Dec. 14, 1954 J. F. JAWOROWSKI ET AL 2,696,787

ROTARY PUMP

Filed June 28, 1948 6 Sheets-Sheet 1

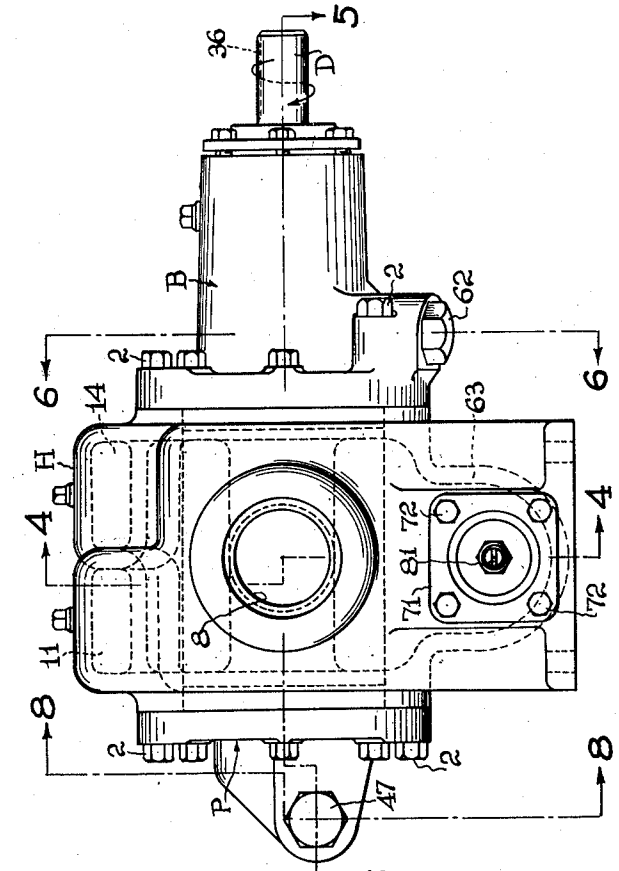


Fig. 2

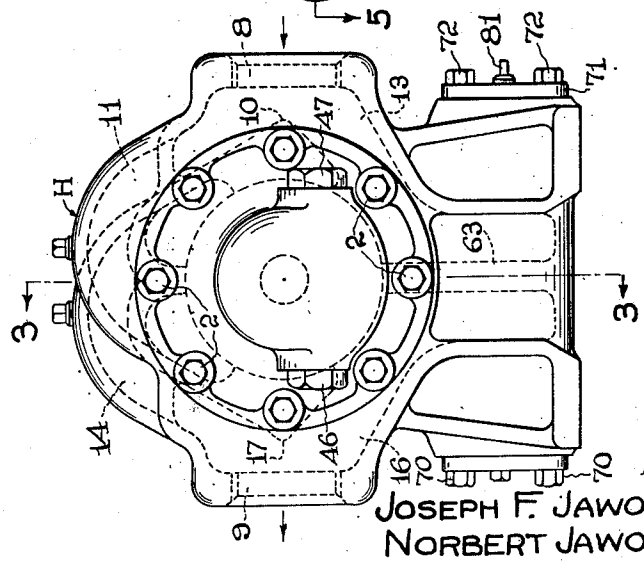


Fig. 1

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ROTARY PUMP

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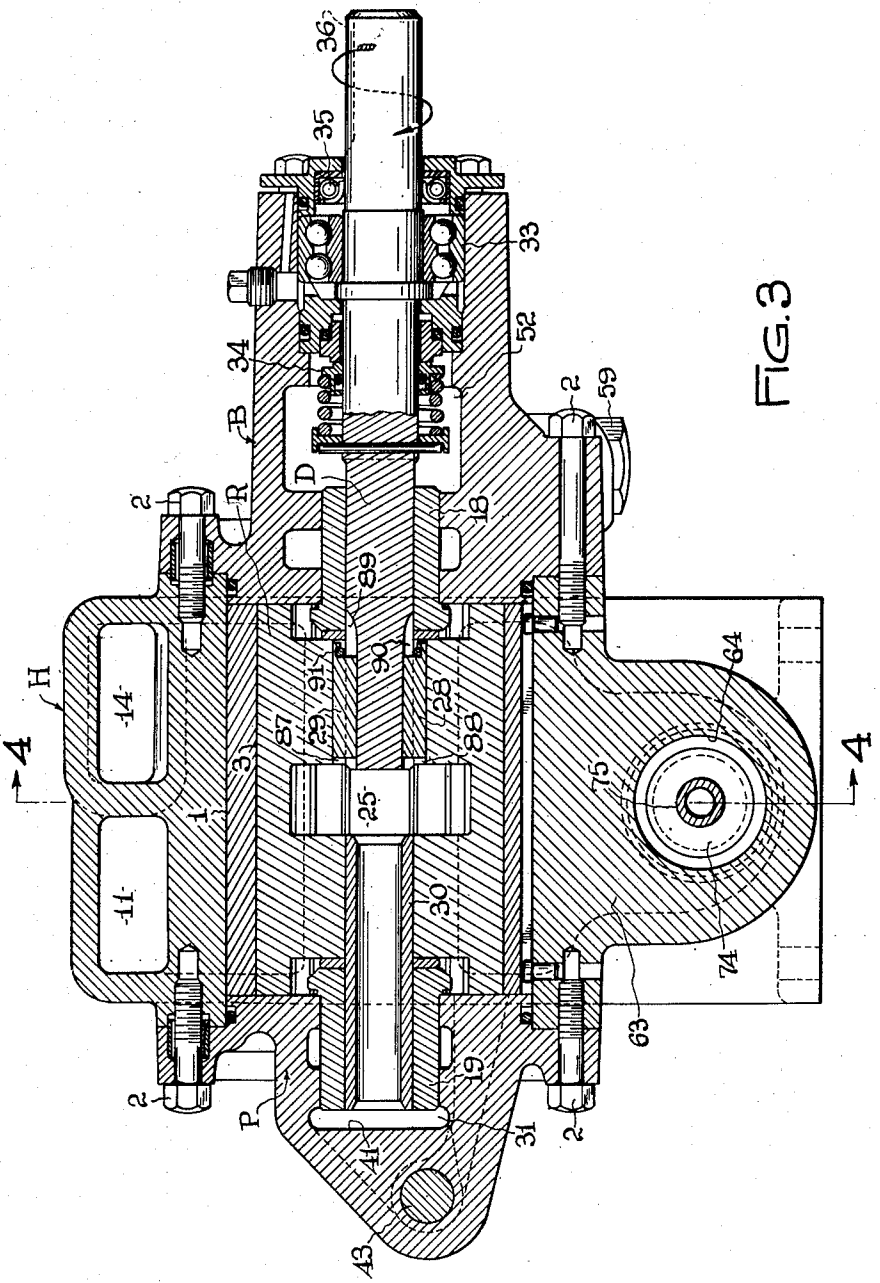


