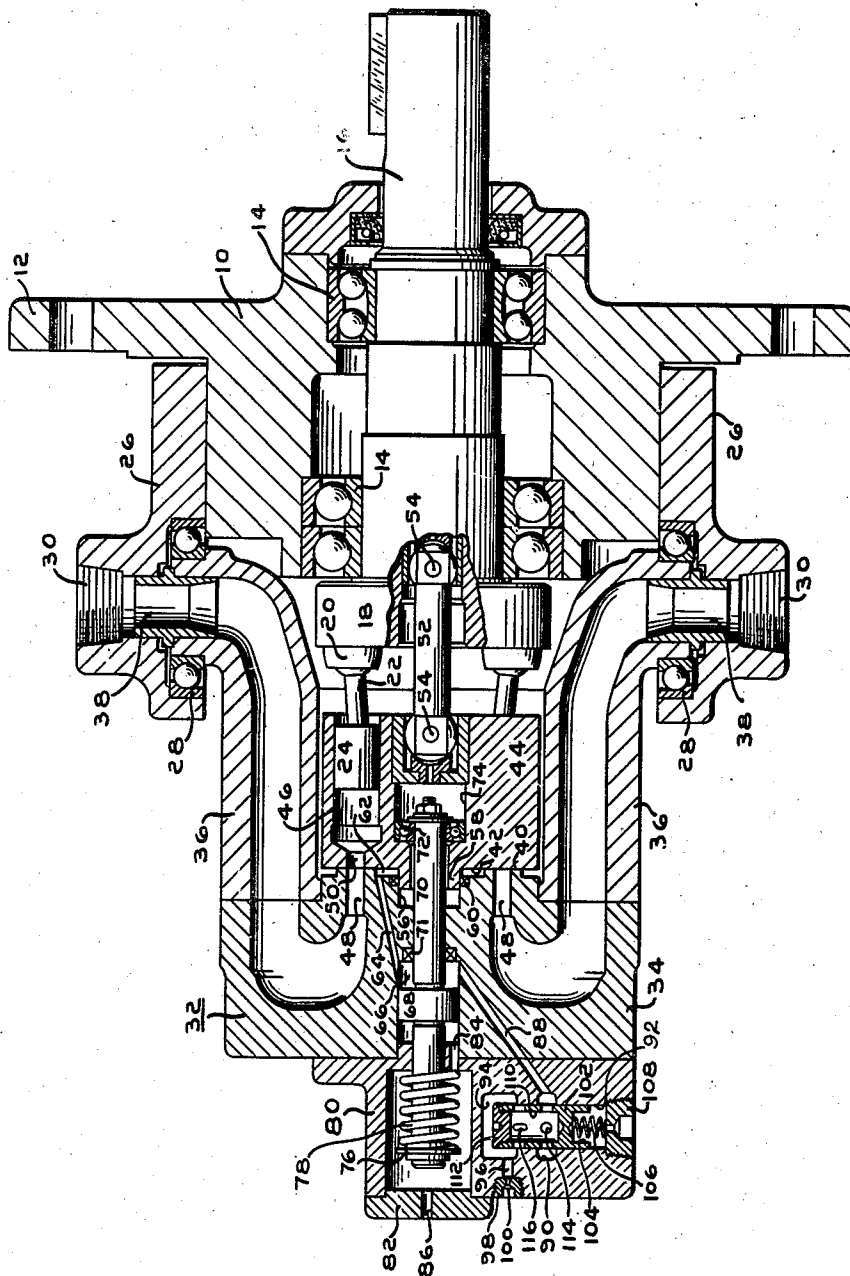


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HYDRAULIC PUMP OR MOTOR

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HYDRAULIC PUMP OR MOTOR

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This invention relates to power transmissions and more particularly to those of the type comprising two or more fluid pressure energy translating devices, one of which may function as a pump and another as a fluid motor. In such devices of the type which comprise a revolving cylinder barrel having a plurality of parallel cylinder bores therein within which pistons are reciprocated by a swash plate device, it is customary to provide a rotary valving mechanism which is operated by the rotation of the cylinder barrel itself for the purpose of alternately connecting each cylinder bore with the inlet and outlet passages of the device. Many machines of this character utilize a plate type valve formed by a flat surface of the cylinder barrel which runs in abutting and in fluid sealing relationship on a stationary flat valve plate. The plate type valve may be so constructed that the cylinder barrel is constantly pressed into engagement with the valve plate so that the clearance at the valve is automatically adjusted to take care of variations in oil viscosity and to compensate for wear. This is a distinct advantage and contributes much to the reliability and long life of machines employing a valve of this character.

