United States Patent [19]

Keller

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[54] **ROTARY VANE DEVICE**

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[51] **Int. Cl.** **F01c 1/00,** F01c 19/00, F04c 1/00

[58] **Field of Search** 418/33, 35, 37, 136, 418/137, 138, 145, 234, 241, 253

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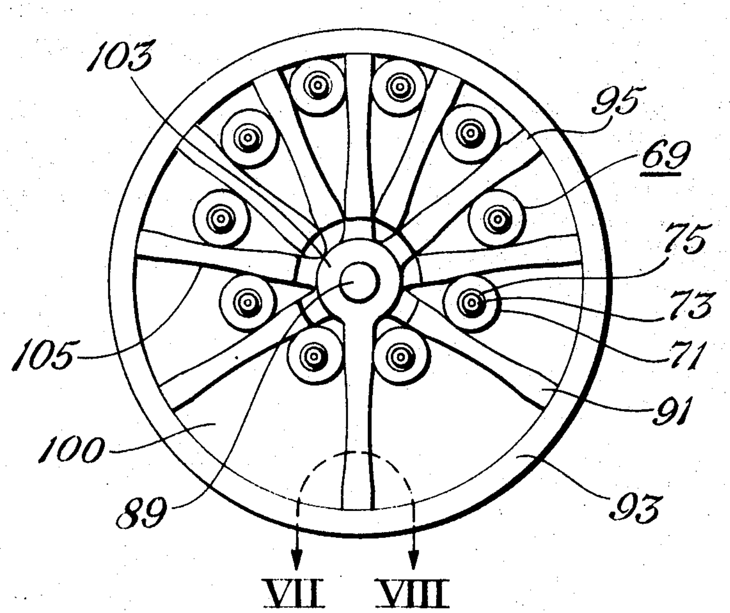
Assistant Examiner—John J. Vrablik
Attorney—Wm. T. Wofford et al.

[57] **ABSTRACT**

An eccentric rotor vane device that may be employed as pumps, including compressors; or engines, including motors, characterized by an improved seal structure; in addition to conventional main chamber; first and second ports communicating with the main chamber; a plurality of angularly related radial vanes, independently pivotal and rotatable about a vane axis within the main chamber; a rotor that is eccentrically mounted with respect to the main chamber; and a power delivery shaft connected with the rotor. The improved seal means, in a specific embodiment, comprises cylindrical vanes guides of the rotor engaging concave faces of adjacent vanes on either side such that the vane guide is maintained in substantially uniform engagement with the vane lateral faces as it traverses radially inwardly and outwardly therealong during rotation of the rotor such that a satisfactory seal is maintained intermediate the vane guide and the vanes so that the vane guide can serve as a piston as well as an interdigitating means for effecting a change in volume of a subchamber defined intermediate the respective vanes, vane guides, and main chamber.

