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[72] Inventor **Clifford H. Allen**
Chesterland, Ohio

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[73] Assignee **TRW Inc.**
Cleveland, Ohio

[54] **TANGENCY SEALS FOR COMPRESSORS**
14 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **418/129,** 418/266, 418/125
[51] **Int. Cl.** **F03c 3/00,** F03c 19/02, F03c 27/00
[50] **Field of Search** ..... 418/129, 125, 126, 127, 128, 250, 251, 152, 153, 156, 271/81 P

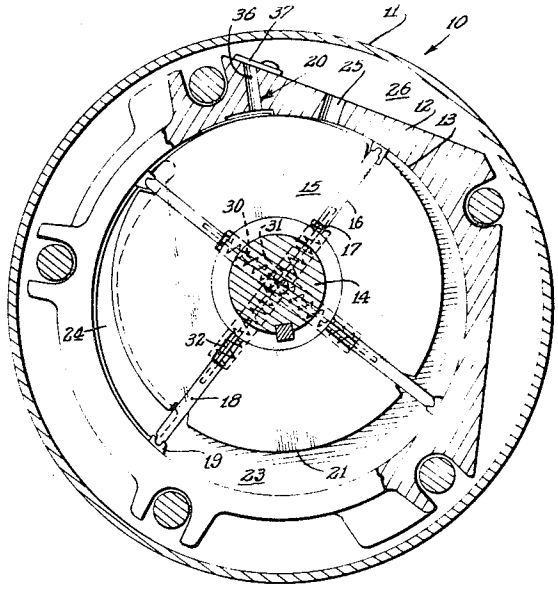
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Primary Examiner—Carlton R. Croyle
Assistant Examiner—Richard E. Gluck
Attorney—Hill, Sherman, Meroni, Gross & Simpson

ABSTRACT: A compressor incorporating a rotor equipped with radially movable vanes eccentrically received in a cylindrical compressor chamber with the outer diameter of the rotor contacting the inner diameter of the compressor chamber along a line of tangency, the compressor chamber being equipped with a tangency seal to assure continued contact between the rotor and the compressor chamber carried seal. In one embodiment, the seal is a cantilever suspended strip backed by a pressure groove open to the interior of the compressor chamber on the high-pressure side of the tangency line, and the groove is ported to the exterior of the pressure chamber. In another embodiment, the seal member is a normally flat deformable sheet received in a variable depth groove in the chamber wall, the sheet having openings therethrough on high-pressure side of the tangency line and the groove being ported to the exterior. In a third embodiment, the seal is a length of material received in a longitudinal groove at the line of tangency, the material having a different rate of expansion than the material of the chamber member to maintain rotor contact at both low and operating temperatures.



