

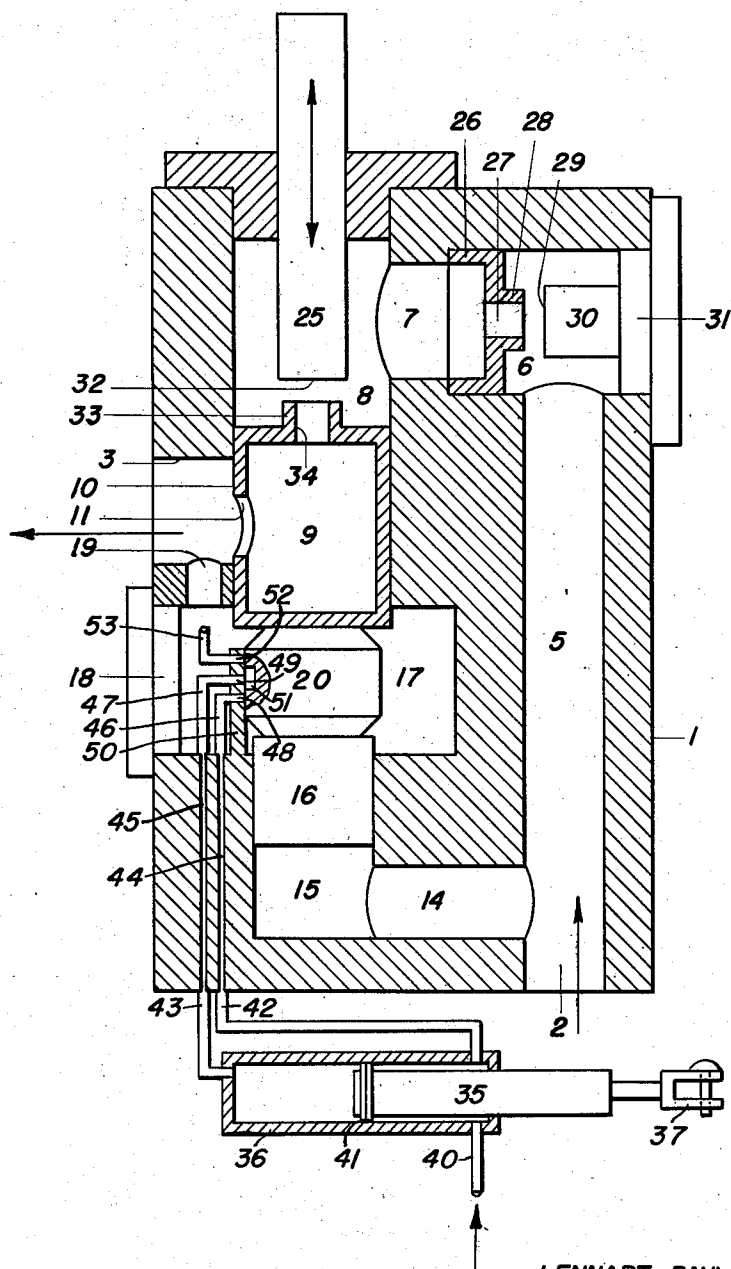
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L. P. PALSSON

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SERVO MECHANISM

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Inventor

LENNART PAUL PALSSON

Eugene K. Helander

Attorney

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SERVO MECHANISM

Lennart Paul Palsson, Karlskoga, Sweden, assignor to Aktiebolaget Bofors, Bofors, Sweden, a joint-stock company of Sweden

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1 Claim. (Cl. 121-41)

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This invention relates to servomechanism and more particularly to a novel hydraulically operated servomechanism wherein a controlling element when actuated brings about corresponding actuation of a controlled element through changes in fluid pressure independently of the viscosity of the fluid employed.

Fluid operated servomechanisms as heretofore constructed have operated satisfactorily under certain conditions but not under others, such for example as when a change in temperature or the like has affected the viscosity of the operating fluid.

It is therefore a principal object of the invention to provide fluid actuated servomechanism so designed and constructed as to operate satisfactorily independently of the viscosity of the operating fluid and thus capable of producing accurate correspondence of positioning of the controlled element to movements of the controlling element notwithstanding changes which may occur in the viscosity of said fluid.

Other objects, purposes and advantages of the invention will hereafter more fully appear or will be understood from the following description of one embodiment of it diagrammatically illustrated in the accompanying drawing which shows in its single figure partly in a transverse section and partly in elevation the essential elements thereof.

