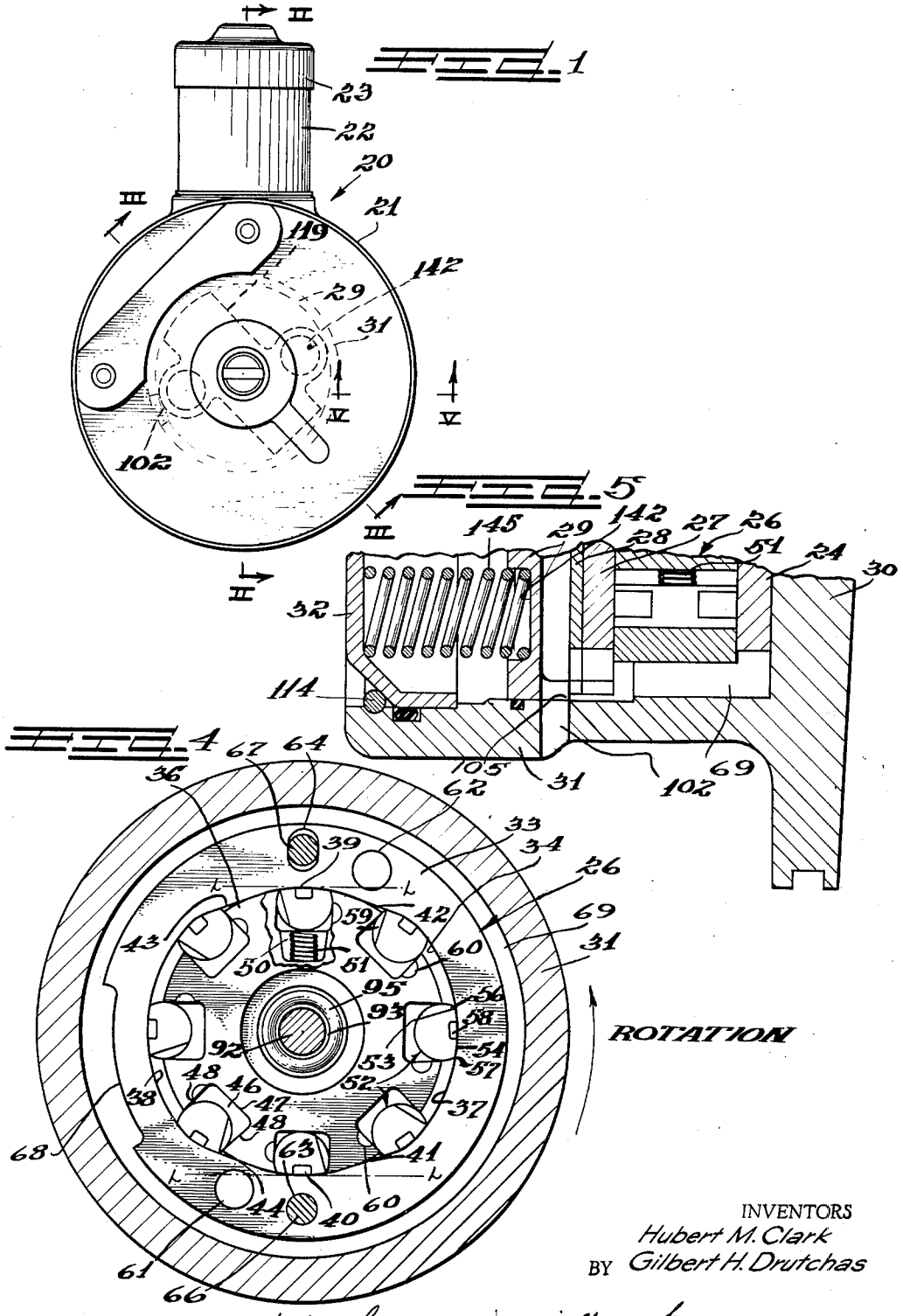
Aug. 17, 1965 H. M. CLARK ETAL 3,200,752

STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

Filed May 16, 1963 5 Sheets-Sheet 1



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STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

