

- [54] **COMBINATION APEX AND SIDE SEALS FOR ROTARY PISTON ENGINES**
- [75] Inventor: **Harold E. McCormick, Ballwin, Mo.**
- [73] Assignee: **Ramsey Corporation, St. Louis, Mo.**
- [22] Filed: **Oct. 27, 1971**
- [21] Appl. No.: **193,059**

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Primary Examiner—Carlton R. Croyle
Assistant Examiner—Michael Koczko, Jr.
Attorney—Carlton Hill et al.

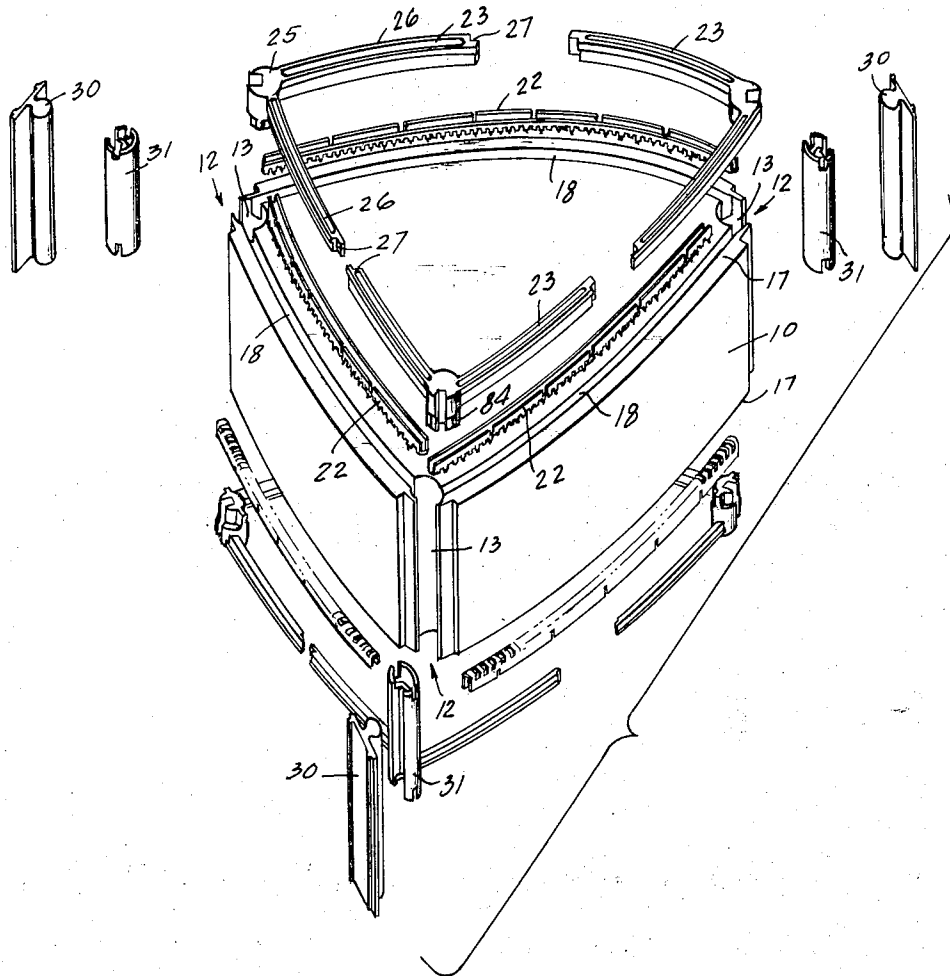
- [52] U.S. Cl. **418/142, 418/113**
- [51] Int. Cl. **F01c 19/08**
- [58] Field of Search..... 418/61, 143, 144, 418/119, 120, 121, 122, 113; 277/81 P

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[57] **ABSTRACT**
 A combination apex corner seal and side compression seal for rotary piston internal combustion engines, the combination consisting of wishbone shaped members having two legs diverging from an integral hub, the hub being shaped to form the end member of an apex seal, the legs of the wishbone indexing with grooves in the side of the piston and forming side compression seals.

