Sept. 18, 1962 D. F. McGILL 3,054,357

DUAL PUMP POWER TRANSMISSION

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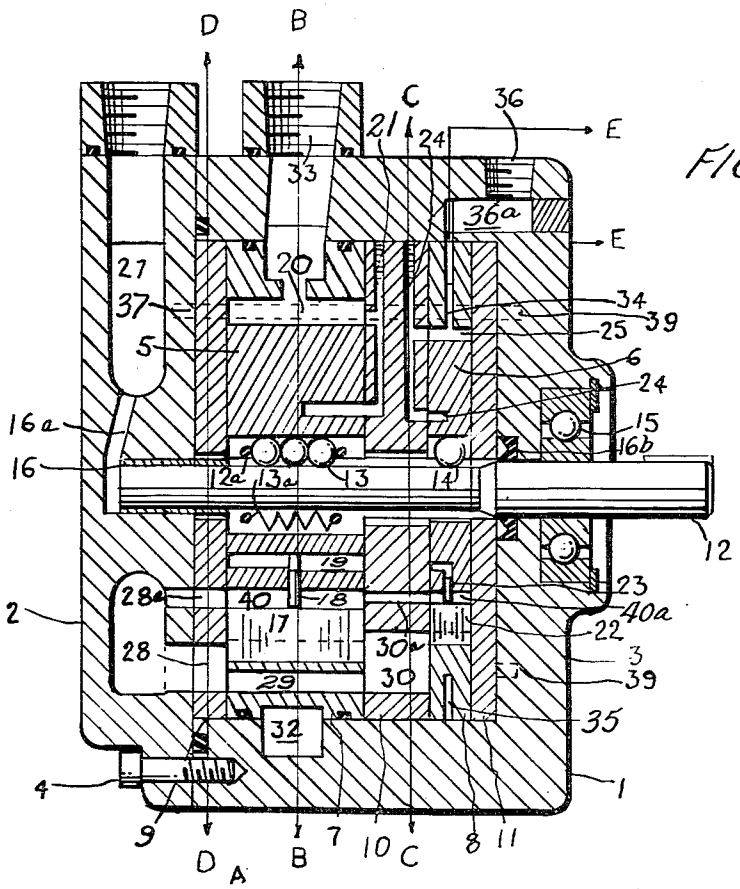


FIG. 1.

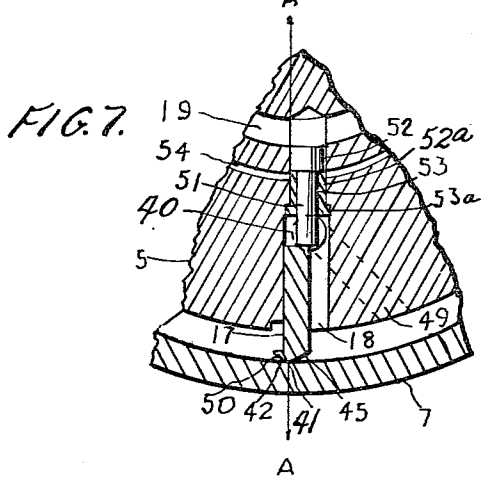


FIG. 7.

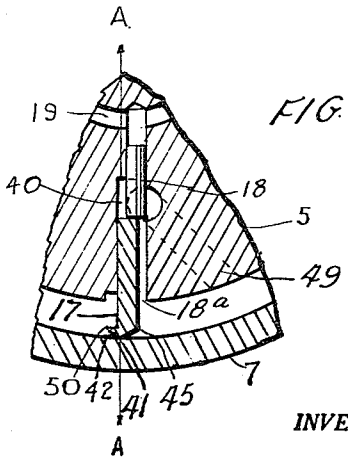


FIG. 6.

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FIG. 4.