Filed May 16, 1963 5 Sheets-Sheet 2

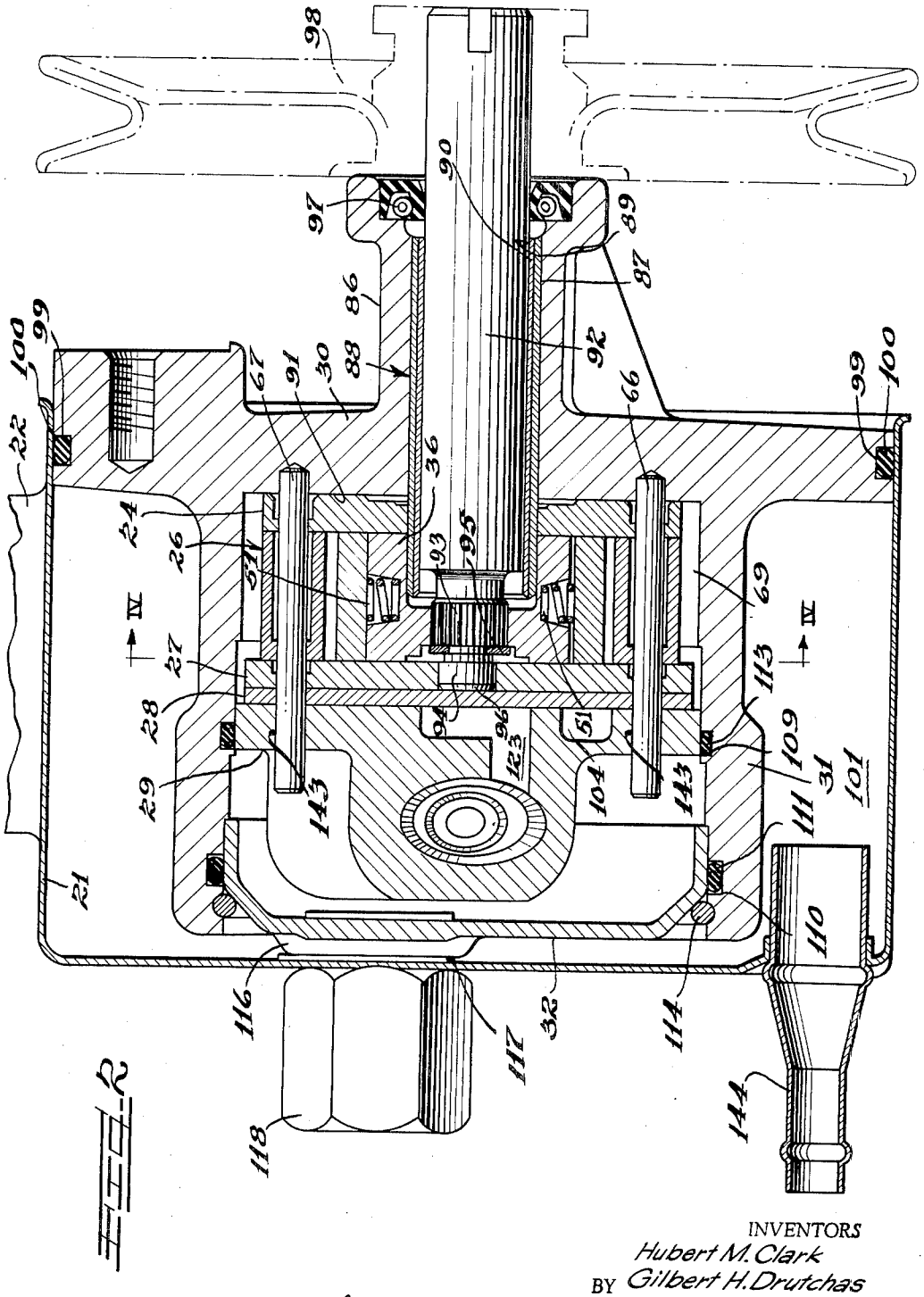


FIG. 2

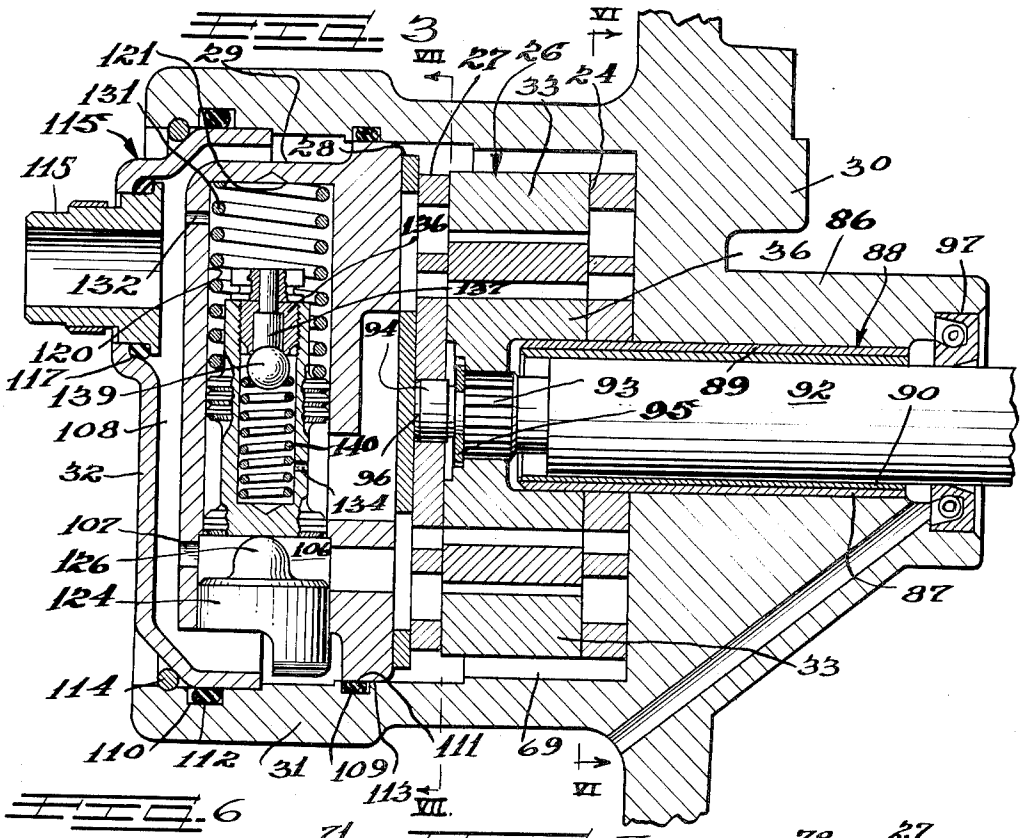
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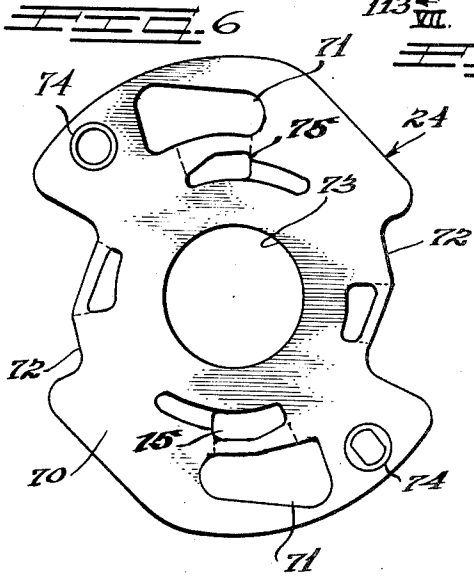
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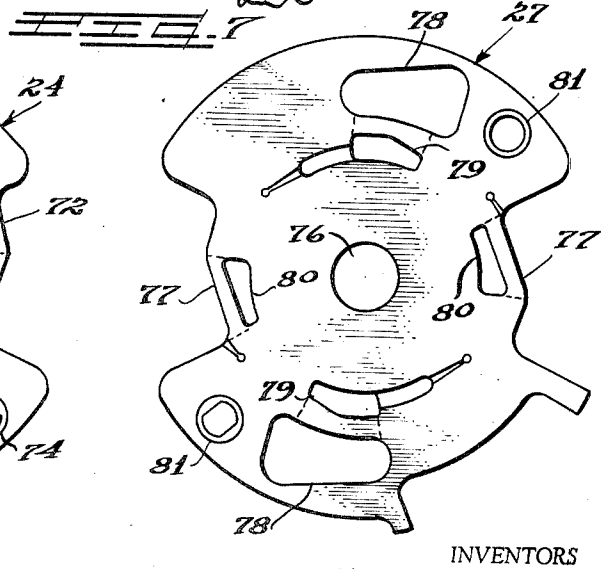
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STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

Filed May 16, 1963 5 Sheets-Sheet 3







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Aug. 17, 1965 H. M. CLARK ETAL 3,200,752

STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

Filed May 16, 1963 5 Sheets-Sheet 4

FIG. 11

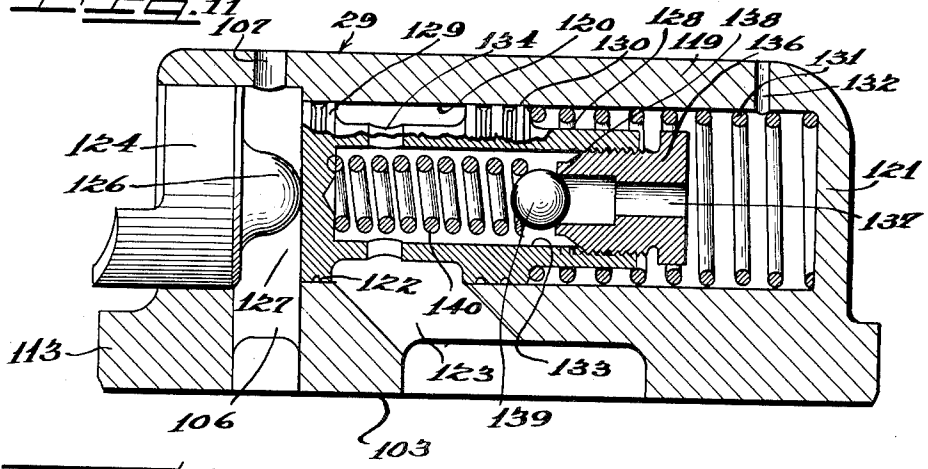


FIG. 9

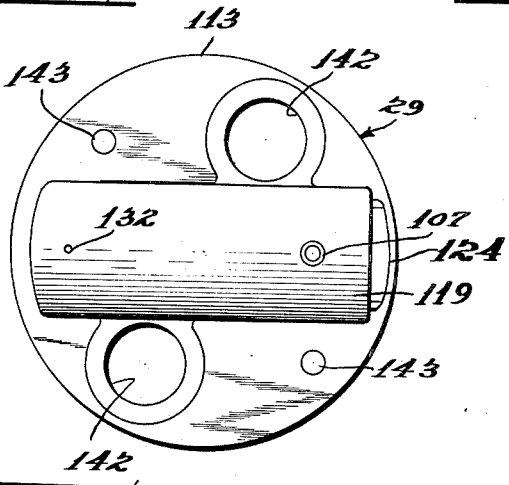


FIG. 8

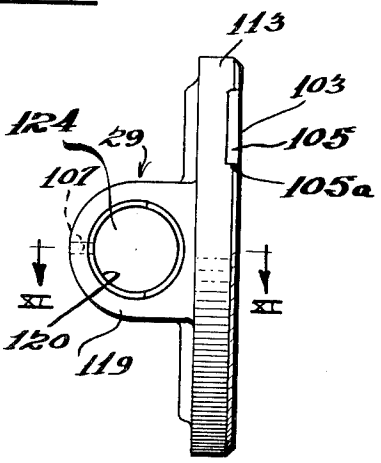
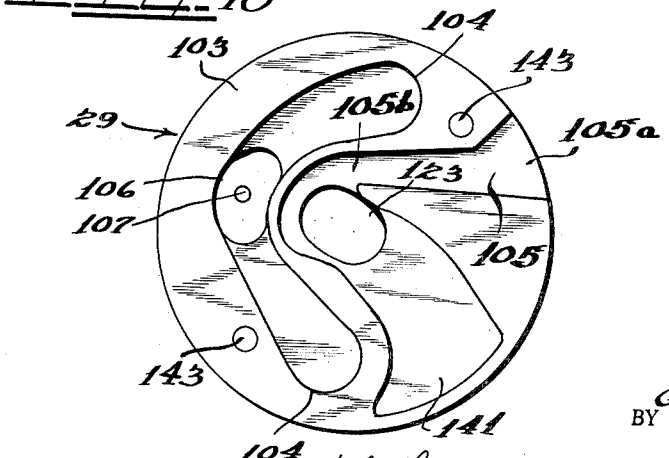


FIG. 10



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Aug. 17, 1965 H. M. CLARK ETAL 3,200,752

STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

Filed May 16, 1963 5 Sheets-Sheet 5

FIG. 12

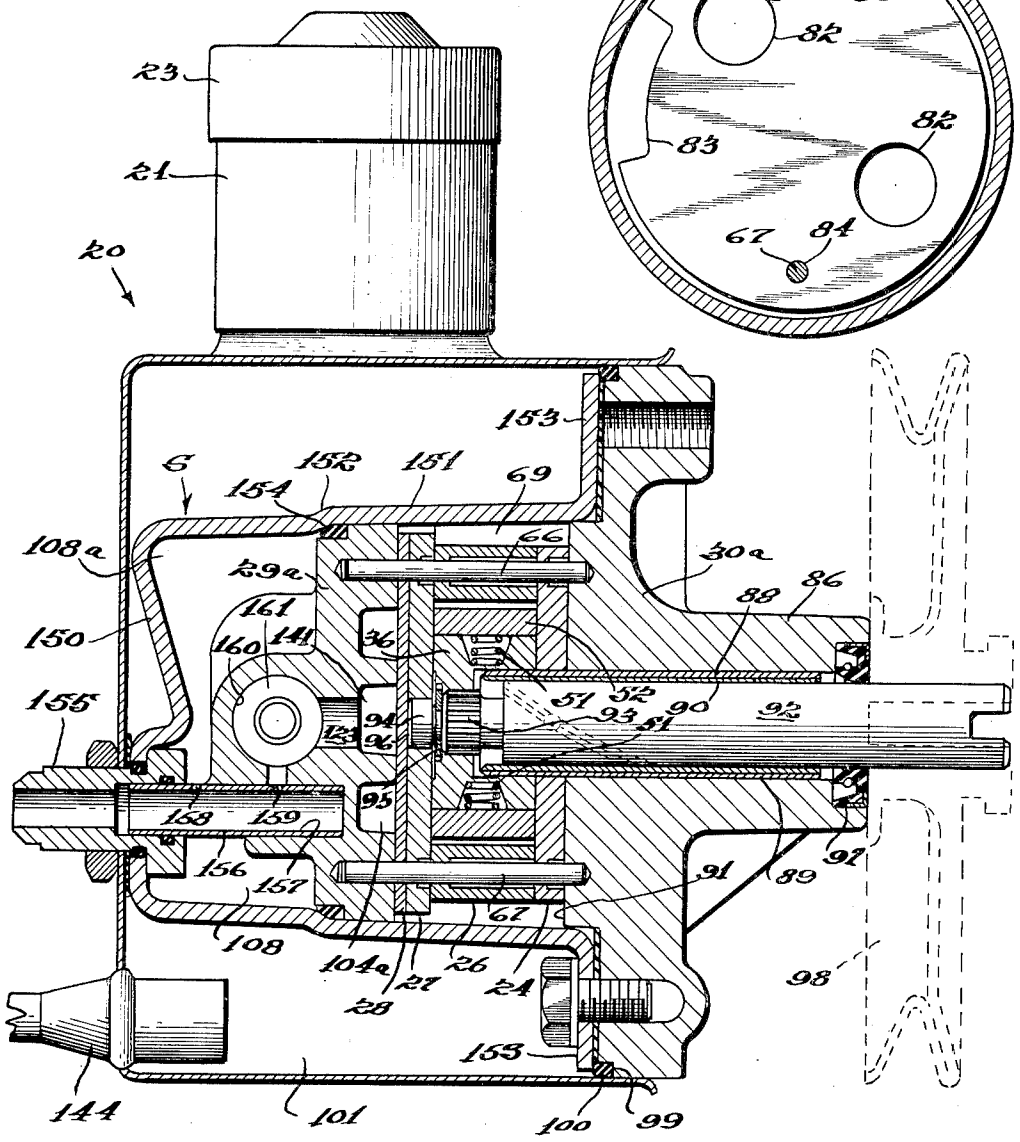


FIG. 13

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United States Patent Office 3,200,752 Patented Aug. 17, 1965

3,200,752

STACK-UP SLIPPER PUMP WITH INTEGRAL FLOW CONTROL VALVE

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Filed May 16, 1963, Ser. No. 280,947
24 Claims. (Cl. 103—42)

This invention relates generally to pumps and more particularly relates to a so-called slipper-type pump utilizing a peripherally notched rotor carrying slippers which are free to move radially and rock angularly in following the adjoining contour of a pumping chamber wall and wherein the pump is particularly characterized by a stack-up of parts including a pumping element cartridge and with which is associated a valve plate carrying a pre-calibrated flow control valve, the entire stack-up of parts being conveniently enclosed in a housing which may take the form of a cup-shaped shell.

It is an object of the present invention to provide a pump construction characterized by a stack-up of parts wherein sealing, accomplished by surface-to-surface face seals, is actuated by pump-generated pressure which squeeze the parts of a cartridge assembly together, thereby eliminating the need for elastic sealing members to prevent leakage and bolts or other fasteners to hold the assembly together.

Another object of the present invention is to provide a shaft bushing construction which accomplishes a dual purpose of aligning a shaft for driving the pump and also piloting the pump rotor on its outer diameter, thereby eliminating the need for a separate sleeve and easing manufacturing tolerances in aligning other internal parts of the pump.

