June 30, 1964 W. FROEDE 3,139,072

TROCHOID COMPENSATION FOR ROTARY ENGINE

Filed May 28, 1962 2 Sheets-Sheet 1

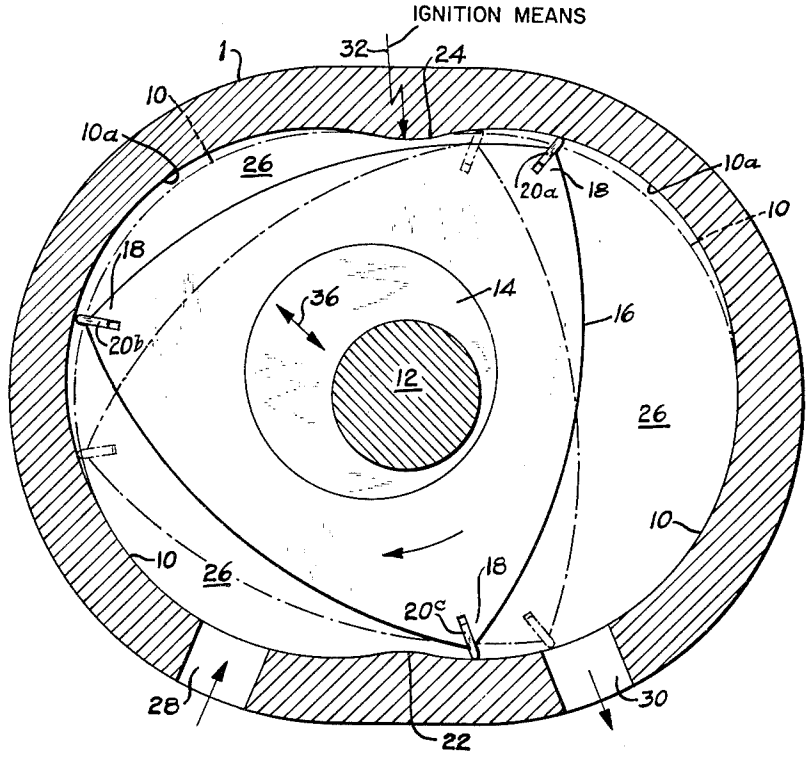


FIG. 1

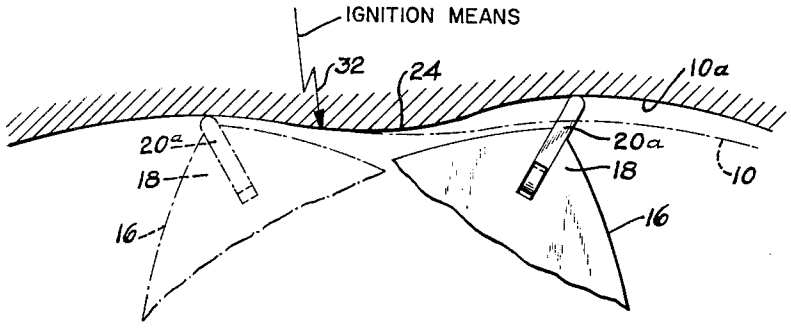


FIG. 2

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TROCHOID COMPENSATION FOR ROTARY ENGINE

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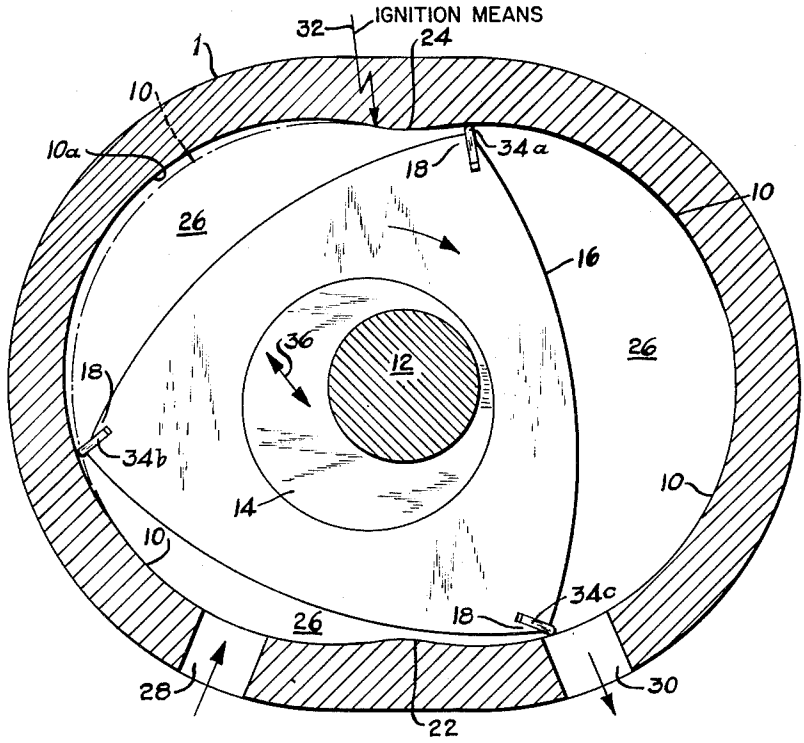


