

[54] VANE SEAL MEANS IN ROTARY VANE MACHINES

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Oct. 11, 1971 Austria 8793/71

[52] U.S. Cl. 418/147, 418/261

[51] Int. Cl. F01c 19/02

[58] Field of Search 418/145, 147, 148

[56] References Cited

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[57]

ABSTRACT

The present invention is concerned with the sealing of vanes in rotary vane machines of the type in which the vanes have axial extensions which project into slots in the end walls of a rotor for guiding the vanes during radial inward and outward movement, and the outer ends of the vanes are engaged by an endless reaction surface. In accordance with the invention, a vane seal bed is formed in the radially outer portion of the vane, extending into vane extensions located in the respective slots in the end walls of the rotor. Preferably the vane seal bed is closed at its axial ends, and a vane seal means, such as a sealing strip, is mounted in the vane seal bed for slight radial movement therein for the purpose of sealing with an outer edge, the inner endless surface of the housing. The vane seal means also is in sealing contact with a longitudinal face along a wall of the vane seal bed for sealing an inter vane chamber of the vane machine while the vane seal means also extends into the vane extensions in the slots of the end walls of the rotor for the purpose of sealing also the corner between the respective rotor end wall, the endless inner housing surface, and the respective vane.

10 Claims, 25 Drawing Figures

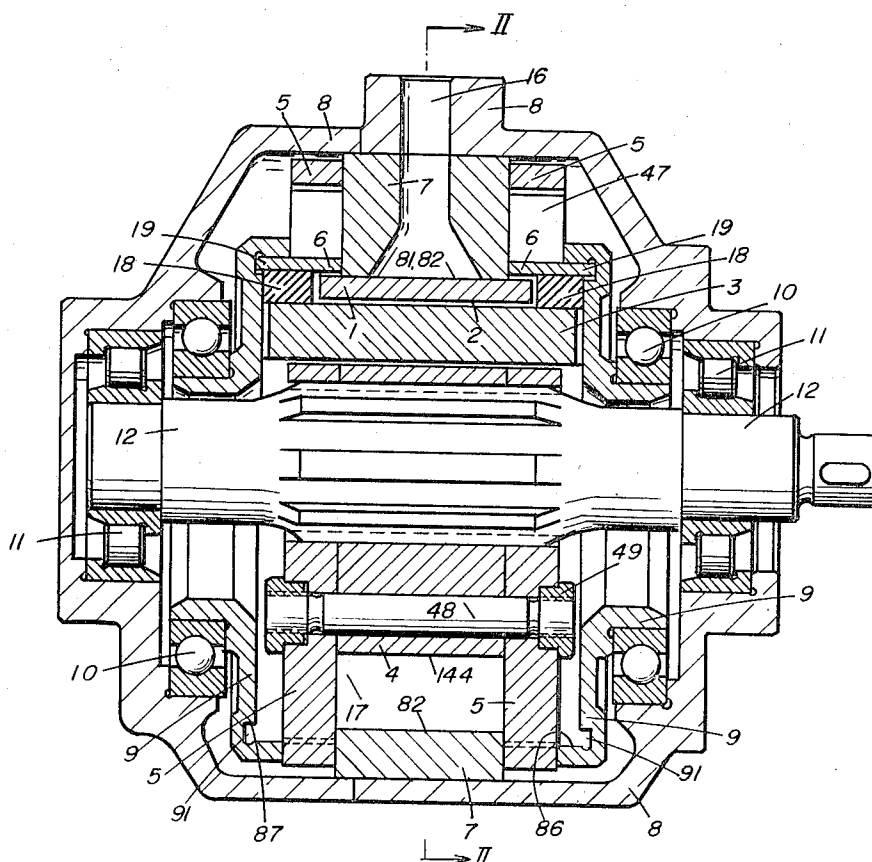


Fig. 1

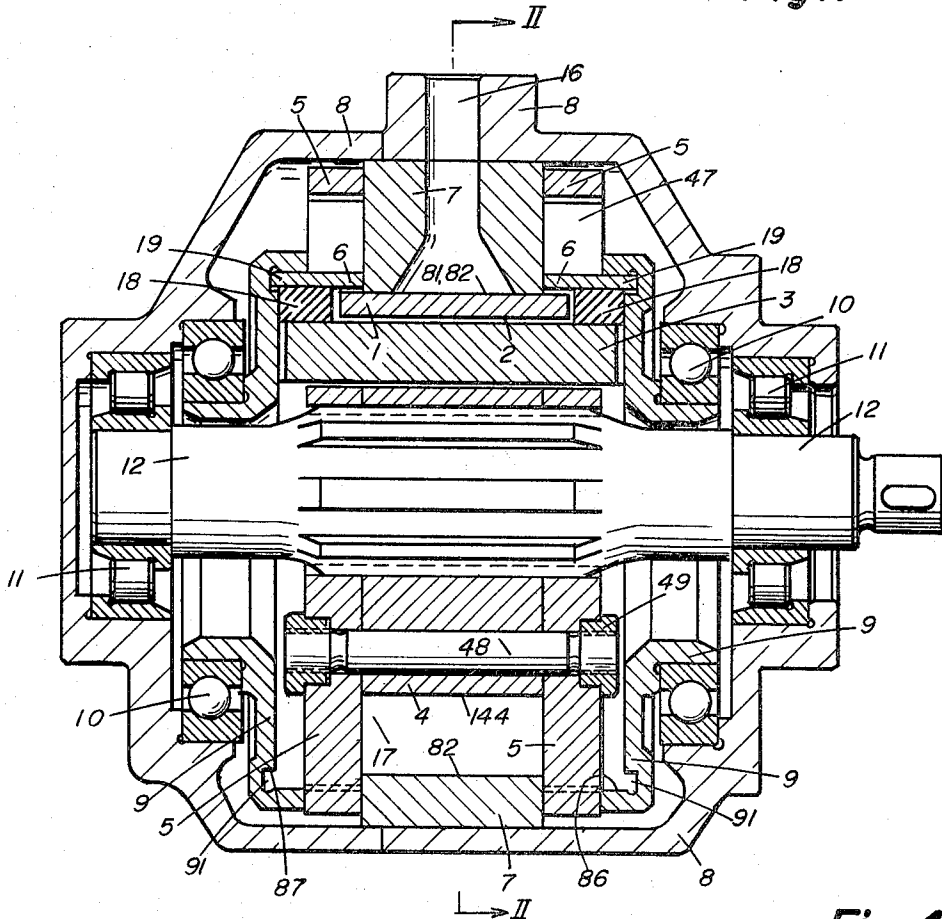


Fig. 3

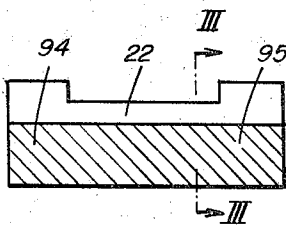


Fig. 3a



Fig. 4

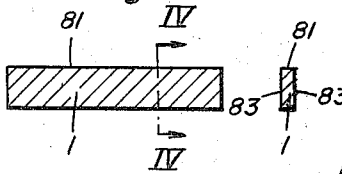


Fig. 4a

Fig. 5

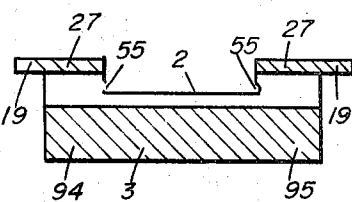


Fig. 6a



Fig. 6

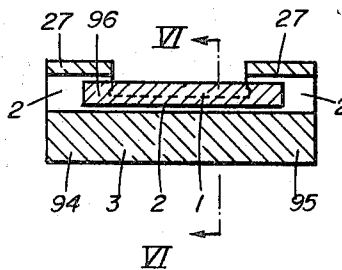


Fig. 2

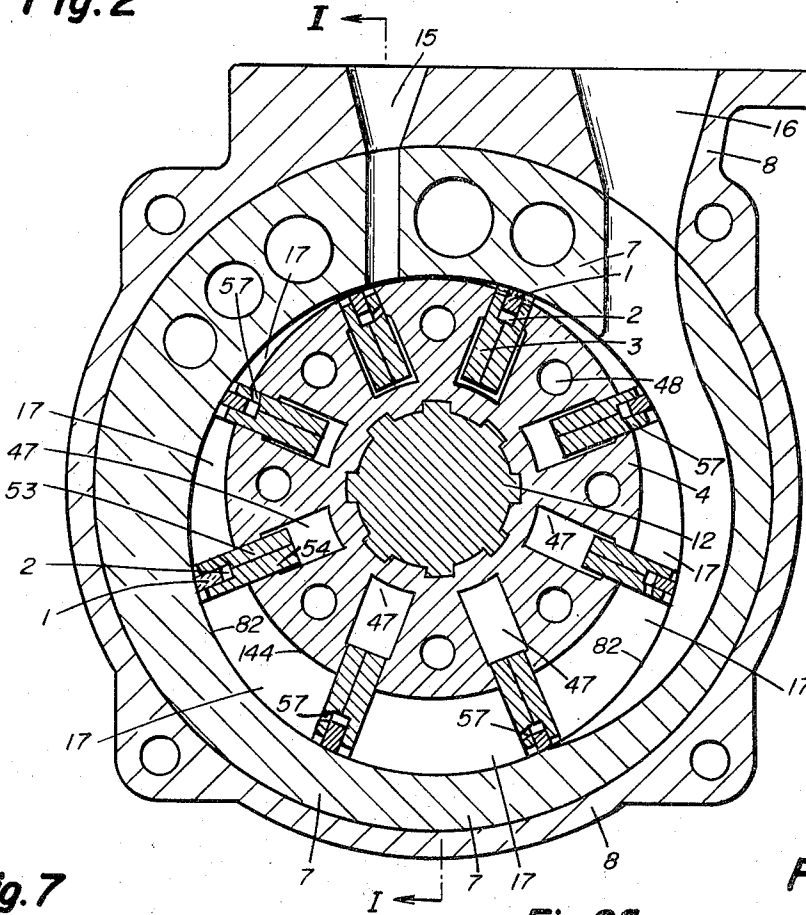


Fig. 7

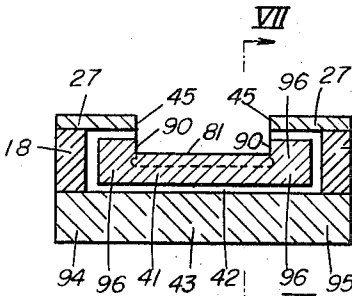


Fig. 7a Fig. 8a

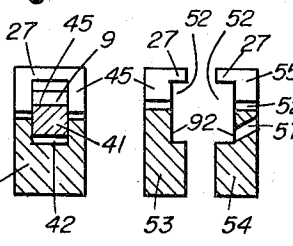


Fig. 8

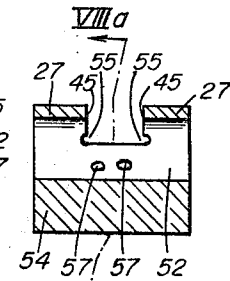


Fig. 10



Fig. 9

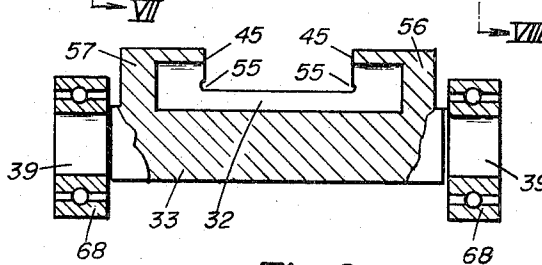
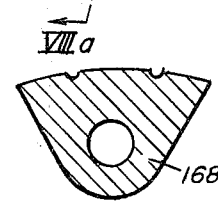


Fig. 11



VANE SEAL MEANS IN ROTARY VANE MACHINES

REFERENCE TO RELATED PATENTS

In my U.S. Pat. No. 2,975,716, a vane machine, which may be a pump, motor, transmission or engine, is disclosed in which the leakage of fluid around the ends of the vanes is prevented by providing extensions of the vanes, and slots in the rotor and walls, while the vane extensions are located in slots of the rotor end walls. In this manner, it has been possible to increase the pressure in vane machines several times, as compared with the prior art.

Due to the extension of the vanes into the end walls of the rotor, however, a corner was formed which was not completely sealed and from which fluid would escape. For the purpose of closing the unsealed corner, my U.S. Pat. No. 3,099,964 discloses a slide element preventing leakage through the respective corner. The vane machines of my U.S. Pat. No. 2,975,716 and of my U.S. Pat. No. 3,099,964 provide a very tight sealing and a high volumetric efficiency and pressure of the machine.

