July 26, 1960 J. D. NORTH 2,946,348

BALANCED ROTARY HYDRAULIC VALVES

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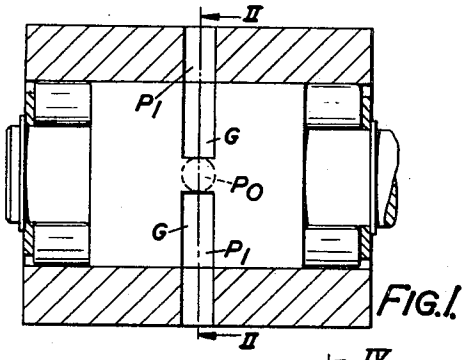

FIG. 1.

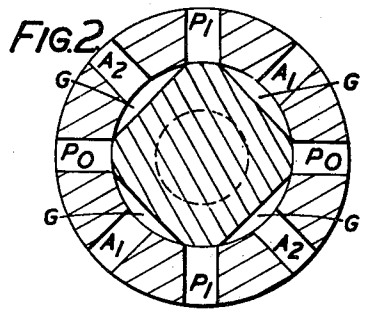

FIG. 2.

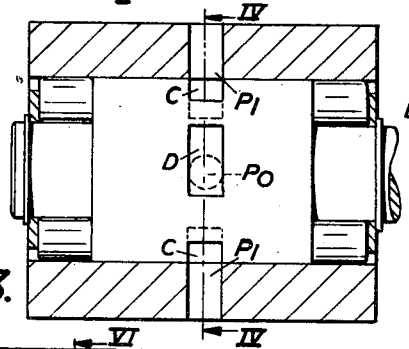

FIG. 3.

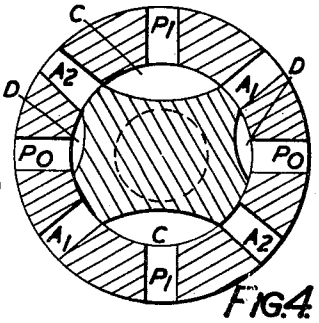

FIG. 4.

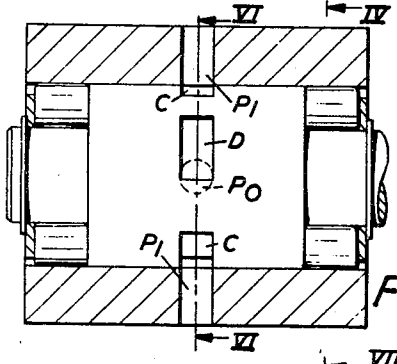

FIG. 5.

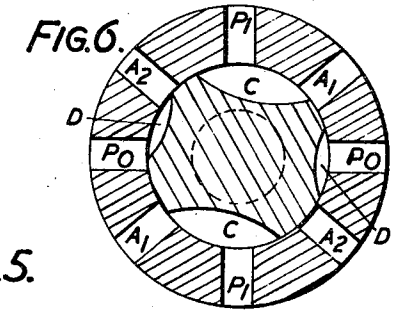

FIG. 6.

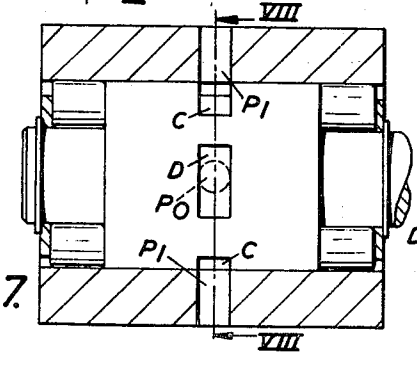

FIG. 7.

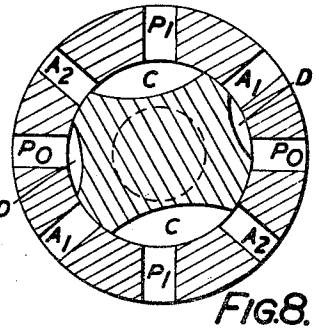

FIG. 8.

