

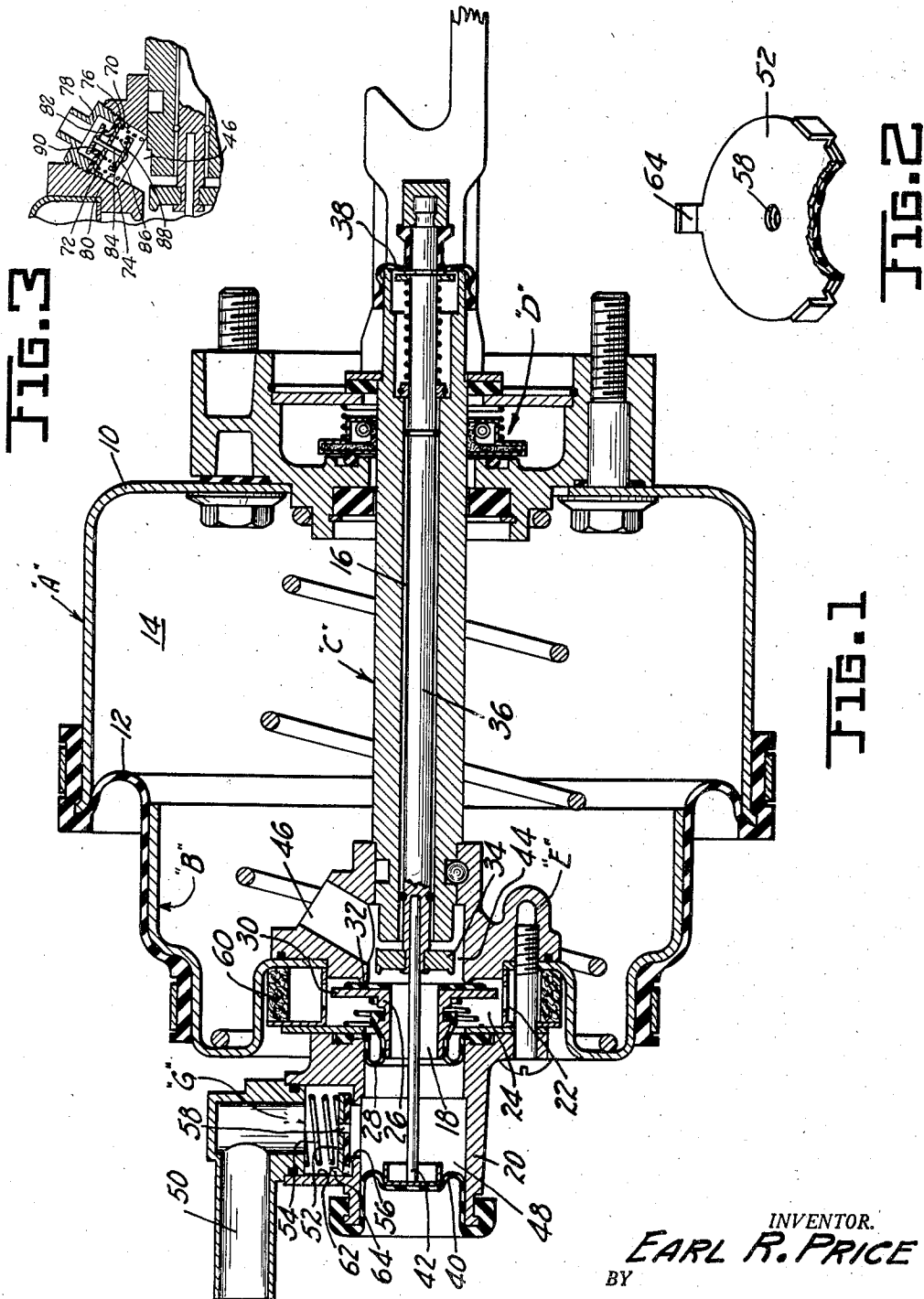
April 7, 1959

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2,880,706

SERVO-MOTOR HAVING CHATTER ELIMINATING MEANS

Filed Sept. 27, 1956



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2,880,706

SERVO-MOTOR HAVING CHATTER ELIMINATING MEANS

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Application September 27, 1956, Serial No. 612,544

8 Claims. (Cl. 121—41)

The present invention relates to fluid pressure control systems; and more particularly to means for controlling chatter in pneumatic control valves for fluid pressure servo-motors and the like.

