July 9, 1963 D. B. PURYEAR 3,096,723

FLOATING PORT PLATE CONSTRUCTION

Filed Dec. 29, 1958 3 Sheets-Sheet 1

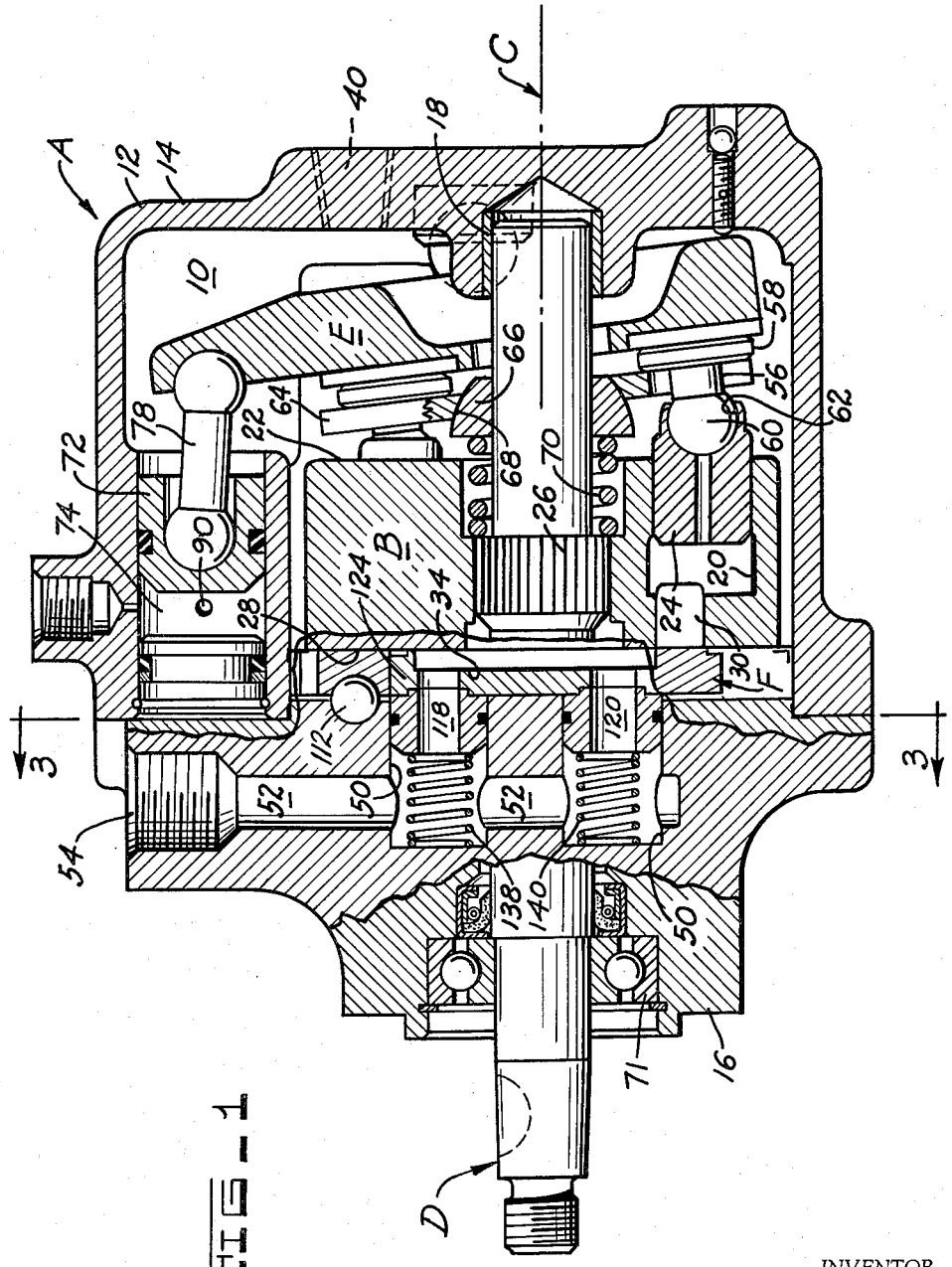


FIG. 1

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Filed Dec. 29, 1958 3 Sheets-Sheet 2

