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DRY ROTARY VANE PUMP

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FIG. 1

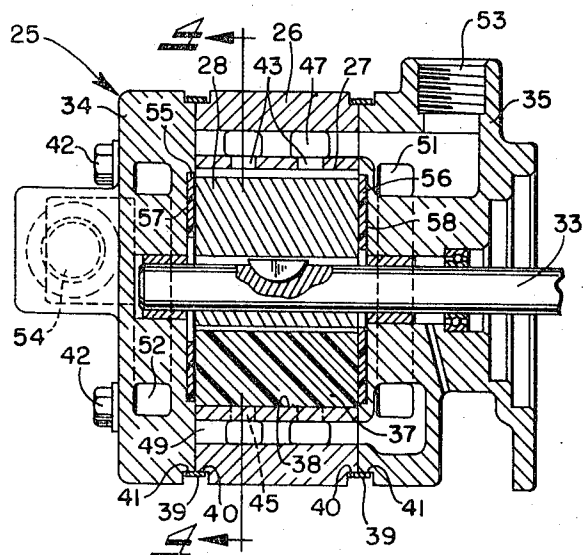
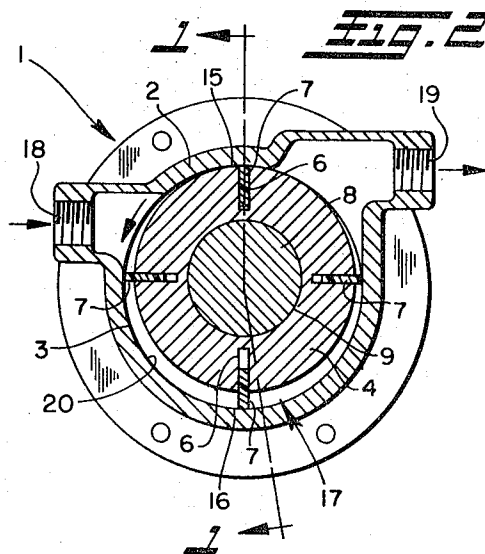
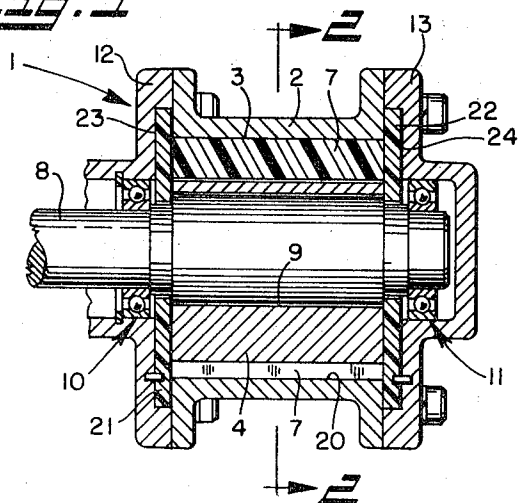


FIG. 3

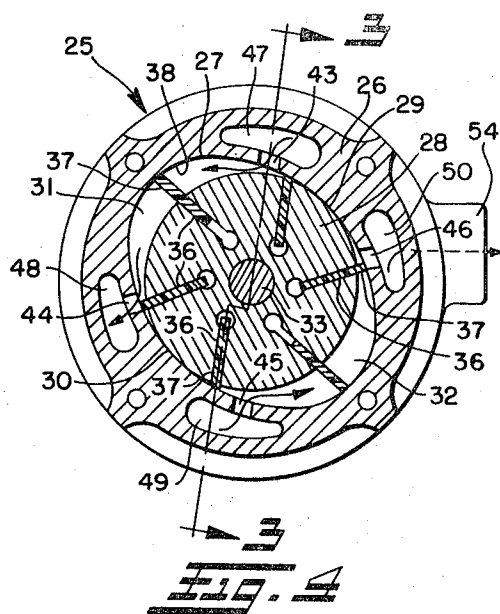


FIG. 4

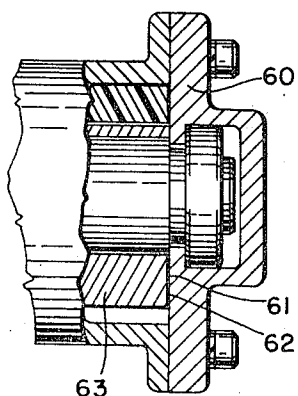


FIG. 5

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DRY ROTARY VANE PUMP

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10 Claims

ABSTRACT OF THE DISCLOSURE

A dry rotary vane pump having an aluminum bore and rotor with a hard aluminum oxide coating to inhibit wear caused by sliding friction between parts. A Teflon or like plastic coating may be applied to the external surfaces of the rotor to further reduce wear and eliminate the need for wear plates at the ends of the rotor.