A further object of the present invention is to provide a pump construction wherein simplified parts made as die castings can be employed with practicality without costly steel inserts, thereby affording greater housing compactness with the accompanying reduction in weight and cost.

A specific object of the present invention is to provide a valve assembly which is incorporated integrally in a valve plate formed as part of the pump cartridge so that the resulting valve assembly can be tested separately, thereby removing the necessity of scrapping the whole pump housing in the event of a fault in the valve bore.

A further object of the present invention is to provide a pump construction which can be manufactured with a reduced amount of capital equipment and wherein simple concentric diameters greatly simplify machining operations, thereby contributing to significant ease in the manufacturing process.

Another object of the present invention is to provide a pump utilizing a stack-up design wherein flexibility in setting flows and pressures may be obtained and wherein the pump may be readily adapted for special purposes and uses without radical changes in production tooling.

Still another object of the present invention is to provide a slipper-type pump wherein the slippers are characterized by a recessed center section providing two points of support on spaced outboard areas, thereby obtaining the classic Kingsbury effect while stabilizing the slipper action through transition areas in a double-lobed pumping cavity.

Yet another object of the present invention is to provide a slipper-type pump wherein a double tangent seal is afforded between the pumping cavity and diametrically opposed sides of the rotor, thereby reducing the number of slipper elements required and permitting the rotor strength to be unimpaired and affording an easily measured means for determining rotor to bore tangent clearances.

A further object of the present invention is to provide a pump wherein a drawn steel shell may be employed as a housing in combination with a stack-up of pumping components.

Yet another object of the present invention is to provide a flow control valve as a part of an insert which, in turn, is part of a total cartridge that forms a complete pump-valve entity.

Still another object of the present invention is to provide a pump with a pumping element cartridge which is completely surrounded by pumping media, thereby muffling noise and insuring quieter operation as well as improving the filling characteristics of the pump by permitting inlet fluid to pass into the slipper inlet area from both sides and in a generally tangential direction relative to the slippers.

A still further object of the present invention is to provide a pump which is characterized by the utilization of an orifice plug extending between the valve plate and a discharge fitting so that the flow through the flow orifice tends to aspirate or reduce pressure in the pipe near the sensing orifice, thereby making the operation of the flow valve more responsive to dynamic changes due to demand variations at the point of utilization.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which preferred structural embodiments of a pump incorporating the principles of the present invention are shown by way of illustrative example.

On the drawings:

FIGURE 1 is an end view of somewhat reduced size showing a pump provided in accordance with the principles of the present invention as embodied in the specific application of a power steering pump.

FIGURE 2 is an enlarged cross-sectional view taken generally on line II—II of FIGURE 1.

FIGURE 3 is an enlarged cross-sectional view taken generally on line III—III of FIGURE 1.

FIGURE 4 is a cross-sectional view taken generally on line IV—IV of FIGURE 2.

FIGURE 5 is a fragmentary cross-sectional view taken generally on line V—V of FIGURE 1.

FIGURE 6 is an elevational view of the lower pressure plate as seen in the plane of line VI—VI of FIGURE 3.

FIGURE 7 is an elevational view of the upper pressure plate as seen in the plane of line VII—VII of FIGURE 3.

FIGURE 8 is a somewhat reduced side elevational view of the valve plate provided in accordance with the principles of the present invention.

FIGURE 9 is an end elevational view of the valve plate of FIGURE 8.

FIGURE 10 is a front elevational view of the valve plate of FIGURES 8 and 9.

FIGURE 11 is a cross-sectional view somewhat enlarged taken on line XI—XI of FIGURE 8.

FIGURE 12 is a cross-sectional view showing the pump of the present invention wherein the housing means utilizes a drawn steel shell and

FIGURE 13 is a cross-sectional view taken generally on line XIII—XIII of FIGURE 12 showing additional details of construction of the separator plate.

As shown on the drawings:

In the pump of the present invention, as will be evident from the description of the structural features incorporated in the pump of the present invention, complete flexibility is afforded as may be desired in connection with any

special applications. However, for purposes of illustrating the principles of the present invention, a particularly useful application is made when the pump of the present invention is incorporated in a hydraulic power assisting arrangement such as a power steering system of a dirigible vehicle. Thus, it is contemplated that a power steering pump shown generally at 20 is provided and the pump has a can reservoir 21 formed with a filling spout 22 closed by a cap 23, thereby permitting the can reservoir 21 to be filled with a requisite supply of fluid.

As will be noted upon referring to FIGURES 2 and 3, the pump of the present invention is particularly characterized by a stack-up of parts, including in a longitudinal row, a lower pressure plate 24, a pumping element cartridge 26, an upper pressure plate 27, a separator plate 28 and a valve plate 29. The stack-up of parts is then enclosed within a housing means and in the particular form of the invention illustrated in FIGURES 1–11, such housing means may constitute a die casting having a main body portion 30 and an axially projecting cylindrical portion 31 which receives, in the open end thereof, a closure cap 32. It will be appreciated that other structural forms could also be used, for example, a casting made in a permanent mold or in a sand mold.

Referring specifically to FIGURE 4, the pumping element cartridge 26 is shown in greater detail and constitutes a ring 33 having an irregularly-shaped bore forming a bore wall 34 which is sized to have a substantial sealing relationship with a substantially circular rotor 36 at diametrically spaced lines of tangency indicated at L—L at both the upper and the lower portions of FIGURE 4.

The "tangent seal" thus provided affords a marked advantage in a slipper-type pump because it substantially reduces the number of slipper elements required and permits the rotor strength to be unimpaired.

In ordinary pumps where a slipper seal or a vane seal is relied upon, a larger number of elements must be employed, thereby removing circumferential rotor stock and reducing the section strength of the rotor between notches or slots.

On opposite lateral sides of the points of tangency between the rotor 36 and the bore wall 34, arcuate working chambers are formed and are indicated respectively at 37 and 38. For better identification, the tangent seal area at the upper portion of FIGURE 4 is indicated by a reference numeral 39 and the tangent seal at the lower part of FIGURE 4 is indicated by the reference numeral 40. Between the tangent seal 40 and the working chamber 37 is a transition area 41 and between the working chamber and the tangent seal 39 is a second transition area 42. Between the tangent seal 39 and the working chamber 38 is a transition area 43 and between the working chamber 38 and the tangent seal 40 is a transition area 44.

The rotor is a generally cylindrically-shaped article which is particularly characterized by a plurality of notches shown generally at 46 and each specific notch includes a bottom wall 47 and substantially parallel side walls each indicated at 48. In this particular embodiment, there are a total of eight notches 46. The bottom wall 47 is characterized by one or more recesses 50 in which is bottomed a coil spring 51 adapted to continuously bias a slipper element shown generally at 52 radially outwardly into sealing engagement with the adjoining pumping chamber wall 34.

In accordance with the principles of the present invention, the slippers are of a specific structural shape in that each slipper member is an elongated extrusion which in cross-section is somewhat circular, thereby to provide a curved inner wall 53 and an arcuate outer wall 54. Thus, the inner and outer walls 53 and 54 of each respective slipper 52 meet at points indicated at 56 and 57 which are actually formed on discrete radii.

Referring, first of all, to the inner wall 53, it will be noted the diameter of curvature of the inner wall 53 is

substantially equal to the width of a corresponding notch 46. The size of the slipper is controlled so that each slipper 52 is free to move radially and to rock angularly with respect to the notch 46 and the rotor 36 in following the contour of the bore wall 34.