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BALANCED ROTARY HYDRAULIC VALVES

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7 Claims. (Cl. 137—624)

This invention relates to hydraulic valves in hydraulic control systems of the kind comprising a source of liquid under pressure, an actuator such as a hydraulic jack or motor and a valve for connecting one or other side of the actuator to the source of supply of liquid under pressure and to a low pressure outlet respectively.

It is known to use for such purposes valves of the rotary type in which a cylindrical rotor or barrel fits within a cylindrical casing and has channels cut in it to provide an adjustable means of communication between ports formed in said casing.

It has previously been proposed to provide roller or ball bearings to support the valve in the casing to reduce friction when the valve is rotated. It is well known that the high pressure ports must be symmetrically arranged so as to balance the static loads on the bearings and to ensure that this pressure does not produce a torque when the valve is closed.

It is further known that even when the valve is opened such static forces can still be balanced but due to the Bernoulli forces arising from the oil flow through the valve this balance is disturbed. The object of the present invention is to provide an improved form of construction of hydraulic valve in which said Bernoulli forces are minimized.

The invention accordingly provides in a hydraulic control system of the kind hereinbefore specified, a rotary hydraulic valve comprising two high pressure inlet ports, two low pressure outlet ports and two ports connected to each side of a hydraulic actuator, the connecting channels in the barrel of the valve being so arranged that when the valve is opened both high pressure inlet ports are connected to the two corresponding actuator inlet ports but only one actuator port is connected to one low pressure outlet port at any one time.

In order that the invention may be more clearly understood reference will now be made to the accompanying drawings in which:

Fig. 1 is a longitudinal section of a known form of valve,

Fig. 2 is a section on the line II—II of Fig. 1,

Fig. 3 is a view similar to Fig. 1 of a hydraulic valve construction in accordance with the present invention and showing the valve closed,

Fig. 4 is a section on the line IV—IV of Fig. 3,

Fig. 5 is a view similar to Fig. 3 but showing the valve opened in one direction,

Fig. 6 is a section on the line VI—VI of Fig. 5,

Fig. 7 is a view similar to Fig. 5 but showing the valve opened in the other direction, and

Fig. 8 is a section on the line VIII—VIII of Fig. 7.

Referring to Figs. 1 and 2 of the drawings, ports marked P_1 are connected to the high pressure source, the ports marked P_0 are connected to return fluid to the reservoir from which the high pressure source draws its supply. The pair of ports marked A_1 are connected to one side of the actuator and the pair of ports marked A_2 to the other side. The grooves G permit fluid to

flow from each of the pair of high pressure ports P_1 to its corresponding member of the pair of actuator inlet ports A_1 or A_2 according to the direction of rotation of the valve. Similarly each of the pair of actuator outlet ports permits fluid to pass from each member of the corresponding pair of outlet ports P_0 to the low pressure sink. It is well known that with this construction the Bernoulli forces produce a torque on the valve, the said torque being in the opposite direction to that in which the valve has been opened.

The construction according to the present invention is illustrated in Figs. 3 to 8. When the valve is opened each member of the pair of high pressure ports P_1 is connected to the corresponding member of the pair of actuator inlet ports A_1A_1 or A_2A_2 (as the case may be) but only one of the pair of actuator outlet ports A_2A_2 or A_1A_1 is connected to one of the low pressure outlet ports P_0 at any one time, one member of the pair A_2A_2 being connected to one port P_0 when the valve is rotated in one direction, see Fig. 6, and one member of the pair A_1A_1 being connected to the other port P_0 when the valve is rotated in the opposite direction, see Fig. 8. Moreover, the channels C and D in the barrel which permit connection between the ports when the valve is opened are given a concave arcuate form. It has been found that with this construction the Bernoulli forces may be almost completely balanced. Most satisfactory balance has been obtained when the angle between the center line of the low pressure ports P_0 and that of the actuator ports is substantially less than that between the center line of the high pressure ports P_1 and that of the actuator ports. It has further been found that a circular arc with a camber of the order of 11% of the chord for the channel C under the high pressure ports and 10% of the chord for the channel under the low pressure ports D is an effective form. The invention is not however confined to this precise form.

