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HYDRAULIC RELAY

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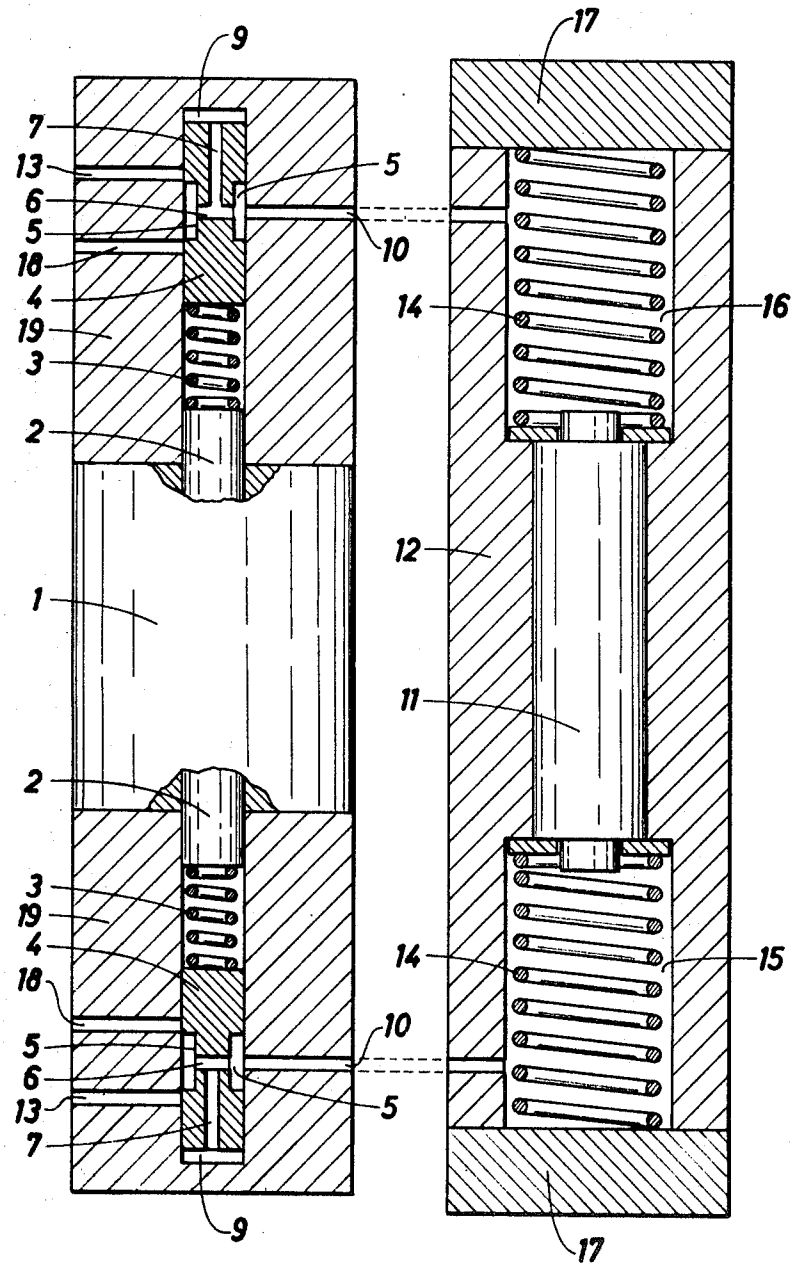

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HYDRAULIC RELAY

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ABSTRACT OF THE DISCLOSURE

The hydraulic relay has a hydraulic control device operable by variable means and which device is constantly under the influence of the hydrostatic pressure of an operating cylinder connected thereto, in a direction opposite to the control force acting to open the pressure medium supplied to the operating cylinder.

The invention relates to a hydraulic relay with a hydraulic control device operable by means of a variable, preferably electromagnetic control force and for the purpose of supplying pressure medium to an operating cylinder and to release pressure medium therefrom, respectively, in such a manner, that the piston of said operating cylinder which is acted upon by one or several springs will perform an operating movement, the magnitude of which is a function of the magnitude of the variation of the control force.

