United States Patent [19]

Denker

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[54] **VALVING**

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[73] Assignee: **Nutron Corporation**, Hingham, Mass.

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[52] **U.S. Cl.** **137/117**, 91/417

[51] **Int. Cl.** **G05d 7/00**

[58] **Field of Search**.........137/101, 117, 514.5, 509, 137/514.3

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Primary Examiner—Robert G. Nilson

[57] **ABSTRACT**

A fluid valve comprising first and second interior chambers, a valve bore extending between the chambers, an exit port in a wall of the first chamber generally opposite the valve bore, a piston including a first portion slidably within the valve bore and, a second portion extending from the first portion to the exit port mounted for movement between a first position wherein the second portion overlies the exit port and a second position wherein the second portion is spaced from the exit port, the piston including also a bore extending therethrough and the first and second portions being of different cross-sectional areas, and a fixed balance pin extending from within the piston bore into the second chamber, the piston being slidable on the pin.

10 Claims, 5 Drawing Figures

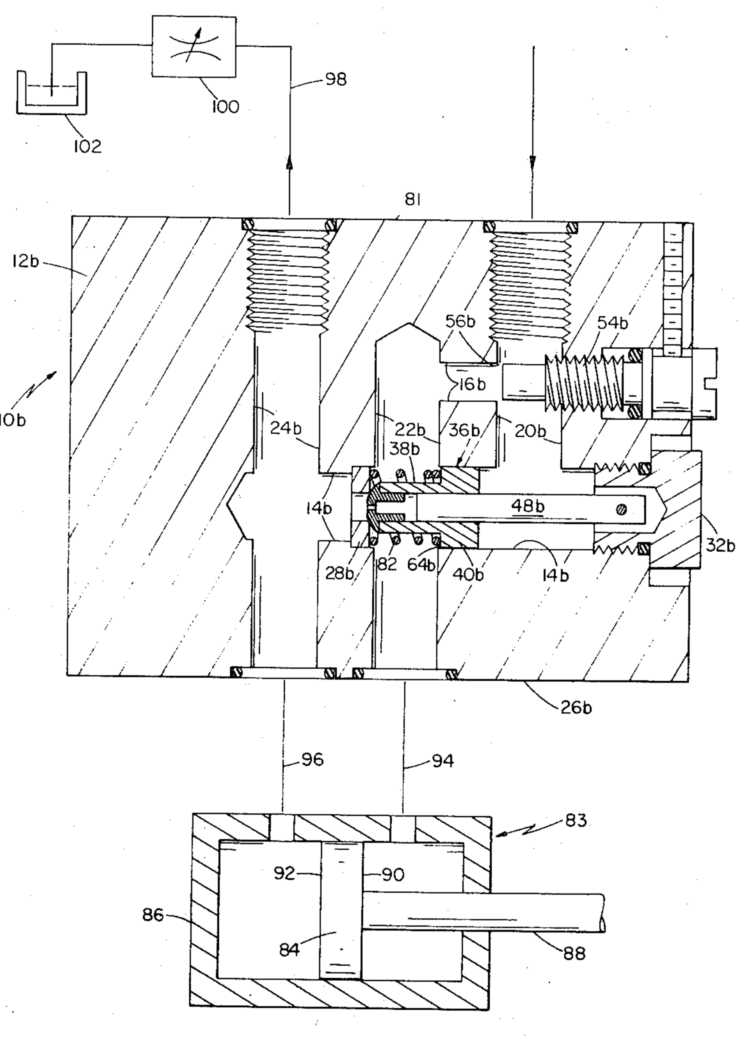

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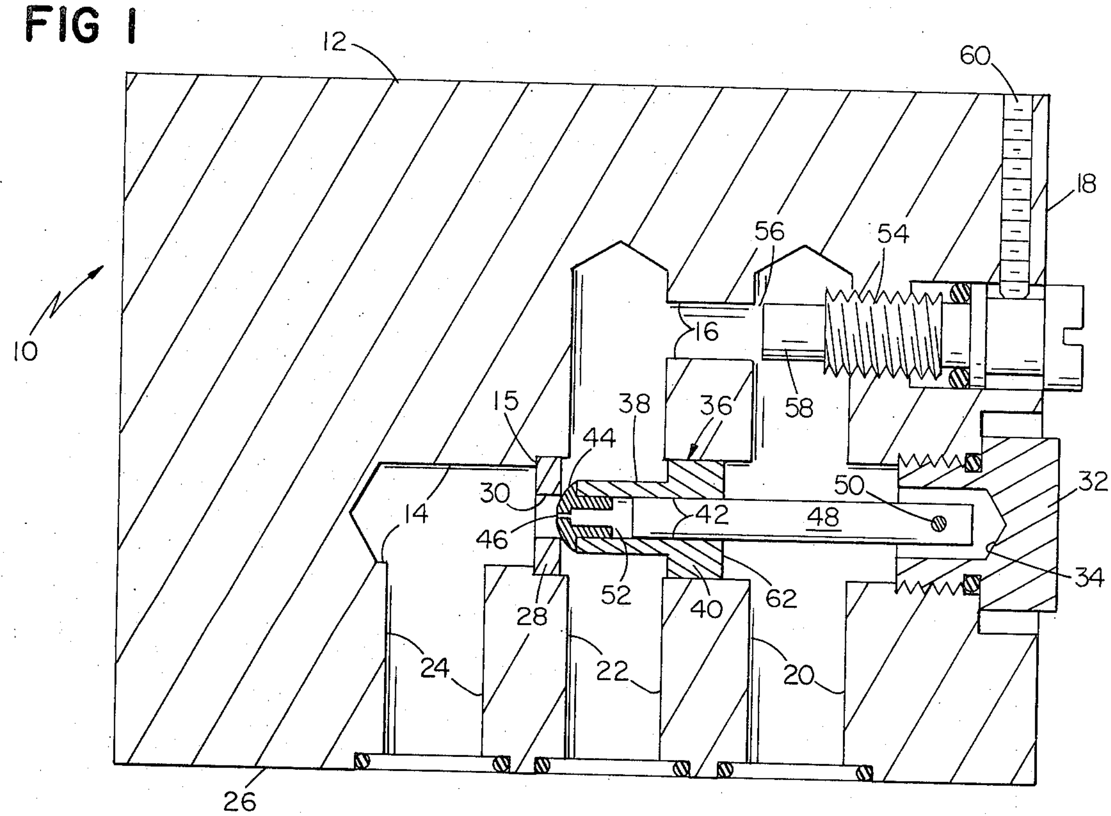
FIG I



