JET ASSISTED SLEEVE VALVE

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FIG. 3

FIG. 4

FIG. 2

FIG. 1
This invention relates to a sleeve valve particularly useful in controlling the flow of fluid to a hydraulic actuator. A present-day high-speed electronic computer, a mechanical positioning device very often has been incorporated. Such a mechanical movement somewhat tends to impose a speed limitation on the overall system which otherwise operates at electronic speed. To illustrate such a mechanical function, in some computers a magnetic transducer may be required to be driven to a given magnetic information track located on one of several rotating disks. Such an arrangement obviously demands an unusually fast transducer movement. In some applications, a satisfactory solution to this speed requirement has been achieved by employing hydraulic actuators connected to the mechanism to be driven.

In using such actuators, it is particularly desirable to minimize the time required to couple them to a pressure or exhaust source, i.e., to condition the actuator to either of these conditions. This conditioning of the actuators has been most satisfactorily achieved by means of hydraulic valves under the operation of electromagnetic solenoids. Such solenoids quite often are arranged so that energizing their coils will drive an armature in one direction against an opposing bias force. Thus, de-energizing the solenoid will permit the bias force to return the armature to its starting position. In the interest of high-speed operation, it has been found that small solenoids react more quickly to electrical energization than do the larger ones. This is due primarily to their smaller electrical coils. However, while smaller solenoids have the advantage of being quicker to respond to electrical energization, they have the disadvantage of developing a correspondingly reduced force. Therefore, the bias force against which these small solenoids must act must also be commensurately reduced. However, reducing the bias force acting to return the valve usually will slow it down for a given load. This problem is particularly critical in miniaturized hydraulic valves since in general for a given stroke it is desirable for various reasons to use sleeve valves as opposed to spool valves in conditioning an actuator, and with sleeve valves it is well known that if the ports in the sleeve are formed at 90 degrees to the longitudinal axis, as is the usual case, there is developed an inordinate force acting in opposition to the opening of the ports as soon as the fluid begins flowing through them. This opposing force builds up rapidly and can overcome the force attempting to open the valve. Obviously, the smaller the solenoids used in order to miniaturize the equipment as well as reduce their electrical response time, the more critical the problem becomes due to the fact that the solenoid will develop less and less force as it is made smaller. Therefore, ports formed in the sleeve at 90 degrees to its axis may very well limit the degree to which the ports can be opened, thereby cutting the rate of fluid flow passing through these ports.

In the present invention, however, jet assisting ports aid the bias force acting to transfer the sleeve in a sleeve valve, but without acting against the solenoid when it is energized. In short, the sleeve transfer movement in one direction is effected by the application of a bias force combined with the reaction force generated by angled ports provided in the sleeve. On the other hand, the forces acting to transfer the sleeve in the opposite direction are supplied by the solenoid acting against the bias force alone. Thus, the quicker and smaller solenoid can still be used without causing a slowing-down of the sleeve transfer movement. Therefore, it is an object of the present invention to provide a hydraulic control valve wherein either of two fluid flow conditions are rapidly established.

It is another object of the present invention to provide a sleeve valve wherein a bias force is supplemented by a jet reaction force.

It is another object of the present invention to provide a sleeve valve wherein high valve switching speeds are achieved while providing a large port opening to give full flow of fluid therethrough.

According to the present invention, a sleeve valve has been provided wherein the control ports are formed at an acute angle to the sleeve axis so that the passage of fluid through the lateral wall of the sleeve applies an assisting force to the movement of this sleeve.

Therefore, it is still another object of the present invention to provide a jet-assisted sleeve valve.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a perspective view partially broken away of the sleeve valve of the invention coupled to a bias piston. Invisible lines have been used only so as to clearly show the relation of the ports of the sleeve.

FIG. 2 is a perspective view of a valve body for cooperating with the sleeve.

FIGS. 3 and 4 show a vertical cross section centrally taken of the valve showing respectively the fluid supply and exhaust conditions of the sleeve.