2 Claims, 10 Drawing Figures



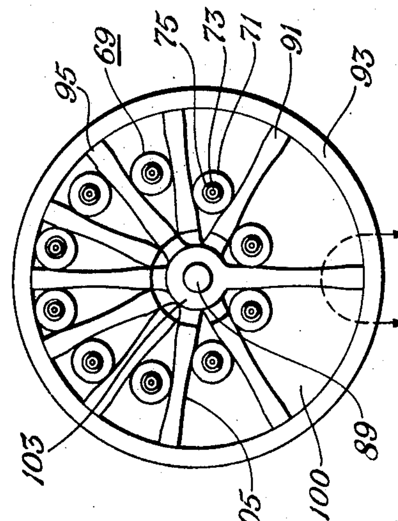


Fig. 3

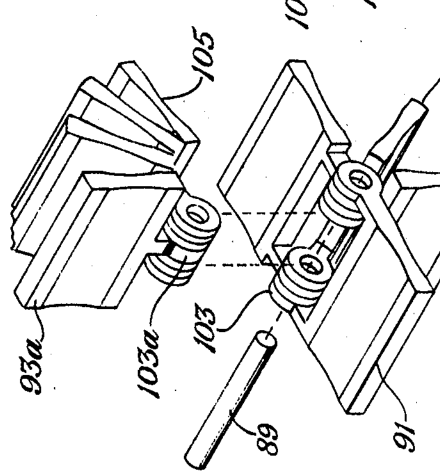


Fig. 4

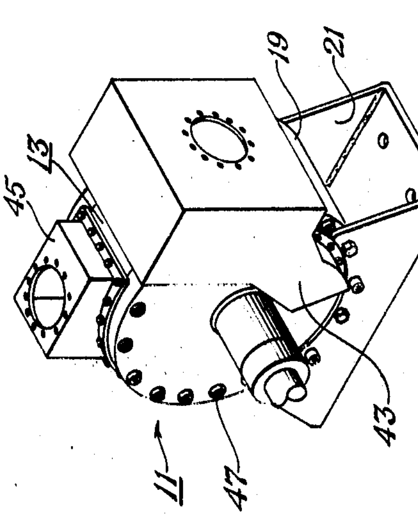


Fig. 1

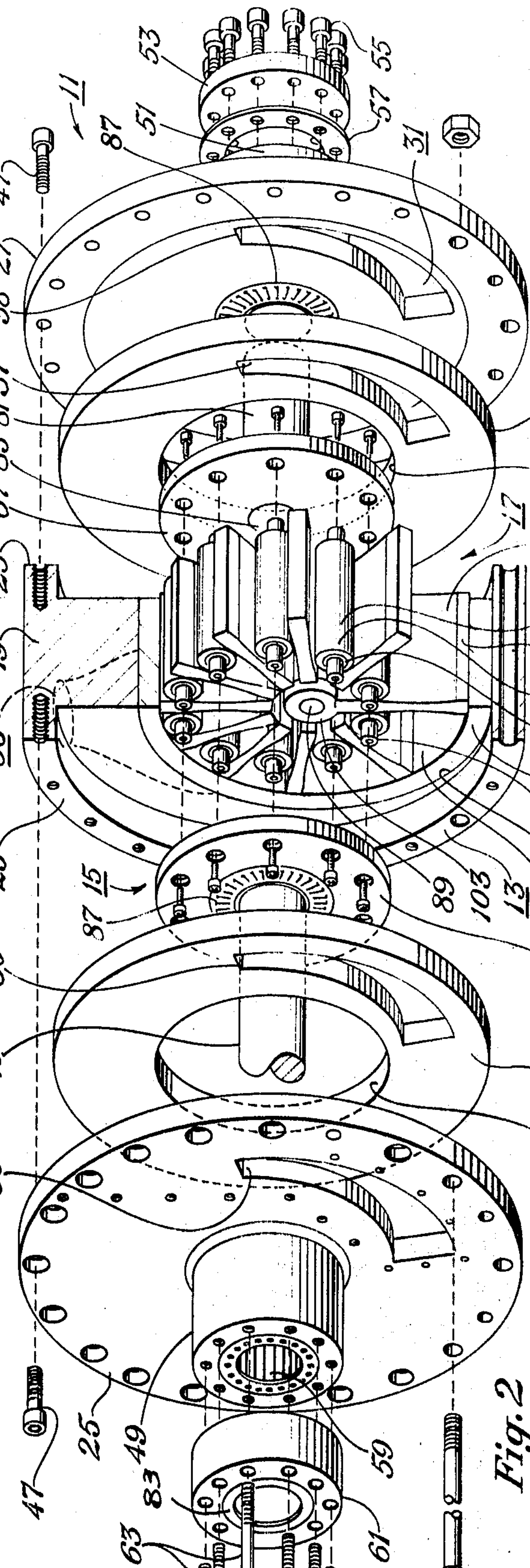


Fig. 2

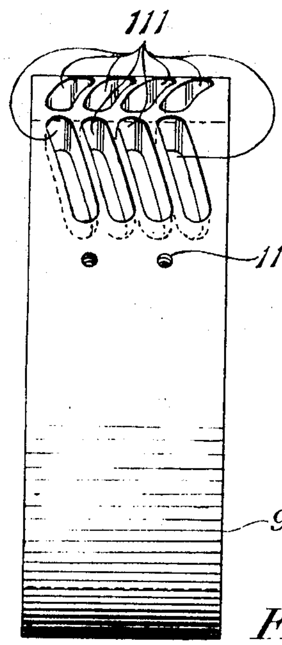


Fig.6A

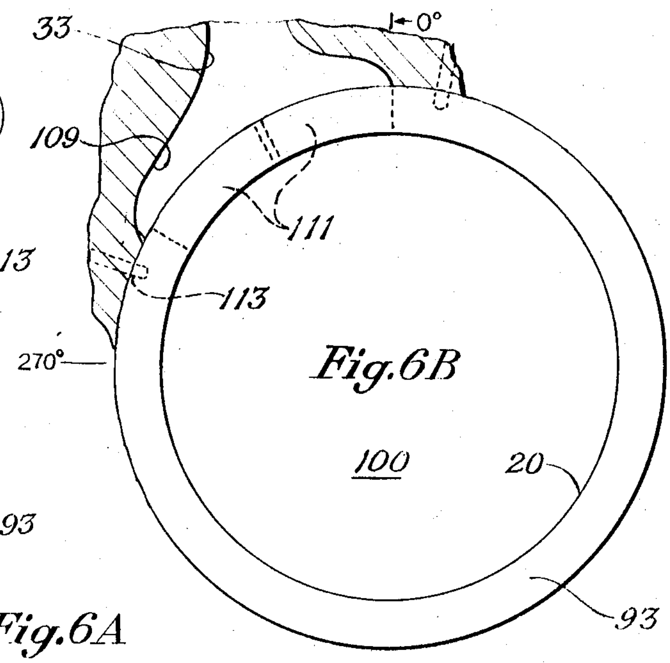


Fig.6B

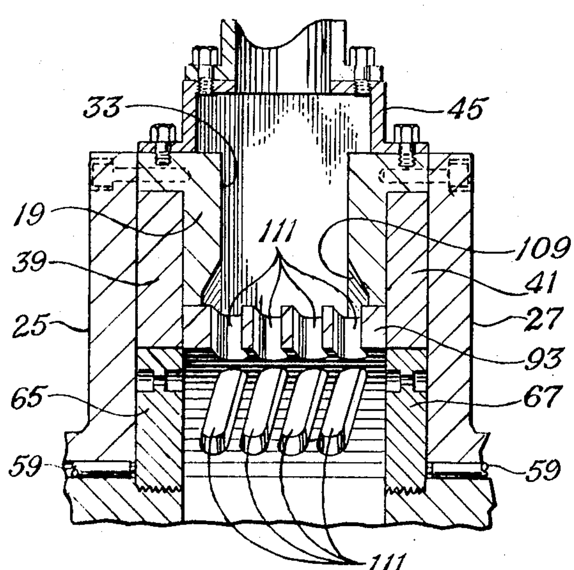


Fig.5

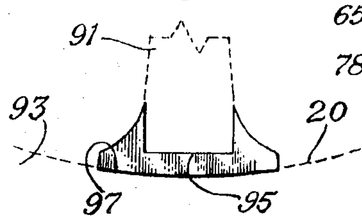


Fig. 7

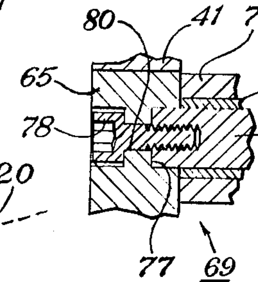


Fig.9

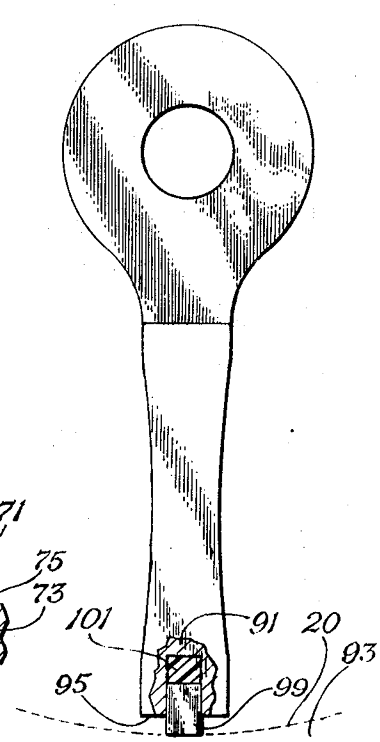


Fig.8

ROTARY VANE DEVICE

BACKGROUND OF THE INVENTION:

1. Field of the Invention

This invention relates to rotary vane, or rotor vane, devices that may be employed as either pumps, including compressors, or engines, including motors. More particularly, this invention relates to an improvement in eccentric rotor, concentric vane devices that may be employed as pumps for pumping incompressible fluids or compressing and pumping compressible fluids; or as engines, including motors powered by either compressible or incompressible fluids and engines powered by internal combustion of a fuel using either the spark ignition cycle or the diesel cycle.

