

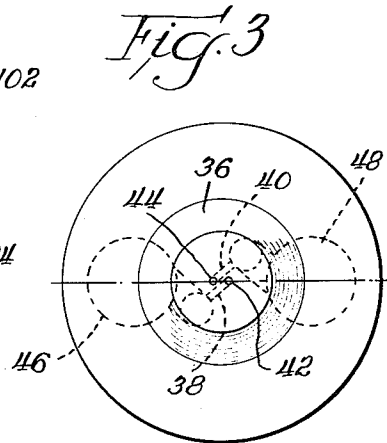
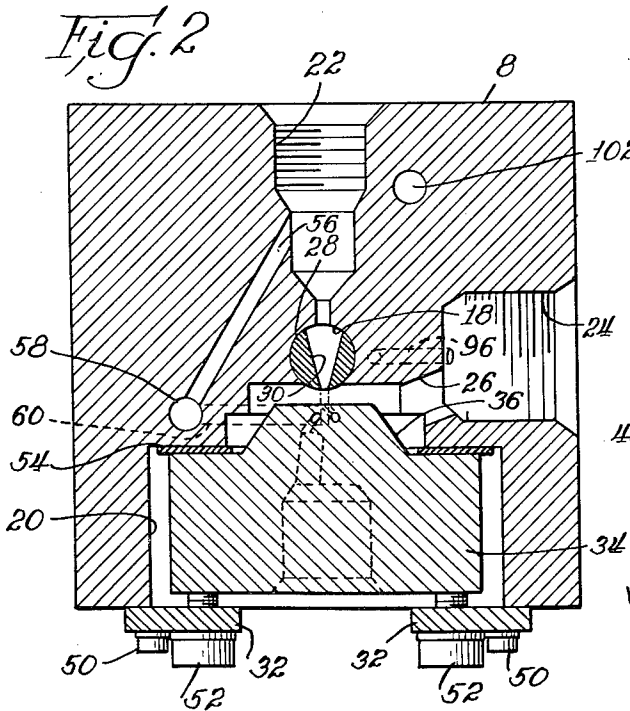
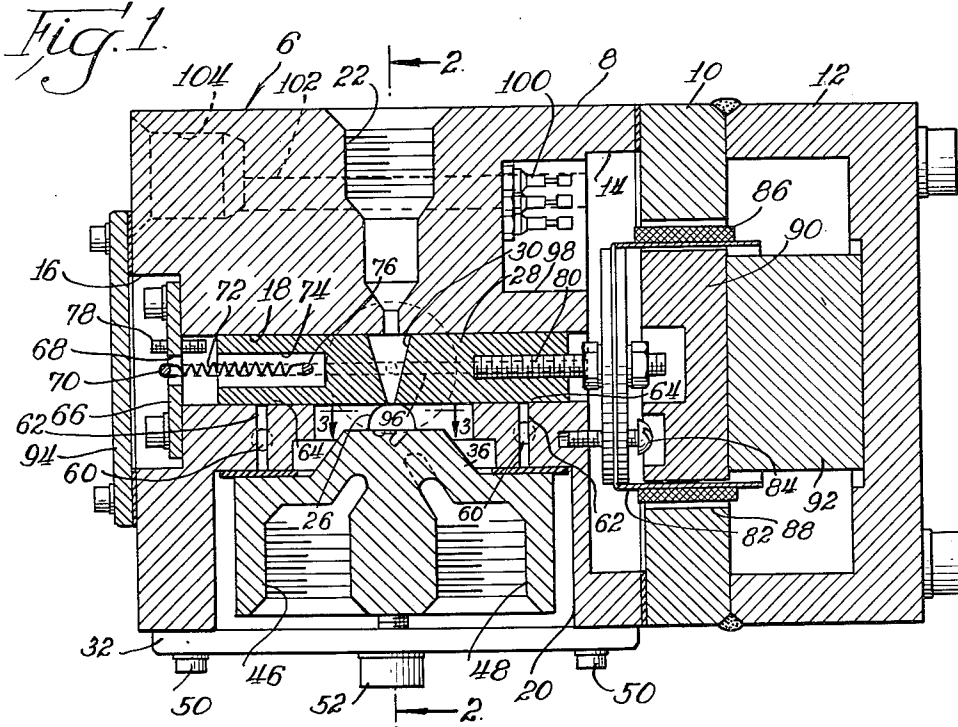
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W. G. HOLZBOCK

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CONTROLLER

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INVENTOR.
 WERNER G. HOLZBOCK
 BY
 Stephen J. Rudy
 atty.