Each arcuate surface 54 extending between the points 56 and 57 is of a curvature substantially the same as the curvature of the bore wall 34, however, the curvature of the arcuate surface 54 is just slightly less than the curvature of the adjoining bore wall in order to obtain the classic Kingsbury effect, namely, a film of oil is introduced under the leading edge of the slipper, thereby permitting the arcuate surface 54 to ride on a film of oil.

Extending longitudinally throughout the length of each entire slipper 52 is a centrally disposed recess 58 which has the effect of forming two positions of support on the arcuate surface 54, or, in other words, two outboard areas. It has been discovered this particular form of slipper construction is especially efficient in a double-lobed pump construction, as illustrated herein, since the "cam surface" or bore wall 34 is somewhat radical and because of the improved slipper characteristics, a good seal is maintained as the double support positions on the arcuate surface 54 engage the bore wall 34 and move through the transition areas 41, 42, 43 and 44. Thus, the grooved slipper top surface is an important factor in stabilizing the overall rock condition and hop of the slipper 52 that is encountered in a double lobe pump when pumping bore accelerations, radial and tangential, become high with the shortening of the intake to the working arc distance. The elimination of the center section throws the two positions of support on the two outboard areas and permits the slippers to retain the classic Kingsbury effect.

In order to maintain the same pressure condition under the slipper and in the bore cavity between two adjacent slippers under the transient pressure condition the slipper is passing through in a 360° revolution, each slipper 52 is particularly characterized by a relief passage 59 formed in the inner surface 53 and extending from the point 56 far enough inwardly to intercommunicate the portions of the notch 46 inwardly of the slipper 52 with the working chambers 37 and 38.

One of the side walls 48, 48 of each respective notch 46 is also characterized by a relief recess shown at 60 which recesses are provided for the purpose of maintaining substantially the same pressure under the slipper and in the tangent arc clearance cavity on the trailing side of the slipper after the slipper leaves the outlet port and enters the tangent arc. Thus, each recess 60 functions as a timing notch and develops a relieving function as the slipper passes through the sealed area.

It will be noted the ring 33 is particularly characterized by a pair of circumferentially spaced axial through openings 61 and 62 which are, for the purpose of forming passageways, intercommunicating ports in the upper and lower pressure plates 24 and 27.

The ring 33 is further characterized by a pair of circumferentially spaced openings 63 and 64 through which extend a pair of dowel pins 66 and 67.

The outer peripheral surface of the ring 33 has an elongated notch formed therein indicated at 68. As shown in FIGURE 4 the cylindrical portion 31 of the housing means is spaced outwardly of the ring 33, thereby forming an annulus 69 around the ring 33, which annulus is filled with pumping media, thereby to surround the pumping element cartridge 26 in such a manner as to muffle noise and insure quiet operation.

Referring now to FIGURE 6, the lower pressure plate is shown as comprising a ported plate member having front and rear parallel faces including a porting face 70. The plate 24 has discharge ports 71, 71 formed therein, one for each working chamber 37 and 38 and each port 71 has minor inlet ports 75, 75 connected thereto to receive any fluid pressurized by the radial inward movement of the slippers 52 in the corresponding notch 46.

The outer periphery of the plate 24 is relieved to form inlet recesses 72, 72, thereby admitting inlet fluid from the annulus 69 down into the inlet areas associated with each respective working arc 37 and 38.

Further, the plate 24 is formed with a large central opening 73. Circumferentially spaced openings 74, 74 are provided for passing the dowel pins 66 and 67.

Referring now to the upper pressure plate 27, shown in FIGURE 7, a plate-like member is illustrated having straight parallel faces and a centrally disposed through opening 76. The outer periphery of the plate 27 has inlet recesses 77, 77. The outlet ports are shown at 78, 78 and are connected with minor outlet ports 79, 79 on the back of the plate 27. The minor ports 79, 79 communicate with the radially innermost portions of the notches 46 in the rotor 36. Inlet openings 80, 80 are also located radially inwardly of the recessed area 77, 77 and are connected to the inlet recesses 77, 77 on the back of the plate 27. The minor inlet openings 80, 80 communicate with the innermost portions of the notches 46. The plate 27 is also provided with openings 81, 81 for the purpose of accommodating the dowel pins 66 and 67.

Referring now to FIGURE 13, the separator plate 28 constitutes a plate form member having spaced parallel faces and is characterized by a pair of axial through openings forming discharge ports 82, 82. The peripheral surface of the plate 28 is also notched as at 83 and the plate 28 has circumferentially spaced openings 84, 84 formed therein for accommodating the dowel pins 66 and 67.

Referring further to FIGURES 2 and 3, it will be noted the main body portion 30 of the housing means includes a boss 86 which extends axially and which has formed therein an opening 87 for carrying a shaft bushing shown generally at 88 and characterized by a sleeve-like shell 89 having a bearing liner 90 such as bronze or babbitt fused thereon. The shaft bushing extends through the boss 86 and projects beyond a radial wall 91 formed on the main body portion 30 of the housing means. Thus, the shaft bushing 88 accomplishes a dual purpose in that the bushing aligns a shaft 92 and also pilots the rotor 36 on its outer diameter, thereby eliminating the need for a separate sleeve which would normally be required to be pressed into the rotor. This feature eases manufacturing tolerances in aligning other internal parts of the pump.

The shaft 92 has a splined portion 93 connected to the rotor 36 and has an extension 94 which is piloted on the inner diameter of the upper pressure plate 27, thereby easing manufacturing tolerances and decreasing noise.

An end face 96 on the shaft 92 engages the center portion of the separator plate 28, thereby permitting the separator plate 28 to absorb thrust loads. The shaft 92 is retained in assembly with the rotor of the pumping element cartridge by means of a snap ring 95.

A shaft seal is shown generally at 97 and is contained in the end of the boss 86. The outer end of the shaft 92 is connected to a pulley wheel 98, thereby forming a drive connection, for example, to the fan belt drive of the automotive engine.

The main body portion 30 of the housing means has at its outermost peripheral point an annular groove 99 in which is received a sealing member such as an O ring 100, thereby to effect a good seal with the can reservoir 21 connected thereto and it will be understood that the entire reservoir space shown at 101 will be filled with pumping fluid medium.

As shown in FIGURES 1, 4 and 5, the cylindrical portion 31 of the housing means has an opening 102 through which make up fluid from the reservoir area 101 is supplied as explained hereinafter to the annulus 69, whereupon the fluid flows radially inwardly from around the ring 33 into the inlet areas 72, 72, 77, 77 and 80, 80 formed in the lower and upper pressure plates 24 and 27, respectively. Thus, the inlet fluid fills the pumping spaces between the adjoining slippers 52 and the fluid is advanced from the inlet areas of the respective working chambers 37 and 38 and discharged at increased pressure into the discharge ports 71, 71 and 78, 78 and 79, 79, of the respective lower and upper pressure plates 24 and 27. The fluid at discharge pressure on opposite sides of the pump rotor is communicated via the passages 61 and 62 formed in the ring 33. The pumped fluid at discharge pressure then passes through the ports 82, 82 (FIGURE 13) in the separator plate and is directed to a radial face 103 of the valve plate shown generally at 29.

