30** to the atmosphere so that the pressure in the chamber portion **112***b* is suddenly reduced toward atmospheric. Because of the annular flow passage within the reset piston around the stem and the fact that the reset piston is at the lower unsealed location of FIG. **4**, the reduction of pressure in the chamber **112***b* is also effected in the chamber portion **112***c* below the reset piston so that there is no pressure differential to hold the reset piston from some downward movement. When the pressure in the chamber **112** below the main piston is reduced to atmospheric, the force of the spring **142** acting downwardly on the main piston together with the control fluid pressure in the chamber **111** acting over the portion **141***a* of the main piston exceeds the control fluid pressure acting upwardly on the valve member **133** tending to hold the valve member closed, so that the main piston is forced downwardly to the position shown in FIG. **5.** The sleeve **132** is pulled downwardly until the bottom face of the valve member **133** at the seal **140** seats on the top face of the housing flange **114** opening the exhaust port **131** and closing the annular passage **135** to the central chamber **111.** The chamber **110** is thus vented to the atmosphere through the exhaust port **131** so that the safety valve control cylinder **32** is bled down through the line **131**, the chamber **110** and the exhaust port **131** to the atmosphere permitting the safety valve **21** to close. The control fluid pressure is shut in by the bottom face of the valve member **133**, and the only control fluid pressure remaining within the device **100** is confined in the central chamber **111.** The pressure is atmospheric in the remaining chambers of the device within the portions of the chamber **112** above and below the piston flanges of both the main piston and the reset piston.

The valve device **100** will remain in the shut-in mode until it is reset by manual operation of the stem **123** to return the main and reset pistons upwardly to the positions shown in FIG. **6.** As previously discussed, it is only necessary to lift the operating stem momentarily to reestablish control fluid pressure within the chamber portion **112***c* below the reset piston which holds the reset and main pistons along with the valve member **133** in the upper reset positions while pressure is being reestablished in the pilot valve line **30** and the chamber portion **112***b*. The operator thus may remove his hand from the handle **125** after having lifted the stem to the position of FIG. **6.** As soon as full operating pressures are again reestablished in the flow system, the device **100** cycles back to the condition illustrated in FIG. **4** at which it remains until the pilot valve again senses a pressure change which will cause it to operate to again exhaust the control fluid pressure in the line **30.**

FIGS. **7–11** illustrate a fluid flow system and two alternate embodiments of flow control devices incorporating features of the invention using two control fluid pressures where it is desired to operate the pilot valve on a low pressure while the safety valve is controlled by a high fluid pressure. For example, conditions may be such that it is desired to operate the safety valve from a 400-pound per square inch supply source while the pilot valve functions with a 30-pound per square inch supply source. In certain types of pilot valves the adjustable pressure band remains constant so that if the high pressure at which the valve is to respond is raised or lowered, a corresponding change is made in the low pressure which operates the valve. In this type of pilot the "in-out" band is said to be fixed. This is particularly true of high pressure type pilot valves. In contrast, certain low pressure pilot valves have an adjustable band, thus making desirable the use of low pressure pilot systems with certain high pressure operated safety valves.

Referring to FIG. **7**, a fluid flow system operating on dual control fluid pressures using devices in accordance with the invention includes a flowline **20** having a safety valve **21** provided with a control cylinder **32A** which operates at a relatively high pressure. A low pressure pilot valve **22A** is connected into the line **20** downstream from the safety valve. Either a flow control device **23A** or a device **100A**, as represented, respectively, in FIGS. **8** and **9** and **10** and **11**, is used to control and communicate the control fluid pressure sources with the safety and pilot valves. A suitable high pressure control fluid source **180** is connected by the line **24** to the flow control device **23A** or **100A**, whichever device is used in the system. The device **23A** or **100A** is connected by the line **30** to the pilot valve **22A**. A low pressure control fluid source **181** is communicated through a line **182** to the line **30** for supplying low pressure control fluid to both the control device and the pilot valve. In order to prevent depletion of the supply source pressure, a velocity check valve **183** of any suitable design is connected into the line **182** for shutting in the low pressure supply source when the pilot valve bleeds the line **30.** A bypass line **184** including a valve **185** is connected into the line **182** around the check valve so that the low pressure portion of the system may be reactivated when desired.

