

Sept. 27, 1966

C. O. JONKERS ET AL

3,274,947

HYDRAULIC PUMP OR MOTOR

Original Filed Aug. 31, 1960

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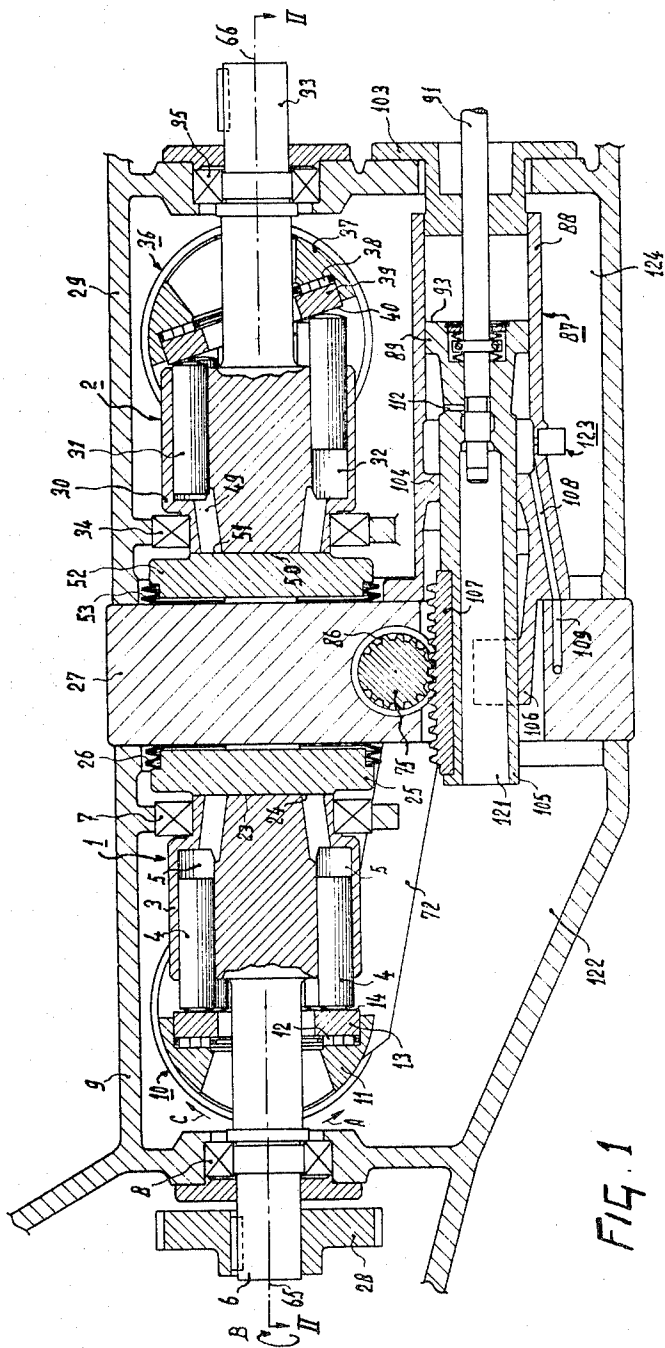


FIG. 1

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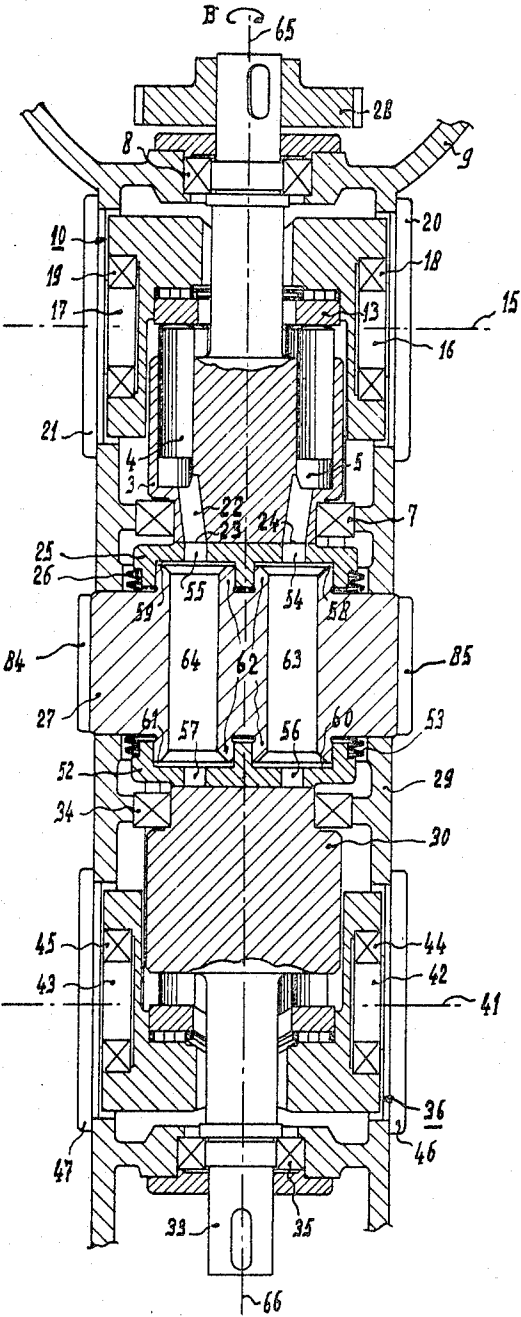
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FIG. 2