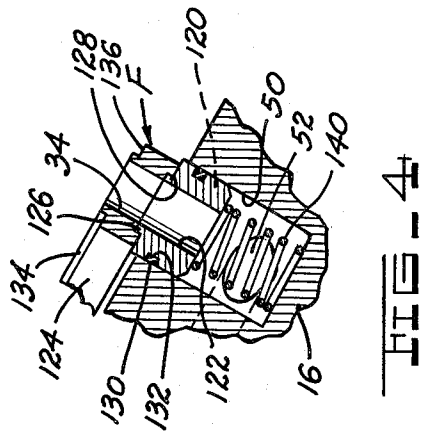


FIG - 4

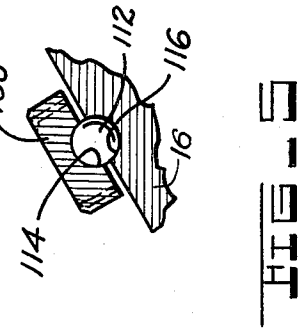


FIG - 5

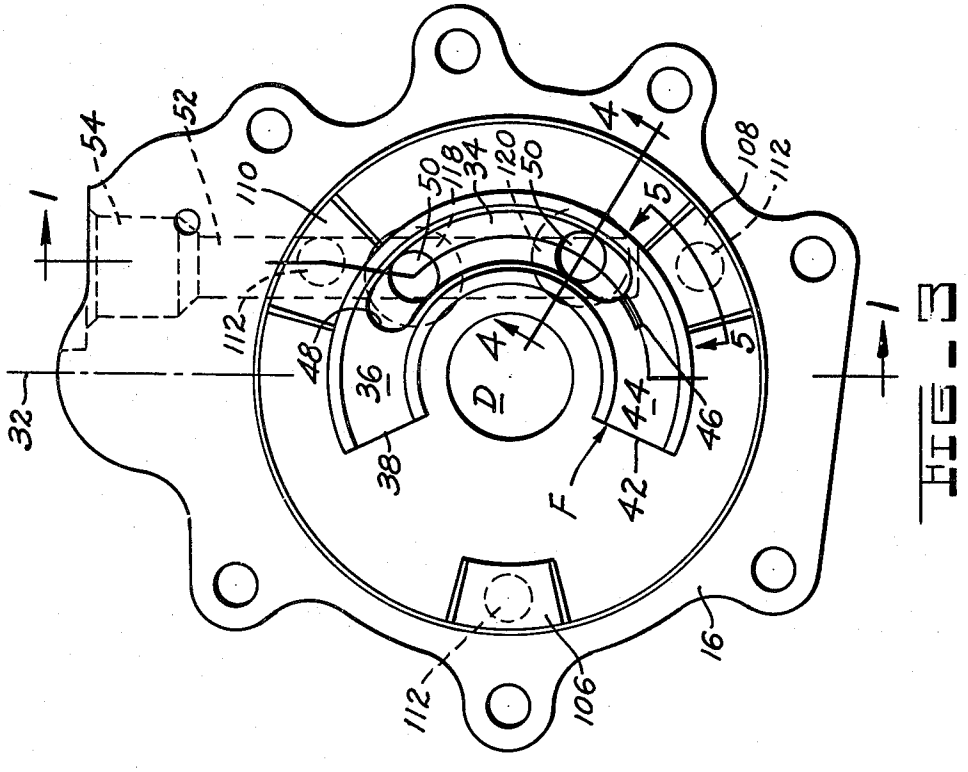


FIG - 3

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FLOATING PORT PLATE CONSTRUCTION

