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Woodier

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[54] **ROTARY ENGINE MODIFIED FOR LOW EMISSIONS**

[75] Inventor: **George H. Woodier,** Ringwood, N.J.

[73] Assignee: **Curtiss-Wright Corporation,** Wood-Ridge, N.J.

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[51] **Int. Cl.**[2] **F02B 53/00**

[52] **U.S. Cl.** **123/8.45**

[58] **Field of Search** 123/8.09, 8.11, 8.13, 123/8.45

[56] **References Cited**

U.S. PATENT DOCUMENTS

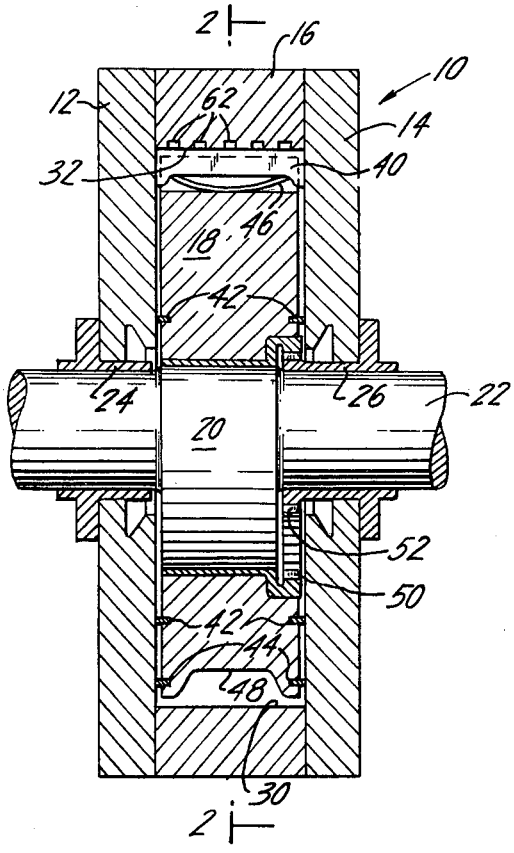
3,393,666	7/1968	Yamamoto et al.	123/8.45
3,754,534	8/1973	Burley	123/8.45 X
3,848,574	11/1974	Fujikawa et al.	123/8.09

Primary Examiner—Carlton R. Croyle
Assistant Examiner—Michael Koczo, Jr.
Attorney, Agent, or Firm—Victor D. Behn; Arthur Frederick

[57] **ABSTRACT**

A rotary combustion engine and method of operating said engine in which grooves are provided in the engine trochoid surface to permit any unburnt fuel at the trailing end of a working chamber of the engine to blow back into the following working chamber so as to reduce the hydrocarbons in the engine exhaust without any material adverse effect on engine performance.

