

[54]	VANE-TYPE FLUID PUMP	2,545,238	3/1951	MacMillin et al.	418/268
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		3,054,357	9/1962	McGill	418/77
		3,086,475	4/1963	Rosaen	418/268
[22]	Filed: Dec. 22, 1969	3,180,271	4/1965	Hartmann	418/268 X
		3,221,665	12/1965	Hartmann	418/268 X
[21]	Appl. No.: 886,982	3,361,076	1/1968	Davis	418/31

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 739,359, June 24, 1968, abandoned.

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FOREIGN PATENTS OR APPLICATIONS

156,691 12/1952 Australia 418/268
551,685 3/1943 Great Britain 418/268
433,488 8/1935 Great Britain 418/257

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[56] **References Cited**

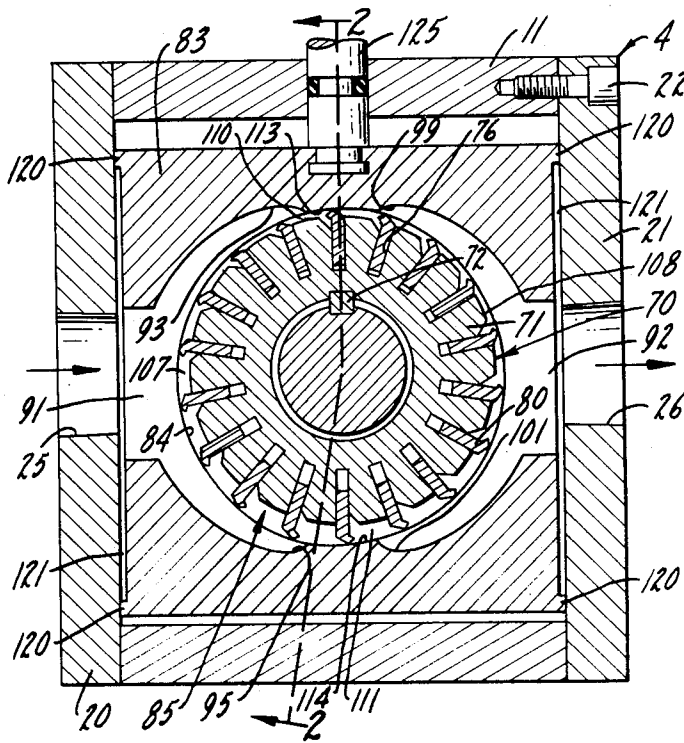
UNITED STATES PATENTS

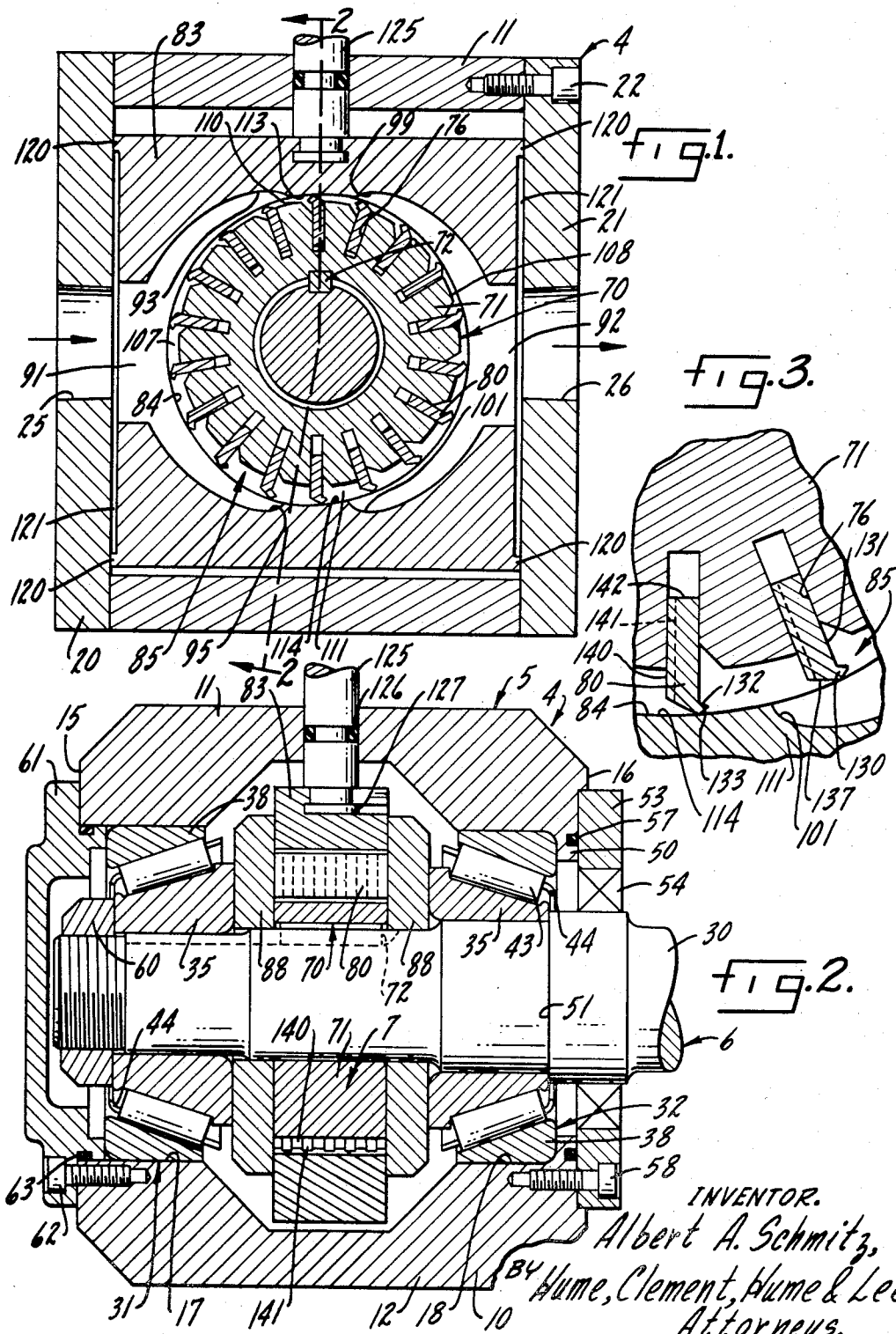
2,669,189 2/1954 DeLancey et al. 418/27
3,083,535 4/1963 Krafft et al. 418/31
3,187,676 6/1965 Hartmann 418/31
1,965,388 7/1934 Ott 418/31

[57] **ABSTRACT**

A vane-type pump in which the vanes are hydrostatically balanced whereby they are urged outward only by centrifugal force. The cam ring sealing surfaces rise in the sealing zones to assure contact with the vanes.

12 Claims, 3 Drawing Figures





VANE-TYPE FLUID PUMP

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of applicant's co-pending application, Ser. No. 739,359, filed June 24, 1968, and now abandoned. The invention is in the field of fluid pumps. It relates particularly to reversible flow, vane-type fluid pumps.