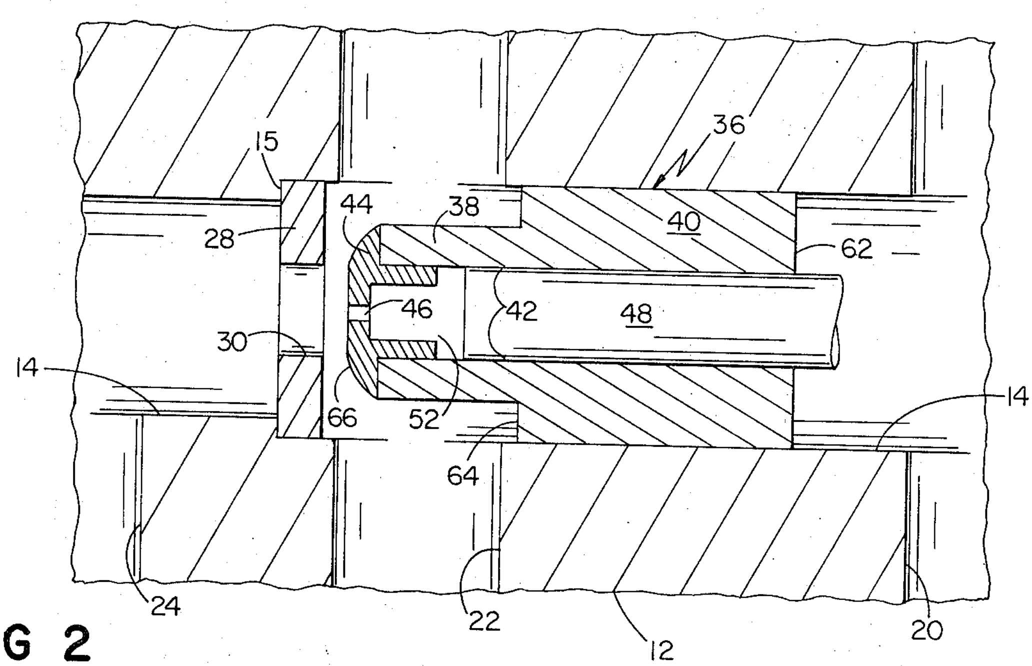


FIG 2

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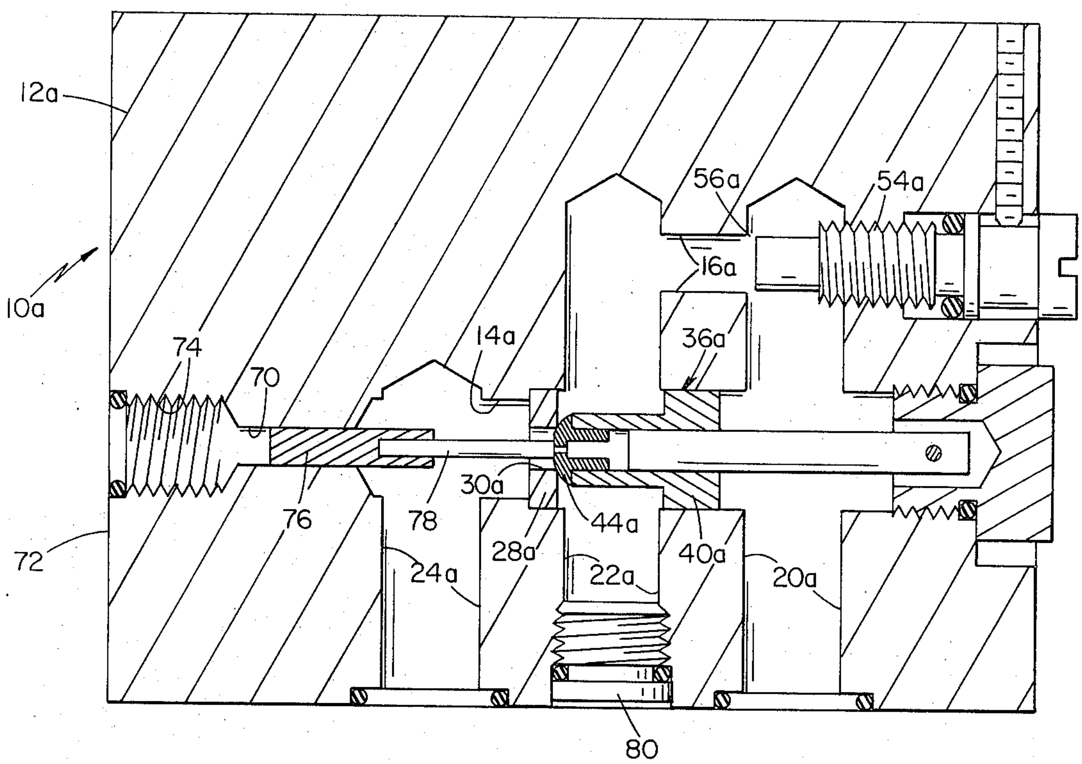
FIG 3