Referring, first of all, to FIGURE 10, the valve plate 29 has its radial face 103 characterized by recessed areas 104 which communicate with the ports 82, 82 formed in the separator plate 28 and conduct the discharge fluid to a through passage 106 in which is formed a flow control orifice 107.

The fluid at pump-generated pressure discharged through the flow control orifice 107 is received in a pressure chamber 108 formed between the valve plate 29 and the closure 32 of the housing means. To insure adequate sealing of the pressure chamber 108, the cylindrical wall portions 31 of the housing means are provided with grooves 109 and 110 in which is received an O ring sealing member 111 and 112, respectively. The sealing member 111 engages against an adjoining peripheral surface 113 formed on the valve plate 29 while the sealing ring 112 engages against an adjoining peripheral surface of the closure 32. The closure 32 is held in assembly with the cylindrical wall portion 31 by means of a snap ring 114 and the closure 32 is provided with an embossment 116 in which is sealably secured, as at 117, a discharge nipple 115 onto which may be connected a discharge fitting 118 which operates to hold the nipple 115 and the reservoir 21 in place and which, in turn, may be connected to a conduit leading to the point of utilization.

As shown in FIGURES 8–11, the valve plate 29 is particularly characterized by an enlarged boss 119 in which is formed a bore 120 having a bottom wall 121 and a land 122 separating the passage 106 from a bypass passage 123. The end of the bore 120 is closed by a plug 124 having a stop 126 formed thereon for abuttingly engaging an end surface 127 on a spool valve shown generally at 128. The spool valve 128 has a control land 129 and a control land 130 on opposite sides of the bypass passage 123 and the land 129 cooperates with the land 122 in order to close the bypass passage 123 when a coil spring 131 bottomed against the wall 121 normally urges the spool valve 128 to a closed position against the stop 126.

The boss 119 has an aperture 132 formed to extend between the pressure chamber 108 and the interior of the bore 120 behind the spool valve 128.

The spool valve 128 is hollow, thereby to provide a passage 133 which communicates via circumferentially spaced apertures 134 with the bypass passage 123. The end of the passage 133 is threaded to receive a fitting 136 having a passage 137 formed therein, which passage is provided with a valve seat 138 seating a ball valve 139 normally loaded by a coil spring 140, thereby to form a relief valve and venting excessive pressures from the pressure chamber 108 through the passage 132 and the bore 120, through the passage 137 and past the valve 139 into the passage 133 and through the openings 134 back to the bypass passage 123.

The radial face 103 of the valve plate 29 also has formed therein a recess 141 which communicates with the bypass passage 123 and conducts fluid to the notch 83 (FIGURE 13) of the separator plate 28 which notch 83 communicates with the notch 68 formed in the ring 33 and hence with the inlet areas 72, 72 and 77, 77, thereby placing the bypass passage 123 in communication with a zone of low pressure near inlet pressure. Accordingly, it will be clear from the foregoing that full pump discharge pressure is present in the passage 106 and some

pressure somewhat lower than full pump discharge pressure is present in the pressure chamber 108 in view of the pressure drop which exists across the flow control orifice 107. Essentially the same pressure is present in the bore 120 and, accordingly, the movement of the spool valve 128 will be a function of the variations in pressure drop across the flow control orifice 107. Thus, the spool valve 128 will connect the bypass passage 123 to the discharge passage 106 as necessary to maintain a constant flow.

As shown in FIGURES 5 and 9, the back face of the valve plate 29 has a pair of recessed wells 142 formed therein in each of which is bottomed a coil spring 145, the opposite end of which is bottomed against the closure 32, thereby to keep the stack-up of parts biased together even when the pump is not operating. As soon as the pump begins to operate and pump-generated discharge pressure is communicated to the pressure chamber 108, it will be evident that sealing, accomplished by surface-to-surface face seals, is actuated by the pressure in the pressure chamber 108 squeezing the parts of the cartridge assembly together, thereby minimizing the need for elastic sealing members to prevent leakage and bolts or other fasteners to hold the stack-up assembly together.

The valve plate 29 is also furnished with a pair of circumferentially spaced openings 143 to accommodate the dowel pins 66 and 67.

In FIGURE 2, the can 21 is shown formed with a nipple 144 which is adapted to return spent fluid from the point of utilization back to the reservoir 101.

In operation, the outlet flow from the rotor 36, the cam insert or ring 33 and the slippers 52 which form the pumping element cartridge 26 passes through the aligned ports in the upper and lower pressure plates and the separator plate (71, 78 and 82) to cast ports in the valve plate 104, whereupon the flow is brought together through an opening 105 in the front end of the flow control valve 128. The flow control orifice 107 passes the controlled flow to the pressure control chamber 108 formed by the valve plate 29 and the end closure 32. From the pressure control chamber 108, the controlled flow is directed to the steering unit through the outlet fitting 118. The pressure differential caused by the flow control orifice 107 is referenced to the back flow valve 128 through the sensing orifice 132. The combination of the pressure differential and the flow control spring 131 provides a controlled output flow to the steering unit. Excess flow is dumped as overflow relief into the bypass passage 123 in the valve body 29 which is adjacent to and at an intersecting angle to the channel passage 141. The valve plate 29 has formed in the face 103 a make-up passage 105 which communicates with the inlet passage 102 as at 105*a*. A reduced neck 105*b* produces an aspirator effect which insures filling the inlet areas with a sufficient supply of fluid. The combined make-up oil and bypass flow discharges through an opening in the separator plate 83, through the upper plate 27 and into the recess 68 of the cam ring and thence in opposing circumferential direction through the annulus 69 to the opposite inlet ports 72, 72 and 77, 77.

The presence of high pressure oil in the cavity, creating a reaction force on the valve body enclosure, also serves to maintain a state of pressure balance between the cavity side and the internal surfaces of the valve spool hole in the valve body. The principal advantage in this feature is in the stability of the spool hole size when pump delivery pressures rise; this maintains a constant valve bore size under all pressure conditions which increases the efficiency of the pump-valve combination and permits greater machine latitudes.

Refering now to FIGURE 12, the housing means which encloses the stack-up of parts is shown as comprising a drawn steel shell S of cup-shaped configuration including an end wall 150, side walls 151 formed with an intermediate shoulder 152 and a radially outwardly extending flange 153 suitably apertured for connection in firm assembly with a relatively flat plate-like body member corresponding to the main body section of the pump of FIGURES 1–11 shown at 30 and herein indicated at 30*a*.

To fabricate the shell S, a plain blank of sheet stock is either drawn or stamped to provide the flanged cup-shaped configuration illustrated in FIGURE 12 and no further machining or finishing operations are effected.

A sealing member 154 is interposed between the shoulder 152 and a valve plate 29*a*, thereby segregating the interior of the drawn steel shell into the pressure control chamber corresponding to the pressure control chamber 108 and the inlet zone corresponding to the annulus 69.

The pump of FIGURE 12 varies from the pump of FIGURES 1–11 in one other aspect in that an orifice plug 156 extends between an outlet fitting shown at 155 and a recess 157 in the valve plate 29*a*. The orifice plug 156 is generally tubular in configuration and contains a flow orifice herein identified at 158 and a sense orifice 159 communicates with a valve chamber 160 behind a valve, herein shown at 161, but corresponding in function and purpose with the valve 128. Fluid flow through the flow orifice 158 tends to aspirate or induce a pressure in the conduit pipe or orifice plug 156 near the sense orifice 159, thereby making the operation of the flow valve 161 more responsive to dynamic changes due to demand variations at the point of utilization. Thus, there is a tendency to get the flow valve moving in the direction it wants to go.

