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HYDRAULIC TRANSDUCER
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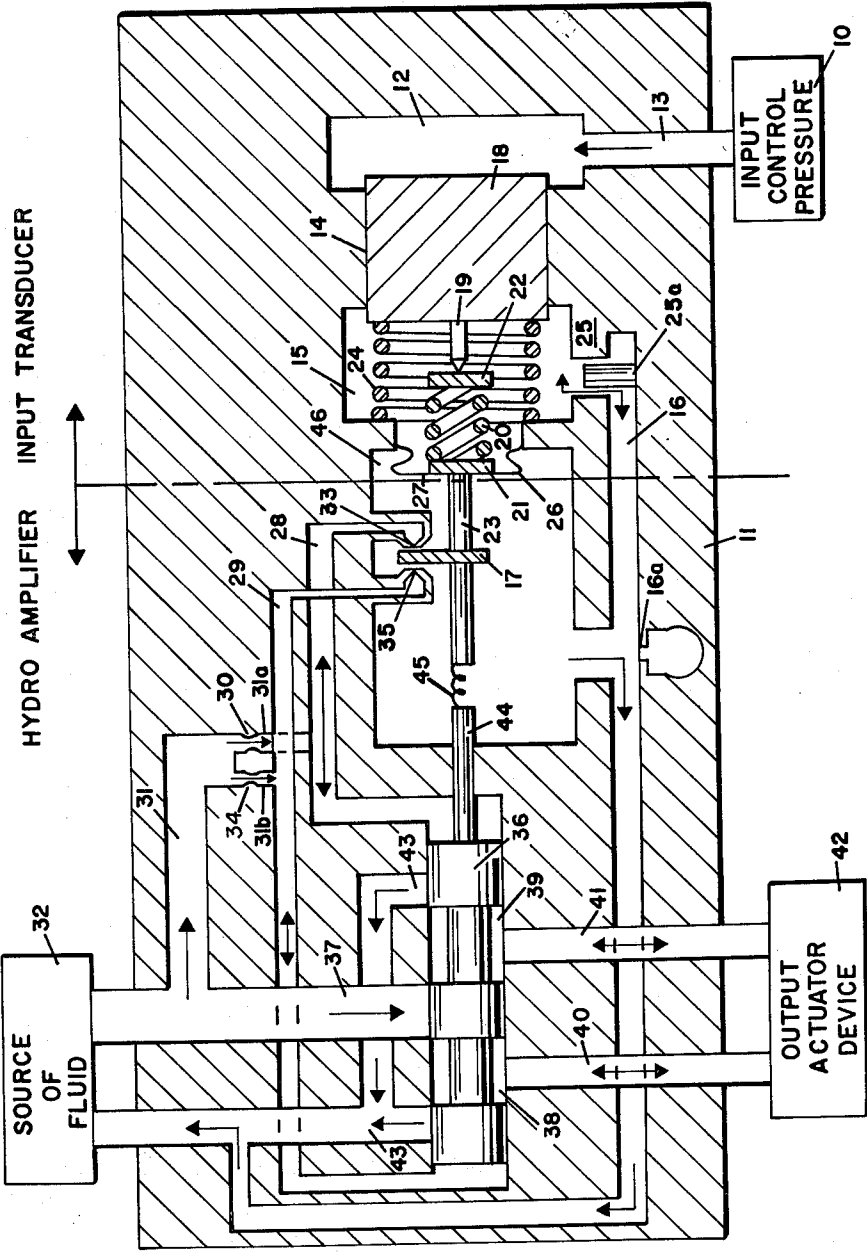


Fig. 1

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This invention relates to the art of hydraulic control. In particular, this invention relates to hydraulic transducers for converting a hydraulic force into a mechanical displacement.

In the prior art many devices exist for converting a phase order signal into a mechanical displacement. Such signals, for example, include pressure, temperature, etc. The problem frequently arises, however, of converting the algebraic sum of such a signal and its rate of change into a mechanical displacement of a hydraulic control part. This is more recently accomplished by electronic devices. In the situation, for example, when one wishes to convert a pressure and the rate of change of the pressure into a control signal, these electronic devices produce an electric signal which is a function of the pressure. The pressure signal so produced is then diverted to provide an electric differential pressure signal. The pressure signal and the differential pressure signal are then combined, for example, in a summing amplifier to provide the desired control signal. Such devices, however, are relatively unreliable, complex, space consuming and expensive.

It is, therefore, an object of the invention to provide an improved hydraulic transducer for converting an input pressure and the rate of change of pressure into a control signal.

A further object of the invention is to provide an improved, hydraulic transducer of the type described which is compatible with modern hydraulic servo valves.

Yet another object of the present invention is to provide an improved hydraulic transducer having improved sensitivity and speed of response.

Still another object of the invention is to provide an improved hydraulic transducer for independently converting an input pressure control signal and the rate of change of the input pressure into a control signal.

Yet another object of the invention is to provide an improved hydraulic transducer having a high degree of sensitivity and speed of response.

Still another object of the invention is to provide a hydraulic transducer having a high degree of reliability in operation.