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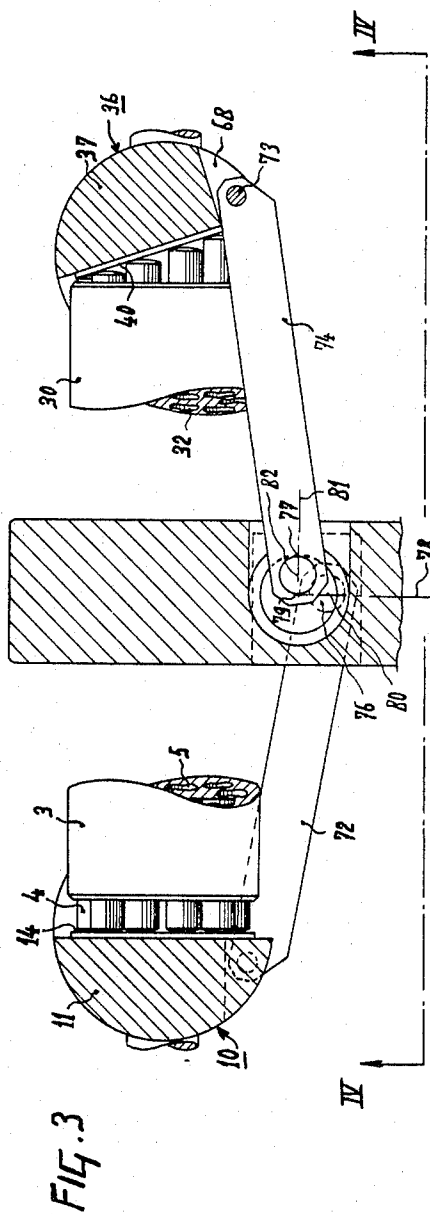
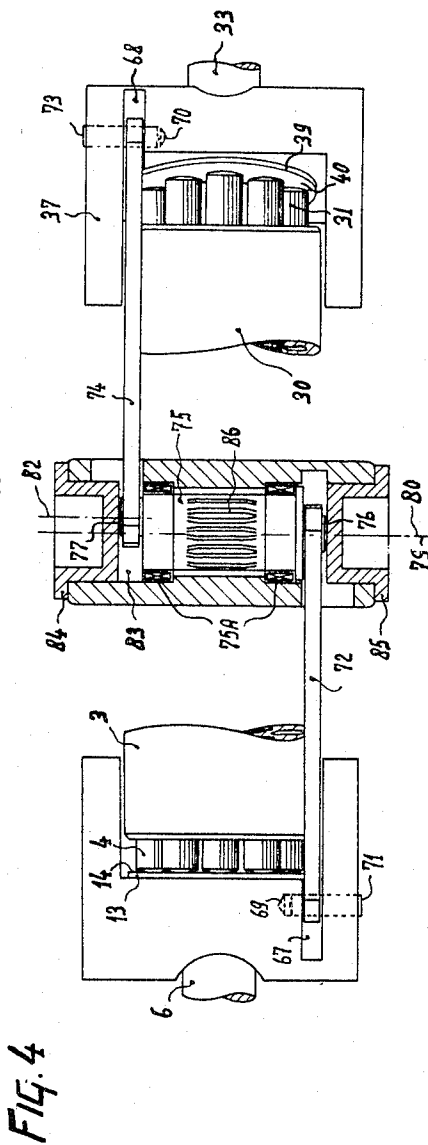
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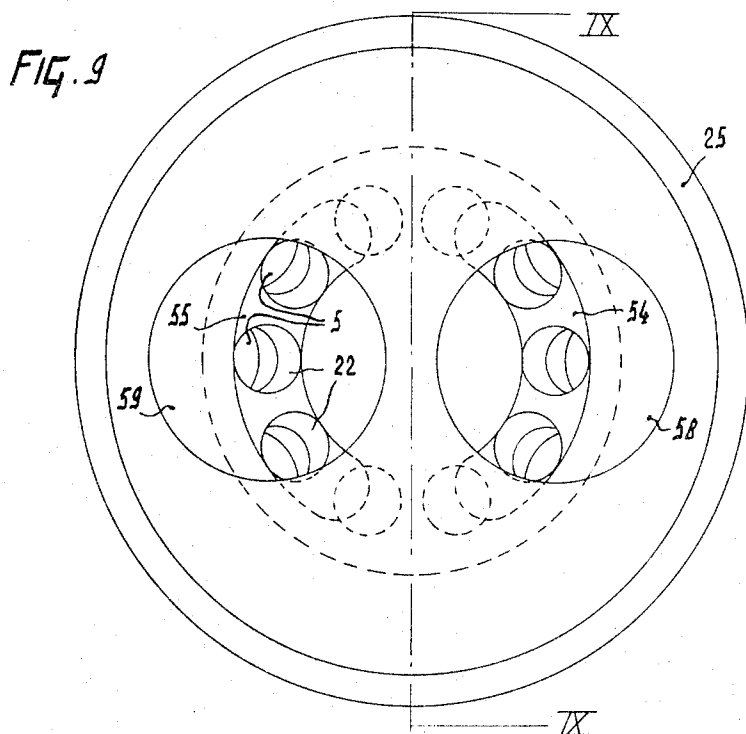
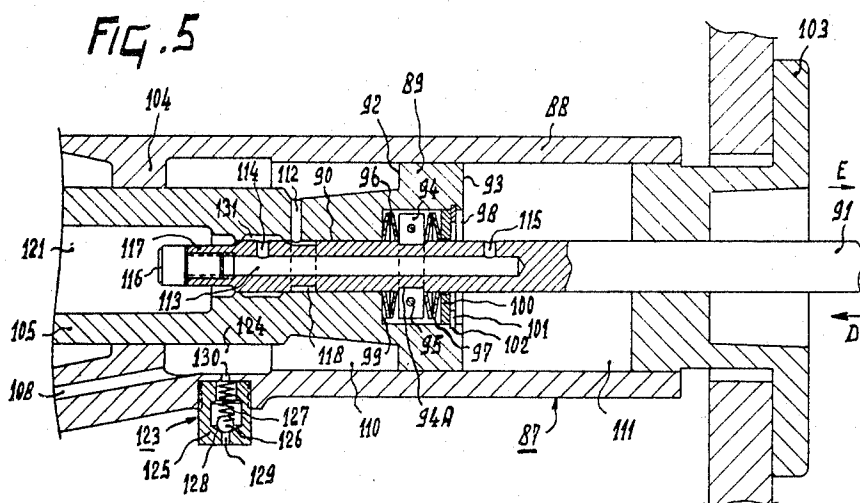
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FIG. 6