3 Claims, 3 Drawing Figures



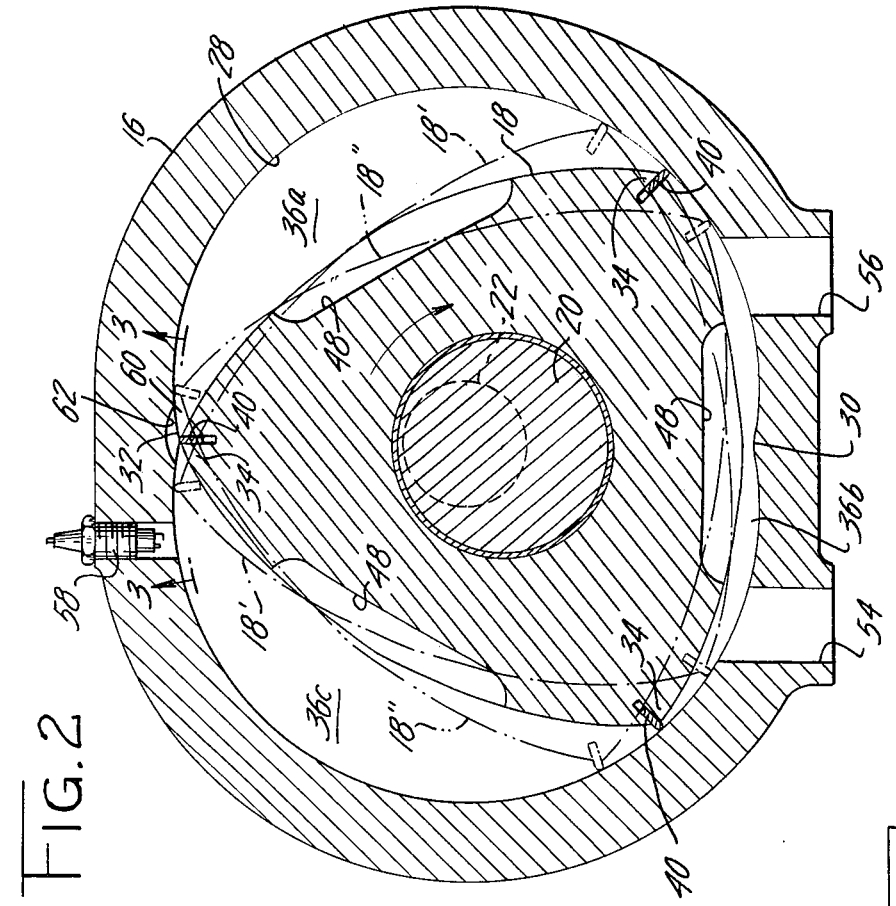


FIG. 2

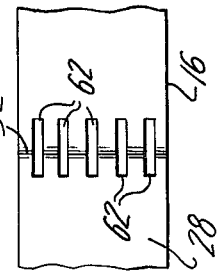


FIG. 3

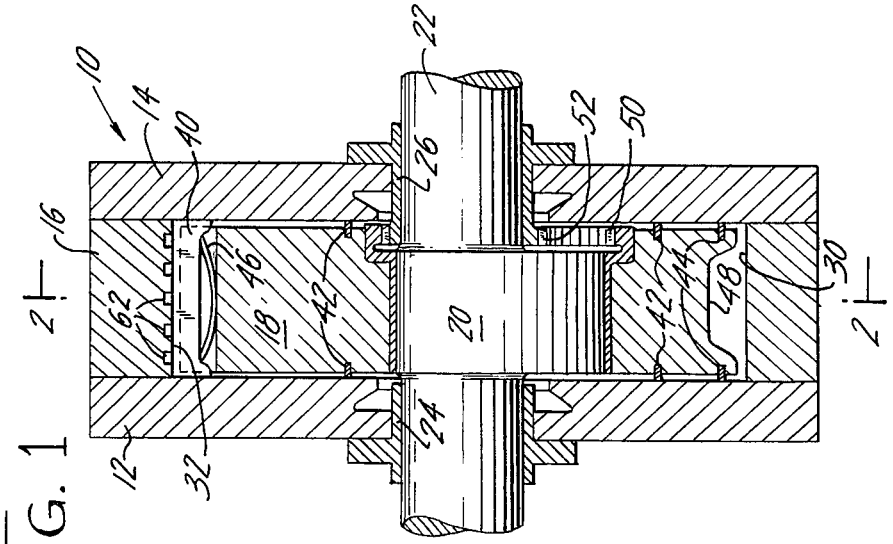


FIG. 1

ROTARY ENGINE MODIFIED FOR LOW EMISSIONS

BACKGROUND OF THE INVENTION

The invention relates to rotary internal combustion engines of the type disclosed in U.S. Pat. No. 2,988,065 granted June 13, 1961 to Wankel et al.

In engines of this type, the engine working chambers rotate with the engine rotor and as a result unburnt fuel tends to accumulate in each working chamber adjacent the trailing end of the chamber from which it is discharged into the engine exhaust port. This problem has been recognized in U.S. Pat. No. 3,393,666 granted July 23, 1968 to Yamamoto et al.

