

[54] **ELECTRO-HYDRAULIC ACTUATOR**

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[58] Field of Search..... **91/47, 363 A, 363 R, 417 R**

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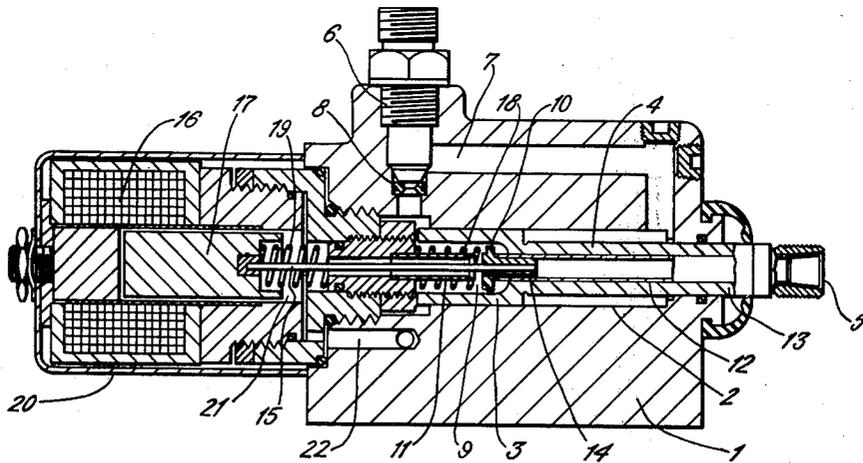
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[57] **ABSTRACT**

An actuator comprising a body having a bore, a piston in said bore and having a piston rod. A system pressure gallery or passage is arranged in the body for the application of system pressure to the annular area between the piston and the piston rod, and a chamber is provided in the body for applying pressure to the other end of the piston. The chamber communicates with the system pressure passage through a fixed orifice, and with an exhaust outlet through a variable orifice controlled by a flapper disc arranged to close the end of an outlet tube. The flapper disc has on its opposite face a pressure balancing tube of the same diameter as the outlet tube and working in a bore in the piston. The pressure in this bore is equalized to the exhaust pressure and the flapper disc is controlled by the spring centered armature of a solenoid or force motor.