Referring to FIGS. **8** and **9**, the two-phase form **23A** of the flow control device **23** is identical in all respects to the device **23** except that the end closure **45** on the device **23** is replaced with a low pressure module **190.** The module **190** includes a plate **191** secured over the gasket **51** on the housing **33** defining an end of the housing chamber **40.** The plate **191** has a port **192** leading into the end of the chamber **40** below the two-stage piston **72.** A housing member **193** provided with an inner chammber **194** is secured to the plate **191.** A circular gasket **195** seals between the plate **191** and the housing member **193.** A side port **200** is provided in the housing member **193** near the upper end of the mem-

ber opening into the chamber **194.** A low pressure piston **201** having a valve stem **202** is slidably disposed in the chamber **194** for movement between a closed position as shown in FIG. **8** and an open position illustrated in FIG. **9.** A gasket **203** is secured in the upper end face of the valve stem **202** for engagement with the bottom face of the plate **191** over the port **192** to control flow through the port **192** between the chambers **40** and **194.** A spring **204** confined between the bottom face of the plate **191** and the top face of the piston **201** within the chamber **194** around the stem biases the low pressure piston downwardly away from the port **192.** A ring seal **205** in an external annular recess around the piston **201** seals between the piston and the wall surface defining the chamber **194.** A side opening blind bore **210** intersects the conical end face of the chamber **40** for connection of the pilot valve line **30** into the low pressure chamber **194.**

With the flow control device **23A** connected into the fluid flow system of FIG. **7,** high pressure control fluid is supplied from the source **180** through the line **24** into the central chamber **35** from which the supply fluid pressure is applied through the line **31** to the safety valve and also downwardly through the stem **52** into the lower portion **40***b* of the third chamber **40** below the piston **72,** in exactly the same manner as previously described in connection with the operation of the device **23** in the flow system of FIG. **1.** The low pressure supply source **181** is communicated through the line **182** into the line **30** to the low pressure module chamber **194** below the piston **201.** The high pressure phase of the safety system of FIG. **7** is placed in operation in the same manner as described in connection with the device **23** while the low pressure phase of the system is activated by supplying low pressure control fluid from the source **81** through the check valve **183** in the line **182** into the line **30** to the chamber **194** below the low pressure piston **201.** The low pressure supply fluid forces the low pressure piston upwardly seating the gasket **203** on the valve stem **202** against the bottom face of the plate **191** closing the port **192** so that the high pressure control fluid within the chamber portion **40***b* is confined in the chamber below the piston **72***b.* The operating position of the various components of the flow control device **23A** is represented in FIGS. **2** and **8** when the high and low pressure control fluids are being supplied to the pilot and safety valves with the flow system of FIG. **7** in normal operation.

When the pilot valve **22A** senses a pressure value at which it is designed to operate, the valve suddenly bleeds the line **30** to the atmosphere reducing the operating pressure within the module chamber **194** below the piston **201** so that the spring **204** expands moving the piston and valve stem downwardly to the open position of FIG. **9** at which the gasket **203** on the valve stem uncovers the port **192.** The high pressure control fluid in the chamber portion **40***b* below the piston **72** is bled to the atmosphere through the end port **192** in the plate **191,** the module chamber **194** above the piston **201,** and module side port **200.** The sudden pressure reduction below the piston **72** in the chamber portion **40***b* causes the valve stem **52** with the valve member **53** to move downwardly to the position of FIG. **3** shutting off the high pressure control fluid source and exhausting the high pressure control fluid to the safety valve through the exhaust port **65** so that the safety valve **21** closes. The safety valve control cylinder **32A** is thus vented to the atmosphere through the line **31,** the chamber **34,** and the exhaust port **65,** while the seating of the valve member **53** downwardly on the gasket **60** shuts in the high pressure supply source at the middle chamber **35.** The chamber portion **40***b* below the piston **72** is vented to the atmosphere through the module side port **200.** The reduction of pressure in the line **30** effected by the pilot valve caused a rush of low pressure supply fluid through the line **182** operating the velocity check valve **183** to shut in the low pressure supply source so that the low pressure fluid is not lost to the atmosphere to any greater extent than the quantity of fluid within the line **30** leading to the device **23A** and the pilot valve and whatever length of line **182** exists between the velocity check valve and the line **30.** After the two phases of the safety system have thus functioned, the various components of the device **23A** are positioned as represented in FIGS. **3** and **9.**