However, the above-mentioned patents left some problems unsolved. For example, the slide element of U.S. Pat. No. 3,099,964 could not follow non-cylindrical configurations of the endless reaction surface, so that dead spaces could not be eliminated, which was inconvenient for compressors, combustion engines, and gas motors since the compression ratio, volumetric efficiency, and power of the respective apparatus was limited.

Another difficulty is that the machines of the above patent, and also other known vane machines, develop very high centrifugal forces acting on the vanes at a high rotary speed, so that the friction between the outer portions of the vanes or other slide elements and the endless reaction surface becomes so great, that the parts are heated, and the efficiency of the apparatus becomes too limited for economic operation. This would, for example, take place if the rotary speed of the rotor having 2 to 6 inch diameters, would be increased to more than 3,000 or 5,000 revolutions per minute.

SUMMARY OF THE INVENTION

It is one object of the invention to overcome the disadvantages of known vane machines and to improve rotary vane machines to operate at high pressure tightly sealed, while the rotor operates at a high number of revolutions, with almost no dead spaces formed.

Another object of the invention is to increase the rotary speed of tightly sealed fluid handling vane machines.

Another object of the invention is to eliminate the volume of dead spaces and thereby to increase the efficiency when handling gases and high pressure, for increasing the power, capacity, pressure capacity and volumetric efficiency of machines of this type.

A further object of the invention is to eliminate or to reduce friction between the outer portions of the vanes and the endless inner reaction surface which closes the fluid handling spaces between the vanes in radially outward direction.

The main object of the invention is to make it possible to build compressors, combustion engines, pumps, and gas and liquid motors of very high volumetric capacity, rotary speed and power. In fact, due to the in-

vention it becomes possible to increase the power of gas compressors, pumps or engines to 3 HP per kilogram weight or to even more.

With these objects in view, the present invention provides a seal bed in the outer edges of the vanes, and inserts a seal element radially movable in the seal bed so that the seal bed and the seal element therein extends beyond a middle portion of the rotor into axial end portions of the vane which are located in slots of the end walls of the rotor.

In addition to this first embodiment of the invention, additional embodiments and modifications of the invention may be provided. In accordance with another embodiment of the invention, a plurality of seal beds and seal elements therein are provided in a single vane, or vane assembly.

In accordance with another embodiment of the invention a plurality of seal beds and seal means are provided in a multiple body vane arrangement.

In accordance with another embodiment of the invention, a space is provided between a plurality of seal beds and seal elements for filling the same with fluid, or for utilizing the same as a sealing space, or as a pressure balancing space.

In accordance with another embodiment of the invention, a straight sealing edge is provided on the outer portion of the seal element in such an assembly that the edge seals with its middle portion abuts along the inner endless surface of the housing or of a closure body, while both ends seal and abut against the rotor end walls while being guided in slots in the rotor end walls. In accordance with still another embodiment of the invention, at least one communication passage extends from the seal bed to a space of the machine, which contains a fluid under pressure.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view taken on line I—I in FIG. 2, and illustrating an embodiment of the invention;

FIG. 2 is a cross-sectional view taken on line II—II in FIG. 1;

FIG. 3 is a longitudinal sectional view illustrating a vane according to one embodiment of the invention, and FIG. 3a is a cross-sectional view taken on line III—III in FIG. 3;

FIG. 4 is a longitudinal sectional view of a seal element according to the invention, and FIG. 4a is a cross-sectional view taken on line IV—IV in FIG. 4;

FIG. 5 is a longitudinal sectional view illustrating a vane according to another embodiment of the invention, provided with guide means;

FIG. 6 is a longitudinal sectional view of a vane assembly according to another embodiment of the invention, and FIG. 6a is a cross-sectional view taken on line VI—VI;

FIG. 7 is a longitudinal sectional view of a vane assembly according to another embodiment, and FIG. 7a

is a cross-sectional view taken on line VII—VII in FIG. 7;

FIG. 8 is a longitudinal sectional view taken on line VIII—VIII in FIG. 8a, and 8a is a cross-sectional view taken on line VIIIa—VIIIa in FIG. 8;

FIG. 9 is a longitudinal sectional view illustrating a vane assembly according to another embodiment of the invention including guide rollers;

FIG. 10 is a sectional view illustrating a guide ring;

FIG. 11 is a sectional view illustrating another embodiment of a guide means, which can be used with the vane assembly shown in FIG. 9;

FIG. 12 is a fragmentary cross-sectional view along the line II—II in FIG. 1 but illustrating a modification of the vane assembly shown in FIGS. 13 to 18;