Filed Dec. 29, 1958 3 Sheets-Sheet 3

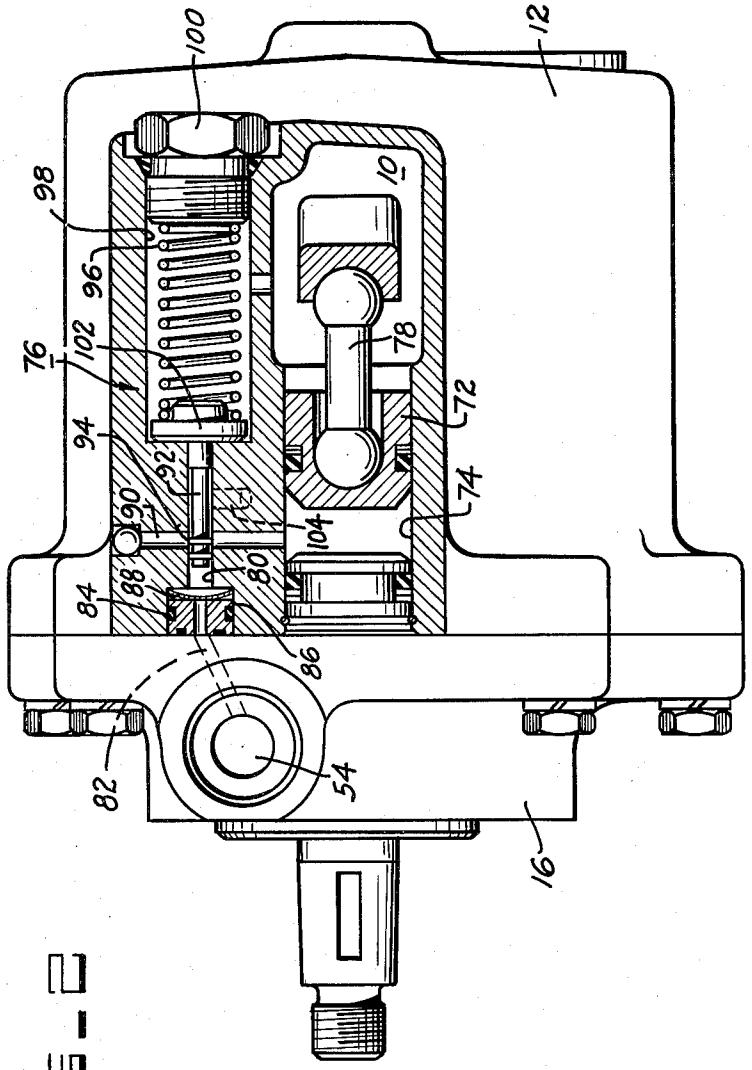


FIG. 2

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United States Patent Office 3,096,723 Patented July 9, 1963

3,096,723

FLOATING PORT PLATE CONSTRUCTION

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Filed Dec. 29, 1958, Ser. No. 783,341
6 Claims. (Cl. 103—162)

The present invention relates to positive displacement fluid handling devices; and more particularly to such devices having internal rotor members to which fluid is added and discharged through one end surface thereof.

An object of the present invention is the provision of a new and improved device of the above described type in which the end surface of the rotor through which fluid is conducted and discharged is supported off of the end wall of the housing of the device by a plurality of slippers, and in which a suitable sliding seal is provided for conducting one of the flows to or from the rotor by means of a partial port plate that slidingly engages the end surface of the rotor and which is pressure biased against the surface with just sufficient force to effect a seal therewith.

The invention resides in certain constructions, and combinations, and arrangements of parts; and further objects and advantages will become apparent to those skilled in the art to which the invention relates from the following description of the preferred embodiment described with reference to the accompanying drawings forming a part of this specification, and in which:

FIGURE 1 is a cross sectional view taken generally in a plane passing through the axis of rotation of a pump embodying principles of the present invention—the view having a center section which is broken away above the plane of the paper generally along line 1—1 of FIGURE 3;

FIGURE 2 is a plan view of the pump shown in FIGURE 1 but having a section broken away through the control mechanism of the pump;

FIGURE 3 is a view of the end cover plate assembly of the pump and is taken generally along the line 3—3 of FIGURE 1;

FIGURE 4 is a fragmentary cross-sectional view taken approximately on the line 4—4 of FIGURE 3; and

FIGURE 5 is a fragmentary cross sectional view through a slipper and is taken generally along the line 5—5 of FIGURE 3.

