ROTARY FLUID PRESSURE PUMPS AND MOTORS OF THE ECCENTRIC VANETYPE

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This invention relates to motors of the eccentric vane type, and especially to rotary fluid pressure pumps and to hydraulic pumps and motors of the kind comprising a casing defining a substantially cylindrical working chamber, a rotor mounted eccentrically within said casing, vane elements spaced around said rotor and mounted therein so as to project radially, their outer parts cooperating with the circumferential wall of the working chamber in a substantially liquid-tight manner, and inlet and outlet passages communicating with the working chamber. Such pumps and motors are herein referred to as "hydraulic pumps or motors of the kind referred to.

It is an object of the invention to provide constructional improvements in this kind of pump or motor which simplify the manufacture and also enable reliable running to be achieved, even under heavy load and high pressure.

In a hydraulic pump or motor of the kind referred to, according to the invention the vane elements comprise shoes of substantially T-shape in cross section, having their transverse portions slidably engaging the circumferential wall of the working chamber, and their stem portions extending inwards into operative connection with the rotor, and a by-pass passage which is provided to allow the escape of pressure liquid from that part of the working chamber adjacent top dead centre after the transverse portion of each vane element has closed the entrance to the outlet passage.

There is further provided according to the invention a hydraulic pump or motor of the kind referred to, wherein the vane elements comprise shoes of substantially T-shape in cross section, having their transverse portions slidably engaging the circumferential wall of the working chamber, and their stem portions extending inwards into operative connection with the rotor, and a by-pass passage formed in at least one end wall of the working chamber to provide an escape for pressure liquid from that part of the working chamber adjacent top dead centre after the transverse portion of each vane element has closed the entrance to the outlet passage.

Preferably the circumferential span of the transverse portion of each shoe is at least twice the depth of the stem portion thereof, measured radially of the rotor. The inlet and outlet passages may have ports disposed in the outer curved wall of the working chamber which may extend for only part of the axial width of said wall, leaving one or more circumferential zones which are uninterrupted, that part of each shoe which passes across the ports conveniently being restricted in circumferential span by comparison with those portions which run upon the uninterrupted zone or zones of the circumferential wall of the working chamber. Thus in one arrangement the inlet and outlet ports are spaced from the end walls of the working chamber, and the transverse portions of the vane are restricted in width where they pass over the ports, making said transverse portions waisted or substantially H-shaped in plan.

If desired the stem portions of the shoes may have mutually parallel plane sides and fit into longitudinal grooves formed in the rotor, said grooves having mouths within which the stem portions fit snugly but with freedom to rock, and the inner parts of said grooves being widened to accommodate the inner edge of the stem portion as the shoe swings; the grooves may be substantially barrel-shaped in cross section.

The by-pass passage conveniently comprises a groove formed in the end wall of the working chamber, the arrangement being such that when the rotor is disposed so that the top dead centre is midway between two adjacent shoes, that end of the groove nearer the rotor hub is covered by that one of said shoes nearer the outlet passage. Thus a by-pass passage may be formed in each of the end walls of the working chamber. Where the pump or motor is required to be reversible a pair of by-pass passages is formed in an end wall of the working chamber, these being associated with the inlet and outlet passages, so as to operate in connection with whichever of said passages is acting as the outlet passage.

By making the span of each vane or shoe relatively large, say one-fifth of the casing diameter, the pump or motor can be arranged to have a large eccentricity (or maximum eccentricity in the case of a variable displacement pump or motor), this being say up to $\frac{1}{6}$ the casing diameter. If desired, of course, the working chamber need be not truly cylindrical as it is sometimes required to shape the casing so that this working chamber departs somewhat from the truly circular form.