FIG. 3

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TROCHOID COMPENSATION FOR ROTARY ENGINE

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6 Claims. (Cl. 123—8)

This invention relates to rotary mechanisms and in particular to means for compensating for and preventing undesirable wear characteristics in such mechanisms.

The concepts embodied in this invention are applicable to rotary mechanisms of the type disclosed in United States Patent Number 2,988,065. Such rotary mechanisms may be used as fluid motors, fluid pumps and rotary combustion engines but for purposes of description is described herein as used in a rotary combustion engine.

In general engines of this type comprise an outer body having end walls interconnected with a peripheral wall in the inner surface of which defines a multi-lobed shape which preferably is basically an epitrochoid. A rotor is mounted within the outer body on an axis eccentric and parallel to the axis of said end walls. The rotor has a plurality of circumferentially-spaced apex portions having axially extending grooves therein in which there are mounted radially moveable seal strips extending from one end face to the other end face of said rotor which upon rotation of said rotor, continuously engage the inner surface of said peripheral wall. An intake port may be provided in one lobe of the outer body, an exhaust port in another lobe and an ignition means is provided opposite the two ports in an area adjacent the minor axis of the epitrochoid or in other words near the junction of two lobes of the epitrochoid. During relative rotation of said outer body and said rotor the working chambers are formed therebetween which vary in volume and successively pass through the stages of intake, compression, expansion, and exhaust. For a more detailed treatment of this type of engine reference may be had to the above mentioned patent.

One of the problems which sometimes arises during operation of this type engine is the formation of chatter marks or deformations on the inner surface of the peripheral wall. This of course will in time affect the sealing qualities beween adjacent working chambers resulting in blow-by, compression loss, seal damage etc. This is in part due to the fact that the seal strips move radially in their grooves. Of course, if it were possible to produce an engine without tolerances and not subject to elastic deformations and heat distortions, the seal strips would slide continuously along the inner surface without making any radial movements at all. However, since, as a practical matter, production of such an engine is impossible, the seal strips must on occasion move radially in order to remain bearing against the inner surface. During this radial movement of the seal strips they may become jammed in their grooves and if any additional radial-inward movement is required the seal strips will be prevented from responding and as a result will dig into the inner surface leaving the chatter marks. Radially inward movement of the seal strips in their grooves may be required when the inner surface deviates inward because of heat distortion, errors in manufacture, or vibrations in the rotor. Such chatter marks are sometimes found substantially in the middle of the lobe having the intake port and also shortly past the end of the epitrochoid minor axis in the combustion zone.

During observation after engine tests it has been found that the beginning of the chatter markings regions correspond to the spacing of adjacent seal strips, that is, at about 120° in engines having a two-lobed shape and a three-lobed rotor. In this case the chatter markings appear at two adjacent seal strips when the third slides over the exhaust port. This may be due to the abrupt drop in pressure produced in a working chamber in its expansion cycle producing vibrations of the rotor which consequently occur in a plane that lies obliquely to the two seal strips doing the chattering, so that these seal strips tend to jam in their grooves.

This invention overcomes this problem by forming the inner surface of the peripheral wall so that it deviates outwardly from basically an epitrochoidal shape at the portions where the chatter marks normally appear. This allows the seal strips to shift outwardly so that digging of the seal strips into the inner surface of the peripheral wall is completely avoided because there are no forces tending to move the strips inwardly at these points.

In another form of the invention the problem is overcome by inclining each seal strip to a radius from the rotor center to the seal strip so that the seal strips are dragged in their sliding contact with the inner surface. By so inclining the apex seals, this gives the advantage that the inner surface need only be deviated outwardly from the basically epitrochoid shape in the lobe into which the intake port has its outlet because the seal strip, which at the instant of uncovering the exhaust port is situated beyond the minor axis zone in which the ignition is effected, is situated substantially parallel to the direction of rotor vibration and therefore its movement is not detrimentally affected and it does not tend to jam.

Accordingly it is an object of this invention to provide a novel and improved relationship for sealing the working chambers of a rotary mechanism.

It is further an object of this invention to provide means for preventing the formation of chatter marks on the inner surface of the peripheral wall of a rotary mechanism.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation together with additional objects and advantages thereof, will be best understood from the following description of the specific embodiment when read in connection with the accompanying drawing.