Although the invention may be otherwise embodied, it is shown and described herein as used in an axial piston pump intended to supply fluid pressure to a closed center hydraulic system of a farm tractor and the like wherein the pump is run at very low flow rates over extended periods of time. As best seen in FIGURE 2, the pump generally comprises a housing A which provides an internal pump chamber 10 and is formed by a generally cup-shaped body member 12, whose bottom forms one end wall 14 of the pump chamber 10, and a removable end wall or cover plate 16 that is swivably bolted to the body member 12. The pump further includes an annular rotor member B that is adapted to be rotated by a shaft D about a longitudinally extending axis C which extends through the end walls 14 and 16. The inner end of shaft D is received in a sleeve bearing 18 mounted in the end wall 14 and the outer end of the shaft D extends through and is suitably journalled in the removable cover plate 16. The rotor member B contains a plurality of fluid displacement chamber or cylinder bores 20 (in the present instance 7) which are spaced around and extend generally parallel to the longitudinally extending axis C. The cylinder bores 20 open into the end face 22 of the rotor B which faces the end wall 14 of the pump; and each of the cylinder bores 20 is provided with a cylindrically shaped piston 24 which projects out of its receiving cylinder bore

20 toward the end wall 14 of the pump. The rotor member B is suitably splined as at 26 to the shaft D so as to be rotatably driven by the shaft; and in and out movement of the pistons 24 is produced during rotation of the rotor B by means of a swash plate E that is positioned between the end face 22 of the rotor B and the end wall 14 of the pump, and against which swash plate the projecting ends of the pistons 24 slidingly abut.

The swash plate E is nonrotatably supported in a manner which will later be described, and is adapted to be inclined at an angle with respect to the longitudinal axis C of the pump; so that as the rotor member B rotates, sliding engagement of the pistons 24 with the swash plate E causes the pistons 24 to be moved inwardly with respect to their receiving cylinder bores 20 during one half of a revolution of the rotor member B while permitting the pistons 24 to move outwardly with respect to their cylinder bores 20 during the remaining half of each rotor rotation, to thereby produce a pumping action in each of the cylinder bores 20.

The opposite end face 28 of the rotor member B slidingly sealingly abuts a port plate F that is nonrotatably fixed to the opposite end wall 16 of the pump. The port plate F communicates the pump's suction with each of the cylinder bores 20 when their pistons 24 are moving slidably within the cylinder bores 20 in a direction away from the port plate, and communicates each of the cylinder bores 20 with the discharge passages of the pump when the pistons 24 are moved within their receiving cylinder bores 20 in a direction toward the port plate. Assuming that the outer end of the shaft D is driven in a clockwise direction, it will be seen that the pistons move outwardly with respect to their bores 20 to produce a suction stroke for each of the pistons when the respective pistons are being rotated from their uppermost position, as seen in FIGURE 1, out of the plane of the drawing to their lowermost position, as seen in FIGURE 1 of the drawing. Similarly the discharge stroke for each of the pistons 24 occurs while the respective piston is being moved from the lowermost position, as seen in FIGURE 1, beneath the plane of the drawing to the uppermost position, as seen in FIGURE 1 of the drawings. As previously indicated, the opposite end face of the rotor member B slidingly, sealingly, abuts the port plate F, and flow from each of the cylinder bores 20 is communicated to and from the opposite end face 28 of the rotor B through respective small diameter extension bores 30 of the respective cylinder bores 20. The face of the port plate F to which the rotor member B slidingly, sealingly, abuts can best be seen in FIGURE 3 of the drawing, and for this view, the rotor rotation proceeds in a counterclockwise direction.

