

Oct. 18, 1966

D. F. MCGILL

3,279,387

REVERSABLE PUMP AND MOTOR

Filed Feb. 3, 1964

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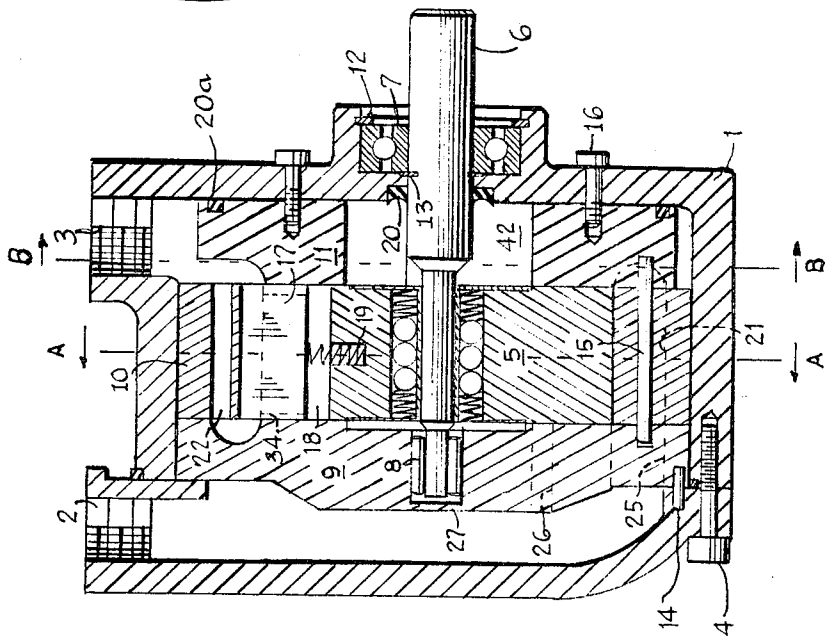
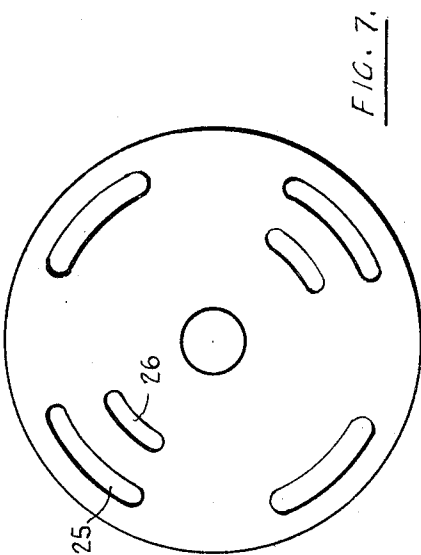
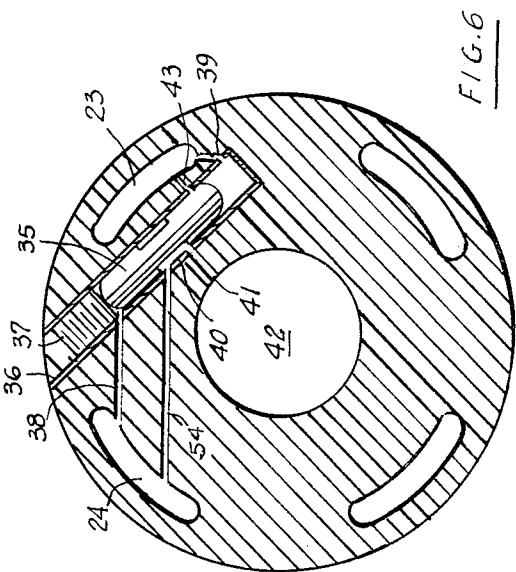


FIG. 1.