In the said drawing, which represents perhaps one of the most readily understandable forms of the invention, there is illustrated a main housing 1 provided with certain fluid chambers and passages as will hereinafter be more fully described and it will be understood that means (not shown) are normally employed for supplying to the housing through a port 2 a substantially constant flow of operating fluid which is exhausted or allowed to escape therefrom through a second port 3. The passages and chambers in the housing through which the fluid flows between these two ports include a rectilinear passage 5, a fixed throttle chamber 6, an intermediate passage 7, variable throttle chamber 8, the interior cavity or chamber 9 of a movable piston 10 and the exhaust port 11 of this piston which connects directly with exhaust port 3 of the housing. A branch passage 14 connecting a chamber 15 in the housing with passage 5 allows the head pressure of the fluid supply to be maintained against one side of a piston 16 in this chamber while an intermediate chamber 17 closed by a plug 18 and interposed between chambers 8 and 15 is connected with exhaust port 3 of the housing through a port 19 to maintain the exhaust pressure of the fluid

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in chamber 17 which also contains controlled element 20 of the servomechanism shown as embraced therein by pistons 10 and 16, this element being arranged to actuate by suitable means hereinafter described the mechanical or other element to be influenced by its movements in response to those of the controlling element 25; thus for example element 20 or its equivalent may operate a valve to control admission of fluid pressure to a cylinder for actuating a piston therein.

Reference has been made to fixed and movable throttles, and these regulate the flow of fluid through the mechanism to assist in causing the controlled element to respond accurately to movements of the controlling element and the structure and functions of these throttles will now be more fully explained. The fixed throttle in chamber 6 comprises a collar 26 having a hole 27 at its center surrounded by a short, thin-walled tube 28 or the like projecting into chamber 6 and terminating a predetermined distance from the end face 29 of a rod 30 which projects from the inner face of a plug 31 forming a closure for the chamber, the edge of the tube and the rod face thus defining an annular fixed throttle port through which fluid can flow from chamber 6 into tube 28 at a rate proportional to the differential pressures and thence through passage 7 to the variable throttle chamber 8. The controlling element 25 projects into the latter and is provided with a plane end face 32 lying adjacent the end of a thin-walled tube 33 preferably as closely similar as practical to tube 28 and providing from the annular variable throttle port it defines with element 25 a passage 34 into the interior cavity 9 of piston 10; the flow of fluid through this port is of course correspondingly a function of the differential pressures and the spacing of element 25 from the adjacent end of tube 33 which changes momentarily as the former is moved.

Desirably the effective area of piston 10 is about twice as great as that of piston 16 although this precise relation is not essential provided piston 10 is always the larger in area, and when the mechanism is in operation with fluid being supplied under predetermined constant pressure through port 2, piston 10 is normally subjected to a smaller pressure differential per unit area tending to move it toward piston 16 than is the latter in being urged toward piston 10.

Thus if the effective area of the larger piston 10 is F surface units and that of smaller piston 16 is $X \times F$ surface units where X has any positive value less than unity, when full fluid pressure P is applied to the mechanism through port 2 a

force of $X \times F \times P$ force units is exerted through passage 14 and against piston 16 in chamber 15. This force is opposed by fluid pressure in chamber 8 tending to move piston 10 and controlled element 20 in opposition to piston 16 so that when these parts are in equilibrium the effect of the throttles on the flow of fluid through the mechanism is such that the force exerted against piston 10 opposing that exerted in chamber 15 against piston 16 may be expressed as $F \times P'$ force units. Disregarding the relatively negligible effects on the pistons of the pressure in chamber 17, to maintain equilibrium $F \times P'$ must equal $X \times F \times P$ and consequently $P' = X \times P$ which demonstrates that the ratio of the effective areas of pistons 10 and 16 is an index of the ratio of the pressures on opposite sides of the fixed throttle during equilibrium conditions in the system and that P' is less than P .

The line pressure P exerted back of piston 16 is as noted desirably relatively constant; consequently when for any reason the pressure in chamber 8 falls below the lower value P' , piston 16 can move under the influence of pressure P to correspondingly move controlled element 20 and piston 10 in a direction to restrict flow of fluid through the variable throttle from chamber 8 into piston 10. When the pistons are so proportioned that their effective areas have the relation mentioned, as when the effective area of piston 10 is twice as great as that of piston 16, the said movement of both pistons and the controlled element as a unit continues until the rate of fluid flow through the variable throttle has been sufficiently restricted to build up pressure in chamber 8 equivalent to the arithmetic mean of the line pressure in passage 5 and the exhaust pressure at port 3, re-establishing a condition of equilibrium wherein the flow of the fluid through both throttles is equalized, regardless of its viscosity, and P' again equals $X \times P$.

Conversely when the pressure in chamber 8 becomes greater than said lower value P' , since the effective area of piston 10 is larger than that of piston 16 the former can move the latter and the controlled element 20 in the opposite direction until through the accompanying widening of the annular port of the variable throttle the excess pressure is relieved, the pistons and controlled element stopping when the pressure in the chamber reaches the value of $X \times P$ as equilibrium conditions are again restored.