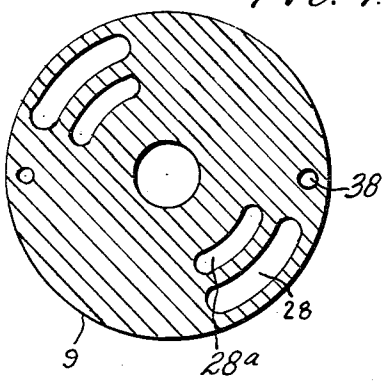
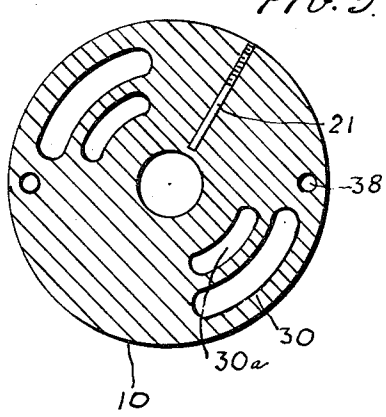


FIG. 3.



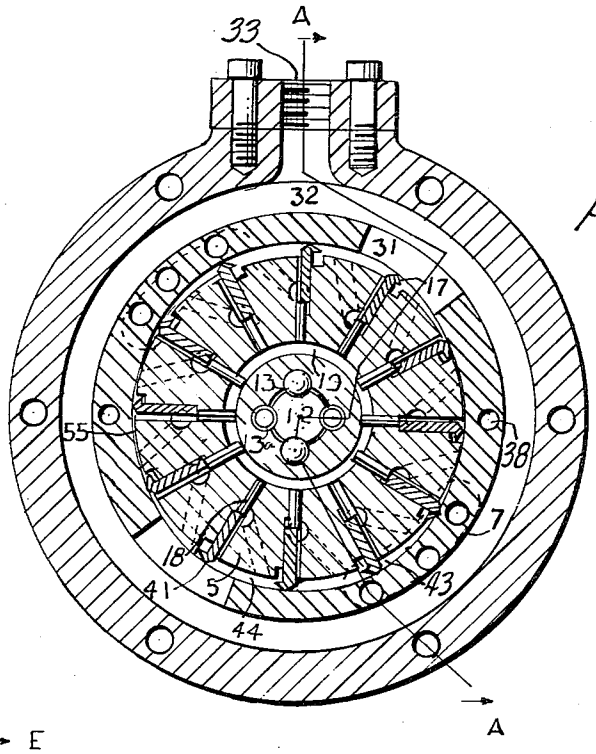


FIG. 2.

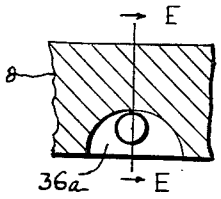


FIG. 5.

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DUAL PUMP POWER TRANSMISSION

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This invention relates to power transmissions and is particularly applicable to those of the type comprising two or more fluid pressure energy translating devices, one or more of which may function as fluid pumps and others as fluid motors.

This invention is generally concerned with multiple pumping units and is more particularly concerned with dual pumping units of the rotary vane type but may be of a single pumping unit. Units of this type are adaptable for use in hydraulic power transmissions having a plurality of motors which must be driven separately and sometimes at different pressure and speeds. Although each pumping unit may be connected to one or more fluid motors for separately operating the same, the pumps may be driven by a common shaft connected to a prime mover and supplied with fluid from a single source.

Multiple units of this type are also utilized with control valves adapted to cooperate therewith in circuits wherein a small or large volume of fluid is required against a fairly low pressure and at other times a small or large volume of fluid is required against a high pressure.

There is one basic reason for loss of efficiency in pumps and hydraulic motors but this invention particularly refers to rotary vane pumps and hydraulic motors.

The problem is to prevent excessive sliding pressure friction that forces the lubrication from between the moving parts causing a metal to metal contact resulting in wear and scoring until the efficiency is destroyed.

The three main problems are as follows:

Cold Starts

In rotary vane pumps and hydraulic motors particularly when working under high fluid pressure where the parts must fit with very close tolerance to prevent fluid blow-by from the high to the low pressure chambers. With close running tolerance during cold starts the fast rotating rotor generates heat by friction between the rotor and the face plates, causing the rotor to expand faster than that of the cam and other parts of the pump, crowding the lubrication from between the rotor and the face plates, causing a metal to metal contact resulting in wear and scoring or sometimes a complete freeze-up. The maintenance necessary to keep reasonable operating efficiency is appalling.