The invention is illustrated by way of example in the accompanying drawings which show one construction suitable for use either as a motor or a pump. In these drawings:

Figure 1 is a sectional end elevation taken on the line 1—1 of Figure 2;
Figure 2 is a longitudinal sectional elevation taken on the line 2—2 of Figure 1;
Figure 3 is a fragmentary sectional plan taken on the line 3—3 of Figure 1 and omitting the motor;
Figure 4 is a fragmentary transverse sectional view to show the action of the by-pass passages;
Figure 5 is a fragmentary sectional view showing a typical plunger device for holding the shoes initially in contact with the wall of the working chamber; and
Figure 6 is a fragmentary sectional view showing a modified construction of shoe.

The pump or motor shown mainly in Figures 1 to 3 comprises a casing which is indicated generally at 10 and is composed of a central ring-like member 11 and two end covers 12 and 13, these parts being secured together by bolts or clamps which are not shown in the drawings. The central member 11 is formed upon its inside with a smooth cylindrical bore 14 which constitutes the circumferential wall of the working chamber 15 of the pump or motor; the end walls 16 and 17 thereof are plane and are of course formed upon the covers 12 and 13. A shaft 18 is mounted in roller bearings 19 and 20 in the covers 12 and 13, respectively, its end extending through a packing gland 21 carried by a bearing cap 22 attached to the end cover 13; the housing for the bearing 17 is closed by a plate 23. A rotor in the form of a cylindrical block 24 fits snugly between the end walls 16 and 17 of the casing 10, and it has a parallel bore 25 which is grooved longitudinally at 26 (Figure 1) so as to fit slidably upon splines 27 formed upon that part of the shaft 16 disposed half-way between the end walls 18 and 19 as shown in Figure 2. Although the grooves 26 are parallel-sided, the splines 27 are tapered in width from their middle towards both ends and they also correspondingly taper in diameter, thus enabling the rotor 24 to rock upon the shaft 18, but at the same time be in firm driving connection therewith. This enables the rotor 24
2,778,317 3 to be fitted very closely between the end walls 16 and 17, for any out-of-truth of either of the end walls 16, 17 relative to the axis of the shaft 18 cannot cause binding of the parts.

Spaced equidistantly around its circumference, the rotor 24 has a number, say five, longitudinal grooves 25 which are of somewhat barrel-shape in cross section, their side walls being bulged and their mouth portions being overhung. Into each of these grooves 25 a vane or shoe 29 is fitted, these shoes being arranged to move round with the rotor 24 but also to slide in engagement with the circumferential wall 14 of the working chamber 15.

Each of the shoes 29 is of substantially T-shape as is seen in Figures 1 and 3, the transverse portion 30 being curved to fit snugly against the wall 14, while the stem portion 31 is arranged to fit into the corresponding groove 28, the shape of which permits the requisite rocking movement of the shoe 29, due to the eccentric mounting of the rotor 24 relative to the circumferential wall 14. In this connection the axis of the shaft 18 and rotor 24 is indicated at 32 in Figure 1, while the axis of the circumferential wall 14 is shown at 33. It will be noted that the transverse portions 30 of the shoe 29 are relatively wide (in the circumferential sense) and in the example shown the total arcuate span of the five shoes 29 amounts to approximately 0.9 of the circumference of the wall 14. This gives the shoes 29 great stability and also enables efficient liquid sealing to be achieved, although it does tend to produce difficulties due to premature cut-off of the outlet port.