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CONTROLLER

Werner G. Holzbeck, Nashua, N.H., assignor to Vickers Incorporated, Troy, Mich., a corporation of Michigan

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This invention relates to an electro-hydraulic controller, and more particularly to a single-stage electro-hydraulic servo-valve adapted for the proportional control of fluid flow and pressure.

The controller of the invention utilizes in a novel way, the jet pipe principle of operation, but differs from the jet pipe controllers of the prior art in many important respects such as, for example, it has no bearings, elimination of sharp internal bends which produce pressure losses is effected, provision is made to balance flow forces thus allowing virtually frictionless operation, freedom from silting and clogging is made possible, more compactness is achieved, and coupled with the latter, is reduction in size for comparable operating range.

The main object of this invention is to provide a single stage electro-hydraulic controller which utilizes the jet pipe principle of operation in a novel and improved way.

A more specific object of this invention is to provide an electro-hydraulic controller of more compactness and of reduced size.

Another specific object of this invention is to provide an electro-hydraulic controller wherein flow forces are balanced to allow virtually frictionless operation.

Still another object is to provide an electro-hydraulic controller wherein sharp internal bends are avoided thus reducing pressure losses.

Another object of the invention is to provide an electro-hydraulic controller wherein bearings are eliminated.

These and further objects and features of the invention will become more apparent from the following description and accompanying drawing wherein:

FIG. 1 is a vertical section view of an electro-hydraulic controller embodying the principles of the invention;

FIG. 2 is a section view generally as seen along line 2-2 in FIG. 1; and

FIG. 3 is a view generally as seen from line 3-3 in FIG. 1.

Referring now to the drawing, the numeral 6 identifies a controller embodying the principles of the invention, which includes a main block, or housing 8 to which is affixed an assemblage including a magnet cover plate 10, and a magnet housing 12. The main block 8, which is substantially cubic in form, has a circular recess 14 provided on a side surface, while on the opposite surface is provided a circular recess 16. A bore, or passageway 18 is centrally arranged in the main block 8 and extends between the circular recesses 14 and 16. An opening 20, of successively reduced diameters, extends upwardly from the bottom of the housing 8 and intersects the passageway 18. A second opening 22, of successively reduced diameter, extends downwardly from the top surface of the housing 8 and intersects the passageway 18. It will be seen that the axis of the openings 20 and 22 coincide. The opening 22 is threaded to receive a pipe fitting whereby the controller may be connected via a pipe or tubing (not shown) to a source of high pressure hydraulic fluid. A third opening 24, formed on the rear surface of the housing 8, extends inwardly and is connected by a passageway 26 to the opening 18, as best seen in FIG. 2. The opening 24 is threaded to receive a pipe connection for conduction of hydraulic fluid via a pipe or tubing (not shown), back to a reservoir, from whence it is pumped under pressure to the controller, in the well known manner.

Slidably positioned within the passageway 18 is a jet

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spool, or piston 28 which has a conically shaped hole, or passageway 30 formed in its mid-region. The upper, or larger end of the hole 30 is arranged adjacent the lowermost end of the opening 22, while the lower end, or smallest diameter end of the hole 30, opens into the opening 20.

Secured within the opening 20 by means of a pair of straps 32, is a jet stream receptor means in the form of a distributor block 34, which has a frusto-conical projection 36 formed on its upper surface. A pair of passageways 38, 40 are formed in the projection 36, the upper extremity of which provide ports 42, 44 respectively, located on the upper surface of the projection 36, while the lower end of said passageways lead to openings 46, 48 respectively, extending upwardly within the distributor block 34. The openings 46, 48 are threaded to receive pipe connections for conduction of hydraulic pressure fluid through a pipe, or tubing (not shown) leading to an actuating mechanism to be driven by the controller 6. It will be seen in FIG. 3, that the ports 42, 44 are on a line coincident with the longitudinal axis of the jet piston 28; accordingly, horizontal movement of the jet piston 28 will direct hydraulic pressure fluid from the lower end of the conical passageway 30, to one or the other of the ports. In such manner, the recovered hydraulic pressure within openings 46 and 48, which may be between 80 to 95 percent of supply pressure, will depend upon the position of the jet piston 28 relative to the ports 42 and 44 respectively. It is to be noted that the large diameter of the flow passages practically eliminates all possibilities from silting and clogging.