In fluid pressure control systems employing valving of comparatively large capacity for controlling devices which are quite sensitive to pressure, control valve chatter is often encountered. This is particularly true of fluid pressure servo-motors of the type employing diaphragms as their movable walls—particularly where the device driven by the diaphragm exerts reactive forces which are largely reversible, and where considerable mass is carried by the diaphragm.

An object of the present invention is the provision of a new and improved control system of the above mentioned type which will substantially eliminate chatter of its control valve without materially reducing the inherent responsiveness of the system.

Another object of the invention is the provision of new and improved means for preventing chatter in control valves, which means is simple in design, rugged in construction and efficient in its operation.

A further object of the invention is the provision of a new and improved control system for a fluid pressure servo-motor and the like, and comprising a control valve for regulating fluid flow communication with the servo-motor, and a throttle or back-pressure valve of relatively large capacity in series flow circuit with the control valve and adapted to provide a restriction to the fluid flow as the flow rate through the control valve approaches zero.

Further objects and advantages will become apparent to those skilled in the art to which the invention relates from the following description of the preferred embodiment described with reference to the accompanying drawing forming a part of this specification, and in which:

Figure 1 is a cross sectional view of a vacuum powered fluid pressure servo-motor adapted to operate the brakes of an automotive vehicle, and embodying principles of the present invention;

Figure 2 is an enlarged isometric view of a part of the device shown in Figure 1; and

Figure 3 is a fragmentary view showing a second embodiment of valve chatter eliminating means.

The fluid pressure servo-motor portion of the device shown in the drawing is generally similar to the one shown and described in Hupp et al. application Serial No. 559,556, now Patent No. 2,829,625, assigned to the assignee of the present invention. One major difference between the fluid pressure motor of the instant case and that of the Hupp device is that the instant device utilizes a diaphragm type of sealing arrangement between its piston and cylinder walls while the Hupp device uses a sliding seal. The instant device generally comprises a cup shaped cylinder A having a piston B made from a sheet metal stamping located adjacent the open end of the cylinder, and provided with a tubular force transmitting member or push rod C extending through an opening in the closed end wall 10 of the cup-shaped

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cylinder. A vacuum tight seal D capable of accommodating a slight amount of lateral movement, and similarly constructed to that described in application 559,556, now Patent No. 2,829,625, is employed between the push rod C and the end wall 10; and a curtain type diaphragm 12 is clamped between the piston B and the open end of the cylinder A to provide an internal vacuum tight power chamber 14.

The internal chamber 16 of the tubular push rod C forms part of a large valve chamber 18 that includes an enlarged opening in the piston B, and the central opening of an axially aligned tubular boss 20 bolted to the outer face of the piston B. The boss 20 is spaced apart from the external face of the piston B by a foraminous spacer member 22 to provide an annular atmospheric chamber 24 which surrounds the valve chamber and which is adapted to be closed off from the inner valve chamber 18 by an annular valve closure member 26. One end of the closure member 26 is sealed to the boss 20 by an annular diaphragm 28, and the other end of the closure member 26 ends in a flange 30 which normally abuts an annular atmospheric valve seat 32 in the opposite radial wall of the atmospheric chamber 24 to separate the atmospheric chamber 24 from the inner valve chamber 18. A movable poppet member 34 is positioned radially inwardly of the atmospheric valve seat 32, and is adapted for sealing engagement with the flange 30 so as to be capable of isolating portions of the axially extending valve chamber 18 falling on opposite sides of the flange 30.

The poppet member 34 is adapted to be moved by a push rod 36 extending through the tubular force transmitting member C to a point outside of the servo-motor; and a diaphragm 38 is positioned between the push rod 36 and the outer end of the tubular force transmitting member C to seal off this end of the valve chamber 18. The opposite end of the valve chamber 18 as formed by the tubular boss 20 is also closed off by a diaphragm 40, and a thrust rod 42 is positioned between the diaphragm 40 and the poppet member 34 to provide a valve balancing effect which will be more completely understood by referring to application 559,556, now Patent No. 2,829,625. The portion of the valve chamber 18 communicating with the tubular push rod C (right-hand portion 44 as seen in the drawing) communicates with the power chamber 14 of the servo-motor by means of passage-way 46.