The pump shown in the drawings has two connections 34 and 35 which are interchangeable as inlet and outlet connections depending upon whether the device is being used as a pump or a motor and the direction in which the shaft 18 is driven or is required to run. For the present description, however, it will be assumed that the device is being operated as a pump, the shaft 18 being turned anti-clockwise, as viewed in Figure 1, so that the connection 35 becomes the outlet connection. The connection 34 leads, by way of a passage 36, to an inlet port 37 formed in the circumferential wall 13, said inlet port being of somewhat elongated or oval shape, but it is relatively narrow so that it is confined to the middle part of the axial width of the wall 14, those portions 38 and 39 of said wall which extend alongside the port 37 being quite narrow. A similar outlet delivery port 40 leads by way of an outlet passage 41 to the connection 35, said port 40 being relatively narrow so as to leave continuous flanking portions 38 and 39. In order to reduce the extent to which the ports 37 and 40 are obstructed by the transverse portions 30, these are cut out of the middle of their leading and trailing edges, as indicated at 42, thus considerably reducing the width of each shoe 29 where it cooperates with the ports 39 and 40. On the other hand, the ends of the transverse portion 30 which cooperate with the flanks 38 and 39 of the circumferential wall 14 are left at their full width so as to support the shoes efficiently and prevent them becoming unseated during operation of the pump. The shoes 29 are preferably made from sheet metal, this being bent double to form the stem portion 31 and the two ends being bent outwards and curved so as to produce the transverse portion 30. The stem portion 31 is, of course, a snug running fit between the end walls 16 and 17, but the transverse portion of each shoe 29 is conveniently tapered slightly at its ends, as indicated for instance at 43, in order to avoid any risk of binding.

As each of the shoes reaches the position which is shown at 29a in Figure 4, it comes into sealing engagement with the edge 44 of the outlet port 40, so that the section 45 of the working space 15 disposed in advance of the shoe 29a becomes substantially isolated, with the result that the liquid contained therein cannot readily escape to the port 40 whilst the volume of the space 45 continues to diminish during the period while the shoe 29a is moving upwards to the top dead centre, indicated at 46. Therefore the liquid trapped in the space 45 would cause rough running of the pump and it would also reduce the operating efficiency. In order to overcome these disadvantages the end covers 12 and 13 are formed with grooves 47 and 48, respectively, which act as by-pass passages in the vicinity of the port 40. As will be seen in Figure 4, the groove 47 extends vertically and at its upper end it has a narrow oblique portion 49a adapted to communicate freely with the isolated working space 45. It also has lateral extensions 49c which are in permanent communication with the port 40 so that as the volume of the isolated space 45 diminishes still further, the liquid can escape freely to the outlet passage 41. It will be noticed that at the lower part of the working chamber 15 the ascending space between the shoes 29 is already decreasing in volume before the upper edge of said shoes clears the lower edge of the port 40 in the position of the parts shown in Figure 1, and in order that liquid may be enabled to escape to the outlet passage 41, the groove 47 has a downward extension 47b to act as a by-pass passage leading to said outlet passage 41 by way of the extensions 47c. The by-pass passage 48 is of similar design. Similar grooves 50 and 51 are provided in the end covers 16, 17 adjacent the inlet port 37, partly to enable the working spaces to be filled more efficiently with working fluid, and partly to enable the pump or motor to be operated in the reverse direction by treating the connection 34 as the fluid outlet.

Any convenient means may be used for urging the shoes 29 outwards into firm engagement with the circumferential wall 14 when the pump is being started up, and one such arrangement is shown in Figure 5. Adjacent each of the grooves 28 the rotor 24 is drilled at 52 to form a socket for a coiled compression spring 53; a plunger 54 is fitted into the outer end of the spring so as to be slidable within the bore 52, and it presses upon the inside surface of the shoe 29, thus forcing the latter outwards against the circumferential wall 14. If desired a pair of plungers 54 can be provided side by side for each of the shoes 29.

In the modified construction of shoe shown in Figure 6, the stem portion 31 is provided along its upper or inner edge with a bead 55, this being thicker than the remainder of the stem portion 31 and lying between a male and female form of the corresponding groove in the rotor 24; this groove is indicated at 28a and has mutually parallel side walls 56. Thus under the operating conditions of the pump or motor, a relatively good liquid-tight seal is produced between the bead 55 and the interior of the groove 28a, the shoe 29 at the same time being free to move angularly to accommodate itself to the wall 14.

