

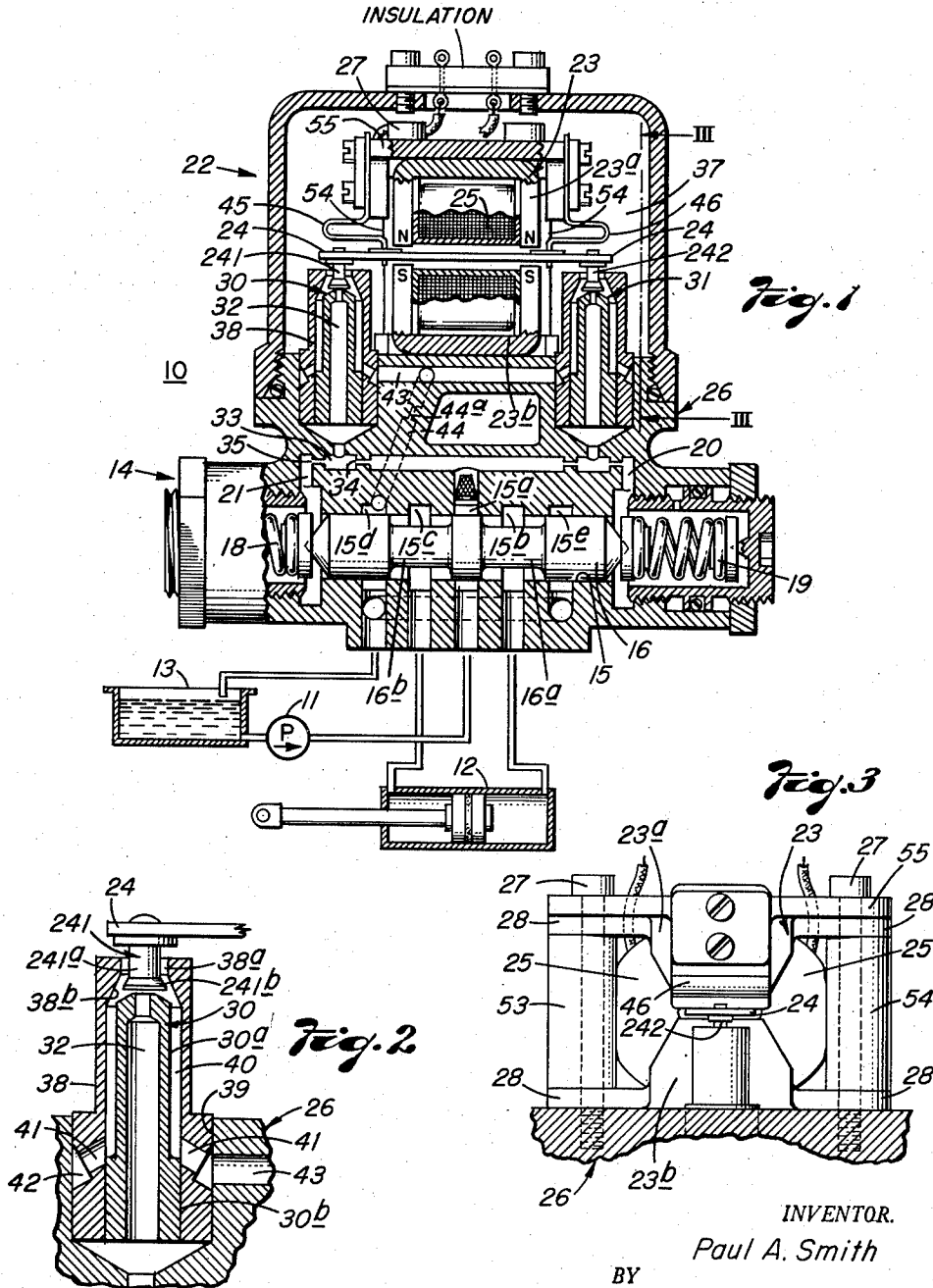
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ELECTROHYDRAULIC SERVO VALVE

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ELECTROHYDRAULIC SERVO VALVE

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This invention relates to electrohydraulic servo valves of the type in which a light movable armature of a sensitive electromagnetic motor or relay varies the position of a flow-impeding element with respect to a flow nozzle, to thereby produce pressure changes for hydraulic actuation of a valve controlling a hydraulic motor.

More specifically, the invention relates to valves of the "wet coil" type in which the electromagnetic motor and the flow nozzle are in a common chamber which is normally filled with fluid escaping from the nozzle. Wet coil valves have recognized advantages over dry coil valves in which the motor is isolated from the fluid-filled nozzle chamber. However, wet coil valves have the disadvantage that dirt in the oil stream may deposit in narrow clearance spaces between moving parts of the motor and interfere with its operation. The problem is serious because of minute clearances in the motor, and because if the dirt contains iron it is attracted to and held against magnetized portions of the motor.

An object of the present invention is to reduce dirt deposition in the motor of an electrohydraulic valve of the wet type.