It is customary with machines of this character to so proportion the size of the distributing ports in the end face of the cylinder barrel relative to the piston area and to the area of the annular surface of contact with the valve plate as to provide approximate hydraulic balance between the fluid pressure forces exerted by piston reaction on the end faces of the cylinder bores and the fluid pressure separating forces exerted in the oil film between the cylinder barrel and valve plate. It is, of course, impossible in practice to provide an exact balance between these forces, and since it is necessary to provide some means for holding the barrel in contact with the valve plate while the machine is idle, a spring or other resilient means is usually provided for urging the barrel into contact with the valve plate with a relatively light force at all times.

It is extremely difficult to predetermine with precision the exact amount of hydraulic unbalance which will exist in a given machine since small variations in dimensions which are entirely within normal manufacturing tolerances produce large changes in the hydraulic balance when the operating pressures are high. If the net unbalance is in a direction holding the barrel in contact and is very large, then the unit bearing pressures at the valve plate are apt to be excessive. On the other hand, if the ma-

chine is designed for a very small net unbalance, it occasionally happens, due to manufacturing variations, that the net unbalance of the hydraulic forces on the barrel is in a direction tending to lift the barrel off from the valve plate, and in such cases the spring is sufficient to maintain the barrel in contact with the valve plate at all operating pressures below a certain maximum. When this maximum is exceeded, however, the barrel lifts away from the valve plate, and since the valve is thereby rendered ineffective, the power drive through the transmission is completely and suddenly interrupted. This difficulty can be extremely troublesome at times, particularly where the transmission is used to operate a device, such as a hoist, which has to overcome a gravity load and in which complete dependence upon the transmission is placed for sustaining that load. In such cases it occasionally happens that the critical pressure at which the barrel will blow off is slightly above the normal operating pressure required for lifting the usual loads and that on rare occasions, due to snagging of hoisting lines or some other momentary small overload during hoisting, the critical pressure is exceeded causing the barrel to lift and resulting in dropping of the load with consequent damage thereto.

It is an object of the present invention to provide a valve plate construction for a fluid pressure energy translating device of the class described in which the above problems are avoided by the provision of means for exerting a variable force tending to hold the barrel on the valve plate and proportional to leakage variations.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form of the present invention is clearly shown.

In the drawing, the single figure is a longitudinal cross section of a fluid pressure energy translating device incorporating a preferred form of the present invention.

The embodiment of the invention selected for illustration comprises a pump of the same general class as that illustrated in the patent to Hans Thoma, No. 1,931,969, and comprises generally a main ring-like frame member 10 having a mounting flange 12 thereon and provided with bearings 14 on which a main shaft 16 is journaled. The shaft 16 is provided with a socket flange 18 carrying a plurality of ball sockets 20 in which are mounted ball-ended con-

necting rods 22 carrying reciprocating pistons 24.

Rigidly secured to the frame member 10 by suitable bolts not shown are a pair of plates 26 provided with bearings 28 and with fluid connections 30. Journalled on the bearings 28 is a swinging yoke generally designated as 32 comprising a valve plate 34 with rigidly attached hollow arms 36 providing trunnions for the yoke and connected to the fluid connection 30 by sealing sleeves 38.

The valve plate 34 is provided with an arcuate raised sealing surface 40 against which runs the flat end face 42 of a cylinder barrel 44 provided with a plurality of cylinder bores 46 therein. Formed in the valve plate 34 are two arcuate fluid distributing ports 48 each of which extends through an arc somewhat less than 180 degrees and communicates with the passages in the hollow arms 36. Formed at the left-hand end of the cylinder bores 46 are a plurality of fluid distributing ports 50 opening into the flat face 42 and adapted to alternately register with each of the distributing ports 48. A shaft 52 provided with universal joints 54 at its opposite ends connects the barrel 44 to rotate with the shaft 16 in any position of the yoke 32. The parts thus far described are in a broad aspect well known in the art and per se form no part of the present invention.

The hydraulic balance of the cylinder barrel 44 is, of course, determined by suitable proportioning of the radial width of the flat pressure surface 40 relative to the total area of all of the ports 50 and the total area of all of the pistons 24. With the present invention these areas are so proportioned as to produce a net fluid pressure force on the cylinder barrel 44 tending to lift the barrel out of contact with the surface 40. This unbalance is preferably, though not necessarily, made small, and is, of course, proportional to the operating pressure.

According to the invention, means is provided for imposing an additional force tending to urge the barrel into contact with the surface 40, which force is determined by the amount of leakage taking place at the valve plate surface. For this purpose the valve plate is formed with a cylindrical recess 56 in which a cylindrical projection 58 formed integrally with the cylinder barrel 44 is rotatably mounted. A suitable oil seal may be provided at 60. There is thus formed an annular chamber 62 radially inward of the annular valve plate surface 40.