To place the safety system of FIG. **7** back in operation, the stem **52** is lifted by means of the handle **84** back to the position of FIG. **2** to resupply the safety valve with high pressure control fluid. The low pressure module and the low pressure pilot **22A** are resupplied with low pressure control fluid from the source **181** by opening the bypass valve **185** to allow control fluid to pass into the line **182** and the line **30** to both the pilot valve and the low pressure module. As soon as a normal operating pressure level of the control fluid is reestablished in the low pressure phase of the system, the low pressure piston **201** is urged downwardly against the spring **204** by the pressure within the chamber **194** below the piston reseating the gasket **203** over the port **192,** thereby closing off the outlet from the end of the chamber **40***b* beneath the piston **72.**

Thus, the low pressure phase of the safety system of FIG. **7** is employed to control the high pressure phase while the two phases are independent to permit the use of the two different pressure levels. It will be recognized that the low pressure phase can be supplied with control fluid from the same source as the high pressure phase with the use of a pressure reducing valve between the high and low pressure phases. Also, it will be recognized that the low pressure control fluid source may comprise such means as a separator. Also, if conditions were such that it is desired that the flow system function in direct relation to the pressure in a separator, it is possible to eliminate the use of a pilot valve by connecting the separator pressure directly into the line **30** so that when the separator pressure drops below a predetermined level, the low pressure module piston **201** is operated to open the port **192** for bleeding down and closing the safety valve.

The device **100** of FIGS. **4–6** may also be modified to provide a device **100A** operating from two control fluid pressure levels as represented in FIGS. **10** and **11.** Referring to FIG. **10,** the features of the device **100A** are basically identical to those of the device **100** with the addition of a low pressure module **220.** For better understanding the device **100A,** FIGS. **10** and **11** should be considered in conjunction with FIGS. **4–6** which show the main portion of the device. The module **220** includes a modified lower housing section **102A** formed by closure of the side port **122** with a threaded plug like that of the plug **165** and the downward extension of the housing wall passage **171** to open at **171***a* through the bottom end face of the housing section **102A.** A body member **221** is connected with the hous-

ing section **102A**. A gasket **222** seals between the body member and housing section. The body member **221** is provided with a blind bore **223** for receiving the lower end of the stem **123** to permit the required longitudinal movement of the stem. The bore **223** connects with a lateral passage **224** opening through a side of the body member to vent the bore **223** to the atmosphere so that there is no pressure increase or reduction when the stem is moved. The body member **221** also has a longitudinal passage **225** communicating with the housing passage **171** at an upper end and connecting with a lateral bore **230** which leads to a short longitudinal port **231** opening through the bottom of the body member **221**. As a manufacturing expedient the bore **230** is drilled from an outside wall of the body member **221** and closed by a threaded plug **232**. The network of interconnecting passages **171, 225, 230** and the port **231** leads into the side of the chamber portion **112***b*, see FIGS. **4–6**, between the main and reset pistons **141** and **152**. An end body member **233** is secured to the end face of the body member **221**. A gasket **234** seals between the body members **221** and **233**. The member **233** has an internal low pressure chamber **235** formed by a blind upwardly opening bore. A lateral blind bore **240** intersects the lower end of the chamber **235** for connection of the line **30** to the pilot valve. A lateral exhaust port **241** opens into the chamber **235** near the upper end of the chamber **235**. A low pressure piston **242** provided with a valve stem **243** is slidably positioned within the chamber **235**. A ring seal **244** in an external annular recess of the piston seals between the piston and the bore wall defining the chamber **235**. A gasket **245** is secured on the top face of the valve stem **243** for engagement with the bottom face of the member **221** over the port **231** for closing the port in the position of the low pressure piston shown in FIG. **10**. A spring **250** is confined in the chamber **235** between the lower end face of the member **221** and the top face of the piston **242** for biasing the piston downwardly toward the position shown in FIG. **11** at which the port **231** is open.