FIG. 3

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ROTARY PUMP

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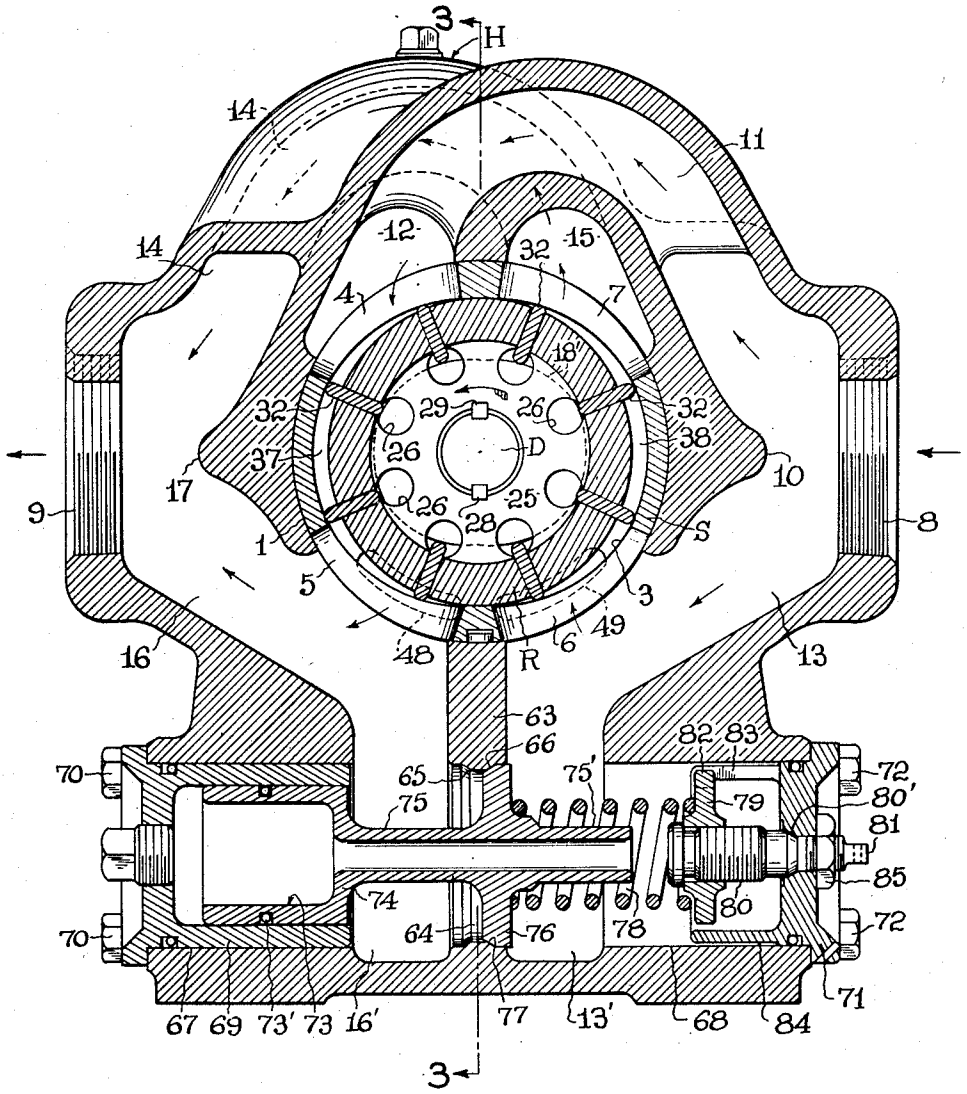


FIG. 4

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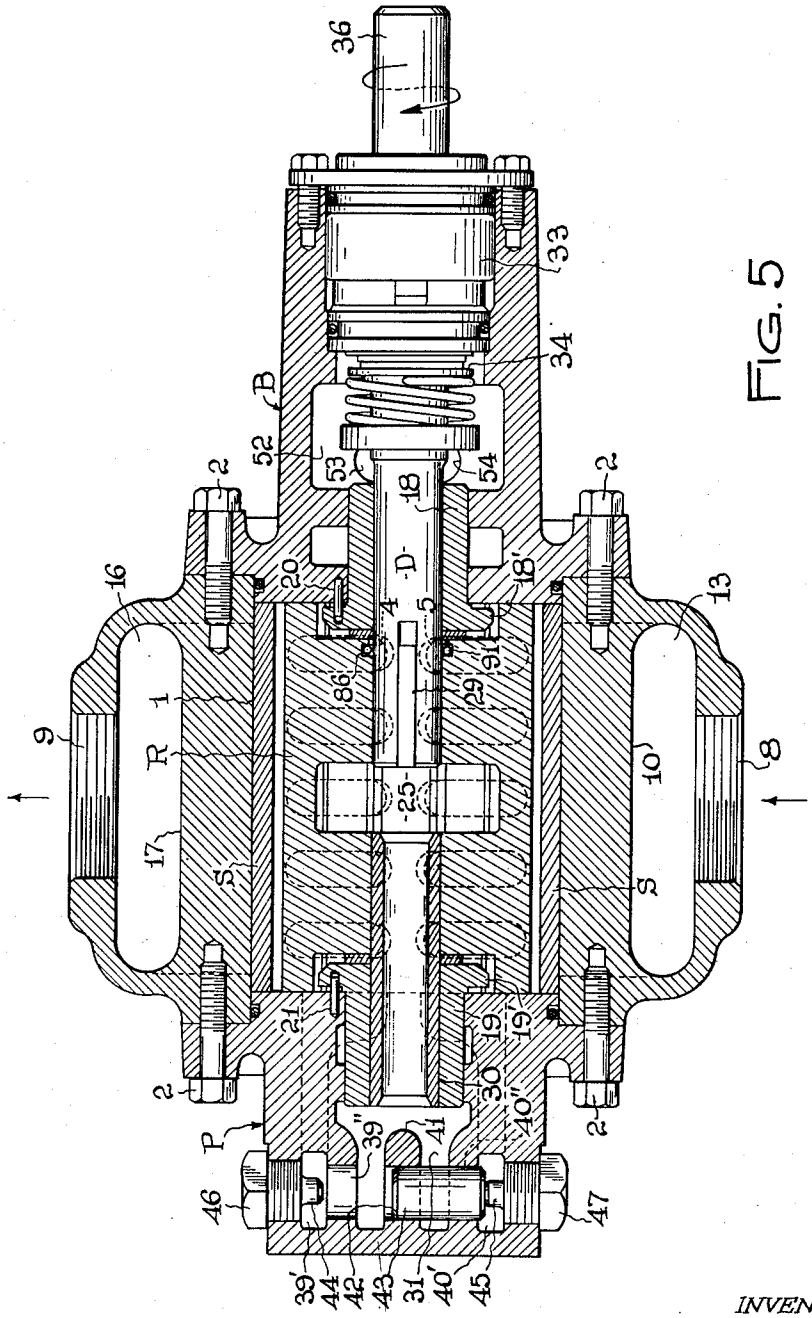