It is thus evident motion of controlled element 20 results from changes in pressure conditions in chamber 8 relatively to those in passage 5 and at port 3 and that in the mechanism here being described equilibrium conditions obtain when the fluid pressure in the former corresponds to the arithmetic mean of the pressures in the latter whatever be the viscosity of the fluid employed. Consequently, assuming equilibrium conditions to obtain with the controlling and controlled elements stationary, if controlling element 25 is now moved to a new position thereby either to enlarge or restrict the variable throttle port the pressure in chamber 8 is immediately correspondingly either decreased or increased as more or less fluid than is admitted to it from the fixed throttle can flow through the variable one; thereupon the unit consisting of pistons 10 and 16 and controlled element 20 under the influence of the pressure differential on the pistons immediately moves correspondingly to the movement of controlling element 25 and promptly restores equilibrium conditions with the controlled element in

a new position spaced from its former one the same distance and direction as the new position of the controlling element is spaced from its former one.

It is especially to be noted that substantial independence of the viscosity of the fluid is attained in the operation of the device, in part through the construction of the fixed and variable throttles, each of which is formed by a relatively thin walled tube of appreciable length, or a part of similar shape, cooperative with a plane surface and defining therewith an annular port having on the side adjacent the tube minimum radial width whereby under equilibrium conditions the same volume of fluid flows through both throttles per unit of time despite differences in absolute pressure conditions, and when the equilibrium is disturbed by motion of the controlling element it is automatically restored, with corresponding motion of the controlled element, regardless of the viscosity of the fluid supplied, which therefore may change from time to time without noticeably affecting the operation of the mechanism.

As above mentioned the controlled element can be adapted to perform any desired appropriate operation, as to open or close a valve or transmit motion to any other mechanical element, similarly to the controlled elements of servomechanisms generally as heretofore known.

Apparatus controlled by the servomechanism may for example include an ordnance gun provided with auxiliary equipment for moving the gun barrel in correspondence to motion of a sighting element (not shown) to which the controlling element 25 may be connected for movement with it. The element 25 through controlled element 20 thus directs a servo piston 35 movable in a cylinder 36 and having at its outer end a clevis 37 for connection with the gun to supply the force for moving the latter. The cylinder 36 is provided with an inlet pipe 40 connected with a source of fluid under pressure, conveniently the same source as that which supplies port 2, and piston 35 therein is proportioned to expose to pressure in the cylinder on opposite sides of sealing rings 41 differential surface areas preferably bearing an area relationship of 2:1. The cylinder is connected thru pipes 42, 43 with fluid passages 44, 45 in the main housing 1 and further pipes 46, 47 connect these passages with ports 48, 49 respectively in a baffle 50 which the directed element 20 slidably engages. A by-pass recess 51 in the latter in one position of the element connects ports 48, 49 together and in another position connects the latter of these ports with outlet port 52 connected with a pipe 53 adapted to discharge fluid into chamber 17 and thence through port 19. The drawing shows element 20 in a neutral position with port 49 disconnected from ports 48 and 52 and when the element moves up from that position in response to upward movement of element 25 port 49 is connected through by-pass 51 with outlet port 52 thereby allowing the pressure applied through inlet 40 to move piston 35 to the left since element 20 then obstructs port 48 and prevents escape of fluid from the right hand end of cylinder 36. Moreover when element 20 moves down from the position illustrated ports 48, 49 are connected together through by-pass 51 and pressure in cylinder 36 is immediately equalized on opposite sides of piston 35 at about the pressure of the source supplying fluid through inlet pipe 40. As noted the areas of the piston against

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which this pressure reacts are in a 2:1 ratio favoring movement of the piston toward the right when the pressure in the left hand end of the cylinder is more than half that in the other end so the piston quickly responds by moving toward the right when the directing element 25 and hence controlled element 20 moves downward.

While I have herein diagrammatically shown and particularly described one embodiment of the invention it will further be understood I do not desire or intend thereby to be limited or confined in any way, as in the adaptation of the said or other embodiments thereof to particular uses and conditions changes and modifications in the form, structure and relationship of the several parts and instrumentalities employed will readily occur to those skilled in the art and may be made if desired without departing from the spirit and scope of the invention as defined in the appended claim.

Having thus described my invention, I claim and desire to protect by Letters Patent of the United States:

An hydraulic servomechanism to control an arbitrary body, which mechanism comprises two antagonistic pistons of different areas, and with opposite actions, the smaller being actuated by a particular working pressure, and the larger

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being actuated by a pressure resulting between two throttles, connected in series, through which pressure fluid from said working pressure is adapted to flow on its way to an arbitrarily chosen lower outlet pressure, one of said throttles being fixed, and the other being responsive to impulses from both controlling and controlled elements, characterized by the members constituting each of said throttles having the same mechanical design and adapted to maintain identical flow conditions at both throttles when their positions are similar irrespective of the viscosity of the fluid, and by the area of the larger piston being a multiple of that of the smaller one.

LENNART PAUL PALSSON.

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