The suction stroke for each of the cylinder bores 20 begins as the cylinder bore extension 30 is centered upon the upper section of the vertical section line 32 as seen in FIGURE 3. In this position, the bore extensions 30 forming rotor ports are out of register with the crescent shaped discharge port 34 and will be totally sealed off by the sealing land 36 of the port plate. The suction cycle for each rotor port proceeds as the rotor ports are moved counterclockwise, as seen in FIGURE 3, until their leading edge moves into communication with the trailing edge 38 of the port plate F, so that the rotor port will thereafter be in communication with the internal pump chamber 10 of the pump. The internal pump chamber 10 is continually supplied with fluid from the pump suction connection 40, so that outward movement of each piston 24 during the suction stroke pulls fluid into its receiving cylinder 20 through the rotor port 30 for substantially the remainder of the pistons, outward movement. Each rotor port 30 remains in communication with the internal pump chamber 10 during its piston's suction stroke until the trailing edge of the rotor port 30

has moved past the leading edge 42 of the port plate F, and is thereafter sealed off by the port plate's sealing land 44. This occurs at a time when its piston 24 is substantially at its limit of travel away from the port plate F and occurs at approximately the time that the centerline of its cylinder bore 20 moves into registry with the bottom portion of the vertical section line 32 as seen in FIGURE 3.

The discharge stroke for each rotor port 30 begins while the rotor port 30 is sealed off by the port plate land 44, and continues as the centerline of its cylinder bore 20 is being moved from the bottom portion of the vertical centerline 32 counterclockwise toward the upper portion of the vertical centerline 32 as seen in FIGURE 3. Each rotor port 30 is sealed off during the time that it is moved a few degrees past the bottom portion of the vertical section line 32; so that the fluid in its cylinder bore will become pressurized before being communicated to the crescent shaped discharge port 34. Inasmuch as the pump is intended to operate at pressures in the neighborhood of 2500 pounds per square inch, compressibility of the fluid is a factor; and in order to minimize the surge of pressure which occurs from the discharge port 34 into each of the cylinder bores 20 when it is first connected to the discharge port 34, a bleed groove 46 is formed in the sealing land 44 in order to throttle any surge of pressure that may occur between the discharge port 34 and the cylinder bore 20. After the leading edge of each rotor port has been moved into registry with the bleed groove 46 and the pressure has been equalized between the cylinder bore 20 and the discharge port 34, rotation toward the upper portion of the vertical centerline 32 causes fluid to be forced out of the cylinder bore 20 into the crescent shaped discharge port 34 of the port plate F. This continues until the trailing edge of each rotor port 30 moves past the trailing edge 48 of the discharge port 34, which will occur when the piston 24 is approximately centered on vertical section line 32. Thereafter, each rotor port 30 will be in sealing engagement with the sealing land 36 of the port plate F for approximately 10 degrees of rotation counterclockwise of the uppermost centered position on vertical section line (FIGURE 3) to isolate the rotor port 30 from the suction until such time as oil in each cylinder bore is decompressed and thereafter a new rotor cycle for the cylinder bore is begun. Fluid discharge into the crescent shaped port 34 of the port plate F passes through a drilling 50 in the cover plate 16 through a vertical drilling 52—the upper end of which is counterbored and threaded to provide the discharge connection 54 of the pump.

As previously indicated, in and out motion for the respective pistons 24 is provided by abutting engagement with the angularly inclined swash plate E; and in order that the continually changing angle between each piston 24 and the surface of the swash plate E will be readily accommodated, each of the pistons 24 is provided with a slipper portion 56 having a flat cylindrically shaped head 58 which abuts the bearing surface of the swash plate E and a ball end 60 that is received within a spherical socket 62 in the main body portion of the piston. The side edge of the spherical socket 62 engages more than one-half of the surface of the ball 60 so as to retain the ball end 60 in the socket 62; and the pistons 24 are urged toward the swash plate E by means of an annular retainer plate 64 which holds the slipper portions in slidable engagement with the swash plate E. The retainer plate 64 is suitably notched out around each slipper portion and bears against the back surface of its head 58 to hold each slipper in engagement with the wearing surface of the swash plate E. The annular retainer plate 64 is biased toward the swash plate E by means of an annular washer 66 having a spherically shaped radially outer surface that is received within a spherical socket 68 in the retainer plate 64, and the annular washer 66 is biased toward the swash plate E by means of a coil spring 70 that is interpositioned between the annular washer 66 and the rotor member B. The end thrust of coil spring 70 upon the shaft D is absorbed by the antifriction bearing 71.