A feature of the invention is a nozzle and motor-actuated variable flow impeding structure that effectively diverts the nozzle stream into a return duct and substantially prevents circulation of fluid from the nozzle to the motor chamber, without introducing closely-fitted moving parts that could reduce the sensitivity of the valve.

Other more specific objects and features of the invention will appear from the description to follow with reference to the drawing, in which:

Fig. 1 is a schematic diagram of a system incorporating a valve in accordance with the invention.

Fig. 2 is an enlarged view of one of the nozzle structures of Fig. 1.

Fig. 3 is a view taken in the plane III—III of Fig. 1.

The present invention is shown applied to an electrohydraulic servo valve of the type disclosed in application of D. V. Healy, Serial No. 437,778, filed June 18, 1954, to which reference is made for details not specifically relating to the present invention.

The system shown in Fig. 1 consists of an electrohydraulic servo valve 10 incorporating the invention, for selectively controlling flow of pressure fluid from a pump 11 to either end of a load cylinder 12 and returning fluid from the other end of the load cylinder to a reservoir 13 which supplies the pump. The lower portion 14 of the valve 10 comprises a conventional spool or shuttle-type four-way valve consisting of a valve cylinder 15 containing a pressure-actuated valve piston 16 movable from a central neutral position into either of two end positions. In the left end position of the piston 16, an annular groove 16a therein connects an annular pressure port 15a in the cylinder to one annular motor port 15b and an annular groove 16b in the piston connects another motor port 15c to a return port 15d, so that the piston of the load cylinder 12 is driven to the left. In the right end position of the valve piston 16, the groove 16b thereof

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connects the pressure port 15a to the motor port 15c, and the piston groove 16a connects the motor port 15b to a return port 15e, so that the piston of the load cylinder 12 is driven to the right. In the neutral position of the valve piston 16, as shown in Fig. 1, the grooves 16a and 16b of the piston are isolated from the pressure port 15a and the motor ports 15b and 15c so that the piston of the load cylinder 12 is locked in position.

The valve piston 16 is normally held in neutral position 10 by helical compression springs 18 and 19 slightly compressed between the opposite ends of the piston and the adjacent ends of the cylinder. The piston is movable in either direction out of neutral position against the restraining force of the springs 18 and 19 by admitting fluid of different pressures to the opposite ends of the cylinder 15 through passages 20 and 21, the relative pressures in which are controlled by an electromagnetic valve mechanism positioned in the upper portion 22 of the assembly.

This upper portion 22 contains an electromagnetic 20 motor or relay having a stationary field structure 23 and a movable armature element 24 and a driving coil 25 surrounding the armature element, the latter being of soft iron or similar material such that it is readily magnetized and demagnetized in response to changes in the current in the winding 25. The field structure 23 comprises a pair of pole pieces 23a and 23b of general U shape, so associated with a pair of permanent magnets 53 and 54 that the upper pole piece 23a has a north pole at each end adjacent to the armature, as indicated by the reference 30 letters N, N, and the pole piece 23b has a south pole at each end adjacent to the armature and juxtaposed to the north poles of the pole piece 23a. It will be apparent that a current in the winding 25 will oppositely magnetize the opposite ends of the armature element 24, producing 35 a force tending to rotate the armature about its midpoint in direction depending upon the direction of the current in the winding 25 and with a force proportional to the amplitude of the current.

As shown in Figs. 1 and 3, the pole pieces 23a and 23b are rigidly mounted with respect to the permanent magnets 53 and 54 and the frame 26 by a clamp plate 55 which overlies the bight portion of the pole piece 23a and is held down by four screws 27 extending into the frame 26. The plate 55 clamps extended portions 28 of the upper and lower pole pieces against the magnets 53 and 54 and secures the assembly of magnets and pole pieces to the frame 26.

Rotative movement of the armature element 24, as previously described, varies the pressure delivered to the passages 20 and 21 in the following manner. The armature 24 has attached to opposite ends thereof pins 241 and 242, respectively, the lower ends of which are juxtaposed to and in closely spaced relation to nozzles 30 and 31, respectively. The nozzle 30 has a passage 32 connecting to a chamber 33 which in turn is connected by a restricted orifice 34 to the pressure port 15a and by a restricted orifice 35 to the passage 21 leading to the left end of the valve cylinder 15. The passage of the nozzle 31 is similarly connected by restricted passages to the pressure port 15a and to the passage 20 leading to the right end of the valve cylinder 15.

When the armature element 24 is in neutral position, the pins 241 and 242 equally impede flow of fluid from the nozzles 30 and 31, respectively, and the pressures in the motor passages 20 and 21 are equal so that the valve piston 16 remains in neutral position. If the armature 24 is rotated counterclockwise in response to energization of the coil 25 in such direction as to move the pin 241 closer to the nozzle 30 and move the pin 242 farther away from the nozzle 31, the flow through the nozzle 30 will be impeded to a greater extent than the flow through the nozzle 31. This causes the pressure to rise in the

chamber 33 and in the left end of the valve cylinder 15, whereas the freer release of fluid from the nozzle 31 reduces the pressure in the right end of the valve cylinder, thereby producing movement of the valve piston 16 to the right. If the armature element 24 is rotated clockwise, the pressures are reversed to move the piston 16 to the left.