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Fig. 1

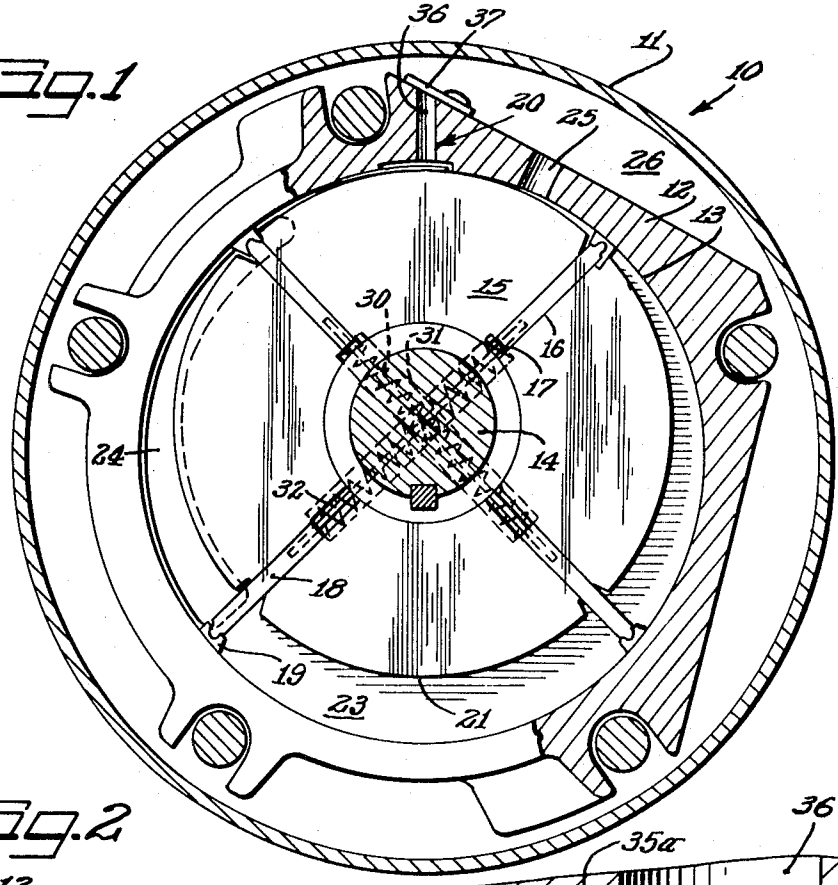


Fig. 2

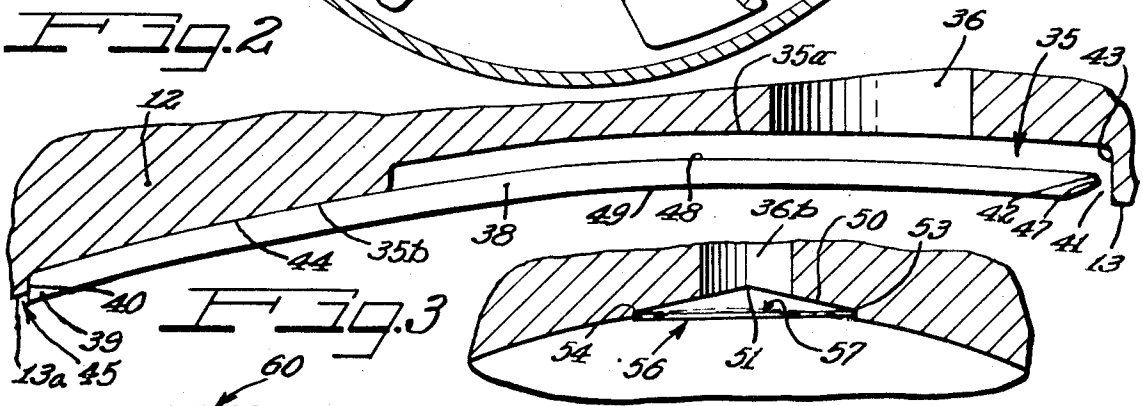


Fig. 3

Fig. 4

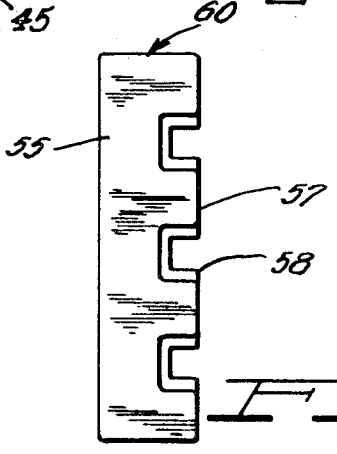
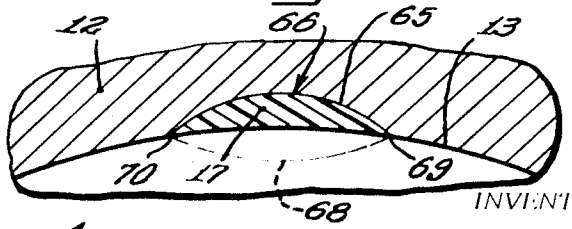


Fig. 5



INVENTOR.