FIG. 5

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ROTARY PUMP

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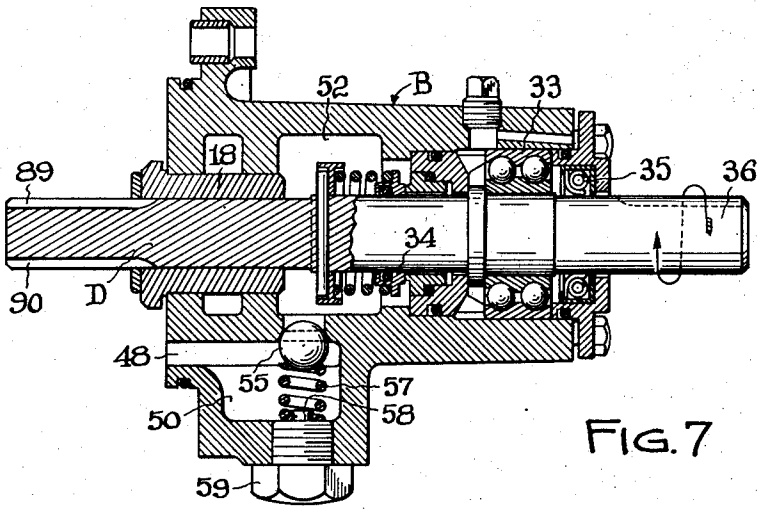


FIG. 7

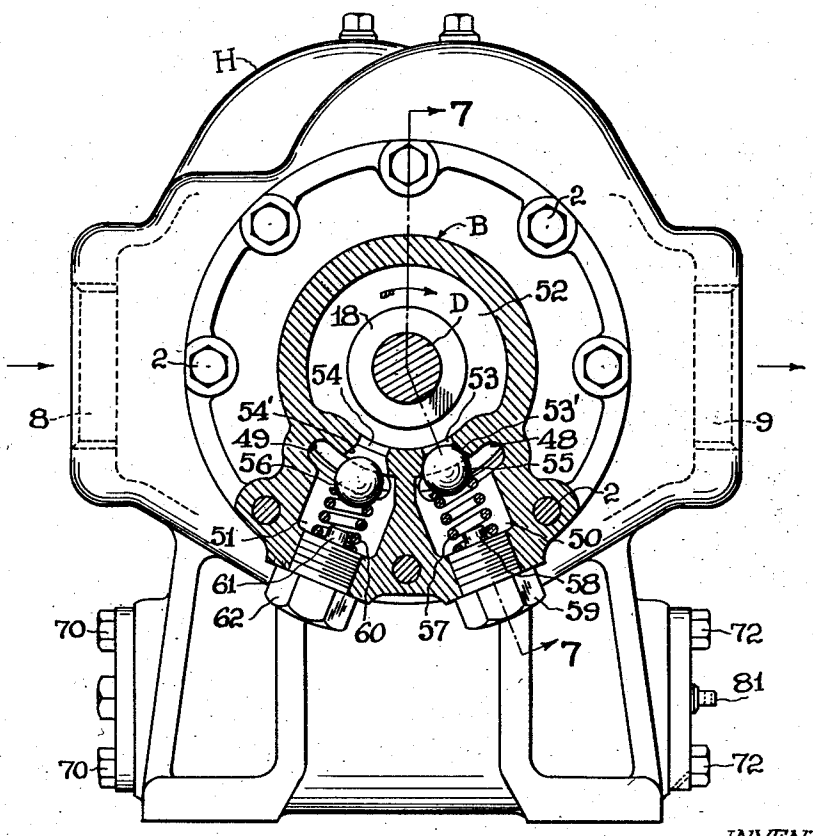


FIG. 6

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ROTARY PUMP

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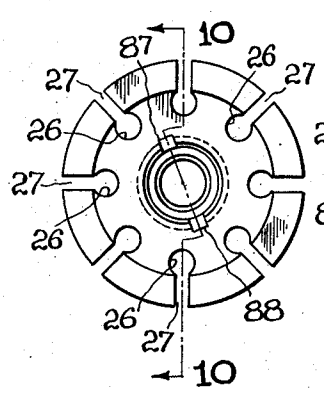


FIG. 9

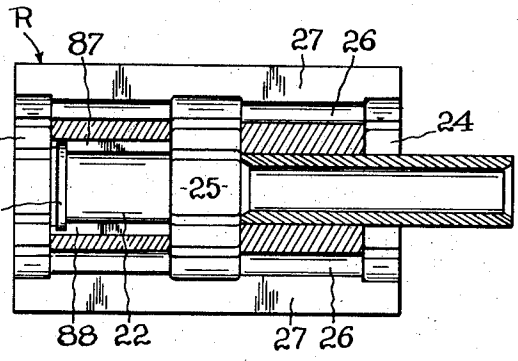


FIG. 10

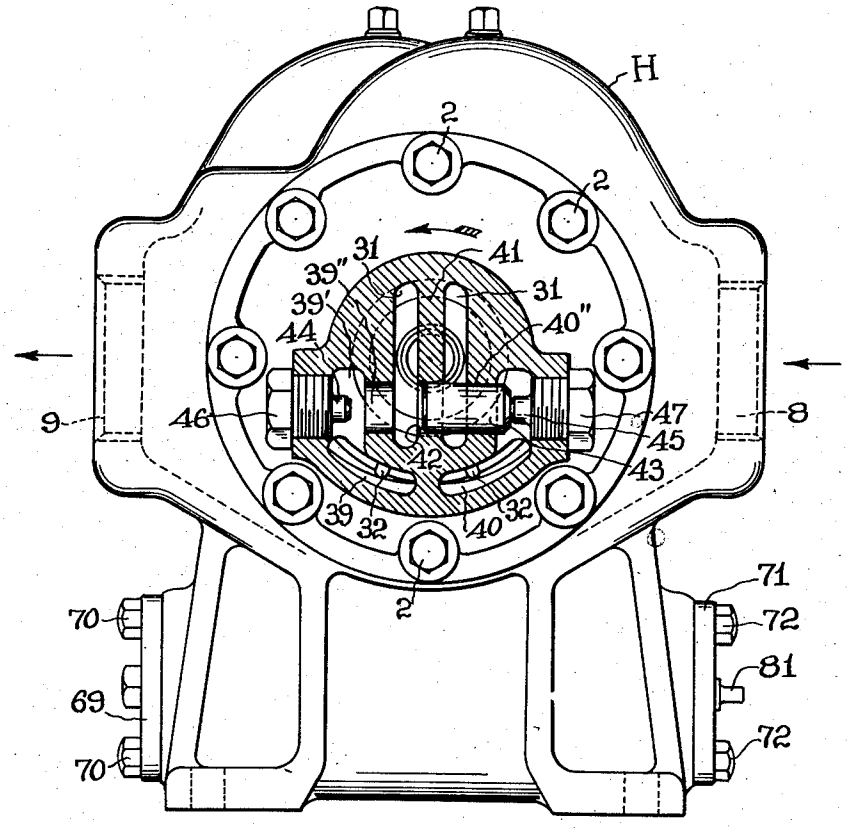


FIG. 8

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United States Patent Office 2,696,787 Patented Dec. 14, 1954

2,696,787

ROTARY PUMP

Joseph F. Jaworowski, Cleveland, and Norbert Jaworowski, Lakewood, Ohio, assignors, by direct and mesne assignments, to Shockey Corporation, Cleveland, Ohio, a corporation of Ohio

Application June 28, 1948, Serial No. 35,618

8 Claims. (Cl. 103—42)

This invention relates to pumps and more particularly to improvements in rotary pumps of the vane type wherein a rotor, carrying a plurality of circumferentially spaced radially movable blades, is disposed within a pump chamber or cylinder provided with suitable fluid inlet and outlet ports.

