Dec. 6, 1960 R. B. PETTIBONE 2,962,973

POWER TRANSMISSION

Filed July 23, 1958

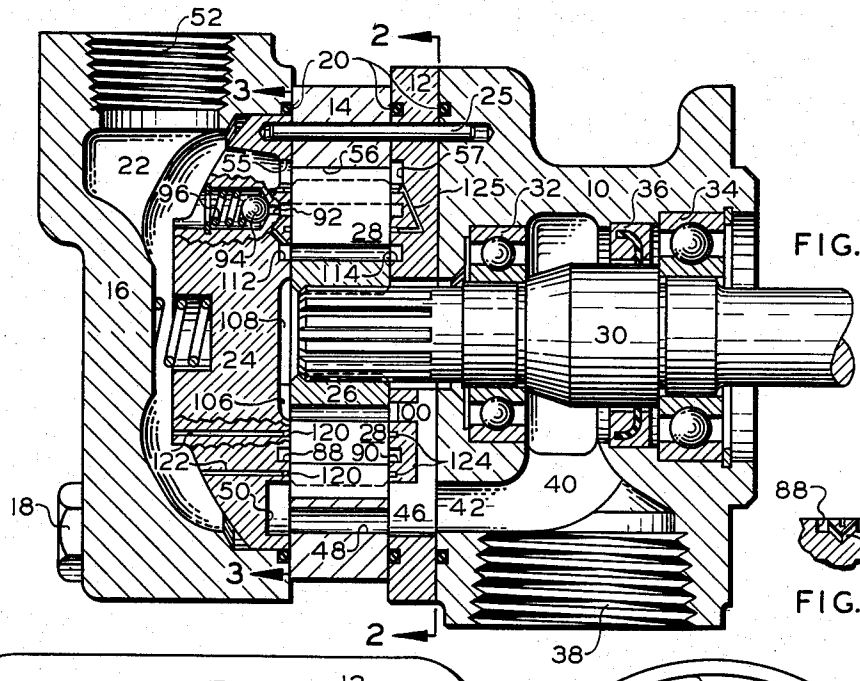


FIG. 1

FIG. 6

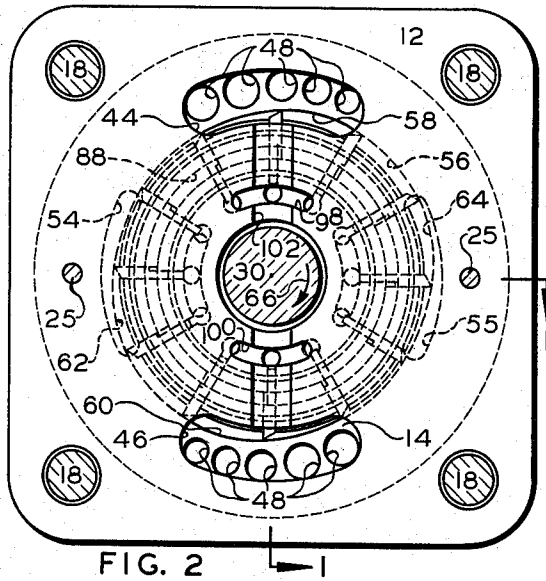


FIG. 2

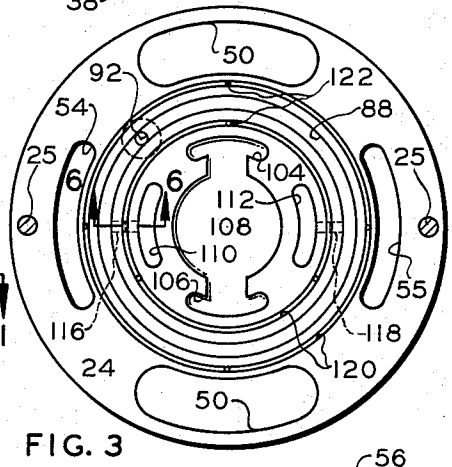


FIG. 3

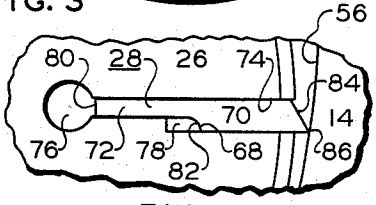


FIG. 4

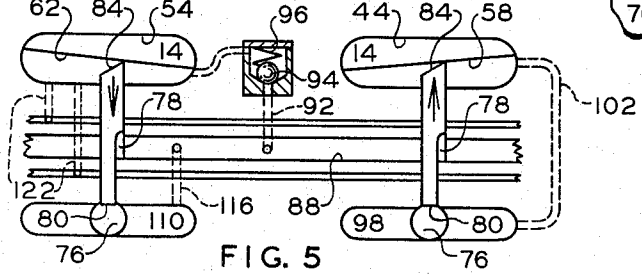


FIG. 5

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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 of which may function as a pump and another as a fluid motor.