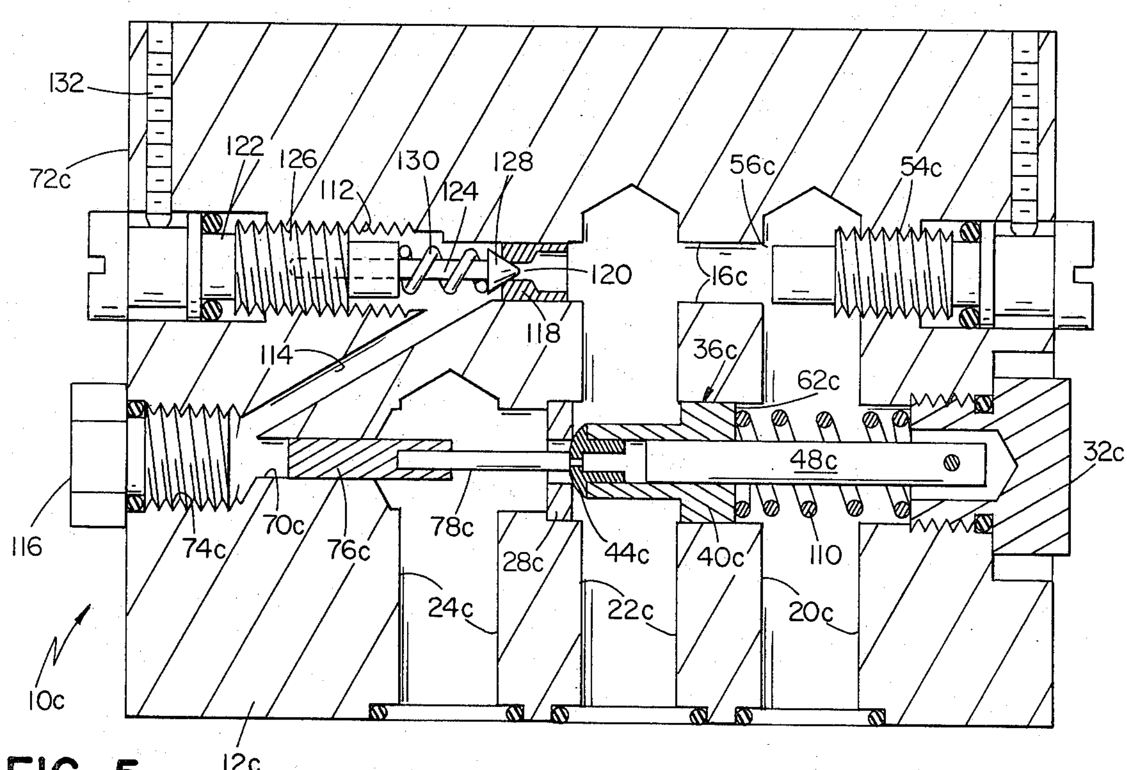