Vacuum is introduced to the opposite portion 48 of the valve chamber 18 (left-hand portion as seen in the drawing) by means of vacuum connection 50; and operation of the servo-motor is controlled by axial movement of the push rod 36, as is more fully explained in the above referred to application.

The fluid pressure motor above described is intended to be used to operate the master cylinder of an automotive hydraulic braking system. It is a property of such systems that movement of the master cylinder's fluid displacement member by the servo-motor is generally reversible; and that the fluid displacement member will return the servo-motor's piston when the force applied by the piston is relaxed. The combined effect of very sensitive valving and a frictionless power piston, when used to actuate generally reversible driven devices, produce control valve chatter which is most difficult to control.

According to principles of the present invention, means are provided which successfully eliminate control valve chatter in this most difficult application. The chatter eliminating means G shown in the drawing is positioned in the fluid flow stream which is controlled by the servo-motor's control valve during actuation of the motor. The servo-motor shown in the drawing is an atmospheric suspended unit that is actuated by communicating vacuum to its internal power chamber 14. During actuation, there-

fore, the control valve of the servo-motor throttles flow out of the power chamber into the vacuum supply line for the unit. The chatter eliminating means G shown in the drawing is positioned on the vacuum supply side of the motor's control valve E and generally comprises a valve closure member 52 lightly biased by a coil spring 54 against a valve seat 56 in a manner as to lightly oppose flow through the system. The valve seat 56 is of large enough diameter, and the spring 54 is so constructed as to pass large fluid flows at a substantially constant, predetermined and relatively small pressure drop, so as not to materially effect the speed of operation of the servo-motor. The closure member 52 is held off its seat 56, at large fluid flow rates through means G and is moved toward the seat by spring 54 as the flow diminishes. The chatter eliminating means G is further provided with a small opening 58 through the valve closure member 52 to permit pressure to equalize across the valve closure member 52 after it engages its seat.

In the normal de-energized condition of the servo-motor, a poppet member 34 is biased against flange 30 to hold the atmospheric valve closure member 26 off of its seat 32, thereby permitting atmospheric pressure to be communicated to the internal power chamber 14 through foraminous spacer member 22 and a ring of filter material 69. Actuating movement for the poppet member 34 will preferably be accomplished by means of a leverage system similar to that shown and described in the above referred to Hupp application. Actuation of the servo-motor is accomplished by the relaxing of pressure against the end of the push rod 36, whereupon poppet member 34 moves to a position generally corresponding to that shown in the drawing. Initial valve movement of the poppet member 34 permits the flange 30 to abut the atmospheric valve seat 32 to isolate atmospheric pressure from the power chamber 14, and subsequent movement opens communication between the power chamber 14 and the vacuum connection 50. Assuming that a fast application has been called for by the operator and that poppet member 34 has been moved out of engagement with the flange 30, the pressure in the left-hand valve chamber 43 will be quickly raised to a level sufficient to move the poppet member 52 out of engagement with the valve seat 56. A relatively small portion of the air flow will of course be continually throttled through the opening 58 of the valve closure member 52, and the bulk of the flow will pass through the annular space between the valve closure member 52 and the bore 62 as maintained by the guides 64. A throttling effect will of course be maintained between the closure member 52 and the valve seat 56 and this throttling effect will be substantially constant regardless of the quantity flowing once the closure member has been lifted from the valve seat 56.

When actuating movement of the poppet member 34 is stopped and the poppet member 34 becomes stationary, continued movement of the piston B causes the flange 30 of the atmospheric valve closure member 26 to approach the poppet member 34, thereby gradually reducing the flow of air out of the power chamber 14. It will be seen that very little friction or retarding force is exerted upon the piston B by reason of the diaphragm 12. By reason of the fact that mass set in motion tends to remain in motion, the valve seat 32 may be carried past the poppet member 34 by the piston B a sufficient distance to admit a small amount of atmosphere to the power chamber 14. This will, of course, cause the piston to move back and forth and the valve to chatter. Another condition tending to produce valve chatter may well be the fact that inertia lag of the piston B inherently permits too much vacuum to be communicated with the power chamber 14 for any particular set point of the poppet member 34, and the atmospheric valve member 26 must again be lifted off its seat to bleed a slight amount of air pressure to the power chamber 14 to achieve

the balanced condition called for by the operator. Still other reasons may exist for explaining valve chatter in devices of the above described type.