FIGURE 1 shows a cross-section of a rotary combustion engine illustrating the invention,

FIGURE 2 is an enlarged section of the area in which ignition is effected showing the seal element in two positions and,

FIGURE 3 is a view similar to that shown in FIGURE 1 showing another embodiment of the invention.

Referring to FIGURE 1, there is shown a housing, generally designated by numeral **1**, in which the peripheral inner surface of the housing has a two-lobed inner contour **10** which is basically an epitrochoid and is shown in part in dot-dash lines and in part in solid lines. The inner contour **10** represents a cross-section of the inner surface of the peripheral wall of the housing which is connected between a pair of end walls. A shaft **12** is rotatably mounted on the housing and carries an eccentric **14** upon which is mounted a rotor **16** having three circumferentially-spaced apex portions designated at **18**. Relative to the housing, the rotor **16** makes a planetary-like rotary movement about the axis of shaft **12**. Seal strips **20***a*, **20***b*, and **20***c* are mounted in grooves in each of the apex portions and said grooves extend parallel to the rotor axis from one end face to the other end face and each of said grooves opens radially outwardly so that each seal strip is movable radially in its groove. During rotation of the rotor **16**, the seal strips **20***a*, **20***b*

and 20c slide continuously along the inner surface of the peripheral wall, said inner surface representing a curve described by the point of contact of the seal member during said circulation. The origin of the use of this curve is clearly disclosed with reference to FIGURE 4 in United States Patent Number 2,988,008, issued to Felix Wankel on June 13, 1961.

As explained in said patent, when using a true epitrochoid curve for the inner surface, the seal strips have to possess a sharp edge contact in order to continuously contact the inner surface along a line. Due to the wear effect between the contacting surfaces, the sharp edge will gradually wear down and the seal strip must then move radially in order to maintain contact with the inner surface. Obviously, the further the sharp edge of the seal strip wears down, the further the radial distance the seal strips must move to remain in contact with the inner surface. Such radial movement of the seal strip is undesirable since it tends to cause chatter marks in the inner surface and compression leaks since the radial movement sometimes lags behind the rotary speeed of the rotor. However, as further explained in said patent if a curve is used which is outside and parallel to the true epitrochoid, the seal strip need not possess a sharp edge contact but may have a rounded engaging portion which is extended out a slight distance from the point on the seal strip which traces the true epitrochoid. Also, if the parallel curve is spaced from the true epitrochoid curve at a distance equal to the distance from the above-mentioned tracing point to the rounded surface of the seal strip said strip does not normally have to make any radial movements since the seal strip may now engage the inner surfaces, or outside parallel curve, at different positions of line contact along its rounded surface. Some movement of the seal strip may be required because of heat distortion, rotor vibration or because of bearing clearances but movement as found in using the true epitrochoid and a sharp edged seal strip is avoided in the above construction. The distance between the outer parallel curve and the true epitrochoid is very small and as described in Patent Number 2,988,008 may be equal to the radius of the tip of the seal strip so that the outer parallel curve is basically epitrochoidal. The curve 10 shown in the present invention corresponds to the outer parallel curve as described in said patent and may be referred to as the parallel curve.

In order to carry out the four cycle process in each of the working chambers 26, there is provided, as shown with respect to the rotor rotation, an intake port 28 disposed in the housing peripheral wall just beyond one minor axis portion 22 of the epitrochoidal inner surface, an exhaust port 30 disposed in the housing peripheral wall just before the minor axis portion 22 and an ignition spark plug, diagrammatically illustrated by arrow 32, disposed in an opposite side of the housing peripheral wall in an area adjacent the minor axis portion of the epitrochoidal inner surface indicated at 24.

After long periods of operation it has been found that chatter marks sometimes appear on the inner surface of the peripheral wall in the two regions shown by dot-dash lines in FIGURE 1. The chatter marks begin at regions extending in the direction of relative rotor rotation from the points located substantially at apex seal strips 20a and 20b when the other apex seal strip 20c is about to open one of the chambers 26 to the exhaust port 30. A position of the rotor corresponding to this situation is shown in dot-dash lines in FIGURE 1. The production of the chatter marks is a result of the seal strips being forced inward in their grooves for example as a result of rotor vibration, thermal distortion of the inner surface 10, rotor bearing clearances, etc. and as a result the apex seal strips in substantially the position shown by apex seal strips 20a and 20b may jam thereby deforming the inner surface of the peripheral wall. In order to make it possible for the seal strips 20a and 20b to shift outwardly instead of inwardly at these two regions of the inner surface, the peripheral wall is made so that it deviates outwardly or is cut back from the parallel curve 10 taking the shape shown by solid lines 10a. One portion of the path of deviation is shown on an enlarged scale in FIGURE 2 where it can be seen how seal strips 20a is able to move outwardly in its groove from the position shown in dot-dash lines to the position shown in solid lines. Therefore, the seal strip 20a is not compelled by the inner surface to make radial inward movement in this region.