Leading from the chamber 62 is a passage 64 of negligible resistance which opens into a cylindrical chamber 66 formed at the left-hand side of the valve plate 34. Slidably mounted in chamber 66 is a piston 68 secured to a rod 70. An oil seal 71 is provided around the rod 70. The latter carries a thrust bearing 72 at its right-hand end which abuts against a shoulder formed at the left-hand end of a recess 74 in the barrel 44. The left-hand end of the rod 70 carries an adjustable spring abutment 76 against which is mounted a spring 78 serving as the normal cylinder barrel spring. Cap members 80 and 82 having drain passages 84 and 86 serve to enclose the spring 78 and the left-hand end of chamber 66.

Formed in the cap member 80 and in the valve plate 34 is a passage 88 communicating between the right-hand end of the chamber 66 and a groove 90 formed in a bore 92 in the cap member 80. At the right-hand end of the bore 92 there is provided a chamber 94 from which a passage

96 extends to the left-hand end face of the cap member 80. The end of the passage 96 is provided with a plug 98 having a restricted orifice 100 of predetermined size. Slidably mounted in the bore 92 is a valve spool 102 having a bore 104 therein at its left-hand end for receiving a spring 106. An aperture plug 108 is provided at the left-hand end of bore 92 to provide a spring abutment while leaving the bore open to tank. The valve spool 102 is provided with a chamber 110 at its right-hand end closed by a plug 112. The walls of the chamber 110 are provided with four large orifices 114 adapted to register with the groove 90 and with four small elongated orifices 116 adapted to partially register with the chamber 94 depending upon the valve position.

In operation, assuming that the conduits 30 are connected into a power transmission circuit in the usual manner so that the upper conduit 30 is the pressure supply connection while the lower one is the suction connection and that the shaft 16 is connected to a suitable prime mover and rotated thereby at a constant speed, with the top moving away from the observer the pistons 24 are reciprocated in the cylinder bores 46 in the well-known manner with a stroke depending upon the angular displacement of the yoke 32.

With the left-hand end of the yoke moved away from the observer each piston 24 will travel to the left during its top-half revolution and will be withdrawn to the right during its bottom-half revolution, thus withdrawing fluid from the lower port 48 into the cylinder 46 and discharging it out of them into the upper port 48.

At zero operating pressure in the upper port 48 the hydraulic unbalance of the cylinder barrel is likewise zero so that the force of spring 78 transmitted through the bearing 72 to the cylinder barrel 44 is the sole force urging the barrel into contact with the valve plate. As the pressure in the upper port 48 increases and before it reaches the critical pressure at which spring 78 can no longer hold barrel 44 against the surface 40, the spring 78 is able to overcome the net hydraulic unbalance of the barrel 44 and hold the same in contact. In increasing to the critical pressure, however, if we assume that the clearance between surfaces 40 and 42 remains constant, the leakage from these surfaces radially inward to the chamber 62 will increase correspondingly. This leakage passes through passage 64 into chamber 66 and out through passage 88.

The valve spool 102 cooperating with the fixed orifice 100 acts to maintain a constant maximum rate of flow through the passage 88. This maximum is equal to the leakage which it is desired to have take place at or near normal operating pressure. So long as the leakage is below this value it is permitted to pass through orifice 100 with very little resistance. As soon as the leakage reaches or exceeds this value, however, the valve 102 comes into effect and acts to thereafter maintain a constant pressure in the passage 88.

It will be noted that the left-hand end of the spool 102 is subject to the force of spring 106 only, the hydraulic pressure thereon being atmospheric. The right-hand end of spool 102 is subject to the pressure in conduit 96, however, and when the maximum rate of flow is reached, sufficient pressure is required to force this quantity through orifice 100 to overcome the force of spring 106 and move the valve spool 102 to the left, thereby tending to close the orifices 116 from chamber 94. Accordingly the valve spool 102 re-

stricts the flow between groove 90 and chamber 94 in sufficient amount to maintain a constant pressure in chamber 94. Consequently the rate of flow through orifice 100 is maintained constant. It will thus be seen that when the leakage increases beyond the value for which the valve 102 and orifice 100 are set, the excess leakage over and above what passes through orifice 100 is trapped in the chambers 62 and 66, thereby forcing the piston 68 to the left and holding the barrel 44 tightly against the valve plate, thus decreasing the clearance between surfaces 40 and 42 and decreasing the leakage. It will be seen that the greater the leakage into chamber 62, the greater will be the force exerted on piston 68 so that under any conditions a balance is reached such that the leakage is held down to a predetermined value.

It will be noted incidentally that the same pressure which is exerted in the chamber 66 against the piston 68 is also exerted in the chamber 62 in the opposite direction against the flat face 42 of cylinder barrel 44. Accordingly it is necessary that the net area of the chamber 66 be greater than the net area of chamber 62.