4 Claims, 2 Drawing Figures



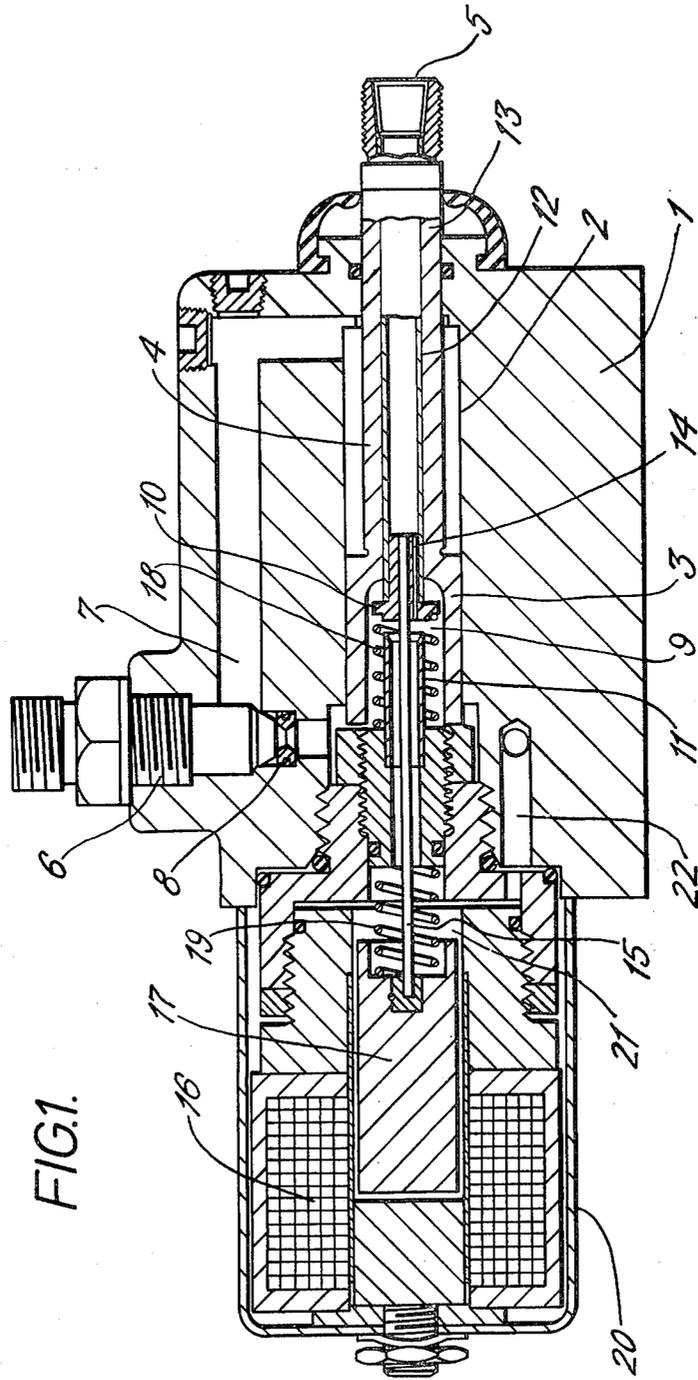
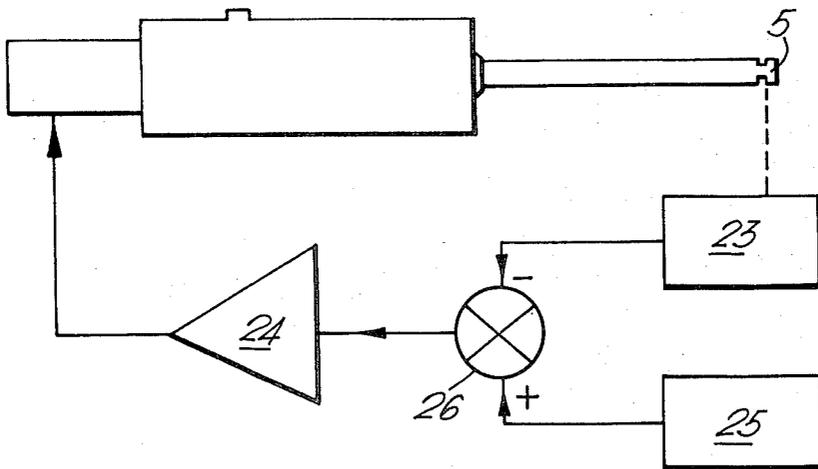


FIG. 1.

FIG. 2.



ELECTRO-HYDRAULIC ACTUATOR

The present invention relates to electrically operated fluid actuators and it is an object of the invention to provide such an actuator of simple and reliable construction. The invention is primarily applicable to electro-hydraulic actuators, but can also be applied to electro-pneumatic actuators.

An actuator according to the invention comprises a piston having a piston rod, a system pressure gallery arranged for the application of system pressure to the annular area between the piston and the piston rod, and a gallery or passage for applying pressure to the other end of the piston, the gallery communicating with the pressure system gallery through a fixed orifice, and with an exhaust outlet through a variable orifice controlled by a flapper disc arranged to close the end of an outlet tube, the flapper disc having on its opposite face a pressure balancing tube of the same diameter as the outlet tube and working in a bore in the piston, the pressure in this bore being equalized to the exhaust pressure, preferably by a passage through the flapper disc, and the flapper disc being controlled by the spring centered armature of a solenoid or force motor. Preferably the outlet tube has a sharp edge at its outer diameter and the pressure balancing tube is of the same outside diameter as this edge.

In operation, the centering springs are set up so that in the absence of any electric current the flapper disc is positioned away from the end of the outlet tube, and the variable orifice thereby fully open. When a suitable current is passed through the solenoid or force motor the flapper disc is drawn towards the outlet tube, closing the variable orifice and increasing the pressure on the piston until the hydraulic forces on it are in balance. Increase in current above this point causes the piston to move outwards, and diminution causes it to be retracted.

The actuator will normally be employed in an electric feed-back circuit by means of which the current to the actuator is controlled in dependence on the position of the piston rod.

The invention includes combinations of an actuator as above described with such an electric feed-back circuit.

The invention will be further described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a longitudinal section through a hydraulic actuator according to the invention, and

FIG. 2 is a diagram showing schematically an actuator with its associated electric feed-back circuit.

Referring first to FIG. 1, the actuator comprises a body 1 having a bore 2 for the piston 3. The piston is formed integrally with a piston rod 4, the outer end of which is provided at 5 with means for coupling it to the apparatus to be actuated.