BACKGROUND OF THE INVENTION

This invention generally relates to a dry rotary vane pump particularly adapted for use in air-assist starting of gas turbine engines and for providing pressure or vacuum on light aircraft which is very efficient and lightweight and may be manufactured at relatively low cost without affecting the life of the pump.

There are a large number of known different types of pumps which may have one or more of the desirable characteristics noted above, but generally not all of them, which often makes a particular pump unsuitable or at least not entirely satisfactory for a particular application. Thus, for example, a pump which is very efficient may be too heavy for aircraft use, or if both efficient and lightweight it may yet be unsuitable because it is too costly, too short lived, or not sufficiently reliable.

SUMMARY OF THE INVENTION

With the foregoing in mind, it is a principal object of this invention to provide a very efficient, lightweight rotary vane pump which may be manufactured at relatively low cost without sacrificing pump life or reliability.

Another object is to provide such a pump which runs cooler than comparable pumps made out of ferrous metals and has a higher resistance to corrosion.

These and other objects of the present invention may be achieved by making the pump bore and rotor out of aluminum which has been hard coated with an aluminum oxide coating to inhibit wear caused by sliding friction between the various pump components. The rotor blades or vanes are desirably made of carbon or may be of a suitable phenolic, and the external surfaces of the rotor may also have a supplemental plastic coatings of Teflon or the like to eliminate the need for wear plates at the ends of the rotor.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features herein-after fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of a few of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a substantial longitudinal section through a preferred form of pump constructed in accordance with this invention, taken on the plane of the line 1-1 of FIG. 2;

FIG. 2 is a transverse section through the pump of FIG. 1, taken on the plane of the line 2-2;

FIG. 3 is a substantial longitudinal section through a

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modified form of pump in accordance with this invention, taken on the plane of the line 3-3 of FIG. 4;

FIG. 4 is a transverse section through the pump of FIG. 3, taken on the plane of the line 4-4 thereof; and

FIG. 5 is a fragmentary longitudinal section through one end of yet another form of pump constructed in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawing, and first especially to FIGS. 1 and 2 thereof, there is shown by way of example a preferred form of dry rotary vane pump 1 in accordance with this invention which generally comprises a pump housing 2 having an annular bore 3 therethrough in which is contained a generally cylindrical rotor 4. The rotor 4 has a plurality of circumferentially spaced substantially radially extending slots 6 therein which extend the entire axial length of the rotor and contain vanes or blades 7 having close sliding engagement with the sides of the slots. For eccentrically mounting the rotor 4 within the bore 3 there is provided a drive shaft 8 extending through a central opening 9 in the rotor and rotatably journaled in bearings 10 and 11 contained in end caps or covers 12 and 13 bolted or otherwise secured to opposite ends of the pump housing.

As clearly shown in FIG. 2, the rotor 4 has a close clearance with the inner surface of the bore 3 at 15 which clearance progressively increases in opposite directions from the place 15 of minimum clearance to a maximum clearance at 16 diametrically opposite the place 15 thus to provide a pumping chamber 17 between the rotor bore 3 and rotor 4. Air is drawn into the chamber 17 by the vanes 7 during rotation of the rotor 4 in one direction or the other through one of the ports 18 and 19 in the pump housing 2 which communicate with the chamber 17 on opposite sides of the area of minimum clearance and such air is carried by the vanes through the chamber where the air is compressed and expelled through the other port. Thus, for example, rotation of the rotor 4 in a counter-clockwise direction as viewed in FIG. 2 by the drive shaft 8 will cause air to be drawn in through the port 18 and carried through the chamber 17 by the vanes 7 for discharge through the port 19. Rotation of the rotor 4 in the reverse direction will cause a reverse flow of air from the port 19 to the port 18.

During such rotation of the rotor 4 in either direction, the vanes or blades 7 are urged radially outwardly by centrifugal force and exert a high unit force against the wall 20 of the bore 3, producing substantial sliding friction between the outer tips of the vanes and bore wall. The pressure differential within the pumping chamber 17 acting on opposite sides of the vanes 7 also forces the vanes against the trailing sides of the slots 6 thus to provide substantial sliding friction therebetween which is further increased due to the drag of the vane tips along the bore wall 20.