The straps 32, which are secured to the lower surface of the main block 8 by fastening means such as screws 50, are each provided with an adjusting screw 52 adapted to abut the lower surface of the distributor block 34 and maintain the latter in fixed position within the opening 20. In such manner, the ports 42, 44 may be adjusted relative to the opening of the passageway 30 formed in the jet piston 28. Gasket means 54 may be interposed between the distributor block 34 and the portion of the housing within the opening 20 against which the distributor block seats, said gasket 54 serving dual purposes, namely, to seal the volume about the projection 36, and to act as a shim means for regulating the distance between the top surface of the projection 36 and the opening of the conical passageway 30. It will be seen that hydraulic pressure fluid impinging upon the upper surface of the conical projection 36, which does not enter either of the passageways 38, 40, will flow from the enclosed volume surrounding the projection 36 via passageway 26 into the opening 24 and back to the hydraulic pump reservoir.

Means to provide hydraulic balance to the jet piston 28 are provided in the controller of the invention. Such balancing means includes a passageway 56 which leads from the opening 22 into a horizontally arranged passageway 58 formed in the housing 8. Extending inwardly from the passageway 58 are a pair of passageways 60 which intersect a pair of vertically arranged passageways 62, the upper end of each opening into the passageway 18. The jet piston 28 is formed with a pair of circular recesses 64 arranged on the lower peripheral surface and in the region of the opening of passageways 62. It will be seen that the pressure of the inlet hydraulic fluid in opening 22 will be exerted upon the underside of the jet piston 28 by virtue of the passageway arrangement 56, 58, 60, and 62. In such manner, the downward thrust of the hydraulic fluid flowing out of the opening 22 and into the conical passageway 30, as well as the weight of the piston 28, and attached elements, will be counterbalanced by the pressure of fluid acting upwardly within the circular recesses 64 of the jet piston 28.

Affixed within the circular recess 16, is a stop plate 66

which covers one end of the passageway 18. The stop plate has a centrally arranged hole 68, and a horizontally arranged groove on one surface for the support of a pin 70. The latter is adapted to secure one end of a tension spring 72 which extends into a bore 74 formed in one end of the jet piston 28, the other end of the spring being affixed to a pin 76 arranged in the jet piston and extending horizontally through the bore 74. An adjusting screw 78 is adapted to extend through the stop plate 66 a predetermined distance to regulate the left end travel of the jet piston 28. A bolt, or stud means 80 is axially secured to the other end of the jet piston 28, which stud is arranged for support of a voice coil assemblage 82. A bolt, or screw 84 is arranged to extend through (with sufficient clearance) the voice coil assemblage 82, and to be screwed into the bottom surface of the circular recess 14; by adjusting the position of the head of the screw 84 relative to the voice coil assemblage 82, the rightward maximum travel of the voice coil assemblage may be controlled.

The voice coil assemblage includes windings 86 arranged for axial movement within a circular gap 88 provided between a magnet center piece 90 and the magnet cover plate 10. The magnet center piece 90 is affixed to a permanent magnet 92 which is secured within the magnet housing 12. It will be seen that with the above described arrangement, a magnetic circuit is provided which passes from the magnet 92, through the magnet center piece 90, across the circular gap 88, through the magnet cover plate 10, and through the magnet housing 12 back to the magnet 92. In such manner, a constant flux field is provided in the circular gap 88.

The voice coil has two windings; a signal winding and a bias winding. Input signals from 30 milliwatts to 5 watts can be accommodated. The signal winding is for positioning the piston 28 in accordance with an electrical input signal. The bias winding is used to obtain a center position of the piston for any desired base value of the control signal that is applied to the signal winding. The bias signal remains constant, while the control signal may vary above or below a given base value, thus positioning the piston 28 against the force of the tension spring 72. The spring rate determines the amount which the piston moves for a given increment of control signal; it thus determines the range. The position of the piston will be proportional to the input signal. The bias winding is connected to a constant D.C. voltage source. The current flow through the winding is adjustable by potentiometer, or similar method which makes fast zeroing of the device possible. Instead of applying a constant current to the bias winding, a feedback signal from the final control element (not shown) may be used.

Another type of constant force bias, which may be practical in certain installations, would involve the use of a liquid column of predetermined level or head, the pressure of which would be applied to one end of the piston 28.

It is customary to have a spring determine both bias and range in many electro-hydraulic controllers. The bias is then obtained by the necessary precompression or preextension of the spring. This limits such devices to comparatively large ranges, i.e., large signals for a given motion of the piston. The reason for such limitation is that for practical considerations, comparatively large spring rates must be used, otherwise the spring will be too long if it is to provide the required pretension or precompression. The arrangement in the controller of the invention, provides a constant—not a spring—signal force, hence, permits operation with very small ranges.

A cover plate 94 is affixed to the housing 8 to enclose the circular recess 16. Passageway means 96 are arranged to connect the region at each end of the jet piston 28 with the opening 24; in such manner, the liquid which leaks past the ends of the jet piston 28 is channeled into the return flow liquid circuit. As an alternative, the region at each end of the jet piston may be connected to the

inlet opening 22, if desired, by suitable passageway means.