It will be seen that with the construction shown and described, the total force urging the cylinder barrel into contact with the valve plate is automatically regulated to control the leakage across the valve plate surfaces.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a fluid pressure energy translating device having a plurality of cylinders and pistons reciprocable therein, a rotary valve structure comprising two relatively rotatable members provided with flat, annular, sealing surfaces in running engagement and containing fluid distributing ports communicating with said cylinders, one of said members having an area exposed to fluid pressure from said cylinders tending to urge said members into abutment with force proportional to said pressure, means forming a chamber for collecting leakage from said valve, a restricted conduit for draining said chamber, said chamber lying between said conduit and the fluid distributing ports, means including a fluid motor communicating with said chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to said one member, and means for limiting the flow through said conduit to a predetermined maximum irrespective of leakage from said valve.

2. In a fluid pressure energy translating device having a plurality of cylinders and pistons reciprocable therein, a rotary valve structure comprising two relatively rotatable members provided with flat, annular, sealing surfaces in running engagement and containing fluid distributing ports communicating with said cylinders, one of said members having an area exposed to fluid pressure from said cylinders tending to urge said members into abutment with force proportional to said pressure, means forming a chamber for collecting leakage from said valve, a conduit for draining said chamber, said chamber lying between said conduit and the fluid distributing ports, said conduit having a restricted portion therein, pressure responsive means for maintaining a predetermined pres-

sure drop through the restricted portion, and means including a fluid motor communicating with said chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to said one member.

3. In a fluid pressure energy translating device having a plurality of cylinders and pistons reciprocable therein, a rotary valve structure comprising two relatively rotatable members provided with flat, annular, sealing surfaces in running engagement and containing fluid distributing ports communicating with said cylinders, one of said members having an area exposed to fluid pressure from said cylinders tending to urge said members into abutment with force proportional to said pressure, means forming a chamber for collecting leakage from said valve, means including a conduit for draining fluid from said chamber at a fixed maximum rate, said chamber lying between said conduit and the fluid distributing ports, and means including a fluid motor communicating with said chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to said one member.

4. In a fluid pressure energy translating device of the type having a revolving cylinder barrel with a plurality of cylinders therein and pistons reciprocable in the cylinders, a rotary valve structure comprising a stationary valve having a flat annular surface with fluid distributing ports therein, means forming a flat annular surface on the cylinder barrel adapted to abut the valve plate surface and provided with fluid distributing ports therein, said barrel being provided with fluid pressure areas exposed to the pressure in said cylinders for exerting a force on the barrel proportional to such pressure tending to urge the barrel into abutment with the valve plate, means forming a chamber for collecting leakage from between said surfaces, a restricted conduit for draining said chamber, said chamber lying between said conduit and the fluid distributing ports, means including a fluid motor communicating with said chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to the barrel, and means for limiting the flow through said conduit to a predetermined maximum irrespective of leakage from said valve.

5. In a fluid pressure energy translating device of the type having a revolving cylinder barrel with a plurality of cylinders therein and pistons reciprocable in the cylinders, a rotary valve structure comprising a stationary valve having a flat annular surface with fluid distributing ports therein, means forming a flat annular surface on the cylinder barrel adapted to abut the valve plate surface and provided with fluid distributing ports therein, said barrel being provided with fluid pressure areas exposed to the pressure in said cylinders for exerting a force on the barrel proportional to such pressure tending to urge the barrel into abutment with the valve plate, means forming a chamber for collecting leakage from between said surfaces, a conduit for draining said chamber, said chamber lying between said conduit and the fluid distributing ports, said conduit having a restricted portion therein, pressure responsive means for maintaining a predetermined pressure drop through the restricted portion, and means including a fluid motor communicating with said

chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to the barrel.

6. In a fluid pressure energy translating device of the type having a revolving cylinder barrel with a plurality of cylinders therein and pistons reciprocable in the cylinders, a rotary valve structure comprising a stationary valve having a flat annular surface with fluid distributing ports therein, means forming a flat annular surface on the cylinder barrel adapted to abut the valve plate surface and provided with fluid distributing ports therein, said barrel being provided with fluid pressure areas exposed to the

pressure in said cylinders for exerting a force on the barrel proportional to such pressure tending to urge the barrel into abutment with the valve plate, means forming a chamber for collecting leakage from between said surfaces, means including a conduit for draining fluid from said chamber at a fixed maximum rate, said chamber lying between said conduit and the fluid distributing ports, and means including a fluid motor communicating with said chamber and connected to one of said members and responsive to pressure variations in said chamber for varying the total force applied to the barrel.

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