Various forms of vane type rotary pumps have been employed in the pumping of fluids and it is among the objects of the present invention to provide an improved high pressure, high output, rotary pump which is particularly adapted for pumping liquids such as oil or the like through pipe lines, and for other heavy duty pumping applications.

Other objects of our invention include the provision of an automatically reversible rotary pump which may be driven in either direction without change in the arrangement or adjustment of the parts thereof and which is equally efficient regardless of the direction of rotor rotation; the provision of a vane type rotary pump in which the discharge pressure is applied to maintain the vanes in proper sealing engagement with the wall of the pump chamber or cylinder and wherein automatic means are provided for maintaining this pressure against the vanes regardless of the direction of rotation of the pump; the provision of a vane type rotary pump of the balanced rotor type having an arrangement of fluid ports and passages whereby restriction or resistance to flow of fluid through the pump in either direction is reduced to a minimum; the provision in a vane type pump of means for automatically bleeding the drive shaft stuffing box chamber back to the low pressure side of the pump regardless of the direction of rotation of the pump rotor whereby the stuffing box or drive shaft seal will never be subjected to the full discharge pressure, thus eliminating leakage therethrough; the provision of a pump structure which incorporates an effective discharge pressure control valve mechanism which may be accurately adjusted to control the maximum discharge pressure of the pump and which may readily be reversed when it is desired to reverse the flow through the pump by changing the direction of rotation of the rotor; the provision of a vane type rotary pump in which the vanes are always maintained substantially in pumping position whereby the pump will start pumping immediately even under extreme low temperature and/or high viscosity conditions; the provision of a rotary pump the main bearings of which are effectively lubricated by the fluid being pumped; and the provision of an extremely compact and rugged rotary pump of the type described which may be economically manufactured, assembled and serviced and which may be operated under heavy duty service conditions for long periods of time without attention or adjustment.

The above and other objects of our invention will appear from the following description of one embodiment thereof reference being had to the accompanying drawings in which:

Figure 1 is an end elevation of the pump assembly, looking at the end opposite the drive shaft end.

Figure 2 is a side elevation of the pump assembly shown in Figure 1.

Figure 3 is a vertical cross-sectional view of our improved pump taken substantially on line 3—3 of Figures 1 and 4.

Figure 4 is a transverse vertical cross-sectional view taken substantially on line 4—4 of Figure 2.

Figure 5 is a horizontal cross-sectional view taken substantially on line 5—5 of Figure 2.

Figure 6 is a vertical cross-sectional view taken substantially on line 6—6 of Figure 2 and illustrating the automatic stuffing box pressure relief or bleeding arrangement.

Figure 7 is a fragmentary cross-sectional view, taken substantially on line 7—7 of Figure 6, and illustrating the rotor drive shaft, the main shaft bearing and their associated parts.

Figure 8 is a vertical cross-sectional view taken substantially on line 8—8 of Figure 2 and illustrating the automatic control means whereby pressure is maintained against the rotor vanes regardless of the direction of rotation of the pump.

Figure 9 is a detached end elevation of the pump rotor.

Figure 10 is a vertical cross-sectional view taken substantially on line 10—10 of Figure 9.

Referring first to Figures 1 and 2, our pump assembly includes a main housing H, an end cover and sub-housing P for the vane pressure control mechanism, and an end and drive shaft bearing housing B. As is clearly seen in Figures 3 and 4 the housing H is provided with a central cylindrical bore 1, the left-hand end of which (Figure 3) is closed by the end cover P and the right-hand end of which is closed by the end cover B. Suitable screws 2 are employed to secure the end covers P and B to the main housing H. Supported within the cylindrical bore 1 is a sleeve S which is restrained against rotation within the housing H by any suitable means and is provided with an interior pump cylinder or chamber 3 of generally oval cross section as seen in Figure 4, the horizontal dimension of this pump chamber 3 in the sleeve S being greater than its vertical dimension.

In order to permit the passage of fluid into and out of the pump chamber 3 the sleeve S is provided with four circumferentially spaced sets of radially extending slots 4, 5, 6, and 7. Each set, as seen in Figure 5, consists of five axially spaced slots and it will be understood that these fluid passages through the wall of the sleeve S may, if desired, be made in the form of a series of drilled holes or any other suitable shape.

The main housing H is provided with fluid passages to convey the fluid being pumped to and from the ports 4, 5, 6, and 7. In describing these passages it will be assumed that the pump rotor is operating in the direction of the arrows on the drawings to draw fluid in through the right-hand (Figure 4) opening 8 and discharge same through the left-hand opening 9. Accordingly opening 8 will be referred to as the pump inlet and opening 9 as the pump discharge outlet but it will appear later that, when the rotation of the rotor R is reversed, the opening 9 will become the inlet and the opening 8 the outlet. Fluid which enters through the inlet 8 is divided at the projection 10 on housing H and a part passes upwardly through the curved passage 11 to the transversely extending header chamber 12 which overlies and connects to the radial ports 4 in the sleeve S (see Figure 4). Another part of the entering fluid passes downwardly through the lower inlet passage 13 which, as is clearly seen in Figure 5, extends across the full width of the sleeve S and connects to the radial ports 6 in sleeve S. An upper discharge passage 14 in the housing H, similar in form and disposed in side-by-side offset relation to passage 11, extends from the transverse header chamber 15, which overlies and is connected to the radial discharge ports 7, to the discharge opening 9. A lower outlet passage 16, similar in form to passage 13, connects the radial discharge ports 5 in sleeve S to discharge opening 9 and the projection 17 on housing H is similar in arrangement and function to projection 10 previously referred to.

Rotor shaft supporting bushings or bearings 18 and 19 are mounted in the end cover members B and P respectively and are held against rotation by suitable pins 20 and 21 (see Figure 5). These bushings 18 and 19 have inner flange portions 18' and 19' which are contoured as indicated in Figure 4 to correspond to the cross-sectional form of pump chamber 3 and serve to support and guide the rotor vanes as will appear later. The pump rotor, generally indicated at R, is best seen in Figures 9 and 10 and has an axially extending bore 22, recessed end portions 23 and 24, a center chamber 25, and a plurality of

axially extending holes 26 into which the open ended vane carrying slots 27 extend.

When the pump is assembled the rotor R is disposed within the pump chamber 3 and its diameter is such that a running fit is provided between the rotor and the wall of the chamber 3 at the narrowest dimension of the chamber (top and bottom thereof as seen in the drawings). The drive shaft D extends through the bushing 18 into the bore 22 of rotor R and is keyed thereto by suitable keys 28 and 29 (see Figure 3) which are supported in a novel manner which will be described later. Shaft D terminates at the center chamber 25 of the rotor R and a hollow tubular supporting shaft 30 is secured in the bore 20 of the rotor R and extends from the opposite side of chamber 25 outwardly through bearing bushing 19 and connects to a vane pressure chamber 31 in the end housing P. As is best seen in Figures 4 and 5, vanes 32 are disposed in each of the slots 27 of rotor R. These vanes are of the same length as the rotor R and the inner edges of their outer end portions extend into the recesses 23 and 24 at the ends of rotor R. As the vane guide or cam portions 18' and 19' of bushings 18 and 19 extend respectively into the recesses 23 and 24 of rotor R the outer ends of the vanes 32 are supported and guided thereby. As these flanges 18' and 19' are contoured to correspond to the cross-sectional form of the pump chamber 3 they serve to maintain the outer edges of the vanes 32 at all times in close proximity to the wall of the pump chamber 3. The flanges 18' and 19' however are not depended upon to maintain sealing contact between the edges of the vanes and the pump chamber as fluid pressure means, to be described in detail later, is provided for urging the vanes into proper sealing contact with the wall of the pump chamber.