In said prior U.S. Pat. No. 3,393,666, one or more grooves are provided in the inner trochoid surface of the rotor housing in the region in which combustion takes place so that when a rotor apex seal passes over the grooves, the pressure differential across the apex seal blows any unburnt fuel into the following working chamber (that is, into the working chamber on the trailing side of said apex seal) for subsequent combustion therein. In U.S. Pat. No. 3,393,666, however, the grooves in the trochoid surface have such length and are so positioned that when an apex seal of the rotor starts across the grooves, the following working chamber (that is, the chamber on the trailing side of said seal) is still open to the engine intake port and before said apex seal passes completely across the grooves, the working chamber on the leading side of the seal opens to the exhaust port. This has several disadvantages. First, any leakage through the grooves in the following working chamber while said following chamber is still open to the intake port will tend to reduce the amount of fresh charge taken into that chamber. In addition, if the working chamber on the leading side of an apex seal opens to an exhaust port before the seal travels completely across the trochoid grooves, then the pressure differential across the seal probably will reverse before the seal is completely across the grooves whereupon there will be a pressure loss from the following chamber into the leading chamber.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a unique arrangement of one or more grooves in the trochoid surface of a rotary engine for permitting any unburnt fuel in the trailing portion of each working chamber to blow back to the follwing chamber but without the aforementioned disadvantages inherent in U.S. Pat. No. 3,393,666.

Specifically, the invention relates to a rotary engine having a housing with an internal cavity, the peripheral surface of which has a multi-lobe profile with the lobes being joined by regions disposed relatively near to the engine axis, and an inner body or rotor is mounted for relative rotation within the housing cavity with the inner body having a plurality of apex portions having sealing cooperation with the multi-lobe surface of the housing cavity to define a plurality of working chambers which vary in volume in response to said relative rotation and with the housing having intake and exhaust ports on opposite sides of one of said near-axis regions, the invention comprising the addition of circumferentially-extending grooves in the multi-lobe surface with the grooves being so positioned that an apex portion of the rotor does not reach the grooves until the working chamber on the trailing side of said apex portion has closed to the intake port and the grooves being of such length that an apex portion of the rotor moves beyond the grooves before the working chamber on the leading side of said apex portion opens substantially to the exhaust port.

With this combination, any unburnt fuel which might accumulate in the trailing region of a working chamber after combustion in said chamber has an opportunity to blow back through said grooves into the following working chamber without adversely affecting the magnitude of the intake charge in said following chamber and at the same time there is not danger of a pressure loss through the grooves from said following chamber.

Other objects of the invention will become apparent upon reading the following detailed description in connection with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an axial sectional view through a rotary engine embodying the invention;

FIG. **2** is a sectional view taken along line **2—2** of FIG. **1**; and

FIG. **3** is a partial view of the rotor housing trochoid surface taken along line **3—3** of FIG. **2.**

DESCRIPTION OF THE INVENTION

Referring to the drawing, a rotary combustion engine is schematically indicated at **10,** the engine being generally similar to the type of rotary engine disclosed in the aforementioned patents. The engine **10** comprises an outer body or housing consisting of two axially-spaced end housings **12** and **14** and an intermediate or rotor housing **16,** these housings being secured together to form the engine cavity therebetween. An inner body or rotor **18** is journaled for rotation within said housing cavity on an eccentric portion **20** of a shaft **22,** said shaft extending through the end housings **12** and **14** and being supported by bearings **24** and **26** respectively in said end housings.