The flow control device **100A** operates in essentially the same manner as the device **23A** in the flow system of FIG. **7**. The device **100A** is initially as represented in a composite of FIGS. **5** and **11**. The stem **123** is down with the valve member **133** closing off flow of high pressure control fluid from the chamber **111** into chamber **110**. The pressures in the chamber **110** above the valve member **133**, in the chamber portions **112***b* and **112***c*, in the low pressure module, as shown in FIG. **11**, is atmospheric. Low pressure control fluid pressure is established in the low pressure module and to the pilot valve by manipulation of the necessary valves between the pressure source **181** and the device **100A**. The pressure within the low pressure module in the chamber **235** below the piston **242** is raised to a normal operating level forcing the piston upwardly until the gasket **245** closes the port **231**. Also, the stem **123** is lifted by the handle **125** to the position of FIG. **6** to admit high pressure control fluid from the chamber **111** to the line **131** to the safety valve through the upper first chamber **110**. This, of course, as previously discussed, also admits high pressure control fluid into the chamber **112***c* below the reset piston so that the valve member **133** and the main and reset pistons are held in the upper positions of FIG. **6** by the control fluid pressure in the chamber **112***c* permitting the operator to release the handle **125** as soon as he has lifted it to the position of FIG. **6**. As previously discussed, the reset piston functions to hold the device in a reset condition until operating pressures are reestablished in the system. Of course, when the stem is initially lifted, the pressure between the main and reset pistons in the chamber portion **112***b* is still at either atmospheric or a substantially reduced level due to the fact that the chamber portion between the pistons is vented to the atmosphere through the passages **171, 225, 230**, the port **231**, the chamber **235**, and the side port **241**. As normal operating pressure is reestablished in the line **20** at the pilot valve **22A**, the port **231** is closed by upward movement of the piston **242** in the low pressure module to the position of FIG. **10**. As soon as the port **231** is closed, the pressure begins rising in the chamber portion **112***b* between the main and reset pistons. When the pressure rises between the pistons to the level at which there is no pressure differential across the reset piston flange **152***b*, the reset piston is moved back downwardly by the spring **155** to the position of FIG. **4**. At this stage the low pressure module remains closed, as in FIG. **10**, while the high pressure portion of the system, as represented in FIG. **4**, supplies high pressure control fluid to the safety valve through the line **31** and the normal control fluid high pressure level exists in the portions **112***b* and **112***c* on opposite sides of the reset piston. All of the components of the device **100A** remain in the positions shown in the FIGS. **4** and **10** under normal operating conditions until the safety system is triggered by a predetermined high or low pressure sensed by the pilot valve **22A**.

When the pilot valve **22A** operates, venting the line **30** to the atmosphere, the pressure within the low pressure chamber **235** holding the low pressure piston **242** at the closed position of FIG. **10** is suddenly reduced permitting the spring **250** to expand moving the piston and valve stem downwardly to the open position of FIG. **11**. The high pressure control fluid which had been contained by the gasket **235** at the port **231** is suddenly released venting the high pressure phase of the device within the chamber portion **112***b* to the atmosphere along the path defined by the flow passage **171**, the passages **225** and **230**, the port **231**, the chamber **235** above the piston **242**, and the side port **241**. This pressure reduction within the chamber portion **112***b* below the main piston **141** causes the main piston to drop downwardly, pulling the sleeve **132** with the valve member **133** to the lower end position of FIG. **5**, thereby shutting in the high pressure control fluid source by the valve member **133** and venting the high pressure control fluid in the line **31** to the safety valve upwardly through the exhaust port **131**. The safety valve closes and remains closed until the device **100A** is again reset as previously described.