While the chatter eliminating means G will be effective in preventing chatter in control valves generally, it is particularly effective when used in conjunction with balanced valves of the above described type. It will be seen that the chatter eliminating means G produces a throttling effect which supplements that produced by the control valve E, as the control valve approaches its set point, thereby causing the piston B to slow down as the set point is reached. A further effect is produced in the device shown in the drawing, inasmuch as the back pressure produced in the valve chamber 48 by the chatter eliminating means G during flow is exerted upon the balancing diaphragm 40 in such direction as to cause the control valve E to approach a lapped condition at a modified set point which will be reached prior to the set point being called for by the operator. As the piston B moves into a position approaching the modified set point, flow through the control valve E is gradually diminished, reducing the amount of air flow being passed by the chatter eliminating valve means G. During the period of time that the control valve E is approaching its seat, valve closure member 52 approaches the valve seat 56 and thereafter dissipates the differential pressure across the valve closure member 52 through the throttle opening 58. During the dissipation of the unbalanced pressure across the valve closure member 52, an increase in the differential pressure across the diaphragm 40 is experienced, which increase in differential pressure is transmitted to the poppet member 34 of the control valve to urge it in a more open position. Chatter eliminating means G, therefore, will be seen to cause the control valve E to approach a modified set point which will always be approached prior to the set point being called for by the operator. By proper design of the chatter eliminating means G, the modified set point produced by the means G may be made to precede any set points that may be called for by an operator by an amount which will be greater than the amount of over shooting which can be experienced in the device by reason of its dynamic forces. While the above explanation represents one theory explaining the operation of the device, theories as to instability of servo-motor valving are in general quite complicated, and applicant does not wish to be limited to any particular theory of operation.

While the present invention has been described in considerable detail, application does not wish to be limited to the particular construction shown and described, as it will be apparent that other modifications and embodiments exist. One such modification would be to position the chatter eliminating means G in the passageway 46 on the opposite side of the control valve E. Were such modification to be made, however, it will be seen that the chatter eliminating means G would have to be positioned in the passageway 46 in such manner that large flows would be permitted from the power chamber 14 to the valve means E—in which case air flow into the power chamber 14 during retraction of the brakes would have to pass through the opening 58. This would make retraction of the brakes too slow for all practical purposes, and another passageway having a check valve therein would have to be used between the control valve E and the power chamber 14 to speed up the release of the unit. The valve shown in Figure 3 generally comprises an annular disc 70 having three inwardly turned ears 72 which slidably engage the sidewalls of the counter-bore 74 that is provided in the outer end of the passageway 46. The center portion of the outer face of the disc 70 is coated with an annular coating of rubber 76 the outer edges of which are normally biased against the annular retainer member 78 by a coil spring 80 to close off the passageway. The radially inner edge of the rubber coating 76 forms a valve seat for the disc

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shaped closure member 82 having a stem 84 which projects through a central opening in the disc 70. The inner end of the stem 70 is provided with a spring retainer 86, and the valve closure member 82 is biased into engagement with its seat by a coil spring 88 positioned between the retainer and the bottom side of the disc 70.

It will be understood that should the valve structure shown in Figure 3 be used, the valve structure G shown in Figure 1 would not be used in the vacuum supply side 2 of the servo-motor's control valve to the control valve E. Actuation of this embodiment as in the previously described embodiment is initiated by movement of the push rod 36 to the right, as seen in Figure 1, permitting the poppet member 34 to be lifted from the flange 30 and thereby communicate vacuum to the passageway 46. Air pressure in the chamber 14 of the servo-motor then causes the disc 70 to move inwardly away from the retainer member 78 and thereby permit air to flow through the clearance provided between the outer edge of the annular disc 70 and the sidewalls of the counterbore 74 as provided by the inwardly turned ear 72. As the set point for the valve structure E is approached, and the velocity of air flow through the passageway 46 diminishes, coil spring 80 will bias the annular disc 70 against the retainer member 78; and thereafter, pressure differential will be equalized across the annular disc 70 through a small opening 90 in the valve closure member 82 which opening corresponds in size to the opening 58 of the previous embodiment.