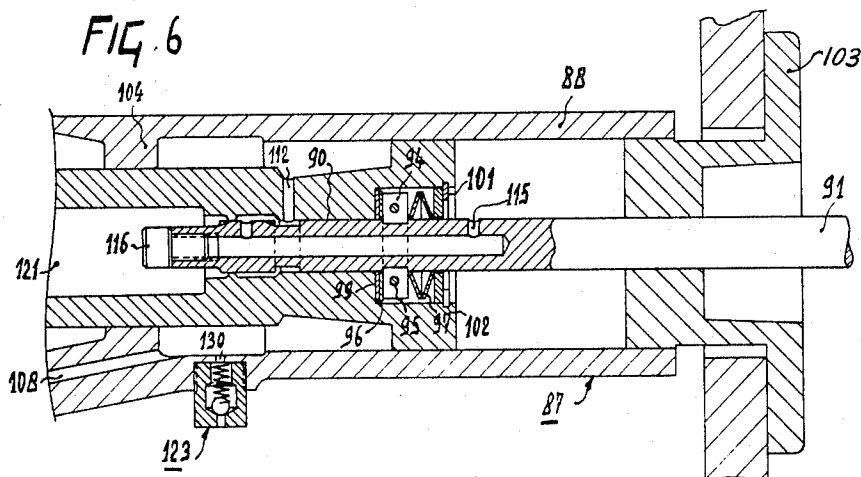


FIG. 7

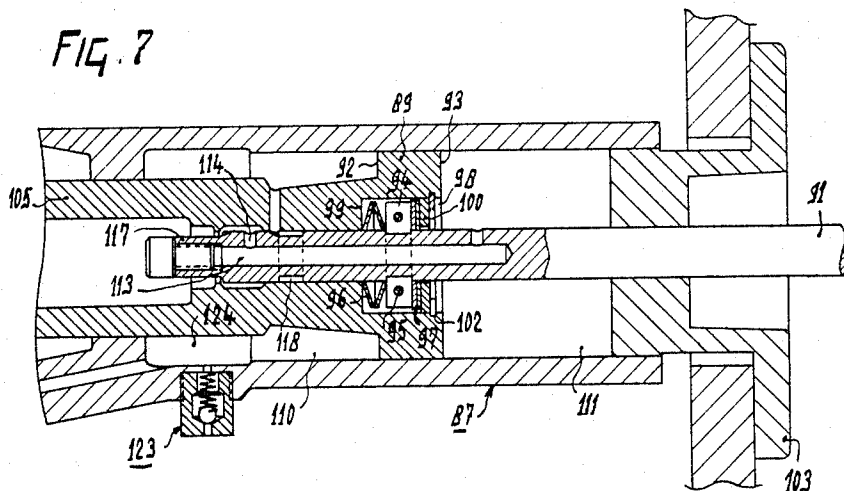
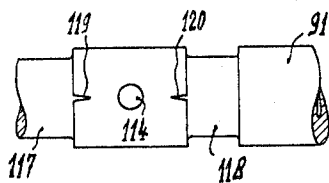


FIG. 8



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FIG. 10

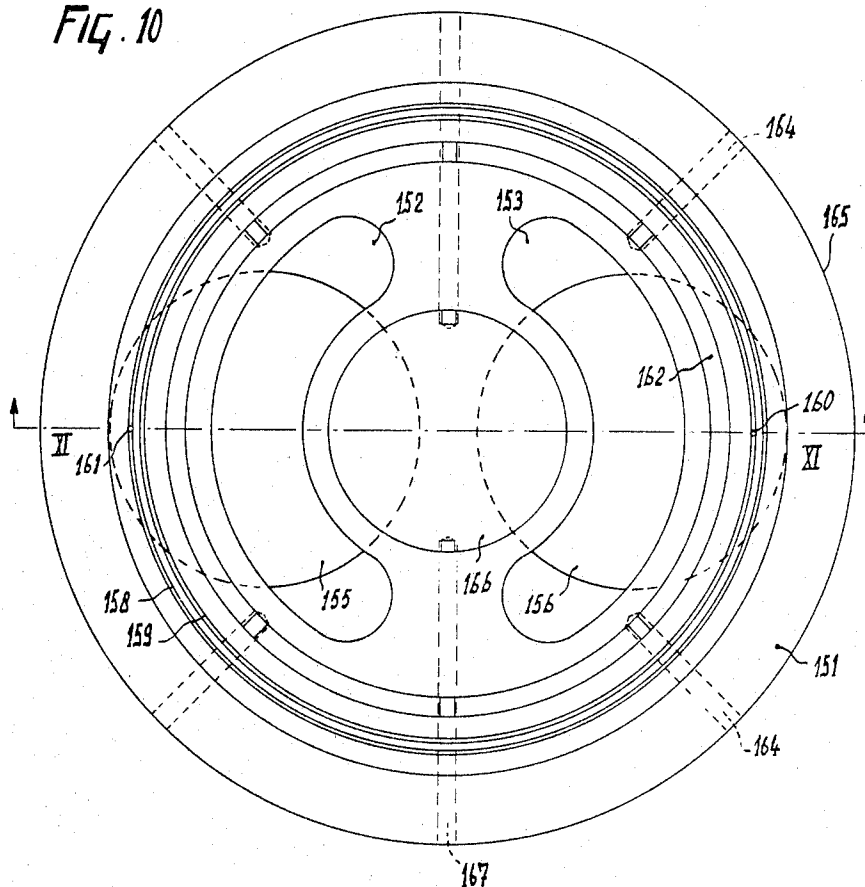
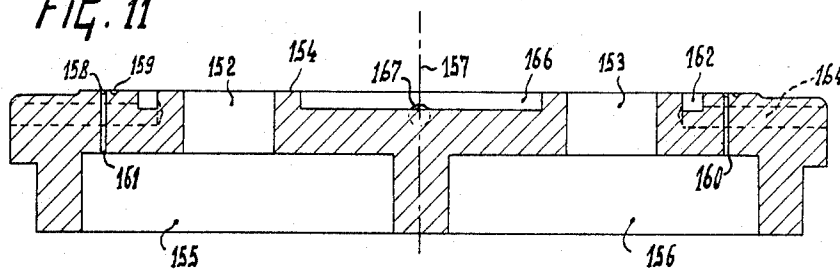