Reversible flow, vane-type fluid pumps are, of course, generally well-known. Such a pump is illustrated in the Wahlmark U. S. Pat. No. 2,842,064, for example. In essence, a rotor, slidably mounting a plurality of radially disposed vanes in its periphery, rotates within an eccentrically arranged, annular chamber, and is effective to draw fluid into the chamber through an inlet port and discharge it under pressure through an outlet port. By reversing the eccentricity of the chamber, the flow pattern is reversed.

In a vane-type fluid pump of this type, there is a normal tendency for fluid pressure in the chamber to urge the vanes into their slots, thus leaving a free path for fluid between the inlet and exhaust ports. If the vanes were permitted to succumb to this urging, the pump would be grossly ineffective, of course. Accordingly, various means have been devised to counter-act the pressure urging the vanes inwardly of their mounting slots.

One means for obtaining this end is a fluid bleed system alternately connecting the inlet and pressure zones of the chamber with the space in each vane slot beneath a corresponding vane. This arrangement results in a pressure induced, radially directed, outward force being effective on the vanes as they rotate. The result is considerable wear on the vane tips, which are urged with substantial force against the annular "cam ring" surface of the chamber.

Another means devised and employed in conventional vane-type fluid pumps to assure operational engagement of the vanes with the cam ring surface is mechanical springs provided in the bases of the vane slots beneath the vanes. The spring force needed to assure operational engagement of the vane tips under all operating conditions is, understandably, substantial. As a result, frictional wear of the vane tips and cam ring surface is, once again, a detrimental factor.