The outer end portion of drive shaft D may be mounted in an anti-friction bearing 33 and a stuffing box or oil seal of any suitable type is generally indicated at 34 and is provided to prevent leakage around the shaft to the outside of the housing. A lubricant retaining seal for the anti-friction bearing 33 is shown at 35 in Figure 3 and the projecting end of shaft D may be keyed at 36 for connection to any suitable source of power.

Before describing the other features of our invention an explanation will be given of the operation of the structure described above to pump a fluid. Assuming that the rotor R is being driven in counterclockwise direction as seen in Figure 4 and that a supply of fluid to be pumped is connected to the inlet opening 8, as the rotor R rotates the vanes 32 will sweep over the inner surface of the pump chamber 3 with their outer edges in engagement therewith and the fluid being pumped will pass from opening 8 through the passages 11 and 13 to the inlet ports 4 and 6 respectively in the sleeve S. Fluid will enter the crescent shaped pumping chamber 37 between the left-hand (Figure 4) side of sleeve S and rotor R through ports 4 and will be picked up by the vanes 32 and discharged through the ports 5 into the outlet passage 16 and out through opening 9. In like manner a portion of the fluid entering through opening 8 will pass through the lower inlet passage 13 to the inlet ports 6 and into the crescent shaped chamber 38 between the right-hand (Figure 4) side of sleeve S and rotor R. This fluid will be picked up by the vanes 32 and carried to and forced out through the outlet ports 7 into the header 15 and outlet passage 14 and out through the discharge opening 9.

By providing diametrically opposed sets of radially extending inlet ports 4 and 6 and radially extending outlet ports 5 and 7 the pressures on the rotor R are balanced, the bearing loads are reduced, and severe stressing of the parts is avoided thus prolonging the life of the pump. Our novel arrangement of inlet and outlet ports and passages provides unrestricted fluid inflow and outflow paths through the pump which paths are of ample cross-sectional area throughout their lengths and free from abrupt bends or sharp corners and thus offer minimum flow resistance with resulting increase in pump efficiency. Our arrangement permits an exceedingly compact and easily serviced pump structure and achieves a substantial reduction in the power required to operate our pump, under any given set of operating conditions, as compared to prior balanced rotor type rotary pumps with which we are familiar. It will be understood that if the direction of rotation of rotor R is reversed from that described above the opening 9 will become the pump inlet and opening 8 will become the pump discharge and the inlet ports and passages will become outlet ports and passages and vice versa.

As noted above, the vanes 32 are held in sealing contact with the bore of the pump chamber or cylinder 3 by means of the discharge pressure of the fluid being pumped. This fluid pressure is applied through the hollow shaft 30, the center chamber 25 of rotor R, and the holes 26 into which the inner edges of the vanes 32 project (see Figures 3, 4, and 10). As the end faces of rotor R have a running fit with the adjacent end faces of cover housings P and B, the oil or other fluid being pumped which enters the holes 26 can only escape by leaking past the ends of the rotor R or through the bushings 18 and 19. A slight leakage at these points is not objectionable as it serves to maintain a positive lubrication of the relatively moving parts.

Fluid under pressure is supplied to the hollow shaft 30 from the vane pressure chamber 31 (see Figures 3 and 5). This chamber 31, as is best seen in Figures 4 and 8, is connected to the pump chamber 3 through axially extending spaced ports 39 and 40. Port 39 extends from pressure chamber 31 and enters the crescent shaped chamber 37 on the left-hand (Figure 8) side of the bottom point of engagement of the rotor R with the pump chamber 3. In like manner port 40 extends from chamber 31 and enters the crescent shaped chamber 38 on the right-hand (Figure 8) side of the lower contact point between the rotor R and the pump chamber 3. Thus, when the impeller is rotating in the direction indicated by the arrows in Figures 4 and 8, fluid under high pump discharge pressure will be forced out through port 39 into the pressure chamber 31 and through the hollow shaft 30, chamber 25, and holes 26 in rotor R to the undersides of the vanes 32, forcing them outwardly into effective sealing engagement with the wall of the pump chamber 3.

As is best seen in Figures 5 and 8 vertical passages 39' and 40' extend from ports 39 and 40 respectively upwardly and connect to transverse bores 39'' and 40'' respectively. A central web 41 extends into the pressure chamber 31 and is provided with a bore 42 of the same size as, and concentrically arranged with, bores 39'' and 40''.

In order automatically to insure a supply of fluid under pressure in the vane pressure chamber 31, regardless of the direction of rotation of the rotor R, a piston or plunger type valve 43 is mounted for reciprocating movement in the bores 39'', 40'', and 42. This plunger valve 43 is of such length that it is at all times partially disposed in the bore 42 of web 41 and is longer than the distance between the inner ends of bores 39'' and 40'' to prevent the possibility of communication between bore 39'' and bore 40'' (see Figure 8). Endwise movement of plunger valve 43 is limited by projections 44 and 45 on the end plug screws 46 and 47 respectively and it will be seen from Figures 5 and 8 that when the rotor is being driven in the direction indicated (counterclockwise) liquid under pressure will pass through the port 39, passage 39', and bore 39'' and act upon the end of plunger 43 to force same to its extreme right-hand position (Figure 8) against the stop projection 45. With plunger 43 in this position liquid under pressure passes freely through the bore 39'' into chamber 31 and on through the hollow shaft 30 as previously described.

If it is desired to reverse the rotation of the pump rotor and thus change the direction of flow through the pump in such a manner that liquid will be taken in through the opening 9 and discharged through opening 8, such reversal of the rotation of rotor R will cause the pump discharge pressure to be established in the port 40 and the passage 40'. When this occurs the plunger 43 will be moved to the left (Figure 8) against the stop projection 44 thus permitting liquid under pump discharge pressure to enter chamber 31 through port 40 and passage 40'. Liquid is prevented by the plunger valve 43 from passing back to the low pressure side of the pump through passage 39' and port 39 and thus the efficiency of the pump is in no way diminished. Our above described arrangement for supplying liquid under pressure to urge the rotor vanes outwardly is rugged, fool-proof, inexpensive, and effectively and automatically functions without any attention from the operator to

insure a proper supply of vane sealing pressure regardless of the direction in which the pump is operated.

In the opposite or drive shaft supporting housing B a pair of ports **48** and **49**, corresponding in form and location to ports **39** and **40** just described, are provided. These ports are seen in Figures 4, 6, and 7 and it will be observed that port **48** connects to a valve chamber **50** in housing B while port **49** connects to a similar but separate and independent valve chamber **51**. The drive shaft D extends through a stuffing box or shaft seal chamber **52** in the end housing B (see Figures 6 and 7) and passages **53** and **54** extend from chamber **52** into valve chambers **50** and **51** respectively. The inner ends of passages **53** and **54** are formed as conical valve seats **53'** and **54'** for the valves **55** and **56** which are here illustrated as ball type valves. A spring **57** urges valve **55** toward its seat **53'** and is located by a stud **58** on screw plug **59**. In like manner spring **60** urges valve **56** toward its seat **54'** and is located by a stud **61** on screw plug **62**.

