United States Patent [19]

Rao

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[45] **Mar. 25, 1975**

[54] **SEAL FOR ROTARY COMBUSTION ENGINE**

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[73] Assignee: **Ford Motor Company,** Dearborn, Mich.

[22] Filed: **Sept. 24, 1973**

[21] Appl. No.: **400,282**

[52] **U.S. Cl.**..... **418/113,** 418/152, 418/178

[51] **Int. Cl.**... **F01c 19/02,** F04c 27/00, F01c 21/00

[58] **Field of Search**..... 418/113, 114, 117–124, 418/152, 156, 178

[56] **References Cited**

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Primary Examiner—John J. Vrablik

Attorney, Agent, or Firm—Clifford L. Sadler; Keith L. Zerschling

[57] **ABSTRACT**

A sealing system for a rotary combustion engine according to the present invention includes an apex seal. The apex seal comprises a graphite block having longitudinal slots or cuts along each lateral side for the purpose of providing flexibility. The base of the seal is secured in a seal receiving groove in the engine's rotor and the radial resiliency of the seal itself urges the seal into contact with the rotor housing.

2 Claims, 5 Drawing Figures

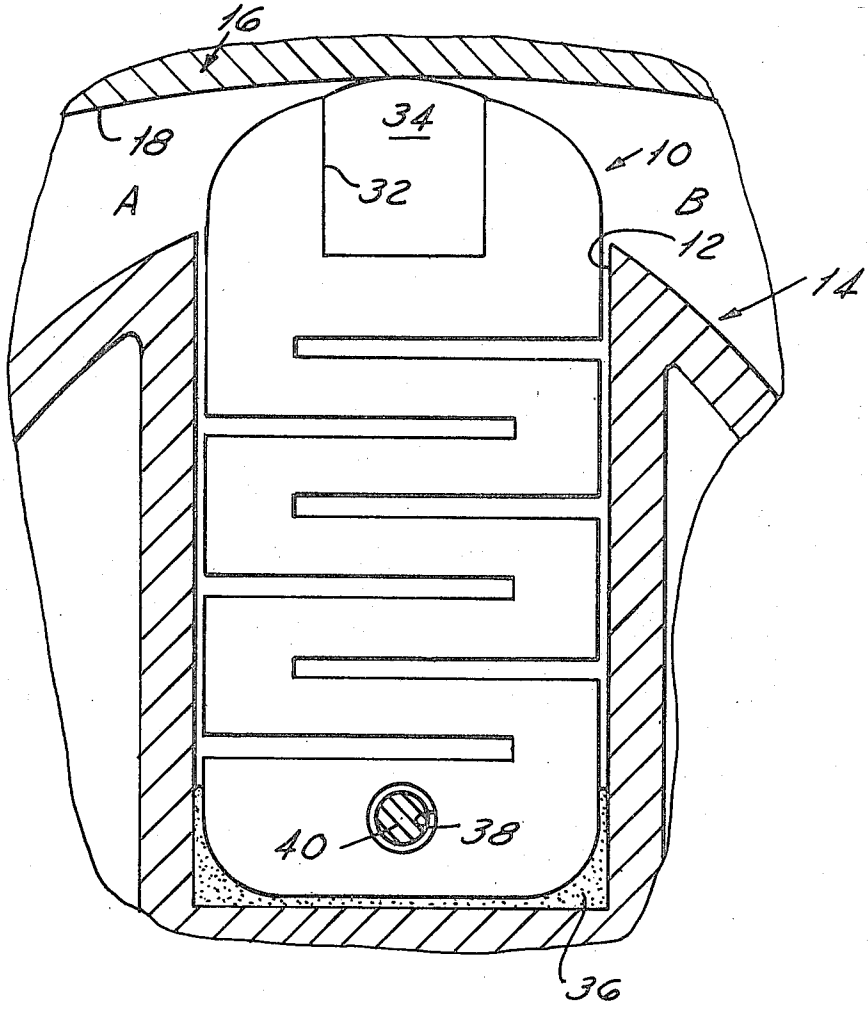


FIG. 2

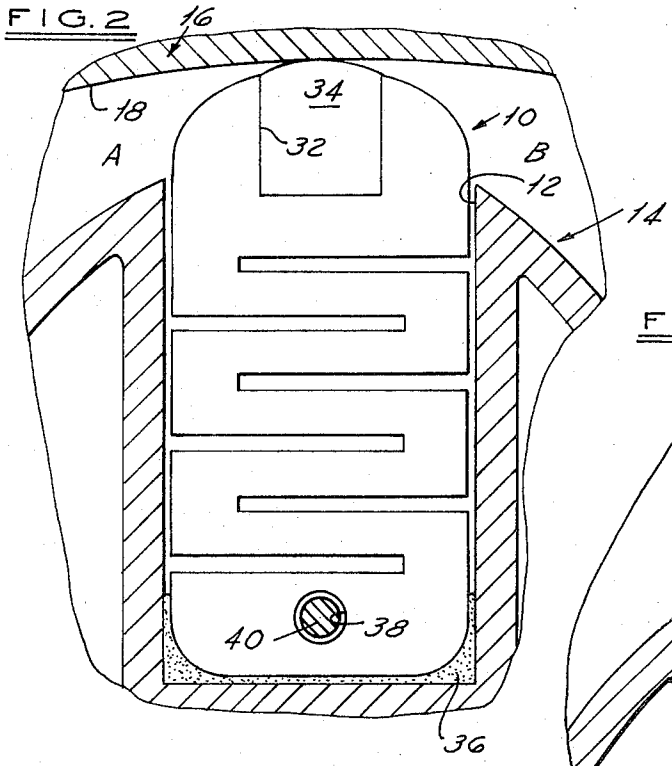


FIG. 3

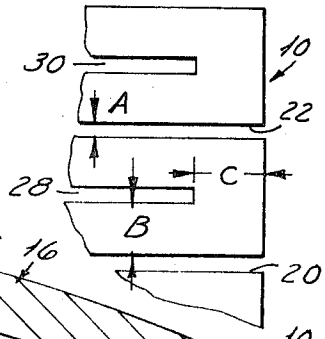


FIG. 4

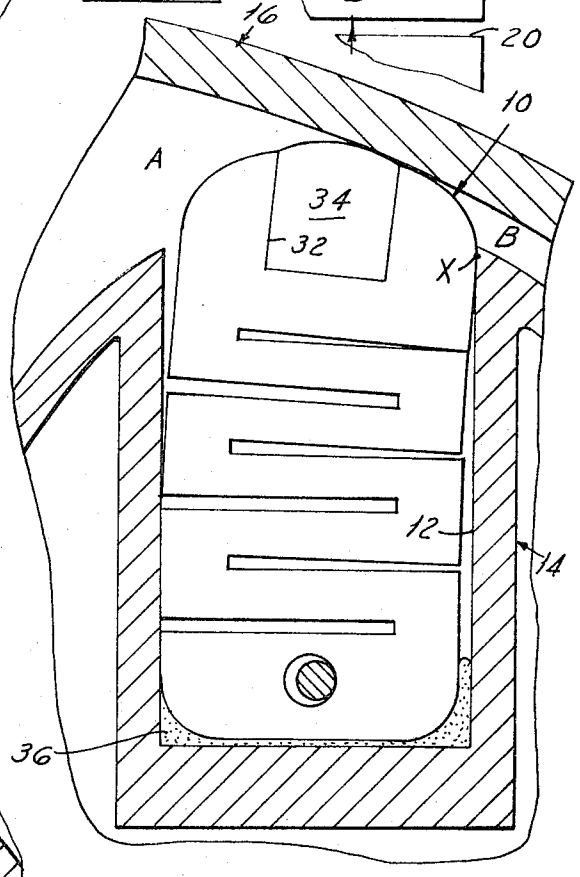


FIG. 5

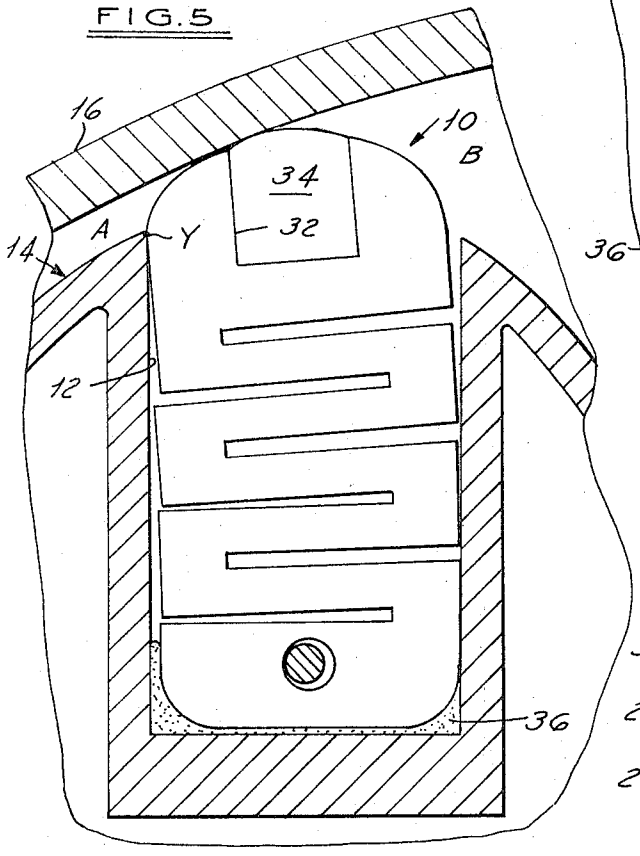
