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SEALING STRUCTURES

3,176,909

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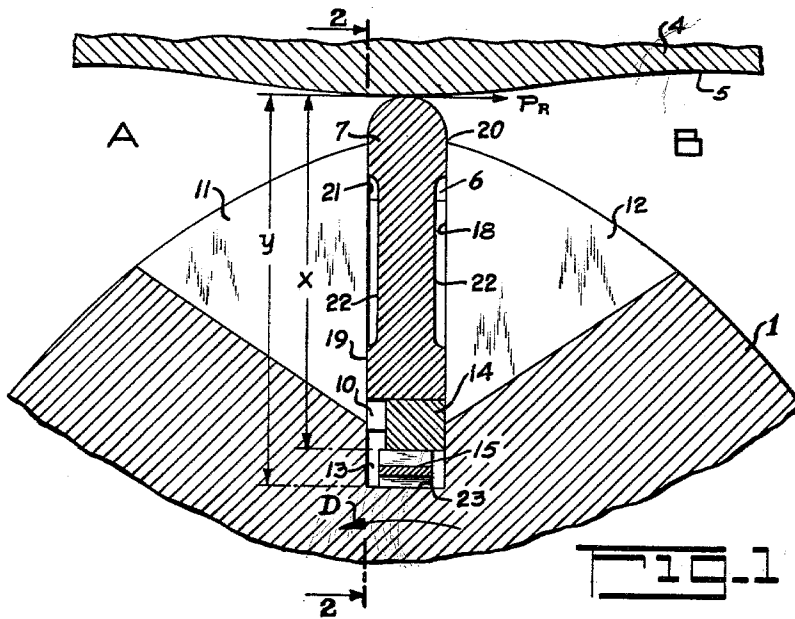
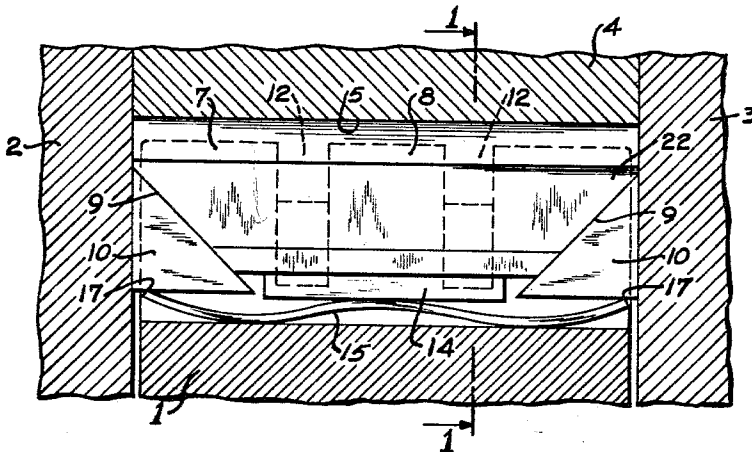


FIG. 2

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This invention relates to sealing structures of the kind used in conjunction with rotary mechanisms, such as combustion engines, compressors, pumps, or expansion engines.

The invention is particularly useful in connection with rotary combustion engines similar to that disclosed in U.S. Patent No. 2,988,065.

Such a rotary combustion engine comprises an outer body having a cavity therein and an inner body relatively rotatable within said cavity, about an axis laterally spaced from but parallel to the axis of said cavity. The outer body has axially-spaced end walls and a peripheral wall interconnecting the end walls to form said cavity, the inner surface of the cavity peripheral wall having a multi-lobe profile which preferably is basically an epitrochoid. The inner body has end faces disposed adjacent to said outer body end walls for sealing cooperation therewith and has a peripheral surface with a plurality of circumferentially-spaced apex portions, each carrying a radially-movable seal for sealing engagement with the multi-lobe inner surface of the outer body peripheral wall to form a plurality of working chambers between the two bodies which vary in volume upon relative rotation of the two bodies. Each such apex seal of the inner body runs axially from one end face to the other of the inner body. The number of apices will usually exceed the number of lobes of the epitrochoid by one.

