

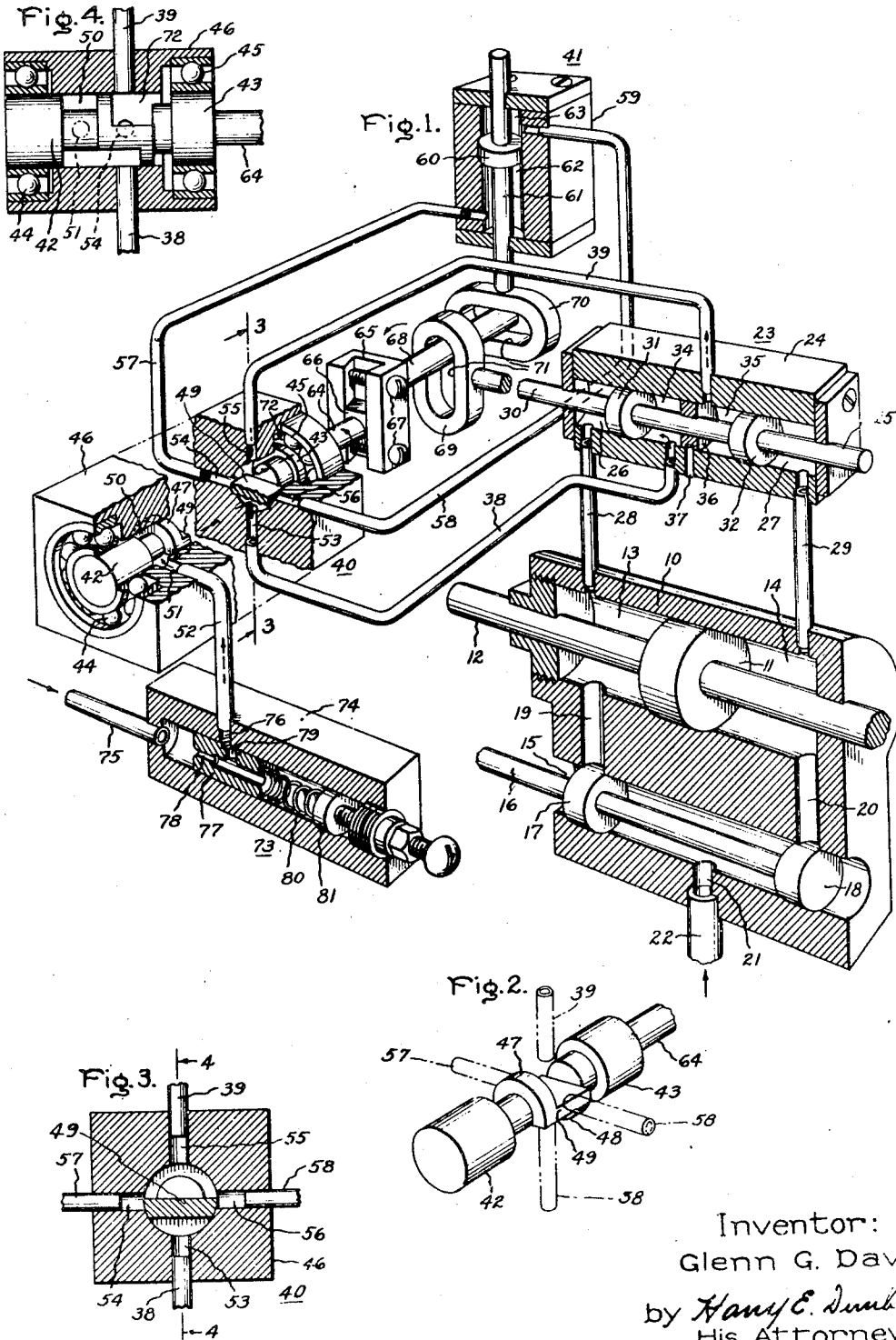
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HYDRAULIC CONTROL MECHANISM

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HYDRAULIC CONTROL MECHANISM

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The present invention relates to hydraulic control mechanisms of the type in which two elements of a device, such as the casing and the piston of a servomotor, are subject to intermittent, relative movements due to hydraulic action. In servomotors the movement of the piston or plunger is effected by change of pressure in the pressure chamber of the servomotor and this change of pressure ordinarily is controlled by a pilot valve or like control member. Any change in pressure in the pressure chamber of the servomotor creates a force, positive or negative, which tends to move the piston. If the piston is already moving, a smaller force is required to affect such movement than when the piston is at rest because in the latter case the force must overcome the friction of rest of the piston which is considerably higher than the friction of movement.