Clifford H. Allen

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

TANGENCY SEALS FOR COMPRESSORS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to rotary vane compressors, and more particularly to tangency seals for such compressors.

2. Prior Art

Rotary vane compressors involving radially movable vane-carrying rotors eccentrically received in cylindrical compressor chambers with the rotor tangent to the chamber wall along a given line of its circumference, are known to the art. Such compressors normally have an inlet to one side of the tangency line and an outlet to the other side, the tangency line dividing the compressor chamber into high-pressure and low-pressure areas around its circumference. Inasmuch as the pressure drop across the tangency line is considerable, it is necessary to provide an effective seal at that point. Heretofore, this has normally been accomplished by the accuracy of contact between the outer diameter of the rotor and the outer periphery of the vanes and the wall of the internally cylindrical compressor chamber. This contact is difficult to maintain in mass production compressors, inasmuch as it must rely upon high-tolerance manufacturing and assembly of the components. It has further been suggested to provide an independent member at the line of tangency to function as a tangency seal. In some cases, these members have been pressure-backed members, however they have not provided for escape of highly compressed fluids from the pressure-containing area behind the seal member. This has resulted in the placement of higher-than-required contact pressures between the seal member and the rotor. Such pressures can cause abnormal wear of the rotor or seal member. Further, it has been possible for the vane tip or vane shoe to collide with the leading edge of the seal member, especially when such member is subjected to excessive pressures, thereby causing excessive noise in the operation of the compressor and increasing the wear problem. On the other hand, those devices which did not utilize pressure backing were unable to accommodate clearance changes caused by temperature.

SUMMARY OF THE INVENTION

This invention overcomes the deficiencies of the prior art compressors by providing improved tangency seals. In one embodiment, the compressor chamber has a stepped groove extending the length of the tangency line with the deepest portion of the groove at the point of tangency. Pressure drainage ports communicate the bottom of the groove to the exterior of the compressor cylinder. A metallic strip having a width less than the width of the stepped groove and a length substantially equal to the length of the groove is received in the groove and fastened to the bottom of the shallow portion of the stepped groove. The strip then overlies the deeper portion of the stepped groove in a cantilever fashion and terminates in spaced relation to the high-pressure side of the groove whereby pressure from the compressor chamber is given access to the deep portion of the groove behind the strip to pressure-bias it towards the rotor. Excessive pressure is ported from the back of the groove to the exterior.

In the second embodiment, the tangency groove is peaked with the greatest depth along or closely spaced to either side of the line of tangency. The depth of the groove at the edges is approximately the thickness of the strip. In this embodiment, the strip is flat and has relieved areas in its leading edge to allow passage of pressure into the groove. The strip is placed in the groove where it is normally nonarcuate and is thereafter arcuately deformed by contact with the rotor.

In the third embodiment, the groove is not ported to the exterior and is substantially filled with a material having a coefficient of expansion selected with reference to the coefficients of expansion of the rotor and cylinder whereby gaps between the cylinder and rotor which will normally occur due to thermal expansion of the unit when it is operating, are accommodated by expansion of the seal material.

Each of the three embodiments, therefore, creates a contact seal at the line of tangency between the rotor and the cylinder member, which seal is effective over the entire thermal cycle of the compressor unit.

It is therefore an object of this invention to provide an improved rotary vane tangency compressor.

It is another and more important object of this invention to provide an improved tangency seal for rotary vane compressors.

It is yet another and more specific object of this invention to provide tangency seals for compressors which accommodate tangency gaps caused by thermal expansion of the components of the compressor.

It is another and more specific object of this invention to provide a tangency seal for rotary vane compressors wherein the compressor chamber has an exteriorly ported stepped groove along the line of tangency which receives a cantilever supported seal member with the seal member pressure-backed into contact with the rotor in response to pressure in the cylinder.

