United States Patent [19]

Sakamaki

[11] **3,781,148**

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[54] **APEX SEAL ASSEMBLY OF A ROTARY PISTON ENGINE**

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[73] Assignee: **Nippon Piston Ring Co., Ltd.**, Tokyo, Japan

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[21] Appl. No.: **233,688**

[30] **Foreign Application Priority Data**

Mar. 12, 1971 Japan 46/13586

[52] **U.S. Cl.** **418/117**, 418/122

[51] **Int. Cl.** **F01c 19/02**

[58] **Field of Search** ..... 418/122, 123, 117; 277/81 P

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Assistant Examiner—Richard Sher
Attorney—Richard C. Sughrue et al.

[57] **ABSTRACT**

An apex seal assembly which has combined apex seal members with at least one side at an angle expanding toward the lower portion of the side surface and an arcuate spring of U-shape in section to hold the members together and in contact with the inner wall of a rotary piston engine.

4 Claims, 12 Drawing Figures

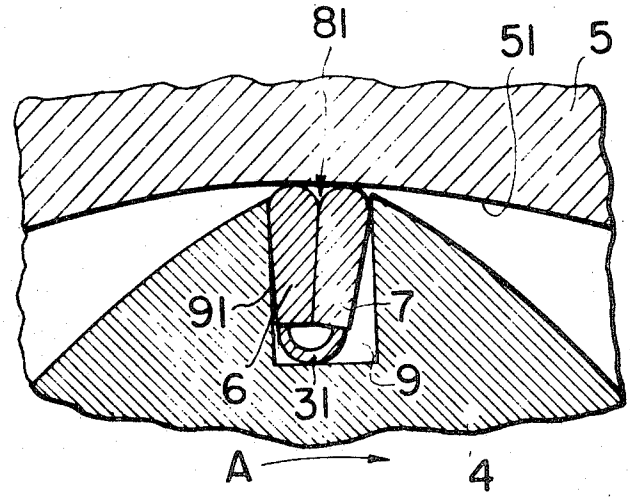


FIG. 1
PRIOR ART

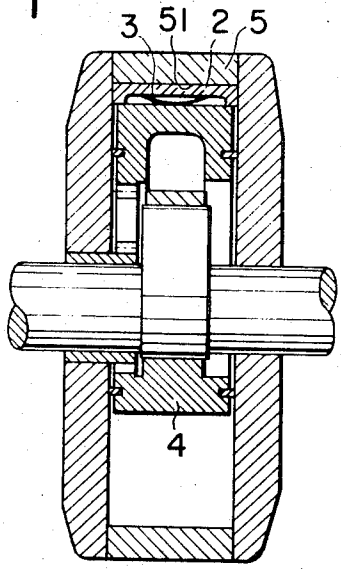


FIG. 2

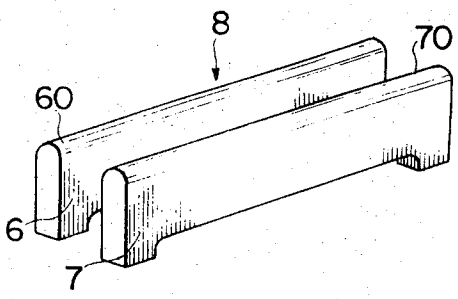


FIG. 3

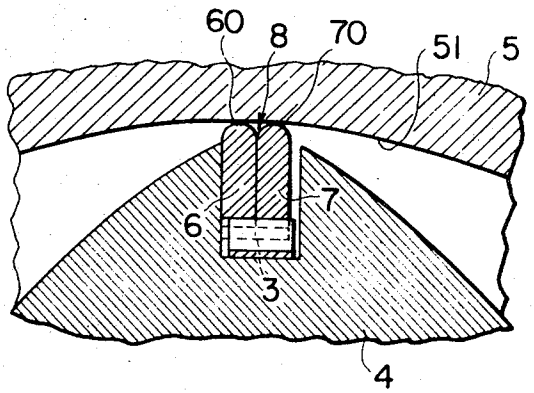


FIG. 4

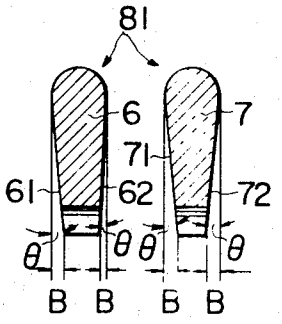


FIG. 5

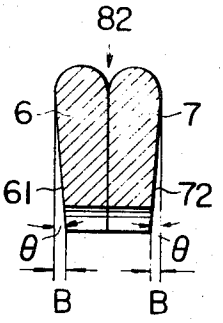


FIG. 6

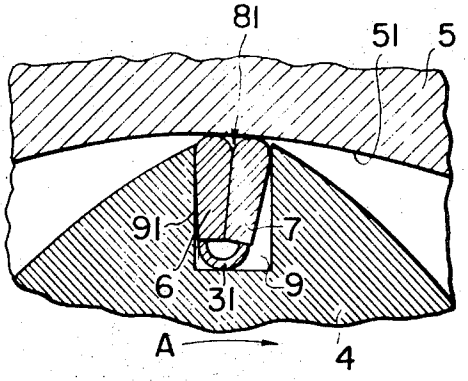


FIG. 7

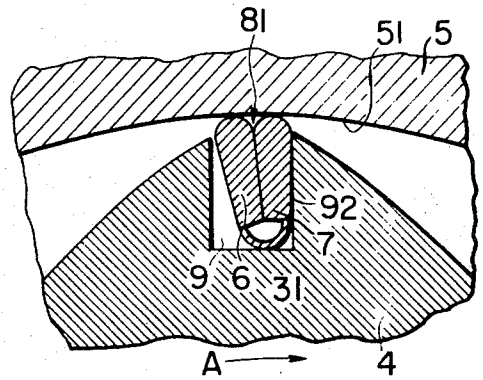


FIG. 8

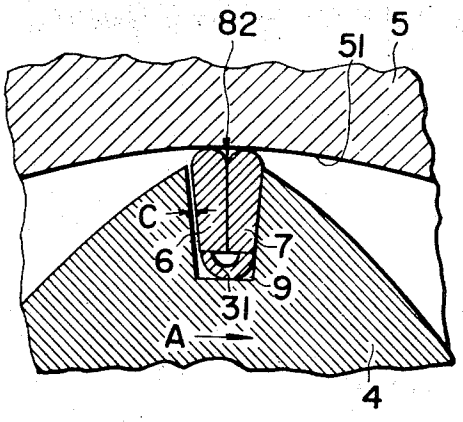


FIG. 9

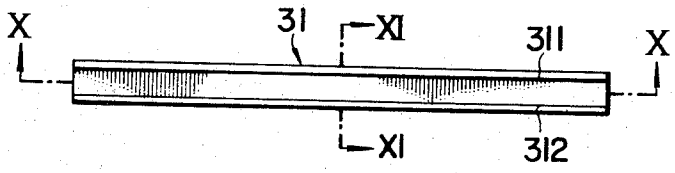


FIG. 10

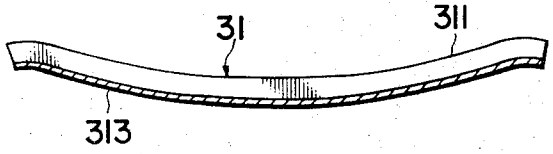


FIG. 11

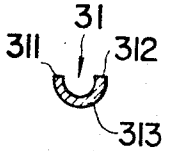
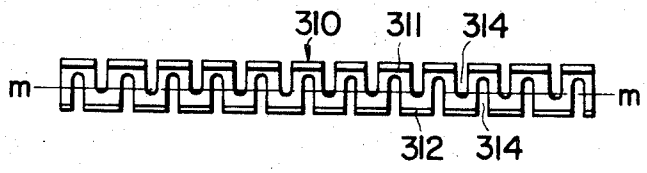


FIG. 12



APEX SEAL ASSEMBLY OF A ROTARY PISTON ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a rotary piston engine, and more particularly to an apex seal assembly for a rotary piston engine.