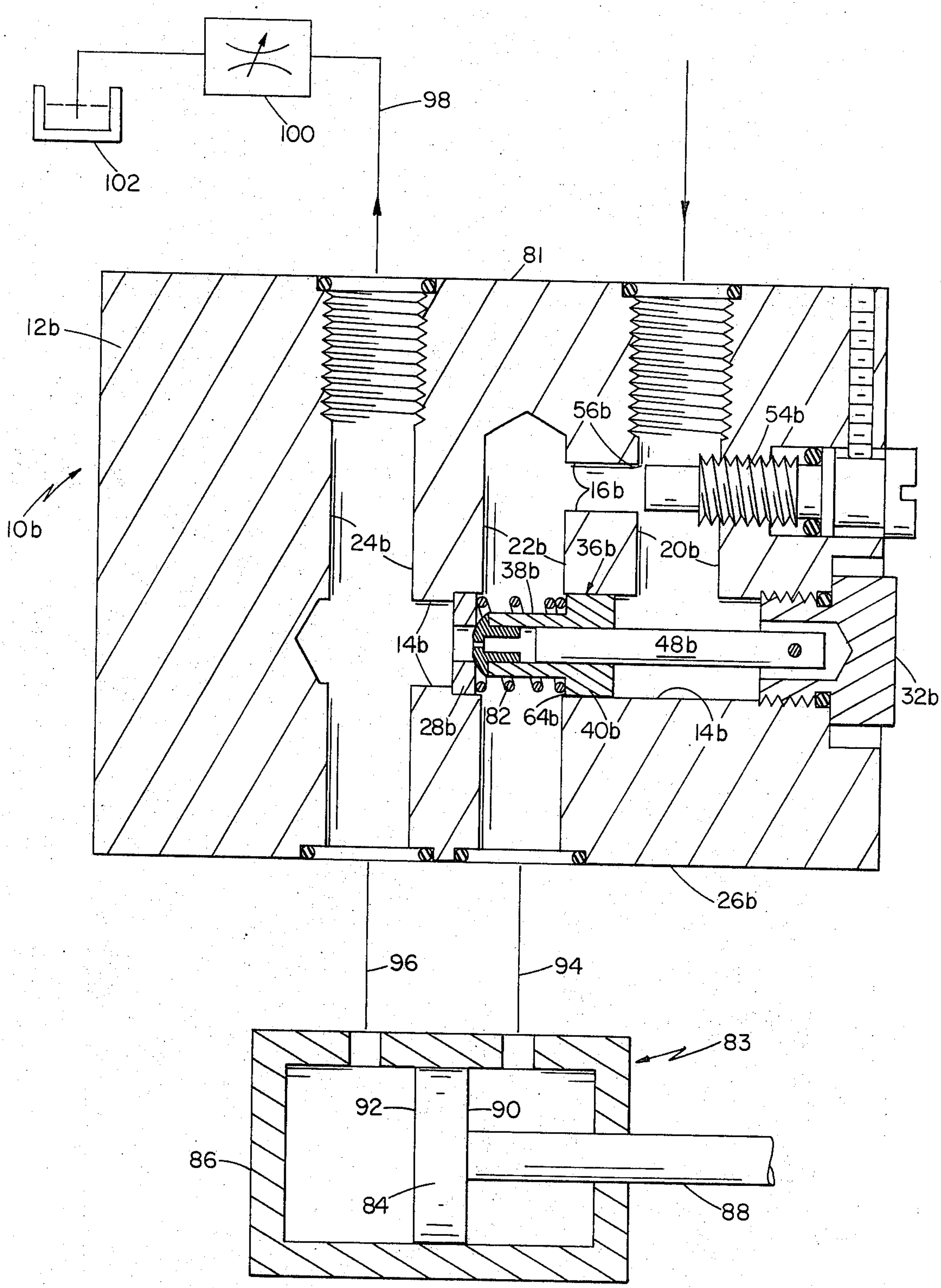