It will be understood that the above details are given by way of example only and that various modifications may be made to suit requirements. The improvements can readily be incorporated in pumps of the kind having provision for varying the displacement, and in one arrangement which is not illustrated, the central member 11 of the casing is mounted so as to be free to move angularly between the end covers 12 and 13, the pivotal axis being adjacent the outlet port, and the movement being effected by a screw-threaded rod acting on the opposite side of the central member. A convenient method of shaping the driving shaft 20 for this purpose is to have the splines 27 in one way as follows. The outer surface of the shaft is progressively reduced in diameter from a point half-way along the splines 27, the taper being, say, 0.020 inch of the diameter for each inch of length. Spline grooves are then formed along these tapered surfaces, the shaft axis being suitably tilted during milling, so that these grooves conform to the taper and are therefore of constant depth and constant width. Thus the rotor is free to rock slightly on the shaft, but in any position the
splines are a reasonably close fit and are well able to carry the imposed torque loading.

I claim:

1. A hydraulic pump or motor comprising a casing defining a substantially cylindrical working chamber, with a circumferential wall and two end walls, a rotor mounted eccentrically within said casing, a plurality of grooves extending longitudinally in the circumference of the rotor, a plurality of vane elements of T-shape in cross section each having its stem portion mounted in the corresponding groove of the rotor with freedom to slide radially therein and to rock therein, and having a transverse head portion slidably engaging with the circumferential wall of the casing, and a by-pass passage formed in an end wall of the casing and arranged to allow pressure liquid to pass around the corresponding end of the vane elements and thus escape from that part of the working chamber adjacent the top dead centre after the transverse head portion of each vane element has closed the outlet port.

2. A hydraulic pump or motor comprising a casing defining a substantially cylindrical working chamber, with a circumferential wall and two end walls, a rotor mounted eccentrically within said casing, a plurality of grooves extending longitudinally in the circumference of the rotor, a plurality of vane elements which are of T-shape in cross section, each with its stem portion rigid with the transverse head portion, each of said vane elements having its stem portion mounted in the corresponding groove of the rotor with freedom to slide radially therein and to rock therein, and having a transverse head portion slidably engaging with the circumferential wall of the casing in a fluid-tight manner, inlet and outlet ports formed in the circumferential wall of the casing, and a by-pass passage formed in an end wall of the casing and arranged to allow pressure liquid to pass around the corresponding end of the vane elements and thus escape from that part of the working chamber adjacent the top dead centre after the transverse head portion of each vane element has closed the outlet port.

3. A hydraulic pump or motor according to claim 2, in which the by-pass passage comprises a groove formed in the end wall of the casing.

4. A hydraulic pump or motor according to claim 2, in which the by-pass passage comprises a main groove formed in the end wall of the casing and extending chordwise across the outlet port, with branch grooves leading into the working space between said port and the rotor.

5. A hydraulic pump or motor according to claim 2, in which the grooves are substantially barrel-shaped in cross section, their mouths being a snug fit on the stem portions of the vane elements.

6. A hydraulic pump or motor according to claim 2, in which the stem portions of the vane elements have beads formed along their inner edges, which fit snugly within parallel-sided grooves formed in the rotor, and which allow the vane elements to swing in conformity with the eccentricity of the circumferential casing wall relative to the rotor axis.

7. A hydraulic pump or motor according to claim 2, in which a spring-pressed plunger is fitted into the rotor and bears at its outer end upon the transverse head portion of one of the vane elements, to urge said head against the circumferential wall of the casing.

8. A hydraulic pump or motor comprising a casing defining a substantially cylindrical working chamber, with a circumferential wall and two end walls, a rotor mounted eccentrically within said casing, a plurality of grooves extending longitudinally in the circumference of the rotor, a plurality of vane elements of T-shape in cross section each having its stem portion mounted in the corresponding groove of the rotor with freedom to slide radially therein and to rock therein, and having a trans-
12. A hydraulic pump or motor according to claim 11, in which the inlet and outlet ports are spaced from the end walls of the casing, and the transverse head portions of the vanes are restricted in circumferential width where they pass over the inlet and outlet ports, said transverse head portions thus being substantially H-shaped as viewed in the radial direction.

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