To eliminate the cold start problem advantage has been taken of coefficient of expansion of metals. Aluminum having approximately double the coefficient of expansion as that of iron or steel, is used for one or all of the face plates.

The aluminum face plate is floatingly mounted and held in alignment between the end plate and the pump cam and the rotor with not more than running clearance allowed for the rotor at operating temperature and when the pump is cold the aluminum face plate will have contracted twice that of other parts of the pump permitting additional running clearance between the rotor and the face plates during cold starts. The additional running clearance will permit the rotor to warm up slowly and expand more uniformly with that of the other parts of the pump and by the time the pump is at operating temperature the face plates will fit tight between the cam and the end plates with the original new pump running clearance between the rotor and face plates for lubrication.

End Thrust or Side Tipping of Rotor

Excessive end thrust may be caused by unequal expansion of pump parts, hydraulic unbalance of the rotor, or by axial thrust transferred from the operating shaft to axial movement of the rotor against one of the face plates permitting hydraulic unbalance of the rotor. Side tipping of the rotor is caused by side loading of the shaft when the operating shaft is driven by a gear or pulley. By floating the rotor on balls these problems are eliminated. To be explained later.

Sliding Vane Pressure on Cam

The sliding vane pressure friction on the cam is controlled hydraulically. To be explained later.

It is, therefore, an object of this invention to provide an improved and smaller unit of a vane type pump and hydraulic motor with higher operating efficiency maintained at higher fluid pressures than normally possible.

It is also an object of this invention to provide a rotary dual pumping unit which is readily adaptable for interchangeability to meet a variety of circuit volume and pressure requirements by changing the cams and providing different length vane strokes.

It is also the object of this invention to provide a rotary vane pumping unit that will maintain higher efficiency without servicing by the use of metals of different coefficient of expansion permitting closer running fits without causing wear and scoring during cold starts.

It is also an object of this invention to provide a rotary vane pump, or hydraulic motor with a predetermined controlled hydraulically balanced low sliding pressure force of the vane on the cam through the entire circuit without blow-by of the fluid over the outer end of the vanes from the high to the low pressure zones.

It is also an object of this invention to provide a pump, or motor with means to prevent transfer of axial shaft thrust movement to axial rotor movement.

It is also an object of this invention to provide a pump or motor with means to prevent tipping of the rotor when the shaft is operated by a pulley or gear.

It is also an object of this invention to provide a pump with means to prevent hydraulic unbalance of the rotor.

It is also an object of this invention to provide a pump, or hydraulic motor with improved simplified compact construction capable of meeting a variety of volume and high pressure requirements.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of the invention is clearly shown.

In the drawings:

FIGURE 1 is a longitudinal view of the preferred form of the invention taken on line A—A in FIGURE 2;

FIGURE 2 is a cross section view taken on line B—B in FIGURE 1;

FIGURE 3 is a cross section of a face plate taken on line C—C in FIGURE 1;

FIGURE 4 is a cross section of a face plate taken on line D—D in FIGURE 1;

FIGURE 5 is a cross sectional view of the discharge port of the smaller pump taken on line E—E in FIGURE 1;

FIGURE 6 is a cross sectional view of an enlarged detail of a vane pump assembly; and

FIGURE 7 is a cross sectional view of an enlarged detail of a hydraulic motor vane assembly.

Referring to FIGURE 1, a dual rotary vane pumping unit is shown having a casing in two sections comprising a common intake end plate 2 and a common discharge end plate and housing 3 for both pumping units, which are held together by bolts 4. Rotors 5 and 6, cams 7 and

8 are mounted between face plates 9, 10 and 11 with rotors 5 and 6 mounted on a common drive shaft 12.

Aligned grooves are formed in shaft 12 and rotors 5 and 6 are mounted on shaft 12 on balls 13 driving rotor 5 with balls 14 driving rotor 6. Springs 13*a* are clamped on wire rings 12*a* holding balls 13 centered in rotor 5 but free enough to permit axial thrust movement of shaft 12 without transferring axial thrust movement to rotor 5 against one of the face plates.

