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2,916,334

HYDRAULIC MOTORS AND PUMPS

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9 Claims. (Cl. 308—170)

This application is a continuation of applicant's United States application, Serial Number 319,279, filed November 7, 1952, now abandoned.

This invention relates to improvements in hydraulic motors and pumps and has particular application to such machines of the axial piston type either of the type in which the cylinder block rotates about a fixed axis such as shown in U.S. patent to Janney, 1,020,285, or of the type in which the rotatable cylinder block is oscillatable such as shown in applicant's U.S. Patents 1,931,969 and 2,155,455, although certain features of the present invention may be applicable in other machines.

In such machines there are usually present thrust bearings comprising a rotatable member sliding on a stationary or stator member—usually a cylinder block, containing a plurality of cylinder bores around its axis, rotating relative to a stationary valve plate thrust member formed with two diametrically opposed circular ports each extending somewhat less than 180°. The cylinder bores have exit passages terminating adjacent the valve plate running in alignment with the circular ports in the valve plate. Said circular ports are so arranged circumferentially that one of them is in communication with the exit passages of cylinder bores in which the pistons are moving inwardly while the other circular port is in communication with the exit passages of those cylinders in which the pistons are moving outwardly. The said circular ports constitute, respectively, parts of the intake and delivery conduits.

Among the objects of the present invention is to improve the means for lubricating the co-acting surfaces of such a cylinder block and stator; to provide means for introducing lubricating oil between said surfaces; to assure the formation and preservation of an oil film therebetween and automatically to control the pressure of said lubricating oil film whereby the surfaces are automatically separated slightly while keeping the leakage of oil to a minimum.

It has been proposed heretofore to provide such co-acting rotary and stator members with provisions for introducing pressure oil therebetween, the distribution of the oil being by means of throttling grooves of very small cross-sectional area extending substantially radially. Due to the fact that such grooves were necessarily short their cross-section had to be kept almost microscopically small to prevent excessively high pressures in the oil film, with the consequent excessive oil leakage. Such small, short throttling grooves have the further disadvantage that they can be easily clogged by foreign matter in the oil and their cross-section is quickly reduced by wear of the parts. It is an object of the present invention to provide grooves extending generally circumferentially in a complete or substantially complete circular or substantially circular path which permits the use of a very long groove which can, therefore, be made of larger cross-section while it still provides the desired oil flow. Furthermore, such grooves are not so readily clogged by foreign matter due

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to their increased size and the fact that foreign matter can be more easily washed out of the groove by the relative motion existing between the parts. Furthermore, such grooves being larger and deeper are not substantially changed in cross-section by wear of the parts.

Another object is to provide passages to an oil distributing groove which is brought into communication only intermittently with a source of oil under pressure.

Another object is to provide such passages with a check valve to prevent return of oil from the oil distributing groove.

Other objects will become apparent from the following description taken in connection with the attached drawings showing several illustrative embodiments of the invention, wherein:

Fig. 1 is a longitudinal cross-sectional view of part of such a pump or motor taken on lines 1—1 of Fig. 2 and also on line 1—1 of Fig. 3;

Fig. 2 is a face view of the valve plate of Fig. 1;

Fig. 3 is a face view of the end of the cylinder block of Fig. 1;

Fig. 4 is a view similar to Fig. 2 showing a modified form of construction; and

Fig. 5 is an enlarged cross-sectional view showing certain parts of Fig. 4.

Referring to said drawings, Z indicates the rotatable cylinder block formed with cylinder bores C with which connect exit passages C' (Figs. 1 and 3). P indicates one of the pistons. St represents the valve plate or stator. Although, as appears from Fig. 1, the joint between the cylinder block Z and the valve plate St is on the surface of a sphere any other surface of revolution may be used including a cone, cylinder or a plane. As seen in Figs. 2 and 4 the face of the valve plate is provided with two circularly arranged ports D and S lying at the same radius as the exit passages C' so that each cylinder bore C will communicate alternately with the suction port S (while the pistons in cylinder bore C are moving outwardly) and the delivery port D (while the pistons in cylinder bore C are moving inwardly). Under these circumstances high pressure will prevail in port D whereas a substantially atmospheric pressure will prevail in port S. It is to be understood, however, that these conditions may be reversed by so adjusting the pump as to reverse the flow of oil.