It will be seen from Figures 3, 5, and 7 that the shaft bearing **18** extends into the chamber **52** and the function of the double ball valve arrangement just described is to permit the oil or other liquid being pumped to pass outwardly between the bushing **18** and drive shaft D to provide positive lubrication therefor but to prevent excessive pressure from building up in chamber **52** against the oil seal or stuffing box arrangement indicated at **34** which might cause leakage therethrough. With our ball valve arrangement pressure within the chamber **52** is automatically maintained at or below a desired predetermined maximum value regardless of the direction of rotation of the pump rotor. With the rotor being driven in the direction indicated by the arrow in Figure 6, which is the same direction as indicated in Figure 4, fluid under the pump discharge pressure will be forced through the passage **48** into the valve chamber **50** and will tend to maintain the ball valve **55** seated against the seat **53'**. Liquid which enters the chamber **52** around the shaft D is also under substantially the pump discharge pressure and, when chamber **52** becomes filled with liquid, the ball valve **56** may be pushed downwardly against the spring **60** into open position as seen in Figure 6 permitting the escape of liquid from chamber **52** back into the suction or inlet side of the pump through the passage **49**. The spring **60** will, of course, be of such strength and be so adjusted that the valve **56** will open whenever a pressure is built up in chamber **52** such that there is danger of leakage past the oil seal **34**. Thus the ball valve **56** in effect becomes a pressure regulating valve for maintaining the pressure which can be built up in chamber **52** below a predetermined safe value.

If the pump is operated in the opposite direction from that indicated in Figure 6 the functions of valves **55** and **56** automatically are reversed and valve **56** becomes effective to seal off the high pressure side of the pump from the chamber **52** while valve **55** acts as a pressure regulating valve to limit the pressure which can build up in chamber **52** and to bleed excess liquid which enters chamber **52** back into the inlet side of the pump. It will be understood from the above description of our improved automatic bleed valve arrangement that, regardless of the direction of rotation of the pump rotor, a build up of excessive pressure against the drive shaft stuffing box or oil seal **34** will be automatically and positively prevented. No attention is required on the part of the operator to effect the change over in functioning of our automatic control when the direction of rotation of the pump is changed and our arrangement accordingly insures positive lubrication of the main shaft bearing in the bushing **18** at all times.

We have also incorporated in the illustrated pump an automatic discharge pressure control means which will now be described. The housing H is formed with a center web **63** (see Figures 3 and 4) which extends in the direction of the axis of rotation of rotor R and separates the passage **13** from the passage **16**. It will be noted that these passages have downwardly extending portions **13'** and **16'** disposed on opposite sides of web **63** and that a communication or by-pass port **64** extends through web **63** and is adapted to connect passages **13** and **16**. Port **64** is formed with oppositely facing valve seats **65** and **66** and the housing H is bored to provide similar cylindrical openings **67** and **68** symmetrically arranged on opposite sides of the web **63** and axially aligned with each other and with the communication port **64**.

As illustrated in Figure 4, in which the pump is arranged for rotation of the rotor in counterclockwise direction and fluid flow from right to left, a cylinder member **69** having a closed outer end and open inner end is held in position in the opening **67** as by screws **70** and an end cover and spring abutment plate member **71** is secured to housing H, as by screws **72**, to close the outer end of cylindrical opening **68**. Disposed within the cylinder **69** is a hollow piston or plunger **73** having a closed inner end portion **74** and opening into the cylinder **69** at its opposite end. A suitable piston sealing means, such as a piston ring indicated at **73'**, is preferably provided to reduce possible leakage past the piston **73** which, as will appear later, is subjected on one end to the relatively low pressure of the pump inlet and on its other end to the relatively high pressure of the pump outlet. Extending from the closed end **74** of piston **73** is a hollow valve stem member **75** which carries a poppet valve **76** having a seating face **77** disposed to coact with valve seat **66** in web **63** to close the communicating port **64** between the passages **13** and **16**. The hollow valve stem **75** extends beyond the poppet valve **76**, as indicated at **75'**, and forms a guide for the pressure regulating spring **78** one end of which abuts against the poppet valve **76** and the other end against an adjustable abutment **79**. Adjusting screw **80** extends through the end cover plate **71** and has a flattened outer end portion **81** adapted to be engaged by a wrench or the like. The abutment member **79** has a threaded support on screw **80** and is provided with a lug **82** at its outer periphery which projects into a slot **83** formed in the cup shaped housing **84** which extends inwardly from the end cover plate **71**. The degree of preloading of the spring **78** can be adjusted within certain limits by releasing the lock nut **85** and turning the screw **80** by means of its flat end **81** to cause the abutment member **79** to move axially on screw **80** and thus increase or reduce the compression of spring **78**. A tapered shoulder **80'** on screw **80** is adapted to seat on a corresponding seat in cover plate **71** and spring **78** tends to hold shoulder **80'** seated even when lock nut **85** is loosened, thus preventing leakage at all times. The end **75'** of the hollow valve stem **75** opens into the cylindrical chamber or opening **68** and thus is connected directly with the passage **13—13'** of the housing H. When the rotor is being driven in counterclockwise direction as seen in Figure 4 passage **13** is one of the low pressure inlets and accordingly the low pump suction or intake pressure will prevail throughout the chambers **13—13'**, cylindrical opening **68**, the interior of tubular valve stem **75**, cylinder **69** and against the left-hand (Figure 4) end of piston **73**. The pressure on the opposite side of web **63** in passage **16—16'** will however be the high pump discharge pressure. This high presure will be effective against the outer surface of the end wall **74** of piston **73** and also against the left-hand side (Figure 4) of poppet valve **76**. It will be noted that the area of the poppet valve **76** which is exposed to the pump discharge pressure is greater than the area of the piston **73** which is exposed to the same pressure. Accordingly the pump discharge pressure will exert a force urging the valve **76** towards open position (to the right in Figure 4) which is equal to the difference in the exposed areas of valve **76** and piston end **74** multiplied by the pump outlet pressure in the passage **16**. By making the difference in the effective areas of the valve and piston relatively small a relatively small force will be exerted tending to move the valve-piston assembly toward its open position even when the pump is operating at a high discharge pressure such as 800 to 1000 lbs. per square inch and accordingly the pressure regulating spring **78**, which opposes opening movement of valve **76**, may be made relatively light. This enables the pressure regulating by-pass controls to be made in an exceedingly compact form and susceptible to easy and accurate adjustment.

The operation of our discharge pressure control by-pass valve mechanism just described is as follows. If, for example, it is desired to deliver the pump output at a maximum pressure of 500 lbs. per square inch the spring **78** will be so proportioned and adjusted that when the pressure in the discharge passage **16—16'** reaches 500 lbs. the pressure differential effective to move valve **76** will be sufficient to overcome the spring **78** and open valve **76** permitting fluid to be by-passed from the pump outlet **16** back into the low pressure inlet **13**, thus preventing excessive pump discharge pressure. This by-pass pressure control is, of course, entirely automatic and the maximum discharge pressure may be varied by

changing the spring 78 or by adjustments thereof through the screw 80 and abutment 79.

