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3,446,229

HYDRAULIC SERVOSYSTEM

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FIG. 1

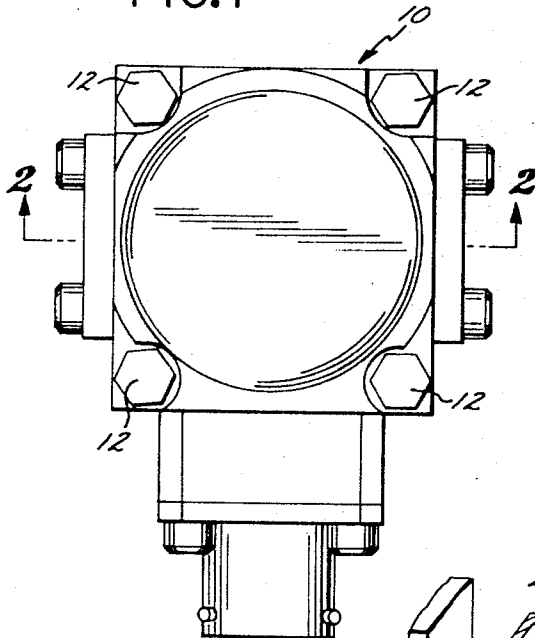


FIG. 2

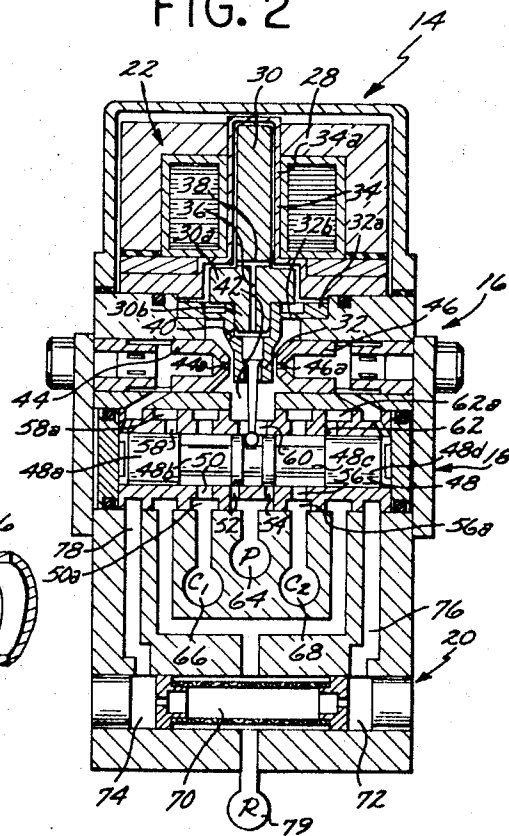


FIG. 3

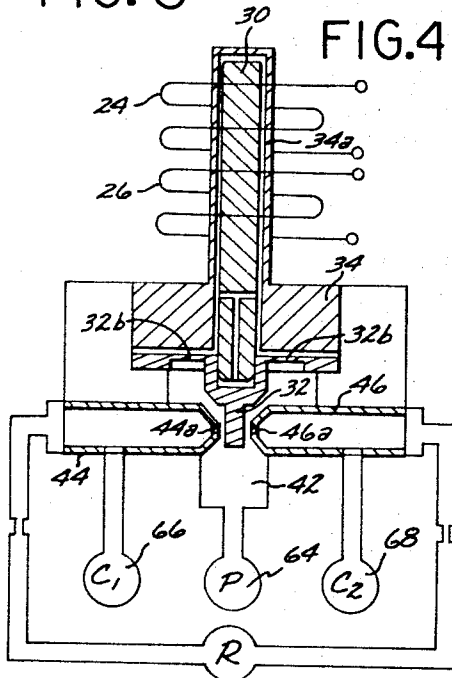


FIG. 4

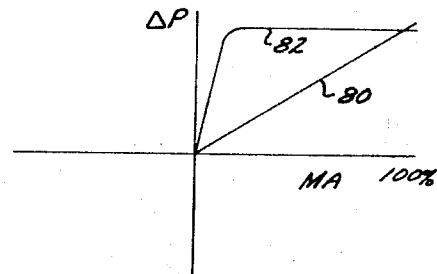


FIG. 5

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1

2

3,446,229

HYDRAULIC SERVOSYSTEM

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5 Claims

ABSTRACT OF THE DISCLOSURE

This is an improved hydraulic servosystem wherein relatively small changes in electrical current flow through an electromagnetic operator effects predetermined accurate changes in the control function of a flow control device.