The use of the device **100A** in the fluid system of FIG. **7** provides a safety system having an automatic reset feature using a high pressure control fluid source for the safety valve and a low pressure control fluid source for the pilot valve.

What is claimed is:

1. A valve device comprising: a body having a bore divided into first, second and third chambers; means providing a first port leading to said first chamber; means providing a second port leading to said first chamber; means providing a third port leading to said second chamber; means providing a fourth port leading

to said third chamber; means providing a flow passage between said first and second chambers; means providing a valve seat around said flow passage between said first and second chambers; a valve stem in said body bore provided with a valve member disposed in said first chamber and movable between a first position closing said first port from said first chamber while opening said passage between said first and second chambers and a second position opening said first port and closing said passage between said first and second chambers; means providing a passage between said first and third chambers; and operator piston means on said stem for moving said stem and valve member between said first and second positions responsive to a pressure differential across said piston, said piston having a first portion movable in said second chamber responsive to pressure in said second chamber, and said piston having a second larger portion movable in said third chamber responsive to said pressure in said third chamber.

2. A valve device in accordance with claim **1** including means for biasing said stem from said first position closing said first port to said second position opening said first port and closing said passage between said first and second chambers.

3. A valve device in accordance with claim **1** wherein said passage between said first and third chambers extends through said valve stem and is positioned to continuously communicate said first and third chambers independently of the position of said valve member in said first chamber.

4. A valve device in accordance with claim **1** wherein said passage means between said first and third chambers extends through a wall of said body opening into said first and third chambers at locations to communicate said chambers continuously independently of the position of said valve member, said passage opening into said third chamber on the same side of said operator piston as said fourth port into said chamber.

5. Apparatus in accordance with claim **3** including a flow rate restriction in said passage between said first and third chambers.

6. A valve device in accordance with claim **4** including a flow restriction member in said passage between said first and third chambers.

7. A valve device in accordance with claim **1** including means providing a fifth port into said third chamber between said first and second portions of said operator piston venting said third chamber to the atmosphere.

8. A valve device in accordance with claim **3** including means providing a fourth chamber in said body in communication with said fourth port into said third chamber; means providing an exhaust port into said fourth chamber; a second operator piston and valve member movably disposed in said fourth chamber for movement between a first position wherein said valve member closes said fourth port opening into said fourth chamber and a second position at which said valve member opens said fourth port into said fourth chamber, said piston and valve member being located in said fourth chamber to permit communication from said fourth port through said chamber to said exhaust port to said chamber when said piston and valve member are in said second position; and means providing a port opening into said fourth chamber on the side of said operator piston opposite from said fourth port.

9. A valve device in accordance with claim **8** including means biasing said second operator piston and valve member toward said second position in said fourth chamber.

10. A valve device in accordance with claim **1** including means providing a fourth chamber in said body in communication with said fourth port to said third chamber and piston and valve means in said fourth chamber for controlling flow from said third chamber in said fourth port responsive to a pressure change in said fourth chamber.

11. A valve device in accordance with claim **1** including means for restraining said stem at said first position until normal fluid operating pressures are established in said device when activating said device in a fluid flow system.

12. A valve device in accordance with claim **11** wherein said restraining means comprises a reset piston movable on said stem in said third chamber having one side responsive to pressure in said third chamber supplied through said fourth port and means providing a second passage independent of said first passage communicating said first and third chambers, said second passage opening into said third chambers, said second passage opening into said third chamber on the opposite side of said reset piston from said fourth port into said third chamber.