INVENTOR

Daniel F. McGill

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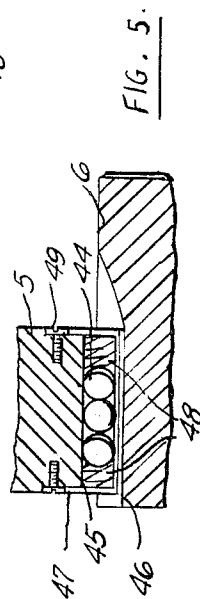
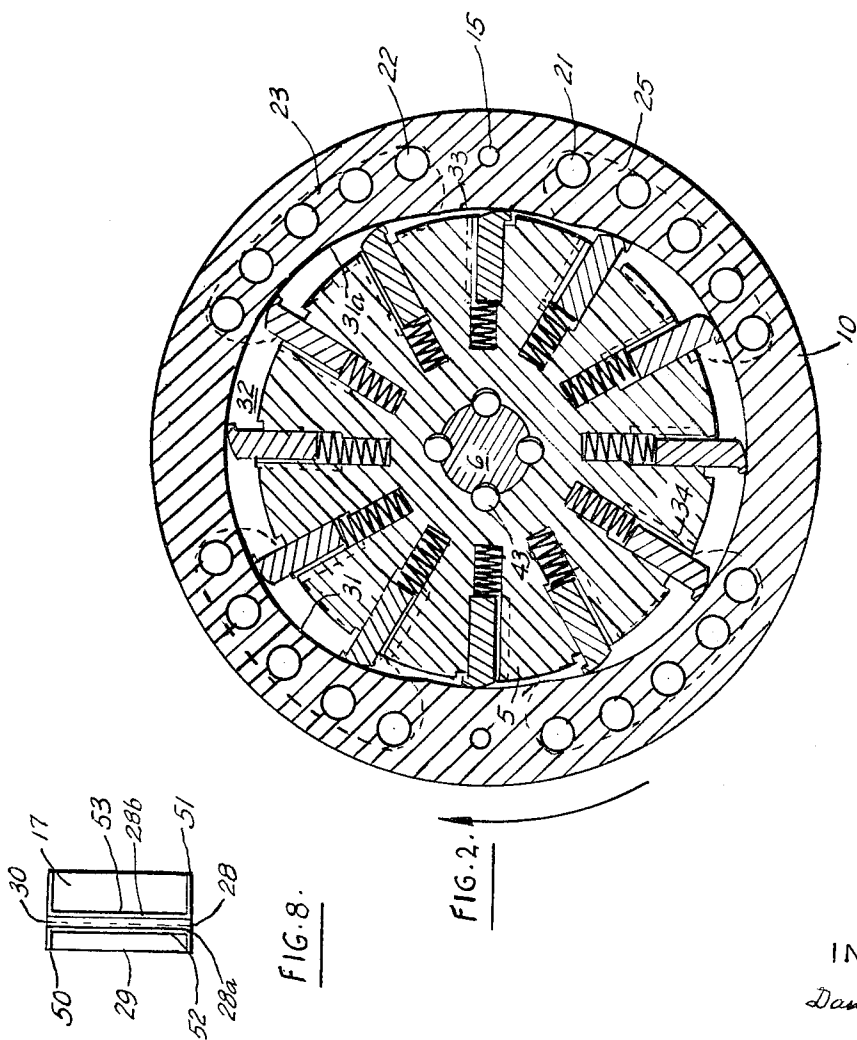
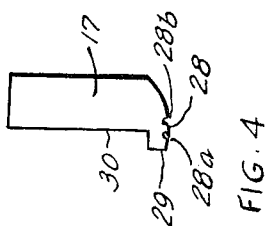
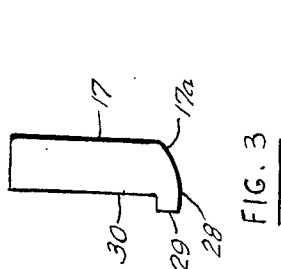


FIG. 8.

FIG. 2.

FIG. 5.

INVENTOR

Daniel F. McGill

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REVERSABLE PUMP AND MOTOR

Daniel F. McGill, 2344 NE. 52nd Ave., Portland, Oreg.

Filed Feb. 3, 1964, Ser. No. 342,145

9 Claims. (Cl. 103-136)

This invention relates to rotary pumps and motors and more particularly to high pressure vane type pumps and vane type motors.