It is another and specific object of an embodiment of this invention to provide a tangency seal for rotary vane compressors wherein the compressor chamber has a ported peaked groove and the seal member is a normally flat strip received in the groove with openings therethrough to pass pressure to the groove to pressure-bias the seal member against the rotor, the seal member being deformed into arcuate conformity with the rotor.

It is yet another specific object of one embodiment of this invention to provide a tangency seal for rotary vane compressors wherein the compressor chamber has a groove in the inner diameter thereof substantially filled with a material having a coefficient of expansion sufficiently great to maintain tangency line contact with the rotor when the assembly is subjected to thermal changes.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure, and in which:

FIG. 1 is a fragmentary cross-sectional view of a rotary vane compressor equipped with the tangency seal according to this invention.

FIG. 2 is a fragmentary cross section enlarged view of the tangency seal of FIG. 1.

FIG. 3 is a fragmentary enlarged cross-sectional view of a modified tangency seal according to this invention.

FIG. 4 is a plan view of the seal member of FIG. 3.

FIG. 5 is a fragmentary enlarged cross-sectional view of another embodiment of a tangency seal according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a cross-sectional view of a rotary vane compressor **10** received in a housing **11**. The compressor section consists of a compressor chamber defining member **12**, having a cylindrical inner diameter **13**. An axle **14** is eccentrically position within the member **12** and carries a rotor **15**. The rotor **15** has a plurality of slots extending radially thereinto **16** which bottom as at **17** in spaced relation to the axle **14**. The slots **16** contain vanes **18** which are radially slidable in the slots. The outer periphery of the vanes **18** carries shoes **19** which ride against the inner diameter **13** of the member **12**. The rotor **15** is tangent to the inner diameter **13** at a given point, generally indicated at **20**, on the circumference of the inner diameter. The outer diameter **21** of the rotor is less than the inner diameter **13** of the member **12** thereby creating an almost 360° crescent-shaped space **23** between the rotor and the inner diameter **13**. This space is divided, in the embodiment il-

lustrated, into four sections by the vanes. The member 12 is capped at both ends by end caps. The rotor and vanes extend from end cap to end cap riding against each in sealing relation. An inlet 24 is provided through one end cap to the space 23 on one side of the tangency line 20 and an outlet 25 is provided from the space 23 through the member 12 to the area 26 interior of the housing 11 on the other side of the tangency line 20.

Coil springs 30 received in bores 31 through the axis 14 cooperate with pins 32 to assure that opposite vanes 18 function as pairs so that when one vane is forced into its slot, the opposite vane is forced out of its slot. In this manner, the shoes continuously ride against the inner diameter 13 to sealingly separate the four quadrants of the space 23 from one another. As the rotor rotates 15, the area of the quadrants increases from the line of tangency through the inlet area and thereafter decreases past the outlet to the line of tangency. In this manner, fluids let into the quadrants through the inlet 24 will be compressed until they escape through the outlet 25. As a quadrant is passing the outlet 25, its leading edge will terminate at the line of tangency 20. The line of tangency therefore divides the high-pressure side of the compressor chamber from the low-pressure side.

Inasmuch as the pressure drop across the line of tangency can be considerable, leakage will occur unless a seal is maintained between the member 12 and the rotor 15. Such leakage decreases the efficiency of the compressor and can cause undue erosion wear at the line of tangency.

It has been suggested to provide a groove in the inner diameter 13 at the line of tangency and place a separate seal member in the groove to contact the rotor. In some instances, it has been suggested to open the groove to the high-pressure side of the compressor so that the groove admits high pressure to pressure-back the seal member against the rotor. While such measures provide an effective seal between the seal member and the rotor, they either leak pressure through the groove to the low-pressure side bypassing the seal member, or they retain pressure in the groove thereby forcing the seal member, or they retain pressure in the groove thereby forcing the seal member against the rotor at a high pressure when the corresponding pressure drop across the line of tangency may have dropped. Further, such seals have not allowed escape of the extreme high pressure of trapped fluids after the trailing shoe of a quadrant has passed the outlet. Such trapped fluids are then ported to the groove which results in extreme pressure application against the back of the seal member.