FIG. 13 is a longitudinal sectional view of another embodiment of the vane, and taken on line XIII—XIII in FIG. 16;

FIG. 14 is a longitudinal sectional view taken on line XIV—XIV in FIG. 17, and illustrating a vane assembly;

FIG. 15 is a longitudinal sectional view, illustrating another embodiment of the vane taken on line XV—XV in FIG. 18;

FIG. 16 is a cross-sectional view taken on line XVI—XVI in FIG. 13;

FIG. 17 is a cross-sectional view taken on line XVII—XVII in FIG. 14; and

FIG. 18 is a cross-sectional exploded view taken on line XVIII—XVIII in FIG. 15;

FIG. 19 is an elevation illustrating a vane element according to the invention; and

FIG. 20 is a cross-sectional view taken on line XX—XX in FIG. 19.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 and 2, a shaft 12 is rotatable in bearings 11 in a hollow housing 8. A rotor 4 having a small diameter central or median rotor portion and end walls 5 is mounted on shaft 12. Rotor 4 and its end walls 5 are provided with slots 47 extending substantially in radial direction in the rotor end walls for guiding vanes 3 radially inward and outward.

Rotor 4 and rotor end walls 5 are preferably bolted together by bolts 48. The outer and inner ends of the radial axially parallel slots 47 in the rotor end walls are closed, while the axially extending slots in rotor 4 having only the inner ends closed. Portions on the rotor 4 and end walls 5 for closing the slots 47, reinforce the rotor means 4, 5 by being integral with the rotor parts between the slots 47.

A closure member 7 is partially inserted between the rotor end walls 5, and surrounds the rotor 4 with an endless inner surface 82, see FIG. 2, so that between the rotor end walls 5, the outer surface of rotor 4, and the endless inner surface 82, and two adjacent vanes 3, intervane spaces or fluid handling chambers 17 are formed which expand and contract during rotation of the rotor means. The radially outer ends of the vanes or vane assemblies slide along the endless inner surface 82 so that the vanes 3 move radially outward during half a revolution, and radially inwardly in the second half of each revolution. An inlet passage 16 passes through housing 8 and closure member 7 receiving a gas or liquid, and an outlet passage 15 passes through closure member 7 and housing 8 for the discharge of a fluid, which may be a liquid or gas.

Bearing means 10 are provided in housing 18 and form an axis eccentric to the axis of the rotor shaft and rotor bearings 11.

Rotary guide members 9 are carried by the bearings 10, or stationary guide members 9 are mounted on housing 8 eccentrically to the axis of the shaft 12. Guide members 9 embrace guide members 19 or 39, 268, 168 of the vanes 3 for guiding the vanes during the radial movement in the rotor assembly 4, 5, 47, 48.

In the following description, reference is made to several Figures illustrating modifications of the vanes without mentioning the numbers of the Figures, but relying on corresponding reference characters in which the unit order is the same to indicate corresponding parts in different Figures.

The vanes 3, 23, 33, 43, 53, include central portions which after assembly in the slots 47 of the rotor means 4, 5, are located along axial slots of the rotor 4, with the vane end portions 94, 95 disposed at the ends of the central rotor portion 4. The vane end portions 94 and 95 extend into the radial slots 47 in the inner faces of the rotor end walls 5, while the central vane portions are located in the axial slots 47 in the central rotor portion 4, dividing the intervane spaces or fluid handling chambers 17 from each other.

Each vane end portion 94 or 95 has radial extensions which project radially outward beyond the central portion of the respective vane. Each vane extension has an inner face 45, see FIG. 7, 8, 9, which embraces a guide portion of the closure member 7 for sealing purposes. The inner confronting faces 45 are therefore perpendicular to the longitudinal faces of the respective vanes, and the distance of the confronting inner faces 45 from each other is substantially the same as the axial length of the closure member 7. However, a small clearance remains, having the magnitude of a few hundredths or thousandths of a millimeter, between the respective surface of closure member 7 and the respective inner face 45 of the radial vane extensions so that the inner faces 45 can smoothly and tightly sealing, slide along the end face of the closure member 7.

In order to make the manufacturing of the inner faces 45 possible, the intersecting groove 55, see FIG. 5, FIG. 8, FIG. 13, is provided between the radial edges, and the central portion of the respective vane. In this manner, accurate grinding, pressing, or machining of the inner faces 45 is assured.