It is a feature of our invention that the automatic discharge pressure control mechanism just described may easily be reversed when it is desired to reverse the rotation of the pump rotor. This reversal of the parts is possible because the cylindrical openings 67 and 68 are identical and it is only necessary to remove the screws 70 and 72, reverse the positions of the cylinder 69 and end cover plate 71 and at the same time reverse the piston 73 and valve 76 so that the valve 76 will seat upon seat 65 on the opposite side of web 63. This operation may be effected in a very short time without special equipment or skill. As our improved pump includes automatic controls whereby the pump output pressure is applied to the inner edges of the vanes regardless of the direction of pump rotation and automatic means for control of the bleed-off of oil passing through the main shaft bushing regardless of direction of pump rotation, it will be seen that with the pump disclosed herein it is only necessary to reverse the pressure control valve 76 in order to change over the pump from operation in one direction to operation in the opposite direction. Furthermore the pump is exactly as effective and efficient in either direction of rotation. If the pump discharge pressure control is not desired or necessary the valve 76 may be blocked in closed position by interposing a suitable block member (not shown) between the screw 80 and the end of valve stem extension 75' to hold valve 76 seated on the web 63. When the pump is so operated with valve 76 locked in closed position it may be reversed without any attention whatever on the part of the operator. It will also be understood that for some service requirements or conditions it may be desirable to supply pumps in which the discharge pressure control by-pass is omitted in which case the by-pass port 64 will be omitted and the web 63 left solid. Such pumps, of course, retain all of the other advantageous features of our automatically reversible vane type balanced rotor pump.

By providing means for applying the pump discharge pressure against the rotor vanes to urge them outwardly into proper sealing contact with the wall of the pump chamber we provide a vane pump wherein leakage past the vanes is minimized and which automatically compensates for wear of both the vanes and the pump chamber. The vane cams or end flanges 18' and 19' of the bushings 18 and 19 serve to keep the vanes from dropping into the rotor slots when the pump is stopped and to hold the vanes sufficiently close to their pumping positions adjacent the wall of chamber 3 to start the pump action and build up initial discharge pressure which will force the vanes out into proper sealing engagement with the walls of chamber 3. Thus our vane cams insure immediate and positive pumping operation under all service conditions, and particularly at low temperatures or after a pump has been standing idle for a long time.

It will be seen from the above description of our improved pump that we have provided a compact and rugged vane type rotary pump having effective automatic controls for the vane pressure and stuffing box bleed-off. We have also provided a pressure control by-pass arrangement which eliminates the necessity for heavy springs and may most readily be reversed to accommodate changes in pump rotation.

Another feature of our improved pump design is the arrangement of the keys 28 and 29 which effect driving connection between the main shaft D and the rotor R. As is seen in Figure 10 the bore 22 in rotor R is provided with a circumferential groove 86. Opposed key slots 87 and 88 (Figure 9) are also formed in the bore 22 of rotor R and corresponding key slots 89 and 90 are cut into the shaft D. The keys 28 and 29 are held in position in the slots 87 and 88 of rotor R by a split expansion ring 91, of spring wire or the like, which engages suitable grooves in the ends of keys 28 and 29 and also lies in the groove 86 of rotor R. This arrangement is clearly illustrated in Figure 3 and it makes it possible to maintain the inner end of shaft D at the full diameter of the bore in bushing 18 while still permitting the shaft to be assembled after the rotor has been installed in the pump chamber 3. With the key support illustrated and described the entire end unit B can be removed by taking out screws 2 and withdrawing the housing B and shaft D from the housing H. If the keys 28 and 29 were supported in the shaft in the usual manner, instead of being held in the shaft receiving hole in rotor R, this mode of assembly and disassembly would not be possible.

Although we have described the illustrated embodiment of our invention in considerable detail it will be understood that variations and modifications may be made in the form, proportions, and arrangement of parts making up our improved pump. Accordingly we do not wish to be limited to the specific structure herein shown and described but claim as our invention all embodiments thereof coming within the scope of the appended claims.

We claim:

1. A vane type rotary pump including a housing structure having a pump chamber, said pump chamber having an inlet port at a lower pressure portion thereof, and a discharge port at a high pressure portion thereof, a rotor supported substantially in sealing contact with a portion of the wall of said chamber for rotation therein, a vane carried by said rotor for radial movement relative thereto, said housing structure having a vane pressure chamber therein at one end of said pump chamber, a hollow shaft extending from one end of said rotor into said vane pressure chamber, said rotor having a fluid conducting passage extending from said hollow shaft to the inner edge of said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said vane pressure chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact to said vane pressure chamber, a shiftable sliding plunger valve supported in said vane pressure chamber with one end exposed to fluid pressure from said fluid passage on one side of said sealing contact and its other end exposed to fluid pressure from said fluid passage on the other side of said sealing contact, said plunger valve being adapted to have movement between one position in which said fluid passage on one side of said sealing contact is connected to said vane pressure chamber and said fluid passage on the other side of said sealing contact is shut off from said vane pressure chamber and another position in which said connections are reversed, said plunger valve being adapted automatically to shift between said positions when rotation of said rotor is reversed, a drive shaft extending from the other end of said rotor in axial alignment with said hollow shaft, and bearing means carried by said housing for rotatably supporting said drive shaft.

2. A vane type rotary pump including a housing structure having a pump chamber, said pump chamber having an inlet port and a discharge port, a rotor supported substantially in sealing contact with a portion of the wall of said chamber for rotation therein, a vane carried by said rotor for radial movement relative thereto, said housing structure having a vane pressure chamber therein, a hollow shaft extending from one end of said rotor into said vane pressure chamber, said rotor having a fluid conducting passage extending from said hollow shaft to the inner edge of said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said vane pressure chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact to said vane pressure chamber, valve means, responsive to the pump discharge pressure, for automatically connecting said vane pressure chamber to the one of said fluid passages which extends from the high pressure portion of said pump chamber and shutting said vane pressure chamber off from the one of said fluid passages which extends from the low pressure portion of said pump chamber regardless of the direction of rotation of said rotor, said housing structure having a second chamber therein, a drive shaft extending from the other end of said rotor into said second chamber, a bearing for said shaft having one end in said second chamber and its other end in said fluid conducting passage in said rotor whereby said other end of said bearing is subjected to the same pressure as said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said second chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact into said second chamber, and independent spring-backed valves in said last named fluid passages for automatically controlling the maximum pressure in said second chamber regardless of the direction of rotation of said rotor.

3. A vane type rotary pump including a housing structure having a pump chamber, said pump chamber having an inlet port and a discharge port, a rotor supported substantially in sealing contact with a portion of the wall of said chamber for rotation therein, a vane carried by said rotor for radial movement relative thereto, cam means carried by said housing structure for maintaining said vane adjacent the wall of said pump chamber during rotation of said rotor, said housing structure having a vane pressure chamber therein, a hollow shaft extending from one end of said rotor into said vane pressure chamber, said rotor having a fluid conducting passage extending from said hollow shaft to the inner edge of said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said vane pressure chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact to said vane pressure chamber, valve means, responsive to the pump discharge pressure, for automatically connecting said vane pressure chamber to the one of said fluid passages which extends from the high pressure portion of said pump chamber and shutting said vane pressure chamber off from the one of said fluid passages which extends from the low pressure portion of said pump chamber regardless of the direction of rotation of said rotor, said housing structure having a second chamber therein, a drive shaft extending from the other end of said rotor into said second chamber, a bearing for said shaft having one end in said second chamber and its other end in said fluid conducting passage in said rotor whereby said other end of said bearing is subjected to the same pressure as said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said second chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact into said second chamber, and independent spring-backed valves in said last named fluid passages for automatically controlling the maximum pressure in said second chamber regardless of the direction of rotation of said rotor.