2. Description of the Prior Art

The apex seals mounted at the respective corners of the rotor of the rotary piston engine for sealing the work fluid in contact with the inner peripheral surface of a two or more lobed center housing of the rotary piston engine are known per se. In order to maintain air-tightness in the rotary piston engine, the respective apex seals mounted at the corners of the rotor of the rotary piston engine are strongly urged into contact with the inner peripheral surface of the two or more lobed center housing by springs provided at the back side of the apex seals. Centrifugal force of the rotor upon rotation and gas pressure of the work fluid in the combustion chamber of the rotary piston engine, etc., also contribute to maintaining the seal. For this reason, the inner peripheral surface of the two or more lobed center housing and the apex seals are subject to severe wear and further the inner peripheral surfaces of the center housing of the rotary piston engine tends to be abnormally worn by the rotating contact of the apex seals. The primary causes of such abnormal wear of these components of the rotary piston engine are many and various, but the particular note is the wearing force as a result of the apex seal being urged more than necessary onto the inner peripheral surface of the two or more lobed center housing acting on the apex seal assembly. And, the greater the mass of the apex seal, the larger the wearing force becomes. Accordingly, it is considered that the foremost cause of such abnormal wear is due to the mass of the apex seal. From this fact, the mass of the apex seal should be made small, and yet it is strongly desired to have wear resistance and mechanical strength.

As a result of studies of the apex seal made of carbon alloy, the mass of the apex seal has been reduced but the mechanical strength of the apex seals is low because it is very brittle. In order to improve the mechanical strength of the apex seal, it is most desirable that the apex seal be made of metals such as cast iron, steel, etc. This however causes the mass of the apex seal to become large with the result that present apex seals are not made of metal.

SUMMARY OF THE INVENTION

It is, therefore, one object of the present invention to provide an apex seal assembly which is superior in wear resistance and mechanical strength while still being relatively low in mass.

It is another object of the present invention to provide an apex seal assembly which is not worn abnormally on the inner peripheral surface of the two or more lobed center housing.

According to one aspect of the present invention, there is provided an apex seal assembly which comprises combined apex seals having an angle expanding toward the lower portion of the side surface of at least one side thereof with an arcuate spring of U shape in section to hold the seals together and against the inner peripheral surface.

These and other objects, features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of a rotary piston engine mounted with the conventional apex seals;

FIG. 2 is a perspective view of an apex seal for the explanatory purpose of the apex seal of the present invention;

FIG. 3 is a partial enlarged longitudinal sectional view of the apex seal shown in FIG. 2 mounted in the apex seal groove of the rotor of the rotary piston engine;

FIG. 4 is an enlarged longitudinal sectional view of one embodiment of the apex seal of this invention;

FIG. 5 is an enlarged longitudinal sectional view of another embodiment of the apex seal according to the present invention;

FIGS. 6 and 7 are partial enlarged longitudinal sectional views of the apex seal of this invention shown in FIG. 4, mounted in the apex seal groove;

FIG. 8 is a partial enlarged longitudinal sectional view of the present invention shown in FIG. 5 mounted in the wedged apex seal groove of the rotor of the rotary piston engine;

FIGS. 9 and 10 are plan and side views of one embodiment of the spring for apex seal used in the apex seal assembly of the present invention;

FIG. 11 is a sectional view of the combined apex seal with spring shown in FIG. 9 taken along the line XI—XI in FIG. 9 of the present invention; and

FIG. 12 is a plan view of another embodiment of the spring used in the apex seal assembly of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to clearly understand the apex seal assembly of the present invention, the conventional apex seal will now be described at first with reference to FIG. 1 which shows the rotary piston engine mounted with the conventional apex seals thereto.

