May 5, 1964 R. G. LA BORDE 3,131,605

FLAT VALVE FOR HYDRAULIC MACHINE

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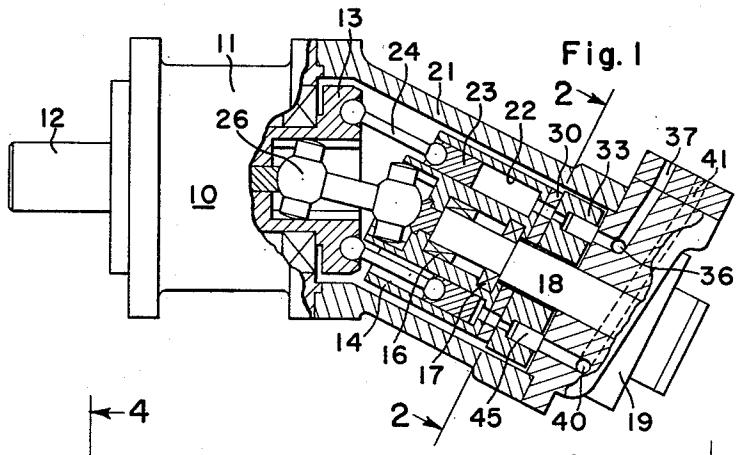


Fig. 1

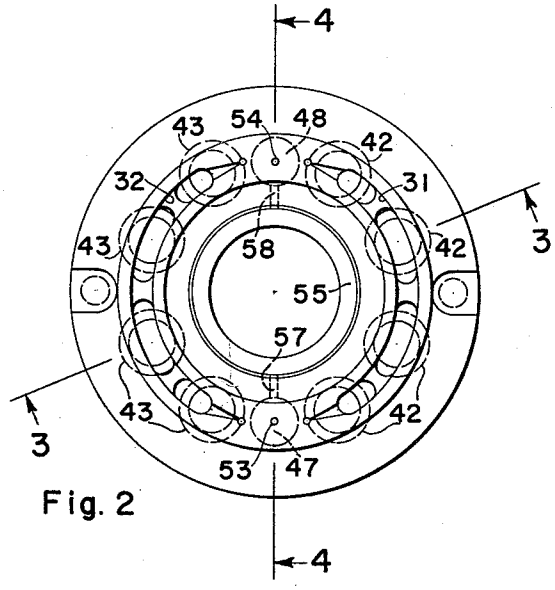


Fig. 2

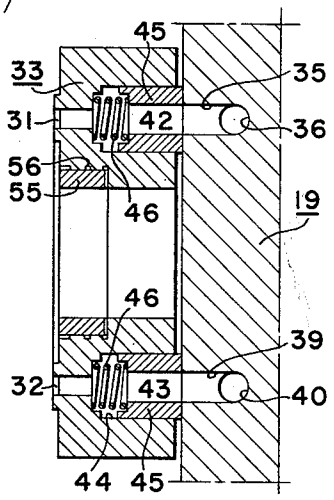


Fig. 3

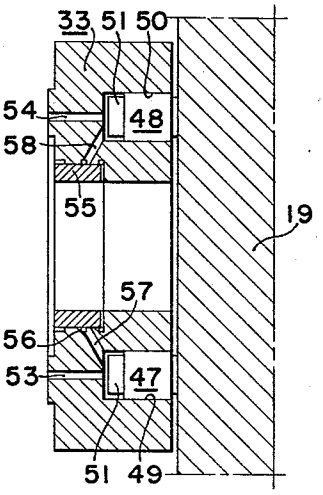


Fig. 4

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FLAT VALVE FOR HYDRAULIC MACHINE

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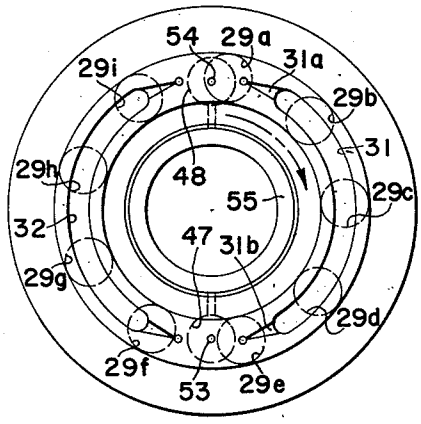