Shaft 12 is mounted on ball bearing 15 at the front end and on sleeve bearing 16 at the back end. A sleeve or frictionless bearing may be used as fluid pressure loads on the rotor are balanced out. Port 16*a* provides low pressure lubrication to sleeve bearing 16 and fluid seal 16*b* preventing leakage around shaft 12.

Vanes 17 and pistons 18 are mounted in rotor 5 with each piston bearing on the inner end of a vane. Pistons 18 are provided with fluid working pressure on their inner end through port 19 holding vanes 17 in contact with cam 7. Rotor 5, vanes 17, cam 7, face plates 9 and 10 forming high and low pressure chambers. Port 19 gets its fluid pressure from pressure chamber 20 through port 21 in face plate 10, in FIGS. 1 and 3.

Fluid chambers in the small pump are formed by rotor 6, cam 8, vanes 22, face plates 10 and 11 with pistons 23 bearing on the inner end of vanes 22 holding them on cam 8. Fluid pressure is applied from pressure chamber 25 to the inner end of pistons 23 through port 24 in face plate 10. Rotor 6 is mounted on balls 14 functioning as a spline between shaft 12 and rotor 6. Common fluid intake 27 supplies both pumping units through ports 28 and through ports 29 in cam 7 supplying both sides of rotor 5 and to one side of rotor 6 through port 30 in face plate 10 shown in FIGS. 1 and 3 and in dotted lines in FIG. 2. Ports 28*a* lead to the inner end of vane slots 40 and ports 30*a* in face plate 10 to the inner end of vane slots 40*a* in the small pump. Individual intake ports are provided to supply fluid to the inner end of the vane slots to prevent cavitation and a noisy pump. Cavitation is usually caused by the inability to completely fill the inner end of the vane slots at high speed of the rotor.

Discharge from the larger pumping unit is out through ports 31 in cam 7 into circular pressure chamber 32 and out through pipe connection 33. Discharge from the smaller pump is by way of ports 34 in cam 8 into circular pressure chamber 35 to pipe connection 36 through port 36*a*. Both pumping units are similar in construction with the difference being the volume output and having the capability of operating under different fluid pressures while operated from a common drive shaft.

Face plate 9 is mounted between end plate 2 and cam 7. Face plate 10 is mounted between cam 7 and cam 8 with face plate 11 mounted between cam 8 and end plate 3. The face plates and cams are floatingly mounted and held in alignment by pin 37. One or all of the face plates to be made of aluminum. The coefficient of expansion of aluminum is approximately double that of iron or steel. The face plates are mounted to fit tight between end plate 2 and cams 7, 8 and end plate 3 when the pump is at operating temperature with not more than running clearance allowed for lubrication between rotors 5 and 6 and the face plates. When the pump is cold the aluminum face plate or plates will have contracted more than that of the iron or steel cam and pump housing permitting additional running clearance between the rotor and the face plates for lubrication. This additional running clearance for the rotor will permit the rotor to warm up more slowly and expand more uniformly with the cam and the pump housing preventing wear and scoring of the rotor and face plates. The thickness of the aluminum face plate or plates determines the additional running clearance allowed between the rotor and the face plates during cold starts.

End plate 3 is shown with additional holes 39 permitting rotation of end plate 3 to accommodate piping needs for different installations. When pumping certain fluids it may be advisable to use a different metal for the actual face plate between the aluminum face plate and the rotor so that the fluid will not contact the aluminum. The additional running clearance for lubrication during cold starts will still be determined by the thickness of the aluminum plate.

FIGURE 6 is a cross sectional view of an enlarged vane assembly detail for a pump showing a section of rotor 5 with vane 17 mounted in vane slot 40 and piston 18 mounted in bore 18*a* bearing on the inner end of vane 17. Vane slot 40 must be in the lead of bore 18*a* to prevent fluid blow-by.

Fluid pressure from the pump working chamber 20 is applied to the inner end of piston 18 through ports 19 and 21.