Whenever great accuracy is required of hydraulic control mechanisms it becomes desirable to reduce the friction of rest to a minimum or to eliminate it entirely.

The general object of my invention is to provide an improved construction and arrangement of hydraulic control mechanisms of the kind above specified in which the friction of rest of a hydraulic device, especially of the piston of a hydraulic motor, is reduced or substantially eliminated. This is accomplished in accordance with my invention by a hydraulic control mechanism which includes hydraulic means for vibrating the piston or like element of a hydraulic motor or like device. These means in a preferred embodiment consist of an adjustable flow control mechanism whereby the frequency of vibration of the element to be vibrated may be varied and maintained constant. The vibrating means preferably has an auxiliary motor with a chamber connected to the pressure chamber of the hydraulic motor to be vibrated and means for reciprocating the piston of the auxiliary motor to effect a continuous alternate increase and decrease of pressure in the auxiliary hydraulic motor, more particularly in the pressure chamber therein and accordingly in the pressure chamber of the main hydraulic motor.

For a better understanding of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawing.

In the drawing Fig. 1 illustrates a diagrammatic, perspective view, partly in section, of a hydraulic control mechanism embodying my in-

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vention; Fig. 2 is a perspective view of a detail of Fig. 1; Fig. 3 is a section along line 3—3 of Fig. 1; and Fig. 4 is a section along line 4—4 of Fig. 3.

The arrangement shown in the drawing comprises a hydraulic device in the form of a hydraulic motor or servomotor having a casing 10 with a cylindrical bore and a piston 11 secured to a stem 12 slidably disposed in the cylindrical bore and forming therewith two pressure chambers 13, 14 on opposite sides of the piston 11. The piston stem projects slidably through the end walls of the casing. The supply of fluid under pressure to the pressure chambers 13, 14 and the discharge of fluid therefrom are controlled by a control member or pilot valve 15 which has a casing united with the casing 10 and a cylindrical bore with a movable valve member therein. This valve member has a stem 16 and valve heads 17, 18 secured thereto and associated with two channels or ports 19, 20 leading to the chambers 13, 14. A third channel or port 21 is formed in the casing between the valve heads 17, 18 and connected to a conduit 22 for conducting fluid under pressure from a source, not shown, to the pilot valve 15.

In the position shown, the valve heads 17, 18 are in their normal position in which they cover the ports 19, 20. Upon movement of the pilot valve stem 16 to the left, fluid under pressure may be conducted from the conduit 22 through the pilot valve and the port 19 to the pressure chamber 13 and at the same time fluid under pressure may be discharged from the pressure chamber 14 through the port 20 and the right-hand open end of the pilot valve casing. During such operation the piston 11 of the hydraulic motor with its stem 12 are forced towards the right and this movement continues until the pilot valve heads 17, 18 are restored to their normal position in alignment with the ports 19, 20 respectively.

Upon movement of the pilot valve stem 16 towards the right, fluid under pressure may be conducted from the conduit 22 to the chamber 14 while fluid under pressure is discharged from the chamber 13 through the channel 19 and the left-hand open end of the pilot valve casing.

In order to render the hydraulic mechanism sensitive to slight changes of fluid pressure in the chambers 13, 14 means are provided for continuously vibrating or reciprocating the piston 11 and the stem 12, thus reducing or eliminating the static friction or friction of rest between the movable and stationary elements of the hydraulic