In the subsequent discussion it will be assumed that the inner body is rotary whereas the outer body is stationary. Accordingly, the inner body will be identified as the rotor and the outer body as housing. It will be appreciated, however, that the considerations applicable to the prior art as well as to the described invention apply equally in the situations where the relations of inner and outer body are inverted, or where both inner and outer body may be rotating as described in the mentioned Patent 2,988,065.

Each apex seal is seated in a slot or groove that is provided at the corresponding apex of the inner body, with play in both the radial and also the peripheral or lateral directions. Ideally, one or the other of the side surfaces of the seal should engage its confronting slot side wall with surface contact, depending upon the relative pressures prevailing in the adjacent working chambers. In other words, the seal disposition should be essentially radial.

During rotation of the inner body, or rotor, relative to the outer body, each apex seal strip slidably engages the inner surface of the outer body peripheral wall such that the apex seal strip serves to seal two adjacent working chambers on each side of the apex seal strip from one another. The apex seal strips are maintained in contact with the inner surface of the outer body peripheral wall through gas pressure from one of the working chambers adjacent the seal strip which flows into the seal groove between the groove side wall and the seal strip side wall forcing the seal strip against the opposite groove side wall. The gas pressure flows under the seal strip and urges the seal strip radially outwardly in the groove and into engagement with the inner surface of the outer body peripheral wall. In addition, a spring is also normally

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positioned under the seal strip in the groove to urge the seal strip into contact with the inner surface of the peripheral wall when there is not sufficient gas pressure in the adjacent working chambers, as for example, when starting the engine. During operation of the engine, the pressure in the adjacent working chambers on each side of an apex seal strip varies so that at one instant the higher pressure may change from one adjacent working chamber to the other and consequently the seal strip will first bear against one side wall of its groove with one seal strip side wall and then against the opposite groove side wall with the other seal strip side wall. However, at other times during rotation of the rotor, the seal strip comes into positions wherein no difference in pressure exists between the adjacent work-chambers and the pressure in the working chambers is relatively low. When this occurs, the forces acting on the seal strip tend to tilt it within the groove about the outer edge of said groove.

In order to provide sufficient gas pressure beneath the seal strip in the seal groove to urge the seal strip into contact with the inner surface of the peripheral wall, the width of the seal strip and the groove are so related that a relatively large gap between the seal strip side wall and groove side wall is present when the seal strip is pressed against the other groove side wall. This relatively large gap allows the seal strip to have a relatively large tilting movement within the groove and, when the pressures in the adjacent working chambers is substantially equal, as explained above, the seal strip can jam in the groove. Jamming of the seal strip in the groove impairs the sealing action and the jamming can only be eliminated by gas pressure from one of the working chambers, when it becomes high enough, bringing the seal strip out of its tilted position and into contact with the groove wall and the side wall of the seal strip. Furthermore, when the seal strip is in a tilted position, gas pressure cannot flow into the seal groove below the seal strip so that the gas pressure force, which normally urges the seal strip into engagement with the inner surface of the peripheral wall, is lost. It will be apparent that tilting and jamming of the seal strips is undesirable for a number of reasons, the major reason being, a loss of sealing between the working chambers and, therefore, a loss in compression and engine power.

The prime object of the invention is to provide a sealing means wherein gas pressure beneath the seal strip in the seal groove for urging the seal strip radially outwardly in the groove will always be available from one of the adjacent working chambers while permitting the use of a relatively narrow seal strip groove which therefore, substantially eliminates the tilting of the seal strip in the groove. The invention is generally carried out by providing passageways in the rotor, there being one passageway connecting each working chamber adjacent a seal strip with the bottom of the seal strip groove. The seal strip is normally positioned so that it is radially-spaced from the radially inner wall of the seal groove to form a gap beneath the seal strip and the radially inner wall of the groove. Each of the passageways has an opening in the seal groove wall to the gap so that the gap will always be in communication with the passageways and a working chamber. It will be apparent therefore, that the gas pressure for urging the seal strip comes in through the bottom of the seal groove and not between a groove side wall and seal strip side wall and as a result the seal groove can be formed so that the seal strip fits therein with only a slight clearance allowing very little lateral play of said strip in the groove but with sufficient play for the seal strip to move radially. Because of this arrangement, the seal strip only has to move a small distance from one groove side wall to the other during contact change with said walls, the force of impact between

the seal strip and all contacting surfaces is decreased when the seal strip changes position and a quicker restoration to sealing action is obtained during movement of the seal strip.