FIG. 11



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FIG. 14

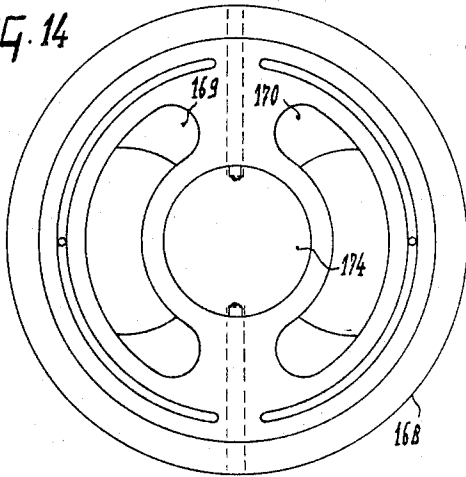


FIG. 15

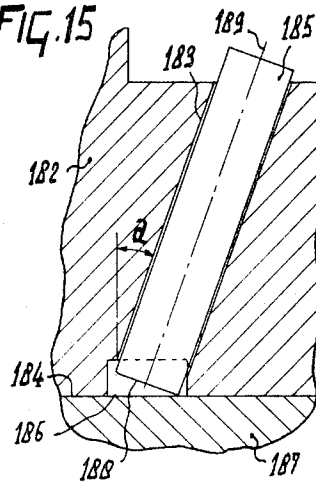


FIG. 13

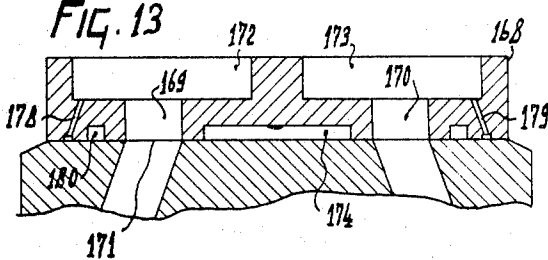


FIG. 16

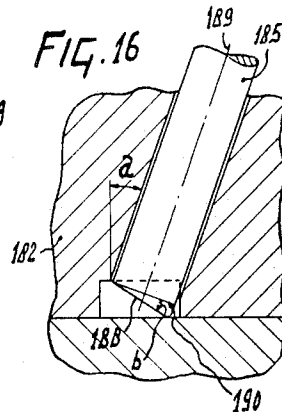
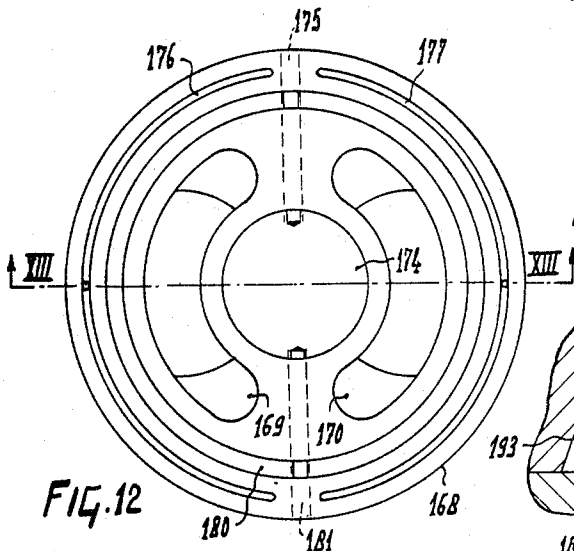
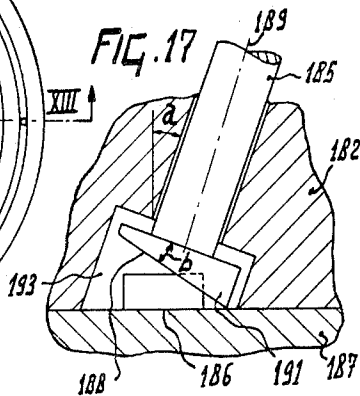


FIG. 17



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HYDRAULIC PUMP OR MOTOR

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Original application Aug. 31, 1960, Ser. No. 53,289, now Patent No. 3,132,486, dated May 12, 1964. Divided and this application Dec. 31, 1963, Ser. No. 334,814
8 Claims. (Cl. 103-162)

This application is a division of application Serial No. 53,289, filed August 31, 1960, and now Patent No. 3,132,486.

This invention relates to a hydraulic pump or motor of the kind comprising a housing having a plurality of chambers in each of which a piston or plunger is axially movable, a surface of the housing being in slidable engagement with a surface formed on a port plate and the housing being turnable relative to one another about an axis of rotation, ports provided in the afore-said port plate, at least one of which ports forms part of a duct, which is adapted to contain hydraulic liquid under a relatively high pressure and at least one of which forms part of a duct, which is adapted to contain liquid under a relatively low pressure.

According to the invention the housing and the port plate are movable relative to one another in a direction extending transverse to a plane containing the surfaces of the housing and the port plate, which are in relatively slidable engagement.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

FIGURE 1 is a sectional elevation of a power-transmission system in accordance with the invention,

FIGURE 2 is a section taken on the line II—II of FIGURE 1, some of the parts occupying different positions to those shown in FIGURE 1,

FIGURE 3 is a side elevation of some of the parts shown in FIGURES 1 and 2,

FIGURE 4 is a view taken in the direction of the arrows IV—IV of FIGURE 3,

FIGURE 5 is a sectional elevation, to an enlarged scale, of parts of the system shown in FIGURES 1 and 2,

FIGURE 6 is similar to FIGURE 5 but shows some of the parts in a different position,

FIGURE 7 is similar to FIGURES 5 and 6 but shows some of the parts in a still further different position,

FIGURE 8 is a detail view, to an enlarged scale, of part of one of the members shown in FIGURES 5 to 7,

FIGURE 9 is an elevation, to an enlarged scale, of one of the parts of the system shown in FIGURES 1 and 2,

FIGURE 10 is similar to FIGURE 9 but shows an alternative embodiment,

FIGURE 11 is a section taken on the line XI—XI of FIGURE 10,

FIGURE 12 is a view similar to FIGURES 9 and 10 but on a smaller scale, showing a further alternative embodiment,

FIGURE 13 is a section taken on the line XIII—XIII of FIGURE 12,

FIGURE 14 is similar to FIGURE 12 and shows a still further alternative embodiment,

FIGURE 15 is an elevation, partly in section, showing a detail of part of a member of the kind shown in FIGURES 12 to 14,

FIGURE 16 is similar to FIGURE 15 but shows a modified construction,

FIGURE 17 is similar to FIGURES 15 and 16 but shows a further modified construction.

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Referring to the drawings, the system shown in FIGURES 1 and 2 comprises as its principal features a hydraulic pump 1 and a hydraulically operated motor 2. The hydraulic pump 1 has a housing 3 in which is formed a plurality of chambers 5. Each chamber 5 receives a piston or plunger 4 which is movable longitudinally of the chamber 5. The housing 3 is integral with the inner end of an input shaft 6 and is rotatably supported in a casing 9 by means of bearings 7 and 8. The bearing 7 is disposed around a portion of the housing of reduced diameter whereas the bearing 8 surrounds the aforementioned shaft 6. The outer end of the shaft 6 which projects through the casing 9 is provided with a rigidly mounted pinion 28.