Referring to FIG. 1, the invention is there shown comprising a sleeve 10 provided with a threaded intermediate portion 11 for receiving the threaded end of a flexible connecting rod 12. With rod 12 screwed into place, portion 11 effectively divides the interior of sleeve 10 into an upper and lower chamber 14 and 15, respectively. Both the upper and lower ends of rod 12 have been provided with a threaded portion as well as a limiting boss or hub integral therewith, designated 16 and 17, respectively. The lower end of rod 12 is screwed to a bias piston 19. The outside diameter of piston 19 is slightly less than the outside diameter of sleeve 10, thereby creating a force differential acting to move the sleeve upwardly when pressure is applied between these two elements.

As shown in FIG. 2, there has been provided a cylindrical valve body 20 provided with a pair of large transverse holes 21 for supplying fluid under pressure to the interior thereof. As shown in FIGS. 3 and 4, the bore of body 20 is smaller below holes 21 than above so as
to properly fit the difference in diameters of sleeve 10 and piston 19. The flexibility in rod 12 is sufficient to accommodate any misalignment in machining the bores for sleeve 10 and piston 19. Body 20, provided with O-rings 22, is held in a housing 24 at its lower end by a retaining ring 26 at its upper end by an abutting shoulder 26.

As thus assembled, body 20 can be easily inserted into housing 24 so they can be considered as though they were a single housing unit. A pressure supply conduit 28 is formed in housing 24 to lead into holes 21 in sleeve 10, which is supplied with pressure to the interior of chamber 15.

The portion of body 20 above its intermediate land 23 is provided with the usual porting for a three-way valve. Specifically, there has been provided a tier of upper ports 30 each leading into a common annular recess 31 encircling sleeve 10. The center ports 33 are provided with an annular recess 34 which can cooperate with ports in either chamber 14 or 15 depending upon whether the sleeve 10 is in its upper or lower position. Finally, body 20 is provided with a lower tier of ports 36 leading into a common annular recess 37.

For purposes of clarity, an actuator cylinder 40 has been shown with a connecting channel 41 leading into what might be termed an annular "fluid transfer manifold" 42 located between the upper and center lands of body 20 since fluid will pass in both directions through this area depending upon whether the valve is conditioned to pressurize or exhaust.

The upper end of sleeve 10 is provided with an enlarged portion 43 so as to form a shoulder 44 which rests upon the upper end of body 20. Portion 43 functions as an exhaust manifold and is connected by ports 45 to an exhaust conduit 46. The top of portion 43 is provided with interior threads to receive a plug 47 having a cap 48 associated therewith. As shown in FIGS. 3 and 4, a solenoid armature 49 of a push-type solenoid (not shown) has been shown for purposes of clarity in demonstrating the operation of the invention.

In sleeve 10 a number of jet assisting ports 50 or booster ports have been provided to a sleeve wall leading from chamber 15. Ports 50 are formed at an acute angle of substantially 45 degrees to the longitudinal axis of sleeve 10 and are arranged to cooperate with recesses 34 and 37. However, while the most desirable angle is 45 degrees, various angles will provide some assistance in transferring the sleeve. A practical range, however, might be considered to include angles between 20 and 60 degrees. Furthermore, while a single angled port will give some thrust, a number of such angled ports have been provided to increase this thrust and to achieve maximum flow through the valve. In the upper portion of the sleeve, a plurality of exhaust ports 52 have been formed at right angles to its longitudinal axis and arranged to cooperate with recesses 31 and 34.

In operation and as shown in FIG. 4, with the push-type solenoid of armature 49 energized, sleeve 10 will be pushed down to exhaust fluid from cylinder 40 via channel 41, manifold 42, ports 30 and 33 in alignment with ports 52, then through chamber 14, ports 45 and conduit 46. The moment that the solenoid is de-energized, the bias force created by the differential in diameters between sleeve 10 and piston 19 causes an upward movement of sleeve 10. Pressure applied via conduit 28 and holes 29. As soon as sleeve 10 has moved only slightly upwardly, a jet reaction force assisting the sleeve movement is generated by the passage of fluid out of ports 50 into annular recesses 34, 37 and then to cylinder 40 via ports 33, 36, manifold 42 and channel 41.