The object is to provide a fluid pump or fluid motor of the vane type that controls the radial fluid force of the vane on the cam while operating in either direction of rotation, simple and effective in design and inexpensive to manufacture.

Another object is to provide a pump or fluid motor of the vane type that the vane has a step on one side with a single sealing contact of the vane on the cam through the sealing zones formed by grinding the outer end of the vane with a center taken from a line on the step side edge of the vane producing an equal overlap on each side of the step side edge thereby, providing the same fluid pressure sealing force holding the vane on the cam when the high fluid pressure is on either side of the vane.

Another object is to provide means controlling the difference of inward and outward radial fluid forces on the vane by the radius used in grinding the outer end of the vane, thereby, controlling the width of the vane sealing overlapping contact on the cam.

Another object is to provide means maintaining the same difference of radial inward and outward fluid forces on the vane after a long time in use without servicing by limiting the vane contact on the cam to a controlled width.

Another object is to provide a vane in a fluid pump or hydraulic motor with a sealing contact on the cam that provides a fluid pressure per square inch of vane contact on the cam equal to one half of the p.s.i.

Another object is to provide automatic means to supply low pressure fluid to the center of the machine and seal around the shaft as the rotor changes from one direction of rotation to another.

Another object is to provide means lifting the sealing contact of the vane off the cam except through the sealing zones.

In the drawings:

FIGURE 1 is a horizontal cross section of the machine.

FIGURE 2 is a cross section of the cam rotor and shaft taken through A—A of FIG. 1.

FIGURE 3 is an enlarged view of the vane.

FIGURE 4 is an alternate enlarged view of the vane.

FIGURE 5 is an enlarged sectional view of the rotor and shaft mounting.

FIGURE 6 is a cross section of end plate 11 taken through B—B.

FIGURE 7 is an end view of end plate 9.

FIGURE 8 is an enlarged outer end of the vane.

In the specification:

In FIGURE 1, as indicated by arrow in FIG. 2 for illustration, the machine is operating in a clockwise direction of rotation as a pump with numeral 1 representing the housing provided with intake port 2 and discharge port 3. Housing 1 is made in two parts and held together by bolts 4. Rotor 5 is mounted for rotation on shaft 6 on ball bearing 7 in housing 1 at the shaft outlet and on needle bearing 8 at the enclosed end of the shaft in end plate 9. Cam 10 is mounted between end plates 9 and 11.

Ball bearing 7 is held in housing 1 by snap ring 12 and snap ring 13 on shaft 6 permitting axial movement of the shaft only to the extent of the clearance necessary to mount the snap rings. This point is mentioned because rotor 5 must be fit between end plates 9 and 11 with but

two and one half tenths of an inch clearance, for lubrication, one each end of rotor 5, preventing fluid blowby under high fluid pressure.

End plate 9 is held in alignment with housing 1 by pin 14 and cam 10 is held in alignment with pin 15 while end plate 11 is held in alignment with housing 1 by bolts 16. Vanes 17 are mounted in rotor 5 in vane slots 18 with springs 19 holding them extended against cam 10 with a predetermined force, in FIGS. 1 and 2, forming low and high pressure fluid chambers.

Centrifugal force on the vane will cause the vanes to follow the contour of cam 10 when the machine is operating as a fluid pump in either direction of rotation, therefore, springs 19 are not necessary in a pump.

A suitable oil seal 20 in center 42 of the machine is provided around shaft 6, which must be provided with low pressure fluid explained later. O-rings 20a are provided where necessary.

Intake ports 25 in end plate 9, in dotted lines, leading to rotor 5 through cam 10 by cross ports 21 supplying fluid to both sides of rotor 5 and through cross ports 22 in cam 10 discharging fluid from both sides of rotor 5 out through port 3.

When the machine is built to operate as a pump in one direction of rotation individual ports 26, in dotted lines in FIG. 1, leads to the inner end of vane slots 18 providing free flow of the fluid to the inner end of the vane slots lessening the possibility of cavitation in the pump. Port 34, in FIG. 2, also leads to the inner end of vane slots 18 providing intake and discharge from the vane slots.