19 Claims, 11 Drawing Figures



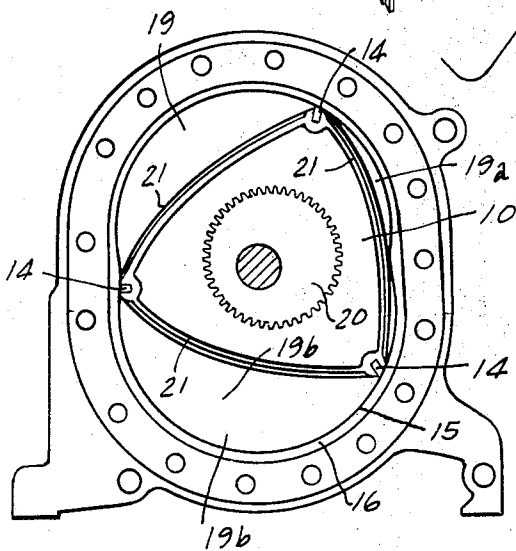
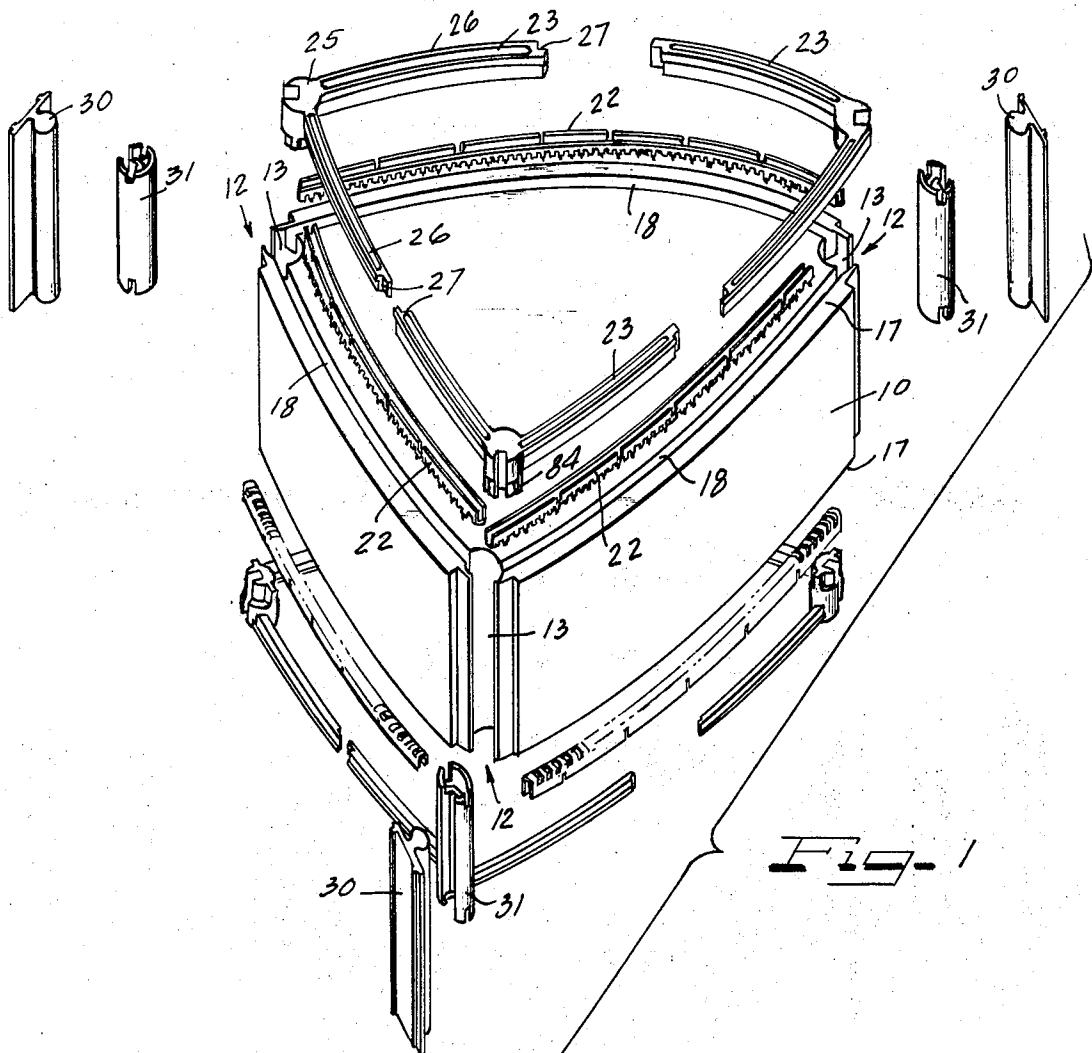
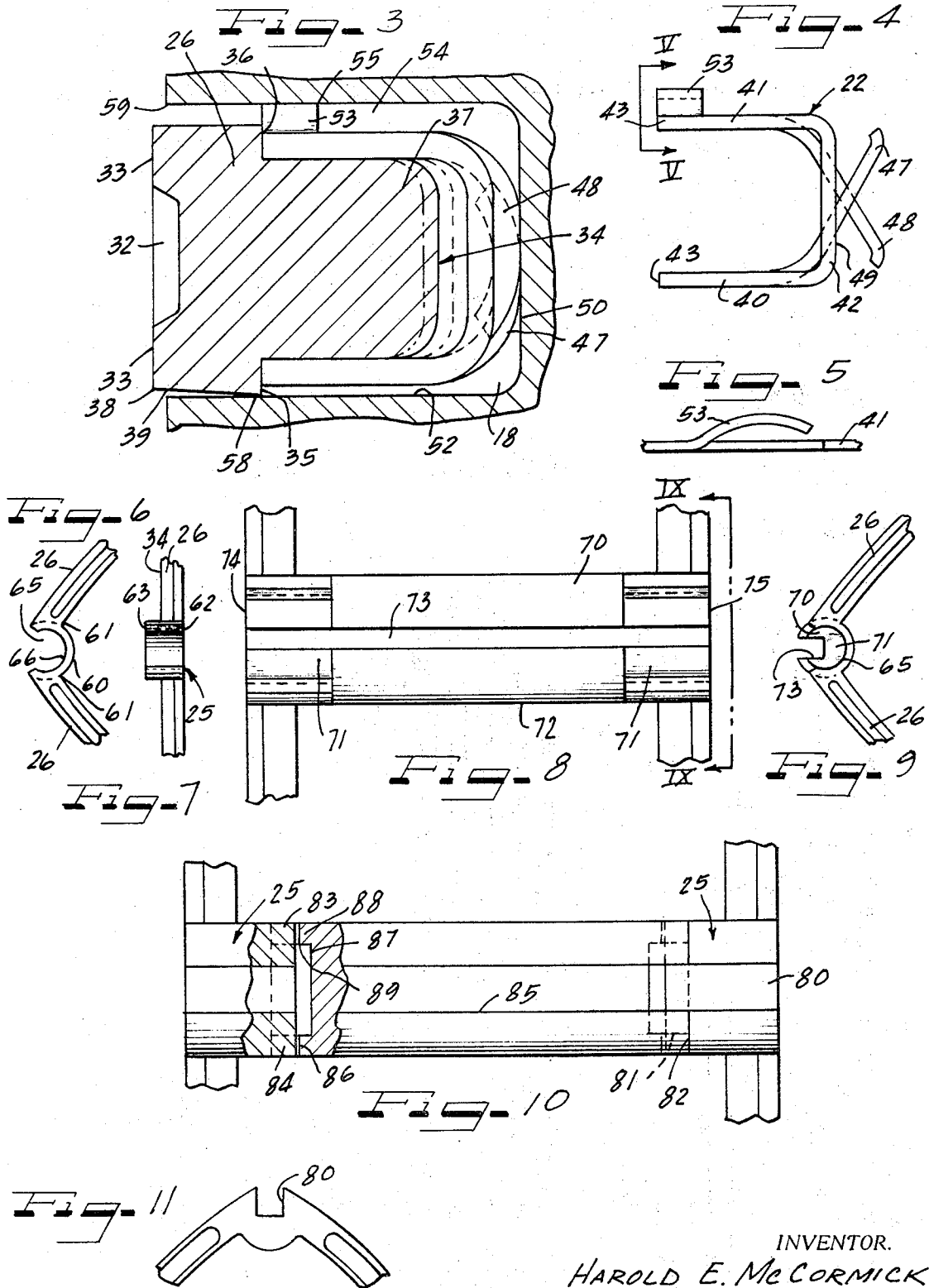