FIG 5

FIG 4


98
100
102
81
12b
56b
54b
16b
10b
24b
22b
36b
20b
38b
48b
14b
32b
28b
82
64b
40b
14b
26b
96
94
83
92
90
86
84
88

VALVING

This invention relates to valves.

It is a primary object of the present invention to provide a simple and inexpensive flow control valve that is the hydraulic equivalent of an electrical transistor. Other objects include providing pressure compensated valves in which the set flow rate can be varied from a remote connection by changing an applied pilot pressure, and which with little or no modification are useful in a wide range of servo applications.

The invention features a fluid valve comprising first and second interior chambers, an interior flow passage and a valve bore extending between the chambers, an exit port in a wall of the first chamber generally opposite the valve bore, a piston including a first portion slidably within the valve bore and, a second portion extending from the first portion to the exit port mounted for movement between a first position wherein the second portion overlies the exit port and a second position wherein the second portion is spaced from the exit port, the piston including also a bore extending therethrough and the first and second portions being of different cross-sectional areas, and a fixed balance pin extending from within the piston bore into the second chamber, the piston being slidable on the pin. In preferred embodiments in which the piston, exit port, piston bore and balance pin are of circular cross section and the exit port is defined by a valve seat, there is featured a nose portion mounted in the end of the piston bore adjacent the exit port and including a damping orifice therethrough, a flow restrictor disposed in the flow passage, and a biaser comprising one of a spring and a pilot piston for bearing against the piston and biasing it one of toward and away from the exit port.

Other objects, features and advantages will appear from the following detailed description, taken together with the attached drawings, in which:

FIG. 1 is a plan sectional view of a valve embodying the invention;

FIG. 2 is a plan sectional view of portions of the valve of FIG. 1;

FIGS. 3 and 5 are plan sectional views of second and third valves embodying the invention; and,

FIG. 4 is a plan sectional, partially diagrammatic, view of a fourth valve embodying the invention, together with apparatus used therewith.

Referring more particularly to the drawings, there is shown in FIG. 1 a basic pressure compensating valve **10** comprising a rectangular valve housing **12** in which there are provided five drilled bores or conduits, each extending inwardly from a side wall of housing **12**. As illustrated, bores **14, 16** which define respectively a valving chamber and a control conduit, extend parallel to each other in spaced relationship from housing end wall **18**. Bores **20, 22** and **24** extend, parallel to each other and perpendicular to the axes of bores **14, 16**, into housing **12** from housing side wall **26**. Each of bores **20, 22** extends through valving chamber bore **14** to control conduit bore **16**. Bore **24** extends to valve chamber bore **14**, but does not intersect control conduit bore **16**.

The portion of valve chamber bore **14** intersecting bores **20, 22** is of slightly greater diameter than that intersecting bore **24**, providing an annular step **15** between the two bore portions. An annular valve seat **28** having a drilled orifice **30** extending threrethrough coaxially with chamber bore **14** is seated on step **15**, intermediate bores **22, 24**. The end of chamber bore **14** adjacent end wall **18** is closed by a plug **32** having a coaxially cylindrical recess **34** in the inner end thereof.