In a previously known type of hydraulic relays, the control device operable by means of said control force co-operates with two opposite valve seats for variable choking of a flow of pressure medium constantly supplied through oblong diaphragms. The bore of the two valve seats are in open communication each with one of two chambers on opposite sides of a plunger which is acted upon by two opposed springs for being maintained in a middle position. When the choking is increased at one of the valve seats and a corresponding decrease in the choking takes place at the other valve seat, a pressure in one of such chambers will be increased and the pressure in the opposite chamber will be reduced, whereupon the plunger will be displaced correspondingly.

The plunger is coaxially arranged within a second plunger in which said chambers are provided, and is provided with sliding surfaces for varying choking of the release of fluid from chambers on opposite sides of the outer plunger, said last mentioned chambers likewise having a constant supply of pressure medium through choking diaphragms. When the first (inner) plunger is displaced upon a change of the control force acting upon the control device it will consequently cause a change in the out-flow from the chambers on opposite sides of the outer plunger in that the outflow from one of the chambers will be completely cut off, whereas the outflow from the other chamber will be increased. The changed pressures on opposite sides of the outer plunger caused hereby will therefore cause such a displacement of the outer plunger that similar outflow conditions in the two chambers will be established anew, i.e., the outer plunger will follow the inner plunger until it is in the same position with respect to the inner plunger as before the change in the control force. This movement of the outer plunger may then be used as an operating movement.

This known relay has several disadvantages. First of all, it is rather complicated, mainly due to the fact that in view of the principle of operation of relay (constant outflow of pressure medium through diaphragms) it will be necessary to insert a servo amplifier, that is the inner plunger, between the control device and the operating plunger. Further, due to the principle operation mentioned, the relay is very sensitive to dirt particles in the pressure fluid which may cause complete or partial blocking of the choking diaphragms and thereby change the characteristic of the relay, i.e., the relation between the magnitude and direction of the control force and the position of the operating plunger. Finally, the control device must be positioned as close to the operating cylinder as possible, so that the conduits connecting the operating cylinder and the valve seats of the control device will be short. Should said conduits be too long they would present such a high resistance to flow to the constant fluid flow, that a change of the choking by means of the valve seats co-operating with the control device would give a relatively smaller change in the pressure conditions on opposite sides of the inner plunger, or, in other words, the sensitivity of the relay would be decreased.

It is often desirable, however, to position the control device and the operating cylinder some distance from one another. This is the case for instance if the control force is generated electrically and the operating movement is to be utilized in a place where the use of electricity would be dangerous.

The present invention has for its object to provide a hydraulic relay which does not present the above mentioned inconveniences. The relay according to the invention is characterized in that the control device is constantly under the influence of the hydrostatic pressure in the operating cylinder in a direction opposite to the control force acting to open the pressure medium supplied to the operating cylinder. Consequently, the relay operates in such a manner that the control device, when actuated by a given control force, will open the pressure medium supply to the operating cylinder until the pressure therein, which depends upon the compression of the spring opposing the movement of the plunger, will be sufficient to move the control device back to closed position against the action of the control force. If the control force is then decreased by a certain value, the hydrostatic pressure in the operating cylinder will be able to displace the control device from the closed position and thereby to open for the outflow of fluid from the operating cylinder, so that the spring will be permitted to move the plunger back until the spring tension and thus, the pressure in the cylinder will anew balance the control force. The invention, thus, provides, in a simple manner and employing static forces, a precise relation between the magnitude of the control force and the position of the operating plunger in the cylinder. Since there are no diaphragms through which there is a constant flow of pressure medium, the risk for malfunctioning due to complete or partial cut-off of the diaphragms will be eliminated. Also, it will be unnecessary to provide a servo amplifier between the control device and the operating plunger since the latter may be made with a sufficiently large plunger area with respect to the surface on which the hydrostatic pressure in the operating cylinder acts upon the control device. As a result of the employment of purely hydrostatic forces for the returning of the control device to the closed position, resistance to flow in long connecting conduits will practically have no influence, and the control device may therefore, be disposed a large distance from the operating cylinder. It is also possible to control several operating cylinders with one and the same control device, so that several operating cylinders may be synchronized, in that they will always show the same hydrostatic pressure. These operating cylinders may have similar or different "specific plunger movement," i.e., the plunger movement caused by a given change in the control force, depending on whether they have similar or different relations between the plunger area and the spring characteristic.