It is characterized by requiring the fluid controlled by the valve member to flow around such member prior to its entering the flow control orifice. More specifically, the source of fluid pressure is so oriented with respect to the valve or flow control member that the flow of fluid is not in opposition to the magnetic force attempting to locate the precise position of the flow control member but rather is additive to such magnetic force. Thus, the valve member is upstream of the flow control orifice.

The present invention relates generally to hydraulic servosystems, and more particularly to such systems which exhibit improved operating characteristics.

Hydraulic servosystems are used extensively today for controlling the operation of many different instrumentalities. Such systems are particularly useful in conjunction with electrical operating means whereby variations in electrical current flow can be used to control relatively large physical movements as effected by the hydraulic system.

Hydraulic servosystems in the broadest definition, are not new today, but many of the prior systems have not operated satisfactorily for various reasons. One particular shortcoming of prior systems has been the inability to respond to very small changes in electrical current flow. That is, under certain conditions, it is desirable, if not mandatory, to have a pressure responsive element such as a piston, respond to very small changes in current flow.

The electroresponsive actuator used in such cases usually comprises an electromagnetic operator such that the magnetic polarization is varied to provide the different control conditions. In attempting to alleviate the above-mentioned shortcomings, improvements have been made in the electromagnetic operators, such as by utilizing resistance free mounting means for the armature so that it will respond to extremely small changes in magnetic flux as accompanies a very small change in control current applied to such operator.

However, in spite of the various prior improvements that have been attempted, there has heretofore existed a limitation regarding the minimum amount of current variation that could be used to control a hydraulic servosystem. One reason for this has been the fact that the armature of the electromagnetic actuator has been required, under certain circumstances, to work against the fluid pressure being controlled. This condition has not only required relatively large forces to accomplish the desired work but has also resulted in a less efficient, less sensitive and less accurate servosystem.

It is an object of the present invention to provide a hydraulic servosystem which is considerably more efficient than prior systems in converting a control energy into actual work.

Another object of the present invention is to provide a hydraulic servosystem as characterized above, wherein the control force is not caused to act directly against the force of the hydraulic fluid.

Another object of the present invention is to provide a hydraulic servosystem as characterized above, which utilizes the force of the pressurized hydraulic fluid to advantage in assisting the control function during the most critical periods of operation of the servosystem.

A still further object of the present invention is to provide a hydraulic servosystem as characterized above, wherein the direction of fluid flow is reversed as compared to previous systems so that the movable control element is urged toward the control orifice by the pressure of the fluid which it is controlling.

A still further object of the present invention is to provide a hydraulic servosystem as characterized above which is simple and inexpensive to manufacture and which is rugged and dependable in operation.

The novel features which I consider characteristic of my invention are set forth with particularity in the appended claims. The device itself, however, both as to its organization and mode of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIGURE 1 is a top plan view of a hydraulic servosystem according to the present invention;

FIGURE 2 is a sectional view of the system of FIGURE 1, taken substantially along line 2—2;

FIGURE 3 is a diagrammatic sectional view of certain portions of the system of FIGURE 1;

FIGURE 4 is a fragmentary sectional view of a control element and orifice of the present system; and

FIGURE 5 is a graph of certain characteristics of previous systems as well as the present invention.

Like reference characters indicate corresponding parts throughout the several views of the drawings.

Referring to FIGURE 1 of the drawings, there is shown therein a servosystem according to the present invention contained within a housing identified generally with the numeral 10. Such housing, as shown more particularly in FIGURE 2, is formed of several housing members which are held together by any appropriate fastening means such as bolts 12.

The subject servosystem comprises generally an electromagnetic actuator 14, a hydraulic actuator 16, slide valve 18 and a pressure responsive element or slave valve 20. These parts cooperate in a manner not unlike servosystems heretofore available, but differ therefrom by the manner in which the fluid flow to the slave valve is controlled, as will hereinafter become apparent to those persons skilled in the art.

The electromagnetic actuator 14 comprises an electromagnetic unit 22 which includes one or more windings, shown schematically in FIGURE 3 at 24 and 26, and suitable magnetic core means 28. As is well-known in the art, such electromagnetic actuator is frequently termed a "torque motor" and responds to changes in electrical energy in the windings 24 and 26 to create changes in magnetic flux flow along predetermined paths. Such flux flow is operable to attract an armature 30 in opposite directions as will hereinafter be explained in greater detail.

The armature of the present embodiment is formed integrally with a control element 32, the resulting combination being termed an "armature-control element" throughout the description and claims.

As shown most clearly in FIGURE 2 of the drawings, electromagnetic actuator 14 includes a frame member 34 which comprises a cylindrical hollow portion 34a. Such portion constitutes a housing for the armature 30,

such armature being movable therewithin in accordance with the aforescribed changes in magnetic flux afforded by the electromagnetic unit 22. Frame member 34, of course, is firmly anchored to the other housing members as will be readily apparent to those persons skilled in the art.