The reaction force generated by the passage of fluid through ports 50 aids the bias force acting to transfer sleeve 10, thereby moving it quickly to the condition shown in FIG. 3. In this manner, ports 50 are completely opened and a full flow of fluid passes therethrough, resulting in a more rapid actuation of a piston in cylinder 40. The exhaust condition for cylinder 40 is also quickly established by energizing a small solenoid pushing down on sleeve 10 via cap 48, since in the static condition it does not have to act against the jet reaction force created by the dynamic action of ports 50. Consequently, only a small solenoid force need be provided since the valve is one thereby described.

In short, the sleeve transfer movement in one direction has been effected by combining a bias force with a dynamic jet reaction force assisting in the transfer of the sleeve in one direction while its transfer in the opposite direction is effected by the force of the solenoid acting only against the bias force.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in the form and details may be made therein without departing from the spirit and scope of the invention. For example, it would not depart from the spirit of this invention to apply its teaching to the control of gases rather than hydraulic fluids. Likewise, the bias force could be supplied by a spring. Additionally, while the reaction ports in the present arrangement are shown assisting the conditioning of sleeve 10 to pressurize cylinder 40, it is contemplated that in some circumstances it may be more desirable to apply a jet assisting force in order to quickly establish the exhaust condition. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In a fluid control sleeve valve wherein a cylindrical sleeve is shiftable between a first and second position to establish either of at least two fluid flow conditions, valve urging means for assisting in the establishment of one of said conditions, said urging means including at least one port constructed and arranged to pass fluid under pressure through the lateral wall of said sleeve, said port being formed in said sleeve at an acute angle to the longitudinal axis of said sleeve, said angle being constructed and arranged to apply an assisting thrust to said sleeve in establishing said one condition.

2. In a fluid control sleeve valve wherein a cylindrical sleeve is shiftable between a first and second position to establish either of two fluid flow conditions, valve urging means for assisting in the establishment of one of said conditions, said urging means comprising a plurality of ports constructed and arranged to pass fluid under pressure from the interior of said sleeve to the exterior thereof via the lateral wall of said sleeve, said port being formed in said sleeve at an acute angle to the longitudinal axis of said sleeve and in a manner which applies an assisting thrust to said sleeve in establishing one of said conditions.

3. In a fluid control sleeve valve wherein a cylindrical sleeve is shiftable between a first and second position to establish either of two fluid flow conditions, valve urging means for assisting in the establishment of one of said conditions, said urging means comprising a plurality of ports constructed and arranged to pass fluid under pressure from the interior of said sleeve to the exterior thereof via the lateral wall of said sleeve, said port being formed in said sleeve at an acute angle to the longitudinal axis of said sleeve and in a manner which applies an assisting thrust to said sleeve in establishing one of said conditions.

4. The invention according to claim 3 wherein said angle is substantially 45 degrees to the longitudinal axis of said sleeve.

5. The invention according to claim 3 wherein said angle is within the range of 20 to 60 degrees to the longitudinal axis of said sleeve.
to said sleeve to assist in establishing one of said conditions.

7. A fluid control valve for selectively either supplying fluid from a pressure source to an actuator or exhausting fluid from said actuator to a source of lower pressure, said valve comprising a housing having a cylindrical bore, a cylindrical sleeve longitudinally movable within said bore to selectively establish either of said supply and exhaust conditions, a partition in said sleeve dividing the interior thereof into a first and second chamber, said chambers being isolated from each other, means for passing fluid from said pressure source into said first chamber, a plurality of reaction ports in said sleeve for passing said fluid under pressure from said first chamber to said actuator to drive said actuator, said reaction ports being disposed at an acute angle to the axis of said sleeve, said angle being sufficiently acute to generate an assisting thrust applied to said sleeve, and means for exhausting fluid from said actuator via said second chamber.

No references cited.