The hydrostatic pressure in the operating cylinder may be made to act upon the control device in numerous different ways, both directly and indirectly. The invention provides a very simple solution to this problem, in that the control device consists of a slide valve in the form of a slide piston provided in a cylinder the operating chamber of which is in communication with the inner chamber of the operating cylinder. A minimum of components is required for such an arrangement. The open connection between the cylinder for the control plunger and the operating cylinder may, according to the present invention, be obtained in a simple manner, in that the control piston bore opening into the operating chamber of the cylinder, said bore communicating with a fluid supply conduit from the control piston to the operating cylinder. This conduit thus serves both for supplying pressure fluid to the operating cylinder and for transferring the hydrostatic pressure thereof to the operating chamber of the control piston cylinder. This may be of importance, especially when the control piston and the operating cylinder are spaced from one another a considerable distance, and if the control piston controls several operating cylinders.

The invention will be more closely described herebelow with reference to the accompanying drawing, which shows a section through a hydraulic relay according to the invention in a double-acting embodiment.

In the relay shown, the control force is provided by means of a solenoid **1** known per se with a premagnetized armature **2** which is displaceable upwards or downwards according to the drawing from the middle position shown, depending upon the direction of the current in the solenoid and with a force which is proportional to the current. At each end of the solenoid **1** there is secured a housing **19** with a bore **9** aligned axially with the armature and closed at the end facing away from the solenoid, a piston **4** being provided in said bore. Between the piston **4** and the armature **2** there is inserted a spring.

Each of the pistons **4** has a cut-down portion **5**, which, depending upon the position of the piston may be made to communicate with a supply-conduit **13** for pressure fluid and an outlet conduit **18** and which in both instances is in constant communication with a conduit **10**. The conduits **10** are connected each to one end of an operating cylinder **12** more closely described herebelow.

The cut-down portion **5** of the pistons **4** further communicate constantly with the closed end of the bore **9**, which serves as a cylinder for the piston through a cross bore **6** and an axial bore **7**.

The operating cylinder **12** comprises a plunger **11** displaceable therein and acted upon by springs **14** provided in chambers **15** and **16** at opposite sides of the plunger to keep the plunger in a middle position. The above-mentioned conduits **10** open each into one of the chambers **15** and **16**.

The relay hereinbefore described operates in the following manner.

When the armature **2** is displaced by the influence of a control current in the solenoid **1**, for instance downwards according to the drawing, it will displace the lower piston **4** by means of the spring **3** downwards and thereby establish communication from the pressure fluid supply conduit **13** to the conduit **10** opening into the cylinder chamber **15**. Pressure fluid is therefore supplied to the chamber **15**. The plunger **11** will therefore be displaced upwardly against the action of the spring **14** provided in the chamber **16** and will simultaneously displace fluid from the chamber **16** through the conduit **10** connected thereto to the upper piston **4** which is taken to be disposed in the middle position shown in the drawing where the connection to the outlet conduit **18** is closed. The supplied fluid will therefore enter through the bores **6** and **7** into the closed end of the upper cylinder **9** and will thereby cause such a displacement of the upper piston that the latter will open the connection from the chamber **16** to the outlet conduit **18**. The plunger **11** may thus be displaced upwardly under the influence of the pressure fluid entering into the chamber **15** and against the action of the spring **14** provided in the chamber **16**. The hydrostatic pressure in the chamber **15** which is determined by the compression of the spring **14** provided in the chamber **16** will then act through the conduits **6** and **7** also on the end surface of the lower piston **4**, and when this pressure has reached such a value that it will be able to overcome the control force exerted on the plunger by the armature **2** and the spring **3**, the piston will be moved back to the middle position shown in the drawing and will thereby cut off the pressure medium supply to the chamber **15** in the operating cylinder **12**. The plunger **11** has thus been displaced a distance upwardly corresponding to the control force generated by the solenoid **1** and the armature **2**. The relation between the control force and the displacement of the operating plunger may be linear or non-linear, depending upon the characteristics of the springs **14**, but it will always be unique for a given spring characteristic. The plunger **11** will remain in the displaced position as long as the control current in the solenoid is maintained or unchanged.