In order to reduce the friction at the outer portions of the vanes, the vanes are guided by the guide means 9 in such a way that a small clearance remains between the radially outer portions of the vanes, and the endless inner surface 82 of closure member 7.

The friction between the radially outer portions of the vanes and the inner endless face 82 of closure member 7, is caused by the action of the centrifugal force. In order to avoid friction between the vanes and the inner endless face 82 due to the centrifugal force, vanes, see FIGS. 1, 5, 9, are provided with vane guide means 19, 39. Vane guide means 19 or 39 extend from the end portions of the vane means into the annular guide ways 95 of the guide members 9 which may be provided with outer guide faces 86 for guiding the radially outer portions of the vane guide means 19 or 39. The guide members 9 may also be provided with inner guide faces 87 for guiding the inner portions of the vane guide means 19 or 37. In order to reduce friction between the vane guide means 19 and the guide mem-

bers 9, guide shoes 168, see FIG. 11, or guide rollers 268, see FIG. 10, may be mounted on the vane guide means 19 or 39 for sliding or rolling along the guide faces 86 or 87 of the guide members 9.

According to the invention, the vane seal bed 2, 22, 32, 42, 52 is provided in the outer edge of the vane and extends from the main body of the respective vane into the respective end portions 94 and 95 of the vane. Furthermore, in accordance with the invention, a seal element 1, 41 is inserted into the vane seal bed 2, 22, 42, 32, 52 in such a manner that it can slide radially therein to a limited extent.

A further specific feature of the invention resides in that the seal element 1 or 41 has an axial extension 96 extending within the seal bed 2, 22, 32, 42, 52, into the vane extensions 94 and 95. The vane seal elements of the invention may have the form of a strip, provided with bearing faces 83 along the vane seal elements 1 or 19 for supporting the seal elements 1 with the bearing faces 83 abutting the faces 92 of the vane seal bed 2, 22, 32, 42, 52.

Furthermore, a seal element 1 or 41 is placed to cover the corner grooves 55 so that the grooves 55 are closed and leakage therethrough is prevented. This is an important feature of the invention because it results in tight sealing of the fluid handling chambers 17.

Seal elements 1 or 41 are of a much lesser weight than the weight of the vanes 3. Only the vane seal elements 1 or 41 are subjected to the centrifugal force to slide and seal along the inner endless face 82 of the closure member 7. The sealing between the closure body 7 and the vane 3 is provided by the fact that outer face 81 or the edge 88, see FIGS. 19 and 20, slides along the inner endless surface 82 of the closure member 7 in sealing contact, while the bearing faces 83, or one of them, lies on the respective face 92 of the vane seal bed 2, for example, thereby providing an exact seal.

A particularly tight seal is assured by the straight corner 88 between bearing face 83 and inclined outer face 89 of the vane seal element 1, as shown in FIGS. 19 and 20. The middle portion of the straight edge 88 seals along the inner endless face 82 of closure member 7, and the ends of the straight corner 88 seal along the face portions 92 of the vane seal bed 2, 22, 32, 42, 52, respectively, by means of the extensions 94, 95 of the vanes.

Closure members 18 may be inserted into the ends of the vane seal beds 2, 22, 32, 42, or 52 in order to close the vane seal beds in axial direction. Instead of inserting a closure member 18 into the vane seal bed, it is also possible, as shown in FIGS. 9, 14 and 15, to close the vane seal bed 2, 22, 32, 42, 52 by portions 56 or 57, or by other portions of the vane extensions 94 and 95. The closing of the vane seal beds in the vane extension in radial outward direction, may be effected by the outer members, see FIG. 5.

In order to assist the pressing of the vane seal elements, 1, 45 against the inner endless face 82 of the closure member 7, and unto the respective hole surface 92 of the vane seal bed, communication passages 57, see FIG. 8, may be provided at the bottom of the respective seal bed of the respective vane 3, and may extend through a portion of the respective vane in order to communicate with the respective space, which contains fluid, for example, within adjacent intervane space or fluid handling chamber 17. This provides the necessary pressure of fluid against the vane seal ele-

ment 1 or 41 in order to assure, even at low rotary speed, a sealing contact between the vane seal element and the faces in contact therewith.