The vacuum formed by centrifugal force on the vanes is the only means of filling the vane slots and the lack of free flow of fluid to the inner end of the vane slots is quite often responsible for cavitation in a pump.

Partition 27 in end plate 9 can be eliminated with low pressure fluid provided to center 42 of the machine from the intake side of the pump when operating in one direction of rotation.

When operating as a reversible pump springs 19 may also be eliminated with centrifugal force moving the vanes out against cam 10, but when operating as a fluid motor spring 19 are required because the vanes must be forced to follow the contour of the cam when high fluid pressure is applied to both ends of vane 17 while the rotor is stationary and with the radial fluid forces on the vane balanced out, spring 19 forcing the vanes to follow the contour on the cam. The tension on spring 19 may be low since after rotor 5 attains the higher speeds of operation centrifugal force on the vanes will be added to the spring tension force. The springs are required only when starting and at low speeds of the rotor. After the rotor is up to higher operating speeds centrifugal force will cause them to follow the cam, the same as in the pump, without the use of springs in either direction of rotation.

The bolted end of housing 1 may be rotated to other positions to accommodate piping needs by providing pin holes for pins 14 alignment.

FIGURE 3 is an enlarged view of vane 17 showing single contact 28 on the outer end of the vane in line with step 29 side edge 30 of the vane overlapping each side of edge 30.

The width of the overlap may be controlled by two methods.

1st, by the radius used in grinding the outer end of the vane. The grinding radius should be shorter than that of the neutral zones in both methods. The shorter the radius the narrower the overlap on each side of edge 30.

2nd, by a relief on each side of the single sealing contact center line of edge 30. The second method the grind-

ing radius of the vane can be near the radius of the cam in the neutral zones with the relief controlling its width, in FIG. 4. The object is to make the areas, subject to radial forces, nearly equal providing but little difference of the over-balancing fluid radial forces as possible and it together with centrifugal force forming the sealing contact between the vane and the cam permitting a thin film of lubrication to remain between the vane and the cam preventing a metal to metal contact the cause of wear wear and scoring. The inability to prevent excessive fluid force, plus centrifugal force, of the vane on the cam crowding out the lubrication is the problem in most vane pumps, requiring frequent and expensive servicing.

When operating in a clock-wise rotation step 29 is on the leading side of the vane and as it follows out on ramp 31, by centrifugal force, heel 17a holds vane contacts 28 free from cam 10 until it reaches the concentric sealing area through working zone 32, then high pressure fluid is on the outer end of vane 17 ahead of sealing contact 28 on step 29 urging vane 17 radially inward with a slightly larger area on the inner end of step 29 over-balancing the inward radial fluid force forming the fluid force holding the vane on the cam plus centrifugal force of the vane forming the sealing force of the vane on cam 10. The more nearly the forces are balanced out the longer the pump will operate without servicing.

Centrifugal force is controlled by the weight of the vane and r.p.m., therefore, the vane should be as short and as thin as the length of the stroke and the p.s.i. will permit.

After passing through working zone 32 step 29 bears on ramp 31a as it forces vane 17 back into vane slot 18 lifting contact 28 free from cam 10 until it reaches concentric neutral zone 33.

Contact 28 bears on cam 10 only through working zones 32 and neutral zones 33 with step 29 and heel 17a of the vane taking most of the wear. This is true because if the vane is properly designed the fluid outward radial force is so nearly balanced out through working zones 32 and neutral zones 33. While the vane is passing through the ramps the vane is not under high fluid pressure lubrication and the vane contact on the ramp is on nearly a knife edge with centrifugal force increasing the pressure per square inch bearing surface crowding out the lubrication causing a metal to metal contact. Therefore, the vane should be made as short and as thin as practical, reducing its weight, each determined by the vane stroke and the p.s.i. The advantage of this type vane over other types of vanes is that the difference in fluid radial forces and its centrifugal force can be controlled, requiring much less servicing.

Ports 34, in FIGS. 1 and 2, in dotted lines, are shown on each side of rotor 5 and lead to the inner end of vane slots 18, providing free flow of fluid to and from the inner end of the vanes.

