March 19, 1963 R. T. HURLEY 3,081,745

GAS SEAL FOR ROTARY MECHANISMS

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FIG. 1.

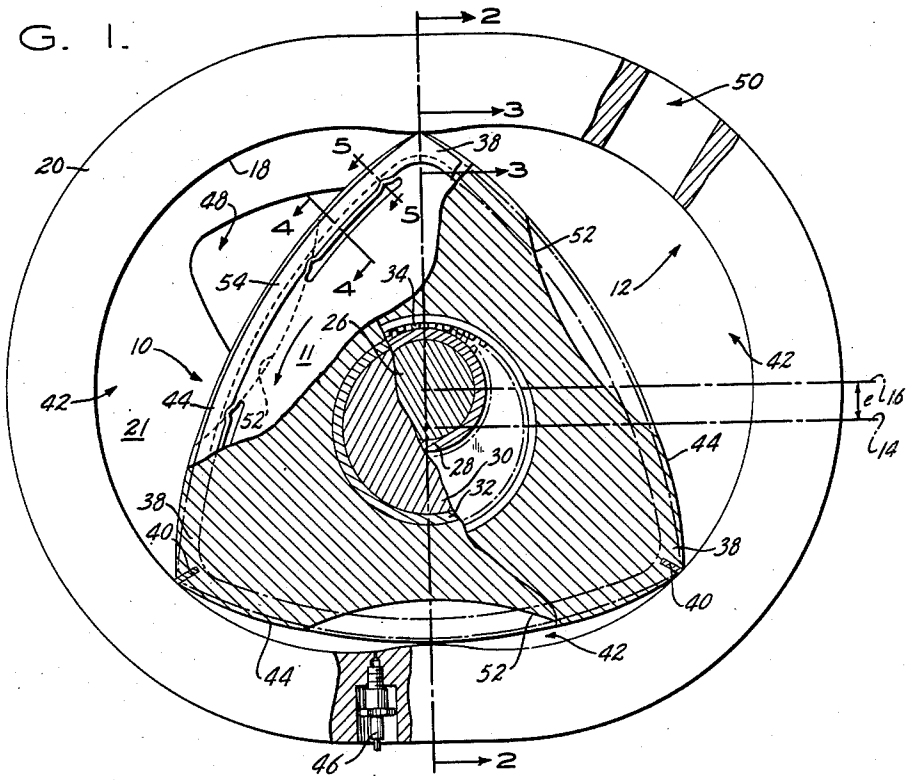
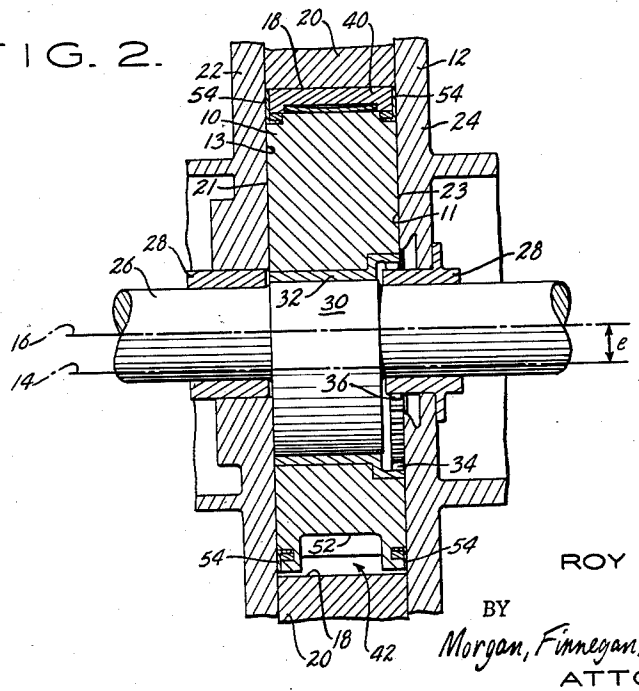


FIG. 2.



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FIG. 3.