A pump swash-plate generally indicated by the reference numeral 10 comprises a pivotable body 11 which supports a ring 13 by means of a roller thrust bearing 12. The body 11 is pivotable about an axis 15 (FIGURE 2) which is afforded by two aligned stub axles 16 and 17 (FIGURE 2) which support the body 11 by means of bearings 18 and 19. The stub axles 16 and 17 are secured to two covers 20 and 21 respectively, the said covers being themselves secured to the casing 9. The ring 13 has a flat surface 14 which bears against the outer domed end of each piston 4. The inner end of each chamber 5 is connected by means of a passage 22 formed in the housing 3 with a surface 23 of the housing 3, the said surface 23 being in sliding engagement with a surface 24 formed on a flat port plate 25. The surface 25 is urged against the surface 24 by means of a dish-spring 26 which extends between a block 27 rigid with the casing 9 and a shoulder formed in the port plate 25.

A second casing 29 is also rigid with the block 27 and contains the hydraulic motor 2 which latter comprises a housing 30 having a plurality of chambers 32 in each of which a piston or plunger 31 is axially movable. The housing 30 is integral with the inner end of an output shaft 33 and is rotatably supported in the casing 29 by means of a bearing 34 which surrounds a portion of reduced diameter of the housing 30 and by means of a bearing 35 which surrounds the aforementioned integral shaft 33. A motor swash-plate generally indicated by the reference numeral 36 comprises a pivotable body 37 which is turnable about an axis 41 (FIGURE 2) afforded by two stub axles 42 and 43 upon which the body 37 is mounted by means of bearings 44 and 45. The stub axles 42 and 43 are rigidly secured to covers 46 and 47 which, in turn, are rigidly secured to the casing 29. The body 37 rotatably supports a ring 39 by means of a roller thrust bearing 38, the ring 39 having a flat surface 40 which is in engagement with the domed head of each of the pistons 31.

Each chamber 32 is connected by means of a passage 49 with a surface 51 of the housing 30, the said surface 51 being in sliding engagement with a surface 50 formed on a flat port plate 52. The surface 50 is urged into sliding engagement with the surface 51 by means of a dish-spring 53 which extends between the aforementioned block 27 and a shoulder formed on the port plate 52.

The port plate 25 of the hydraulic pump 1 is provided with two elongated arcuate slots 54 and 55 (see FIGURE 9) which slots constitute a communication between the opposite sides of the said plate 25, the said slots opening, on the side of the port plate 25 adjacent to the block 27, into recesses 58 and 59.

Substantially identical slots 56 and 57 are formed through the thickness of the port plate 52 of the hydraulic motor 2 and these slots open similarly into recesses 60 and 61 (see FIGURE 2). The block 27 has bosses 62 which engage in the matching recesses 58-61 of the port plates. This arrangement ensures that no substantial movement of the port plates 25 and 52 can take

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place in directions parallel to the sliding surfaces 23, 24 and 50, 51.

The recess 58 in the port plate 25 communicates with the recess 60 in the port plate 52 by way of a bore 63 formed in the block 27 and the recess 59 communicates similarly with the recess 61 by way of a bore 64. The axis of rotation 65 of the hydraulic pump 1 is coincident with the axis of rotation 66 of the hydraulic motor 2, both these axes being perpendicular to the respective pivotal axes 15 and 41 of the bodies 11 and 37.

As shown in FIGURES 3 and 4, the pivotable body 11 is provided with an elongated slot 67 while pivotable body 37 is similarly provided with an elongated slot 68. A transverse bore 69 crosses the slot 67 at right angles thereto and receives a pivot pin 71 about which one end of a coupling rod 72 is turnable. A transverse bore 70 similarly crosses the slot 68 and receives a pivot pin 73 about which one end of a coupling rod 74 is turnable. The bores 69 and 70 are spaced at equal distances from the corresponding pivotal axes 15 and 41 (see FIGURE 2). The end of the coupling rod 72 remote from the pivot pin 71 is journaled on a stub shaft 76 whose longitudinal axis 80 is eccentric with respect to the longitudinal axis 79 of a control shaft in the form of a toothed drum 75 from whose end it projects. In FIGURE 4, axis 79 is directly above axis 80 and these axes coincide. In FIGURE 3, however, the lead lines for axes 79 and 80 are directed to their geometric location at the centers of toothed drum 75 and stub shaft 76, respectively. The end of the coupling rod 74 remote from the pivot pin 73 is similarly journaled on a stub shaft 77 whose longitudinal axis 82 is also eccentric with respect to the longitudinal axis 79 of the toothed drum 75. A perpendicular line of connection 78 (see FIGURE 3) between the axes 79 and 80 is inclined at 90° to a similar perpendicular line of connection 81 between the axes 79 and 82. However, as will be seen from FIGURE 3, the eccentricity of the stub shaft 76 relative to the axis of rotation 79 of the toothed drum 75 is greater than that of the stub shaft 77. The toothed drum 75 is rotatably journaled by means of bearings 75A in a recess 83 formed in the block 27, substantial axial movement of the drum 75 being prevented by means of covers 84 and 85 which fit into the opposite ends of the recess 83 and the drum 75 being provided around the greater part of its periphery with a set of teeth 86 (see FIGURES 1 and 4).

The system also includes an hydraulically operated mechanism which is generally indicated by the reference numerals 87 in FIGURES 1 but which is shown in greater detail in FIGURES 5 to 8. The mechanism 87 consists principally of a piston 89 which is movable in a cylinder 88 which, during operation of the system, is filled with liquid under pressure, and a control rod 91 which is axially slidable in a bore 90 formed in the piston 89. The piston 89 has a surface 92 whose area is smaller than that of the opposite surface 93. A ring 94 formed of two parts secured to one another by bolts 95 is arranged in a recess 94A formed in the control rod 91. Dish-springs 96 and 97 are mounted around the control rod 91 on opposite sides of the ring 94, the ring 94 and both the dish-springs 96 and 97 being received within a recess 98 formed in the surface 93 of the piston 89. The dish-spring 96 bears between the innermost surface 99 of the recess 98 and one side of the ring 94 whereas the dish-spring 97 bears between the opposite side of the ring 94 and a further ring 100 which is maintained in a position which closes the recess 98 by means of a split ring 101 disposed in a groove 102 formed just inside the mouth of the recess 98. Thus, the control rod 91 is linked with the piston 89 but is movable axially through a small distance in either direction relative thereto against the resilient opposition of either the dish-spring 96 or the dish-spring 97. One end of the cylinder 88 is closed by a cover 103 through a hole in the center of which passes the control rod 91. The opposite end of the cylinder 88

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is formed by a cylinder wall 104 through which passes an extension 105 of the piston 89, the said extension 105 being supported by a semi-cylindrical bearing 106 rigid with the body of the cylinder 88. A toothed rack 107 is rigid with the extension 105 and co-operates with the teeth 86 of the toothed drum 75.