A system pressure inlet 6 communicates with a gallery 7 by means of which system pressure is applied to the annular area between the piston and piston rod. The cross-section of the piston rod is half that of the piston itself, so the system pressure acts effectively over half the piston area.

The pressure inlet 6 also communicates by way of a fixed orifice 8 with a chamber 9 at the other end of the piston. From this it can escape to tank through a vari-

able orifice formed between the flapper disc 10 and the sharpened edge of an outlet tube 11.

The opposite side of the flapper disc 10 carries a counter-balance tube 12 working in a bore 13 in the piston rod, and maintained at tank pressure by means of a passageway 14 in the flapper disc. Within the perimeter of the outlet tube 11 and the counterbalance tube 12 the pressure on both sides of the disc 10 is equalized by means of the passage 14. Outside this perimeter the pressure on both sides of the disc 10 is equal, being merely the pressure in the chamber 9. The forces acting on the disc 10 are therefore in balance, except for the relatively small Bernoulli force due to the flow of fluid through the gap between the flapper disc 10 and the sharpened edge of the outlet tube 11. The flapper disc is coupled by a rod or cable 15 to the armature 17 of a solenoid, and is also acted on by a spring 18 urging it towards the open position, while a further spring 19 acts on the armature to urge it in the opposite direction.

A cover 20 encloses the solenoid. The space 21 surrounding the armature is filled in operation with fluid at tank pressure and communicates with tank by means of a tank port 22.

Referring now to FIG. 2 the actuator is coupled at 5 to the equipment which it is required to operate and is also linked to an electric pick-off 23 which may be, for example, an inductive or capacitive pick-off or of the potentiometric type. The signal from this pick-off is summed with a demand signal from a signal source 25 at the junction 26, and the resultant error signal is fed to the solenoid winding of the actuator. Preferably the amplifier 24 is arranged to include a standing bias current so as to eliminate any residual stand-off error.

The output from the pick-off 23 represents the position of the actuator, and the amplified signal fed to the solenoid causes the actuator to move in such a direction as to reduce the position error, between demanded position from 25 and the actual position of the actuator.

Referring now also to FIG. 1, the centering springs 18 and 19 are initially set up so that the flapper disc 10 stands clear of the outlet tube 11 when no current is passing through the solenoid, and when about half the maximum operating current is passed through the solenoid the flapper disc moves so that the pressure in the chamber 9 is half the full system pressure, at which point the forces on the two sides of the piston 3 are in balance.

Suppose now that the extension of the actuator falls short of that called for by the demand signal from source 25. The resulting error signal which is amplified by the amplifier 24, increasing the solenoid current, drawing the flapper disc 10 closer to the outlet tube 11, and so increasing the pressure at the inner side of the piston, causing it to extend. If the position error is in the opposite sense the feed-back signal reduces the solenoid current, allowing the flapper disc 10 to move away from the end of the outlet tube 11, the pressure in the chamber 9 to drop, and the piston to be forced inwards by the pressure in the gallery 7.

An electro-pneumatic actuator and feed-back circuit according to the invention are constructed and operate in the same manner. However, different valves will be necessary for the apertures of the restrictors, and additional damping will generally be required in the feed-back circuit.

I claim:

1. An actuator comprising a body having a bore, a piston in said bore and having a piston rod, said body including a system pressure passage arranged for the application of system pressure to the annular area between said piston and said piston rod, and a chamber for applying pressure to the other end of said piston, a fixed orifice through which said chamber communicates with said system pressure passage through said fixed orifice, and a flapper disc arranged to close the end of an outlet tube and provide an exhaust outlet through a variable orifice controlled by said flapper disc, a pressure balancing tube of the same diameter as the outlet tube on the opposite face of said flapper disc, said piston rod having a bore, the pressure balancing tube working in said bore in said piston rod, passage-

way means for maintaining the pressure in said last mentioned bore equal to the exhaust pressure, a solenoid having a spring centered armature controlling said flapper disc.

2. An actuator according to claim 1 in which the outlet tube has a sharp edge and the pressure balancing tube has the same outside diameter as said outlet tube.

3. An actuator according to claim 1 designed for operation with hydraulic fluid.

4. An actuator according to claim 1 in combination with an electric feed-back circuit whereby the current to the actuator solenoid is controlled in dependence on the position of the piston rod and an external demand signal.

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