The passageways and openings to a seal groove gap result in a connection or short circuit between adjacent working chambers. In order to prevent the gases from flowing between the working chambers through the passageways, an insert member is provided in the seal groove gap between the radially inner surface of the seal strip and the radially inner surface of the groove with said insert member having a lateral dimension smaller than the width of the seal groove to permit lateral movement of the insert member in the groove. The insert member however, has a larger radial dimension than the openings from the passageways to the seal groove gap. It will be apparent that gas pressure coming from one working chamber having a higher pressure than an adjacent working chamber will flow through a passageway opening into the seal groove gap and force the insert member laterally toward the opening from the other passageway and close off this opening so that gas pressure will not flow into the other working chamber. At the same time, the gas pressure will act under the insert member in a radially outward direction to urge the seal strip into contacting engagement with the inner surface of the peripheral wall. Thus, whichever chamber has the higher gas pressure, a gas pressure force will be provided for urging the seal strip radially outwardly while a short circuit between the adjacent working chambers will be prevented.

A spring may also be provided below each seal strip, as explained above. However, it is possible to eliminate the spring when the height of the seal strip and the height of the insert piece are made such that their sum is only slightly smaller than the spacing of the groove bottom from the inner surface of the outer body peripheral wall so that only a small gap is left. The gas pressure flowing through this gap creates a suction which acts to immediately restore the contact between the seal strip and the inner surface of the outer body peripheral wall or between the underside of the seal strip and the insert piece.

Supplying gas under pressure below the seal strip is preferably accomplished by means of passageways that extend as far as the groove corners and are of relatively large cross section. Through this construction, carbonization by combustion residue, when the engine is used as a combustion engine, is prevented. It also ensures a substantially unthrottled impingement on the seal strip side walls by the gas pressure, which effects the abutment of the seal strip against the opposite groove side wall up to the instant of pressure change-over in the working chambers which leads to completely avoiding any tilting of the seal strip in the seal grooves.

Reference may also be made to copending application Serial No. 165,896 by Ulrich Schaller and Hanns-Dieter Paschke filed on January 12, 1962 for further description of seal tilting and jamming and another means for overcoming these drawbacks.

Other objects, novel features and advantages of the invention will be understood from the following, more detailed specification, of which the appended claims form a part when considered together with the accompanying drawing in which:

FIG. 1 is a sectional view of a rotor apex taken along line 1—1 of FIG. 2; and

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1.

Referring to FIGS. 1 and 2, reference numeral 1 designates the rotor of a combustion engine of the described character. The rotor rotates in the counter-clockwise direction indicated by arrow D, inside of, and eccentrically with respect to a housing that is composed of the end plates 2 and 3 and of the peripheral wall 4 that connects them together. The inner surface 5 of the peripheral

wall has a profile of a multi-curved form, preferably basically a multi-lobed epitrochoid. The rotor 1 has a plurality of apices, one of which is illustrated in the drawing. Each apex is provided with a slot or groove 6, which extends across the full axial depth of the rotor. A seal member 7 is seated within slot 6 with play in the radial direction. The seal member 7 continuously engages the inner surface 5 of the peripheral wall 4 with sliding movement, and seals from one another the adjacent working chambers A and B in a peripheral direction. In the course of a given engine cycle the volumes of the chambers will vary. By way of example, the seal member is composed of plural parts, namely a middle part 8 having beveled ends 9, against which are set triangular end pieces or end legs 10. By virtue of such multi-part construction, the seal member may change in length because of thermal expansion of the housing, and yet bear against the inner surface of the end plates 2 and 3.

In the operation of the engine the seal member is urged against the inner surface 5 of the housing peripheral wall by the gas pressure from that of the adjacent chambers in which the higher pressure prevails. For the purpose of enabling the pressure gas to arrive below the strip, there are provided pairs (see FIG. 2) of cut-outs 11 and 12, which connect the groove space 13 underneath the seal member 7 with the adjacent working chambers A and B. The pairs of cut-outs 11 and 12 are located symmetrically with respect to rotor end walls 2 and 3, with respect to the median axial plane through the seal, and with respect to each other in accordance with the teachings of the mentioned Schaller et al. application, but in accordance with the teaching of the present invention they extend to the underside of the seal 7. Further in accordance with the teaching of the Schaller et al. application, the seal member is recessed in the peripheral direction to form recess portions 22 which are subjected to pressures A and B so that the seal 7 is maintained in one or the other desired position in which a seal side wall engages a slot side wall.