Such sliding friction between these various pump parts would ordinarily preclude the making of the pump housing 2 and rotor 4 out of aluminum despite its advantages of being lightweight and easily machineable where the pump is to be run dry without lubricants in the pumping chamber because of the high susceptibility of aluminum to abrasion. However, it has been found that aluminum may be used for the pump housing 2 and pump rotor 4 and the pump operated dry without reducing the life of the pump as compared to similar dry pumps utilizing ferrous type materials by providing a hard aluminum oxide coating of the type described, for example, in the U.S. Government Aerospace material specification AMS 2468A on the external surfaces of the rotor 4 (including the

slots 6) and bore wall 20, with carbon or phenolic vanes 7 and carbon wear plates 21 and 22 at opposite ends of the rotor to resist abrasion of the aluminum by the vanes and wear plates.

The rotor bore 4 may be finish ground and then hard coated preferably to a depth of between .002 inch and .003 inch, after which the hard coating itself may be ground or polished to decrease friction between the tips of the vanes 7 and bore wall 20. Although the hard coating need only be placed on the ends of the rotor 4 and on the walls of the rotor slots 7 where there is considerable sliding friction, it is usually more convenient to hard coat the entire outer surface of the rotor which has the advantage of giving enhanced corrosion protection to the entire outer surface. Moreover, if the minimum clearance at 15 between the rotor 4 and bore 3 is to be maintained very close, not only will the oxide coating be necessary on the external surface of the rotor, it may also be desirable or necessary to supplement the oxide coating on the rotor or bore wall with a Teflon or other plastic coating to reduce the abrasion which would ordinarily occur if the metallic surfaces of the rotor and bore wall contacted each other.

Recesses 23 and 24 are provided in the end caps 12 and 13 for the wear plates 21 and 22. Such recesses may extend slightly radially outwardly beyond the ends of the bore 3 for properly locating the wear plates 21 and 22 with respect to the ends of the rotor 4, and a suitably epoxy may also be used for securely holding the wear plates in place.

In FIGS. 3 and 4 there is shown another form of dry rotary vane pump 25 in which the housing 26 contains a generally ellipsoidal bore 27 rather than an annular bore as in FIGS. 1 and 2, and the rotor 28 is concentrically mounted therein and has a very close clearance at two places 29 and 30 diametrically opposite each other on the minor axis of the bore thus to provide two pumping chambers 31 and 32 which progressively increase in size in opposite directions from the places of minimum clearance. The rotor 28 is keyed to a drive shaft 33 suitably journaled in end covers 34, 35 bolted or otherwise secured to the ends of the housing as before, and has a plurality of circumferentially spaced generally radially extending slots 36 therein containing carbon or phenolic vanes 37 which are urged outwardly into frictional engagement with the bore wall 38 by centrifugal force during rotation of the rotor. Also as before, the housing 26 and rotor 28 are made of aluminum to provide a lightweight, low cost construction which has been provided with a hard aluminum oxide coating to resist abrasion of the sides of the slots 36 and bore wall 38 by sliding friction between the relatively moving parts. Moreover, because there are two pumping chambers 31 and 32, very close clearances must be maintained at the places 29 and 30 of minimum clearance, thus making it desirable to provide a supplemental Teflon coating over the aluminum oxide coating on the outer surface of the rotor to reduce abrasion in the event that contact occurs between the metal surfaces at these places. Alignment rings 39 or the like may be inserted over shoulders 40, 41 on the adjacent ends of the housing 26 and end covers 34, 35 during assembly for properly locating the various parts of the pump with respect to each other prior to tightening of the bolts 42.

One or more ports 43, 44, 45, 46 are provided in the housing 26 adjacent opposite ends of the pumping chambers 31, 32 and the ports 43, 45 and 44, 46 communicating with the same ends of the pumping chambers are desirably diametrically opposite each other so that when air is drawn into one set of the ports 43, 45 and pumped out of the other set 44, 46 during rotation of the rotor 28 in one direction or the other, the rotor will be pressure balanced. Each set of ports 43, 44, 45, 46 communicates with an axial passage 47, 48, 49, 50 in the housing 26 and the passages 47, 49 associated with the ports 43, 45

at one end of the pumping cylinders 31, 32 desirably communicate with each other through a semi-circular passage 51 in one of the end covers 35 and the passages 48, 50 associated with the ports 44, 46 at the other end of the pumping chambers communicate with each other through a similar passage 52 in the other end cover 34 so that only one inlet or outlet port 53 and 54 is required for both of the pumping chambers.