Fig. 5

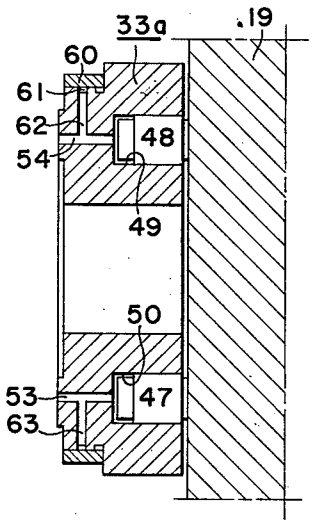


Fig. 7

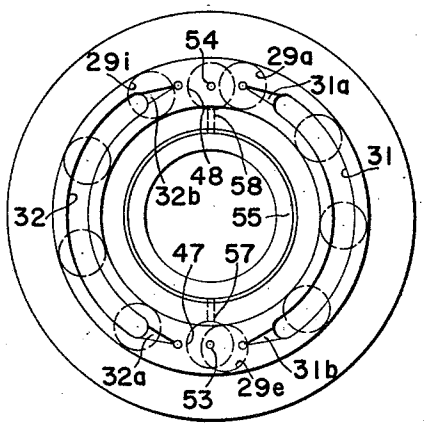


Fig. 6

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3,131,605

FLAT VALVE FOR HYDRAULIC MACHINE

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4 Claims. (Cl. 91—198)

This invention relates to rotary hydrodynamic machines in which pistons and cylinders are arranged in a cylinder barrel and the pistons reciprocate as the cylinder barrel rotates. The flow of liquid to and from the cylinders is controlled by a floating flat valve that has a pair of arcuate ports with which the cylinder ports alternately register. More particularly, the invention relates to the energization and de-energization of auxiliary hold-up motors provided in bridges of the valve.

The hydrodynamic machine has a rotary cylinder barrel, and fluid flow to and from the cylinder ports therein is valved by a non-rotatable and axial floating type of flat valve in the manner illustrated in U.S. Patents 2,406,138 and 3,037,489 assigned to the assignee of this application.

The arrangement of the hold-up motors and of the auxiliary hold-up motors, as is well known, is such as to make the summation of the force moments on the flat valve equal to zero for limit conditions of pressure field distribution. Thus, when the pressure field is a minimum, balance is provided by the hold-up motors, and when the pressure field is a maximum, such balance is obtained by both the hold-up and auxiliary hold-up motors. It has been found advantageous to obtain such balance of moments by simultaneously energizing auxiliary hold-up motors under both bridges of the flat valve.

The present invention is well suited for operation of the motor at slow speed as well as at higher speeds. The auxiliary hold-up motors are simultaneously energized whenever a greater number of cylinder ports register with the valve pressure port and are simultaneously de-energized whenever a greater number of cylinder ports register with the valve exhaust port.

According to the present invention and an object thereof, the auxiliary hold-up motors under both bridges of the flat valve are energized and maintained energized when an even number of cylinder ports are in communication with the pressure port of the flat valve and these auxiliary hold-up motors under both bridges are de-energized and maintained de-energized when an odd number of cylinder ports are in communication with the pressure port of the flat valve, when the total number of cylinder ports is odd.

Another object of the invention is to provide a floating type valve with peripheral passage means for interconnecting the auxiliary hold-up motors under both the bridges of the flat valve. Such means of interconnecting the auxiliary hold-up motors is economical to provide and is the only practical means of providing such interconnection in a stud mounted flat valve where the valve is small or relatively small for the number of hold-up motors that are provided.