In addition to avoiding chatter marks, the invention also has the advantage that the seal strips are subjected to only dynamic friction between themselves and the groove wall, which is substantially less than the static friction encountered, so that less force is required to press the seal strips against the inner surface of the peripheral wall and the seal strips are thus able to act more rapidly in accordance with the forces acting on them.

The jamming of the seal strips in their grooves may result from vibration of the rotor being produced at the time of the uncovering of the exhaust port 30 as a result of a sudden reduction in pressure in the expanding working chamber. Accordingly deviation in the inner surface in the region following the ignition can be dispensed with if the seals are disposed in the rotor so that each apex seal is inclined to a rotor radius through said seal in a direction so that during rotor rotation the apex seals in effect are dragged over the inner surface 10. In other words, the seals would be mounted at a trailing angle with respect to the direction of rotation as shown at 34a, 34b, and 34c in FIGURE 3. When seal strip 34c is about to uncover the exhaust port 30, the seal strip 34a is situated so that it is movable in its groove in a direction substantially parallel to the direction of rotor vibration as indicated by the double pointed arrow 36, and therefore is not apt to jam in its groove. However, the other seal strip 34b at this time is inclined at a substantial angle to the direction 36 of rotor vibration and therefore, although the strip 34a is not apt to jam in its groove on inward movement, the seal strip 34b is apt to so jam on inward movement. Hence, with the apex seal strips inclined as in FIGURE 3, it is only necessary to cut back the inner surface in the region 10a, shown therein, to minimize jamming of the apex seals in their grooves and thereby preventing chatter marks on the inner surface 10.

The deviation or cutting back of the contour of the inner surface from the parallel curve has been greatly exaggerated in FIGURES 1, 2 and 3 in order to make the illustration more readily understandable. In practice such deviation amounts to only fractions of a millimeter.

From the foregoing it can be seen that the invention eliminates chatter marks in the inner surface of the peripheral wall which in turn results in more efficient sealing and engine operation. The invention is not intended to be limited to the specific embodiments shown herein and is intended to cover modifications and forms which would be obvious to one skilled in the art without departing from the spirit and scope of the invention defined in the following claims.

I claim as my invention:

1. A rotary combustion engine comprising a hollow outer body having a cavity with a peripheral wall, the inner surface of said peripheral wall having basically the profile of a two-lobed epitrochoid; a rotor mounted within said cavity and having three circumferentially-spaced apex portions, each of said apex portions having an outwardly-opening groove extending from one end face to the other end face of the rotor; and apex seal strip means in each apex groove for sealing cooperation with said epitrochoidal inner surface to form a plurality of working chambers which vary in volume upon relative rotation of said rotor and outer body, said outer body having intake and exhaust ports opening into said cavity on op-

posite sides of and adjacent to one end of the minor axis of said epitrochoidal inner surface, at least one region of said epitrochoidal inner surface being enlarged to require outward movement of each apex seal strip means in said region during engine operation to maintain contact with said inner surface in said region, said region extending in the direction of relative rotor rotation from a point located substantially at an apex seal strip means when another of said apex seal strip means is about to open a working chamber to the exhaust port.

2. In a rotary combustion engine as recited in claim 1 wherein said intake port is located in one of said lobes beyond said one end of said minor axis of said epitrochoidal surface with respect to the rotation of said rotor and said one region of enlargement is located in said lobe having said intake port.

3. In a rotary combustion engine as recited in claim 2 wherein said exhaust port is located in the other of said lobes before said one end of said minor axis of said epitrochoidal surface and said epitrochoidal surface is

enlarged in a second region, said second region being located in the lobe having said exhaust port in an area shortly past the other end of said minor axis.

4. In a rotary combustion engine as recited in claim 1 wherein said inner surface is enlarged in regions where two of said apex seal strip means engage said inner surface when a third of said apex seal strip means has uncovered said exhaust port.

5. In a rotary combustion engine as recited in claim 1 wherein each of said apex seal strip means is mounted in its respective apex groove so that it is inclined to a rotor radius through said seal strip whereby each of said strips assumes a dragging position with respect to its engagement with said inner surface.

6. In a rotary mechanism as recited in claim 1 wherein said rotor is mounted on an axis eccentric and parallel to the axis of said epitrochoid and an ignition means is provided adjacent the other end of said minor axis.

No references cited.