The embodiment illustrated in FIGS. 1 and 2 provides a seal member received in a stepped groove 35. The groove has its deepest portion 35*a* along the line of tangency and extending to either side thereof. A shallower portion of the groove 35*b* extends circumferentially beyond the portion 35*a* on the low-pressure side of the line of tangency. Ports 36 extend from the bottom of the portion 35*a* of the groove to the exterior of the member 12. In this manner, the groove is vented to the pressure space 26 between the member 12 and the housing 11. A one-way valve 37 may be provided in connection with the groove port 36 in order to prevent backflow of pressure from the area 26 to the groove 35.

A seal member 38 is provided in the groove 35. The seal member is an elongated strip, preferably made of spring metal, which has a width less than the width of the groove 35 and a length approximately equal thereto. In this manner, with the strip 38 received in the groove 35, the groove will be sealed at the axial ends thereof due to the substantial equivalent length between the seal member and the groove.

The trailing edge 39 of the seal member 38 is bottomed against the trailing edge 40 of the portion 35*b* of the groove 35. Because the seal member 38 is slightly narrower than the groove 35, a gap 41 will exist between the leading edge 42 of he seal member 38 and the leading edge 43 of the groove 35.

The seal member 38 is arcuately bent from leading edge to trailing edge and has a width approximately the same as the depth of the portion 35*b*. The seal member 38 is secured to the bottom 44 of the portion 35*b* as by adhesives, brazing, welding or the like fastening means. Preferably the inner diameter 13 is increased at 13*a* on the trailing edge of the groove to provide a dropoff from the surface of the sealing member 38 to the inner diameter 13*a* of the member 12. Alternatively, the trailing edge 39 of the sealing member 38 may be slightly thicker than the depth of the portion 35*b* so as to provide a dropoff 45 from the surface of the sealing member 38. This prevents the shoes 19 from striking an edge at the interface between the sealing member 38 and the member 12 at the trailing edge.

The leading edge 42 may be bevelled as at 47 or the arc of the member 38 may be such that it drops off at the edge 42. This allows the shoes 19 to drop from the inner diameter 13 to the surface of the sealing member without striking an edge. The gap 41 is less than the width of the shoes 19 and pivotability of the shoes allows them to move from the surface 13 to the surface of the sealing member and from the surface of the sealing member back to the surface 13 without chatter.

As the leading shoe of a quadrant passes the line of tangency, pressure building up in the quadrant will be passed through the space 41 into the groove 35. This pressure will act against the back 48 of the seal member 38 in the area 35*a* to force the front surface 49 into sealing contact with the rotor. The amount of pressure maintained in the groove 35 will be dependent upon the amount of pressure in the area 26 plus the force necessary to overcome the valve 37. Whenever excess pressures are encountered in the groove 35, they will be ported through the ports 36 to the area 26. Therefore, as the trailing shoe of a quadrant passes the outlet 25, fluids trapped between it and the line of tangency can escape through the gap 41 into the groove 35 and thence outwardly through the ports 36. Therefore, these excessive pressures will not act against the seal member 38 except momentarily, as required to maintain the contact between the surface 49 and the outer diameter 21 of the rotor. By choosing the arc at which the member 38 is bent, in comparison with the natural arc of the inner diameter surface 13, the member 38 can be caused to contact the outer diameter of the rotor with a given normal pressure, absent a pressure in the groove 35. This is caused by displacement of a portion of the seal member 38. The cantilever attachment of the member allows a spring nature to the member to continue to act against the outer diameter of the rotor.

The attachment of the seal member 38 to the floor of the portion 35*b* provides a downstream seal for the groove, thereby preventing flow of high-pressure compressed fluid from the groove to the low-pressure side of the compressor.