device, in the present example between the piston 11 and the stem 12, and the casing 10. This means comprises auxiliary hydraulic motor means, in the present instance an auxiliary hydraulic motor 23, having a casing 24 and a movable member 25 disposed in the casing 24 and forming therewith two chambers 26 and 27 connected by channel members 28 and 29 respectively to the pressure chambers 13, 14 respectively of the hydraulic motor. The movable member 25 has a stem 30 with two spaced pistons 31 and 32 attached to the stem 30 and slidably disposed within a cylindrical bore of the casing 24. The aforementioned chamber 26 is defined by said bore between one end of the casing 24 and the piston 31 while the chamber 27 is formed by said cylindrical bore between the other end of the casing 24 and the piston 32. The chambers 26 and 27 communicate continuously with the pressure chambers 13, 14 and during operation therefore the chambers 26, 27 are continuously filled with oil or like operating fluid under pressure. The mechanism includes means for continuously vibrating or reciprocating the movable member 25 of the auxiliary motor 23. During such reciprocation the stem 30 is alternately moved to the right and to the left. Upon movement to the right the chamber 26 is enlarged and the chamber 27 is reduced. Thus, operating medium is forced from the chamber 27 into the pressure chamber 14 and simultaneously operating medium is displaced from the pressure chamber 13 into the chamber 26. The opposite action takes place upon movement of the member 25 towards the left during which operating medium is forced from the chamber 26 into the pressure chamber 13 and simultaneously operating medium is displaced from the pressure chamber 14 into the chamber 27. Hence, reciprocation or vibration of the member 25 of the auxiliary motor causes reciprocation or vibration of the movable member 11, 12 of the main hydraulic motor. As the piston 11 moves towards the right the pistons 31, 32 move towards the left, that is, in the present example the two elements vibrate at the same frequency with a phase relation of 180 degrees.

In order to effect vibratory or reciprocatory movement of the member 25, two pressure chambers 34 and 35 are formed adjacent the pistons 31, 32 respectively. These chambers are separated by a stationary wall 36 between the pistons 31, 32 fixed to the casing 24 by a key 37. Fluid may be supplied to and discharged from the chambers 34, 35 by means of channel members 38 and 39 respectively. The mechanism includes means for controlling the supply and discharge of fluid under pressure to the chambers 34, 35 arranged alternately to effect supply of fluid to one chamber and discharge of fluid to the other, and vice versa. This means includes a rotary valve 40 together with another auxiliary hydraulic motor 41. As will be more fully described hereinafter, the auxiliary motors 23 and 41 cause continuous rotation of the rotary valve 40 whereby fluid is alternately supplied and discharged from the respective pressure chambers of said motors and stalling of the rotary valve in the dead-center position of one of the motors is eliminated.

More specifically, the rotary valve 40 has a movable member produced from a cylindrical body forming spaced shaft portions 42 and 43 supported on ball-bearings 44 and 45 respectively, held in a casing or stationary member 46. The movable valve member has two spaced, segmental

cylinder portions 47, 48 which are angularly displaced by 180 degrees and connected by a flat portion 49. The portion 47 faces and is spaced from the shaft portion 42 and the portion 48 faces and is spaced from the shaft portion 43 (Figs. 2, 4).

The valve member is located within a cylindrical chamber 50 in the casing 46. The casing has a plurality of ports cooperatively associated with the rotatable valve member. One port 51 connected to a supply conduit 52 conducts operating fluid to the annular inlet space formed between the bearing portion 42 and the segmental cylinder portion 47. Four circumferentially, uniformly spaced ports 53, 54, 55 and 56 are formed in the casing 46 around the flat portion 49 of the rotatable valve member. The ports 53 and 55 are spaced 180 degrees and connected to the aforementioned channel members 38, 39 respectively. The other ports 54 and 56 are likewise spaced 180 angular degrees and connected to channel members 57 and 58 respectively.

The channel members 57, 58 serve to control the supply of fluid to and the discharge of operating fluid from the second auxiliary motor 41. The latter has a casing 59 forming a cylindrical bore and a piston 60 movably disposed therein and connected to a stem 61 projecting through opposite ends of the casing. The piston and the casing form two pressure chambers 62 and 63 on opposite sides of the piston 60 and have ports connected to the channel members 57, 58 respectively.