A stepped cylindrical poppet piston **36** is closely-slip fitted within bore **14** with the smaller diameter portion **38** thereof adjacent valve seat **28** and the larger diameter portion **40** thereof intermediate bores **20, 22**. A cylindrical bore **42** of diameter equal to that of orifice **30** extends coaxially through piston **36** and a piston nose **44** is fitted in the end of smaller diameter portion **38** in position for overlying and closing orifice **30** when piston **36** is seated against valve seat **28**. A damping orifice **46** extends through nose **44**. A cylindrical balance pin **48** one end of which is tightly slip fitted within piston bore **42**, extends axially of chamber bore **14** from within piston **36** to within recess **34** of plug **32**, where it is fixed by a transverse pin **50**. As illustrated, the length and position of pin **48** are such that an internal chamber **52** is provided within piston bore **42** between nose **44** and the adjacent end of pin **48**.

An axially adjustable needle valve **54** is threaded into control bore **16** to provide an annular adjustable reference orifice **56** between bores **20, 22**. As shown, the reference orifice is defined by the cylindrical valving portions of bores **16, 20**. Set screw **60** locks needle valve **54** in position.

Referring now to FIG. **2** which is an enlarged view of a portion of FIG. **1** with piston **36** slightly spaced from valve seat **28** for purpose of clarity it will be seen that the annular end **62** of piston **36** facing plug **32** has an area, A_1, perpendicular to the piston axis, equal to the area of bore **14** less that of bore **42**. End **62** is exposed to and worked on by fluid in bore **20**. When piston **36** is closely adjacent valve seat **28**, the other annular end **64** of piston major diameter portion **40** and the annular portion of rounded end **66** of nose **44** radially outward from valve seat orifice **30** are exposed to and worked on by fluid in bore **22**. As valve seat orifice **30** and piston bore **42** are the same, the effective area, A_2, perpendicular to the piston axis of the areas worked on by fluid in bore **22** is equal to area A_1. After damping through orifice **46**, fluid within orifice **30** will be equal to that within piston chamber **52**, and the forces acting in opposite directions on opposite sides of piston nose **44** of diameter will be equal.

Accordingly, it will be seen that, after damping, the total force urging piston **36** toward seat **28** will be the product of area A_1 and the pressure within bore **20**; the total force urging the piston away from the seat will be the product of area A_2 and the pressure within bore **22**. As the two areas are equal, the movement of the piston will depend entirely on the pressures in bores **20, 22** and not on that in bore **24**. The damping provided by the orifice **46** in piston nose **44** insures stability.

As previously indicated, valve **10** is principally useful for passing a constant flow, regardless of the pressure of the fluid applied thereto. For such use, means are provided for applying a biasing force to piston **36** to urge it, depending on the desired use, toward or away from valve seat **28**. FIGS. **3–5** illustrate three different valves designated **10*a***, **10*b***, **10*c***, respectively, each of which is basically identical to valve **10** but includes additional components dependent on the desired end use. In each valve the respective portions identical to corresponding portions of valve **10** are identified by the same reference numbers, but with a differentiating letter, *a*, *b*, or *c*, added thereto. In each valve, flow of fluid between bores **20, 22** through reference orifice **56** results in a pressure drop, causing the fluid in the upstream bore to be greater than that in the downstream bore. The pressure difference acts on the piston, urging it toward the lower pressure bore.

Referring now particularly to FIG. **3**, valve **10*a*** is a pilot governed pressure compensating valve and includes a pilot pressure bore **70** extending in coaxial alignment with chamber bore **14*a*** from housing end wall **72** to chamber bore **14*a***. The outer portion **74** of pilot bore **70** is tapped to receive a fluid coupling. A pilot piston **76** is closely fitted in pilot bore **70** for axial movement therein; and a control rod **78**, one end of which is press-fitted coaxially into the inner end of pilot piston **76**, extends from the pilot piston through valve orifice **30*a*** and bears against the end of piston nose **44**.

In operation, bore **20*a*** of valve **10*a*** is an inlet conduit, bore **24*a*** is an outlet conduit, and bore **22*a*** is closed by plug **80**. Fluid from inlet conduit bore **20a** flows the length of the bore, through reference orifice **56a**, into the portion of control bore **16*a*** intermediate bores **20*a*, 22*a***, and thence into bore **24*a***, through valve seat orifice **30*a***. A fluid pilot pressure is applied to the outer (spaced from piston **36*a***) end of pilot piston **76**. As is evident, the total force acting on piston **36*a*** and urging it away from valve seat **28*a*** is equal to that applied by pilot piston **76**, plus that applied by the pressure P_1 of fluid in bore **22*a*** to area A_{2a}. The total force urging the piston toward the seat is applied by the pressure P_2 of fluid in bore **20*a*** to area A_{1a}. For any set pilot pressure and reference orifice size, the rate of flow through the valve will stabilize at the rate such that the pressure drop, P_1-P_2, across reference orifice **56*a*** is equal to force applied by pilot piston **76**, F_{76}, divided by the effective piston area, A_{1a} or A_{2a}. The flow rate may be changed remotely simply by varying the pilot pressure.