In order to hold the air-tightness or sealing sufficiently in the rotary piston engine, the apex seals 2 mounted at the corners of the rotor 4 of the rotary piston engine are strongly urged in contact with the inner peripheral surface 51 of the two or more lobed center housing 5 by the springs 3 provided at the back side of the apex seals 2, centrifugal force of the rotor 4 upon rotation and gas pressure of the work fluid in the combustion chamber of the rotary piston engine, etc. For this reason, the inner peripheral surface 51 of the two or more lobed center hosuing 5 and the apex seals 2 are severely worn, and further the inner peripheral surfaces 51 of the center housing 5 of the rotary piston engine tend to be abnormally worn by the rotational contact with the apex seals 2. The primary causes of such abnormal wear of these components of the rotary piston engine are many, but of particular note is the wearing force as a result of the apex seal 2 being urged more than necessary onto the inner peripheral surface 51 of the center housing 5 acting on the apex seal assembly.

The present invention overcomes the conventional disadvantages of the apex seal by a particular structure

of the apex seal with respect to the massive metal apex seals to provide novel apex seals.

Reference is now made to the drawings, particularly to FIGS. 2 and 3, which show the special structure of the apex seal mounted in the apex seal groove of the rotor of the rotary piston engine. The embodiment shown in FIGS. 2 and 3 incorporates one of the features of this invention, namely the use of two seal members. The seal members 6 and 7 have sliding surfaces 60 and 70, respectively, of semi-circular section as shown in FIGS. 2 and 3 to provide a combined apex seal 8. The frictional force of the apex seal 2 contacting the inner peripheral surface 51 of a two or more lobed center housing 5 due to the centrifugal force, is approximately one-half that of the single apex seal made of the same material. The result is that the frictional force due to the massive apex seal is lessened to be equal to the less massive apex seal made of less massive material.

As a result of experimentation it has been found that the combined apex seal 8 tends to be adhered onto the apex seal groove of the rotor of the rotary piston engine by the carbon slag on all the surfaces of the apex seal groove and both side surfaces of the apex seals. The carbon slag is produced by the combustion of lubricating oil, etc.

Further, as shown in FIG. 3, it is impossible with the conventional spring 3 to independently follow the seal members 6 and 7 of the combined apex seal 8 with the inner wall of the center housing of the rotary piston engine. Therefore, the present invention eliminates such trouble by providing an apex seal assembly of a rotary piston engine which has combined apex seals 8 provided with an angle expanding toward the lower portion of the side surface of at least one side thereof and an arcuate spring of U shape in section.

Referring now to FIG. 4, which shows one embodiment of the apex seal constructed according to the present invention, an angle θ expanding toward the lower portion of both side surfaces 61, 62 and 71, 72 of the seal members 6 and 7 is provided. In other words, an acute angle is formed between the side surface of the seal member and a line parallel to the axis of the seal member. The angle is formed at the upper portion of the seal member such that the distance between the side surface and the parallel line increases at the lower portion of the seal member. The seal members 6 and 7 are combined to provide a combined apex seal 81. FIG. 5 shows another embodiment of the apex seal constructed according to the present invention wherein an angle θ expanding toward the lower portions of both side surfaces 61 and 72 of the seal members 6 and 7 is provided to form a combined apex seal 82 which eliminates the adhesion of the apex seals on the apex seal groove. More particularly, the seal members 6 and 7 having angles θ on at least one of their side surfaces are combined to provide a combined apex seal 81 or 82.

In operation, the combined apex seal 81 is mounted in the rectangular apex seal groove 9 provided on the corner of the rotor 4 together with the spring 31, as shown in FIG. 6. The apex seal of this invention is mounted in the apex seal groove of the rotor of the rotary piston engine. The combined apex seal 81 is disposed at the side surface 91 of the rectangular apex seal groove 9 at the intake and exhaust strokes. It is disposed at the side surface 92 of the rectangular apex seal groove at the ignition, expansion and compression strokes as shown in FIG. 7. Thus, the combined apex seal is repeatedly moved. Arrows A shown in FIGS. 6, 7 and 8 indicate the rotating direction of the rotor 4.

