

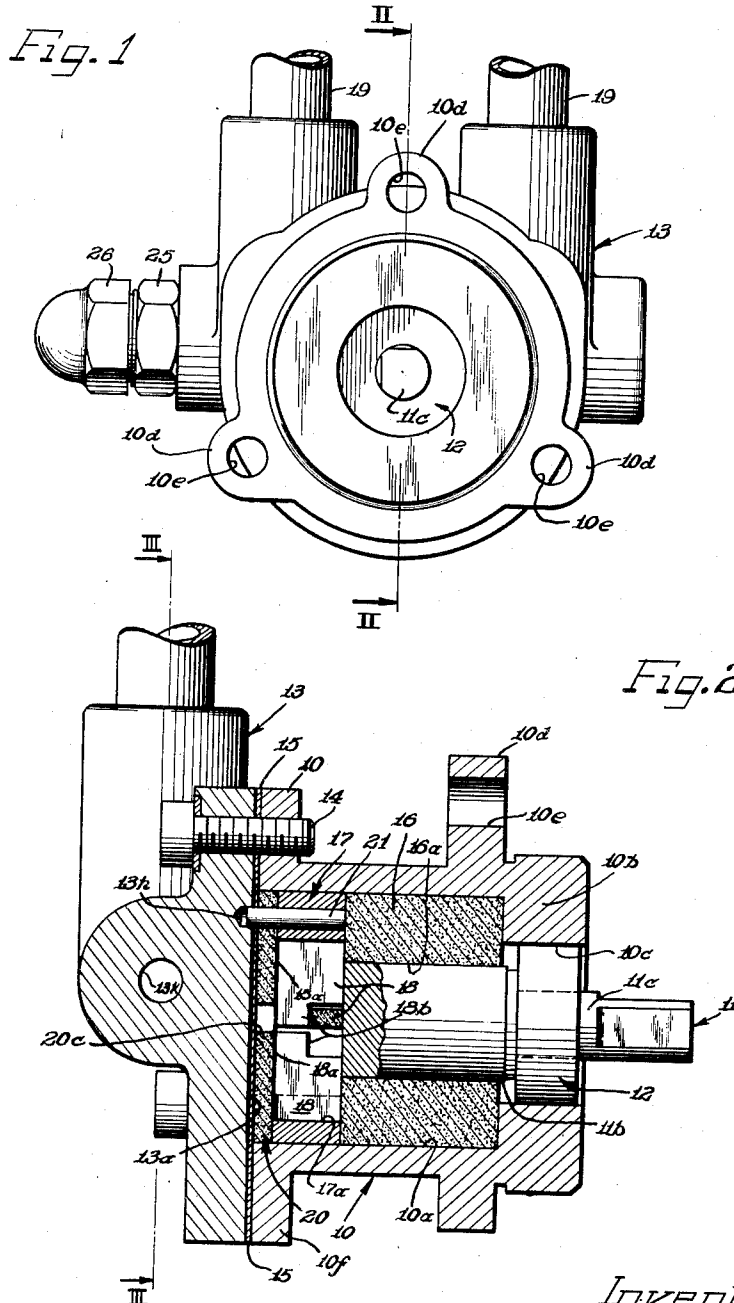
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F. E. SMITH ET AL
ROTARY VANE PUMP