FIG. 3 illustrates another embodiment of the tangency seal. In this embodiment, a peaked groove 50 is provided along the tangency line with the peak 51 of the groove located along or close to the point of tangency. A port 36*b* is provided to serve the same function as the port 36 in FIG. 1. The leading and trailing edges 53 and 54 of the groove 50 are recessed at an abrupt angle to receive the seal member 55. The seal member, illustrated best in FIG. 4, is a sheet of springable material such as spring steel or the like which is dimensioned to be received in the groove. The sheet is normally flat as illustrated at 56 in FIG. 3. However, the sheet is designed to be bulged as illustrated at 57 in FIG. 3, by the pressure of the outer diameter 21 of the rotor acting against it. In this manner, the bulge of the spring material sheet 55 will maintain it in normal sealing contact with the rotor. The leading edge 57 of the sheet 55 has a plurality of relieved areas 58 therein to allow passage of pressure from the high-pressure side to the groove 50. The relieved areas 58 terminate prior to the tangency line of contact with the rotor. The line of contact is indicated by the arrow 60.

In order to prevent shoe contact with an edge, the groove 50 may have a depth slightly greater than the thickness of the sheet 55 at the leading edge 53 and a depth slightly less than the thickness of the sheet 55 at the trailing edge 54. The pressure backing of the sheet 55 will continue to force it in engage-

ment against the rotor even though heat expansion of the rotor and of the member **12** may have created a greater than normal gap thereby lessening the spring force by which the sheet would otherwise contact the rotor.

Dimensioning of the port **36***b* as well as the provision of the valve **37** can provide for the maintenance of the desired pressure in the groove **50**. For example, when the exit port **36** in FIG. **1** discharges into an area which is maintained at or close to compressor discharge pressure, the seal backup pressure will be maintained at or slightly above discharge pressure. If this is not feasible a simple pressure reducing valve can be used to control the seal backup pressure.

Pressure leak through the groove will be prevented on the low-pressure side of the tangency line by the contact between the sheet **55** and the bottom wall of the groove adjacent the trailing edge **54**. Inasmuch as this contact pressure will be a function of the pressure of the rotor against the spring sheet, the seal will be effective in view of the provision of the exit port **36***b*.

In those instances where the outlet port **25** is spaced close enough to the line of tangency to reduce the problems caused by trapped fluid ahead of the trailing shoe, the embodiment illustrated in FIG. **5** will provide a tangency seal which will accommodate tangency gaps caused by heat expansion of the components. FIG. **5** illustrates an arcuate groove **65** in the inner diameter **13** of the member **12**. The arcuate groove has its greatest depth at the line of tangency indicated at **66**. The groove is filled with a material **67** having an expansion coefficient different from the coefficient expansion of the member **12**. In those instances where heat expansion of the assembly causes a gap to occur between the rotor and the inner diameter **13** at the line of tangency, a material having a higher coefficient of expansion than the material **12** will cause the material **67** in the groove to expand inwardly to reduce or eliminate the gap. This expansion is indicated at **68**. By providing an arcuate groove **65**, the expansion will not cause an edge to form at the leading and trailing edges **69** and **70** of the groove. This will allow the shoes **19** to accommodate the bulge caused by the seal.

It can therefore be seen from the above that my invention provides a tangency seal for a rotary vane compressor which will maintain a seal between the rotor and the inner diameter wall of the compressor chamber irrespective of the pressure generated by the compressor and irrespective of thermal expansion caused gaps between the normal tangency contact between the rotor arc and the chamber inner diameter.

The seal is effectuated without excessive pressure acting against the seal member to force it into greater than desired contact with the rotor.

Although the teachings of my invention have herein been discussed with reference to specific theories and embodiments, it is to be understood that these are by way of illustration only and that others may wish to utilize my invention in different designs or applications.