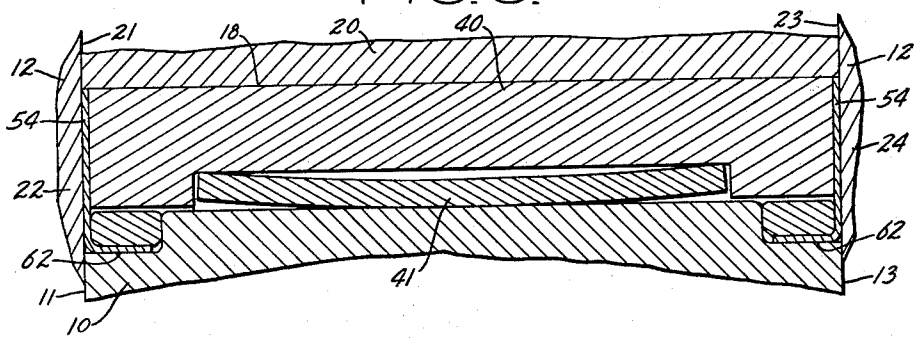


FIG. 4.

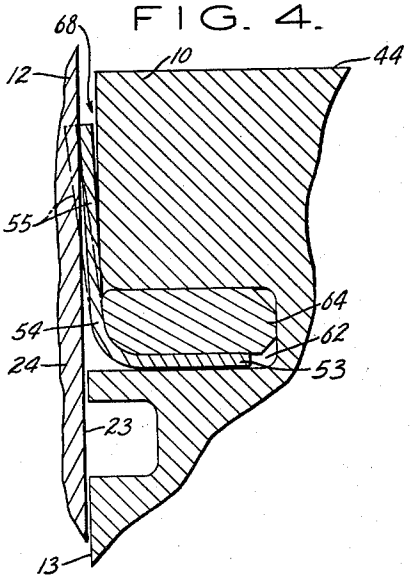


FIG. 5.

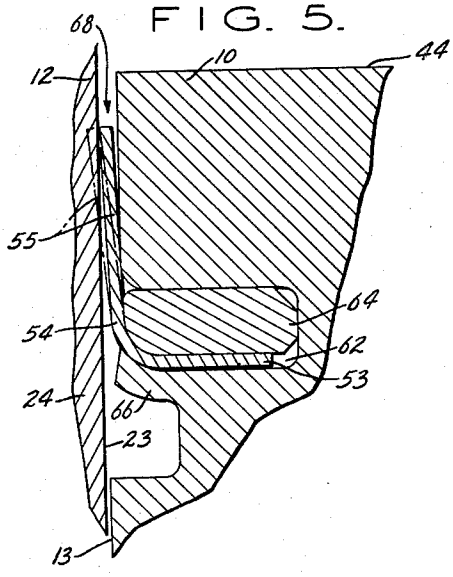
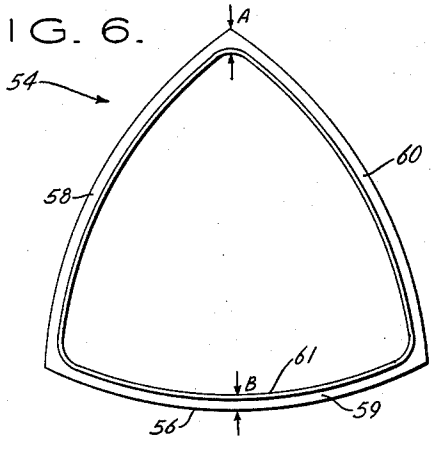


FIG. 6.



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GAS SEAL FOR ROTARY MECHANISMS

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2 Claims. (Cl. 121—68)

This invention relates to sealing means for rotary mechanisms and more particularly to gas sealing means for improving sealing characteristics of the mechanism and helping insure relatively trouble-free and smooth functioning of the mechanism.

Although this invention is applicable to and useful in almost any type of rotary mechanism, which presents a gas sealing requirement, such as combustion engines, fluid motors, fluid pumps, compressors, and the like, it is particularly useful in rotating combustion engines. To simplify and clarify the explanation of the invention, the description which follows will, for the most part, be restricted to the use of the invention in a rotating combustion engine. It will be apparent from the description, however, that with slight variations, which would be obvious to a person skilled in the art, the invention is equally applicable to other types of rotary mechanisms.