The valve **10*b*** illustrated in FIG. **4** differs from valve **10** in that bore **24*b*** extends completely through valve housing **12*b***, from side **26*b*** to side **81**, helical compression spring **82** surrounds piston portion **38*b*** with its opposite ends bearing against valve seat **28*b*** and the axially-facing end **64*b*** of piston major diameter portions **40*b*** and bore **20*b*** extends from side **81** rather than side **26*b*** to permit the valve more conveniently to be connected, as shown, to a controlled fluid device such as double-acting hydraulic actuator **83**. Actuator **83** comprises a piston **84** within a cylinder **86** and having a piston rod **88** extending axially through one end of the cylinder. The area of the side **92** of piston **84** opposite rod **88** is twice that of the side **90** to which rod **88** is attached. A fluid line **94** connects the smaller area side of the actuator to bore **22*b***; line **96** connects the larger area side to bore **24*b***. Bore **24*b*** is also connected, at side **81** of housing **12 *b***, to a line **98** leading from the bore through a variable orifice **100** to a fluid sump **102**.

Spring **82** provides a constant force, F_{82}, urging piston **36*b*** away from valve seat **28*b***. When fluid is introduced into valve **10*b*** through bore **20*b***, flow through reference orifice **56*b*** will stabilize at a rate, Q_0, such taht the pressure drop ΔP, across orifice **56*b*** balances the biasing force F_{82}. In the mode of operation shown in FIG. **4**, fluid from a constant pressure source, at pressure P_0, is introduced into valve **10*b*** through bore **20*b***, and variable orifice **100** is adjusted as desired to control actuator **83**. When orifice **100** is set to maintain a pressure P_{24} in bore **24*b*** equal to one half that in bore **22*b***, P_{22} which is equal to $P_0 - \Delta P$, the position of piston **84** within cylinder **96** is static and the entire flow Q_0 through reference orifice **56*b*** passes through the valve to sump **102**. Closing control orifice **100** increases the pressure, P_{24}, in bore **24*b*** and causes piston **84** to move to the right (as shown in FIG. **4**); opening orifice decreases pressure P_{24}, causing the piston to move to the left.

Valve **10*c***, shown in FIG. **5**, includes a pilot piston **76*c*** arranged to urge piston **36*c*** away from valve seat **28*c***, and a helical spring **110** surrounding balance pin **48*c*** (with its opposite ends bearing against end **62*c*** of piston major diameter portion **40*c*** and plug **32*c***) urging the piston toward the valve seat. A relief pressure control bore **112** extends from housing end wall **72*c***, parallel with pilot bore **70*c*** and coaxially with control bore **16*c***, to control bore **16*c***. An internal conduit **114** extends from bore **112** to pilot bore **70*c***, the outer end of which is closed by a plug **116**. A valve seal **118** having an orifice **120** extending axially therethrough is press fitted within relief bore **112** intermediate bore **22*c*** and conduit **114**. A relief pressure adjustment screw **122** is threaded into the outer portion of bore **112** for axial adjustment therein, and carries a poppet **124**, one end of which is slip fitted within a coaxial cylindrical recess in the inner end **126** of screw **122** and the other end of which defines a conical closure **128** facing and arranged for closing orifice **120**. A helical compression spring **130** surrounds poppet **124**, with its opposite ends engaging the axially-facing surfaces of screw **122** and closure **128**, urging the closure toward valve seat **118**. Set screw **132** holds screw **122** in place.

In operation, bore **22*c*** is connected to a constant flow, variable pressure supply source, such as a fixed-displacement pump; bore **20*c*** to a load; and bore **24*c*** to a tank or sump. During normal flow, the pressure in pilot piston bore **70*c*** and in relief pressure bore **112** is equal to that in bore **24*c***, and pilot piston **76*c*** exerts no force on piston **36*c***. Flow through the valve stabilizes at a flow rate such that the pressure drop across reference orifice **56*c*** balances the force exerted by spring **110**. It should be noted that, unlike valves **10*a*** and **10*b***, the pressure in bore **20*c*** is less than that in bore **22*c***.