As previously indicated, the pump shown in the drawing is capable of varying the quantity of its output. This, of course, is accomplished by varying the angle of the swash plate E with respect to the longitudinal axis C of the pump. Tilting of the swash plate is accomplished by means of a hydraulic piston 72 that is slidingly sealingly received in a cylinder bore 74 located above the rotor member B in the top portion of the pump. Fluid pressure supplied to the cylinder bore 74 from a control valve structure 76 causes force from the hydraulic piston 72 to be transmitted through a push link 78 to move the swash plate E to its vertical or "nonpumping" position wherein substantially no in and out movement of the pistons 24 is produced. The control valve 76 is intended to control the discharge pressure of the pump at approximately 2500 pounds per square inch, and functions to bleed pressure fluid into the hydraulic cylinder bore 74 as the pump discharge pressure exceeds approximately 2500 p.s.i. The control valve structure 76 is formed by a bore 80 which generally parallels the cylinder bore 74 and which extends through opposite end surfaces of the cup-shaped body member 12. Pressure fluid from the pump discharge 54 is conducted through a suitable drilling 82 in the removable cover plate 16 to the adjacent end of the bore 80. A seal is provided around the end of the bore 80 and the cover plate by means of an annular washer 84 that is positioned in a counterbore 86. The annular washer 84 carries suitable seals which respectively engage the counterbore and cover plate, and a dish-shaped washer 88 is positioned between the bottom of the counterbore and the annular washer to bias the washer into sealing engagement with the cover plate 16. Control pressure from the control bore 80 is communicated with the cylinder bore 74 through a lateral control port drilling 90, and the control of pressure within the drilling 90 is had by means of a spool valve 92 capable of covering the intersection of the drilling 90 with the control bore 80. The sealing land 94 of the spool valve 92 is normally biased to a position between the inlet end of the control bore 80 and the control port 90 by means of a coil spring 96. Coil spring 96 is received in a counterbore 98 in the opposite end of the control bore 80, and is interpositioned between an adjustable plug 100 and a head 102 of the spool valve structure 92 to normally hold the head 102 in engagement with the bottom of the counterbore 98 and the spool valve in its normal position. As the discharge pressure of the pump increases above approximately 2500 p.s.i., force upon the end of the spool valve 92 causes spring 96 to compress and permit pressure to flow into the hydraulic chamber 74 to thereby cause piston 72 to move the swash plate E into its vertical or "non-pumping" position. When the discharge pressure of the pump falls below approximately 2500 p.s.i., coil spring 96 causes the spool valve 92 to close off communication between the discharge port 54 and the control port 90, and thereafter bleed pressure from the hydraulic cylinder bore 74 to the internal chamber 10 of the pump through bore 104.

The port plates of the prior art, and with which applicant is familiar, have been planed and lapped with respect to the end surface of the rotor B; and have served the purpose of both supporting the rotor B against end thrust, and providing a sliding sealing valving surface for the rotor. Considerable drag has been produced by these surfaces, and slight misalignment of the pump's parts has created leakage problems.

According to principles of the present invention, the end thrust of the rotor, which can be considerable, especially at high pumping pressures, is absorbed by a plurality of slippers (preferably three) which engage a

flat annular outer area of the rotor which is provided and finished solely for that purpose. There is also provided a generally crescent shaped port plate F substantially no larger than required to adequately perform its valving function, and which is supported independently of the slipper surfaces. The port plate F is preferably positioned as close to the axis of rotor rotation as is possible, and is preferably supported in a manner which will accommodate a slight amount of universal movement so that it can adjust itself to the sliding sealing surface of the rotor. The port plate F may be biased into sealing engagement with the rotor solely by spring action; but in the preferred arrangement, will be provided with piston means which is subject to the pump's discharge pressure and which biases the port plate against the rotor with just sufficient force to effect a suitable sliding seal therebetween.

In the preferred embodiment shown in the drawing, three comparatively small arcuately shaped slipper segments **106**, **108**, **110**, are provided for bearing engagement with a smooth annular surface of the rotor B radially outwardly of the ports **30**. In order that the slippers will be capable of angularly adjusting themselves to the surface of the rotor B, each is supported from the end surface of the internal chamber **10** of the pump by means of identically shaped balls **112** received in spherically shaped sockets **114** and **116** in the slippers and end wall, respectively.