The present invention is particularly useful in rotating combustion engines of the type which comprise an outer body having an axis, axially-spaced end walls, and a peripheral wall interconnecting the end walls. In such rotary mechanisms the inner surfaces of the peripheral wall and end walls form a cavity, and the mechanism also includes an inner body or rotor which is mounted within the cavity between its end walls.

The axis of the rotor is eccentric from and parallel to the axis of the cavity of the outer body, and the rotor has axially-spaced end faces disposed adjacent to the end walls of the outer body and a plurality of circumferentially-spaced apex portions. The rotor is rotatable relative to the outer body such that the apex portions continuously engage the inner surface of the outer body to form a plurality of working chambers which vary in volume during engine operation, as a result of relative rotation between the rotor and the outer body.

The inner surface of the peripheral wall of the outer body has a multi-lobed profile which is preferably an epitrochoid and the number of lobes of this epitrochoid is one less than the number of apex portions of the inner body or rotor.

By suitable arrangement of ports, such rotary mechanisms may be used as fluid motors, compressors, fluid pumps, or internal combustion engines. The invention is of particular importance when employed with a rotary mechanism which is designed for use as a rotating combustion engine, and, accordingly, will be described in combination with such an engine. As the description proceeds, however, it will be apparent that the invention is not limited to this specific application.

When the rotary mechanism is designed for use as a rotating combustion engine, such engines also include an intake passage means for admitting a fuel-air mixture to the variable volume working chambers, an exhaust passage means communicating with the working chambers, and suitable ignition means so that during engine operation the working chambers of the engine undergo a cycle of operation which includes the four phases of intake, compression, expansion and exhaust. This cycle of operation is achieved as a result of the relative rotation of the inner body or rotor and outer body and for this purpose both the inner body or rotor and outer body may rotate at different speeds, but preferably the inner body or rotor rotates while the outer body is stationary.

For efficient operation of the engine, its working chambers should be sealed, and therefore, an effective seal is provided between each rotor apex portion and the inner surface of the peripheral wall of the outer body, as well as between the end faces of the rotor and the inner surfaces of the end walls of the outer body.

Between the apex portions of its outer surface the rotor has a contour which permits its rotation relative to the outer body free of mechanical interference with the multi-lobed inner surface of the outer body. The maximum profile which the outer surface of the rotor can have between its apex portions and still be free to rotate without interference is known as the "inner envelope" of the multi-lobed inner surface, and the profile of the rotor which is illustrated in the accompanying drawings approximates this "inner envelope."

For purposes of illustration, the following description will be related to the present preferred embodiment of the engine in which the inner surface of the outer body defines a two-lobed epitrochoid, and in which the rotor or inner body has three apex portions and is generally triangular in cross section but has curved or arcuate sides.

It is not intended that the invention be limited, however, to the form in which the inner surface of the outer body approximates a two-lobed epitrochoid and the inner body or rotor has only three apex portions. In other embodiments of the invention the inner surface of the outer body may have a different plural number of lobes with a rotor having one more apex portion than the inner surface of the outer body has lobes.

The operating cycle of the engine may include at least the phases of intake, compression, expansion and exhaust and it will be readily apparent, to those with ordinary skill in the art, that it is necessary that the working chambers be sealed from each other during the operating cycle of the engine. In order to prevent loss of pressure and fuel during the compression phase and loss of power during the expansion phase, it is obviously of paramount importance that there be no leakage of gas between the inner member or rotor and the end faces of the outer body. Should there be such leakage, either in the areas between apexes or at the apexes themselves, poor engine performance, loss of efficiency and malfunctioning would result.

There are known several prior types of gas seals which have been used in rotary mechanisms. For example, the gas has been sealed within and at the adjacent end walls of the working chambers through use of relatively thick and rigid seals. Because of their relative rigidity it was difficult for such prior seals to adapt themselves to variations in the flatness of the end walls of the outer member caused by production tolerances or thermal distortions. Also it was generally necessary to provide an additional spring means to maintain the seal in sealing contact with the end wall. Some of these prior seals were of a segmental type thus having a plurality of parts.