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2 Sheets-Sheet 1



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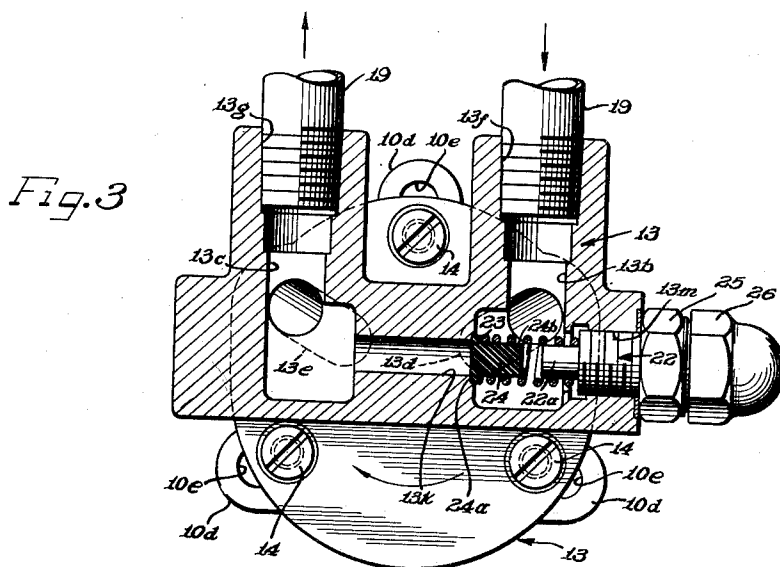
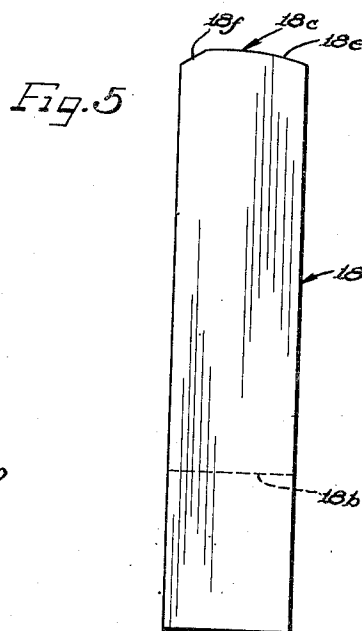
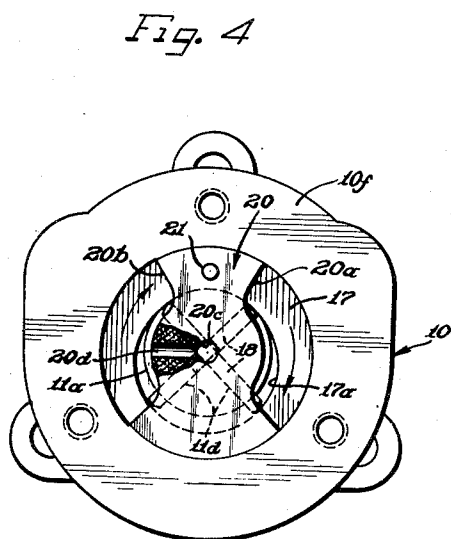
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UNITED STATES PATENT OFFICE

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ROTARY VANE PUMP

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9 Claims. (Cl. 103—136)

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This invention relates to improvements in the construction of rotary vane type pumps, and particularly to an economically manufacturable rotary vane pump capable of not only quieter but also longer operation before replacement of the wearable components of the pump is required.

A feature of this invention is the construction of a rotary vane pump in such manner that the vane-carrying rotor is supported in cantilever fashion within a pump casing. The slots in which the rotor vanes are mounted project through the axial end face of the rotor and hence permit the vanes to be mounted flush with such axial end face. Inlet and outlet ports are then provided in an end wall for the casing immediately adjacent to the aforesaid end face of the rotor and a thrust plate of antifriction material is interposed between the end face of the rotor and the aforesaid ported end wall for the casing. Such thrust plate not only provides bearing support for the rotor and rotor vane elements, but is apertured or recessed to provide fluid communication between the rotor vanes and the inlet and outlet ports in the casing end wall. The thrust plate is further apertured to bypass a portion of the discharge fluid pressure generated by the pump to the center of the rotor wherein the bypassed fluid is effective to urge the rotor vanes outwardly into snug engagement with the peripheral wall of the pumping chamber.

Still another feature of this invention is the initial shaping or preforming of the tips of the blades of vanes of a rotary vane pump in such manner that such tips initially have a configuration conforming to the tip configuration eventually achieved by a worn blade. In particular, the initial tip configuration of the vane is such as to provide a large surface engagement of the tip of the vane with that portion of the annular pumping chamber wall in the vicinity of the inlet port, and at all other portions of the pumping chamber wall, lesser area contact is maintained, approaching a line contact. Such construction permits the pump to be initially operated at its maximum efficiency and not only makes the pump substantially quieter in its initial operation but results in a substantially longer life of the wearable components of the pump due to elimination of all possibility of scouring the annular pumping chamber wall by the limited area frictional contact therewith suffered by vanes having conventional tip configuration.

Still another feature of this invention is the

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provision of an improved check valve arrangement for automatically bypassing a portion of the discharge fluid into the inlet of the pump when the discharge pressure exceeds a predetermined maximum. Furthermore, the construction of this invention permits convenient adjustment of the pump discharge pressure by adjustment of the spring bias maintained on the check valve.