Below the sealing member 7 is disposed within the slot 6 an insert member 14, having large lateral play. This insert member has the purpose of blocking the communication between working chamber B and seal underside via cut-outs 12 when higher pressure prevails in working chamber A; and conversely of blocking communication between working chamber A and the underside of the seal via cut-outs 11 when higher pressure prevails in working chamber A. In the absence of insert member 14, the cut-outs would provide a direct short circuit between the chambers. The insert member 14 is small in size and mass in relation to the main seal member 7 and is therefore capable of responding rapidly to any interchange in relations A and B to assume positions of alternately blocking cut-outs 11 on the one hand and cut-outs 12 on the other. Also, the insert member has smaller lateral width than the main seal member 7 for purpose of play, whereas the lateral width of the slot 6 may be made so as to provide very small clearance for the seal 7, say several hundredths of a millimeter as stated in the introductory part of the specification.

Below the insert member 14 is provided a spring member 15 which presses the insert member 14 against the underside of the seal 7. As may be seen from FIG. 2 the spring 15 moreover serves to press the triangular end pieces 10 of the seal 7 outwardly. The locations 17 where the spring 15 bears against the end pieces 10 are selected, so that the force of the spring exerts no tilting moment on the end pieces 10.

The described seal structure operates in the following manner. Assume that the higher pressure prevails in chamber A. The pressure gas arrives through the cut-outs 11 in the slot space 13 and acts on the underside of the seal member 7, the side surface of insert member 14 in the path of such gas pressure, and at the underside of

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insert member 14. As a result, the insert member 14 in the first place is urged to bear against the slot wall 18 opposite chamber A (adjacent chamber B) and is also urged against the underside of the seal member 7, which in turn is urged outward to bear against the inner surface 5. In addition, the gas pressure acts against the side wall 19 of the seal member, also the recess portion 22 thereof, and consequently presses the seal member 7 against the side wall 18. Thus, the seal member 7 and the insert member 14 serve to provide a gas-tight seal for sealing off the cut-outs or passageways 12 extending from the slot side wall 18 to chamber B.

When the gas pressure in chamber A decreases, the frictional force P_R at the seal top may preponderate momentarily, and the seal member 7 may tend to tilt in its slot 6 about the slot edge 20. Such tendency to tilt is minimized, and in any event the sealing is not reduced in efficiency, because the gas pressure in chamber A, now as before, is able to arrive through the cut-outs 11 into the slot space 13 and thus, now as before, force the seal member 7 outwardly, and force the insert member 14 against the underside of the seal member 7 and against the slot wall 18. When pressure builds up inside chamber B that is greater than the pressure in chamber A, the seal member 7 and insert member 14 are brought to bear against the slot wall 21. The pressure gas from chamber B arrives in the slot space 13 and impinges upon the underside of the seal member 7 and of the insert member 14. The axially-extending recessed portions 22 insure that the seal member always bears against the confronting slot wall 18 or 21 at two areas, even when the slot wall experiences bulging deformation under influence of heat. This substantially diminishes the tendency of the seal member to tilt as explained in the Schaller et al. application. In the described example of construction, the gas pressure is supplied through the cut-outs 11 and 12, which extend as far as the bottom slot edges. Instead of such cut-outs, channels or bore holes may be provided, which run from below the seal member 7, from slot walls 18 and 21 through the rotor body, terminating in the adjacent working chambers A and B respectively. It should be noted that the spring 15 serves principally to press the insert piece 14 against the seal member 7 and thereby press the seal member 7 against the inner surface of the housing peripheral wall 4, so long as the gas pressure available in one of the chambers A or B is not of sufficient magnitude to perform this function. The spring 15 may under certain circumstances be omitted, for example when the total radial height x of the seal member 7 and insert member 14 is only slightly smaller than the spacing of the slot bottom wall 23 from the inner surface 5. In this case only a very small gap is left between the seal member 7 and the inner surface 5, or between the underside of the seal member 7 and insert member 14, through which pressure gas could flow from chamber A to chamber B or vice versa. Such a flow produces a suction in the gap, which immediately causes the seal member 7 and/or insert member 14 to bear against the inner surface 5 or the underside of the seal 7 respectively, so that the leakage losses caused by the gap are negligibly small.