Carbon wear plates 55, 56 may also be provided adjacent the ends of the rotor 28 which are desirably disposed in recesses 57, 58 within the end covers 34, 35 where they may be retained in place by providing a slight overlap between the wear plates and the ends of the housing 26 in the regions of the minor axis, and a suitable epoxy may also be used for that purpose.

Alternatively, the wear plates 21, 22 and 55, 56 of the pumps of FIGS. 1 and 3 may be made out of aluminum which has been provided with a hard aluminum oxide coating on the inner face thereof or the wear plates and recesses therefor may be eliminated altogether and the entire end covers 60 made of aluminum as shown in FIG. 5. In either event the aluminum wear plates or end covers should be hard coated on the inner surface opposite the rotor ends, and a supplemental Teflon coating 61 should be placed over the ends 62 of the rotor 63 as well as around the outer circumference thereof to reduce the abrasion that would occur if there was direct metal to metal contact between the ends of the rotor and end covers as further shown in FIG. 5. Otherwise, the pump of FIG. 5 may be substantially the same as those previously described.

From the foregoing, it will now be apparent that the various pumps disclosed herein are made out of aluminum to reduce the weight of the pumps and permit them to be made at lower cost. Moreover, the hardened aluminum oxide coating which is placed on the bore and rotor surfaces reduces abrasion between the rotor and carbon vanes and wear plates, thereby substantially extending the life of the pumps, and also reduces corrosion. In actual tests, a pump made in accordance with this invention was run dry approximately 1000 hours and showed no sign of appreciable wear. The pump also ran cooler than comparable ferrous pumps because of the higher conductivity of aluminum and was more efficient. The pump was driven by a one half horsepower motor at 3600 r.p.m. and delivered 15 c.f.m. of air at 4 p.s.i. Its efficiency was approximately 50%. The entire weight of the pump and one half horsepower motor which was connected to the drive shaft for driving the rotor was only approximately 11 pounds.

I, therefore, particularly point out and distinctly claim as my invention:

1. A rotary vanepump comprising a housing containing a bore, a rotor, means mounting said rotor for rotation within said bore, said rotor defining with the wall of said bore a pumping chamber, a pair of ports communicating with opposite ends of said pumping chamber, said rotor having a plurality of circumferentially spaced slots containing vanes which are urged outwardly by centrifugal force into engagement with the wall of said bore for drawing air into said chamber through one of said ports and expelling the air through the other port during rotation of said rotor; wherein the improvement comprises the use of aluminum for said rotor and bore wall, with a hard aluminum oxide coating on the sides of said slots and said bore wall to reduce abrasion of the aluminum by said vanes.

2. The pump of claim 1 wherein said vanes are made of carbon to further reduce abrasion of the aluminum by said vanes.

3. The pump of claim 1 wherein said vanes are made of a phenolic material to further reduce abrasion of the aluminum by said vanes.

4. The pump of claim 1 wherein the ends of said rotor have a hard aluminum oxide coating thereon, and there are carbon wear plates adjacent the ends of said rotor to

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resist abrasion of the aluminum rotor by said wear plates.

5. The pump of claim 1 wherein the entire outer surface of said rotor has a hard aluminum oxide coating thereon.

6. The pump of claim 1 wherein the outer periphery of said rotor has a hard aluminum oxide coating thereon, and there is a plastic coating over the hard aluminum oxide coating on such outer periphery.

7. The pump of claim 6 wherein said plastic coating is Teflon.

8. The pump of claim 1 wherein the ends of said rotor also have a hard aluminum oxide coating thereon, and there are aluminum end covers adjacent the ends of said rotor having a hard aluminum oxide coating on the inner surface thereof, and a plastic coating on the ends of said rotor for resisting abrasion between the rotor and end covers.

9. The pump of claim 1 wherein said bore is annular and said rotor is eccentrically disposed within said bore to provide a close clearance with said bore wall at one place and define with said bore wall one of said pumping chambers, said rotor having a hard aluminum oxide coating on the outer periphery which is covered by a plastic coating to resist abrasion between said aluminum rotor and bore wall.

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10. The pump of claim 1 wherein said bore is elliptical and said rotor is concentrically disposed within said bore to provide a close clearance with said bore wall at two places diametrically opposite each other and define with said bore wall two of said pumping chambers, said rotor having a hard aluminum oxide coating on the outer periphery which is covered by a plastic coating to resist abrasion between said aluminum rotor and bore wall.

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U.S. Cl. X.R.,

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