The outer end of vane 17 bearing on cam 7 at sealing line contact 41 through both the working and neutral zones of the pump, which are concentric with the center of the rotors to prevent radial movement of vane 17 while under transverse pressure loading. Contact 41 is located at line A—A at one side of center on vane 17 forming a narrow side area 42 and a wide side area 45 with both areas exposed to fluid. Port 49 on wide side area 45 leads to the inner end of vane 17 in vane slot 40 and to the outer end of piston 18 in bore 18*a*.

With rotor 5 rotating in a clockwise direction narrow side area 42 of vane 17 is the leading side of the vane and as the vane passes through the low pressure zone 43 the fluid pressure on the inner end area of piston 18 plus centrifugal force controls the sliding force of vane 17 on cam 7.

As vane 17 moves ahead through the working high pressure zone 44 with sealing line contact 41 bearing on cam 7, narrow side area 42 on the outer end of vane 17 is exposed to high fluid pressure urging vane 17 radially inward with high fluid pressure on the inner end area of piston 18 urging piston 18 and vane 17 radially outward with the difference of these areas controlling the fluid force holding vane 17 on cam 7.

As vane 17 moves over discharge ports 31 the fluid pressure is on both sides of the outer end of the vane and on the inner end of the vane and outer end of piston 18 balancing out all fluid forces on the vane and piston with centrifugal force the only force holding vane 17 on cam 7.

As vane 17 moves through neutral zone 55, when the vane is retracted into vane slot 40, the fluid pressure has changed to the trailing side of the vane with fluid pressure on wide side area 45. Port 49 directs fluid pressure to the inner end of vane 17 and to the outer end of piston 18 balancing out the fluid forces on piston 18 with fluid pressure force on the inner end of vane 17 and wide side area 45 with the difference of the areas across the ends of the vane exposed to high fluid pressure the controlling fluid force holding vane 17 on cam 7.

If contact line 41 is located so that narrow side area 42 is approximately one half that of the area on the inner end of piston 18 the sealing force holding vane 17 on cam 7 will be the same through working zone 44 as that through neutral zone 55. Stop 50 on vane 17 is to provide additional material on vane 17 when narrow side area 42 is only a few thousandths of an inch wide when using a very small diameter piston in high pressure pumps. Centrifugal force can be held to a minimum by using a very small diameter piston and by using a vane as thin as the length of the stroke and p.s.i. will permit.

FIGURE 7 is an enlarged detail of a vane assembly when operating as a hydraulic motor. In hydraulic motors the vane must be forced out against fluid pressure across the outer end of the vane and the piston. The only change necessary is to enlarge the piston head.

Piston 51 having an enlarged head 52 with fluid pressure applied through port 19. Tubing 53 is turned to fit cylinder 52*a* forming a shoulder 53*a* as a stop. A push

fit will hold tubing 53 in cylinder 52*a* with all fluid pressure on the inner end relieved through port 54.

With rotor 5 rotating clockwise when vane 17 is passing through the high pressure intake zone all fluid forces are balanced out on vane 17 with fluid pressure force on the outer end area of piston 51 urging piston 51 inwardly and fluid pressure on the inner end area of enlarged head 52 urging piston 51 outwardly. The difference of the areas on the outer end of piston 51 and the inner end area of enlarged head 52 is the area controlling the force holding vane 17 on cam 7.

When vane 17 is passing through working zone 44 the fluid pressure is on the trailing side of vane 17 and on the outer end wide side area 45 urging vane 17 inwardly with fluid directed through port 49 to the inner end of the vane urging the vane outwardly and urging piston 51 inwardly with the fluid pressure force on the enlarged head 52 area urging piston and vane 17 outwardly with the difference of the sum of these area forces holding vane 17 on cam 7.

When vane 17 is passing through the outlet zone 31 there is no pressure on the outer or inner end of the vane or on the outer end of piston 51 with the area on the enlarged head 52 of piston 51 controlling the fluid force holding vane 17 on cam 7.

When passing through the neutral zone 55, while vane 17 is retarded into vane slot 40, the fluid pressure has changed to the leading side of the vane with narrow side area 42 on the outer end of the vane subjected to high intake fluid pressure urging vane 17 inwardly with high intake fluid pressure on enlarged head 52 urging piston 51 and vane 17 radially outward with the difference of these areas controlling the fluid force holding vane 17 on cam 7.