Accordingly, it is an object of this invention to provide an improved rotary vane pump construction characterized by the unusual simplicity of manufacture and assembly of its components, quieter operation, and longer life of the wearing parts of the pump than has heretofore been possible of attainment.

A particular object of this invention is the provision of a rotary vane pump construction wherein a thrust plate of antifriction material is interposed between an axial end face of a vaned rotor and a ported end wall or cover for the pump casing, and wherein such thrust plate not only defines apertures providing communication between the inlet and discharge ports and the vaned portion of the pump rotor, but also defines a fluid passage for bleeding a portion of the discharge fluid pressure into the central portion of the rotor slots in which the vanes are mounted, thus urging the vanes outwardly into snug engagement with the annular wall of the pumping chamber.

Still another object of this invention is the provision of a simplified adjustable bias check valve arrangement for effecting control of the discharge pressure of a pump by selective bypassing of a portion of the fluid from the discharge side of the pump to the inlet side of the pump.

The specific nature of the invention as well as other objects and advantages thereof will become apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred example only, illustrate one specific embodiment of the invention.

On the drawings:

Figure 1 is a front end elevational view of an assembled rotary vane pump unit embodying this invention.

Figure 2 is a sectional view taken along the plane II—II of Fig. 1.

Figure 3 is a sectional view taken along the plane III—III of Fig. 2.

Figure 4 is an elevational view, partly in section, of the rear end of the pump with the end cap removed from the vane casing.

Figure 5 is a greatly enlarged scale, side eleva-

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tional view of a vane or blade element of a pump construction in accordance with this invention.

As shown on the drawings:

The major elements of the pump are assembled within a generally cup-shaped metallic casing 10 which defines a large cylindrical chamber 10a. The base portion 10b of the casing 10 is centrally apertured, as indicated at 10c, to accommodate a conventional fluid sealing unit 12 for journaling the shaft portion 11c of a rotor 11. The unit 12 includes an inner ring in sealing engagement with an end face or shoulder between the rotor portions 11b and 11c. An outer casing of the seal 12 seats tightly in the bore 10c. At spaced intervals around its periphery, casing 10 is provided with projecting ears or lugs 10d which are apertured as at 10e to permit the convenient mounting of the pump on a panel or similar supporting surface.

An outturned radial flange 10f is formed at the mouth of the casing 10 and an end cap 13 is bolted to the flange 10f to enclose the chamber 10a. A plurality of bolts 14 are employed for this purpose and a gasket 15 is interposed between the planar end face 13a of end cap 13 and the flange 10f of casing 10.

Within the chamber 10a, a sleeve type bearing 16, which is preferably formed of molded graphitic material, is snugly inserted, seating against the bottom wall 10b of the casing 10. An annular liner 17 of suitable non-corrosive metallic material is then mounted in the chamber 10a, abutting against the axial end face of the sleeve bearing 16. Liner 17 is provided with a pump bore 17a of desired contour, the axis of which is eccentrically disposed with respect to the axis of cylindrical chamber 10a. The bore 17a thus defines a pumping chamber for a rotary vane pump in conventional fashion.

The rotor 11 constitutes a unitary, cylindrical member having an enlarged head portion 11a disposed within the pumping chamber bore 17a, an intermediate diameter bearing portion 11b which is journaled in the bore 16a of bearing sleeve 16, and a reduced diameter shaft portion 11c which, as has already been mentioned, projects out of casing 10 through a sealing unit 12. The projecting end of rotor 11 is connected to a suitable driver (not shown).

Since the rotor 11 is journaled in only a single bearing sleeve 16 located on only one side of the pumping chamber 17a, the rotor 11 is of the "cantilever" type with the impeller or vane components being located on the projecting head portion 11a of the cantilever type rotor 11.

The head portion 11a has a plurality of circumferentially spaced slots, here shown as two slots 11d disposed at 90° with respect to each other, milled entirely through said head portion and opening both in the axial end face of the rotor head portion and in the peripheral wall surface. Shiftable vanes or blades 18 are then mounted in the slots 11d. Such vanes are of sufficient axial length so as to have their axial end faces 18a disposed substantially flush with the axial end face of the rotor. Two of such blades or vanes 18 are mounted in each of the slots 11d and the inner end portion of each of the blades 18 is reduced in width as indicated at 18b so that such may be assembled in overlapping relationship in the intersecting rotor slots 11d without interference.