2. Description of the Prior Art

Eccentric rotor concentric vane devices have been known at least since about the middle of the nineteenth century; U.S. Pat. Nos. 43,744 and 83,186 being granted, respectively, in 1864 and 1868 on rotary steam engines. Subsequently, there have been at least 16 different United States patents issued on similar structures for one or more of the uses delineated hereinbefore. Yet, not a single one of the patented devices, insofar as I am aware, has achieved widespread commercial use. The failure to be widely useful is generally conceded to be due to the lack of having a satisfactory seal between the vanes and the vane follower, or vane guide, portion of the rotor that interdigitates the vane. The seal means attempted have either allowed too much leakage to be practical or have imposed too much frictional resistance to movement to allow the machine sufficient mechanical efficiency to be pracitcal. The early attempts; intermediate attempts, such as exemplified by U.S. Pat. No. 2,129,431; and very recent attempts, such as delineated in U.S. Pat. No. 3,572,985, employed a semi-cylindrical seal member slidably engaging each side of planar vanes as they slid radially inwardly and outwardly along the vanes. Other patents, such as U.S. Pat. No. 2,022,209, described employing a seal having a knife-like edge that engaged planar vanes, attempting to seal as it moved radially inwarldy and outwardly along the vane. None effected the desired satisfactory seal.

Thus, despite the large number of attempts to employ the positive displacement rotor vane devices in the prior art becuase of their obvious efficencies, no completely satisfactory rotor vane device has been developed tYat would provide a suitable seal between the vane guides, or followers, and the vanes. Moreover, the prior art devices did not provide a rotor vane device having a large degree of variation in the volumes of the subchambers between their minimum and maximum volumes and were accordingly relatively inefficient for several applications.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of an air compressor in accordance with one embodiment of this invention.

FIG. 2 is an exploded view of the embodiment of FIG. 1.

FIG. 3 is a partial side elevational view of the main chamber, vanes and rotor subassemblies, with the end cover of the rotor removed; all of the embodiment of FIG. 2.

FIG. 4 is a partial isometric view, partly exploded, illustrating the vanes and the vane shaft of the embodiment of FIG. 3.

FIG. 5 is a parital cross sectional view illustrating the discharge port and chamber of the embodiment of FIG. 1.

FIGS. 6A and 6B are front and side views of the sleeve containing the discharge apertures of the embodiment of FIG. 5.

FIG. 7 is a partial cross sectional view illustrating one type of seal intermediate the outermost end of the vane and the main housing, in accordance with another embodimentof this invention.

FIG. 8 is a partial cross sectional view illustrating still another type of seal intermediate the outer end of the vanes and the main housing.

FIG. 9 is a partial cross sectional view of one end of a vane guide retained in a circular plate of the rotor assembly in accordance with the embodiment of FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENT(S)

It is a primary object of this invention to provide an eccentric rotor vane device that obviates the disadvantages of the prior art sructure. Specifically, it is an object of this invention to provide an eccenttric rotor vane device having an improved seal between the interdigitating portion of the rotor and adjacent vanes throughout the full 360° of rotation of the rotor such that the interdigitating portion can operate as a piston, as well as a vane guide; regardless of whether the rotor vane device is being employed as an engine, or a pump.

It is also an object of this invention to provide a rotor vane device having a wide variation in the volume of the respective subchambers between the adjacent vanes as the subchambers are traversed fron their (0°, or minimum volume position, to their 180°, or maximum volume position.

It is another object of this invention to provide an eccentric rotor vane device having specific improved structure in accordance with the respective embodiments delineated and described hereinafter and taken in conjunction with the accompanying drawings.

Referring now to the figures, and particularly, FIGS. 1–4, there is illustrated one embodiment of this invention in the form of an air compressor **11**. As indicated hereinbefore, this invention is also applicable to engines and other types of pumps as well. In fact, use of this invention as a fluid powered motor is described in my copending application Ser. No. 227,393, entitled "Rotor Vane Motor Device", filed even date herewith. In that application there is described a variable torque, variable power motor employing this invention and an improved torque and power control means. The air compressor, a rotor vane device, **11** comprises a stator **13**, a rotor assembly **15**, FIG. 2, and a vane assembly **17**.

The stator **13** includes a main body member **19** having a base or mounting bracket **21**, FIG. 1. The main body member **19** has peripherally disposed circular flanges **23**, FIG. 2, that extend longitudinally for affixing ends, or cap members, **25** and **27**. A longitudinal cylindrical cavity **29** is formed in the inner face of the main body member **19** and defines a main chamber. Intake and discharge ports **31** and **33** communicate with the longitudinal cylindrical cavity, or main chamber, **29**. The exact location of the respective intake and discharge ports **31** and **33** will be determined by whether the device is being employed as an engine or a pump and the nature of the fluid; for example, whether the fluid is compressible or not. As illustrated in the air compressor application of FIG. 2, the intake port 31 comprises a plurality of elongate apertures 35–38 extending through the plates on both sides of the longitudinal cylindrical cavity 29; namely, end cap members 25 and 27 and the annular plates 39 and 41. The elongate apertures 35–38 have a cross sectional shape commensurate with the subchamber defined intermediate the faces of the vanes and the respective vane guides and the inner wall 20, FIG. 6B of cylindrical sleeve 93 which is inside the longitudinal cylindrical cavity 29 to facilitate influx of the compressible fluid, such as air, to be compressed. A discharge port 33 is formed in the inner face of the body member 19 and extends from the rear, or about 280° position with respect to the top, clockwise toward the top. The discharge port 33 has a series of elongate openings, illustrated in FIGS. 6A and 6B. Ports having various other opening shapes may be employed if desired.