As pointed out above, the pistons of the two auxiliary hydraulic motors 23, 41 are connected to drive the rotary valve 40. This is accomplished by a crank shaft connection between the rotary valve 40 and the piston stems 30, 61. In the present example the shaft portion 43 of the rotary valve is provided with an extension 64 adjustably connected to a crank arm 65. The arm 65 is in the form of a block with a dovetailed slot for receiving a dovetailed square portion 66 of the driven shaft 64. Two screws 67 through opposite wall portions of the crank arm and on opposite sides of the portion 66 bias these wall portions into firm contact with the portion 66 of the driven shaft 64. When it is desired to adjust the crank arm on the driven shaft 64 the screws 67 are loosened whereupon the crank arm may be slid relative to the portion 66.

A crank pin 68 is secured to the crank arm 65. The crank pin 68 is engaged by two cross heads 69, 70 secured to the ends of the stems 30 and 61 respectively. The cross heads in the present example are in the form of oval-shaped members each having a slot 71 through which the crank pin 68 passes. The extensions of the stems 30 and 61 fastened to the cross heads 69, 70 constitute connecting rods for connecting said cross heads to the pistons of the auxiliary hydraulic motors 23 and 41 respectively.

In the position shown, oil or other operating fluid under pressure is conducted from the supply conduit 52 to the inlet space between the shaft portion 42 and the segmental cylinder portion 47 and from this space oil may flow along the lower side of the flat portion 49 into the port 53 and through the channel member 38 to the pressure chamber 34 of the auxiliary motor 23. At the same time, oil may be discharged from the other pressure chamber 35 of this motor through the channel member 39 and the port 55 of the rotary valve into the outlet space 72 formed to the right of the segmental cylinder

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portion 47 and above the flat portion 49 (Fig. 4). The space 72 constitutes a drain chamber, fluid being discharged therefrom axially through the bearing 45 into a reservoir, not shown. This fluid acts as a lubricant for the bearing 45. The other bearing 44 is lubricated by fluid leaking from the inlet space along the shaft portion 42. Thus, in the position shown, fluid under pressure is discharged through the port 53 to one pressure chamber of the motor 23 and returned from the other pressure chamber of said motor through the port 55. The two ports 54, 56 of the rotary valve member are substantially covered by the flat portion 49 of the valve member. The supply of fluid under pressure through the chamber 34, as pointed out above, causes movement of the valve member 25 towards the left, resulting in rotation of the crank pin 68 and rotation of the rotatable valve member. In the position shown in Fig. 1 the piston 60 and the crank pin 68 are in their upper end positions. It would not be desirable in this position to supply operating fluid under pressure to the chamber 63 because downward movement of the piston 60 effected by such supply could not be usefully transmitted to the crank pin. Therefore the mechanism is arranged to produce a delay between the downward movement of the piston 60 and the rotary movement of the crank pin 68 in order first to rotate the crank pin 68 a certain angular degree away from its upper end position before downward force is supplied thereto by action of the piston 60. This is accomplished by offsetting the flat portion or port-controlling portion 49 of the rotary valve relative to the ports 53 to 56. As shown in Fig. 3, in the position indicated the flat portion 49 in the horizontal position is not in alignment with the ports 57, 58 but is displaced about 15 angular degrees with respect to said ports. Hence, while the piston 60 is in its top upper end position both chambers 61 and 63 are connected to the discharge space 72 and this simultaneous connection continues during approximately 15 degrees angular movement of the rotary valve member. During such movement the crank pin 68 is moved away from its upper end position. Upon termination of this delaying action the port 56 is uncovered so that fluid under pressure may be supplied through the port 56 into the chamber 63 of the auxiliary motor 41 and at the same time fluid may be discharged from the chamber 62 of said motor through the channel member 57, the port 54, into the drain space 72. This causes downward movement of the piston 60 and through the connection of the latter to the crank pin 68 rotary movement of the valve 40. Upon further rotary movement, ports 53 and 55 are disconnected or covered by the flat portion 49. While this takes place the rotation of the valve 40 is effected solely by the auxiliary motor 41. Upon further rotation the rotatable valve member comes into a position opposite that shown. In this case the port 55 is connected to the supply conduit 52 and the port 53 is connected to the drain space of the valve, thus causing movement of the motor 24 in opposite direction. Upon further movement of the valve member the port 54 is connected to the supply conduit 52 and the port 56 is connected to the drain chamber, causing upward movement of the second auxiliary motor 41.