As in the previous embodiment deactivation of the servo-motor is accomplished by air flow through the passageway 46 back into the chamber 14. Air flow in this direction passes through the central opening in the annular disc 70 causing the valve closure member 82 to be biased off of the radially inner end edge of the annular piece of rubber 76 to provide substantially unrestricted flow for this return passage of air. Still other modifications will occur to those skilled in the art, and it is my intention to cover hereby all adaptations, modifications, and uses thereof which come within the practice of those skilled in the art to which the invention relates.

I claim:

1. A fluid pressure servo-motor control system comprising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a fluid pressure source which when communicated to said chamber produces movement of said movable wall; a throttling control valve for regulating fluid flow in a first direction between said source and said chamber, said valve including first and second relatively movable portions one of which is manually actuatable and the other of which is moved by said movable wall to provide follow-up of said manually actuatable portion by said movable wall; an anti-chatter valve in series flow relationship with respect to said control valve, said anti-chatter valve having a valve closure member which opposes flow therethrough in said first direction with generally predetermined force and being movable by the force of fluid flowing therethrough from a first upstream position where it has but a small flow capacity to a downstream position where it is capable of passing the full flow capacity of said control valve at a generally predetermined pressure differential; the amount of resistance to flow when said valve closure member is in its first position, and the amount of biasing of said valve closure member being sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated portion of said control valve regardless of the speed at which it is moved.

2. A fluid pressure servo-motor control system com-

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prising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a fluid pressure source which when communicated to said chamber produces movement of said movable wall in a first direction; a throttling control valve carried by said movable wall for regulating fluid flow between said source and said chamber, said valve including a manually actuated valve closure member which when moved in said first direction opens communication between said source and said chamber to provide follow-up of said manually actuatable closure member by said movable wall; an anti-chatter valve in series flow relationship with respect to said control valve, said anti-chatter valve having a valve closure member which opposes said actuating fluid flow with generally predetermined force and being movable by the force of fluid flowing therethrough from a first upstream position where it has but a small flow capacity to a downstream position where it is capable of passing the full flow capacity of said control valve at a generally predetermined pressure differential; the amount of resistance to flow in said first position, and the amount of biasing of said valve closure member being so sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated valve closure member regardless of the speed at which it is moved.

3. A fluid pressure servo-motor control system comprising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a fluid pressure source which when communicated to said chamber produces movement of said movable wall in a first direction; a throttling control valve carried by said movable wall for regulating fluid flow between said source and said chamber, said valve including a manually actuatable valve closure member which when moved in said first direction opens communication between said source and said chamber to provide follow-up of said manually actuatable closure member by said movable wall; an anti-chatter valve in series flow relationship with respect to said control valve, said anti-chatter valve comprising a first flow path having a valve seat facing in the downstream direction of said actuating fluid flow and having a valve closure member biased against said valve seat with generally predetermined force, said flow path having passages of relatively large capacity to conduct flow away from said valve seat with little flow resistance when said valve closure member is off of its seat; and a second flow path in parallel flow relationship with respect to said first flow path, said second flow path having an appreciably smaller flow capacity than said first flow path; the amount of resistance to flow of said second flow path, and the amount of biasing of said valve closure member being so sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated valve closure member regardless of the speed at which it is moved.