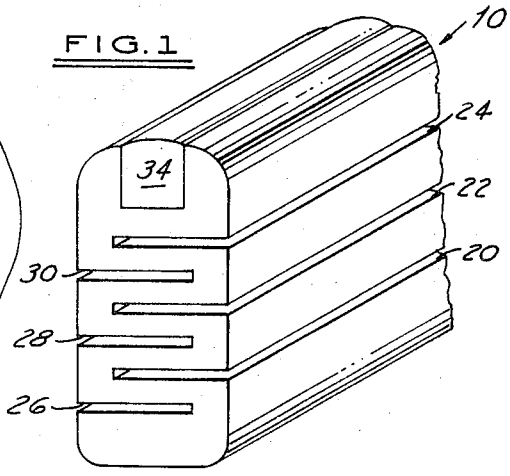


FIG. 1



SEAL FOR ROTARY COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

The present invention relates to apex seals for rotary combustion engine, and more particularly to seals for rotary engines having a trochoid rotor housing and a rotor of generally triangular shape fitted within the housing and eccentrically mounted on an eccentric shaft. In accordance with the present invention, an apex seal is provided that uses conventional materials, is of inexpensive construction and provides superior performance.

BRIEF SUMMARY OF THE DISCLOSURE

In the presently preferred embodiment of this invention, an apex seal for a rotary combustion engine is formed from a graphite block and has longitudinally extending slots along its lateral sides which increase the effective flexibility of the seal. The apex seal is fitted in a seal receiving groove at one of the apexes of the rotor. A longitudinally extending pin that is radially stationary with respect to the rotor holds the base of the seal in the groove. The bottom of the groove is filled with an expanded silicone sponge and provides a gas-tight seal between the depth of the seal receiving groove and the base of the apex seal.

The outer longitudinal edge of the seal is provided with a groove that is filled with a friction reducing polymer that is constructed to smear the trochoid surface of the rotor housing. The polymer may be polyarylsulfone.

The expanded silicone sponge material forming a seal between the base of the apex seal and the groove and the smearable polymer are described in detail in my U.S. Pat. application Ser. No. 391,134, filed Aug. 24, 1973 entitled "RUBBING SEAL SYSTEM FOR A ROTARY COMBUSTION ENGINE."

BRIEF DESCRIPTION OF THE DRAWINGS

The many objects and advantages of a seal system for a rotary combustion engine in accordance with this invention will become apparent upon consideration of the following detailed description and the accompanying drawings, in which:

FIG. **1** is a perspective view of a unique apex seal;

FIG. **2** is an elevational view, partly in section, of the apex seal fitted in the apex groove of a rotor or rotary piston and engaging the trochoidal wall of a rotor housing;

FIG. **3** is an enlarged view of a portion of the apex seal of FIGS. **1** and **2**;

FIG. **4** is an end elevational view, partly in section, of the apex seal, the rotor and the rotor housing showing the seal flexed under the effects of prevailing forces; and

FIG. **5** is an elevational end view, partly in section, similar to FIG. **4** showing the seal flexed in the opposite direction under the effects of prevailing forces.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An apex seal **10** constructed in accordance with the presently preferred embodiment of this invention is illustrated in the drawings.