SUMMARY OF THE INVENTION

The present invention is embodied in a pump arrangement wherein the vanes are hydro-statically balanced in their slots, thus neutralizing the radial fluid pressure forces normally effective on the vanes. Centrifugal force is sufficient to urge the vanes outwardly into engagement with the cam ring surface, and minimal frictional wear results. The configuration of the vanes according to the invention results in this hydro-static balance.

A subsidiary feature of the invention is embodied in the arrangement of the cam ring sealing surfaces relative to the axis of rotation of the pump rotor. As is well-known, a force component tangential to the rotor is created as the vanes pass through the sealing zones between the inlet zone and the pressure zone, tending to bind the vanes against the sides of their respective slots. In the present invention, the sealing surfaces are formed so their radii of curvature decrease in the direction of vane rotation, except in oppositely extreme

positions of eccentricity relative to the rotor where a constant radius might be effected, whereby as the vanes pass over these surfaces they are never required to move in an outward direction in order to follow the surface. During this "power phase" of the pumping cycle, the vanes are then either stationary in their slots or are being moved slightly inwardly by a cam surface rise.

Thus, with the vanes hydrostatically balanced and the cam ring formed to eliminate outward movement of the vanes during their passage through the sealing zones, centrifugal force maintains the vane tips in contact with the cam surface. Centrifugal force is sufficient to maintain excellent operational engagement of the vane tips with the cam surface but is never excessive so as to cause undue frictional wear on either component.

Other features of the invention are found in a housing assembly including a unitary body in which bearing bores are easily machined and heavy duty bearings maintained in perfect alignment. The construction of the housing assembly is such that it is easily matched to the width of the cam ring to control the clearance between the ring and thrust plates forming the sides of the housing assembly. The cam ring, in itself, has external dimensions sufficiently large to permit the full side thrust of internal pressure to be balanced by an opposing fluid cushion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view, partially in section, of a vane-type fluid pump embodying features of the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1; and

FIG. 3 is an enlarged sectional view through a portion of the pump rotor assembly at a cam ring sealing surface.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, and particularly to FIGS. 1 and 2, a vane-type fluid pump embodying features of the present invention is illustrated generally at 4. The pump 4 includes a housing assembly 5 which contains a drive assembly 6 and a pumping cartridge 7.

The housing assembly 5 comprises a body 10 having an upper wall 11 and a lower wall 12 formed unitarily with an annular front wall 15 and a rear wall 16. An annular bore 17 is machined in the front wall 15 and a corresponding bore 18 is machined in the rear wall 16. Removable side walls 20 and 21 are secured to the body member 10 by a plurality of conventional machine screws 22. A fluid inlet-outlet port 25 is formed in the side wall 20 while another fluid inlet-outlet port 26 is formed in the side wall 21.

The pumping cartridge 7 is mounted within the housing assembly 5 on the drive shaft 30 of the drive assembly 6. The shaft 30 is rotatably driven by a prime mover such as a motor (not shown). The shaft 30 is rotatably mounted in the housing assembly 5 on substantially identical rotor bearing assemblies 31 and 32 at the front and rear of the body 10.

Each bearing assembly 31 and 32 comprises an inner race 35 journaled on a mating section of the drive shaft 30 and an outer race 38 seated in a corresponding annular bore 17 and 18 extending through the front wall

15 and rear wall 16, respectively of the body member 10. A plurality of conventional tapered roller bearings 43 are disposed between the bearing races 35, and 38, in suitable carrier cages 44.

The outer bearing race 38 in the rear wall 16 of the body 10 is seated against an inwardly extending shoulder 50 in the bore 18. The inner bearing race 35 in the rear wall is seated, at its outermost end, against an annular shoulder 51 on the shaft 30. An end plate 53 mounting a resilient seal 54 encircles and forms an oil seal with the shaft 30 in a conventional manner. The end plate 53 is secured to the rear wall 16 of the body 10 over an O-ring 57 by conventional machine screws 58.

The inner bearing race 35 in the front wall 15 of the body 10 is retained on the shaft 30 by a lock-nut 60 in a conventional manner. The outer race 38 in the front wall 15 is, in turn, retained in the bore 17 by an end plate 61 secured to the body 10 by conventional machine screws 62. An O-ring 63 acts as an oil seal.

The pumping cartridge 7 is disposed between and bracketed by the inner bearing races 35. The cartridge 7 includes a rotor assembly 70 mounted on the shaft 30 for rotation therewith. The rotor assembly 70 includes a rotor disc 71 keyed to the central section of the shaft 30 in a conventional manner by a key 72. Radially disposed in the annular periphery of the rotor disc 71 are a plurality of evenly spaced, vane receiving slots 76. Vanes 80 embodying features of the present invention are slidably received in corresponding slots 76.