In accordance with Figs. 2 and 4 a thrust-bearing surface Sp is provided exteriorly of the valve ports S and D. In the form shown in Fig. 2 there is provided outwardly of the thrust bearing surface Sp a continuous circular oil distributing groove Dr which is supplied with oil under pressure through bores d in a manner to be described presently. Two bores d are provided, one leading from port D and the other from port S. A suitable check valve comprising, for example, the ball d' (Fig. 1), may be advantageously provided to insure unidirectional oil flow. The bore d opens out onto the face of the valve plate St. As seen in Figs. 1 and 3 the cylinder block is provided with one or more pockets L each of which extends sufficiently outwardly to overlie the groove Dr and to intermittently overlie the bore d so as to form a bridging connection therebetween. Therefore, while such bridging occurs oil under pressure flows from, say, the port D past the check valve, through bore d through pocket L and into the oil distributing groove Dr. Thus, pressure oil is supplied only intermittently to the groove Dr. This permits the use of a larger cross-section in groove Dr while at the same time it reduces the amount of leakage oil. Any number of pockets L may be used as required, seven such pockets being shown in Fig. 3. Furthermore, they need not necessarily be round as shown in Fig. 3 but may have any other suitable shape,

Their number and circumferential extent will be so selected as to provide adequate but not excessive average oil pressure in the groove Dr and in the oil film supplied therefrom.

It will be noted that Figs. 1 and 2 show two bores *d* one leading from each of the ports D and S. Only one of said bores is under pressure at any one time but it is desirable to provide at least two such bores so that when the pressure in the ports D and S is reversed, as when reversal of the direction of flow through the unit, when used as a pump, takes place, there will still be provisions for supplying pressure oil to the oil distributing groove Dr and the rubbing surfaces. At any one time only one of the bores *d* is connected with the pressure side whereas the other bore *d* communicates with the suction or intake side which is under very little or no pressure. This permits oil to flow through the bore *d* connected with the intake port into said port. This is, however, not necessarily objectionable since this reduces the development of pressure between the thrust bearing surfaces and therefore permits the utilization of an oil distributing groove Dr of larger cross-section without an undue separation of the valve surfaces whereby a substantial oil leakage would take place. However, it is desirable in some cases to prevent this flow of oil through a bore *d* to the intake channel and for this purpose one or several check valves of any suitable construction may be used, such as the ball check *d'*, preferably held on its seat by a light compression spring *d''*. Such a check valve, if used, would be provided in some or all of the channels *d*.

It will be noted that the locations of the bores *d* are so related to the spacing of the pockets L that there is at no time an open passage leading from a bore *d* through a pocket L, through the groove Dr to another pocket L and out through the other bore *d*. This causes the pressure oil to be confined in the oil distributing groove Dr and in the oil film between the parts Z and St. In the form shown in Figs. 1, 2 and 3, this is brought about by locating the bores *d* diametrically opposite whereas there are seven pockets L. Therefore, at the moment when pressure oil is admitted to the groove Dr there is no exit therefrom to the low pressure port S. It is obvious that this result would be achieved by using any odd number of pockets L while the bores *d* are diametrically opposite and that the same result can also be achieved although an even number of pockets L is used if the bores *d* are so spaced that when one bore *d* is in communication with a pocket L the other bore *d* will lie between two pockets L, preferably midway between. This arrangement of parts provides for intermittent feeding of pressure oil between the relatively moving surfaces and intermittent release of the oil from between the surfaces, the intermittent feeding and intermittent releasing occurring at different times.

While not always necessary, it is often desirable to provide a circular drainage groove *r* arranged between the valving area St and thrust bearing area Sp in which atmospheric pressure may exist due to the provision of discharge passages A.

It is usually desirable that the oil distributing groove Dr be made as long as possible. To obtain this it is desirable that it approach a circle or at least be arranged generally concentrically as by using a generally serpentine path.

In some cases it is found desirable to interrupt the oil distributing groove Dr by barriers B (Fig. 4) since in some cases the individual sections of the oil distributing groove can be made of sufficient length with the space available. Furthermore, it has been found desirable to provide within the groove Dr or within the sections thereof as shown in Fig. 4 depressions or widened portions T (Figs. 4 and 5) as this arrangement has been found desirable to obtain a better spreading of the oil between the thrust bearing and the valving surfaces. Thus, the groove Dr may be broken up into a number

of small groove sections whereby the succession of groove sections provides the desired distributing action.

Fig. 4 shows a form of the invention in which the number of the bores or passages *d* has been increased to four. These bores may be supplied with check valves as shown in Fig. 1 so that for either direction of oil flow pressure oil will be made available to the bores *d*. The four barriers B divide the oil distributing groove into four sections each supplied individually with pressure oil through its bore *d*. Furthermore, instead of the groove Dr being of uniform cross-section, cutouts or depressions T are shown formed in the throttling groove Dr (Figs. 4 and 5) whereby the spreading of the oil between the thrust bearing and valving surfaces is facilitated without, however, eliminating the desired oil distributing effect. The depressions T may be of any desired shape if they do not approach too near to the edges of the thrust bearing surfaces. It is usually preferred to make them round, as shown in Fig. 4, and with funnel shaped walls as is clear from Fig. 5. The funnel formation (usually conical) provides sloping walls so that the desired oil film is formed not only through the original oil pressure but also by the usual lubricating film formation between sliding surfaces. The depressions T will also serve to collect and store any foreign matter which might otherwise clog the groove Dr.