Other objects and advantages of the invention will be apparent on reading the following description with the accompanying drawings, in which:

FIG. 1 is a view in elevation and partially in section of a hydraulic motor embodying the present invention;

FIG. 2 is a view taken on line 2—2 of FIG. 1 to show the operating face of the flat valve with the relative position of opposing cylinder posts indicated thereon;

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 2 and also showing part of the support structure for the flat valve;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 2;

FIGS. 5 and 6 are similar views of the valve plate shown in FIG. 2 but with the opposing cylinder ports indicated in different rotative positions of distribution thereon; and FIG. 7 is a sectional view of another embodiment of the flat valve corresponding to the arrangement shown in FIG. 4.

The machine embodying the improved flat valve construction may be a variable displacement pump or motor having a rotatable cylinder barrel with radially or axially arranged pistons. As shown in FIG. 1, this machine is a fixed displacement axial piston motor 10.

A shaft adapted for coupling to a load device has a drive flange 13 mounted for rotation with the shaft in section 11 of the casing. The shaft 12 and the flange 13 are suitably rotatably supported on radial and thrust bearings, not shown, in casing section 11.

A cylinder barrel 14 is rotatably supported on axially spaced bearings 16, 17 disposed on an axially extending stud 18 in the end head 19 of the casing section 21. The bearings 16, 17 hold the cylinder barrel against axial and radial displacement. The axes of shaft 12 and of cylinder barrel 14 are inclined relative to each other to provide the fixed displacement for the motor. The cylinder barrel 14 is provided with a plurality of cylinders 22 parallel with its axis and has axially reciprocable pistons 23 therein. The pistons 23 are connected to the drive flange 13 by piston rods 24 whose ends are held in ball sockets in the drive flange 13. The cylinder barrel is provided with an odd number of N cylinders herein shown with nine cylinders. The shaft is linked to the cylinder barrel by a constant velocity coupling 26 such as a Cardan shaft which couples a pair of universal joints in the axis of the shaft and in the axis of the cylinder barrel.

The cylinders 22 provide N cylinder ports 29 in the end face of the cylinder barrel and each alternately registers with a supply port 31 and an exhaust port 32 of a flat valve 33 as the cylinder barrel rotates. The ports 31, 32 are diametrically arranged arcuate slots in the front or cylinder opposing the face of the flat valve. Axial passages in the flat valve extend through hollow pistons 45 of hold-up motors 42 and connect port 31 with axial passages 35 in the head 19 and these join common manifold passage 36 which terminates in an outer connection 37 which may be either a supply or discharge connection for the motor.

Axial passages in the flat valve extend through hollow pistons 45 of hold-up motors 43 and connect port 32 to aligned axial passages 39 in end head 19 which join a common manifold passage 40 that terminates in the other outer connection 41. Fluid supply entering outer connection 37 flows through manifold passage 36, thence through axial passages 35 and aligned passages in the flat valve to its relatively high pressure or supply port 31. Cylinder ports registering with valve supply port 31 receive pressure fluid therefrom to displace their pistons. Cylinder ports registering with the relatively low pressure or discharge port 32 of the valve discharge their fluid thereto which fluid flows through axial passages in the flat valve and aligned axial passages 39 in end head 19 to manifold passage 40 and to discharge connection.

The flat valve 33 is annular and is disposed coaxially of the stub shaft 18 and of the cylinder barrel. The flat valve is secured on the end head against rotation and for freedom of axial movement. The flat valve is hydraulically balanced between the cylinder barrel and the end head by a hold-up system which produces hold-up forces acting between the cylinder barrel and the flat valve.

The hold-up system comprises hold-up motors 42, 43 and auxiliary motors 47, 48 located in the bridges of the valve which are the portions between the arcuate ports 31, 32. The hold-up motors 42, 43 comprise cylinders 44 always connected to their respective ports 31, 32 and have hollow pistons 45 for connecting the valve ports to the end head passages.

Springs 46 urge the pistons 45 in seating engagement with the aligned passages 35, 39 in the end head. The hold-up motors 42 are arranged relative to their associated valve port 31 to provide a hold-up force equal and opposite the separating force developed when an odd number, ½ of $(N-1)$, cylinder ports register with and are evenly distributed on valve port 31. Hold-up motors 43 are similarly arranged relative to valve port 32 as hold-up motors 42 to valve port 31. The centroid of the hold-up force due to hold-up motors 42 lies on a transverse axis which lies on a horizontal diametrical line bisecting the ports 31, 32, FIG. 2.