Since the combined apex seal 81 has an angle θ expanding toward the lower portion of the seal members 6 and 7, the moving amount of the lower portions of the seal members 6 and 7 is longer than the upper portions thereof. Therefore, since there is such movement of the seal members 6 and 7, the aforementioned carbon slag is pulverized thereby preventing the apex seal and the apex seal groove from adhering.

FIG. 8 shows the apex seal mounted in the wedged apex seal groove of the rotor of the rotary piston engine. The combined apex seal 82 is mounted together with spring 31 in the wedged apex seal groove 91 provided at the corner of the rotor 4.

In operation of the apex seal shown in FIG. 8, the side clearance C is varied every time the combined apex seal 82 follows the inner wall 5 of the center housing of the rotary piston engine. When the clearance C is varied, the carbon slag is pulverized according to the movement of the combined apex seal in the apex seal groove so as to prevent the adhesion thereof.

Experimentation has shown that the angle θ expanding toward the lower portion of the seal members 6 and 7 is most preferable if the width B designated in FIGS. 4 and 5 is 50 to 500 microns.

The apex seal assembly of the present invention also comprises a spring combined with the thus constructed combined apex seal. Since the seal members 6 and 7 are combined to provide the combined apex seal 81, the seal members 6 and 7 of the combined apex seal 81 are required to independently follow the inner wall 5 of the center housing of the rotary piston engine.

The spring is used for the combined apex seal so as to independently follow the respective seal members 6 and 7 of the combined apex seal with respect to the inner wall 51 of the center housing 5. More particularly, as shown in FIGS. 9, 10 and 11, which show the spring used together with the apex seal used in the apex seal assembly, the spring 31 is arcuate of U shape in section. As thus constructed, the upper surfaces 311 and 312 are formed thereon for causing contacting under pressure with the seal members 6 and 7 of the combined apex seal 81. This allows the seal members to independently follow in contact with the inner peripheral surface under pressure of the center housing of the rotary piston engine.

Reference is now made to FIG. 12, which shows another embodiment of the spring used together with the apex seal assembly of the present invention. Slits 314 are nonsymmetrically and alternatively provided on the spring 31 from longitudinal edges 311 and 312 of both sides with respect to the longitudinal central line m—m. This arrangement is advantageous in the following property of the respective seal members with the inner wall of the center housing.

Thus, when the spring 31 is used together with the combined apex seal, a more effective seal is formed.

It should be understood from the foregoing description that the apex seal of this invention is made of metal so as to provide superior wear resistance and mechanical strength and the massive structure is eliminated by the combined two individual members of the apex seal. Further, the apex seal has an angle expanding toward the lower portions of the seal members so as to also

eliminate the adhesion of the apex seal to the apex seal groove.

It should also be understood that since the spring is combined with the combined apex seal, the seal members independently follow the inner wall of the center housing under pressure and the apex seal assembly operates more effectively.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An apex seal assembly for a rotary piston engine having a radial seal groove in the rotor of said engine, said seal assembly comprising:

a. at least two seal members within said groove, each seal member having a curved contact surface and two flat side surfaces, a line coinciding with at least one side surface forming an acute angle with the travsverse axis of said seal member, said acute angle being located radially inwardly of said seal member, whereby said seal member continuously tapers from its contact surface toward its radial inner end; and

b. a U shaped arcuate spring within said groove having ends contacting the inner ends of the respective seal members for forcing said seal members against the inner peripheral surface of the housing of said engine.

2. The apex seal assembly as set forth in claim 1 wherein an acute angle is formed by said transverse axis and respective lines coinciding with each of said side surfaces.

3. The apex seal assembly as set forth in claim 1 wherein said seal groove is wedged shaped.

4. The apex seal assembly as set forth in claim 1 wherein said spring has a plurality of slits formed therein.

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