The armature element 24 is yieldably supported by a pair of elongated resilient spring elements 45 and 46, each of which is attached rigidly at one end to the armature and is anchored to an extended portion of the clamp plate 55 at the other end.

It is evident that in a valve of this type sensitivity is dependent upon the absence of frictional resistance to free movement of the armature element 24, and such frictional resistance is eliminated by positioning the armature element and pins 241 and 242 out of contact with any stationary structures. This means that fluid seals, to prevent the oil issuing from the nozzles 30 and 31 from reaching the armature element and the magnets, are impracticable. A great advantage of the wet coil type of valve as herein disclosed is the absence of seals and their resultant static friction. However, as previously indicated, a disadvantage of wet coil valves is that any dirt in the oil issuing from the nozzles into the motor chamber 37 may lodge in clearance spaces next to the armature structure and obstruct its free movement. For example, the clearance between the armature and the pole faces of the magnets 23a and 23b may desirably be very small, and minute particles lodging there can interfere with armature movement.

The present invention reduces the introduction of oil-borne dirt into the motor chamber 37 without the use of seals or narrow clearances, by means of nozzle flow return path structures including the pins 241 and 242.

Thus, referring to Fig. 2, each nozzle has an upper cylindrical portion 30a of reduced external diameter relative to a cylindrical base portion 30b, the latter being press-fitted in a tubular nozzle shield 38 which in turn is press-fitted in an aperture 39 provided therefor in the valve body 26. The shield 38 extends beyond the upper end of the nozzle 30, and its internal diameter is reduced to define an aperture 38a through which the pin 241 extends. Pin 241 has a neck portion 241a extending through the aperture 38a, and a head portion 241b of larger diameter than the neck portion and only slightly smaller than aperture 38a (to permit its passage there-through at the time of assembly). The reduced upper portion 30a of the nozzle and the juxtaposed inner surface of the shield 38 define an annular return passage 40 connected at its lower end by passages 41 in the nozzle shield 38 to an annular groove 42 in the exterior surface of the latter, which groove is connected by passages 43 and 44 in the body 26 to the return port 15d. To maintain a slight positive fluid pressure in the motor chamber 37, a restriction 44a (Fig. 1) may be provided in the passage 44.

In the operation of the valve, the motor chamber 37 is completely filled with oil and is connected through the shield apertures 38a with the return passage. However, there is no inducement to circulation of new oil from the

nozzles into the motor chamber. The oil issuing from the nozzles is deflected laterally by the flat faces of the heads 241b of pins 241 against the conical surfaces 38b of the nozzle shields 38, which conical surfaces in turn deflect the flow downwardly into the annular return passages 40. The passages between the necks 241a of pins 241 and the apertures 38a of shields 38 are ample to insure against frictional contact between the pins and the shield, but are relatively long and thereby discourage circulation of oil therethrough to and from the motor chamber. Such circulation tends to be induced by eddy action of the nozzle flow into the annular passage 40.

In practice, the nozzle 10 and shield structure described have been found to reduce fouling of the motor mechanism to a greater extent than any prior known structure.

Although for the purpose of explaining the invention a particular embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and I do not desire to be limited to the exact details shown and described.

I claim:

1. An electrohydraulic valve comprising: means defining a fluid-tight chamber; a motor means in said chamber having an armature movable back and forth in response to control signals applied to the motor; a nozzle projecting into said chamber in juxtaposed relation to said armature such that the said armature movement is toward and away from the nozzle, and means exterior of said chamber for delivering fluid through said nozzle as a nozzle stream; a pin secured to said armature in alignment with said nozzle and projecting from said armature and having an end face larger than the nozzle in close proximity to said nozzle for variably impeding flow therefrom in response to said armature movement, and thereby vary the pressure in the nozzle; a tubular shield surrounding said nozzle and projecting therebeyond about a portion of said pin and defining with the outer surface of said nozzle an annular return passage for fluid issuing from said nozzle, and means for conducting fluid from said annular return passage away from said motor chamber; that portion of said shield projecting beyond said nozzle and about said pin having clearance there-with permitting free fluid flow therebetween in response to a pressure differential between said motor chamber and said annular return passage.

2. A valve according to claim 1 in which the inner surface of said shield tapers inwardly adjacent the end of said nozzle whereby fluid directed laterally from the nozzle by said pin impinges on and is deflected into said annular return passage by said tapered surface.

3. A valve according to claim 2 in which said pin has a reduced neck portion and a larger head juxtaposed to said nozzle.

4. A valve according to claim 3 in which said head is opposite said tapered inner surface of said shield.

References Cited in the file of this patent

UNITED STATES PATENTS

2,556,436 Moore June 12, 1951