According to this hold-up system, the hold-up forces applied by the hold-up motors 42 or 43 are sufficient to hold the valve balanced against the separating force developed when four cylinder ports register with the supply port of the valve but are insufficient to prevent separation when five cylinder ports register with the supply port. In this manner an excessive hold-up force is not applied when four cylinder ports register with the pressure port and wear between the cylinder barrel or a wear plate 30 thereon and the valve is avoided.

The auxiliary hold-up motors 47, 48 provide additional hold-up force only when five cylinder ports, $\frac{1}{2}(N+1)$, cylinder ports, communicate with the pressure port of the valve. Auxiliary hold-up motors 47 and 48 comprise cylinders 49, 50 formed in the rear face of the flat valve, FIG. 4, each having a solid or closed end bridge piston 51 therein urged by fluid under pressure against the face of end head 19. The face of the bridges are provided with drilled passages 53, 54 to cylinder 49 and cylinder 50, respectively.

The face of the flat valve and different relative positions of cylinder ports thereon are shown in FIGS. 5 and 6. Valve port 31 has port extensions 31*a* and 31*b* and valve port 32 has port extensions 32*a* and 32*b*. These port extensions are provided by tapered slots whose adjacent ends are spaced apart an amount corresponding to the circumferential length along the flat valve of a cylinder port, and when the machine is a motor, such spacing is slightly greater than the circumferential length of a cylinder port, so that a cylinder port crossing the bridge does not interconnect the valve ports.

When a cylinder port is centered on a bridge segment of the flat valve, it is in registration with a hole 53 or 54 connecting a bridge cylinder to the face of the bridge segment. FIGS. 5 and 6 show sequential positions of the nine cylinder ports 29*a* to 29*i* inclusive, on the flat valve. For clockwise rotation of the cylinder barrel, cylinder port 29*a* is leaving a bridge in FIG. 5 but is still in communication via hole 54 with a bridge motor or auxiliary hold-up motor 48 and is also now in communication with the port extension 31*a* of pressure port 31. On the diametrically opposite bridge we see cylinder port 29*e* beginning to cross the bridge and is not yet in communication with auxiliary hold-up motor 47 but is still in communication with pressure port 31 through its portion extension 31*b*. Thus, five of the nine cylinder ports are in communication with pressure port 31. Auxiliary hold-up motor 48 is thus energized by pressure fluid conducted from pressure port 31 by means of the overlying cylinder port 29*a*.

Slightly further rotation of the cylinder barrel, as illustrated in FIG. 6, shows cylinder port 29*a* having moved out of registration with hole 54 to auxiliary hold-up motor 48. Such rotation has also brought cylinder port 29*e* into registration with bridge hole 53 while

cylinder port 29*e* is still in communication with pressure port 31 through port extension 31*b*. Thus, auxiliary hold-up motor 47 is energized by pressure fluid conducted by means of overlying cylinder port 29*e*. Continued rotation, not shown, will center cylinder port 29*e* on the bridge and out of registration with either port 31 or 32, and thereafter begin registration of cylinder port 29*e* with exhaust port 32 via port extension 32*a* while cylinder port 29*i* begins to cross the opposite bridge. Thus, one auxiliary hold-up motor 47 is sequentially energized and de-energized by each cylinder port crossing its associated bridge and the other auxiliary hold-up motor 48 is sequentially de-energized and energized by each cylinder port crossing its associated bridge, for a clockwise direction of rotation of the cylinder barrel on the flat valve, and vice versa for the opposite direction of rotation of the cylinder barrel.

The cylinder ports are odd in number, and therefore when one cylinder port is centered on a bridge, the other bridge has one cylinder port entering and another leaving the bridge, such that only one of the bridge motors or auxiliary motors are directly connected to a cylinder port at one time.