The terminal block 100 is arranged within the recess 98. It is adapted for electrical connection with the windings 86. The passageway 102 connects the recess 98 with a threaded opening 104 formed in the housing 8, which opening 104 is adapted to receive an electrical connector (not shown) for wires which are brought to the controller for connection to the terminal block 100.

The foregoing description has been given in detail without thought to limitation since the inventive principles involved are capable of assuming other forms without departing from the spirit of the invention or the scope of the following claims.

What is claimed is:

1. An electro-hydraulic controller comprising in combination a housing, a distributor block being formed to provide a jet stream receptor means, said housing being formed with an opening adapted to receive and direct a hydraulic jet stream toward the distributor block, a piston means positionable in a passageway formed in said housing and in open communication with said opening, said piston means being in sliding engagement with the wall of said passageway and movable normal to said jet stream and having a passageway positionable in the path of said jet stream said passageway tapering toward a minimum diameter in the jet downstream direction, and electro-magnetic means for moving said piston means.

2. An electro-hydraulic controller comprising in combination a housing, a distributor block being formed to provide a jet stream receptor means, said housing being formed with an opening adapted to receive and direct a hydraulic jet stream toward the distributor block, a piston means positionable in a passageway formed in said housing and in open communication with said opening, said piston means being in sliding engagement with the wall of said passageway and movable normal to said jet stream and having a passageway positionable in the path of said jet stream, said passageway tapering toward a minimum diameter in the jet downstream direction, said passageway being adapted to cause deflection of the flow of said jet stream relative to said distributor block, an electro-magnetic means for moving said piston means in a first direction, and means for moving said piston means in a second direction.

3. An electro-hydraulic controller comprising in combination a housing, a distributor block being formed to provide a jet stream receptor means and having at least one passageway means one end of which is defined by a port on an upper surface of the distributor block, said housing being formed with an opening adapted to receive and direct a jet stream toward the distributor block, a piston means positionable in a passageway formed in said housing and in open communication with said opening, said piston means being in sliding engagement with the wall of said passageway and movable normal to said jet stream and having a passageway positionable in the path of said jet stream, which passageway is tapered to a minimum diameter in the jet downstream direction, said passageway being adapted to cause deflection of the flow of said jet stream toward and into said port means, an electro-magnetic means for moving said piston means, and a spring means affixed to said piston means.

4. An electro-hydraulic controller comprising in combination a housing, a distributor block positioned in the housing and being formed to provide a jet stream receptor and having a pair of passageways one end of each being defined by a port located on an upper surface of the distributor block, said housing being formed with an opening adapted to receive and direct a jet stream toward the distributor block, a piston means positionable in a passageway formed in said housing and in open communication with said opening, said piston means being in sliding engagement with the wall of said passageway and movable normal to said jet stream and having a passageway positionable in the path of said jet stream, which passageway

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is tapered to a minimum diameter in the jet downstream direction, said passageway being adapted to cause deflection of the flow of said jet stream from one to the other of said ports, an electro-magnetic means for moving said piston means, and a spring means arranged to resist movement of said piston means.

5. An electro-hydraulic controller comprising in combination a housing, a distributor block positioned in the housing and being formed to provide a jet stream receptor and having a pair of passageways one end of each being defined by a port located upon an upper surface of the distributor block the other end of each passageway leading to one of a pair of openings formed in the distributor block, said housing being formed with an opening adapted to receive and direct a jet stream toward said distributor block, a passageway formed with its longitudinal axis normal to the axis of said jet stream opening and having a piston slidably arranged therein, said piston having a tapered passageway positionable in the path of said jet stream for directing the flow of said jet stream to either one or the other of said ports, a passageway means extending between said jet stream opening and said piston containing passageway to direct pressure fluid upon the piston in opposition to the flow of said jet stream, an electro-magnetic means for moving said piston, and a spring means arranged to resist movement of said piston.

6. An electro-hydraulic controller according to claim 5

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wherein said electro-magnetic means includes electric conducting coils movable in a magnetic field.

7. An electro-hydraulic controller according to claim 6 wherein said magnetic field is provided by a permanent magnet core.

8. An electro-hydraulic controller according to claim 7 wherein the electric conducting coils include a bias winding and a signal winding, said bias winding being arranged for connection to a constant D.C. electrical source, while said signal winding is connected to an electrical input signal source.

9. An electro-hydraulic controller according to claim 5 wherein said distributor block is adjustable relative to the tapered passageway of said piston.

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