As with the other valves previously discussed, the rate of flow through reference orifice **56*c*** will remain constant, regardless of variations in the absolute pressure of inlet fluid from the fluid source. To prevent too great a pressure being applied to the load, through bore **20*c***, closure **128** opens whenever the pressure in bore **22*c*** (which is equal to that in bore **20*c*** plus the pressure drop across the reference orifice **56*c***) exceeds a predetermined level. This level is controlled by spring **130**, and may be varied by adjusting adjustment screw **122**. When closure **128** opens, high pressure fluid is applied to the left (viewed in FIG. **4**) end of pilot piston **76*c***, forcing the pilot piston to drive piston **36*c*** away from valve seat **28*c***, thereby relieving the pressure in bore **22*c*** and, hence, in bore **20*c*** also. As soon as the pressure in bore **22*c*** drops below the predetermined level, closure **128** moves back against seat **118**.

Other embodiments within the scope of the following claims will occur to those skilled in the art.

What is claimed is:

1. A fluid flow control valve comprising:

a housing defining first and second interior chambers, an interior flow passage and a valve bore each extending between said chambers, an inlet port, an inlet passage connecting said inlet port and one of said chambers, a first outlet port, an exit port in a wall of said first chamber generally opposite said valve bore, and a first outlet passage connecting said first outlet port and said exit port;

a piston including a first portion slidable within said valve bore and a second portion extending from said first portion toward said exit port, said piston being mounted for movement between a first position wherein said second portion overlies said exit port and a second position wherein said second portion is spaced from said exit port, and including a bore extending therethrough generally parallel to the direction of movement thereof, said first and second portions being of different cross-sectional areas measured in respective parallel planes perpendicular to said direction of movement;

a biaser for biasing said piston one of toward and away from said exit port;

a fixed balance pin extending from within said piston bore into said second chamber, said piston being slidable on said pin; and

a flow restrictor disposed at least in part in said flow passage for controlling fluid flow therethrough,

the areas, measured in respective planes perpendicular to said direction of movement, of said balance pin and said exit port being equal, and

the effective areas, projected on respective planes generally perpendicular to said direction of movement, of the portion of said piston exposed to fluid in said second chamber, and of the portions of said piston exposed to fluid in said first chamber being equal when said piston is in said first position.

2. The valve of claim **1** wherein said biaser includes a spring mounted adjacent and bearing against said piston.

3. The valve of claim **1** wherein said biaser comprises a pilot bore, and means extending from within said pilot bore to adjacent said piston and including a pilot piston slidably mounted within said bore, said means being responsive to pressure of fluid within said pilot bore for bearing against said piston.

4. The valve of claim **1** including a relief passage extending from said first chamber and a valve disposed in said relief passage for preventing flow therethrough when pressure of fluid in said first chamber is below a predetermined level.

5. The valve of claim **4** including a pilot bore, a pilot piston disposed within said bore and including a member carried thereby extending through said exit port to adjacent said valve piston, and a conduit extending from said relief passage to said pilot bore on the side of said pilot piston opposite said valve piston.

6. The valve of claim **1** wherein said piston, said piston bore, said exit port, said valve bore and said balance pin are coaxial, and the end of said piston adjacent said exit port includes a nose portion having a rounded end surface facing and arranged for overlying said exit port, said nose portion substantially closing an end of said piston bore and including a damping orifice extending coaxially therethrough.

7. The valve of claim **1** including a second outlet port and a second outlet passage connecting said second outlet port and the other of said chambers.

8. The valve of claim **7** wherein said inlet passage connects said inlet port and said second chamber, and said second outlet passage connects said second outlet port and said first chamber, said biaser biasing said piston away from said exit port.

9. The valve of claim **8** including a third outlet port connected to said first outlet passage.

10. The valve of claim **8** wherein said biaser comprises a spring surrounding said second portion of said piston and biasing said piston away from said exit port with a predetermined force, whereby said piston is balanced when the force on said piston from fluid in said second chamber acting on said portions exposed to fluid in said second chamber is equal to the sum of the force on said piston of fluid in said first chamber acting on said portions exposed to fluid in said first chamber and said predetermined force.

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