A duct 108 is formed in the wall of the cylinder 88 and connects the space 110 on one side of the piston 89 with a further duct 109 formed in the block 27, the duct 109 leading to a source of liquid under pressure. The control rod 91 is formed with an axial duct 113 whose end is closed by a plug 116, two transverse bores 114 and 115 opening into the said duct 113 at different points along the length of the control rod 91. The end 117 of the control rod 91 at which the plug 116 is disposed is of reduced diameter with respect to the major part of the length of the rod and an annular recess 118 is formed in the rod at a point in between the end 117 and the two-part ring 94. Both these parts 117 and 118 of reduced diameter have V-shaped grooves 119 and 120 respectively (see FIGURE 8) which grooves taper into the thicker part of the control rod 91 in directions parallel to the length of the latter. The end 117 of the control rod 91 is disposed in a cavity 121 formed within the extension 105 of the piston 89. The cavity 121 is in communication with a liquid reservoir space 122 and the aforementioned space 110 in the cylinder 88 is in communication via a one-way valve 123 with a further space 124 (see FIGURE 1). The one-way valve 123 (see FIGURE 5) consists of a housing 125 having an inlet passage 129 and an outlet passage 130 in which a ball 126 is pressed against a seating 128 to close the inlet passage 129 by means of a coiled compression spring 127. Liquid can only flow through the one-way valve 123 when the pressure in the said further space 124 exceeds that in the space 110.

The system whose construction has been described operates as follows:

The pinion 28 is coupled with a suitable source of power, such as an internal combustion engine, so that, upon starting the said engine or other prime mover, the input shaft 6 and integral pump housing 3 are rotated about the axis 65 in the direction indicated by the arrow B (FIGURES 1 and 2). When the swash plate 10 occupies the position shown in FIGURES 1 and 2 in which the surface 14 of the ring 13 lies in a plane perpendicular to the axis of rotation 65, the pistons 4 in contact with the ring 13 are not axially displaced in the chambers 5. Thus, the liquid which fills the chambers 5, the passages 22, the slots 54 and 55, the recesses 53 and 59, the bores 63 and 64, the recesses 60 and 61, the slots 56 and 57, the passages 49 and the chambers 32 is at rest so that it is evident that the hydraulic motor 2 will not be driven at this time.

If the swash-plate 10 is angularly displaced about its pivotal axis 15 in the direction indicated by the arrow A (see FIGURE 1), the surface 14 will be disposed in a plane which is inclined at other than 90° to the axis of rotation 65 so that the pistons 4 whose domed heads bear against the said surface 14 are compelled to perform a reciprocating movement in the chambers 5, the liquid in the chambers 5 thus being displaced by the said pistons 4. The liquid displaced by the pistons 4 is urged through the slot 54, the bore 63 and the slot 56 towards the hydraulic motor 2 where the liquid displaces the pistons 31 so that the housing 30 and output shaft 33 rotate together in the same direction as the housing 3 and input shaft 6. If the swash-plate 10 is turned further in the direction of the arrow A, the stroke of the pistons 4 becomes larger and the amount of liquid displaced during each piston stroke increases. If the stroke of the pistons 31 were to remain the same, the speed of revolution of the housing 30 would increase. The liquid supplied to the motor 2 will, in any case, flow back to the pump 1 through the slot 57, the bore 64 and the slot 55.

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If the swash-plate 10 is turned in the direction indicated by the arrow C in FIGURE 1, the directions in which the liquid flows through the bores 63 and 64 will both be reversed so that the hydraulic motor 2 will then rotate in a direction opposite to that of the pump 1. The system described can thus operate as a reverse gear.

Since both the pump swash-plate 10 and the motor swash-plate 36 are, in fact, coupled to the toothed drum 75, any movement of the latter about its axis 79 will cause a movement of both the said swash-plates about their respective pivotal axes. As may be seen from FIGURE 3, the swash-plate 36 is always turned in the same direction about its pivotal axis 41 regardless of the direction in which the swash-plate 10 is turned about its pivotal axis 15. The two swash-plates are, in fact, coupled together in such a way that when the pump swash-plate 10 is turned in either direction so that the stroke of the pump pistons 4 becomes larger, the motor swash-plate 36 is turned in the same direction which is such that the stroke of the motor pistons 31 becomes smaller.

In the position of the body 37 shown in FIGURES 1 and 2, the stroke of each motor piston 31 is a maximum. The body 37 can, in fact, be turned out of the position shown to an extent which is such that the plane containing the surface 40 is inclined at an angle of about 6° to a plane perpendicular to the axis of rotation 66, the strokes of the pistons 31 being a minimum at such time. The arrangement is such that the plane containing the surface 40 can never itself be perpendicular to the axis of rotation 66.

The rotation of the toothed drum 75 about its axis 79 is effected by means of the hydraulically operated mechanism 87, which, as previously described, includes a toothed rack 107, the teeth of which are in engagement with the teeth 86 of the drum 75. Thus, when the piston 89 is displaced in either direction, the toothed rack 107 is similarly displaced and the toothed drum 75 is turned in a corresponding direction.

The hydraulically operated mechanism 89 functions in the following manner:

A liquid such as oil is supplied under pressure through ducts 109 and 108 into the space 110. The oil exerts a force on the surface 92 of the piston 89, which force tends to move the piston 89 towards the right in FIGURE 5. However, a space 111 to the right of the piston 89 is completely filled with oil which cannot escape so that an equilibrium position is reached in which the oil in the space 111 is very slightly compressed. Since the surface 93 is of greater area than the surface 92, the actual pressure in the space 111 is lower than that in the space 110 when the equilibrium is reached. If, in these circumstances, the control rod 91 is displaced in the direction indicated by the arrow D in FIGURE 5, the dish-spring 96 is compressed and the recess 118 is brought into a position in which it communicates with an annular recess 131 formed in the body of the piston extension 105. Since the control rod recess 118 always communicates with a bore 112 leading to the space 110, oil can then flow from the space 110 through the bore 112, the recesses 118 and 131, the bore 114, the duct 113 and the bore 115 to the space 111 so that the pressure in the spaces 110 and 111 is equalized. Due to the fact that the surface 92 and 93 upon which the equal pressure acts are different in area, the piston 89 will be moved towards the left in FIGURE 6 (which shows the position of the control rod 91 just described). The control rod 91 does not itself move with the piston 89 so that the piston 89 and control rod 91 rapidly regain the relative positions shown in FIGURE 5 in which the assembly is again in a state of equilibrium. However, if the control rod 91 is moved a further distance in the direction indicated by the arrow D, the piston 89 will be moved a corresponding further distance in the same direction.