The pumping cartridge 7 further includes a casing or cam ring 83 encircling the rotor disc 71 and the radially extending vanes 80. The casing 83 defines a generally circular bore 84 in which the rotor assembly 71 is mounted for rotation. The bore 84 has a diameter substantially larger than the diameter of the rotor disc 71. A chamber 85 is thus defined between the bore 84 surface and the outer periphery of the disc 71.

Enclosing this chamber 85 and retaining the vanes 80 in the slots 76, which extend transversely through the width of the rotor disc 71, are bracketing retainer plates 88. The retainer plates 88, which form the sides of the pumping cartridge 7 and are retained in this relationship by abutment with the inner bearing races 35, hereinbefore discussed, maintain the casing 83 in axial alignment with the rotor disc 71, i.e. axially of the shaft 30. The lock-nut 60 ties the inner bearing races 35, the retainer plates 88, the rotor assembly 70, and the shaft 30 together.

Formed in the casing 83 on opposite sides thereof, in registry with the inlet-outlet ports 25 and 26 through side walls 20 and 21, respectively, and the bore chamber 85, are inlet-outlet chambers 91 and 92. The upper and lower extremities 93, 95, 99 and 101, of these chambers 91 and 92 define the angular limits of inlet discharge zones 107 and 108 in the annular chamber 85. Intermediate the inlet discharge zones 107 and 108 are the sealing zones 110 and 111 defined by surface sections 113 and 114, respectively, in the bore 84. For reasons hereinafter discussed, the radii of curvature of the surface sections 113 and 114 decrease slightly in the direction of rotation of the rotor assembly 70, relatively to the axis of the shaft 30, in all positions of the rotor assembly 70. It is within the contemplation of the invention, however, that in positions

of maximum eccentricity of the rotor assembly 70, portions of the surface sections 113 and 114 might not decrease in radius relative to the shaft 30 but actually remain constant relative thereto, rather than increasing at any point.

As will readily be understood, the position of the casing 83 relative to the axis of the shaft 30 and, accordingly, the axis of rotation of the rotor assembly 70, determines both the direction of fluid flow and flow volume of the pump 4 in operation. The casing 83 is thus vertically slidable between the side walls 20 and 21 of the housing assembly 5 on bearing faces 120.

Each bearing face 120 is, according to the invention, formed with a shallow recess 121 therein. According to the invention, the surface area of each recess 121 approximates in size the projected area of the internal area of the casing 83 which is subjected to fluid pressure. During operation of the pump 4, these recesses 121 fill with fluid under pressure equal to the fluid pressure in the casing 83 interior, thus balancing any forces tending to create excessive friction between the casing 83 and the side walls 20 and 21.

To control flow direction and volume of the pump 4, the casing 83 is moved vertically in the housing 5 through the medium of a control rod 125. The control rod 125 extends through a suitably formed bore in the top of the body 10 and carries a sealing O-ring 126. An annular flange 127 on the lower end of the rod 125 slides loosely (from the side) into a corresponding slot in the casing 83 to connect the rod to the casing for vertical movement together.

According to the invention, the pumping cartridge 7 is positioned securely between the rotor bearings 31 and 32 so that the casing 83 need not be restrained axially by the housing assembly 5 but is allowed to float and seek its own position relative thereto. As a result, axial forces imparted to the shaft 30 by outside means are not transmitted as thrust loading on the casing 83.

Turning now to the construction and arrangement of the vanes 80 in their slots 76, it has been pointed out that they are subjected to balanced forces tending to urge them radially outward and inward of their slots, thus placing reliance on centrifugal forces alone to keep the vanes in contact with the casing or cam ring surface 84. To this end, the tip of each vane 80 is formed with a projection 130 extending in front of the leading face 131 of the vane. This projection is defined by a planar upper surface 132 inclined at an angle of approximately 45° to the leading face 131, and a planar lower surface 133 forming approximately a 70° angle with the surface 132.

The lower surface 133, in turn, intersects an opposite lower planar surface 137 of the vane tip to form a "line" of contact with the cam ring surface 84 in the exact plane of the vane face 131. Alternatively, the surfaces 133 and 137 might be a continuous curved surface so disposed that line contact with the casing 58 is effected in alignment with the plane of the face 131.