It is, therefore, an object of this invention to provide a novel and simple gas seal which is inexpensive to manufacture and expeditiously assembled.

It is a still further object of the present invention to provide a seal wherein there is endless contact between the seal and the end walls of the outer body.

Another object of the present invention is to provide a gas seal which is flexible enough to adapt itself to variations in the end wall of the outer member.

It is still another object of the present invention to provide a gas seal which is normally biased toward and in engagement with the inner wall of the outer member.

A still further object of the present invention is to provide a gas seal which will not be subjected to the destructive effect of high temperature combustion gases.

Another object of the present invention is to provide

a gas seal which achieves effective sealing at the apexes and substantially reduces blowby.

A further object of the present invention is to provide a gas seal wherein gas pressure is used to increase the sealing contact area.

Another object of the present invention is to provide a seal which is assembled by means so that the temperature rise to which the rotor and sealing means is subjected will be used to increase sealing contact between the gas seal and the outer body.

Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention, the objects and advantages being realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

Briefly described, the present invention provides means for continuously engaging in gas sealing contact the inner surfaces of the end walls of the outer member.

As herein embodied, this means comprises a thin, flexible, triangular shaped, single piece sheet metal gas seal with an L-shaped cross section which is carried by the inner member and is in gas sealing contact with the inner faces of the end wall of the outer member.

The invention consists in the novel parts, constructions, arrangements, combinations, and improvements shown and described.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one embodiment of the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

FIGURE 1 is a side elevation of the mechanism with the end wall of the outer body removed to show the rotor positioned within the outer body and wherein portions of the rotor and outer body are shown partially in section;

FIGURE 2 is a central vertical section of the mechanism taken along line 2—2 of FIGURE 1 in which the rotor and outer body are shown in section and the shaft and eccentric are shown without section;

FIGURE 3 is a sectional view taken along line 3—3 of FIGURE 1 showing the gas seal in relation to the apex seal;

FIGURE 4 is a sectional view taken along line 4—4 of FIGURE 1 showing the gas seal in relation to the inner end wall of the outer body.

FIGURE 5 is a sectional view taken along line 5—5 of FIGURE 1 showing one method of securing the gas seal to the rotor.

FIGURE 6 is a plan view of the gas seal.

It is to be understood that both the foregoing general description and the following detailed description are examplary and explanatory but are not restrictive of the invention.

In the description which follows it is to be recognized that in practice either the outer body or the inner rotor may rotate while the other member remains fixed or stationary, or both members may rotate as long as there is relative rotation between them to provide variable volume working chambers. In the description of the present preferred embodiment, for purposes of clarity, the invention will be described with reference to a rotary mechanism in which the outer body or housing is stationary and the inner body or rotor is rotatable.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings. As shown in FIGURE 1, a generally triangular rotor 10 having arcuate sides is eccentrically supported for rotation within an outer body 12. Although in the illustrative embodiment shown in the drawings the outer body 12 is fixed or stationary, a practical and useful form of the invention may be constructed in which both the outer body and rotor are rotary, but the eccentric is stationary; in this latter form of the invention the power shaft is driven directly by the rotation of the outer body and the inner rotor rotates relative to the outer body.

As shown in FIGURES 1 and 2, the rotor 10 rotates on an axis 14 which is eccentric from and parallel to the axis 16 of the curved inner surface of the outer body 12. The distance between the axis 14 and 16 is equal to the effective eccentricity of the engine and is designated *e* in the drawings. The curved inner surface 18 of the outer body 12 has basically the form of an epitrochoid in geometric shape and includes two arched lobe-defining portions, or lobes.

As embodied, the generally triangular shape of the rotor 10 corresponds in its configuration to the "inner envelope" or the maximum profile of the rotor which will permit interference-free rotation of the rotor 10 within the outer body 12.

In the form in the invention illustrated, the outer body 12 comprises a peripheral wall 20 which has for its inner surface the curved inner surface 18, and a pair of axially-spaced end walls 22 and 24 which are disposed on opposite sides of the peripheral wall 20.