More particularly the invention relates to a rotary, vane type pumping unit having a vane track against which the vanes are biased to cause in and out movement, so as to generate a pumping action.

In order to pump effectively it is necessary that the ends of the vanes be kept in continuous contact with the vane track. Since pressure forces on the outer ends of vanes traversing the pressure ramps tend to cause the vanes to leave the track, it is necessary that these pressure forces be balanced, either mechanically or by applying pressure to the opposite end of the vane. Mechanical counterbalancing is impractical for high pressures. Hydraulic counterbalancing has been accomplished by the prior art in a variety of ways.

One of the earliest and still most widely used forms of pressure counterbalancing is that in which outlet pressure is continuously conducted to the full underside area of all the vanes. While this has proved to be a simple and relatively effective device for maintaining the vanes in contact with the vane track, practical considerations have resulted in a maximum operating pressure of the order of 1000 p.s.i. This is due to the fact that the vanes traversing the suction ramp of the vane track have only the low, inlet pressure on the outer end, although the inner end is continuously subjected to the high, outlet pressure. At pressures above approximately 1000 p.s.i. the oil film between the suction ramp of the vane track and the ends of the vanes tends to break down and the vane track and vanes are soon worn beyond usability. An additional disadvantage of these devices is that the vanes traversing the pressure ramp, although fully balanced hydraulically, sometimes "skip" or leave the track for brief periods even though centrifugal force continuously urges them toward the vane track.

Another approach to the problem of maintaining contact between the end of the vane and the vane track has been to fully balance the vane as it traverses both the pressure ramp and the suction ramp by the use of porting which maintains the pressure on both the inner and outer end of each vane substantially in phase and equal. Units of this type have been found to be capable of considerably higher pressures than those units discussed above in which outlet pressure is continuously imposed on the inner end of the vanes. Two main difficulties have been encountered in devices which employ phased, equal pressures on the inner and outer ends of the vanes. One of these difficulties is that the same previously discussed "skipping" of the vanes traversing the pressure ramp has been encountered. Another difficulty is that at high speed, centrifugal force is inadequate to insure continuous contact between the vane and the vane track as the vanes traverse the inlet ramp.

It is an object of this invention to provide an improved high speed, high pressure vane pump.

More particularly it is an object of this invention to provide a vane pump in which the vanes are continuously and positively urged into engagement with the vane track but in which the magnitude of the biasing force is small enough to avoid excessive wear between the vane and the track.

It is also an object of this invention to provide a vane pump in which the pressure forces on each vane are in a continuous and controlled outward unbalance while the vanes traverse both the inlet and outlet ramps.

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

In the drawing:

Figure 1 is a longitudinal section through pumping mechanism embodying the present invention and taken on line 1—1 of Figure 2.

Figure 2 is a section taken on line 2—2 of Figure 1.

Figure 3 is a section taken on line 3—3 of Figure 1.

Figure 4 is an enlarged fragmentary view of a portion of a vane and associated structure.

Figure 5 is a schematic drawing illustrating the hydraulic circuitry of the present invention.

Figure 6 is a fragmentary section taken on line 6—6 of Figure 3.

Referring to Figure 1 there is shown a body 10, a wear plate 12, a ring 14 and a head 16. These members are held together by a plurality of bolts 18, and are sealed at their junctures by O-rings 20. The head member 16 includes a pressure chamber 22 in which is disposed a pressure plate 24 which abuts the ring 14. Dowel pins 25 maintain angular alignment of body 10, wear plate 12, ring 14, and pressure plate 24. Disposed between the wear plate 12 and the pressure plate 24 is a rotor 26 which carries a plurality of vanes 28. The width of ring 14 is slightly greater than the width of rotor 26 and vanes 28 so as to provide a small running clearance. Pressure in chamber 22 is imposed on pressure plate 24 so as to maintain the running clearance substantially constant regardless of pump outlet pressure.

The rotor 26 is supported on and driven by a shaft 30, which is rotatably supported in bearings 32 and 34 in body member 10. A shaft seal 36 prevents leakage from the body 10 at the point of egress of shaft 30.

The body member 10 includes an inlet port 38 which leads to an inlet cavity 40. A pair of branched passages 42, only one of which is shown in Figure 1, extend to the face of body 10 which abuts wear plate 12, and communicate respectively with inlet ports 44 and 46 in the wear plate 12.

In the region of inlet ports 44 and 46 a plurality of cross-over holes 48 extend through the ring 14 to communicate with a pair of blind ports 50 in the pressure plate 24. Ports 50 are mirror images of ports 44 and 46.