Fig. 1

Fig. 2

INVENTOR.
HAROLD E. McCORMICK

BY *Wells, Sherman, Messer, Chase & Simpson* ATTORNEYS



INVENTOR.
HAROLD E. McCORMICK

BY *Bill Thomas, Meritt, Cross & Singer* ATTORNEYS

COMBINATION APEX AND SIDE SEALS FOR ROTARY PISTON ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the internal combustion engines and more particularly to compression and apex seals for rotary piston engines.

2. Description of the Prior Art

Rotary piston engines, particularly of the Wankel type, utilize a rotating piston or rotor having axial end walls and a variously dimensioned periphery having thereon corners at the apexes of the sides of the periphery. In order to separate the sides from one another when the rotor is received in the chamber, apex seals are used at the intersections of the peripheral sides to seal against the wall of the chamber. Further, the rotor is received between two non-rotating end plates and side seals are necessary to prevent fluid flow between the chamber cavity radially outward of the rotor and the central opening in the rotor. In order to reduce such leakage to a minimum it is desirable that the side seals be placed as close to the periphery as possible. Heretofore, the prior art has provided grooves in the periphery extending along the line of the apex for receipt of the apex seal. These grooves have extended from side to side of the rotor and have intersected thereat with grooves in the side walls of the rotor extending between the ends of the apex grooves. The side grooves receive compression seals which are sprung urged axially outwardly. The point of intersection between the side seals and the apex seals presents a mechanically difficult sealing point. Part of the mechanical difficulty arises from the fact that the apex seals must be urged radially outwardly in contact with the surface of the rotor chamber while the ends of the apex seal need to be sealed against side leakage between their ends and the end plates. This requires an axially expansive force. A typical method of solving the problem, as used in the prior art, required the provision of counterbores in the axial ends of the apex seal groove, the counterbores receiving corner seal members which were sprung backed, urging them axially outwardly. The corner seals had slots for receipt of the apex seal which in turn was sprung backed to urge it radially outwardly. While such prior art constructions were effective to reduce leakage, they required a number of parts for the corner seal and left open leakage paths around the corner seal.

In typical prior art embodiments, two or more side seals were provided, requiring two or more grooves extending between the apex seal grooves. Linearly curved seals were received in the grooves and had their ends abutting corner seals received in the apex grooves. This required a clearance between the compression seal on the side and the corner seal to compensate for expansion as well as to allow easy installation.

Further, the corner seal and apex seal required a multipiece construction wherein the corner seal comprised a multiplicity of parts including expander members etc.

Prior art constructions according to the above described type do not adequately seal, require expensive machining of the rotor for the provision of narrow grooves, are difficult to install, and require extremely close tolerances in manufacturing.

SUMMARY OF THE INVENTION

My invention overcomes the disadvantages of the prior art in that it provides a combination side seal and apex corner seal. The invention, in its preferred embodiment, makes use of a wider side seal, allowing the use of a wider groove, thereby eliminating the need for complex machining of the rotor. Additionally, because I have combined the apex corner seal and the combustion seals into one piece, the problem of sealing at the intersection between the side seal and the apex seal is eliminated.

My invention also provides a novel apex seal construction consisting of a cylindrical member interposed between two of the corner seal portions of the combination and indexed therewith. The cylindrical member has a configuration allowing receipt of the apex seal.

The seals of this invention are specifically illustrated for use in connection with a three-sided rotor of the type normally used in a trichoid chamber of a rotary combustion engine such as a Wankel engine. The rotor is formed with grooves at the three apexes and with side grooves extending between the ends of the apex grooves in close spaced relation to the periphery of the rotor. Three of the combination apex and side seals are used on each side of the rotor with a portion of the seal received in the groove of the apex and with legs depending therefrom received in the side grooves. The legs terminate in stepped portions which index with a leg of the adjacent combination seal intermediate the apexes. The legs may be sprung backed in the grooves.

Preferably the legs have a longitudinally extending groove intermediate the side thereof, the groove providing for distribution of lubricating oil in the rotor chamber.

In the preferred embodiment the combination seals are formed of a polyimide material. This material may be filled with graphite if desired. The use of the polyimide material aids in elimination of compression seal sticking in the grooves, which problem has been common to the prior art. The use of the graphite further aids in the elimination of side sticking, while also reducing the coefficient of friction between the seal and the end plate and adding to the life span of the seal.

It is therefore an object of this invention to provide a new method of sealing for rotary piston engines.

It is a further object of this invention to reduce the number of components necessary for sealing the rotor of a rotary piston combustion engine.

It is another object of this invention to provide side and apex seals for the rotor of a rotary piston engine which is capable of being installed by automatic machinery.

It is a further object of this invention to reduce the complexity of installation of side and apex seals in rotary engines.

It is another and specific object of this invention to provide a combination apex corner seal and combustion side seal for rotary piston engines.

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 an exploded perspective view of a rotor equipped with the seals of this invention.

FIG. 2 is a side plan view of a rotary piston engine rotor received in a trochoid chamber.

FIG. 3 is a fragmentary cross sectional view of one of the side seal legs of the seal of this invention received in a ring groove in the rotor.

FIG. 4 is an end plan view of the expander spring of this invention.

Fig. 5 is a fragmentary plan view taken along the lines V—V of FIG. 4.

FIG. 6 is a fragmentary side plan view of one embodiment of the combination corner and combustion seal of this invention.