The end walls 22 and 24 support a shaft 26, the geometric center of which is coincident with the axis 16 of the outer body 12. This shaft 26 is supported for rotation by the end walls 22 and 24 on large and ample bearings 28. A shaft eccentric 30 is rigidly attached to or forms an integral part of the shaft 26, and the rotor 10 is supported for rotation or rotatively mounted upon the shaft eccentric 30 by a rotor bearing 32 which is fixed to the rotor.

As shown in FIGURES 1 and 2, an internally-toothed or ring gear 34 is rigidly attached to one end face of the rotor 10. The ring gear 34 is in mesh with an externally-toothed gear or pinion 36 which is rigidly attached to the stationary end wall 22 or the outer body 12.

From this construction, it may be observed that the gearing 34 and 36 does not drive or impart torque to the shaft 26 but merely serves to index or register the position of the rotor 10 with respect to the outer body 12 as the rotor rotates relative to the outer body and removes the positioning load which would otherwise be placed upon the apex portions of the rotor 10.

As shown most clearly in FIGURE 1, the rotor 10 includes three apex portions 38 which carry radially movable sealing members 40. The sealing members 40 are in substantially continuous gas-sealing engagement with the inner surface 18 of the outer body 12 as the rotor 10 rotates within and relative to the outer body 12.

By means of the rotation of the rotor 10 relative to the outer body 12, three variable volume working chambers 42 are formed between the peripheral working faces 44 of the rotor 10 and the inner surface 18 of the outer body 12. As embodied in FIGURE 1, the rotation of the rotor relative to the outer body is counterclockwise and is so indicated by an arrow.

A spark plug 46 is mounted in the peripheral wall 20 of the outer body 12, and at the appropriate time in the engine cycle, the spark plug 46 provides ignition for a compressed combustible mixture which, on expansion, drives the rotor in the direction of the arrow.

Also shown in FIGURE 1, there is provided in the end walls of the outer body an intake port 48, and an exhaust port 50 in the peripheral wall 18. As the rotor 10 rotates, a fresh charge is drawn into the working chambers 42 through the intake port 48. This charge is then successively compressed, ignited, expanded and finally exhausted through the exhaust port 50.

All four successive phases of the engine cycle: intake, compression, expansion, and exhaust, take place within each one of the variable volume working chambers 42 each time the rotor 10 completes one revolution within the outer body, and therefore for each revolution of the rotor, each working chamber completes a cycle.

The working faces 44 of the rotor 10 are provided with cut-out portions or channels 52 which permit combustion gases to pass freely from one lobe of the epitrochoidal inner surface 18 to the other lobe, when the rotor is at or near the top dead center compression position. Also, the compression ratio of the engine may be controlled by adjusting the volume of the channels 52.

Since the gear ratio between the rotor ring gear 34 and the outer body gear or pinion 36 is 3:2, each time the rotor 10 completes one revolution about its own axis 14, the shaft 26 rotates three times about its axis 16.

This invention is primarily directed towards a gas-sealing means 54 located between inner faces 21, 23 of end walls 22, 24 of the outer member or housing and the end faces 11, 13 of the rotor which provides new, novel and unexpected beneficial results.

In the description which follows, for the purpose of clarity, the gas seal of the present invention will be described with reference to one end face of the rotor and the adjacent inner face of the end wall for outer body or member. It is to be understood, of course, that the other end face of the rotor has a similar gas seal in sealing relation with the inner face of the end wall of the outer body.

In accordance with the invention means are provided for insuring an effective gas seal between the rotor end face and outer body end wall and between adjacent chambers at the apexes of the rotor.

As embodied herein, the means comprises FIGURES 1–4, a gas seal 54 which in transverse cross section is a substantially L-shaped seal having a thin and flexible cross section. The seal can be made of any suitable material which has strength at elevated temperatures, resistance to wear at all temperatures and elasticity which remains substantially constant during wide temperature differentials. Although beryllium copper-alloy in sheet metal form has produced excellent results, obviously, other materials having the characteristics hereinafter described will occur to those skilled in the art and may be used in the practice of this invention.