When the vane is passing through neutral zone 33 the fluid pressure has changed to its trailing side with the high fluid pressure on the outer end area of the main body of the vane back of contact 28 urging the vane radially inward with a slightly large area on the inner end of the vane with high fluid pressure over-balancing the inward fluid force and it together with centrifugal force forming the means of holding the vane on the cam in neutral zones 33. All radial fluid forces on vane 17 are balanced out with contact 28 raised off the cam except through sealing zones 32 and 33. Centrifugal force is the only force in a pump holding the vane on the cam as it passes over the ramps, therefore, the lighter the vane the less wear.

A gradual wear will occur in time on sealing contact 28, widening the contact, providing a greater difference in the radial inward and outward fluid forces on the vane. To prevent the widening of contact 28 in FIG. 4, relief 28a is provided on step 29 side of sealing contact 28 and relief 28b on the side of the main body of the vane preventing its widening, permitting long usage while maintaining its original designed width without servicing, by

maintaining the low fluid pressure of the vane on the cam.

FIG. 8 is an enlarged outer end view of vane 17 with step 29 side vane edge 30, in dotted lines, showing sealing contact 28 overlapping each side of edge 30 up to relief 28a on step 29 side and 28b on the side of the main body of the vane.

Relief 50 and 51 are provided so that after a long time in service, should contact 28 wear permitting edge 52 on step 29 and edge 53 on the main body of the vane, contact cam 10, relief 50 and 51 will provide ports to relief 28a and 28b.

When operating as a reversible machine as a fluid pump or a fluid motor it is necessary to provide low fluid pressure on fluid seal 20 around shaft 6 to prevent leakage. An automatic piston type valve 35 is provided in cylinder 36 and mounted in end plate 11, in FIG. 6, and cylinder 36 is provided with plug 37. Port 38 leading from port 24 to the plugged end of cylinder 36 and port 39 leading from port 23 to its opposite end. Valve 35 is provided with port 40 registering with port 41 to center area 42 of the machine in which oil seal 20 is located. Port 43 leads from port 23 to cylinder 36 but does not register with valve port 40 because of the position of valve 35.

High fluid pressure in port 23 leads through port 39 to the end opposite the plug in cylinder 36 holding valve 35 in a position that registers low pressure port 54 with valve port 40 and port 41 to center area 42 providing low fluid pressure to fluid seal 20. When the rotor rotates in the opposite direction of rotation the conditions are automatically reversed with high fluid pressure then in port 24 moving valve 35 to a position at the opposite end of cylinder 36 registering port 43 with valve port 40 and port 41 to center area 42 maintaining low fluid pressure on seal 20.

FIGURE 7 is an end view of end plate 9 with intake ports 25, in dotted lines, leading to rotor 5 and cross ports 21 through cam 10 to the opposite side of rotor 5 and ports 23 connecting discharge cross ports 22 with each side of rotor 5.

Independent intake port 26 leads to the inner end of vane slots 18 and used only in a pump designed to operate in one direction of rotation, providing free flow of the fluid to the inner end of vane slots 18. When using ports 26 partition 27 and valve 35 will be eliminated, thereby, providing low fluid pressure to seal 20 around shaft 6 through the intake side of the pump.

FIGURE 5 is an enlarged sectional view of rotor 5 mounted on shaft 6 on ball bearing 44 splines in channels 45 in rotor 5 and channels 46 in shaft 6 with balls 44 held in rotor 5 by retainer 47. Retainer 47 is held in position by screws 49. Balls 44 are held centered in rotor 5 by light springs 48, or otherwise permitting shaft 6, when under load driving rotor 5, to roll axially on balls 44, to the extent of the clearance necessary for mounting snap rings 12 and 13, without effecting the axial movement of rotor 5, thereby, permitting rotor 5 to float between end plates 9 and 11, never permitting a hydraulic unbalance of rotor 5 crowding the lubrication from between the rotor and one of the face plates. Shaft 6 is free to slide in and out when assembling the same as a regular spline.

Balls 44 are fitted free enough to center in rotor 5 by light springs 48 when not under load driving rotor 5.