The armature-control element 32, as above described, may be formed as a single unitary structure but is shown in the drawings as comprising two separate elements firmly attached together. Armature 30 is generally cylindrical in construction and is provided with an enlarged intermediate portion 30a and a reduced lower portion 30b. The latter portion is press-fitted within an opening formed in the control element 32.

Element 32 is further formed with an annular flange 32a, a portion 32b of which is reduced in thickness to provide annular flexible mounting means. The peripheral portion of flange 32a is heavier and is firmly fastened between suitable housing members so as to firmly anchor the armature-control element in proper position. The relatively thin reduced annular portion 32b permits the armature 30 and the control element 32 to pivot as a unit as will hereinafter become apparent.

Suitable pressure equalizing passageways 36 and 38 are provided within the armature 30, and a similar opening 40 is provided in the side of control element 32. The pressure within the armature-control element is thus caused to equal the pressure therewithout so that such fluid pressure in no way influences the position or movement of such structure.

The control element 32 is positioned within a fluid chamber 42 for movement between certain flow controlling positions. Such chamber 42 is formed between various housing members as shown in the drawings.

A pair of oppositely disposed orifice members 44 and 46 are positioned within the housing to extend within the fluid chamber 42. Such orifice members are individually formed with control orifices 44a and 46a, respectively, the aforementioned placement of such orifice members thereby disposing said orifices in opposed relation as shown in FIGURES 2 and 3 of the drawings. As will hereinafter be explained in greater detail, the control element 32 is movable relative to and against each of said orifices, alternatively, to control the flow of fluid there-through.

Immediately beneath pressure chamber 42 as shown in FIGURE 2 of the drawings, is a slide valve 48. Such valve comprises four annular control portions 48a, 48b, 48c and 48d which cooperate with various fluid ports formed in a cylinder or cylindrical housing for said valve. The fluid ports are shown in FIGURE 2 at 50, 52, 54, 56, 58, 60 and 62, the ports 50 and 56 having both upper and lower portions in the cylinder as shown in FIGURE 2.

Each of the fluid ports in the cylinder cooperates with a separate one of the annular control portions of the slide valve 48, and is connected to one or more passageways.

For communication with ports 52 and 54 there is provided a source of fluid pressure 64 which may take substantially any desired form. In like manner, there is associated with each of ports 50 and 56 suitable reservoirs 66 and 68, respectively.

The slave element 20 shown in the lower portion of FIGURE 2, may take substantially any desired form. For instance, the piston 70 may be employed to respond to changes in fluid pressure in chambers 72 and 74. That is, if the pressure in chamber 72 predominates, such piston 70 is moved to the left, and conversely, if the pressure in chamber 74 predominates, the piston 70 is moved to the right. As will be readily apparent to those persons skilled in the art, the slave unit 20 shown in the drawings is primarily for purposes of illustration, it being understood that corresponding equipment or instrumentalities might be utilized which produces the same or

similar response to the operation of the electromagnetic actuator. The chambers 72 and 74 are provided with fluid flow through conduits 76 and 78 respectively which receive fluid under pressure from the orifice members 46 and 44, respectively, in a well known manner. A reservoir or accumulator 79 is provided for relieving the pressure at one end of the piston 70 when the latter is caused to move in response to increased pressure at the other end thereof.

Referring to the schematic showing in FIGURE 3 of the drawings, the operation of the subject invention will now be explained. As is well understood, the armature 30 is pivoted to the left or right as viewed in this figure in accordance with the energization of either or both of the windings 24 and 26. The direction of current flow in such windings as well as the amount of such current flow determines the amount and direction of flux flow which results. Accordingly, the armature 30 is attracted to either the right or the left.

The relatively thin disk like mounting means 32b enables such armature to be pivoted in response to small magnetic flux flow by such windings. As said armature pivots, of course, the flow control element 32 is caused to approach one or the other of the orifices 44a and 46a. In the event such armature is moved to the left, as viewed in FIGURE 3, such flow control element approaches the orifice 46a. Conversely, if the armature 30 is moved to the right, the control element approaches the orifice 44a.

Initially, the source of fluid pressure 64 provides fluid pressure within the chamber 42. Such pressure results in fluid flow from chamber 42 through both of the orifices 44a and 46a as well as orifice members 44 and 46.

When the armature 30 is attracted to one position or the other, the control element is moved into a flow restricting position with respect to one of the orifices 44a and 46a. Such flow of fluid has considerable effect upon the action of the control element 32 as it cooperates with the respective orifice due to the fact that the path around such element is restricted.