As illustrated in FIGURE 6, the gas seal has a peripheral contour 56 complementary with and substantially identical to the contour of the inner member or rotor 10. As shown in the illustrated form, this contour is essentially triangular wherein the sides 58, 59 and 60 of the triangle are bent or bowed outwardly. For reasons more fully described below it should be observed that in FIGURE 6 the gas seal width A measured from the inner surface 61 of the seal to the outer periphery 56 of the seal is larger at the apexes of the triangular seal than is the width B measured from the inner surface 61 of the seal to the outer periphery 56 of the seal intermediate the apexes of the gas seal.

As clearly shown in FIGURES 3 and 4 the rotor end face 11 is provided with a generally triangular recess or slot 62 which conforms substantially to the outer periphery of the inner member or rotor 10. The width of the slot 62 is approximately five times the thickness of the gas seal 54. As mentioned previously the gas seal, as herein embodied, has a cross sectional shape which approximates an L. As herein disclosed for illustrative purposes, the short or rotor engaging leg 53 of the L is placed into the slot 62 and maintained therein by means hereafter described. A retainer or filler strip 64 having a width substantially the same as the rotor engaging leg 53, is provided for the purpose of cooperating with the rotor engaging leg of the seal and for maintaining that leg in tight frictional engagement with the recess 62 in the inner member or rotor 10.

Additional means illustrated in FIGURES 1 and 5 show one preferred way of maintaining the seal 54 and retainer or filler strip 64 within the slot 62 during the assembly process. As embodied herein, the outer edge portion of the recess is bent or peened into engagement with the seal and retainer strip at desired locations 66.

Of course, it will be obvious to those skilled in the art that other means and methods may be devised for maintaining the gas seal in engagement with the rotor which do not depart from the inventive principles explained herein. For example, it would be possible to eliminate the retainer or filler strip and merely provide a slot which is suitably dimensioned so that one leg of the seal would fit snugly therein. Similarly, the seal 54 and retainer ring 64 need not be peened into position but can be maintained within the slot 62 in the rotor by means such as screws or welding. Moreover, as will be apparent to those skilled in this art, means are not necessary to prevent the seal from axial movement during operation of the rotary mechanism but that the bending, peening or equivalent step is taken only for ease in assembly and for maintaining the seal in its position during assembly of the rotor.

It will be still further obvious that the gas seal 54 need not have a long and a short leg to embody the principles of this invention but may have legs of equal lengths for example.

In accordance with the invention, means are provided for maintaining the gas seal in continuous sealing engagement regardless of variations in the end walls of the outer body.

As shown in FIGURE 4, it will be observed that the gas seal has extending substantially perpendicular from the rotor engaging leg 53 an outer member engaging leg 55. In the present preferred embodiment this leg has been formed so that in its normal unobstructed condition it will form an angle of approximately 94°–97° with the rotor engaging leg as shown in dotted lines in FIGURE 4. This last mentioned feature taken in conjunction with the fact that, as embodied, the thicknesses of the gas seal legs, which range from 1/32–1/16 of an inch, provide a flexible seal which will maintain a tight gas-sealing contact with the outer body inner wall. In effect, a seal is provided which has an inherent resiliency or spring effect which negates a requirement for a separate spring means to insure engagement of the seal with the stator end face. Obviously, were a separate spring means provided, the seal would be more expensive and more difficult to manufacture and assemble.

Through use of the simple construction described herein, the seal is maintained in firm, flexible sealing contact with the inner faces 21, 23 of the end wall of the outer body and will retain this condition even though there might be variations in the surface condition of the end wall inner face. In other words, the gas seal, owing to its inherent resiliency, will readily and automatically adapt itself to variations in the end wall inner face of the outer body which are created by unavoidable manufacturing tolerances. In addition, when the gases attempt to flow past the seal they will not be able to escape past the end portion of the seal but will be guided into the pocket 68, FIGURE 4, formed between the inner face 21 of the outer body engaging leg 55 of the gas seal and the rotor's end face 11. As a result, these gases will force the outer body engaging leg 55 into tight engagement with the end wall, and provide thereby a leakproof seal. At the same time these gases will force the rotor engaging leg 53 of the gas seal into gas sealing tightness with the rotor recess 62 thereby insuring against blowby, or escape of gases past the seal.