While a regular spline may be fitted free enough to permit a rotor to float between end plates when unloaded, when loaded a spline becomes a solid connection and as it moves axially forcing the rotor against one of the end plates, causing hydraulic unbalance, crowding out the lubrication, permitting a metal to metal contact. Having described the enclosed invention as being the preferred form, it is understood that other forms might be adopted, what I claim as new is set forth in the following claims.

1. In a reversible machine comprising a housing having inlet and outlet ports, a rotor mounted for rotation on a shaft in said housing, vanes mounted in vane slots in said rotor bearing on a vane track forming low and

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high pressure fluid chambers, a step on the outer end of said vanes, ports on side opposite said steps leading from one of said fluid chambers to the inner end of its main body of each said vane, said vanes having a single sealing contact on said vane track with its center in line with its step side edge over-lapping each side of said side edge forming a predetermined width of its bearing surface on said vane track through the sealing zones in said machine, areas on each side of said over-lap and its respective inner end areas exposed to fluid, when said fluid pressure is exposed to either side of said vane its larger area on its inner end over-balancing its smaller area on its outer end providing a sliding friction fluid pressure force per its square inch of area bearing on said vane track equaling one half the p.s.i. in said machine through said sealing zones while transferring fluid under high pressure.

2. In combination with claim 1, automatic means providing low fluid pressure to the center of said machine comprising a valve having a cylinder, a port in said valve registering with a port to the center of said machine, a first port leading from each low and high pressure side of said machine registering with each end of said cylinder, a second port leading from each low and high pressure side of said machine to said cylinder, when said high fluid pressure is on either end of said cylinder said valve is held in a position that one of said second low pressure ports is in register with said valve port and said port to the center of said machine providing low fluid pressure to a seal around said shaft preventing fluid leakage.

3. In a reversible fluid machine comprising a housing having inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes in vane slots in said rotor bearing on a vane track across from said rotor forming low and high pressure fluid chambers, said vanes having a step on one side, ports from said fluid chambers leading to the inner end of each main body of said vanes on side opposite said step, said vanes having a single sealing contact with its center in line with its vane side edge on said step side over-lapping each side of said line edge to a prescribed width forming a pressure on said track per its square inch area of bearing surface on said track through the sealing zones equal to one half that of the p.s.i. in the machine when said high fluid pressure is on either side of said vane while transferring fluid.

4. In a reversible machine comprising a housing having inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes in vane slots in said rotor bearing on a vane track through a space between said rotor and said track forming low and high fluid pressure chambers, said vanes having a step on one side, ports leading from said fluid chambers to the inner end of each main body of said vanes, said vanes having a single sealing contact on said track formed by its step side edge as a center for its bearing contact over-lapping each side of said center to a prescribed width, said vanes having an area on each side of said bearing surface on said track through the sealing zones and on its respective inner end exposed to fluid, when said high fluid pressure is on said step side it is on said outer and inner end areas of said step with its larger inner end area forming outward fluid force over-balancing its outer end area inward fluid force providing the fluid force holding said vane on said track through said sealing zones, when said high fluid pressure is on said main body side of said vane its larger inner end area forming an outward fluid force over-balancing its outer end area inward fluid force providing the fluid force holding said vane on said track through said sealing zones while transferring fluid.

5. In a reversible fluid machine comprising a housing having inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted in vane slots in said rotor bearing on a vane track forming low and high pressure fluid chambers, springs in said vane slot holding said vanes in contact with said track, a step on the outer end of said vanes, ports on opposite sides of said

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steps leading from said fluid chambers to the inner end of the main body of each of said vanes, said vanes having a single sealing contact on said vane track through the sealing zones in line with its step side edge over-lapping each side edge forming a predetermined width of its said bearing sealing surface on said vane track through said sealing zones, areas on said outer end of said vanes on each side of said bearing surface and its respective inner end exposed to fluid, when said high fluid pressure is on said step side areas its said outer end and inner end areas are exposed to high pressure fluid with a larger area on its inner end over-balancing its radial fluid forces providing the fluid force holding said vane sealing contact on said vane track through said sealing zones, when high fluid pressure is on said main body side of said vane said high fluid pressure is on both areas of its respective ends with the larger inner end area over-balancing its inward fluid force providing the fluid force holding said vane on said vane track through said sealing zones while transferring fluid.