If the control current is changed, for instance decreased, the forces acting upon the pistons i.e., the control force generated by the solenoid **1** and the hydrostatic pressure in the cylinders **9**, will no longer balance one another, and the pistons will therefore be displaced in such a manner, that a balanced condition, where the plunger **11** is in a position corresponding to the control force will be obtained anew through the supply of fluid to the operating cylinder **12** and the release of fluid therefrom, respectively.

In the embodiments shows and described, the plunger **11** may be moved to both sides of a middle position corresponding to the control force "zero." However, it will also be possible to make the relay act in a single direction, so that the plunger **11** may be displaced only, for instance upwardly from the position shown in the drawing and back to said position. In such a case, the upper control piston housing **19** and the lower spring **14** are left out.

I claim:

1. A hydraulic relay comprising a housing having a bore closed at one end and open at its opposite end, a piston slideable in said bore, a spring in said bore on the side of said piston opposite to said bore closed end, a fluid supply conduit in said housing extending to said bore, an outlet conduit in said housing also communicating with said bore, said piston having an axial bore opening in the closed end of said bore and a lateral bore opening in said axial bore and positioned for communicating with either said supply conduit or said outlet conduit for different positions of said piston, a cylinder having a bore and a pair of chambers on each side of and communicating therewith, a plunger displaceable in said cylinder bore, a second spring in one of said cylinder chambers tending to move said plunger towards an end of the other of said cylinder chambers, a conduit connecting said housing bore, piston lateral bore, and said other cylinder chamber at all times, and electrically operated variable means mounted on said housing bore open end and extending into said housing bore and capable of pressing said first spring and thus said piston to a position placing said supply conduit in communication with said piston lateral bore.

2. A hydraulic relay as claimed in claim **1** including a second housing having a bore closed at one end and open at its opposite end, a second piston slideably in said second housing bore, a third spring in said second housing bore on the side of said second piston opposite to said second housing bore closed end, a second fluid supply conduit in said second housing extending to said second housing bore, a second outlet conduit in said second housing also communicating with said second housing bore, said second piston having an axial bore opening in the closed end of said second housing bore and a lateral bore opening in said second piston axial bore and positioned for com-

municating with either said second supply conduit or said second outlet conduit for different positions of said second piston, a fourth spring in said cylinder other chamber tending to move said plunger towards said second spring, a conduit connecting said one of said cylinder chambers and said second housing piston lateral bore at all times and said variable means being positioned between said housing bore open ends and also extending into said second housing bore and capable of pressing said third spring and thus said second piston to a position placing said second supply conduit in communication with said second piston lateral bore.

3. A hydraulic relay as claimed in claim 1 wherein said variable means is a reversible solenoid mounted on said housing and an armature slideable in said solenoid and having an end positioned against said first spring.

References Cited

UNITED STATES PATENTS

2,273,171	2/1942	Bennett	91—434X
2,918,085	12/1959	Govan et al.	91—434X
3,520,322	7/1970	Kaptur	137—116.3
3,103,230	9/1963	Kutsche	137—116.3
3,452,776	7/1969	Chenoweth	137—505.28

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