4. In a rotary pump, a housing having a pump chamber of generally oval transverse cross section, a cylindrical rotor supported for rotation in said pump chamber and substantially engaging the wall thereof along diametrically opposed surfaces whereby two generally crescent shaped chambers are formed between said rotor and said wall of said pump chamber, a pluralty of radially movable vanes carried by said rotor, means for urging said vanes outwardly into engagement with said wall of said pump chamber, said housing having inlet and discharge openings symmetrically arranged on opposite sides of the axis of rotation of said rotor, each of said crescent shaped chambers having spaced inlet and discharge ports leading radially thereinto adjacent said surfaces of engagement of said rotor with said pump chamber, said housing having an inlet passage extending from said inlet opening to the inlet port of the crescent shaped chamber on the opposite side of the rotor axis from said inlet opening and a substantially identical discharge passage disposed in overlapping side-by-side relation to said inlet passage and extending to said discharge opening from the discharge port of the crescent shaped chamber on the same side of the rotor axis as said inlet opening, said inlet and discharge passages each having an axially extending header portion extending under the other of said passages, said housing also having a second inlet passage extending from said inlet opening to the inlet port of the crescent shaped chamber on the same side of the rotor axis as said inlet opening and a substantially identically arranged and contoured second discharge passage extending to said discharge opening from the discharge port of the crescent shaped chamber on the opposite side of the rotor axis from said inlet opening, a wall in said housing separating said second inlet passage from said second discharge passage, said wall having a by-pass port extending therethrough, and spring-opposed discharge pressure control valve means associated with said by-pass port for controlling the flow of fluid therethrough.

5. In a vane type rotary pump, a housing having a pump chamber of generally oval transverse cross section, a cylindrical rotor supported for rotation in said pump chamber and substantially engaging the wall thereof along diametrically opposed surfaces, circumferentially spaced vanes carried by said rotor for radial movement relative thereto, said housing structure having a vane pressure chamber therein at one end of said pump chamber, a hollow shaft extending from one end of said rotor to said vane pressure chamber, said rotor having a fluid conducting passage extending from said hollow shaft to the inner edges of said vanes, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of one of said diametrically opposed surfaces of engagement to said vane pressure chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said one of said surfaces of engagement, a shiftable sliding plunger valve supported in said vane pressure chamber with one end exposed to fluid pressure from said fluid passage on one side of said one of said surfaces of engagement and its other end exposed to fluid pressure from said fluid passage on the other side of said one of said surfaces of engagement, said plunger valve being supported for movement between one position in which said fluid passage on one side of said one of said surfaces of engagement is connected to said vane pressure chamber and said fluid passage on the other side of said one of said surfaces of engagement is shut off from said vane pressure chamber and another position in which said connections are reversed, said plunger valve being adapted automatically to shift between said positions when rotation of said rotor is reversed, a drive shaft extending from the other end of said rotor in axial alignment with said hollow shaft, and bearing means carried by said housing for rotatably supporting said drive shaft.

6. A vane type rotary pump including a housing structure having a pump chamber, said pump chamber having an inlet port and a discharge port, a rotor supported substantially in sealing contact with a portion of the wall of said chamber for rotation therein, a vane carried by said rotor for radial movement relative thereto, a second chamber in said housing structure, a drive shaft extending from one end of said rotor into and through said second chamber, a bearing for said shaft having its outer end in said second chamber and its inner end subjected to substantially the fluid pressure in said discharge port, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said second chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact to said second chamber, and independent spring backed valves in said last named fluid passages for automatically controlling the maximum pressure in said second chamber regardless of the direction of rotation of said rotor, said spring backed valves in said fluid passages being adapted to permit the flow of fluid only from said second chamber into said last named passages and to prevent the flow of fluid from said last named passages into said second chamber.

7. A vane type rotary pump including a housing structure having a pump chamber, said pump chamber having an inlet port at a low pressure portion thereof and a discharge port at a high pressure portion thereof, a rotor supported substantially in sealing contact with a portion of the wall of said chamber for rotation therein, a vane carried by said rotor for radial movement relative thereto, said housing structure having a vane pressure chamber therein at one end of said pump chamber, said rotor having a fluid conducting passage extending from said vane pressure chamber to the inner edge of said vane, said housing structure having a fluid passage extending from said pump chamber adjacent to and on one side of said sealing contact to said vane pressure chamber and another fluid passage extending from said pump chamber adjacent to but on the other side of said sealing contact to said vane pressure chamber, a shiftable valve supported in said vane pressure chamber with one end exposed to fluid pressure from said fluid passage on one side of said sealing contact and its other end exposed to fluid pressure from said fluid passage on the other side of said sealing contact, said valve being adapted to have movement between one position in which said fluid passage on one side of said sealing contact is connected to said vane pressure chamber and said fluid passage on the other side of said sealing contact is shut off from said vane pressure chamber and another position in which said connections are reversed, said valve being adapted automatically to shift between said positions when rotation

of said rotor is reversed, a drive shaft for said rotor, and bearing means carried by said housing for rotatably supporting said drive shaft.

8. In a reversible, balanced rotor, rotary pump, a main housing member in the form of a hollow metal casting having oppositely disposed main inlet and outlet openings for liquid on respective sides of a generally cylindrical opening through the casting, sub-housing members generally closing the ends of the cylindrical opening, a metal sleeve substantially fitting the cylindrical opening and fixed snugly therein against rotation, the sleeve having a bore of generally oval transverse cross section with the long axis of the oval bore directed toward the inlet and outlet openings, a generally cylindrical rotor with radially movable fluid-pumping vanes, the rotor being supported for rotation by the sub-housing members coaxially of the cylindrical opening, said rotor being approximately in peripheral sealing contact with the oval bore at diametrically opposite regions of the rotor along the short axis of the oval, thus forming with said bore two symmetrically opposed crescent shaped pumping chambers with their apices adjacent the areas of sealing contact between the rotor and said bore, the sleeve thereby having relatively thin wall portions disposed respectively between the rotor axis and said inlet and outlet openings, wall portions of the sleeve having therethrough radial inlet and outlet ports in alternating arrangement circumferentially of the sleeve comprising two inlet ports and two outlet ports symmetrically located for communication with the crescent shaped chambers respectively near the apices of those chambers, said casting having, for communication of said inlet and outlet openings respectively with the sleeve ports, two operatingly identical channel-forming passages with branch portions extending partly around the sleeve peripherally thereof, the branches of one passage communicating with the inlet ports of the sleeve and the branches of the other with the outlet ports of the sleeve, and said casting having thickened wall portions adjacent the sleeve on diametrically opposite sides of the sleeve, extending parallel to the axis of said cylindrical opening and of diminishing cross section toward the inlet and outlet openings and respectively approximately aligned therewith to provide fluid guides to and from respective branched passages while buttressing the sleeve at its relatively thin walled portions.

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