In order that both bridge motors 47, 48 will be simultaneously energized and simultaneously de-energized by a cylinder port crossing either bridge, means are provided for interconnecting the cylinders 44, 45 of the auxiliary hold-up motors 47, 48. Such interconnecting means comprises a ring or sleeve 55 fitted to the flat valve 33 to cooperate therewith to provide a circumferentially extending passage 56 that interconnects drilled passages 57, 58 which extend generally radially from the bridge cylinders 49, 50, respectively. FIGS. 3 and 4 show the sleeve 55 fitted in a counterbore in the flat valve 33 and show that the circumferentially extending passage 56 is formed by an annular groove in the wall of the counterbore which is enclosed by the sleeve 55. Interconnection of the bridge motors results in both bridge motors being simultaneously energized when a cylinder port is in overlying communication with one bridge hole 53 or 54 and the pressure port 31 and results in both bridge motors being simultaneously de-energized when a cylinder port is in overlying communication with one bridge hole 53 or 54 and the exhaust port 32.

FIG. 7 shows a modification of the arrangement of FIGS. 2, 3, and 4 in which a ring 60 is fitted over the radially outer cylindrical surface of a flat valve 33*a*. A circumferentially extending passage is provided by an annular groove 61 in one of the abutting surfaces of the ring and flat valve and as shown the groove 61 is preferably provided in the cylindrical surface of the flat valve. Generally radially drilled holes 62, 63 connect the bridge cylinders 49, 50, respectively, to the annular groove 61 to thereby interconnect the bridge cylinders 49, 50. The function and operation of flat valve 33*a* is the same as that of flat valve 33.

While but one embodiment and one modification of the invention has been shown and described, changes may be made therein within the scope of the appended claims.

I claim:

1. In a hydraulic machine comprising a rotatable cylinder unit having a coaxial end face having an odd number of circumferentially spaced cylinder ports and a stationary end head having an annular face coaxial with said cylinder unit, an annular flat valve adapted to be non-rotatably supported on said end head for axial movement relative thereto for sealing engagement with said end face of said cylinder unit, said flat valve having diametrically opposite arcuate supply and exhaust ports with which said cylinder ports alternately register upon rotation of said cylinder unit, hydraulic hold-up motors under the ports of the flat valve to urge the flat valve toward the cylinder unit, auxiliary hydraulic hold-up motors in opposite segments of the flat valve between the ports thereof, axial passages

in the segments of the flat valve connecting the auxiliary hold-up motors to the face of the segment for successive registration with the cylinder ports crossing the face of the segment upon rotation of the cylinder unit, an annular member secured to said flat valve a circumferentially extending passage formed in one of the abutting surfaces of said annular member and flat valve, and connecting passages in said flat valve connecting said auxiliary hold-up motors in both segments to said circumferentially extending passage.

2. In a hydraulic machine as defined in claim 1 in which the flat valve has the annular member fitted on a cylindrical surface of the flat valve and encloses the circumferentially extending passage therebetween, and the connecting passages thereto extending generally radially from said auxiliary hold-up motors.

3. In a hydraulic machine as defined in claim 1 in which the flat valve cooperates with the annular member in providing the circumferentially extending passage, said flat valve having a coaxial bore and an annular groove in the wall of said bore, said annular member defined by a sleeve fitted in said bore to enclose said annular groove

and define said circumferentially extending passage, and the connecting passages thereto extending generally radially from said auxiliary hold-up motors.

4. A flat valve having a front face for seating on an end of a relatively rotatable cylinder unit having an uneven number of cylinder ports, said flat valve having diametrically opposite arcuate ports with which said cylinder ports are adapted to alternately register, the radial segments of said flat valve between said arcuate ports having bridge cylinders formed in a back face of the flat valve connected by axial passages to the front face of the flat valve for communication with cylinder ports crossing the segments of the flat valve, a sleeve fitted to a cylindrical surface of said flat valve to enclose an annular groove therein, and generally radially extending passages in said segments connecting said annular groove to said bridge cylinders.

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UNITED STATES PATENTS

2,406,138	Ferris et al.	Aug. 20, 1946
3,037,489	Douglas	June 5, 1962