The opposite face 140 of the vane 80 is formed with fluid passage grooves 141 extending between the lower planar surface 137 and the inner end surface 142 of the vane. Fluid pressure at the vane face 140 is effective, through the grooves 141, on the inner end surface 142 of each vane, as well as on the surface 137 of the vane. Since these surfaces are substantially equal in area, a

balanced radial thrust condition is effected. Similarly, fluid pressure at the face 131 of the vane is effective on both the upper surface 132 and the lower surface 133 of the projection 130, which surfaces are substantially equal in area, to also create a balanced radial thrust condition. A substantially fluid tight seal is formed between the face 131 and the adjacent wall of the slot 76.

Referring again to FIG. 1, in operation of the pump 4 the rotor 71 is driven in a counterclockwise direction by the shaft 30. With the eccentric arrangement of the casing 83 relative to the rotor 71 as illustrated in FIG. 1, the fluid flows in a direction from left to right, from the inlet-outlet port 25 to the inlet-outlet port 26.

The rotation of the rotor 71 produces centrifugal force which urges the rotor vanes 80 outwardly against the cam ring surface 84 of the casing 83. As each vane passes from the suction zone 107 into the sealing zone 111, increased pressure is exerted against the face 131 of the vane, tending to bind the vane in its slot and overcome the centrifugal force urging the vane outwardly. According to the invention, however, the radius of curvature of the sealing zone surface 114 in the casing 83 decreases relative to the axis of the rotation of the rotor 71, in the direction of rotation, thus effectively causing this surface 114 to "rise". During passage through this sealing zone 111, the vanes 80 are thus forced progressively inwardly by the surface 114, assuring contact of the vane tips with the surface and preventing fluid leakage past the vanes.

In traversing the discharge zone 108 of the chamber 85, the vanes 80 are again free to respond to centrifugal force and follow the chamber wall 84 to the sealing zone 110. Here the flow pressure in the discharge zone 108 is cut off from the face 131 of each vane and unbalanced pressure against the face 140 again tends to bind the vane 80 in its slot 76. Once again, however, the "rise" in the sealing zone surface 113 maintains contact with the vane tips and preserves the seal.

Control of the pump 4 volumetric output is effected by manipulation of the control rod 125. As the casing 83 is retracted toward a position more nearly concentric with the rotor 71, flow diminishes and finally ceases at the point of concentricity. Movement of the casing past this point of concentricity causes the flow to begin in the opposite direction through the pump 4 and increase until the casing 83 has reached the point of maximum eccentricity in the opposite direction to that shown in FIG. 1.

A variable volume, reversible flow, vane-type pump has now been described which produces a highly efficient pumping operation with minimum wear of moving components. The pump assembly has a compact body construction which is easily machined and fabricated to require tolerances. Throughout the pump, fluid pressures reacting upon various surfaces are substantially balanced so as to minimize sliding friction between components.

The pump has been described in terms of counterclockwise rotation so that the faces 131 of the vanes 80 are "leading" and the faces 140 are "trailing". This is the preferred mode of operation. However, it has been found that excellent performance is also obtained with the vanes 80 reversed in their slots so that the slotted faces 140 become the "leading" faces, and it is in-

tended that this application cover such mode of operation.

While the embodiment described herein is at present considered to be preferred, it is understood that various modifications and improvements may be made therein.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. In a variable volume pump including a rotor formed with a plurality of circumferentially spaced slots slidably receiving substantially radially extending vanes, radial movement of said vanes being controlled by a curved surface defining a chamber in a casing encircling said rotor, said chamber having inlet and outlet means which define suction, discharge and sealing zones in said casing; the improvement wherein said curved surface defining said chamber in the region of said sealing zones is formed in such a manner as to present to the rotor and vanes a constant or decreasing radius in the direction of rotation of said rotor in all positions of said casing relative to the axis of rotation of said rotor.

2. The improvement of pump of claim 1 further characterized by and including means for radially balancing said vanes in corresponding slots so that centrifugal force is substantially the only force urging the vanes outwardly through the operational cycle of said pump.