If, on the other hand, the control rod 91 is moved

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in the direction indicated by the arrow E in FIGURE 5, the dish-spring 97 will be compressed and the control rod 91 and piston 89 will take up the relative positions shown in FIGURE 7. The recess 131 is then in communication with a cavity 121 formed around the reduced diameter end 117 of the control rod 91 so that the oil trapped in the space 111 can flow to the cavity 121 via the bore 115, the duct 113, the bore 114 and the recess 131. The oil in the space 110 exerts pressure on the piston surface 92 and moves the piston 89 in a direction towards the right in FIGURE 7 so that the equilibrium position shown in FIGURE 5 is rapidly regained. Further displacement of the control rod 91 in the direction of the arrow E will produce a corresponding further movement of the piston 89 in the same direction. The V-shaped grooves 119 and 120 are provided so that the piston 89 shall commence to move gradually in either of the cases just described. When the control rod 91 is displaced, communication between the recess 118 or the cavity 121 with the recess 131 is first established by way of the corresponding groove 119 or 120 so that a relatively gradual build-up of the oil flow takes place.

In the system just described, the port plates 25 and 52 are freely movable in directions parallel to the axes of rotation 65 and 66 since the bosses 62 co-operate with the recesses of the port plates in a manner which allows a substantial degree of relative movement in such directions. However, as previously stated, no substantial amount of movement of the port plates 25 and 52 is possible in directions perpendicular to the axes 65 and 66.

Consideration will now be given to the forces which act in the neighborhood of the sliding surface 23 (FIGURES 1 and 2). During operation of the system, a force directed towards the right in FIGURE 1 acts at this surface, the said force being equal to the sum of the operative surfaces of the various pistons 4 multiplied by the pressures exerted by these pistons. There are ten pistons 4 of which five always form the high pressure or delivery side of the pump 1 whereas the remaining five form the low pressure or receiving side of the pump. In order that the force just mentioned shall not tend to cause disengagement of the housing 3 and the port plate 25, the surface area of the recess 58 in the port plate 25 is equal to half the total operative surface of all the pistons which, in the present case, is equal to five times the operative surface of one piston 4. The operative surface of the recess 59 has the same area as that of the recess 58. The term "operative surface of a piston" is to be interpreted as meaning the total surface area of the piston which has a component acting in a plane at right angles to the direction of movement of the piston.

If desired, a plurality of smaller recesses may be used in place of recesses 58 and 59. This can be seen from FIGURE 9 in which a view of the pump 1 is shown, the hydraulic motor 2 and the intermediate block 27 being omitted. It will be assumed for the sake of illustration that the high pressure or delivery side of the pump 1 is located on the right hand side of the line IX—IX with the low pressure or return side of the pump on the opposite side thereof. Thus, the five pistons 4 on the right hand side of the line IX—IX will exert a force at the surface 23 which is substantially equal to the product of their total surface area and the pressure which is exerted by them. The same force is also exerted in an opposite direction on the surface of the recess 58 in the port plate 25 since the area of this surface is five times that of a single piston 4 whereas the pressure exerted is the same. The recess 58 is so positioned with respect to the chambers 5 that the resultant of the forces acting on the high pressure side of the housing 3 and those acting on the port plate 25 are at least substantially co-linear. In the same way the resultant of the forces acting on the low pressure side of the housing 3 and those acting on the

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surface of the recess 59 are at least substantially co-linear. Since, as has just been described, these forces are equal to one another and act in opposite directions, they will at least substantially cancel one another out so that no appreciable force will tend to cause separation between the housing 3 and the port plate 25. The port plate 52 is arranged in a substantially identical manner with respect to the housing 30 whereby a similar state of substantial equilibrium is also maintained between these parts when the system is in operation.

FIGURES 10 and 11 show an alternative embodiment of a port plate which may be used in place of the port plates 25 and 52 shown in FIGURES 1 and 2. The port plate 151 shown in FIGURES 10 and 11 has two arcuate slots 152 and 153 which constitute a communication between a sliding surface 154 and two recesses 155 and 156. The port plate 151 has an axis 157 which, when the port plate is in position, will substantially coincide with the axis of rotation of the pump or hydraulic motor concerned. The sliding surface 154 is formed with two concentric grooves 158 and 159, the groove 158 communicating with the recess 155 by way of a bore 160 and the groove 159 similarly communicating with the recess 156 by way of a bore 161. The grooves 158 and 159 are concentrically arranged with respect to the aforementioned axis 157 and are both located further from this axis than are the arcuate slots 152 and 153. Between the said grooves and the said slots a circular duct 162 whose center of curvature is also afforded by the axis 157 is formed in the sliding surface 154. This duct 162 communicates by way of bores 164 with the outer periphery 165 of the port plate 151. A still further circular recess 166 is formed in the center of the sliding surface 154 of the port plate 151 and this recess also communicates with the outer periphery 165 by way of ducts 167. The arrangement is such that a film of oil can be maintained between the sliding surface 154 and the cooperating sliding surface of the corresponding housing so that friction between these parts can be substantially reduced in an advantageous manner. The port plate 151 is adapted to operate in the following manner:

If the slot 152 is in communication with the high pressure side of a hydraulic pump or motor of the kind previously described whereas the slot 153 is in corresponding communication with the low pressure side, a small quantity of oil will leak from the slot 152 onto the sliding surface 154 and the other sliding surface co-operating therewith. The pressure exerted by this oil will, of course, tend to separate the two sliding surfaces but the duct 162 and the recess 166 are in such close proximity to the slots 152 and 153 that the oil pressure just mentioned can only build up to an extent which is sufficient to support a film of oil of a thickness adequate to reduce the friction between the two surfaces. The grooves 158 and 159 will be constantly fed with oil under pressure from the recesses 155 and 156 by way of the bores 160 and 161. Owing to the small cross-sectional areas of the two grooves, which may be each of the order of between 0.5 and 1.0 square millimeter, a film of oil pressure will build up between the sliding surfaces around the two grooves whose pressure magnitude at any point will depend to a great extent upon the proximity of that point to the location at which the bore 160 or 161 opens into the groove 158 or 159 respectively. By a suitable choice of the dimensions of the grooves 158 and 159 and the bores 160 and 161, the co-operating sliding surfaces will be urged away from one another to an extent which is just sufficient to reduce friction to a minimum while preventing any substantial leakage of oil from around the edges of the co-operating surfaces and through the ducts 164 and 167.