FIG. 7 is a top plan view of the seal of FIG. 6.

FIG. 8 is a top plan view of a pair of seals according to FIGS. 6 and 7, equipped with the apex seal receiving member of this invention.

FIG. 9 is a fragmentary end plan view of the device of FIG. 8 taken along the lines IX—IX of FIG. 8.

FIG. 10 is a view similar to FIG. 8 illustrating a modification thereof.

FIG. 11 is a view similar to FIG. 6 illustrating another modification of the combination corner and side seal of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is an exploded perspective view of a rotary piston internal combustion engine rotor 10. The rotor has three sides around its outer periphery, each of the sides being curved and meeting the adjacent side at an apex point 12. An axial groove 13 is formed into the body of the rotor at each of the apexes and extends from axial side to axial side of the rotor.

As illustrated in FIG. 2, each of the apex grooves contains an apex seal 14 which projects therefrom into contact with the inner surface 15 of the trochoid shaped piston chamber 16.

In each of the side walls 17 of the rotor, three grooves 18 are formed. The grooves extend axially into the rotor 10. Each of the grooves extends from the end of one apex groove 13 to the end of another groove 13 and each of the grooves 18 is opened at its longitudinal end to the corresponding apex groove 13.

The grooves 18 receive compression seals which are urged into contact with the end plates closing the trochoid housing. In this manner the apex seals 14 seal the periphery of the housing dividing the housing into a number of moving chambers while the compression seals seal against the end plates thereby effectively sealing each of the three volume changing chambers 19, 19a and 19b defined between the periphery of the rotor 10 and the inner surface of the trochoid. The compression seals are necessary to prevent leakage from the chambers 19 along the side of the rotor between the side walls 17 and the end plates to the open center 20 of the rotor. Additionally because some areas of the rotor chamber are always under high pressure whereas other areas are always under low pressure, the compression seals 21 which are received in the grooves 18 prevent sideways leakage from the high pressure areas to the low pressure areas.

In order to reduce the cavity at the sides of the rotor outward from the compression seals 21, the seal

grooves 18 are formed as close as possible to the peripheral surface of the rotor. It is for this reason that the grooves 18 communicate with the apex grooves 13.

In prior art embodiments, it has been known to provide a plurality of such grooves and to use a plurality of seals. However, to the extent that the seals in the prior art embodiment terminated in the apex grooves, difficulty was encountered in sealing at the corner or intersection between the apex groove and the compression seal groove. Further, the compression grooves were normally narrow and deep on account of which the grooves were difficult to machine.

The normal manner of achieving a seal at the corner was to abut the longitudinal ends of the compression seals against a corner seal, which seal was normally independent from the apex seal and which in turn had a groove receiving the apex seal. In order to provide for expansion of the seals, a clearance fit relation was required between the compression seals and corner seal.

This allowed for leakage paths. Further, the complex nature of the seal required numerous parts including expanders and the like. In some embodiments as many as 36 parts per rotor were required just for the compression and corner seals and not including the apex and oil seals. Assembly and installation were therefore extremely expensive and time consuming.

My invention provides for a combustion corner and compression seal which overcomes all of the disadvantages of the prior art. First, the grooves 18 are considerably wider than prior art grooves, thereby reducing the machining expense. The grooves 18 receive expander springs 22 and combination corner and compression seal members 23. The combination corner and compression seal members, as illustrated in FIG. 1, are substantially wishbone shaped. That is to say that they have a common hub 25 representing the corner seal. Projecting a V-shaped angle from the hub are two compression seal portions 26. The compression seal portions 26 are integral with the hub 25. Each of the compression seal sections terminates in a stepped end 27 which is indexable with the stepped end 27 of an adjacent compression seal section.

Three such seal members are used per rotor side, each of the seal members having its hub 25 received at the longitudinal end of the apex seal groove 13 and the compression seal leg portions 26 received in the grooves 18 diverging from the apex groove 13. The legs or compression seal portions 26 are dimensioned to extend approximately half of the distance of the grooves 18 from one apex 12 to the next. At the point of termination, they interfit with the stepped end portion 27 of the member 23 used in connection with the next apex 12.

It is to be understood that, if desired, the legs of a given member may be of unequal length. One reason for doing this can be for accommodating port placement in the end plates.

The compression seals are backed by the springs 22. One spring is received in each groove 18 and backs the compression seal portions 26 of the two adjacent seal members 23.