In accordance with the invention means are provided to insure a good seal at the apexes of the rotor and to prevent blowby at the apexes.

The gas seal, as embodied, has a novel relationship with the apex seal 50 of the rotor leading to beneficial and unexpected results. With reference to FIGURE 3, there is shown a radially movable apex seal 40 which is biased in a radial direction by a spring means 41. As can be observed in FIGURE 3, the gas seal 54 has a width A (FIGURE 6) such that it extends to the end of the apex sealing means 40. By virtue of this relation-

ship in conjunction with the gas sealing relationship between the apex seal 40 and the gas seal 54 there is a substantial reduction in gas leakage that has not been heretofore possible.

It should be observed also that providing a continuous gas seal in combination with a radial movable apex sealing means 40 substantially reduces the number of sealing elements and the number of surfaces to be sealed. In known constructions where the gas sealing means has had a segmental construction, it has been necessary to provide a connecting seal means intermediate the apex seal and the end face gas seal. The instant invention eliminates the need for connecting seal means and yet, since the number of surfaces to be sealed are reduced, achieves an effective seal which is simple and inexpensive.

In accordance with the invention, means are provided for minimizing the destructive effects of high temperatures on the seal and contact of hot gases with the seal.

As hereinbefore observed, although the gas seal extends substantially to the periphery of the rotor at the apex 38 of the rotor, the gas seal does not extend to the periphery of the rotor intermediate the apexes of the rotor. This relationship is graphically illustrated in FIGURE 6 wherein the distances just mentioned are illustrated at A and B respectively. This relationship of distances provides novel, beneficial and unexpected results.

As will be apparent to those skilled in the art, the peripheral working face 44 of the rotor intermediate the apexes will, during the ignition phase of the engine, be subjected to the extreme temperatures created during the ignition phase. Since, however, the gas seal does not extend to the periphery of the rotor at this point, the seal will not be subjected to highest level of these temperatures and is less likely to suffer from warping, burning or other destructive effects caused by such high temperatures. On the other hand, the apexes of the rotor are not subjected to the high ignition temperatures to which the peripheral portions are subjected and the seal can extend to the periphery of the apex seal, without damage, thereby achieving an effective and longlasting seal which reduces undesirable blowby to a minimum.

In accordance with the invention, means are provided for forcing the seal into tighter sealing engagement with end walls of the outer body as the temperature of the engine increases.

Still further novel, beneficial and unexpected results are achieved according to the invention as herein embodied according to the materials used for the retaining or filler strip 64 and the rotor or inner member. If the rotor is made of steel, for example, and the retainer or filler strip 64 made of aluminum alloy, the filler strip will have a higher coefficient of thermal expansion than does the rotor or inner member. Thus, when the filler strip is subjected to increased temperatures, it will expand in an axial direction a greater amount than will the rotor, thereby forcing the outer body engaging leg 55 of the gas seal into tight gas sealing contact with the inner face 21 of the outer member and with recess 62 in the rotor. Obviously, other and different materials can be used for making the rotor and filler strips which achieve the beneficial and unexpected results noted above.

It will be apparent to those skilled in the art, that the gas seal as herein embodied has the advantages that it can be made of sheet material, such as beryllium copper, and can be formed by a simple stamping operation performed in a conventional stamping machine. The gas seal is wear resistant, flexible and yet resists distortions caused by temperature differentials thereby insuring effective and longlasting sealing contact. The seal, as herein embodied, has a novel continuous contour reducing the number of sealing surfaces. The seal according to the present invention is assembled by an expeditious and simple snap-in action which reduces the number of parts and the cost of assembly.

It will be readily apparent to those skilled in the art that the principles and advantages of the instant invention can be realized by variations in the embodied invention which do not depart from the principles utilized therein.

What is claimed is:

1. A gas-sealing means for use in rotary mechanisms having a substantially triangular periphery wherein the sealing means is wider at its apexes than it is intermediate the apexes and includes two engaging portions giving the seal an approximately L-shaped transverse cross section.

2. A gas-sealing means as defined in claim 1, wherein the angle between the engaging portions has a range of 94° to 97°.

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