It is understood that many changes may be made in construction without affecting the principles involved in this invention.

Having described the enclosed invention, what I claim as new and desire to protect as Letters of Patent is:

1. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted to reciprocate in vane slots in said rotor forming with said housing low intake and high pressure discharge fluid chambers, pistons in said rotor bearing on the inner end of each of said vanes, outer end of said vanes having a single line sealing contact on the peripheral wall of said housing forming a narrow side area and a wide side area on opposite sides of said single line sealing contact exposed to fluid, said vanes urged radially inward when said outer ends are exposed to said high discharge fluid pressure on either side of said single line sealing contact, a port leading from said high discharge pressure fluid chamber to the inner end area of said pistons urging said pistons and said vanes radially outward, ports on said wide side area leading to the inner end area of each of said vanes and to the outer end area of each of said pistons, said inner end area of said vanes larger than said wide side area of said vanes, said inner end area of said pistons larger than said narrow side area of said vanes, said ports when subjected to said high discharge fluid pressure urging said vanes radially outward and said pistons radially inward, said ports said vanes and said pistons forming structural means directing said high fluid pressure hydraulically controlling a low sliding force of said vanes on said peripheral wall of said housing preventing fluid blow-by over the outer end of said vanes from said high to said low pressure chamber.

2. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted between face plates on a shaft for rotation in said housing, vanes mounted to reciprocate in vane slots in said rotor with the outer tip of said vanes bearing on a single sealing line contact on the peripheral wall of said housing forming low pressure inlet and high pressure discharge fluid chambers, said sealing line contact forming a narrow side area and a wide side area exposed to fluid on opposite sides of the outer end of said vanes, outer end of said vanes when subjected to said high discharge fluid pressure on either side of said sealing line contact between said high and said low pressure chambers urging said vanes radially inward, pistons mounted in said rotor bearing on the inner end of each of said vanes, ports on said wide side area of said sealing line contact leading from one of said fluid chambers to the outer end of each of said pistons and to the inner end of each of said vanes, said ports when subjected to said high fluid pressure urging said vanes radially outward and said pistons radially inward, a port leading from said high pressure discharge fluid chamber to the inner end of each of said pistons urging said pistons and said vanes radially outward, said high discharge fluid pressure on the inner end of said vanes or the inner end of said pistons over-balancing said radial inward force on said vanes controlling the sliding sealing force of said vanes on said peripheral wall between said high and said low pressure fluid chambers, a face plate floatingly mounted and held from rotating between said housing and said rotor with not more than running clearance between said rotor and said face plates allowed for lubrication at operating temperature, said face plate of a material having greater coefficient of expansion than that of said housing said rotor and said vanes permitting additional running clearance between said rotor and said face plates for lubrication reducing friction heat between said rotor and said face plates during cold starts while said device is warming up to operating temperature equalizing expansion of said device parts preventing wear and scoring.

3. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted to reciprocate in vane slots in said rotor forming with said housing low intake and high pressure discharge fluid chambers, pistons in said rotor bearing on the inner end of each of said vanes, outer end of said vanes having a single line sealing contact on the peripheral wall of said housing forming a narrow side area and a wide side area on opposite sides of said single line sealing contact exposed to fluid, said vanes urged radially inward when exposed to said high discharge fluid pressure on either side of said single line sealing contact, a port leading from said high discharge pressure fluid chamber to the inner end area of said pistons urging said pistons and said vanes radially outward, ports on said wide side area leading from one of said chambers to the inner end area of each of said vanes and to the outer end area of each of said pistons, said high discharge fluid pressure on a larger area on said inner end of said pistons or a larger area on said inner end of said vanes forming hydraulic means overbalancing said radial inward pressure force on said vanes controlling the sliding fluid force of said vanes on said peripheral wall on said housing, axially aligned grooves in said rotor and said shaft, said rotor mounted on said shaft on balls in said grooves forming means of rotating said rotor, said balls centered in said rotor by springs linked to rings forming a retainer but free to roll axially in said grooves to accommodate axial movement of said shaft without transmitting axial shaft movement to axial thrust movement of said rotor against one end of said housing preventing hydraulic unbalance of said rotor, said balls mounted loosely in said grooves permitting said shaft to flex when driven by pulley or gear without tipping said rotor.

4. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted on a shaft for rotation between face plates in said housing, balls mounted in axially aligned grooves in said shaft and said rotor, said balls centered in said rotor by springs linked to rings, said balls while rotating said rotor free to roll axially with said shaft in said grooves permitting said rotor to float between said face plates,

vanes mounted to reciprocate in vane slots in said rotor with the outer end of said vanes bearing on a single line contact on the peripheral wall of said housing forming low and high pressure fluid zones, said single line contact forming a narrow side area and a wide side area exposed to fluid on opposite sides of said single line contact, pistons mounted in said rotor bearing on the inner end of each of said vanes, ports on said wide side area leading to the inner end of each of said vanes and to the outer end of each of said pistons, a port leading from said high pressure fluid zone to the inner end of each of said pistons urging said pistons and said vanes radially outward, said vanes urged radially inward when subjected to said high fluid pressure on said narrow side area only of said vanes with a larger area on said pistons over-balancing said inward fluid force controlling the sliding fluid force of said vanes on said peripheral wall, said vanes urged radially inward when subjected to said high fluid pressure on said wide side area only with the fluid forces balanced out on said pistons and with a larger area on the inner end of said vanes urging said vanes radially outward over-balancing said radial inward force controlling the sliding fluid force of said vanes on said peripheral wall of said housing, one of said face plates floatingly mounted and held from rotating between said housing and said rotor with not more than running clearance allowed for lubrication between said rotor and said face plates at operating temperature, said face plate of a material having greater coefficient of expansion than that of said housing said rotor and said vanes permitting additional running clearance for lubrication reducing friction heat between said rotor and said face plates during cold starts while said device is warming up to operating temperature equalizing expansion of said device parts preventing wear and scoring.

5. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted on a shaft for rotation in said housing, vanes mounted to reciprocate in vane slots in said rotor with the outer end of said vanes bearing on a single line contact on the peripheral wall of said housing forming high pressure intake and low pressure discharge fluid chambers, said single line contact forming a narrow side area and a wide side area on opposite sides of the outer end of said vanes exposed to fluid, pistons mounted in said rotor bearing on the inner end of said vanes, enlarged heads on the inner end of said pistons, a port leading from said high pressure intake fluid chamber to the inner end of said enlarged piston heads urging said pistons and said vanes radially outward, a port at the outer end of said enlarged piston heads leading to said low pressure side of said device preventing a fluid lock of said pistons, ports on said wide side area of said single line contact leading from one of said fluid chambers to the inner end of each of said vanes and to the smaller outer end of each of said pistons, said vanes urged radially inward when subjected to said high fluid pressure on said narrow side area only of said single line contact with said high fluid pressure force on said enlarged piston heads over-balancing said radial inward fluid pressure force controlling the sliding sealing force of said vanes on said peripheral wall between said high and said low pressure fluid chambers, said vanes urged radially inward when subjected to said high fluid pressure from said intake fluid chamber on said wide side area only of said single line contact with said high fluid pressure on the outer smaller end of said pistons urging said pistons radially inward and said high fluid pressure on the inner end of said vanes urging said vanes radially outward with the sum of outward fluid forces over-balancing said inward fluid forces controlling the sliding sealing fluid force of said vanes on said peripheral wall between said high and said low fluid pressure chambers, said fluid forces balanced out on said vanes when exposed to said high fluid pressure on their outer ends and inner ends with said high fluid pressure on the inner end of said enlarged piston heads over-balancing said fluid pressure force on the smaller outer end of said pistons forcing said vanes to follow out on a ramp on said peripheral wall, said vanes when passing through said low pressure discharge fluid chamber urged radially inward into said vane slots by a ramp on said peripheral wall against said high fluid pressure on said enlarged piston heads.