In the valve plate construction of FIGURE 12, the valve plate 29*a* has a a discharge port 104*a* which is communicated directly to the pressure control chamber 108*a*, for example, past the front end of the valve 161, so that fluid at pump-generated pressure is available to act on the back of the valve plate 29*a* as well as to flow through the orifice 158 into the orifice plug 156 and out of the discharge fitting 155 to a point of utilization.

It will be understood that other seals and gaskets illustrated but not specifically numbered may be incorporated between various fitted-together parts as may be necessary to insure the fluid-tight integrity of the pump and its hydraulic circuitry.

It should also be understood that the stack-up or cartridge arrangement could be varied, for example, by constructing two or more of the parts as one part. Thus, the valve plate, separator plate and upper pressure plate could be unitized without departing from the spirit of this invention. In like manner, the valve plate and the separator plate could be one, or the upper pressure plate and the separator plate could be one part. The lower pressure plate could also be eliminated by forming ports in the adjoining housing wall, or conceivably, porting could be accomplished from one side of the pumping element cartridge. Such variations and permutations are referred to for the purpose of demonstrating that the basic concept of the present invention can take alternative embodiments.

Other minor modifications might be suggested by those versed in the art, but it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In a pump,

a stack-up of parts including

a ring part having a contoured bore forming a pumping chamber,

first and second ported pressure plate parts on opposite sides of said ring part and forming inlet and outlet areas communicating with the interior of said ring part,

a valve plate part carrying a flow control valve integrally therewith and having a discharge passage for receiving the discharge of the pump and

directing a controlled flow outwardly, said valve plate part and said flow control valve forming a single unit,

a separator plate part between said valve plate part and one of said pressure plate parts to regulate the inlet and outlet areas,

and retaining means aligning and retaining said parts in assembly with one another,

a notched rotor in said ring part having a slipper means in the notched portion free to move radially and rock angularly in following the bore contour to move fluid from the inlet to the outlet areas,

and means to rotate said rotor comprising a rotatable shaft connected to said rotor,

support means for journaling said shaft,

and a cup-shaped can connected to said support means and enclosing said stack-up of parts and together therewith forming an inlet zone surrounding said ring part and an outlet zone spaced therefrom.

2. In a pump,

a stack-up of parts comprising in an axial row,

a housing plate,

a lower pressure plate,

a pumping element cartridge,

an upper pressure plate,

a separator plate,

and a valve plate having a flow control orifice and having a flow valve integrally therein forming a single unit,

a shell member connected to said housing plate and surrounding said stack-up of parts,

and sealing means between said shell member and said valve plate to segregate the interior of the shell into a low pressure zone surrounding the remaining parts of the stack-up and a high pressure zone behind said valve plate receiving fluid discharge through said flow control orifice,

whereby the stack-up of parts is squeezed together into operative assembly without the need of additional fasteners.

3. In a pump as defined in claim **2**,

said housing plate having a radial face and carrying a shaft bushing projecting axially outwardly of said radial face,

said pumping element cartridge comprising a ring forming a pumping chamber,

a rotor piloted on the outer diameter of said bushing,

said rotor having a notched periphery and including slipper means free to move radially and rock angularly in following the contour of the adjoining pumping chamber wall in said ring,

and a shaft aligned and journaled in the inner diameter of said shaft bushing and connected to said rotor to drive the rotor rotatably.

4. In a pump as defined in claim **2**,

said housing plate having a flat radial end wall formed with a centrally disposed opening,

an elongated shaft bushing in said opening having an end projecting axially from said end wall,

said lower pressure plate piloted on the outer diameter of said bushing,

a rotor piloted on the outer diameter of said bushing and having one side abutting said lower pressure plate,

said upper pressure plate abutting the other side of said rotor,

said separator plate abutting said upper pressure plate,

and said valve plate abutting said separator plate,

a shaft piloted on the inside diameter of the bushing and being rotatably connected to said rotor,

said pumping element cartridge comprising a ring sandwiched between said upper and lower pressure plates and forming a pumping chamber for said rotor,

said upper pressure plate being piloted on the end of said shaft and said separator plate abutting said end of said shaft to absorb shaft thrust loads.

5. A pump comprising,

a stack-up of parts comprising in an axial row

a lower pressure plate,

a pumping element cartridge including

a ring forming a double-lobed pumping cavity,

a rotor and

a plurality of slippers carried by the rotor for radial and rocking movement in following the contour of the cavity,

an upper pressure plate, and

a valve plate having a flow control orifice and having a flow control valve incorporated integrally therein and forming a single unit,

and housing means for enclosing said stack-up of parts including sealing means engaging said valve plate and said housing means to segregate the interior of said housing means into a low pressure inlet zone surrounding other parts of the stack-up and a high pressure zone behind said valve plate receiving fluid at pump generated pressures to pressure-clamp the stacked up parts into operative relation without any additional fastening means.

6. A pump as defined in claim **5**, wherein said housing means comprise a plate-like housing member adjoining said lower pressure plate,

and a flanged cup-shaped shell fastened thereto and enclosing said stack-up of parts.

7. A pump as defined in claim **5** and further characterized by said pump cavity being prescribed by a bore wall having tangent sealing contact along a line of tangency with said rotor at diametrically opposite points between said rotor and said bore wall,

said bore wall forming two separate arcuate working chambers extending between said tangent seals.

8. In a pump as defined in claim **5**,

said rotor having a plurality of peripheral notches,

each said slipper in each said notch free to move radially and rock angularly in following the wall of a pumping chamber,

and said slipper being characterized by

a sealing area shaped arcuately to the approximate contour of the adjoining pumping chamber wall but sufficiently less to afford a Kingsbury effect between the wall and slipper, said sealing area having two circumferentially separated positions of support and a transverse relieved portion therebetween open at both ends, thereby stabilizing the slipper action through transition areas of the pumping chamber wall.

9. A rotary pump comprising

a stack-up of parts including

upper and lower pressure plates having a pumping element cartridge therebetween,

and a valve plate having a flow control orifice and having a flow control valve incorporated integrally therein and forming a single unit,

and housing means enclosing said stack-up and providing inlet and outlet means for the pump,

said cartridge including a peripherally notched rotor having slipper means free to move radially and to rock angularly in following the adjoining bore wall of a pumping chamber,

said cartridge further including a ring having a pumping chamber bore forming two points of tangency with said rotor and forming two tangent seals at opposite sides of said rotor,

said pumping chamber bore being shaped to form two separate arcuate working chambers extending between said tangent seals,

and ports formed in said stack-up of parts providing inlets and outlets for said working chambers to conduct

fluid toward and away from the pumping chamber.

10. In a rotary pump as defined in claim 9, each said slipper means comprising an elongated member having a sealing area characterized by two circumferentially spaced positions of support separated by a transverse longitudinal recess open at both ends,

said positions of support being disposed generally on a path of curvature conforming closely to an adjoining pump bore but sufficiently less to obtain a Kingsbury effect between the slipper and the bore wall.

11. A rotary pump as defined in claim 9, said slipper means characterized by a transversely recessed center section open at both ends providing two circumferentially positions of support on spaced outboard areas thereby obtaining a Kingsbury effect while affording an improved slipper action through transition areas of a pump cavity.