As illustrated in FIGS. 5 and 6B, the main body member 19 has the cavity 109 formed thereinto and defining the discharge port 33. The cavity 109 extends peripherally around the sleeve 93 for a distance of about 60°, intermediate the 280° position and the 360°, or 0°, position. A plurality of discharge apertures 111 are provided in the sleeve 93. The sleeve 93 may be retained in place within the longitudinal cavity 29 by means of cap screws inserted into apertures, such as aperture 113. On the other hand, suitable splines may be employed to prevent the sleeve 93 from rotating, the spline being retained intermediate the respective annular plates 39 and 41.

The inlet ports 31 communicate with intake manifold 43, FIG. 1, to facilitate the connecting of the inlet to a source of the gas to be compressed; for example, a filter for ambient air. Similarly, the discharge ports 33 communicate with discharge manifold 45 to facilitate connection with a device or system using the compressed gas, or air.

A pair of cap members 25 and 27 are affixed to the opposite sides of the main body members 19, as by bolts or cap screws 47, FIGS. 1 and 2. Only a few of the cap screws are shown in FIG. 2 to prevent cluttering up the drawings. As is well known, of course, the cap screws 47 engage aligned bores in the cap members 25 and 27 and tapped bores in the flanges 23. Coaxial bearing sleeves 49 and 51 are integrally formed with the cap members 25 and 27. A thrust plate 53 is secured to the bearing sleeve 51 by suitable cap screws 55, with a suitable seal 57 sandwiched therebetween. A coaxial collar 61 is secured by cap screws 63 to the outer end of bearing sleeve 49. The coaxial collar 61 is disposed about a shaft extending therethrough and contains a suitable shaft seal 83. Suitable bearings are interposed intermediate the bearing sleeves and their respective shafts. The bearings will be appropriate to the use in which the rotor vane device is being employed. As illustrated, roller bearings 59 are employed.

The rotor assembly 15 includes a pair of opposite and mating circular plates 65 and 67 that rotatably engage or proximate the circular apertures 68 and 70 in the annular plates 39 and 41. If desired, bearing materials can be provided at the interface between the respective circular plates 65 and 67 and the inner walls of apertures 68 and 70. Follower means, such as the vane guides 69, are retained intermediate the oppositely disposed faces of the circular plates 65 and 67. The vane guides 69 serve as both pistons and means for interdigitating the vanes, thereby effecting a change in volume of a subchamber intermediate the respective adjacent vanes as the rotor assembly and the vanes are rotated within the main chamber. As can be seen, each subchamber is defined by a pair of confronting vane faces on its sides, by a vane guide and the interior surface of the main chamber at its inner and outer boundaries, and the annular plates 39 and 41 at its ends. Each subchamber varies from a minimum volume at the outermost, or 0°, position of the vane guide to a maximum at the 180°, or innermost, position of the vane guide 69. If desired, each respective vane guide may be cantilevered from a single circular plate; although having two circular plates and having the vane guides affixed to each of the plates affords a reinforced structure that is, ordinarily, more advantageous. Similarly, the shaft 81 provides a better structure, but it may be omitted if a cantilevered structure is desired. The vane guides 69 traverse inwardly and outwardly radially along the adjacent vanes to effect the improved seal, as described with respect to the vanes and the vane assembly later hereinafter.

Each of the illustrated follower means comprises a vane guide 69 that extends longitudinally along the rotor with vane engaging surfaces on each side that are disposed symmetrically about a central axis thereof. Each of the vane engaging surfaces of a vane guide 69 has the same predetermined radius of curvature with respect to the central axis. As illustrated, eah vane guide 69 comprises a cylindrical roller 71, FIGS. 2, 3 and 9, rotatably mounted on a shaft 73. Rotation of the cylindrical roller 71 is facilitated by suitable bearing means, such as insert 75. Each shaft 73 is fixed between shoulders 77 of the circular plates 65 and 67 by cap screws 78 penetrating through apertures 80 in the circular plates 65 and 67, FIG. 9.