In accordance to the invention there is provided a hydraulic transducer for converting an input pressure and the rate of change of the pressure into a control signal. The transducer comprises a source of fluid under pressure, an output transducer control member and fluid-pressure-response means. The pressure response means is coupled to the control member and the source for displacing the control member in response to the input pressure. A variable pressure means is coupled to the source for developing a differential pressure in proportion to the rate of change to the input pressure. A fluid-differential-pressure-responsive means is coupled to the control member of the variable pressure means to displace the control member in proportion to the differential pressure. The control member is thus displaced in response to the input pressure and the rate of change of the input pressure to provide the control signal.

For a better understanding of the invention, together with other and further objects, thereof, reference is made to the following description taken in connection with the accompanying drawing, and its scope will be pointed in the appended claims.

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In the drawing:

FIG. 1 is a partial schematic, sectional view of a hydraulic control apparatus embodying the present invention.

Description of the Hydraulic Control Apparatus in FIG. 1

Referring now to FIG. 1, there is here illustrated a hydraulic transducer for converting an input pressure and the rate of change of the pressure into a control signal. The transducer as shown is integrated with a hydraulic servo valve to provide a hydraulic control apparatus. The transducer is shown coupled to a source 10 of fluid under pressure. The transducer comprises a transducer body 11 having an input pressure chamber 12 coupled through a conduit 13 to the source 10. A cylinder 14 is formed in the body adjacent the chamber 12. A variable pressure chamber 15 is formed in the body adjacent the cylinder 14 having fluid return passageway 16 extending from the chamber 15. An output transducer control member 17 is provided. A movable piston 18 is disposed in the cylinder 14 with its opposite ends adjacent the input chamber 12 and the variable chamber 15. The piston 18 is coupled to the control member 17 through a shaft 19, a spring 20 and spring end plates 21 and 22. The end plate 21 is affixed to a shaft 23 which carries the control member 17. The piston is resiliently coupled to the body 11 through a spring 24. A restriction generally indicated as 25 is disposed in the passageway 16 adjacent the variable chamber 15. An expansible bellows 26 is affixed to the body 11 as shown. A diaphragm 27 is affixed to the shaft 23 adjacent the spring end cap 21. The diaphragm is also connected to the bellows 26 as shown.

The hydraulic servo valve comprises a pair of variable pressure chambers which are controlled by the member 17. The variable pressure chambers are connected through a pair of passageways formed in the variable pressure chambers control the positioning of the control piston. The control piston in turn controls the application of fluid pressure to an output actuator device such as a servo motor. The servo valve is thus a two stage valve controlling a control valve which in turn controls an output actuator device.

Thus, the control member 17 is transversely disposed between a pair of variable pressure chambers 28 and 29. The chamber 28 is formed by a restriction 30 and a passageway 31a connected through a passageway 31 to a source 32 of fluid under pressure. At the other end of the chamber 28 is a nozzle 33 for directing a jet stream of fluid to the member 17. Similarly, the chamber 29 is formed by a restricted orifice 34 in a passageway 31b hydraulically coupled to the source 32. At the other end of the chamber 29 is a nozzle 35 for directing an opposing jet stream of fluid at the member 17. In addition, the variable pressure from the chambers 28 and 29 are coupled through passageways 31a and 31b to the opposite sides of a control piston-valve 36 of a four way control. Piston valve 36 has three cylindrical lands which are formed by undercutting as shown. The central land of the piston valve 36 controls the application of fluid under pressure through a passageway 37 connected to the source 32. The fluid is selectively conducted from the passageway 37 through the chambers 38 and 39 into one of the pair of control conduits 40 or 41 to an output actuator device 42. The outermost lands of the piston valve 36 controls the application of the fluid return through passageways 43 to the source 32. A shaft 44 extends from the piston valve 36 and is coupled through a feed back spring 45 to the shaft 23 which supports the control member 17.

Operation of the Hydraulic Control Apparatus in FIG. 1

In the preferred embodiment, as shown in FIG. 1, the transducer, in response to an input control pressure and an input rate of change of the control pressure, provides a control signal which is proportional to the algebraic sum of the differential of the control pressure and the differential control pressure. This control signal is hydraulically coupled to position the control piston-valve of the servo valve, which in turn controls the application of the source of fluid to an output actuator device.