Head member 16 includes an outlet port 52 which leads from the pressure chamber 22. A pair of diametrically opposed pressure ports 54 and 55, only one of which is shown in Figure 1, effect communication between the rotor chamber and pressure chamber 22. A pair of blind ports 57 are provided in wear plate 12 to axially balance rotor 20 and vanes 28. Ports 57 are mirror images of ports 54 and 55, only one being shown in Figure 1.

The ring member 14 forms a generally elliptical vane track 56 which surrounds rotor 26 and vanes 28. The vane track includes a pair of diametrically opposed inlet ramps 58 and 60 across which the vanes move outward as the rotor turns, and a pair of diametrically opposed outlet ramps 62 and 64 which urge the vanes inward.

True-arc portions of the vane track connect the inlet and outlet ramps.

The structure so far described is conventional and it will be recognized by anyone skilled in the art that, as rotor 26 turns in the direction indicated by arrow 66 in Figure 2, fluid will be taken into the spaces between adjacent vanes at the inlet ports 44 and 46 and that that fluid will be discharged through the outlet ports 54 and 55 at an increased pressure.

Referring now to Figure 4, it will be noted that the vanes 28 include a step 68 which extends the full width of the vane, thus resulting in a vane having a thick outer portion 70 and a narrower inner portion 72. The vane slots 74 are stepped so as to snugly receive both the thick outer portion 70 and the narrower inner portion 72. There is thus formed beneath each vane a pressure chamber 76 and a pressure chamber 78. It should be noted that the thickness of step 68 is approximately one-half the thickness of the narrow portion 72 of the vane 28. Thus each vane 28 presents a relatively large area 80 to the pressure existing in chamber 76 and a relatively small area 82 to the pressure existing in the chamber 78. The outer end of each vane 28 is chamfered at 84 so as to make contact with the vane track 56 only at the leading edge 86, thus exposing substantially the entire outer area of each vane to the pressure existing between it and its following vane.

Pressure plate 24 is provided with a trenched, annular groove 88, and wear plate 12 has a similar trenched annular groove 90 of the same dimensions as groove 88. Grooves 88 and 90 communicate with the chambers 78 which, as heretofore noted, impose pressure on the step areas 82 of each vane. The registry between groove 88 and the chamber 78 can be clearly seen in Figure 2.

A drilled passage 92 extends from the groove 88 to communicate with the pressure chamber 22 across a one-way, back pressure valve 94. Valve 94 is urged by a spring 96 in a direction such as to block flow from pressure chamber 22 into the groove 88. The spring 96 is selected to have a load value such that the pressure in groove 88 must exceed the pressure in pressure chamber 22 by a desired amount before fluid can flow from groove 88 into pressure chamber 22. In a particular unit which gave excellent performance, spring 96 was so selected that the pressure in groove 88 was required to exceed outlet pressure by 25 p.s.i. before fluid could flow into pressure chamber 22.

A pair of ports 98 and 100 extend through the wear plate 12 and communicate through a radial groove 102 with the inlet ports 44 and 46 and the main inlet port 38. A pair of ports 104 and 106 in pressure plate 24 are mirror images of ports 98 and 100 and they communicate through a trenched central recess 108 with the drive shaft opening, through rotor 26, and thence with the inlet cavity 40. Ports 98 and 100 have an arcuate length substantially coextensive with that of inlet ports 44 and 46, and are radially located so as to communicate with the chamber 76 at the inner end of each vane.

A second pair of ports 110 and 112 in pressure plate 24 are radially positioned so as to communicate with the undervane chambers 76 and have an arcuate length substantially coextensive with the arcuate length of outlet ports 54 and 55. Axial balance of the rotor 26 is maintained by a pair of ports 114, only one of which is shown in Figure 1, which are mirror images of ports 110 and 112. Ports 110 and 112 are connected by drilled passages 116 and 118 with the annular groove 88, as can best be seen by reference to Figure 6.

A pair of barrier grooves 120 are trenched in the face of pressure plate 24. One of the grooves 120 is outward of groove 88 and the other is inward thereof. Barrier grooves 120 communicate with the pressure chamber 22 through a plurality of drilled passages 122. A similar pair of barrier grooves 124 are trenched into the face or wear plate 12 and are mirror images of barrier grooves 120. Grooves 124 are connected to the pump outlet through drilled passages 125 which effect communication with the blind ports 57. Since the barrier grooves 120 completely surround the groove 88 and since the barrier grooves 124 completely surround the groove 90, and further, since grooves 120 and 124 are continuously subjected to pump outlet pressure, it will be understood that there will be very little tendency for radial fluid flow from either of the grooves 88 or 90 through the running clearance space. Grooves 120 and 124 do not communicate with either the chambers 76 or 78.