The conventional rotary combustion engine includes a rotor housing having an internal surface that is machined to the shape of an epitrochoid. A generally triangular shape rotor or rotary piston is eccentrically mounted on an eccentric shaft that is supported within the trochoid housing. The conventional rotary engine includes a sealing system that provides gas-tight seals between the rotor, the housing side walls and the trochoid surface of the housing. For this purpose, the sealing system includes side seals, corner seals and apex seals, all of which are carried by the rotor. The apex seals are fitted into longitudinally extending seal receiving grooves at the apexes of the rotor and engage the trochoid surface. The corner seals are of generally cylindrical shape and are fitted within cylindrical recesses in the end faces of the rotor at each end of the apex seal. The corner seals engage the end wall of the rotor housing and are displaceable only axially in their recesses. The side seals are of strip form and interconnect the corner seals. These seals fit within grooves in the end faces of the rotor.

The present invention is particularly directed to the construction of a unique apex seal and to the manner in which it cooperates with the rotor groove and the trochoid surface of the rotor housing.

The apex seal **10** is an elongated member and is formed from a hard material such as graphite. The material of the seal **10** is characterized by its low modulus of elasticity and its high strength. It fits within a groove **12** that parallels the axis of rotation of a rotary piston or rotor **14.** The rotor **14** is of conventional triangular configuration and is rotatably supported on an eccentric portion of an eccentric shaft situated within a housing **16.** The housing **16** has a trochoid bearing surface **18.** A pair of side walls cooperate with the trochoid surface **18** to define a cavity within which the rotor **14** rotates.

The apex seal **10** has a width that is only slightly less than the width of the groove **12.** It protrudes radially from the open side of the groove **12** by an amount that is approximately equal to the clearance between the apex portion of the rotor **14** and the trochoid surface.

The apex seal **10** is of an elongated construction and has a series of overlapping slots or cuts formed along its two lateral sides. A series of slots **20, 22** and **24** are cut into the seal **10** from the right-hand side. A second series of slots **26, 28** and **30** are cut into the left side of the seal. The several slots are cut sufficiently deep so that the slots **20, 22** and **24** are in overlapping relationship with the slots **26, 28** and **30.**

The upper edge of the seal **10** is provided with a groove **32** in which a friction reducing plastic piece **34** is embedded. The embedment **34** comprises a friction smearable fluxing agent in the form of polyarylsulfone. This material engages the trochoid surface **18** and cooperates with the surface **18** during rotation of the rotor **14** in the manner described in my aforementioned United States patent application entitled "RUBBING SEAL SYSTEM FOR A ROTARY COMBUSTION ENGINE."

The base of the seal **10** is sealed with respect to the depth of the groove **12** by means of an expanded silicone sponge material **36.** This material is also described in my recent patent application.

It is intended that the apex seal **10** be used in cooperation with a pair of corner seals as described above. Conventionally, each corner seal is of cylindrical construction and fits within a cylindrical recess in the end face of the rotor. The corner seals are displaceable only in an axial direction. In accordance with the present in-

vention, a longitudinal hole **38** may be provided in the base portion of the seal **10** and a pin **40** extended through the hole **38.** The ends of the pin **40** engage the corner seals and provide a means for preventing radial displacement of the seal **10** with respect to the rotor **14.** Other means may also be provided for securing the base of the seal **10** in the groove **12.** For an example, the seal base may be cemented in position by using a sealing material **36** which has adhesive qualities in addition to sealing qualitied.

OPERATION

In operation, the base of the apex seal **10** is retained in the groove **12** by means of the material **36** and additionally by means of the pin **40,** if desired. Although the seal **10** is formed of rigid graphite, it has limited flexibility due to the overlapping side slots **20** to **30.** This construction provides a seal that is flexible both from side to side as well as having adequate radial resiliency.