Apex seals such as the seals 14 or the seals 30 illustrated in FIG. 1 are received in apex spacers 31 which are received in each of the apex grooves 13. The spacers interfit with the hub portions 25 in a manner which either allows the spacer 31 to rotate in the groove 13 to provide a swinging apex seal or which is restrained

against rotation for use in connection with non-swinging type seals.

As best illustrated in FIG. 3, each of the leg portions 26 has a central groove 32 running for most of the length of the leg portions 26. The central groove may be closed at both the hub 25 and the stepped end 27. The groove 32 has the function of carrying lubricant for sealing and wear purposes. The groove is centrally located transversely of the seal providing a raised land 33 to either side of the groove.

The reverse side, or backside 34 of the leg members, in the preferred embodiment, is centrally reduced in radial width providing two ledges 35 and 36 with a central projecting portion 37 extending behind the ledges.

If desired, the bottom or inside edge 38 of the leg portions may be tapered as illustrated at 39.

The spring member 22 is best illustrated in FIG. 4, being substantially U-shaped in cross section having inner 40 and outer 41 diameter legs interconnected at one axial end thereof by a bight section 42. The free axial ends 43 of the legs 40 and 41 abut the ledges 35 and 36. The spring 22 is preferably formed of spring metal and has struck-out portions 47 and 48 formed from portions of the legs 40 and 41 and the corresponding bight portions. The portions 47 and 48 extend beyond the back 49 of the bight section 42 and are adapted to be springingly deformed from their normal position illustrated in FIG. 4 to the position illustrated in FIG. 3. In this manner, they bottom against the back wall 50 of the grooves 18 and by their spring resiliency urge the spring member 22 away from the back wall 50. This urging of the spring member is transmitted through the ledges 35, 36 to the compression seals, thereby urging the compression seals partially out of the ring groove 18 and into contact with the end plates.

It is desirable not only to seal against the end plates but also to seal against one wall of the groove. Normally this is best accomplished by sealing against the innermost side wall of the groove 52. For this purpose, portions 53 of the outer leg 41 are punched out in the manner of a tab from the material of the outer diameter leg, as best illustrated in FIGS. 4 and 5. The portions 53 are preferably bent and are resilient due to the spring nature of the material of the ring. These portions 53 abut the outer side walls 54 of the groove 18 as illustrated at 55 in FIG. 3. This urges the spring 22 and consequently the compression seal 26 against the opposite side wall 52 providing a seal between a portion of the bottom side 58 of the compression seal and the side wall 52 of the ring groove. This seal is aided by the pressure of gases trapped in the chambers 19, 19a and 19b which may gain access to the groove 18 at the top corner 59 thereof from the space between the sides of the rotor and the end plates. This pressure is entrapped in the ring groove because of the seal point 58 and aids in urging the compression ring out of the groove into tighter contact with the end plate.

The spring also is capable of holding the combination apex corner and compression seal members in a unitary assembly. That is to say that the spring member can be pre-attached to the three wishbone shaped seals prior to the assembly into the grooves in the engine and will thereafter maintain the wishbone units in assembled-together relation, allowing installation by automatic machinery.

The hub portions 25 of the seal members 23 may be configured differently. FIGS. 6 through 9 and FIGS. 10

and 11 illustrate alternative embodiments. In FIGS. 6 through 9, the hub portion is configured to receive an apex spacer in a manner which will allow the spacer to pivot within the hub portion. FIGS. 10 and 11 illustrate a non-pivoting configuration.

Basically, as illustrated in FIG. 1 and in FIGS. 8 and 9, the hub portion 25 is wider than the compression seal portion 26 of the member 23. The hub portion is semi-cylindrical having an arcuate portion 60 which depends below the connecting point 61 between the hub portion and the undersides of the compression seal portions 26. The hub portion is also curved beyond the outer side of the seal portions. The apex grooves 13 are preferably cylindrical and open to the exterior along a line. The hub portions 25 are receivable in the cylindrical apex grooves. The outside face 62 of the hub portion is substantially planar with the outside faces 33 of the compression seal while the inside face 63 extends beyond the inside face 34 of the compression seal member. Because the outside face 62 is flush with the sealing surfaces 33 of the compression seals, the hub serves as a corner seal at the intersection between the compression seal grooves and the apex seal groove. The fact that the hubs are insertable into the axial ends of the apex seal groove 13 blocks those ends and seals against the end plates.

The hub portions 25 have grooves therein. In the embodiment illustrated in FIGS. 6 through 9, the grooves 65 have curved bottoms 66 and are open to the top of the seal member, the top being definable as that point of the cylindrical body most remote from the point of projection of the compression seal legs. The opening is dimensioned to receive the ends of the apex spacer. The apex spacer, as illustrated in FIG. 8, is a cylindrical member 70 having reduced diameter end portions 71 with a constant diameter central portion 72. A groove 73 extends axially of the spacer and is open to the periphery thereof, the groove extending into the spacer approximately half of its diameter.