13. A valve device in accordance with claim **12** including means for operating said device responsive to a fluid pressure independent of a fluid pressure applied through said third port into said second chamber, said means including a fourth chamber communicating with said fourth port to said third chamber and having an exhaust port connected with said fourth chamber for communicating said fourth port through said fourth chamber to said exhaust port into said fourth chamber, a second operator piston including a valve member movable in said fourth chamber between a first position closing said fourth port into said chamber and a second position opening said fourth port into said chamber, and means providing a fluid inlet and exhaust port leading into said fourth chamber on the opposite side of said operator piston from said fourth port and said exhaust port whereby said second operator piston is responsive to a fluid pressure supplied through said inlet and exhaust port into said fourth chamber.

14. A valve device in accordance with claim **13** including means biasing said second operator piston toward said second open position in said fourth chamber.

15. A valve device in accordance with claim **13** including means between said first operator piston in said reset piston biasing said pistons apart toward a nonsealing relationship on said stem.

16. A valve device in accordance with claim **15** including seal means on said stem between said first operator piston and said reset piston for sealing between said piston to isolate portions of said third chamber on opposite sides of said reset piston when said pistons are urged together.

17. A fluid flow control device for directing control fluid between a source and safety and pilot valves in a fluid flow system comprising: a body having a bore divided into first, second and third chambers opening into each other; a valve stem disposed for movement along the longitudinal axis of said stem within said bore, said axis of said stem being coincident with the axis of said bore; a valve member on said stem in said first chamber; an end plate of said body at said first chamber having an opening around said stem spaced

from said stem defining an exhaust port from said first chamber; said end plate providing a valve seat surface within said first chamber around said exhaust opening for engagement by a surface of said valve member on said stem for closing said exhaust port at one position of said valve member and stem; means providing a port through said body into said first chamber for supplying control fluid to said safety valve and exhausting control fluid from said safety valve through said first chamber to said exhaust port to said first chamber when said valve member is spaced from said valve seat around said exhaust port; means defining an internal annular flange within said body around said bore encircling said stem on the opposite side of said valve member from said exhaust port, said flange being spaced from said stem defining a flow passage between said first and second chambers around said stem, the surface of said flange in said first chamber providing a valve seat surface for said valve member and the surface of said flange in said second chamber defining a stop shoulder; a seal around said stem within said first chamber between said valve member and said valve seat surface on said flange between said first and second chambers, said seal being engageable by said valve member in said first chamber at a second position of said valve member for shutting off flow through said passage between said first and second chambers; means defining a control fluid supply port through said body into said second chamber; a stepped piston supported in said bore on said stem, said piston having a first portion movable in said second chamber on the opposite side of said control fluid supply port from said flange between said first and second chambers, and said piston having a second larger portion movable in said third chamber; means within said second chamber between said stop shoulder and said first piston portion biasing said piston away from said flange for movement of said stem and valve member from said first position closing said exhaust port to said second position closing said passage between said first and second chambers; means coupling said piston with said stem; means in said body providing a port into said third chamber at the juncture of said second and third chambers venting a portion of said third chamber between said second piston portion in said second chamber to the atmosphere; means providing a port in said body opening into said third chamber on the opposite side of said second piston portion from said port communicating said chamber with the atmosphere; means providing a passage through said stem from said first chamber to said third chamber opening into said third chamber on the side of said second piston portion exposed to said second port into said chamber; and means providing a handle on said stem for resetting said stem and valve member from said second position back to said first position.

18. A valve device in accordance with claim **17** including a low pressure module for operating said device from two control fluid pressure levels comprising a module body member secured to said main body member and provided with a fourth chamber communicating with said second port leading to said third chamber, said module body having an exhaust port communicatable through said fourth chamber with said second port to said third chamber; said module body having a second port for supplying control fluid between said pilot valve and said fourth chamber; a movable piston in said fourth chamber between said exhaust port and said control fluid port; a valve member on said piston engageable over said port into said third chamber at a first position of said piston and movable from said port into said third chamber at a second position of said piston to permit exhaust of control fluid from said third chamber through said port into said third chamber and said fourth chamber into said exhaust port from said fourth chamber; and means in said fourth chamber engaged with said piston for biasing said piston away from said port into said third chamber toward said second port leading to said pilot valve.