3. In a variable volume pump including a rotor formed with a plurality of circumferentially spaced slots slidably receiving substantially radially extending vanes, radial movement of said vanes being controlled by a curved surface defining a chamber in a casing encircling said rotor, said casing formed with inlet and outlet means which define suction, discharge and sealing zones in said chamber; the improvement wherein said curved surface defining said chamber in the region of said sealing zone is formed in such a manner as to present to the rotor and vanes a decreasing radius in the direction of rotation of said rotor in all positions of said casing relative to the axis of rotation of said rotor.

4. A variable volume-reversible flow pump comprising a housing with removable side walls, a shaft in said housing rotatably supporting a rotor formed with a plurality of circumferentially spaced slots slidably receiving substantially radially extending vanes, radial movement of said vanes being controlled by a curved surface defining a chamber in a casing encircling said rotor, said casing formed with inlet and outlet means which define suction, discharge and sealing zones in said chamber, said casing being slidably mounted between said side walls for movement relative thereto and free to assume a position in axial alignment with said rotor, said casing being positionable for selection of the degree and direction of eccentricity between said rotor and said chamber of said casing, said eccentricity determining the volumetric displacement of said pump and the direction of the fluid flow, said curved surface being formed with a decreasing radius in the region of said sealing zones in relation to the normal direction of rotation of said rotor.

5. In a variable volume pump including a rotor formed with a plurality of circumferentially spaced slots slidably receiving substantially radially extending vanes, radial movement of said vanes being controlled by a curved surface defining a chamber in a casing en-

circling said rotor, said casing formed with inlet and outlet ports defining suction, discharge and sealing zones in cooperation with said chamber surface and said rotor; the improvement wherein said curved surface defining the inner chamber of said casing in the region of said sealing zones is formed in such a manner as to present to the rotor and vanes a constant or decreasing radius in the direction of rotation of said rotor in all positions of said casing relative to the axis of rotation of said rotor.

6. In a pump including a rotor formed with a plurality of circumferentially spaced slots slidably receiving substantially radially extending vanes, each of said vanes having a leading face and a trailing face, radial movement of said vanes being controlled by a curved surface defining a chamber in a casing encircling said rotor; the improvement wherein said casing is formed with inlet and outlet means which define suction, discharge and sealing zones in said chamber, said curved surface defining said chamber in the region of said sealing zones being formed in such a manner as to present to the rotor and vanes a constant or decreasing radius in the direction of rotation of said rotor in all positions of said casing relative to the axis of rotation of said rotor, each of the vanes being formed so that its outer tip engages said curved surface only in single line contact and said single line contact is substantially in the plane of one of said faces, radially extending fluid passage means formed in said vane placing inner and outer end surfaces of said vane in fluid communication through said passage means, one face of each of said vanes and the adjacent wall of each corresponding slot cooperating to form a substantially fluid tight seal between the vane and slot.

7. In a variable volume pump including a housing, drive shaft means rotatably mounted in the housing, a rotor mounted on the drive shaft means and positioned between retainer plates, the rotor having a plurality of slots on its peripheral surface, and a substantially radially extending vane confined in each of said slots by a

casing having an annular inner surface encircling said rotor to form a pumping chamber therebetween, the improvement wherein said housing includes a unitary body having integral upper, lower, front and rear walls, removable side walls secured to said body to form a substantially closed housing, said casing being slidably movable between said side walls, said retainer plates maintaining said casing in axial alignment with said rotor.

8. The improvement in a variable volume pump of claim 7 further characterized by and including means for radially balancing said vanes in corresponding slots so that centrifugal force is substantially the only force urging said vanes outwardly through the operational cycle of said pump.

9. The improvement in a variable volume pump of claim 7 further characterized in that said drive shaft means are rotatably supported by bearings mounted in said integral front and rear walls of said body.

10. The improvement in a variable volume pump of claim 7 further characterized in that said casing is formed with inlet and outlet means which define suction, discharge and sealing zones in said chamber, said annular inner surface encircling said rotor in the region of said sealing zones being formed in such a manner as to present to the rotor and vanes a constant or decreasing radius in the direction of rotation of said rotor in all positions of said casing relative to the axis of said rotor.

11. The improvement in a variable volume pump of claim 7 further characterized by and including bearing faces on said casing slidable on said side walls, and recess means formed in each of said bearing faces, said recess means being in fluid communication with said pumping chamber.

12. The improvement in a variable volume pump of claim 11, further characterized in that the surface area of each recess means approximates in size the corresponding projected area of the interior of the casing which is exposed to fluid pressure so as to balance fluid pressure forces between said casing and said side walls.

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