Thus, the two motors 23 and 41 together with the rotary valve cooperate to effect continuous rotation of the valve 40 and vibratory axial

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movement of the member 25 of the main motor 23. In order to maintain this vibratory movement at constant frequency and also to permit variation of the frequency a flow control valve 73 is connected to the supply conduit 52.

The flow control valve or constant flow valve 73 has a casing 74 forming a cylindrical valve chamber with an inlet connected to a conduit 75 for receiving oil under pressure and an outlet port 76 connected to the aforementioned supply conduit 52. The flow through the valve is controlled by a movable valve member 77 which has a restriction 78 and a lateral port 79 co-operatively associated with the outlet port 76. The flow from the port 79 to the port 76 depends upon the overlap between the two ports. The valve member 77 is biased towards the left by a spring 80 bearing against the valve member 77 and against an adjustable spring plate 81. During operation the pressure of the fluid passing through the orifice or restriction 78 is reduced. The valve member 77 is forced towards the right by the pressure exerted on the left-hand end of the valve member and this force is balanced by the force of the spring 80 and the fluid pressure set up on the right-hand end of the valve member 77. An increase in flow causes an increased pressure drop through the orifice 78 whereby the force exerted on the left-hand end of the valve member 77 increases relative to the force on the right-hand end of the valve member 77, causing movement of the valve member towards the right and accordingly an increased overlap between the ports 79 and 77, thus reducing the flow therethrough or, from another viewpoint, preventing an increase in flow therethrough, thus maintaining the flow to the supply pipe 52 substantially constant and independent of variations in pressure in the inlet conduit 75. With constant flow through the supply conduit 52 the frequency of vibration of all hydraulic motors remains constant. This frequency of vibration may be varied by adjustment of the spring plate 81 of the flow control valve 73.

Having described the method of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is,

1. In a hydraulic control system the combination comprising a main servo motor having a servo cylinder and a piston movable in said cylinder, a control valve for selectively admitting fluid under pressure to either side of said piston to control movement of said servo motor, means for causing a continuous vibratory movement of said piston to reduce static friction and thereby render said piston more sensitive to movement of said control valve, said means comprising an auxiliary hydraulic motor, said auxiliary motor comprising first and second cylinders, piston means comprising first and second pistons co-operating respectively with and adapted to reciprocate in said first and second cylinders, valve means operated by said piston means for controlling the flow of hydraulic fluid to said auxiliary motor to reciprocate said piston means, conduit means connecting said valve means to one end only of said first and second cylinders, and conduit means connecting the other ends of said first and second cylinders and opposite ends

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of said main servo motor cylinder whereby pulsations in fluid pressure produced by operation of said auxiliary hydraulic motor are transmitted to said main servo motor to cause a vibratory movement of said piston of said motor.

2. In a hydraulic control system, a main hydraulic motor having movable and stationary members, one of said members defining a pressure chamber into which hydraulic fluid is introduced at opposite ends of said pressure chamber to cause movement of said movable member of said motor, means for causing a vibratory movement of said movable member comprising an auxiliary hydraulic motor having first and second pistons operated by a common power means and reciprocating in first and second cylinders thereby defining a pair of chambers in opposed relation in each cylinder the volumes of which are changed by reciprocation of said pistons, and fluid conduit means interconnecting two of said chambers in opposed relation with said opposite ends of said main servo motor pressure chamber.

3. Means for causing a vibratory movement of a piston of a hydraulic servo motor, said motor having a pressure chamber into which hydraulic fluid is introduced to control movement of said piston of said servo motor, said means comprising an auxiliary hydraulic motor having two cylinders and pistons reciprocating in said cylinders, said cylinders and pistons defining cham-

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bers on either side of said pistons, valve means operated by said pistons for controlling flow of hydraulic fluid to two of said chambers and conduit means connecting said valve means to said two chambers to cause reciprocating movement of said pistons, and conduit means interconnecting the other two chambers and opposite sides of said pressure chamber whereby movements of said pistons cause pulsations in the fluid pressure in said pressure chamber resulting in vibratory movement of said servo motor piston.

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