19. A valve device for directing control fluid flow between a pilot valve and a safety valve in a fluid flow system comprising; a body having a longitudinal bore therethrough defined by interconnecting first, second and third chambers; a longitudinally movable valve and operator stem, the axis of said stem being coincident with the axis of said bore through said body; an end closure on said body at said first chamber provided with an opening for said stem defining an exhaust port around said stem to said first chamber; means providing a control fluid port to said first chamber for connection of a control fluid line between said first chamber and said safety valve; an internal flange formed in said body dividing said first and second chambers extending around said stem defining a flow passage along said stem between said first and second chambers on an opposite side of said first chamber from said exhaust passage from said chamber; means defining a valve seat within said end closure at said first chamber around said exhaust port; said flange between said first and second chambers defining a valve seat around said passage between said first and second chambers within said first chamber, and the side of said flange facing said second chamber defining a stop shoulder around said passage between said first and second chambers; a valve operator sleeve on said stem disposed along said stem in said first, second and third chambers; a valve member on said stem within said first chamber engageable with said valve seat around said exhaust port at one position for opening and closing said exhaust port and engageable at another position with said valve seat on said flange between said first and second chambers for opening and closing said passage in said chambers; means defining a port in said body into said second chamber for supplying control fluid from a pressure source into said chamber; said third chamber being larger in cross sectional area along said stem than said second chamber; a main operator piston on said valve sleeve, said operator piston being of a two stage stepped type having a first portion telescoping into said second chamber on the opposite side of said port into said second chamber from said flow passage between said second and first chambers and said piston having a larger second portion movable in said third chamber; means within said second chamber between said main piston and said stop shoulder on said flange biasing said main piston away from said flange between said first and second chambers; means between said sleeve and said main piston coupling said piston with said sleeve; means defining a vent port in said body into said third chamber at the junction of said third chamber with said second chamber for exposing said second portion of said main piston on the side of said piston facing said second chamber to atmospheric pressure continuously; a reset piston on said stem within said third chamber in loose fitting movable relation on said stem whereby

fluid flow may occur along said stem within said piston; a seal on said stem between said main piston and said reset piston for sealing between said reset piston and said main piston when said pistons are urged together on said stem while permitting fluid flow along said stem within said piston when said main and reset pistons are urged apart on said stem; means within said third chamber between said main piston and said reset piston biasing said pistons apart on said stem to a non-sealing relationship; said main piston and said reset piston dividing said third chamber into a first portion communicating with said vent port, a second portion between said main piston and said reset piston and a third portion on the other side of said reset piston toward the second end of said body; means defining a port into said third chamber portion between said main piston and said reset piston for flow of control fluid into and out of said chamber between said pistons; means defining a passage in said body between said first chamber and said third portion of said third chamber for continuously communicating said first chamber and said third portion of said third chamber; and means defining a second flow passage in said body between said first chamber and said second portion of said third chamber between said main piston and said reset piston continuously communicating said first chamber and said middle portion of said third chamber independently of the position of said pistons and said valve member.

20. Apparatus in accordance with claim **19** including an operating module adapting said device to function responsive to two separate control fluid pressure levels, said device comprising a module body secured with said main body at said second end of said body, said module body having a fourth chamber therein communicating with said port into said third chamber whereby control fluid from said second portion of said third chamber between said pistons may flow to said fourth chamber in said module body; means defining an exhaust port in said module body leading to said fourth chamber for exhaust of control fluid from said fourth chamber; a piston in said fourth chamber; a valve member on said piston in said fourth chamber movable with said piston between a first position closing said port from said fourth chamber into said third chamber and a second position opening said port from said third into said fourth chamber whereby control fluid may flow from said third chamber through said port into said fourth chamber and from said fourth chamber through said exhaust port; biasing means in said fourth chamber engaged with said piston for biasing said piston and said valve member away from engagement over said port leading to said third chamber; and means defining a second control fluid supply port into said fourth chamber on the opposite side of said piston in said chamber from said exhaust port leading to said chamber.

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