The radial length of the blades 18 is such as to insure that such blades will contact the eccentrically disposed peripheral wall of the pumping

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chamber bore 17a. The outer tips 18c of the blades 18 are shaped in a peculiar fashion as will be described in more detail later.

As best shown in Fig. 3, the end cap 13 defines a pair of spaced passages 13b and 13c which at one end open in the planar end face 13a of the end cap 13 to function as inlet and outlet ports 13d and 13e respectively (Figure 3) for the pumping chamber 17a, and at their other ends connect with threaded counterbores 13f and 13g, which respectively receive threaded nipples 19 for effecting the connection of the pump in a fluid system in conventional fashion.

In accordance with this invention, a thrust plate 20 of disk-like configuration is mounted intermediate the outer axial end face of liner 17 and the planar end face 13a of the end cap 13. Such thrust plate is preferably formed of anti-friction material which, for example, may comprise molded graphite. As best shown in Fig. 4, the thrust plate 20 has segmental portions of the periphery cut away or apertured as indicated at 20a and 20b to respectively provide fluid communication to the inlet and outlet ports 13d and 13e in planar end face 13a of the end cap 13. In this manner, the inlet and discharge ports are placed in communication with annularly spaced regions of the vaned head portion 11a of the rotor 11. Because of the fact that the thrust plate 20 is formed of anti-friction material, only a few ten thousandths of an inch clearance relationship with axial end face 11e of the rotor is necessary, thus minimizing fluid leakage along such end face while at the same time maintaining the frictional resistance to the rotation of the rotor at a minimum. Thrust plate 20 not only provides anti-friction thrust bearing support for the rotor 11 against axial displacement, but also provides antifriction guide surfaces for guiding the radial movements of the vanes 18 within the rotor slots 11d.

In accordance with this invention, the thrust plate 20 may be further provided with a central hole 20c which communicates with the center of the intersecting rotor slots 11d. Furthermore, a radially extending passage 20d is then formed in thrust plate 20 providing fluid communication between the center hole 20c and the discharge port 13e of the pump. With this arrangement, a portion of the pressured fluid is withdrawn from the discharge side of the pump and applied to the radially inward faces of the vanes 18. Since the vanes 18 are snugly mounted within the rotor slots 11d, such pressure is effective in maintaining an outward bias upon the blades 18, such tending to maintain the tip ends of the blades in snug engagement with the peripheral wall of the pumping chamber.

To retain the liner 17, and hence the eccentric pumping chamber bore 17a in proper angular relationship with respect to the inlet and outlet ports, an axially extending pin 21 is provided which passes through suitable aligned holes in the liner 17, thrust plate 20, gasket 15 and the outer end thereof projects into a recess 13h formed in the planar end face of the end cap 13. Hence, once the end cap 13 is assembled to the pump, the liner is maintained in fixed angular relationship with respect to the inlet and discharge ports.

As will be recognized by those skilled in the art, since the pumping vanes or blades 18 are being rotated about an axis which is eccentric with respect to the pumping chamber bore 17a, it is not possible to provide any form of arcuate surface which

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will achieve a large area surface engagement with all portions of the pumping chamber bore 17a as the particular blade rotates therearound. In rotary vane pump constructions heretofore known it has been customary to round off the tip ends of the blades 18 prior to the initial assemblage of the pump and to use materials which are not supposed to wear. However, no known material will resist wear during severe pumping conditions and pre-designed rounded contours cannot be maintained.

In accordance with this invention, the tip ends of the blades 18 are preferably preformed to a configuration closely resembling that attained by the blade tips in their worn condition, i. e., after substantial operation in the pump. Since the discharge pressure is continuously maintained against the inner faces of the blades 18, irrespective of the angular position of the blades, it follows that the region of greatest blade tip pressure against the pump chamber bore exists adjacent the inlet port of the pump, for in this region the full pressure differential between the inlet and discharge sides of the pump is effective to urge the blades 18 radially outwardly into engagement with the pumping chamber bore. At all other angular positions of any particular blade 18 in the pumping chamber bore, less radial pressure is maintained on the blades, due to the fact that an inwardly directed component of pressure is produced upon the blade tips.