The spacer has an axial dimension approximately equal to the width of the rotor whereby its axial ends 74 and 75, when received in the groove 65 of the sealing member 23, will be flush with the axial ends of the rotor. If desired, the apex spacer may be shorter than the operating distances between opposed sealing surfaces 33 of opposed sealing members 23, the apex seal then being formed by the bottom wall 66 of the groove 65 and the outer face 62 of the hub member. The diameter reduction of the end portions 71 is dimensioned axially and radially so as to allow receipt of the axial ends 71 within the grooves 65 of the hub portions 25 in the manner illustrated in FIG. 8. If desired, the diameter of the end portion 71 may be slightly larger than the dimension of the opening of the groove 65 so that the apex spacer is snapped thereinto. The groove 73 of the spacer receives the apex seal. The embodiment illustrated in FIGS. 6 through 9 is designed to receive a seal snugly within the groove 73 in a non-pivotal relation therein. The spacer 72, however, is pivotable in the hubs 25 of opposed sealing members 23 to provide for pivotability of the apex seal against the surface 15 of the rotor chamber. The diameter of the central portion 72 of the apex spacer is substantially equal to the diameter of the grooves 13 and of the hubs 25 whereby the spacer and hubs will be snugly received in the grooves to reduce pressure escape paths. Of course, it is to be understood that the curvature of the cylindrical section

of the hub 25 and of the spacer 70 is dimensioned with respect to the curvature of the grooves 13 and that if the grooves 13 are not cylindrical, then the hub and spacer configuration will be equally non-cylindrical in this embodiment.

It should further be understood that although the groove 65 of the hub has been described as being open at both axial ends thereof, in a modified form, the groove could be closed at the outer axial end which contacts the end plate. In such an instance, the closure of the groove will act as a further seal. Further, if it is desired to use the spacer 70 in a non-pivotal embodiment, then the grooves 13 of the rotor and the corresponding exterior surfaces of the hub 25 and of the spacer 70 can be configured to prevent rotation in the groove. It will be further appreciated that the hubs and spacer are not locked together axially and the spacers are axially movable with respect to the hub so as to allow axial expansion of the combination corner seal and compression seal members.

FIGS. 10 and 11 illustrate a modified form of the hub configuration together with a modification of the apex spacer. This configuration is designed to prevent twisting or rotation of the apex spacer with respect to the hubs. The embodiments of FIGS. 6 through 9 allowed such movement of the spacer with respect to the hubs.

In the embodiment illustrated in FIG. 10 and illustrated in FIG. 1, the hub 25 has a narrower groove 80 than the previous embodiment. Further, the hub has a reduced diameter extension 81 projecting from the inside end 82 of the main hub section. The reduced diameter portion has a pair of opposed full diameter sections 83 which provide locking nibs 84. The spacer has a groove 85 substantially the same width as the groove 80 of the hubs. Further, the axial ends 86 of the spacer terminate with a central cavity 87 dimensioned to receive the reduced diameter end 81 of the hubs therein. The peripheral portion 88 around the cavities 87 has a pair of slots 89 therein. The slots are aligned with the tabs 84 and dimensioned to receive the tabs. Thus, when the spacer is fitted over the reduced diameter end 81 of the hubs, with the reduced diameter section extending into the cavity 87, the tabs 84 will interfit with the slots 89 thereby locking the spacer against rotation with respect to the hubs. In this embodiment, the spacer has an axial length sufficient to extend from one hub to the opposed hub at one apex and to substantially fill the apex groove 13. The spacer terminates at the interfit with the hubs rather than extending to a point adjacent the sides of the rotor as is the case with the embodiment of FIGS. 6 through 9. It is to be appreciated that the grooves 80, 85 illustrated in the embodiments of FIGS. 10 and 11 are substantially wider than the grooves 73 of the spacer 70 of FIG. 8. This is to allow receipt in the spacer of a wider or of a pivotable apex seal. However, the grooves could be of different dimensions depending upon the apex seal which they are to be used with.

In the preferred embodiment, the combination corner and compression seal as well as the apex spacer are composed of high-temperature resisting plastic material such as polyimide resins filled or intermixed with graphite or metallic materials. In a preferred embodiment, some of the filler is in fibrous form - graphite fibers being used in an amount of about 20 percent by weight, particulate graphite in about the same amount and the remainder polyimide resin.