FIGURES 12 and 13 show a further alternative embodiment of a port plate which may be used in a system in accordance with the invention. The port plate 168 has two arcuate slots 169 and 170 which, in a manner similar to that previously described, constitute connections be-

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tween the sliding surface 171 and corresponding recesses 172 and 173. A central recess 174 is provided in the port plate 168 which recess communicates with the outer periphery of the latter by way of two bores 175 and 181. The port plate 168 is also provided with two semi-circular grooves 176 and 177 which are located close to the periphery of the plate and communicate with the recesses 172 and 173 by way of bores 178 and 179 respectively. A circular duct 180 disposed between the slots 169 and 170 and the grooves 176 and 177 also communicates with the outer periphery of the plate 168 by way of the aforementioned bores 175 and 181. This port plate operates in a very similar manner to that shown in FIGURES 10 and 11, oil from the slots 169 and 170 from the grooves 176 and 177 in excess of that required to maintain the film between the sliding surfaces passing either directly to the periphery of the plate 168 or through the bores 175 and 181 by way of the recess 174 or the duct 180.

FIGURE 14 shows a further port plate which is similar to that shown in FIGURES 12 and 13 and in which the same reference numerals are used in designate like parts. In this case, however, the circular duct 180 shown in FIGURES 12 and 13 is omitted, thus tending to reduce the leakage of oil from between the sliding surfaces.

FIGURES 15 to 17 show various arrangements by means of which blockage of the bore through which oil is fed from the recesses on one side of the port plate to the grooves on the other side thereof is prevented. A bore 183 of this kind as shown in FIGURE 15 is inclined at an angle a to the sliding surface 184 of a port plate 182. A pin 185 is disposed in the bore 183 and has one end 188 urged hydraulically into engagement with the sliding surface 186 of a housing 187 co-operating with the port plate 182. As the housing 187 rotates relative to the port plate 182, the pin 185 will also be forced to rotate about its longitudinal axis 189, this rotation preventing blockage of the bore 183. FIGURE 16 shows a similar arrangement but, in this case, the plane of the end 188 of the pin 185 is inclined at an angle b to a plane disposed perpendicular to the axis 189. As the pin 185 rotates about its longitudinal axis 189, it will also perform an axial reciprocating movement. In order to ensure that uninterrupted rotation of the pin 185 shall take place, it is essential that the angle b should be less than the angle a .

The embodiment shown in FIGURE 17 is similar to that shown in FIGURE 16 except that the end of the pin 185 is provided with a head 191 of substantially greater diameter than the rest of the pin. The head 191 is received within a recess 193 in the port plate 182 and is so shaped that the pin 185 will perform an axial reciprocating movement at the same time as it rotates about its longitudinal axis 189. However, the greater diameter of the head 191 ensures that a substantially greater turning moment will be applied to the pin 185 during operation than in the cases shown in FIGURES 15 and 16. Thus, any tendency of the pin 185 to drag without rotating is substantially reduced. A reciprocation of greater amplitude will also be produced.

It will be understood that the arrangements described with reference to FIGURES 10 to 17 are capable of application to hydraulic machinery other than the pump 1 or motor 2 previously set forth and that they may be employed in any cases in which two relatively slidable surfaces perform functions similar to those herein described.

What we claim is:

1. A hydraulic pump or motor having a housing with a plurality of chambers each containing a sliding piston, a port plate abutting said housing, said port plate and said housing having abutting surfaces in slidable engagement, said housing and said port plate being rotatable relative to one another about an axis of rotation, said port plate having a first port which forms part of a low pressure fluid duct in said pump and a second port which forms part of a high pressure fluid duct in said pump, said housing and said port plate being movable

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relative to one another in a direction substantially parallel to said axis of rotation but relatively immovable with respect to one another in directions perpendicular to said axis of rotation, the abutting surface of said port plate being provided with two grooves, the first of said grooves being in constant communication with low pressure fluid by a closed circuit provided in the port plate, one end of which directly communicates with low pressure fluid and the other end of which opens in the first of said grooves, the second of said grooves being in constant communication with high pressure fluid by a closed circuit provided in the port plate, one end of which directly communicates with high pressure fluid and the other end of which opens in the second of said grooves, said grooves being substantially circular in configuration and arranged substantially concentrically.

2. A hydraulic pump or motor as claimed in claim 1, wherein a port and a groove are located on either side of a plane of symmetry containing said axis of rotation whereby each groove is in communication via said closed circuit with a port lying on the same side of the said plane of symmetry as said groove.

3. A hydraulic pump or motor as claimed in claim 1, wherein the slidable surface of the port plate has a passageway in communication with the periphery of said port plate, said passageway being disposed between the grooves and the ports.

4. A hydraulic pump or motor as claimed in claim 1, wherein the slidable surface of the port plate has a recess in communication with the periphery of said port plate, said recess being disposed between the two ports.

5. A hydraulic pump or motor as claimed in claim 1, wherein a closed circuit is constituted by a bore provided in said port plate, said bore extending between a groove and the corresponding pressure source.

6. A hydraulic pump or motor having a housing with a plurality of chambers each containing a sliding piston, a port plate abutting said housing, said port plate and said housing having abutting surfaces in slidable engagement, said housing and said port plate being rotatable

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relative to one another about an axis of rotation, said port plate having a first port which forms part of a low pressure fluid duct in said pump and a second port which forms part of a high pressure fluid duct in said pump, at least one of said abutting surfaces being provided with at least one groove, liquid being supplied to said groove by way of a bore, which is disposed at an angle to the slidable surface, said bore housing a pin with one end in engagement with the slidable surface opposite to that into which said bore opens, whereby said pin will be forced to rotate about its longitudinal axis to prevent blockage of said bore.

7. The invention as claimed in claim 6, wherein the surface of said one end of the pin is disposed perpendicularly to the longitudinal axis of the pin.

8. The invention of claim 6, wherein the surface of said one end of the pin is inclined to a plane disposed perpendicularly to the longitudinal axis of the pin at an angle which is smaller than the component of the angle at which the longitudinal axis of the said bore is inclined to said slidable surface.

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