We have observed that the tip configuration of a worn blade invariably includes a substantially cylindrical segment surface configuration extending from the trailing edge of the blade toward and past the mid-region of the blade. Such configuration is indicated at 18e in the enlarged scale view of the blade 18 shown in Figure 5. Furthermore, the curvature of this cylindrical segmental surface portion 18e substantially conforms to the curvature of the pumping chamber bore surface 17a in the vicinity of the inlet port. This naturally follows from the fact that the same region produces the greatest radial pressure between the blade tip and the pumping chamber bore. As a result, in conventional rotary vane pump constructions wherein the configuration of the blade tip was merely rounded off with a radius having geometric relation with other dimensions of the vanes, rotor and pump chamber, the initial operation of the pump would produce an excessive wear of such blade tip portions until they achieved a configuration approaching that shown in Figure 5. Such rapid wear was due to the fact that substantially only line contact was being maintained between the blade tip and the pumping bore surface. Hence, the conventional pumps have not only been sluggish and inefficient in their initial operation until wear-in of the blade tips is accomplished, but they have been substantially noisier in initial operation.

Accordingly, as indicated above, this invention contemplates that the tip surfaces of the blades 18 will be preformed to a configuration substantially resembling the configuration assumed by pump blades after a break-in period of operation of the pump. A suitable configuration, illustrated in Figure 5 of the drawings, includes a cylindrical segment surface portion 18e which extends from the trailing edge of the blade toward and past the mid-region of the blade. In addition, a planar, chordal surface 18f is formed on the blade tip extending from the leading edge of the blade toward the mid-region of the blade but intersecting the cylindrical segment surface

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18f on the leading side of the mid-region of the blade. If desired, the surface 18f can be curved, since it corresponds to the original contour of a conventional blade.

The radius of curvature of the cylindrical segmental surface portion 18e of the blade tip is selected so as to substantially conform to the curvature of the eccentric pumping chamber bore surface 17a in the region of the inlet port. This, of course, does not mean that the radius of curvature of cylindrical segment surface 18e is swung about the axis of rotor 11, for it must be remembered that the axis of rotation of the blades 18 is substantially offset from the axis of the pumping chamber bore surface 17a.

When the blades 18 are formed of an antifriction material such as a molded graphite product, and the described tip configuration is applied to such blades, it has been found that the pump will immediately achieve substantially its maximum operating efficiency and will not only be much quieter in operation, but will operate for longer periods of time with less wear of the blades 18 and the pumping chamber bore surface 17a than conventional constructions. The elimination of the necessity for wearing in the proper blade tip configuration obviously eliminates all possibility of scratching or gouging the pumping chamber bore surface 17a during the initial operation of the pump.

A still further desirable feature of the pump embodying this invention is the incorporation of an adjustably biased check valve to permit the selective control of the discharge pressure of the pump. As best shown in Fig. 3, the end cap 13 has a transverse hole 13k formed therein which is in direct communication between the passages 13b and 13c connecting with the inlet and discharge ports 13d and 13e respectively. A larger diameter hole 13m, which, in effect, constitutes a counterbore of the hole 13k is drilled into the end cap 13 from the side adjacent the inlet passage 13b. This counterbore portion 13m is threaded to receive a bolt-like adjusting member 22. The inner end of adjusting member 22 has an integral rod-like extension 22a thereon which mounts one end of a valve spring 23. At the other end of spring 23, a valve element 24 is mounted. Valve element 24 is of bolt-like configuration and has a head portion 24a arranged to overlie the hole 13k, and an integral shank portion 24b which is snugly inserted within the end coils of spring 23.

With the described arrangement, the valve 24 is obviously maintained in spring-pressed closed engagement with the hole 13k, but the bias of spring 23 is opposed by the fluid pressure existing in the discharge passage 13c. Whenever the discharge fluid pressure exceeds the bias of spring 23, the valve 24 will be moved off its seat and sufficient fluid permitted to bleed from the discharge to the inlet side of the pump so as to maintain the discharge pressure below a predetermined maximum.

The adjusting member 22 may obviously vary the effective bias of the spring 23, hence the effective discharge pressure of the pump, by rotation of such member in the threaded counterbore 13m. A lock nut 25 and a cap nut 26 are mounted on the projecting portion of the adjusting member 22 to permit such member to be locked to the end cap 13 in any selected adjusted position. Gaskets are placed between the nuts 25 and 26 and between the cap 13 and nut 25. While not limited thereto, we have found it

particularly expedient to form the valve member 24 from a fairly rigid material which is yet sufficiently deformable as to have fluid sealing properties. For example, medium hard rubber makes an excellent material for fabrication of the check valve 24.