Operation of the device can best be understood by reference to Figure 5, where a first vane is shown traversing one of the outlet ramps 62 and a second vane is shown traversing one of the inlet ramps 58. It will be understood that the first vane is representative of all inward moving vanes and that the second vane is representative of all outward moving vanes. Referring first to the vane traversing the outlet ramp 62, it will be noted that full outlet pressure will be imposed on the entire outer end 84 of the vane. Since the vane traversing the outlet ramp 62 is moving inward, fluid will be displaced from chamber 76. This fluid will pass through the conduit 116 to the groove 88, which is in communication with the chamber 78 of the outward moving vane. It will be clear that, since at any particular instant a substantially equal number of vanes are simultaneously moving in and out, fluid displaced from the chambers 78 associated with the inward moving vanes will be received by the chambers 78 associated with the outward moving vanes. Thus with the exception of leakage, the fluid requirement of the system comprising the grooves 88 and 90 and the chambers 78 associated therewith is only that quantity required to replace leakage. Since fluid is being discharged into groove 88 by the sets of vanes moving over both outlet ramps 62 and 64, an excess fluid will be discharged from the chambers 76 into the groove 88. The excess fluid has only one place to go and that is through the passage 92 and over the back pressure valve 94, to the pump outlet. As heretofore noted, the fluid cannot pass over back pressure valve 94 until the pressure in groove 88 exceeds the pressure in the outlet port by a predetermined amount. It will thus be apparent that the vane moving over one of the outlet ramps 62 or 64 will be positively urged outward by a hydraulic force which is the product of the sum of areas 80 and 82 and the pressure differential existing across back pressure valve 94. Thus the outward pressure bias on a vane traversing an outlet ramp can be easily established at any desired optimum value to maintain the desired vane tracking, and at the same time avoid wear, by proper selection of spring 96.

Considering now the vane traversing the inlet ramp 58, it will be seen that the outer end area 84 is exposed only to inlet pressure while, at the same time, the area 82 of the step is exposed to a pressure slightly higher than outlet pressure. Thus the vane will be positively urged outward against the vane track. This outward bias against the inlet ramp can be controlled so as to maintain the desired tracking, and yet stay below excessive wear inducing proportions, by a proper selection of the area of step 82. The large area 80 has no outward force producing effect on the vanes traversing the inlet ramp, since it is connected by the conduit 102 to the inlet port.

The barrier grooves 120 and 124 are not required for some service conditions. However, it has been found that if the unit is to operate at elevated temperatures, these grooves maintain leakage from grooves 88 and 90 within acceptable limits, so as to insure an adequate fluid supply for maintaining the vanes in contact with the vane track.

There has thus been provided a simple, low cost, vane pump in which the vanes are positively biased outward by a controlled, pressure produced force, while traversing both the inlet and outlet ramps. Tracking of the

vanes is assured, while at the same time, excessive wear is eliminated.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous, common fluid communication with all the small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a passage effecting fluid communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

2. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous common fluid communication with all the small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a passage effecting fluid communication between said outlet port and said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

3. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes aganist the track; a first port in continuous, common fluid communication with all the small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a passage effecting fluid communication between said outlet port and said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure, said means comprising a one-way, back pressure valve interposed between the outlet port and said first and second ports.

4. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous, common fluid communication with all the small areas; second port means in fluid communication with the large areas of all vanes traversing any pressure ramp; a passage effecting fluid communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

5. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous, common fluid communication with all the small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a third port effecting fluid communication between the inlet port and the large area of vanes traversing a suction ramp; a passage effecting communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

6. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous, common fluid communication with all the small areas; second port means in fluid communication with the large areas of all vanes traversing any pressure ramp; third port means effecting fluid communication between the inlet port and the large area of all vanes traversing any suction ramp; a passage effecting fluid communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

7. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in fluid communication with the small areas; a barrier port in fluid communication with the pump outlet and contiguous to said first port, said barrier port being isolated from at least said small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a passage effecting fluid communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

8. In a vane type pump having inlet and outlet ports, the combination of: a rotor; a plurality of slots in said rotor; a vane slidable in each of said slots; a vane track having at least two suction ramps and two pressure ramps; separate surfaces providing large and small areas mechanically associated with each vane, said areas being so oriented as to be effective under pressure to urge the vanes against the track; a first port in continuous, common fluid communication with all the small areas; a barrier port in fluid communication with the pump outlet and contiguous to said first port, said barrier port being isolated from at least said small areas; a second port in fluid communication with the large area of vanes traversing a pressure ramp; a passage effecting fluid communication between said first and second ports; and means associated with said passage for maintaining the pressure in said first and second ports a predetermined amount above outlet pressure.

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