4. A fluid pressure servo-motor control system comprising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a fluid pressure source which when communicated to said chamber produces movement of said movable wall; a throttling control valve for regulating fluid flow in a first direction between said source and said chamber, said valve including first and second relatively movable portions one of which is manually actuatable and the other of which is moved by said movable wall to provide follow-up of said manually actuatable portion by said

movable wall; an anti-chatter valve in series flow relationship with respect to said control valve, said anti-chatter valve comprising a first flow path having a valve seat facing in the downstream direction of said actuating fluid flow and having a valve closure member biased against said valve seat with generally predetermined force, said anti-chatter valve having passages of relatively large capacity to conduct flow away from said valve seat with little flow resistance when said valve closure member is off of its seat; and a second flow path in parallel flow relationship with respect to said first flow path, said second flow path having an appreciably smaller flow capacity than said first flow path; the amount of resistance to flow of said second flow path, and the amount of biasing of said valve closure member being so sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated portion of said control valve regardless of the speed at which it is moved.

5. A fluid pressure servo-motor control system comprising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a fluid pressure source which when communicated to said chamber produces movement of said movable wall; a throttling control valve for regulating fluid flow in a first direction between said source and said chamber, said valve including first and second relatively movable portions one of which is manually actuatable and the other of which is moved by said movable wall to provide follow-up of said manually actuatable portion by said movable wall; an anti-chatter valve in series flow relationship with respect to said control valve, said anti-chatter valve comprising a valve seat facing in the downstream direction of said actuating fluid flow and having a valve closure member for abutment with said valve seat; a spring biasing said closure member against said seat with predetermined force; said anti-chatter valve having passages of relatively large capacity to conduct flow away from said valve seat with little flow resistance when said valve closure member is off of its seat; and an orifice through said valve closure member, said orifice having an appreciably smaller flow capacity than that provided between said closure member and said valve seat; the resistance to flow of said orifice, and the strength of said spring being so sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated portion of said control valve regardless of the speed at which it is moved.

6. A fluid pressure servo-motor control system comprising: a servo-motor housing; a movable wall in said housing forming an enclosed chamber with said housing, said movable wall having little frictional resistance to motion; a vacuum source which when communicated to said chamber produces movement of said movable wall in a first direction; a throttling control valve carried by said movable wall for regulating fluid flow out of said chamber, said valve including a manually actuated valve closure member which when moved in said first direction opens communication between said source and said chamber to provide follow-up of said manually actuatable valve closure member by said movable wall; an anti-chatter

valve downstream of said control valve, said anti-chatter valve comprising a valve seat facing in the direction of fluid flow out of said chamber and having a valve closure member for abutment with said valve seat; a spring biasing said closure member against said seat with predetermined force, said anti-chatter valve having passages of relatively large capacity to conduct flow away from said valve seat with little flow resistance when said valve closure member is off of its seat; and an orifice through said valve closure member, said orifice having an appreciably smaller flow capacity than that provided between said closure member and said valve seat; the amount of resistance to flow of said orifice, and the strength of said spring being so sized with respect to the frictional resistance of said movable wall, its inertia, and the flow capacity of said control valve as to prevent said movable wall from appreciably overshooting the position called for by said manually actuated valve closure member regardless of the speed at which it is moved.

7. In a fluid flow control circuit, a high pressure chamber, an intermediate pressure chamber, a poppet valve for controlling flow through said circuit, a movable wall in said intermediate chamber operatively connected to said poppet valve for opposing pressure forces across said poppet valve, a back pressure valve in said circuit for controlling the pressure in said intermediate pressure chamber in such manner as to cause said movable wall to urge said poppet valve toward a closed condition when flow is experienced through said circuit, and restricted flow communicating means across said back pressure valve for permitting the differential across said back pressure valve to be dissipated as flow through said circuit approaches zero.

8. In a fluid flow control circuit for a fluid pressure servo-motor and the like, a valve body having a valve chamber therein, movable walls in opposite ends of said valve chamber, said movable walls being subjected to atmospheric pressure on their outer surfaces, a valve seat intermediate the ends of said valve chamber, a poppet valve in said valve chamber constructed and arranged to abut said seat and separate said valve chamber into opposing end chambers, first means communicating one of said opposing end chambers to a high pressure source, second means communicating the other of said opposing end chambers to a low pressure source, means operatively connecting said movable walls to said poppet valve in such manner to substantially balance the forces on said poppet valve, a back pressure valve in one of said first and second means opposing flow through said circuit, and restricted flow communicating means across said back pressure valve for permitting the differential pressure across said back pressure valve to be dissipated as flow through said circuit approaches zero.

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