From the foregoing description it is apparent that this invention provides an improved rotary vane pump having a plurality of unusual features of construction and operation. Each of the components of the pump is readily manufacturable and the pump may be assembled without requiring any special tools or skill. The performance of the pump is maintained more uniform throughout its entire useful life and the useful life of the wearing parts of the pump is substantially improved. Furthermore, the pump embodies conveniently adjustable means for regulating the discharge pressure of the pump to suit varying application.

It will, of course, be understood that various details of construction may be modified through a wide range without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

We claim as our invention:

1. A rotary vane pump comprising a hollow casing defining a cylindrical chamber having a substantially planar end wall, said casing having inlet and outlet ports opening in said end wall, means defining a pumping chamber within said chamber and adjacent to said end wall, a rotor shaft having radial vane slots therethrough opening in both the peripheral surface and one end face of said rotor shaft, a bearing in said casing spaced from said chamber and journaling said rotor shaft as a cantilever for rotation in said chamber with said slotted portion disposed in said pumping chamber and said one end face of said rotor shaft opposed and parallel to said chamber end wall, vanes in said vane slots cooperating with said pumping chamber, and a thrust plate of antifriction material disposed intermediate said one end face and said chamber end wall, said thrust plate having apertures therethrough respectively aligned with said inlet and outlet ports.

2. A rotary vane pump comprising a hollow casing defining a cylindrical chamber having a substantially planar end wall, said casing having inlet and outlet ports opening in said end wall, a liner mounted in said chamber and defining an eccentrically disposed pumping chamber adjacent to said end wall, a rotor shaft having a planar end face and having radial vane slots therein opening in both the peripheral surface and said planar end face, a bearing in said casing spaced from said chamber and journaling said rotor shaft as a cantilever for rotation in said chamber with said slotted portion disposed in said pumping chamber and said planar end face of said rotor shaft opposed and parallel to said chamber end wall, vanes radially shiftable in said vane slots and cooperating with said pumping chamber, and a thrust plate of antifriction material disposed intermediate said planar end face and said chamber end wall, said thrust plate having apertures therethrough respectively aligned with said inlet and outlet ports, said thrust plate also defining a fluid passage communicating between said outlet port and the bottom surfaces of said vanes, whereby pump outlet pressure is applied to said vanes to urge said vanes radially outwardly into engagement with said liner.

3. A rotary vane pump comprising a hollow casing defining a cylindrical chamber having a substantially planar end wall, said casing having inlet and outlet ports opening in said end wall, a liner mounted in said chamber and defining an eccentrically disposed pumping chamber adjacent to said end wall, a rotor having radial vane slots therein opening in both the peripheral surface and one end face of said rotor, means journaling the other end of said rotor in said casing for rotation in said chamber with said slotted portion disposed in said pumping chamber and said one end face of said rotor opposed and parallel to said chamber end wall, vanes radially shiftable in said vane slots and cooperating with said pumping chamber, and a thrust plate of antifriction material disposed intermediate said one rotor end face and said chamber end wall, said thrust plate having apertures therethrough respectively aligned with said inlet and outlet ports, said thrust plate also having a central hole communicating with said rotor vane slots and a radial hole communicating between said central hole and said aperture which is aligned with said discharge port, whereby pump outlet pressure is applied to said vane through said thrust plate to urge said vanes radially outwardly.

4. A rotary vane pump comprising a hollow casing defining a cylindrical chamber having a substantially planar end wall, said casing having inlet and outlet ports opening in said end wall, a liner mounted in said chamber and defining an eccentrically disposed pumping chamber adjacent to said end wall, a rotor having radial vane slots therein opening in both the peripheral surface and one end face of said rotor, means journaling the other end of said rotor in said casing for rotation in said chamber with said slotted portion disposed in said pumping chamber and said one end face of said rotor opposed and parallel to said chamber end wall, vanes radially shiftable in said vane slots and cooperating with said pumping chamber, and a thrust plate of antifriction material disposed intermediate said one rotor end face and said chamber end wall, said thrust plate having apertures therethrough respectively aligned with said inlet and outlet ports, said thrust plate also defining a fluid passage communicating between said outlet port and the bottom surfaces of said vanes, whereby pump outlet pressure is applied to said vanes to urge said vanes radially outwardly, each of said vanes having a tip surface comprising a cylindrical segment surface extending from the trailing edge of the vane to a mid region thereof, and a planar chordal surface extending from said mid region to the leading edge of the blade, said cylindrical segment surface having a curvature selected to substantially correspond to the curvature of the annular pumping wall in the vicinity of the pump inlet port, whereby large area surface engagement of the blade tip is achieved in the vicinity of the inlet port.