The apex seal **10** is constructed to flex from side to side in response to prevailing pressures in the chambers of the rotary engine. As seen in FIG. **2,** the seal **10** divides a portion of the interior of the housing **16** into combustion chambers A and B. Referring to FIG. **4,** when the pressure in chamber A exceeds the pressure in chamber B, seal **10** will flex to the right as shown. The seal **10** is thereby placed in sealed engagement with one of the outer edges of the apex groove **12** as indicated by reference letter X. The flexing of the seal **10** also places it in sealed engagement with the opposite wall of the groove **12.** In addition, the material **36** seals the base of the apex seal **10** with respect to the depth of the groove **12.**

When the gas pressure in chamber B exceeds the pressure in chamber A by an amount sufficient to cause the seal **10** to flex, the apex seal will assume the orientation of FIG. **5.** The seal contacts the outer edge of the left wall of the groove **12** as indicated at Y. In addition, approximately the lower half of the right side of the seal **10** is in gas-tight engagement with the right wall of the groove **12.**

Thus, in accordance with the present invention, a gas seal **10** is provided having excellent properties for isolating chamber A from chamber B. The seal may be manufactured from a rigid graphite material and is characterized by its low cost.

In order to provide optimum flexibility of the apex seal **10,** it has been determined that a certain relationship should exist between the size of the slots and the dimensions of the adjacent portions of the seal. Referring to FIG. **3,** each of the slots **20** through **30** has a width A. The slots overlap and are, therefore, separated by material which has a thickness B. The inner extremity of each slot is spaced from the opposite wall of the seal by a dimension C. In order to provide optimum performance, it has been determined that the width of the slots (dimension A) should be less than the thickness of the material which separates the slots (dimension B). In addition, it has been determined that the width of the slots (dimension A) should be equal to or less than 1/5 of the dimension between the inner end of each slot and the opposite wall of the seal (dimension C).

A graphite apex seal having slots that are formed within these dimensional limits will have the necessary flexibility properties to permit lateral displacement to the right and to the left as shown in FIGS. **4** and **5,** respectively. In addition, the apex seal will have the desired amount of the radial resiliency.

SUMMARY

The apex seal **10** of this invention consists of a graphite block slotted along the lateral sides as shown. A graphite material having a low elastic modulus and high strength is suitable for this application. The rubbing surface of the seal **10** is grooved and filled with a filled polymer coating to provide low friction. The apex seal **10** is held against radial displacement by any suitable means such as the pin **40** extending between two corner seals. Conventionally, corner seals have a fixed position in the radial direction and are permitted axial motion only. The pin **40** restrains the base of the apex seal **10** against radial movement thus neutralizing the centrifugal force component of the seal produced by motion of the rotor. This results in an apex seal with seal loads independent of rotor speed and controlled only by the radial resiliency of the seal element itself. The flexibility and compressibility of the seal **10** provides a positive sealing contact surface several times larger that is possible with conventional seal elements. The contact surface under compression from the leading and trailing sides of the seal are shown in FIGS. **4** and **5,** respectively.

The foregoing description presents the presently preferred embodiment of this invention. Modifications and alterations may occur to those skilled in the art that will come within the scope and spirit of the following claims.

I claim:

1. A rotary combustion engine comprising a housing having a trochoid surface,

a rotor disposed in said housing,

said rotor having an apex groove,

an apex seal disposed in said groove and having one edge engaging said trochoid surface,

said seal being formed of a material having a low modulus of elasticity,

said seal having a plurality of longitudinally arranged slots formed along each of its lateral sides,

said slots of one lateral side being arranged in overlapping relationship with respect to said slots of the other lateral side,

said slots being constructed to increase the effective elasticity of said seal,

sealing means interposed between the base of said seal and the depth of said apex groove,

retaining means stationary with said rotor and engaging said base of said apex seal,

said retaining means being constructed to hold the base of said seal against radial displacement with respect to said rotor,

the outer edge of said apex seal having a longitudinally extending recesses,

a friction reducing material disposed in said recess and engaging said trochoid housing,

said seal being laterally flexible within said groove and radially resilient.

2. An apex seal for a rotary combustion engine according to claim **1** and including:

said slot having a greater depth than one-half the width of said seal measured from said one lateral side to the other lateral side.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,873,249

DATED : March 25, 1975

INVENTOR(S) : Vemulapalli D. N. Rao

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 35, change "391,134" to --391,375--.

Signed and Sealed this

Seventh Day of September 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE

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