The theory underlying the embodiments of the invention illustrated in Figs. 3 to 8 may be discerned by applying the well known laws of fluid flow to the specific passageways and ducts illustrated in these figures. In Fig. 6, for example, an analysis of the conditions in the channels C indicate that by virtue of their configuration, the center of pressure applied to the valve rotor results in a counterclockwise torque. This is evident from the fact that the center of pressure in channels C is displaced from the line of symmetry towards the port P_1 in each channel. There is accordingly a counterclockwise torque associated with upper channel C and a counterclockwise torque associated with lower channel C. Opposing these torques is a compensating torque developed by virtue of the fluid flow in left channel D. The center of pressure in this channel shifts towards port A_2 thereby producing a clockwise torque. It is thus evident that the arrangement provides for a balancing of the Bernoulli forces.

A similar analysis of conditions existing with the valve in the position shown in Fig. 8 establishes a similar result. Thus the pressure decrease from port P_1 to port A_2 in each channel C produces a clockwise torque. Compensating these torques is an opposing torque generated in operative channel D by virtue of the shift in the center of pressure towards port A_1. The torque generated thereby is in a counterclockwise direction. It may also be observed in connection with the above described theory that fluid flow from ports A_2 to P_0 in Fig. 6 and from A_1 to P_0 in Fig. 8 results in moment arms which are larger than each of the moment arms associated with fluid flow in channels C. In this connection it may also be noted that the pressure drop in channels D is a number of times larger than the pressure drop in each channel C.

The invention in its broader aspects is not limited to the specific mechanisms shown and described but departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

I claim:

1. A rotary hydraulic valve for selectively connecting one side of an actuator to a source of supply of liquid under pressure and the other side of said actuator to a lower pressure outlet, said rotary hydraulic valve comprising a cylindrical housing and a rotor rotatable within said cylindrical housing, said cylindrical housing having two opposed inlet ports, two opposed low pressure outlet ports and two pairs of opposed ports for connection one pair to each side of said hydraulic actuator, said rotor having channels disposed between lands arranged so as to be capable of closing said two pairs of opposed ports, the relative positions of said channels and all said ports being such that when the valve is open both high pressure inlet ports are connected to a corresponding pair of said pairs of opposed ports but only one of the other said pair of opposed ports is connected to one low pressure outlet port at any one time.

2. A valve as defined in claim 1, wherein said channels each have a concave arcuate form in the direction from land to land.

3. A valve as defined in claim 1, wherein the ports are so arranged that the angles between the center line of said opposed low pressure ports and those of said pairs of opposed ports are substantially less than the angles between the center line of said opposed high pressure ports and the center lines of said pairs of opposed ports.

4. A rotary hydraulic valve for selectively connecting one side of an actuator to a source of supply of liquid under pressure and the other side of said actuator to a lower pressure outlet, said rotary hydraulic valve comprising a cylindrical housing and a rotor rotatable within said cylindrical housing, said cylindrical housing have two opposed inlet ports, two opposed low pressure outlet ports and two pairs of opposed ports for connection one pair to each side of said hydraulic actuator, said rotor having channels disposed between lands arranged so as to be capable of closing said two pairs of opposed ports, the relative positions of said channels and all said ports being such that when the valve is open both high pressure inlet ports are connected to a corresponding pair of said pairs of opposed ports but only one of the other said pair of opposed ports is connected to one low pressure outlet port at any one time, a plurality of said lands having surface areas larger than other of said lands.

5. A valve as defined in claim 4 in which a pair of adjacent lands have surfaces larger than other of said lands.

6. A valve as defined in claim 4 in which the volumes of one of said channels is different from other of said channels.

7. A valve as defined in claim 4 in which the channels associated with said low pressure outlet ports are each smaller than the channels associated with said high pressure ports.

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