5. In a rotary vane pump, a casing, a pumping chamber therein, a rotor extending into said pumping chamber and aligned coaxially therewith, a bearing in said casing spaced axially from said pumping chamber and journaling one end of said rotor for rotation in said pumping chamber, the innermost end of said rotor terminating in a hub portion having a planar end face, said pumping chamber having a bore providing a pumping cavity eccentrically offset relative to the axis of said pumping chamber and said rotor, a

plurality of radially aligned vanes slidably mounted in said hub portion of said rotor and arranged to be rotated in said pumping cavity with the ends thereof in engagement with said casing, and a disc of anti-friction material in said casing adjacent said pumping chamber forming a thrust plate concurrently engaging the sides of said vanes and said planar end face of said hub portion, whereby said rotor comprises a rotatable cantilever shaft in said casing, said casing having inlet and outlet openings and said thrust plate being apertured in registry with said inlet and outlet openings and together with said casing forming an inlet and an outlet at angularly spaced portions of said vanes in said hub portion of said rotor.

6. A pump comprising a casing means having a bore therein and a pumping chamber at one end of said bore eccentrically offset relative to the axis of said bore, a shaft journaled in said bore and having a planar end face at one end thereof in said pumping chamber, said one end of said shaft having radially aligned intersecting slots formed therein, a vane in each slot, said vanes being arranged to slidably engage the walls of said pumping chamber upon rotation of said shaft, and a disc-shaped thrust plate made of anti-friction material in said pumping chamber abutting said vanes and said planar end face, said thrust plate and said casing means having openings formed therein providing an inlet and an outlet for said pump at angularly spaced apart portions of said pumping chamber.

7. A pump comprising a casing means having a bore therein and a pumping chamber at one end of said bore eccentrically offset relative to the axis of said bore, a shaft journaled in said bore and having a planar end face at one end thereof in said pumping chamber, said one end of said shaft having radially aligned intersecting slots formed therein, a vane in each slot, said vanes being arranged to slidably engage the walls of said pumping chamber upon rotation of said shaft, and a disc-shaped thrust plate made of anti-friction material in said pumping chamber abutting said vanes and said planar end face, said thrust plate and said casing means having openings formed therein providing an inlet and an outlet for said pump at angularly spaced apart portions of said pumping chamber, said thrust plate having a passage extending from said outlet to said intersecting slots to pressure load said vanes radially outwardly.

8. A pump comprising a casing means having a bore therein and a pumping chamber at one end of said bore eccentrically offset relative to the axis of said bore, a shaft journaled in said bore and having a planar end face at one end thereof in said pumping chamber, said one end of said shaft having radially aligned intersecting slots formed therein, a vane in each slot, said vanes being arranged to slidably engage the walls of said pumping chamber upon rotation of

said shaft, and a disc-shaped thrust plate made of anti-friction material in said pumping chamber abutting said vanes and said planar end face, said thrust plate and said casing means having openings providing an inlet and an outlet for said pump at angularly spaced apart portions of said pumping chamber, said thrust plate having a passage extending from said outlet to said intersecting slots to pressure load said vanes radially outwardly, each of said vanes having a segmental tip portion engaging the casing walls of said pumping chamber and being shaped to provide a substantially cylindrical surface configuration conforming substantially to the curvature of said pumping chamber at said inlet and extending from the trailing edge toward and past the mid region of said vane.

9. In rotary vane pump, a shaft having a planar end face on one end thereof, said shaft being radially slotted at said one end, a plurality of radially aligned sliding vanes in said slotted portion of said shaft, a bearing adjacent the other end of said shaft, a casing means surrounding said shaft and supporting said bearing to journal said shaft as a rotatable cantilever rotor, said casing means providing a pumping chamber to receive said vanes and being eccentrically offset from the axis of said shaft, and a plate made of anti-friction material abutting the sides of said vanes and said planar end face, said vanes each having a segmental tip portion engaging said casing means at said pumping chamber and being shaped to provide a substantially cylindrical surface configuration extending from the trailing edge toward and past the mid region of each of said vanes, said casing means and said plate together providing an inlet and an outlet port at angularly spaced portions of said pumping chamber, said segmental tip portions each conforming substantially to the curvature of said pumping chamber in the vicinity of the inlet port.

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