The respective follower means may be retained intermediate the circular plates 65 and 67 by any other conventional means. For example, if desired, the vane guide 69 may be integrally formed and the shaft portion 73 nested in suitable bearing means recessed in the circular plates 65 and 67. The illustrated embodiment has been found to be preferred becuase of the advantages attendant the respective rolling friction instead of requiring a sliding friction. If the duty is unusually severe, the sleeve insert 75 may be replaced by aircraft roller bearings or needle bearings for still further improved performance.

A power shaft 79 is fixed to and extends coaxially from the circular plate 65 through roller bearings 59 in bearing sleeve 49. As indicated hereinbefore, it is journalled within coaxial collar 61 and shaft seal 83; and extends to a prime mover or other source of power. A second shaft 81 extends coaxially from the circular plate 67 and is journalled for rotational movement in roller bearings 59 in bearing sleeve 51, to provide additional support to the rotor assembly. As indicated, the second shaft is not always necessary, particularly for light applications in which the respective vane guides 69 are cantilevered from a plate 65 carried by the power shaft 79.

As illustrated, each of the shafts 79 and 81 has a male threaded portion 85, FIG. 2, of reduced diameter that threadedly engages a tapped aperture in the respective circular plates 65 and 67. The portion 85 pulls the shoulder defined by the juncture of the male threaded portion **85** and the respective shafts **79** and **81**, into tight engagement with each respective circular plate **65** and **67** to form a strong connection therebetween. The threads are formed such that they are not loosened in normal rotation, of course. A set of roller thrust bearings **87** are provided intermediate the exterior of each respective circular plate **65** and **67** and its adjacent end cap **25** and **27**. The thrust bearings **87** may be countersunk to keep the clearance intermediate the plates to a minimum. Preferably, aircraft type roller bearings are employed as the thrust bearings **87**, although other bearings may be employed as appropriate to the use of the rotor vane device. The bearings **87** provide improved structure and should not be omitted casually.

The vane assembly **17** is located in the longitudinal cavity **29** and, as depicted, includes a floating axle pin **89**, FIGS. **2–4**, that is substantially coaxial with the cylindrical cavity **29** and that extends between the circular plates **65** and **67**. A plurality of vanes **91** extend radially outwardly from axle pin **89** and are individually pivotal thereon. As illustrated, each vane is provided with a curved end face **95** of substantially the same radius of curvature as the inside wall **20** of the sleeve **93** which defines the internal surface of the vane assembly cavity **100**. The curved end face **95** of each vane **91** is in substantial sliding engagement with the sleeve **93** such that it forms a satisfactory seal for confining the fluid inthe respective subchamber on either side thereof. The seal intermediate the vanes **91** and the sleeve **93** have not been particularly critical becuase the differential pressure between adjacent subchambers is not inordinately high and because the centrifugal force on the vanes tend to retain sufficient sealing engagement between the respective vane ends **95** and the sleeve **93**. Any type of seal appropriate to the use may be employed. Two other types of seals are illustrated in FIGS. **7** and **8**.

In the embodiment of FIG. **7** a separate seal **97** is fitted on the vane **91** before the vane assembly is emplaced within the sleeve **93**. The separate seal **97** slidably engages the end **95** of the vane **91** and may be thrown outwardly into sealing engagement with the sleeve **93** without sacrificing the seal with the sides of the vane **91**. Such a seal **97** is employed, ordinarily, when a lubricant is injected into the fluid to be compressed, as by bubbling inlet air through an oil-entraining vessel. If desired, of course, the seal **97** may have a lubricant such as a fluorocarbon impregnated thereinto for applications in which a lubricant is not injected in an appreciable quantity.

Preferably, however, a seal such as illustrated in FIG. **8** is employed for the so-called "oilless" applications. Therein, a separate seal element **99** is inset within an end **95** of the respective vanes **91**. Suitable biasing means such as a resilient annular pad **101** may be employed to bias the seal element **99** outwardly, in conjunction with centrifugal force, to sealingly engage the sleeve **93**.

As illustrated, each of the vanes **91** has integrally formed with the inner end thereof at least one annular knuckle **103** that conformingly engages the axle pin **89**. The knuckles **103** are axially offset relative to each other and are stacked on the axle pin **89** with their confronting faces in sliding engagement to permit the relative interdigitating, or rocking, of the vanes **91** about the axle pin **89**. As illustrated in FIG. **4**, the vane ***93a*** has a knuckle ***103a*** that is twice as wide as ordinary and is centrally disposed. If desired, of course, the vanes may have their respective knuckles disposed at one-half of the axle pin **89** plus the thickness of one knuckle and intermeshed such that the use of the wide central knuckle ***103a*** is obviated. In fact, any other method of supporting the vanes that will allow the interdigitating thereof may be employed. However, since the vanes are accelerated and decelerated during rotation, symmetrical arrangement of knuckles with respect to a transverse plane through the vane center is preferable, as illustrated in FIG. **4**.