I claim as my invention:

1. In a compressor having a vane-carrying rotor eccentrically positioned in a compression chamber defining member, the rotor contacting the inner wall of the chamber along a line, the improvement of: a seal along said line comprising a stepped groove in said member extending the length of said line, the groove having a first portion at one depth overlying the line of tangency, and a second portion on the low-pressure side of said first portion at a second depth less than the depth of the said first portion, a strip of seal material received in said groove, said seal material having a length substantially equal to the length of the groove and said seal material attached to the second portion of the said groove and overlying portions of said first portion.

3. The compressor of claim **1** wherein passage means are provided from the bottom of the said groove to the exterior of the said compression chamber.

3. The compressor of claim **2** wherein passage means are provided from the high-pressure side of the compressor to the first portion of the said groove behind the said seal member.

4. The compressor of claim **3** wherein the said passage means comprises a gap between the leading edge of the said seal member and the leading edge of the said groove.

5. The compressor of claim **4** wherein the said seal member is biased towards the bottom of the said groove from its normal position by contact with the said rotor and the said seal member is constructed of a resilient material whereby it is spring-urged against the said rotor.

6. The compressor of claim **5** wherein a dropoff is provided from the trailing edge thereof to the adjacent inner wall of the chamber.

7. The compressor of claim **6** wherein the leading edge of the said seal member is recessed into the said groove during normal operation of the said compressor.

8. A rotary vane tangency compressor comprising a compression chamber defining member, a rotor suspended in said chamber having vanes projecting therefrom in contact with the chamber-defining surface of said member, the said rotor and vanes tangent to the normal arc of said surface along a line, a variable depth groove along said line having its greatest depth adjacent the said line, a seal member in said groove, said seal member attached to the bottom of a portion of said groove spaced from the portion of greatest depth, said seal member having a portion overlying said portion of greatest depth in a cantilever fashion, said seal member having a width less than the width of said groove whereby a gap is provided between the leading edge of said groove and the leading edge of the said seal member, at least one bleed hole communication the bottom of said groove with the exterior of the said member, and the said member effective to contact the outer diameter of the said rotor along said line to provide a circumferential seal along said line.

9. The compressor of claim **8** wherein the said seal member is arcuately curved in a circumferential direction and is deformed from its normal state by contact with the rotor, the seal member being resilient whereby it is resiliently urged against the rotor.

10. A tangency seal for rotary vane compressors having a rotor received within a compression chamber defining surface comprising a variable depth groove in said surface along the line of tangency, the greatest depth of said groove intermediate the circumferential ends of said groove, the said groove ported to the exterior of the compression chamber defining member, a seal member received in said groove, said seal member having leading and trailing edges contacting the backwall of said groove at points spaced to either side of the greatest depth of said groove, the said seal member being resilient, the said seal member being deformed from its normal shape by contact with the said rotor at the said line of tangency and the said seal member resiliently urged against the said rotor by means of the deformation.

11. A tangency seal for rotary vane compressors having a rotor eccentrically received within a compression chamber defining surface, the rotor tangent to the normal arc of said surface along a line of tangency comprising: a peaked groove in the said surface along the said line, the said groove extending circumferentially to either side of said line, the said groove having its greatest depth intermediate the circumferential ends of the said groove, the said groove tapering from the point of said greatest depth to the said circumferential edges, a seal member received in said groove, said seal member having a length substantially as long as the said groove, said seal member having a width substantially as wide as the said groove, said seal member received in said groove with its surface remote from the bottom of the said groove lying in a plane different than the plane of the said surface, the said seal member being resilient, and the said seal member being deformed by contact with the said rotor.

12. The seal of claim **11** wherein the said groove has circumferentially leading and trailing edges and the said seal member has circumferentially leading and trailing edges, the said leading edge of the said seal member having passage means therethrough to flow pressure from the compression chamber to the said groove.

13. The seal of claim 12 wherein the said leading edge of the said seal member is recessed below the said leading edge of the said groove.

14. The seal of claim 13 wherein the said trailing edge of the said seal member projects beyond the said trailing edge of the said groove.

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