The peripheral inner surface **28** of the intermediate housing **16** is illustrated as having a two-lobe profile which preferably is basically an epitrochoid, said two lobes joining at diametrically opposed junctions or near-axis regions **30** and **32.** The rotor or inner body **18** has generally triangular profile with apex portions **34** having sealing cooperation with the trochoidal surface to form three engine working chambers **36** between the rotor **18** and engine housing **12, 14,** and **16.** These three working chambers are distinguished from each other by the reference letters *a, b* and *c* respectively. For this purpose each of the rotor apex portions **34** is provided with a seal **40** which extends across the rotor between the inner walls of the end housings **12** and **14,** and the rotor also has suitable seals **42** and **44** on its end faces for sealing contact with said inner walls of the end housings. As is conventional, suitable springs preferably are provided behind each of the seals **40, 42** and **44.** However, only a spring **46** behind each apex seal **40** has been illustrated. Each of the three peripheral surfaces of the rotor **18** is provided with a trough-like recess **46.**

The rotary engine **10** also includes suitable gears **50** and **52** which are connected to the engine rotor **18** and end housing **14,** respectively, to control the relative rotation of the rotor, such gearing being conventional in such engines. In addition, the engine **10** has an air intake passage **54** disposed adjacent to and on one side of the near-axis region **30** of the trochoid surface **28** and an

exhaust passage **56** disposed adjacent to and on the other side of said near-axis region **30.** A spark plug **58** is disposed adjacent to the other near-axis region **32** of the trochoid surface **28** for initiating combustion in the working chambers **36.**

The engine structure so far described is conventional and is generally similar to that described in the aforementioned patents. With such an engine, during engine operation and with the rotor rotating clockwise, as viewed in FIG. **2,** the volume of each working chamber **36** periodically increases from a minimum volume condition when it is located adjacent to the lobe junction **30** and is open to the intake passage **54,** to a maximum volume condition and closes to said intake passage and then said chamber decreases in volume to compress its intake charge until said working chamber again reaches a minimum volume condition, but this time adjacent to the lobe junction **32.** Thereafter, the volume of said chamber again increases to a maximum and then decreases to a mimimum as the chamber comes into communication with the exhaust port adjacent to the lobe junction **30** to complete the cycle for said chamber. Each of the other working chambers **36** in sequence goes through the same cycle as the engine operates

With such an engine, after combustion has been initiated in a working chamber **36,** probably because of its inertia, unburnt fuel tends to accumulate at the trailing end of the chamber. Accordingly, when this chamber opens to the exhaust passage **56,** this unburnt fuel discharges into the exhaust passage thereby adding to the unburnt hydrocarbons in the engine exhaust emission. For example, with the engine rotor **18** in the position shown in full lines in FIG. **2,** combustion has already been initiated in chamber **36***a* and this chamber is going through its expansion stroke. Unburnt fuel tends to collect at the trailing end or region **60** of this chamber **36***a.*

When the rotor **18** is in its full line position, as shown in FIG. **2,** the pressure in the working chamber **36***a* is greater than the pressure in the following chamber **36***c.* This direction of the pressure differential across the apex seal **40** is disposed between the working chambers **36***a* and **36***c* exists during the initial portion of the compression phase of the chamber **36***c* and continues until the chamber **36***a* has opened substantially to the exhaust passage **56.** The present invention takes advantage of this pressure differential to cause the unburnt fuel which collects at the trailing region **60** of a working chamber to be blown back from this region into the following working chamber **36***c.* For this purpose, a plurality of circumferentially-extending side-by-side notches or grooves **62** are provided in the trochoid surface **28** adjacent to the near-axis region **32.**

Thus, when the rotor **18** is in its full line position of FIG. **2,** unburnt fuel in the region **60** at the trailing end of the working chamber **36***a* is blown back through the grooves **62** into the following working chamber **36***c.* Here this unburnt fuel mixes with the charge in said following chamber for subsequent recombustion. In this way the unburnt fuel accumulating in the trailing region of each working chamber is not discharged into the exhaust passage **56** thereby minimizing the hydrocarbons in the exhaust discharged from the engine and reducing the engine fuel consumption.