Heretofore, such fluid flow has been in the direction from the respective orifice member into the pressure chamber 42, such prior systems having the source of fluid pressure so associated with the several orifice members.

As shown in FIGURE 4 of the drawings, the projection of the orifice on the control element 32 provides an indication of the path of fluid flow in prior devices from the orifice to and against the side of the control element 32. Such fluid flow resulted in the application of a force to the control element, which force constituted a "spring effect" which worked against the control action of the control element in moving toward the orifice. That is, in attempting to restrict the flow of fluid from an orifice toward the control element, the control element was required to generate sufficient additional force to overcome the dynamic characteristics of the moving fluid.

In designing servosystems of such prior construction, it was necessary for such "spring effect" which was calculable as a constant to be taken into account in evaluating the various physical and functional properties of the electromagnetic actuator associated therewith.

With the present invention the flow of such fluid is from the chamber 42, around the control element 32 and then through the respective orifice. The net effect of this arrangement is that the "spring effect" is in the direction of movement of the control element 32. This means that a smaller electromagnetic actuator can be employed and the resulting system is considerably more efficient and sensitive, and is easier to design. Also, it has been found that the system according to the present invention is more reliable and is less expensive to manufacture.

A diagrammatic showing of the improved operational characteristics is shown in FIGURE 5 of the drawings. The curve 80 therein shows for prior systems the relationship between the amount of current flow in the electromagnetic actuator necessary to effect predetermined

5

change in pressure as applied to the slave element. The curve 82 shows the same such relationship but as derived from a system according to the instant invention. It will be noted from these curves that whereas a relatively large change in current flow is necessary with prior devices to effect a predetermined change in pressure on the slave element, the present invention is such that only a small current flow is required to accomplish the same work.

Additionally, such new design increases the sensitivity and accuracy of the resulting servo system due to the cooperative nature of the fluid pressure and the electromagnetic forces as applied to control element 32.

As will be readily apparent to those persons skilled in the art, the other portions of the servosystem are in accordance with prior teachings. The movement of control element 32 also changes the position of slide valve 48 within the cylinder thereof. This results in appropriate control function of the various ports along such cylinder so that fluid under pressure is appropriately applied to the slave piston 70. Also, such control function results in the opening of certain bleed ports so that the pressure on the opposite side of the slave piston is relieved.

It should also be realized that the action of slide valve 48 controls the application of fluid pressure to the chamber 42 as above mentioned. The position of annular control elements 48b and 48c of slide valve 48 with respect to the respective ports 52 and 54 controls the flow of fluid under pressure from source 64 to such chamber. Such operation, however, is part of the overall servosystem as is well understood in the art.

It is thus seen that the present invention provides a unique servosystem which is considerably more accurate, reliable and sensitive as compared to prior systems. Also, the present system is capable of operating properly in response to very small changes in current flow.

I claim:

1. In an electromagnetic servo valve the combination of, means forming a fluid chamber having a wall formed with an orifice, an electromagnetic actuator comprising electrically energizable means and an armature to be moved in accordance with energization thereof, a flapper-type flow control element within said chamber formed integrally with said armature to provide a unitary structure therewith to move relative to said orifice in response to movement of said armature, and means affording fluid pressure to said chamber causing said orifice to be downstream of said flow control element whereby said element

6

is substantially immune to variations in the physical characteristics of the fluid caused by passage thereof through said orifice.

2. The invention defined in claim 1, wherein a valve body is provided with an enclosure for said armature, and pivotal mounting means is provided for said unitary armature and flow control element.

3. The invention defined in claim 2, wherein said electromagnetic actuator comprises an electromagnetic winding about said enclosure to attract and repel said armature to position accordingly said flow control element relative to said orifice.

4. The invention defined in claim 3, wherein substantially linear biasing means is provided between said valve body and said unitary armature and flow control element to act in opposition to the attraction and repulsion of said electromagnetic actuator to thereby cause the position of said flow control element to be infinitely variable within predetermined limits relative to said orifice.

5. In an electromagnetic servo valve the combination of, means forming a fluid chamber having two walls each of which is formed with an orifice, an electromagnetic actuator comprising an electromagnetic winding and an armature to be magnetically attracted and repelled, a flapper-type flow control element within said chamber formed integrally with said armature to provide a unitary structure therewith for reverse movement relative to said orifices in response to movement of said armature, substantially linear biasing support means for said unitary structure, and means affording fluid pressure to said chamber causing each of said orifices to be downstream of said flow control element whereby said element is substantially immune to variations in the physical characteristics of the fluid caused by passage thereof through either of said orifices.

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