The port plate F shown in the drawing is generally crescent shaped and is no larger than is required to adequately cover and seal off the ports **30** in the rotor from the internal chamber **10** of the pump during their discharge cycle. The port plate F is supported from the end wall of the pump by means of a pair of identical pistons **118** and **120**, respectively, which are received in the bores **50**; and the central openings **122** of which conduct fluid out of the crescent shaped discharge port **34** of the port plate. The pistons **118** and **120** may be integrally formed on the crescent shaped body **124** of the port plate; but, because of machining reasons, are formed separately with an annular tongue **126** which is received in an annular groove **128** in the body **124**, and is lapped in place to provide a suitable seal. The outside surfaces of the pistons **118** and **120** are provided with an O-ring seal **130** carried in a groove **132** in the pistons; and the external surfaces extending in either direction from the seal are slightly tapered by a few degrees so that the pistons can accommodate a few degrees of angular movement. The radially inner and outer edges of the port plate are recessed at **134** and **136** to reduce as much as possible the area that need be exposed to pressure, and the combined cross sectional area of the pistons **118** and **120** located in the bores **50** and which is subjected to pressure is made large enough to develop a pressure force slightly greater than the pressure forces on the sliding sealing surfaces of the port plate F. As a further refinement, the radial outer side edges of the port plate body **124** abut the sides of the slippers **108** and **110** for lateral support; and the pistons **118** and **120** are positioned so that the imaginary line connecting their centers approximately passes through the center of the pressure forces on the sliding sealing surface of the port plate body **124**. Coil springs **138** and **140** in the bores **50** bias the port plate F against the rotor B to insure an initial seal during the starting up of the pump.

While the invention has been described in considerable detail, I do not wish to be limited to the particular constructions shown and described, and it is my intention to cover hereby all novel adaptations, modifications, and arrangements thereof which come within the practice of those skilled in the art to which the invention relates.

I claim:

1. In a positive displacement fluid handling device: a housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said chamber, a rotor member in said chamber, means carried by said housing and drivably connected with the rotor member for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted within said fluid displacement chamber and slidable therein for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, at least two slipper segments slidingly abutting said one end surface of said rotor during its rotation to provide reaction surfaces against which said rotor is thrust, swivel means supporting said slipper segments from one end wall of said housing, a port plate separate from said slipper segments in sliding engagement with said one end surface of said rotor, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during one of said predetermined angles, said port plate having a portion surrounding said crescent shaped opening which slidingly sealingly engages said rotor member, said housing having at least one flow port generally opposite to said crescent shaped opening of said port plate, sealing means for effecting a sealing relationship between said crescent shaped opening of said port plate and said at least one housing flow port, said sealing means being so constructed so as to maintain said sealing relationship when said port plate moves toward and away from its respective end wall of said housing, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than produced by fluid pressure tending to separate said port plate and said rotor member to effect a proper seal therebetween.

2. In a pump: a housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said chamber, a rotor member in said chamber, means drivably connected to said rotor for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted in said fluid displacement chamber and slidable therein for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, at least two slipper segments slidingly abutting said one end surface of said rotor during its rotation, swivel means supporting said slipper segments from one end wall of said housing, and a crescent shaped port plate separate from said slipper segments in sliding engagement with said one end surface of said rotor during said first predetermined angle of rotor rotation, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during said first predetermined angle, said port plate having a portion surrounding said crescent shaped opening which slidingly engages said rotor member, said housing having a discharge port generally opposite to said crescent shaped opening of said port plate, sealing means for effecting a sealing relationship between said crescent shaped opening of said port plate and said at least one housing flow port, said sealing means being so constructed so as to maintain said sealing relationship when said port plate moves toward and away from its respective end wall of said housing, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than produced by fluid pressure tending to separate said port plate and said rotor member to effect a proper seal therebetween.