The form of the surfaces between the stator St and cylinder block Z may be spherical as shown, plane, conical, or even cylindrical. With cylindrical or substantially cylindrical valve surfaces the throttling groove would desirably extend in the direction of relative movement.

While the oil distributing groove Dr has been shown as located in the stator member it might, of course, be located additionally or instead in the rotating member such as the cylinder block Z in which case the pockets L would be located in the stator St.

The principles of the invention could also be applied to shaft bearings which are not valving devices, such as journal bearings in machinery since there is usually enough space available to use a sufficiently long circular oil distributing groove.

It will be understood that the devices shown and described above to illustrate the invention may serve either as a pump or as a fluid motor and that the invention may be used in such or other hydraulic devices where members have motions relative to each other.

While I have herein shown and described only certain embodiments of certain features of my present invention it is to be understood that they are to be regarded merely as illustrative and that I do not intend to limit myself thereto except as may be required by the following claims:

I claim:

1. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, said stator face being formed with a generally circular groove extending substantially entirely around the axis of rotation of the rotatable member generally concentric with said axis, and means in communication with the groove for supplying oil under pressure to said groove comprising at least one oil passage from a source of oil under pressure to a point adjacent to but not opening into the groove, and at least one pocket formed in the rotatable member and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member.

2. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, said stator face being formed with a generally circular groove extending substantially entirely around the axis of rotation of the rotatable member generally concentric with said axis, and means in communication with the groove for supplying oil under pressure to said groove

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comprising at least one oil passage from a source of oil under pressure to a point adjacent to but not opening into the groove, at least one pocket formed in the rotatable member and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member, and a check valve in said oil passage arranged to prevent reverse oil flow.

3. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, said stator face being formed with an oil distributing groove, and means in communication with the groove for supplying oil under pressure intermittently to said groove comprising at least one passage from a source of oil under pressure to a point adjacent to but not opening into the groove, and at least one pocket formed in the rotatable member and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member.

4. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, said stator face being formed with an oil distributing groove, and means in communication with the groove for supplying oil under pressure intermittently to said groove comprising at least one passage from a source of oil under pressure to a point adjacent to but not opening into the groove, and at least one pocket formed in the rotatable member and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member, together with an oil escape passage connected to a low pressure space adapted to receive oil flowing from said groove, said oil escape passage being so located that said at least one pocket momentarily connects it with said groove, whereby oil flows intermittently from said groove, through said pocket and said oil escape passage to said low pressure space.

5. The combination according to claim 4 in which the oil supply passage, the oil escape passage and the at least one pocket are so arranged that the oil escape passage is never open at the time when the oil supply to the groove is open.

6. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, said stator face being formed with an oil distributing

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groove, and means in communication with the groove for supplying oil under pressure intermittently to said groove comprising a passage from a source of oil under pressure to a point adjacent to but not opening into the groove, and a plurality of pockets formed in the rotatable member and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member, together with an oil escape passage connected to a low pressure space adapted to receive oil flowing from said groove, said oil escape passage being so located that said pockets momentarily connect it with said groove, whereby oil flows intermittently from said groove, through said pockets and said oil escape passage to said low pressure space.

7. The combination according to claim 6 in which the oil supply passage, the oil escape passage and the pockets are so arranged that the oil escape passage is never open at the time when the oil supply to the groove is open.

8. The combination according to claim 6 in which the oil supply passage is located diametrically opposite the oil escape passage and the plurality of pockets are of an odd number so that when a pocket connects with either passage there is no pocket which connects with the other passage.

9. In a device of the character described, a stator provided with a bearing face, a rotatable member having a bearing face abutting and rotating upon the stator face, one of said faces being formed with an oil distributing groove, and means in communication with the groove for supplying oil under pressure intermittently to said groove comprising at least one passage from a source of oil under pressure to a point adjacent to but not opening into the groove, and at least one pocket formed in the other bearing face and so located and dimensioned as to momentarily connect said oil supply passage with the groove during each rotation of the rotatable member, together with an oil escape passage connected to a low pressure space adapted to receive oil flowing from said groove, said oil escape passage being so located that said at least one pocket momentarily connects it with said groove, whereby oil flows intermittently from said groove, through said pocket and said oil escape passage to said low pressure space.

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