As shown in FIGS. 8, 16, 17, and 18, it is possible to provide the vane assembly with two vane portions 53, 54 or 303. In such an assembly it is particularly convenient to manufacture the vane portions by simple manufacturing operations. One or both vane portions 53 and 54 may then contain the seal bed 52.

In the embodiment of the invention shown in FIG. 12, it is assured that the vane assembly 3, 1, 57 can seal two adjacent fluid handling chambers 17, 172, 173 which may contain fluid at different pressures. The sealing between two adjacent chambers 17, 172, 173 is obtained by providing two vane seal beds 2, 52 in the vanes 3, 53 or 54, and by inserting at least one vane seal element 1 or 41 into each of the vane seal beds 2 or 52, and so forth, and providing communication passages 57 from each of the seal beds 2, 52 to the respective adjacent fluid handling chamber 17, 172, 173 which contain fluid, such as liquid or gas, under pressure.

Specific embodiments of double acting vane assemblies with a plurality of seal means for the vane of the invention are shown in FIGS. 13 to 18. The respective parts of the vane assembly of the double acting vane type are substantially the same and perform substantially the same function as in the above described Figures, but the difference is that the communication passages 57 are extended from the different vane seal beds in opposite directions to the respective vane portions. If vane seals of the type shown in FIGS. 19 and 20 are inserted in the respective seal beds in the vanes of FIGS. 13 to 18, then the inclined faces 89 of the vane seal elements 1 extend toward each other so that the outer edge of the vane seal element 1 abuts against the wall faces 92, as shown in FIG. 18.

FIG. 18 also shows how a divided vane with two vane members 53 and 54 can be utilized for a double acting vane for sealing against communication with two different fluid handling spaces 17, 172. This effect is achieved by inserting a plate or central plate portion 303 between the other vane portions 53 and 54.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of vane seal assemblies for rotary vane machines differing from the types described above.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. In a fluid handling device, a combination comprising a hollow housing; a rotor mounted in said housing and including a smaller-diameter median portion and two end walls disposed at the axial ends of and extending radially outwardly beyond said median portion, said rotor having substantially radially extending slots parallel with the axis thereof and each including a central portion provided in said median portion and outer portions provided in the respective end walls; a closure member provided in said housing and having an internal surface eccentric to said rotor and spacedly surrounding said median portion thereof, said rotor and said closure member defining an annular fluid handling space; inlet and outlet means communicating with said space; vanes radially movably received in said slots and subdividing said space into a plurality of chambers communicating seriatim with said inlet and outlet

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means in response to rotation of said rotor, each of said vanes having an outer part including two end portions extending radially outwardly beyond said internal surface, each of said outer parts being provided with a seal bed having ends extending to the outer portions of the respective slot and radially outwardly into the end portions of the respective vane and beyond said internal surface, and a seal radially movably received in the respective bed, said seals having end portions extending into the ends of the respective beds and each of said seals having a central portion abutting against said internal surface when said rotor rotates to thereby seal said chambers from each other, said end portions of said seals being free to move radially outwardly in the ends of the respective seal beds so that said central portions of said seals continue to abut against said internal surface after pronounced wear upon said central portions of said seals as a result of abutment against and sliding movement along said internal surface; and anti-friction bearing means coaxial with said closure member and arranged to hold said vanes out of frictional engagement with said internal surface.

2. A combination as defined in claim 1, wherein said vanes further include each of said vanes further comprises corner grooves between said median portion and said end portions thereof, each of said seals extending over and sealing the corner grooves of the respective vane.

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3. A combination as defined in claim 1, wherein each of said vanes includes means for sealing the ends of the respective beds at the radially outward and axially outward sides thereof.

4. A combination as defined in claim 1, wherein each of said vanes has at least one passage in communication with the respective bed.

5. A combination as defined in claim 1, wherein each of said vanes consists of a plurality of portions, each of said beds being provided in at least one portion of the respective vane.

6. A combination as defined in claim 1, wherein each of said seals has a straight edge abutting against said internal surface.

7. A combination as defined in claim 6, wherein each of said seals further includes an inclined outer face adjacent to said straight edge thereof.

8. A combination as defined in claim 6, wherein each of said edges extends along the full length of the respective seal.

9. A combination as defined in claim 1, wherein each of said vanes has an additional bed and an additional seal in said additional bed.

10. A combination as defined in claim 9, wherein each of said vanes has at least one passage extending between said beds thereof.

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