6. In a rotary vane type energy translating device comprising a housing, inlet and outlet ports, a rotor mounted on a shaft for rotation between face plates in said housing, vanes mounted to reciprocate in vane slots in said rotor with the outer end of said vanes bearing on a single line contact on the peripheral wall of said housing forming low and high pressure zones, said single line contact forming a narrow side area and a wide side area on opposite sides of the outer end of said vanes exposed to fluid, pistons mounted in said rotor bearing on the inner end of each of said vanes, ports on said wide side area leading from one of said fluid zones to the inner end area of each of said vanes and to the outer end area of each of said pistons, a port from said high pressure fluid zone leading to the inner end area of each of said pistons urging said pistons and said vanes radially outward, said vanes urged radially inward when subjected to said high fluid pressure on said narrow side area only with a larger area on the inner end of said pistons over-balancing said inward fluid pressure force controlling the sliding fluid force of said vanes on said peripheral wall of said housing, said vanes urged radially inward when subjected to said high fluid pressure on said wide side area only with the fluid forces balanced out on said pistons and with a larger area on the inner end of said vanes urging said vanes radially outward over-balancing said radial inward force controlling the sliding fluid force of said vanes on said peripheral wall of said housing, one of said face plates floatingly mounted and held from rotation between said housing and said rotor with not more than running clearance allowed for lubrication between said rotor and said face plates at operating temperature, said face plate of a material having greater coefficient of expansion than that of said housing said rotor and said vanes permitting additional running clearance for lubrication reducing friction heat between said rotor and said face plates during cold starts while said device is warming up to operating temperature equalizing expansion of said device parts preventing wear and scoring.

7. In a rotary vane type pump comprising a housing, intake and discharge ports, a cam, a rotor mounted on a shaft for rotation between face plates, vanes mounted to reciprocate in vane slots in said rotor with their outer ends bearing on a single line contact on the inner wall of said cam forming low intake and high pressure discharge fluid chambers, pistons mounted in said rotor bearing on the inner end of each of said vanes, said single line contact at one side of center of said vanes forming a narrow side area and a wide side area between said cam and the outer end of said vanes exposed to fluid, ports on said wide side area leading from one of said fluid chambers to the inner end area of each of said vanes and to the outer end area of each of said pistons, a port leading from said high pressure discharge fluid chamber to the inner end area of each of said pistons, said vanes when passing through said low intake pressure fluid chamber with said high discharge fluid pressure on the inner end area of said pistons urging said pistons and said vanes radially outward controlling the fluid force holding said vanes on said cam, said narrow side area only when subjected to said discharge fluid pressure urging said vanes radially inward with said high discharge fluid pressure on a larger area on the inner end of said pistons urging said pistons and said vanes radially outward with the difference in these areas controlling the fluid force holding said vanes on said cam, said vanes when passing through said high pressure discharge fluid chamber with the fluid pressure

forces balanced out on said vanes and said pistons urged radially inward into said vane slots by a ramp on said cam against centrifugal force only, said wide side area only when subjected to said high discharge fluid pressure urging said vanes radially inward balancing out the fluid forces on said pistons with a larger area on the inner end of said vanes urging said vanes radially outward with the difference in these areas controlling the fluid force holding said vanes on said cam.

8. In a rotary machine comprising a housing, end plates, a rotor mounted on a shaft for rotation in said housing, a face plate floatingly mounted between said rotor and one of said end plates and held from rotation with not more than running clearance for said rotor allowed for lubrication at operating temperature, said face plate of a material having greater coefficient of expansion than that of said housing and said rotor providing additional running clearance for lubrication for said rotor during cold starts reducing friction heat while said machine is warming up to operating temperature equalizing expansion of said machine parts preventing a metal to metal contact to result in wear and scoring.

9. In a rotary machine comprising a housing, a shaft, a rotor mounted for rotation between face plates in said housing with not more than running clearance allowed for lubrication between said rotor and said face plates at operating temperature, axially aligned grooves in said shaft and said rotor, said rotor mounted on said shaft on balls in said grooves floating said rotor between said face plates and forming means of rotating said rotor, one of said face plates floatingly mounted but held from rotating of a material having greater coefficient of expansion than that of said rotor and said housing providing additional running clearance between said face plates and said rotor during cold starts reducing friction heat while said machine is warming up to operating temperature equalizing expansion between said machine

parts preventing a metal to metal contact to result in wear and scoring.

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