The input control pressure is derived from a source 10 of fluid under pressure and is applied through the passageway 13 to the input chamber 12. The input control pressure may be derived from the source of fluid 32 or from an entirely separate source. Fluid under pressure in the chamber 12 exerts a force on the end of the piston 18 to position it against a bias force applied by the spring 24 on the opposite end of piston 18. The mass of the piston 18 and the spring constant of the spring 24 are so chosen as to provide a resonant frequency on these parts several times that of the expected rate of change of input control pressure. For example, the resonant frequency of piston 18 and spring 24 may be selected in the order of 300 cycles, where the expected rate of change of the input control pressure is 50 cycles. The piston 18 thus follows every variable in pressure exerted. The motion of the piston 18 is transmitted through the shaft 19 and spring 20 to the shaft 23 and output transducer control member 17. The stiffness of the spring 20, preferably chosen to be relatively low, is below that required to follow the transient displacements of the piston 18. The bellows 26 expands and contracts with the motion of the shaft 23 and is preferably substantially non-resilient. The motion of the piston 18 causes fluid in the chamber 15 to flow in and out of the restriction 25 through the passageway 16. The restriction 16A may produce, for example, a back pressure in the passageway 16 in the order of 40 lbs., 15 lbs., above atmosphere. The pressure range acting on the piston 18 may be, for example, from 50 to 650 lbs. The maximum rate at which the input pressure varies may be, for example, 4,000 lbs. per square inch per second. The member 25A may be so chosen as to provide, for example, a differential pressure of ± 10 lbs. per square inch when the input pressure varies at the rate of $\pm 4,000$ lbs. per square inch per second respectively. The restriction then acts to produce a differential pressure which acts between the walls of the chamber 15 and adjacent face of the piston 18 to displace the diaphragm 27. It will be apparent that the displacement of the diaphragm 27 is proportional to the differential pressure and substantially independent of the piston 18 in responding to the rate of change of the input pressure. Since the differential pressure is positive when the input pressure increases and negative when the input pressure decreases, it is substantially regenerative as shown.

From the above discussion, it will be seen that the control member is displaced in response to the input pressure to provide a control signal for the pilot stage of the servo valve. The operation of the servo valve will be outlined with regard to an instantaneous decrease in input pressure plus the resilient negative differential pressure which causes the piston 18 to move to the right and the diaphragm 27 to move to the right due to the negative differential pressure appearing between transducer output chamber 46 and the variable pressure chamber 15.

The motion of the diaphragm to the right attended by the motion of the control member 17 to the right tends to occlude the nozzle 33 and increase the pressure in the pilot variable pressure chamber 28. At the same time the pilot nozzle 35 is relieved, the affected opening is increased and the pressure in the variable pilot pressure chamber 29 decreases. Accordingly the occlusion of nozzle 33 and the resultant increased pressure in chamber

28 is hydraulically coupled to the right hand end of the control piston valve 36 to cause it to move to the left. At the same time the decreased pressure in the chamber 29 is transmitted to the left hand end of the piston valve 36 to further cause it to move to the left. Fluid pressure from the source 32 flows through the pressure passageway 37 through an opening between the center land of the piston valve 36 and the body of the valve, through the chamber 39 and conduit 41 into the output actuator device 42. Fluid returns from the actuator 42 through the conduit 40, the chamber 38 and the return passageway 43 to the source 32. The motion of the control piston valve 36 to the left is transmitted through the feedback spring 45 to tend to restore the control member 17 to its equilibrium position. The extent to which the control member 17 is moved to the left to its equilibrium position depends upon the strength of the force acting on it. When the control member 17 is restored to its position, the control piston valve remains stationary. In general, there is a linear relation between force acting on the control member 17 and the displacement or position of the control piston valve 36.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A hydraulic transducer for converting an input control pressure and the rate of change of said pressure into a control signal, comprising: a source of fluid under input control pressure; a transducer body having an input pressure chamber coupled to said source and a cylinder adjacent said input pressure chamber and coupled thereto; an output transducer control member; a movable piston disposed in said cylinder and extending into said input pressure chamber, said piston being resiliently coupled to said body for biasing said piston against the input control pressure, and to said control member for displacing said control member in response to said input control pressure; a fluid pressure responsive means for displacing said control member in response to the acceleration of said piston and independently of the position said piston in proportion to the rate of change of said input pressure, whereby said control member is displaced in response to said input pressure and the rate of change of said input pressure to provide said control signal.

2. A hydraulic transducer according to claim 1 in which; the fluid pressure responsive means includes, an expansible non-resilient bellows affixed to said body, and a diaphragm affixed to said bellows, and said control member.

3. A hydraulic transducer according to claim 2 in which; the fluid pressure responsive means includes a variable pressure chamber extending between the bellows and said cylinder and coupled to said cylinder opposite the input pressure chamber; said variable pressure chamber being coupled to a fluid return passageway by a branch passageway containing a restriction whereby a pressure may be exerted upon the bellows and diaphragm in response to rate of movement of said piston.

4. A hydraulic transducer according to claim 3 having a control valve comprising in part a slidable control piston; a second fluid source coupled to said control valve by input and exhaust lines; an output actuator coupled to said control valve; at least one control passageway coupling the second source, the control member, and the control valve; means for varying the pressure in the control passageway in response to the position of the control member; whereby the varying pressure in the control passageway is communicated to the control valve in order

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to control fluid pressure from the second source to the output actuator.

5. A hydraulic transducer according to claim 4 in which the means for varying the pressure in the control passageway includes; a restriction between the control passageway and the second source, a jet in the end of the control passageway adjacent the control member; and a plate mounted on the reciprocable control member; the fluid in the control passage impinging on said plate at right angles to the plane of said plate as the

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plate moves toward or away from the jet whereby the pressure in the control passageway is varied.

6. A hydraulic actuator according to claim 5 in which the control piston is connected by a resilient means to the control member, whereby a mechanical feedback is provided for said control member.

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