From the foregoing description, it is evident that the stated objectives of the invention of substantial elimination of seal tilting effects, both first stage, temporary tilting and second stage, permanent tilting, have been realized in sealing structures having described features. It should be understood that this invention is not limited to specific details of construction and arrangement thereof herein illustrated, and that changes and modifications may occur to one skilled in the art without departing from the spirit of the invention.

As used herein "several hundredths" or "few hundredths" of a millimeter shall mean up to five hundredths of a millimeter.

What is claimed is:

1. A sealing means for a rotary mechanism having an

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outer body formed by a peripheral wall interconnected with a pair of end walls to define a cavity, an inner body supported for rotation relative to said outer body about and axis parallel to but spaced from the axis of said outer body with the outer surface of said inner body having a plurality of circumferentially-spaced apex portions for sealing engagement with the inner surface of the outer body peripheral wall thereby defining a plurality of working chambers which during relative rotation between said inner and outer bodies vary in volume, and each said inner body apex portion having a groove formed therein extending axially across the entire width of said inner body, said sealing means comprising; and apex seal member in each said groove with said apex seal member having a lateral width smaller than the lateral width of said groove to permit movement of said apex seal member relative to the walls of said groove and during operation of said rotary mechanism being radially-spaced from the radially inner wall of said groove to form a gap between the radially inner wall of said groove and the radially inner face of said apex seal member; a plurality of cut-out means formed in each apex portion of said inner body, there being at least one cut-out means on each side of said groove communicating with a respective working chamber adjacent each apex portion and having an opening in the side wall of said groove communicating with a side face of said apex seal member and said gap so that gas pressure may flow from said working chambers through said cut-out means into said gap and against an apex seal member side face for urging said apex seal member toward a groove side wall; and an insert member disposed in each said gap with said insert member having a lateral width smaller than the lateral width of said groove to permit lateral movement of said insert member between the side walls of said groove in response to changes in the gas pressure from said working chambers and said insert member having radial and axial dimensions greater than the openings of said cut-out means to said gap so that, when the gas pressure is higher in one of said working chambers than the gas pressure in an adjacent working chamber, said insert member will move laterally in said groove in response to the higher gas pressure to block the opening of said cut-out means to said gap communicating with the working chamber having the lower gas pressure and permit the higher gas pressure to act against said apex seal member for urging said seal member radially into sealing engagement with the inner surface of said outer body peripheral wall.

2. A sealing means for a rotary mechanism as recited in claim 1 wherein said insert member is disposed in abutting relationship with said apex seal member and further comprising resilient means disposed in said gap between the radially inner wall of said groove and the radially inner wall of said insert member for urging said insert member and said apex seal member radially outwardly into sealing engagement with the inner surface of said outer body peripheral wall.

3. A sealing means of a rotary mechanism as recited in claim 1 wherein each said cut-out means has a portion thereof communicating with a side face of said apex seal member and said apex seal member is provided with an axially extending recess disposed intermediate of the radially inner and outer walls of said apex seal member and extending across the entire axial width of each side face of said apex seal member and communicating with said cut-out means for insuring contact between said apex seal member and a groove side wall at two places along an apex member side face even during distortion of said groove side wall.

4. A sealing means for a rotary mechanism as recited in claim 1 wherein said apex seal member comprises a multi-piece seal construction including a first seal piece extending axially across the entire width of said groove and in contacting engagement with each of said outer body end walls and said first seal piece having beveled

faces at each axial end thereof, said insert member being disposed in abutting relationship with said first seal piece; and a second seal piece having an inclined face in mating engagement with the beveled face at each axial end of said first seal piece for permitting relative movement between said first and second seal pieces so that said apex seal member may change in length while maintaining sealing contact between said apex seal member and said outer body peripheral and end walls.

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