In accordance with the invention, this clean-up of the engine exhaust is accomplished without any material adverse effect on engine performance. For this purpose the grooves **62** are so positioned that an apex seal **40** does not start to move across said grooves until the following working chamber **36** has already been closed to the intake passage **54.** Thus, as shown in FIG. **2,** when the rotor is in its dash-dot line position, designated **18'**, the chamber **36***c* has just closed to the intake passage **54** and the apex seal **40** between the chambers **36***c* and **36***a* has not yet reached the grooves **62.** This is important because if the chambers **36***c* and **36***a* were interconnected by the grooves **62** before the chamber **36***c* closed to the intake passage **54,** a high pressure leakage from the chamber **36***a* into chamber **36***c* would raise the pressure in the chamber **36***c* thereby reducing the magnitude of the charge drawn into the chamber **36***c* from the intake passage **54** to reduce the engine power output.

The grooves **62** are also so positioned, and/or are of such length, that an apex seal **40** moves beyond said grooves before the working chamber **36** on its leading side has moved into substantial communication with the exhaust passage **56.** Thus, as shown in FIG. **2,** when the rotor is in its dash-double-dot line positon, designated **18''**, the apex seal **40** at the trailing end of working chamber **36a** has already moved beyond the grooves **62** and said chamber is just about to start to open but has not yet opened to the exhaust passage **56.** This is important because once the chamber **36***a* moves into substantial communication with the exhaust passage **56,** the pressure differential across the trailing apex seal reverses. That is, the pressure in the following working chamber **36***c* then becomes larger than the pressure in the chamber **36***a.* If an apex seal **40** were still moving across the grooves **62** when this pressure reversal occurs, then some of the high compression pressure in the following chamber **36***c* would escape through the grooves **62** into the chamber **36***a* with resulting loss in engine power. Also, the cross-sectional area of the grooves **62** preferably is such that the quantity of combustion gases blown back through these grooves, although small, is sufficient to carry the major portion of the unburnt fuel **60** along with it into the following working chamber **36***c.*

The invention has been described in connection with a rotary engine in which the trochoid surface **28** has two lobes. The invention, however, obviously could be used with a rotary engine having more than two lobes such as shown in the aforementioned patent to Wankel et al. Also, although the invention has been described in connection with a rotary engine in which the intake passage **54** opens through the rotor housing **16,** it obviously could also be used with a rotary engine in which the intake passage opens into the engine through one or both of the engine side walls **12** and **14** in lieu of, or in addition to, the intake passage **54** through the rotor housing. It should be understood that these and other changes may occur to one skilled in the art without departing from the spirit or scope of the invention.

What is claimed is:

1. A rotary combustion engine comprising:

a. an outer body having a peripheral wall and a pair of side walls defining an internal cavity and having an axis transverse to said side walls, the inner surface of said peripheral wall having a multi-lobe profile in which the lobes are joined by regions disposed relatively near to said axis;

b. an inner body of generally polygonal profile mounted for relative rotation within said outer body cavity, the apex portions of said inner body having sealing cooperation with said multi-lobe

peripheral surface to define a plurality of working chambers which vary in volume in response to said relative rotation;

c. said outer body also having an intake port and an exhaust port for communication with said working chambers and disposed adjacent to and on opposite sides of one of said near-axis regions; and

d. said outer body having a plurality of side-by-side circumferentially-extending grooves in its multi-lobe periperal surface adjacent to a near-axis region at which combustion takes place, said grooves being positioned so that an apex portion of the inner body does not reach said grooves until the working chamber on it trailing side has closed to said intake port.

2. A rotary combustion engine as claimed in claim **1** in which the peripheral surface of the said engine cavity is basically an epitrochoid having two lobes and said inner body has a triangular profile.

3. A rotary combustion engine as claimed in claim **2** and in which each of said grooves is of such length that an apex portion of the inner body moves beyond said groove before the working chamber on the leading side of said apex portion opens substantially to said exhaust port.

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