It will therefore be seen from the above that my invention provides a unique combination corner and compression seal for rotary piston engines. The seal combination, as illustrated, consists of three wishbone-shaped seal members, each of which has a hub section receivable in the apex seal groove and two depending leg sections which comprise the compression seals and which are received in compression seal grooves on the sides of the rotor. The legs terminate in stepped configurations allowing overlapping of adjacent legs from adjacent combination members. Also illustrated and disclosed is a configuration of the leg members which has a central projection which can be enclamped by the legs of a disclosed spring member allowing pre-assembly of the entire system providing a unit which is easily insertable into the rotor by automated machinery. Further disclosed is a method of assuring side sealing between the compression seal legs and the side walls of the groove in which they are received and various designs and construction features of hubs and interfitting apex spacers for receipt in the apex groove, the combination of hubs and apex spacers allowing either swinging movement of an apex seal and spacer with respect to the hubs or a locking of the spacer against such movement. Because of the integral construction of the hubs and legs, the heretofore described difficulties of sealing at the intersection between the compression seals and the apex grooves on rotary piston engines has been substantially eliminated.

Although the teachings of my invention have herein been discussed with reference to specific theories and embodiments and although illustrative means for accomplishing explained results have been described, 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 rotary piston engine with the rotor received between end plates, the rotor having apex periphery seals and side compression seals, the apex seals received in apex grooves and the compression seals received in side wall grooves, the improvement of a combination compression seal and apex corner seal member, the compression seal having a length and contacting an adjacent end plate along substantially its entire length.

2. The improvement of claim 1 wherein the combination is substantially wishbone-shaped having a hub adapted to be received in the apex groove and two depending leg members integral with said hub diverging therefrom, the said leg members comprising compression seals and adapted to be received at least partially in the side grooves.

3. A combination corner seal and compression seal for use in rotary piston engines comprising a wishbone-shaped member having a hub portion with a pair of integral diverging compression seal legs projecting from the hub portion, the combination having coplanar sealing faces along substantially the entire surface of one side thereof.

4. The combination of claim 3 wherein the said legs have front and back sides, the said front sides providing sealing surfaces for engagement with an end plate closing a rotary piston chamber.

5. The combination of claim 4 wherein the hub portion has a front and a back surface, the front surface planar with the sealing surface of the legs and the back

surface projecting beyond the back surface of the legs.

6. The combination of claim 4 wherein the sealing surface of the legs has a central groove therein.

7. A sealing assembly for rotary pistons, the rotor having apex grooves and side wall compression seal grooves, the ends of the side wall compression grooves intersecting the axial ends of the apex grooves, the assembly comprising a plurality of sealing members, each of said sealing members having corner seal-forming portion dimensioned to be snugly received in the end of an apex seal groove, each of said members having two compression seal portions, integral with the corner seal portion, the compression seal portions dimensioned to be received in the compression seal grooves which project from and intersect with the apex groove in which the corner seal portion is received, the compression seal portions and corner seal-forming portion having sealing surfaces thereon adapted to be pressed into sealing relation with the wall of an end plate positioned adjacent the rotor.

8. The assembly of claim 7 including spring means received in said compression seal grooves, said spring means effective to resiliently axially bias the said compression seal portions out of the said compression seal grooves.

9. The assembly of claim 8 wherein the said spring means is effective to resiliently bias the compression seal portions against a side wall of the compression seal groove in sealing relation therewith.

10. The assembly of claim 7 wherein two corner seal forming portions are provided for each apex groove, one of said portions received in each end of the apex groove and an apex spacer is provided in the said apex groove spanning the distance between the corner seal portions.

11. The assembly of claim 10 wherein the said apex spacer has axial end portion indexing with portions of the corner seal portions.

12. The assembly of claim 11 wherein the apex spacer is pivotable with respect to corner seal portions.

13. The assembly of claim 11 wherein the apex spacer is prevented from pivoting with respect to the corner seal portions.

14. The assembly of claim 7 wherein the sealing members are formed of a plastic.

15. The assembly of claim 14 wherein the plastic is a polyimide.

16. The assembly of claim 15 wherein the polyimide is graphite filled.

17. The assembly of claim 7 wherein the compression seal portions have end surfaces shaped to mate with end surfaces of an adjacent compression seal.

18. The assembly of claim 17 wherein the mating end surfaces form a seal.

19. The assembly of claim 8 wherein the spring means embraces portions of adjacent sealing members to hold the assembly together as a unit.

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