3. In a positive displacement fluid handling device: a

housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said internal chamber, a rotor member in said chamber, means carried by said housing and drivably connected with the rotor member for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted within said fluid displacement chamber and slidable therein for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, three slipper segments disposed circumferentially about said axis of rotation and having imaginary lines of connection therebetween and slidingly abutting said one end surface of said rotor during its rotation, swivel means supporting said slipper segments from one end wall of said housing, and a crescent shaped port plate separate from said slipper segments in sliding engagement with said one end surface of said rotor during said first predetermined angle of rotor rotation, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during said first predetermined angle, said port plate having a portion surrounding said crescent shaped opening which slidingly sealingly engages said rotor member only during one of said generally predetermined angles of rotor rotation, said housing having a pair of discharge ports generally opposite said crescent shaped opening of said port plate, sealing means for effecting sealing relationships between said crescent shaped opening of said port plate and said housing discharge ports, said sealing means being so constructed so as to maintain said sealing relationships when said port plate moves toward and away from its respective end wall of said housing, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than that produced by fluid pressure tending to separate said port plate and said rotor member to effect a proper seal therebetween, two of said slipper plates being so positioned that an imaginary line connecting their centers approximately passes through said sealing relationships.

4. In a positive displacement fluid handling device: a housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said chamber, a rotor member in said chamber, means carried by said housing and drivably connected with the rotor member for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted within said rotor and slidable within said fluid displacement chamber for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, at least two slipper segments supported on an end wall of said housing slidingly abutting said one end surface of said rotor during its rotation to provide reaction surfaces against which said rotor is thrust, a port plate separate from said slipper segments in sliding engagement with said one end surface of said rotor, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during one of said predetermined angles, said port plate having a portion surrounding said crescent shaped opening which slidingly sealingly engages said rotor member, said housing having at least one flow port generally opposite to said crescent shaped opening of said port plate, sealing means for effecting a sealing relationship between said crescent shaped opening of said port plate and said at least one housing flow port, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than that produced by fluid pressure tending to separate said port plate and said rotor member to effect a proper seal therebetween.

5. In a pump: a housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said chamber, a rotor member in said chamber, means drivably connected to said rotor for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted in said rotor and slidable within said fluid displacement chamber for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, at least two slipper segments supported on one end wall of said housing slidingly abutting said one end surface of said rotor during its rotation, and a crescent shaped port plate separate from said slipper segments in sliding engagement with said one end surface of said rotor during said first predetermined angle of rotor rotation, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during said first predetermined angle, said port plate having a portion surrounding said crescent shaped opening which slidingly engages said rotor member, said housing having a discharge port generally opposite to said crescent shaped opening of said port plate, sealing means for effecting a sealing relationship between said crescent shaped opening of said port plate and said discharge port, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than that produced by fluid pressure tending to separate said port plate and said rotor member to effect a proper seal therebetween.

6. In a positive displacement fluid handling device: a housing member having an internal chamber with opposite end walls providing an axis of rotation extending through said chamber, a rotor member in said chamber, means carried by said housing and drivably connected with the rotor member for rotating it about said axis, said rotor having end surfaces facing said end walls of said internal chamber and at least one fluid displacement chamber therein with a port which opens into one end surface of said rotor, means mounted within said rotor and slidable within said fluid displacement chamber for displacing fluid out of said fluid displacement chamber through said port during a first predetermined angle of rotor rotation and for causing fluid to flow into said fluid displacement chamber through said port during a second predetermined angle of rotor rotation, means supporting said rotor on an end wall of said housing and providing reaction surfaces against which said rotor thrusts during its rotation, said one end surface of said rotor slidingly abutting said last named means, a port plate, separate from and independent of said last named means, in sliding engagement with said one surface of said rotor, said port plate having a generally crescent shaped opening which communicates with said port of said rotor during one of said predetermined angles, said port plate having a portion surrounding said crescent shaped opening which slidingly sealingly engages said rotor member, said housing having at least one flow port generally opposite to said crescent shaped opening of said port plate, sealing means for effecting a sealing relationship between said crescent shaped opening of said port plate and said at least one housing flow port, means for biasing said port plate into engagement with said rotor end surface with slightly greater force than that produced by fluid pressure tending to separate

said port plate and said rotor member to effect a proper seal therebetween.

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