The respective vanes **91** have lateral faces **105** that are concaved inwardly toward the central plane of the vane such that the respective followers, or vane guides, **69** are maintained in substantially uniform sealing engagement with the vane lateral faces **105** as the vane guides **69** traverse radially inwardly and outwardly therealong during rotation of the rotor assembly **15**. By substantially uniform sealing engagement is meant an engagement such that a satisfactory seal is maintained intermediate the respective vane guides **69** and the vanes **91** so that the vane guides **69** can serve as pistons as well as interdigitating means as they traverse radially inwardly and outwardly along the respective vanes **91**. As is well recognized, what is a satisfactory sealing engagement will vary depending upon the application, which determines several factors; such as, the size of the unit, the differential pressure across a vane guide **69** from the subchamber to the interior of the rotor assembly **15**, the total pressure of the fluid being handled in the subchamber, and the efficiency desired. To illustrate, I have found that as much as 0.010 inch clearance may be tolerated between the vane guides **69** and the vane lateral faces **105** with large devices, such as may be employed with low pressure steam. For example, with low pressure steam that may be emitted from geothermal wells, the rotor vane device may be employed as a motor and will have dimensions as large as 30 inches in length by 36 inches in diameter, or larger, if used on individual steam wells. On the other hand, when employing the device as an engine; or, more specifically, as a motor with low entropy fluids flowing therethrough; I have found it preferable that a clearance of less than 0.005 inch; for example, about 0.001–0.003 inch; be employed between the surface of the vane guides **69** and the vane lateral faces **105**. These engines may be only about 4 inches in length and 6 inches in diameter, yet develop enough power to operate a smal automobile.

This improved seal means makes practical the rotor vane device of this invention after many years of attempts by the prior art to successfully employ the rotor vane devices on a commercial scale. The preferred embodiment employing rollers for vane guides makes use of rolling friction for low, even wear. Consequently, the improved seal means is durable and troublefree, the roller vane guides rolling along the concave vane face. I have attempted to delineate, through mathematical experts and computer computations, the exact definition of the concavity of the surface of the lateral faces **105** but have not been successful to date. The concavity can be delineated graphically, employing a scale that is larger than actual size. I have developed an empirical formula by trigonometry that is close, also. In practice, I have found exact delineation to be unnecessary. Instead, I employ a grinding jig with grinding rollers to duplicate the physical relationships and dimensions employed in the rotor vane device **11**. Specifically, the grinding of the vane faces is effected by moving the vanes and sized grinding rollers through 360° as the vanes would be moved by the rotor assembly **15**, with increasing distances of eccentricity, up to the eccentricity actually employed in the device **11**, of the shaft of the vane axle pin **89** and the axis of the shaft of the grinder rollers that is equivalent to the axis of the shafts **79** and **81** of the rotor assembly **15**. In this way, I get exact initial engagement and do not have to worry about clearance. Once a vane contour, or concavity, has been established, it may be reproduced by conventional methods.

In operation of the rotor vane device **11** of FIGS. **1–4**, employed as an air compressor, the respective subchambers are defined, as described hereinbefore, and take in the fluid through intake ports **31** as the respective vanes **91** are moved further apart by the inwardly radially traversing vane guides **69**. As indicated hereinbefore, the respective intake ports communicate, by way of intake manifold **43** and suitable conduit, with a source of the gas to be compressed. Moreover, each inwardly traversing vane guide **69** further creates a larger subchamber to induce the fluid to flow into the vane assembly cavity **100** through the intake port **31**. It is particularly noteworthy that in this invention, the volume expansions of the sum of the subchambers during a single rotation of the rotor exceeds the total volume of the cavity **100**. This particularly advantageous facet enables a wide variation in volumes and hence, an unusually large capacity of this positive displacement rotor vane device, as compared with the prior art devices. Expressed another way, the vane guides are able to move completely to the sleeve **93** in the 0° position and reduce the volume of the subchamber to substantially zero, or nothing; and the vane guide moves inwardly substantially to the knuckles **103** of the vanes to create the maximum possible radial dimension for the respective subchamber at the 180° position. Because of the separate wall of the rotor of the prior art structures, in conjunction with the semi-cylindrical seals traversing along the planar vanes, this wide variation in volume of the respective subchambers was not possible. FIG. **3** illustrates the closeness of the oppositely disposed faces of adjacent vanes at the top, or 0° position, as contrasted with the widely spaced apart facing surfaces of the vanes at the bottom, or 180° position.