12. A pump comprising

a stack-up of parts including

upper and lower pressure plates,

a pumping element cartridge therebetween having a ring forming a pumping cavity and a rotor in said ring carrying a plurality of slippers free to move radially and to rock angularly,

and a valve plate,

housing means for said stack-up of parts,

said valve plate having an enlarged boss formed thereon providing a bore for a spool valve, said valve plate having an outlet passage receiving all of the fluid pumped by said slippers, a flow control orifice formed in said valve plate through which the fluid in said outlet passage is directed,

and a spool valve incorporated integrally in said valve plate forming therewith a single unit and having motive surfaces responsive to variations in the pressure drop across said orifice and controlling flow of discharge fluid back through said stack-up to an inlet zone surrounding said ring.

13. In a pump as defined in claim 12,

said rotor having peripheral notches formed therein, each notch having a bottom wall and substantially parallel side walls,

each said slipper for each said notch comprising

an elongated member having an outer face formed with two support positions separated by a center recess open at both ends and said support portions being disposed in substantially the same curvature as the adjoining pumping chamber wall to achieve a Kingsbury effect,

said slipper having an inner face formed in an arc of a diameter substantially equal to the width of the corresponding notch, whereby the slipper is free to rock angularly and to move radially with respect to the rotor.

14. In a slipper-type pump as defined in claim 13, each of said notches having a recess formed in one of said side walls to develop a relieving function when the slipper enters a sealing area.

15. In a slipper-type pump as defined in claim 13, each of said slippers having a passage means formed to conduct fluid into and out of the corresponding notch.

16. In a pump, an axial row of stacked-up parts forming a pump unit, the outermost of said parts comprising,

a valve plate for abutting side ported means of a pump part and comprising a radial face having formed therein inlet and outlet ports separated by sealing lands,

a boss on said valve plate having formed therein a valve bore closed at one end,

a coil spring in said valve bore bottomed against said one end,

housing means forming together with said valve plate a pressure chamber,

said boss having an aperture formed therein communicating said pressure chamber with the interior of said bore,

said boss having formed therein a flow passage extending transversely of said valve bore and communicating pump discharge into said pressure chamber,

said flow passage having a flow control orifice formed therein,

said boss having a bypass passage formed therein communicating with the pump inlet,

a valve spool in said boss having a bypass passage formed therein communicating with the pump inlet,

a valve spool in said boss engaged by said spring and normally closing said bypass passage,

said valve spool having surfaces thereon responsive to variations in the pressure drop across said orifice to regulate said bypass passage as a function of flow and forming together with said valve plate a single unit,

and a relief valve in said valve spool controlling a relief valve passage from said aperture to said bypass passage.

17. A pump having an axial row of stacked up parts forming a pump unit and the outermost of which constitutes a valve plate,

and a housing enclosing said stacked up parts,

an orifice tube extending between said housing and said valve plate,

said housing having a discharge fitting connected to one end of said orifice tube,

said valve plate having a discharge port communicating with the interior of said housing,

said orifice tube having a flow orifice conducting fluid from the housing to the discharge fitting,

a bypass passage in said valve plate,

a bypass valve incorporated integrally in said valve plate for controlling said bypass passage and forming with said valve plate a single unit, and said orifice tube having a sense orifice communicating pumping fluid at controlled discharge pressure to said bypass passage and to the front of said valve,

whereby flow through the flow orifice tends to aspirate or reduce pressure in the area of the sense orifice,

thereby making the operation of the valve more responsive to dynamic changes in demand as a function of the changing degree of aspiration.

18. A pump comprising

a stack-up of parts including

upper and lower pressure plates,

a pumping element cartridge therebetween having a ring forming a pumping cavity and a rotor in said ring carrying a plurality of slippers free to move radially and to rock angularly,

and a valve plate,

housing means for said stack-up of parts,

said valve plate having an enlarged boss formed thereon providing a bore for a spool valve,

a housing means surrounding said stack-up of parts including a sealing means between said valve plate and said housing means to divide the interior of said housing means into an inlet zone around the other parts of the stack-up of parts and a discharge zone behind the valve plate,

a discharge fitting in said housing means,

a flow control valve incorporated integrally in said bore of said valve plate to form together therewith a single unit, and having one end subject to pressure in the discharge zone,

said valve plate having a bypass passage communicating with said inlet zone and a discharge passage communicating with said discharge zone and said flow control valve controlling the flow therebetween,

an orifice plug extending between said discharge fitting and said valve plate,

said orifice plug having a flow orifice intercommunicating the discharge zone and the discharge fitting to supply a controlled supply to the discharge fitting,

and said orifice plug having a sense orifice intercommunicating the other end of said valve to the controlled flow,

whereby the flow through said flow orifice tends to reduce pressure in the area of the sense orifice, thereby stabilizing the action of the bypass valve.

19. A pump comprising,

an axial row of stacked up parts forming a pump unit,

the outermost part of the pump unit comprising a valve plate having a flow control orifice and having a flow control valve incorporated integrally therein forming a single unit,

and housing means enclosing the pump unit and forming together therewith a discharge zone at one end of the axial row and an annular inlet zone around the parts.

20. A pump as defined in claim **19**,

said housing means comprising a sheet member shaped to form a cup configuration with an end wall spaced from the end of the row and side walls surrounding the parts, and a sealing member between said side walls and one of said parts for separating said zones in sealed-apart relation.

21. A pump as defined in claim **19**, said housing means comprising,

a housing member having a radial face and carrying a shaft bushing projecting axially outwardly of said radial face one of said stacked up parts comprising,

a ring forming a pumping chamber,

a rotor piloted on the outer diameter of said bushing and having pumping elements carried thereby,

and a shaft aligned and journaled in the inner diameter of said shaft bushing and connected to said rotor to drive the rotor rotatably.

22. A pump as defined in claim **19** and further characterized by

a rotor,

pumping elements carried by said rotor for engaging an adjoining bore wall of a pumping chamber formed in one of said stacked up parts,

and said one of said stacked up parts comprising pumping chamber means having a bore formed therein prescribed by a bore wall having tangent sealing contact along a line of tangency with said rotor at diametrically opposite points between said rotor and said bore wall,

said bore wall forming two separate arcuate working chambers extending between said tangent seals.

23. In a pump,

a stack-up of parts comprising in an axial row

means forming a pumping element cartridge and ported means providing surface-to-surface face seals including a valve plate having a flow control orifice and having a flow control valve incorporated integrally therein forming a single unit to direct fluid towards and away from the pumping element cartridge,

and housing means including a shell member to surround said stack-up of parts,

and sealing means between said shell member and said valve plate to segregate the interior of said shell member into a low pressure zone surrounding the remaining parts of the stack-up and a high pressure zone behind said valve plate receiving fluid at pump generated pressure from the flow control orifice,

whereby the stack-up of parts is squeezed together into operative assembly.

24. A pump comprising means forming a pumping chamber,

means including a movable valve plate closing one side of said pumping chamber and having a discharge passage for receiving fluid at pump-generated pressure,

and a flow control valve incorporated integrally in said valve plate and together therewith forming a single unit,

said flow control valve controlling the flow of fluid in said discharge passage,

an orifice formed in said valve plate through which pump discharge from said discharge passage is directed,

said flow control valve being responsive to the pressure drop across said orifice,

and means forming a pressure chamber behind said valve plate for receiving pump generated pressure from said orifice,

thereby to hold the parts together in sealed relationship and having an outlet formed therein through which a constant flow of fluid is directed to a point of utilization.

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