6. In a machine comprising a housing having inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes in vane slots in said rotor having a bearing on a vane track in said housing forming low and high pressure fluid chambers in spaces between said rotor and said vane track, said vanes having a step on one side of its outer end, said vanes having a single sealing bearing contact on said vane track through the sealing zones formed by using its edge on said step side as its center line, said single bearing contact over-lapping each side of said center line to a prescribed width, ports on side opposite said step leading from one of said fluid chambers to each inner end of said vane slot, a groove on each side of said bearing contact width preventing its widening by wear after a long time use, said grooves and said outer ends on each side of said bearing contact and its respective inner end of exposed to fluid, when high pressure fluid is on said step side of said vane it is on its outer end area exposed to fluid and its opposing inner end area with its larger inner end area over-balancing its outer end area providing its outward fluid force equaling one half the p.s.i. in the machine per its square inch of area bearing surface on said track through said sealing zones, when said high fluid pressure is on the side of said main body of said vane its larger inner end area over-balancing its outer end area force providing its outward fluid force equaling one half the p.s.i. in said machine per its square inch area of bearing surface on said track through said sealing zones while transferring fluid under high pressure.

7. In a reversible translating energy machine comprising a housing having inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted in vane slots in said rotor, springs in said vane slots extending said vanes through a space to bear on a track in said housing forming low and high pressure fluid chambers, said vanes having a step on one side, ports leading from said fluid chambers to the inner ends of the main body of said vanes on side opposite said steps, outer ends of said vanes having a single bearing surface on said track formed by using the edge of said vanes on said step side as its center, said bearing surface over-lapping each side of said center to a prescribed distance leaving an area on each side of its said bearing surface exposed to fluid, inner end of said step exposed to fluid, when high fluid pressure is on step side its larger inner end area exposed to high pressure fluid over-balancing its outer end area exposed to high fluid pressure providing the fluid force holding said vane on said track through the sealing zones in said machine, when said high fluid pressure is on the side of said main body of said vane its larger inner end area force over-balancing its outer end area force providing the fluid force holding said vane on said track through said sealing zones forming an energy translating machine through its said shaft inwardly

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or outwardly with said rotor rotating in either direction of rotation while transferring fluid energy.

8. In combination with claim 7; automatic means providing low fluid pressure to the center of said machine comprising a valve having a cylinder, a port in said valve registering with a port to the center of said machine, a first port leading from each low and high pressure side of said machine registering with each end of said cylinder, a second port leading from each low and high pressure side of said machine leading to said cylinder, when said high fluid pressure is on either end of said cylinder said valve is held in a position that one of said second low pressure ports is in register with said valve port and said port to the center of said machine providing low fluid pressure to a seal around said shaft preventing fluid leakage.

9. In a fluid machine comprising a housing have inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted in vane slots in said rotor extending through a space contacting a vane track forming low and high pressure fluid chambers, a step on the outer end of said vanes, ports on side opposite said steps from one of said chambers leading to the inner end of the main body of said vanes, said vanes when passing through the sealing zones in said machine having a single sealing contact on said vane track, said single sealing contact on said vane track being formed by using said edge on said step side as its center in forming said vane contact to a prescribed width of bearing surface on said vane track while leaving an area on each side of said contact exposed to fluid, when said side area is exposed to high fluid pressure on said step side the inner end of said step

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is also exposed to high fluid pressure with its larger area over-balancing its said outer end area with the difference in forces forming the fluid force holding said vane on said vane track through said sealing zones, when high fluid pressure is on said main body side of said vane the difference in areas on its ends forming the force holding said vane on said vane track through said sealing zones controlling the sliding fluid force of said vane on said vane track while transferring fluid under high pressure.

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MARK NEWMAN, *Primary Examiner.*

JOSEPH H. BRANSON, SAMUEL LEVINE,
Examiners.

R. M. VARGO, *Assistant Examiner.*