The rotor forces the vane guides and consequently the vanes to rotate, expanding the subchambers and taking in an ever increasing amount of gas to proximate the lower position of the vanes, at the cut-off of the intake port **31**. Further rotation of the rotor causes the respective vanes to begin to be moved closer together, compressing the fluid contained in the respective subchambers defined intermediate the adjacent vanes. As the fluid is compressed to the desired pressure, the respective subchamber will have been moved to the discharge apertures **111**, at which point the fluid begins to flow from the subchamber. Substantially all of the fluid will have flowed from the subchamber as it moves to near the top. At the top, the respective vane guide will have been moved to the outermost pesition to reduce the volume of the subchamber to substantially zero, as can be seen in FIG. **3**. Further rotation begins the intake cycle over again.

The materials of construction ordinarily employed in this art may be employed herein and no exotic new materials are necessary. The structural strengths and the wearing properties of the materials that interfere together will be chosen appropriate to the application. For example, in certain applications it may be possible to employ plastics to reduce the friction as they interfere with adjacent metallic components. In general, we have been working with the most deleterious types of materials and have employed noncorrodible metals in those surfaces coming in contact with the fluids.

Thus, it can be seen that a highly efficient positive displacement device is provided that finally achieves all of the advantages heretofore known but not practically achievable, because of the difficulties with the seals intermediate the rotor housing and the vanes. Specifically, this invention provides a rotor vane device that achieves the objects delineated hereinbefore and obviates the disadvantages of the prior art devices. Its size and weight are unbelievably more compact and lighter than conventional air compressors. The use of roller vane guides, with the attendant rolling friction, effects a long-wearing, trouble-free seal that is an important advance in the technology to improve our ecology, since the rotor vane device **11** makes practical essentially nonpolluting engines, when used as the expander in an external combustion Rankine cycle system.

Moreover, the large changes in volume of the subchambers allow unusually large variation in compression ratios when the rotor vane device **11** is employed as an engine.

A wide variety of other embodiments employing this basic improved seal are feasible. Only a few of the different embodiments are implicit in the description matter hereinbefore, and it would be virtually impossible to catalog all of these embodiments in one application. Hence, although this invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made ony by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of this invention.

What is claimed is:

1. In an eccentric rotor vane device having:

a. a main chamber having a substantially cylindrical interior surface;

b. first and second ports spaced around and communicating with said main chamber;

c. a plurality of angularly related radial vanes, independently pivotal and rotatable within said main chamber about a vane axis therewithin; said vanes occupying substantially the total radial distance from said axis to said interior surface of said main chamber;

d. a rotor that is eccentrically mounted with respect to said main chamber and rotatable about a rotor axis spaced from said vane axis; said rotor having follower means for interdigitating said vanes and effecting a change in volume of a sub chamber intermediate respective said vanes as said rotor and said vanes are rotated within said main chamber; each sub chamber being delineated by a pair of confronting vane faces and a corresponding follower means between said vane faces and said main chamber interior surface and varying from a minimum volume at the radially outermost position of said follower means with respect to said vane axis, said minimum volume position being referred to as the 0° position, to a maximum volume at the radially innermost position of said follower means, referred to as the 180° position; and

e. a power delivery shaft connected with said rotor for delivering power in association therewith;

the improvement comprising an improved seal means intermediate said vane and said follower means in which:

f. said follower means is disposed intermediate said respective vanes and comprises vane guides that are substantially cylindrical rollers extending longitudinally of said rotor and having respective vane engaging surfaces on each side that are disposed symmetrically about and have a predetermined radius of curvature with respect to the central axis of each respective vane guide; and

g. said vanes have lateral faces that are concaved inwardly toward the central plane of the vane such that said follower means is maintained in substantially uniform sealing engagement with said vane lateral faces as said follower means traverse inwardly and outwardly therealong during rotation of said rotor such that a satisfactory seal is maintained intermediate said follower means and said vanes so that said follower means can serve as a piston as well as an interdigitating means; said vanes being symmetrically contoured with respect to said central plane of the vane such that each said respective vane maintains said satisfactory seal at their respective points of contact with adjacent vane guides.

2. The device of claim **1** wherein said vane guides are rotatably mounted in said rotor and intermediate respective said vanes.

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