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3,465,729

ROTARY ENGINE CORRECTED FOR OPERATING DEVIATIONS

Filed April 1, 1968

2 Sheets-Sheet 1

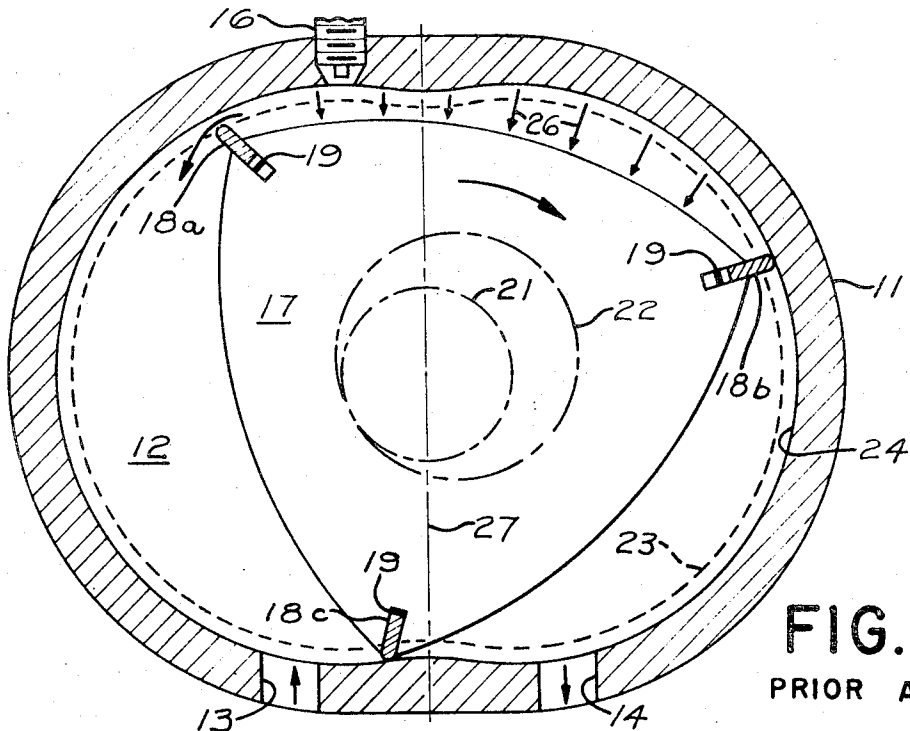


FIG. 1
PRIOR ART

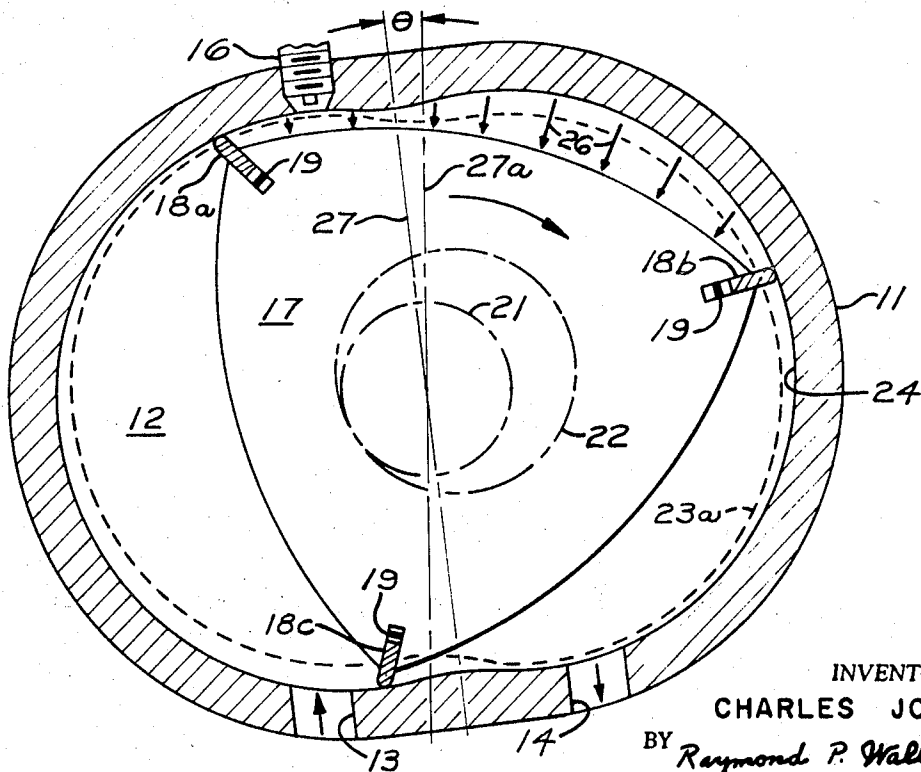


FIG. 2

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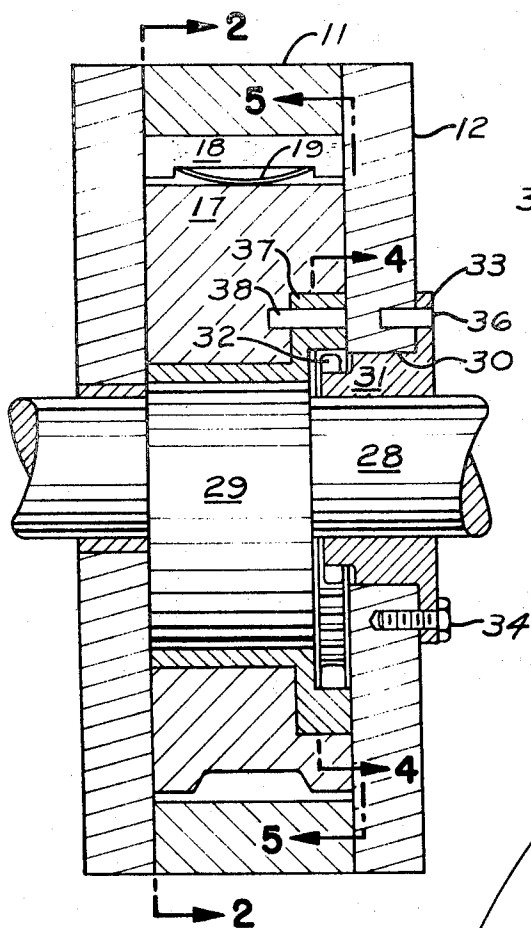


FIG. 3

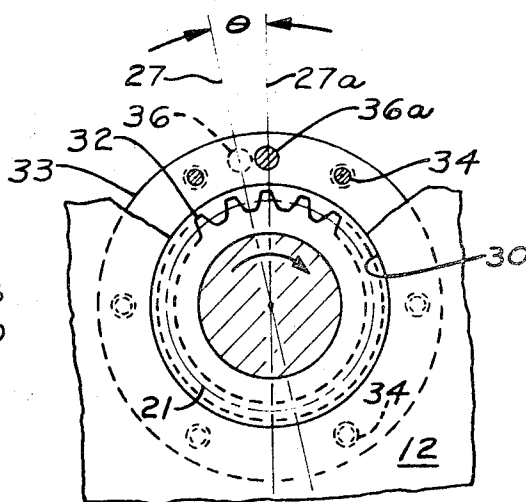


FIG. 4

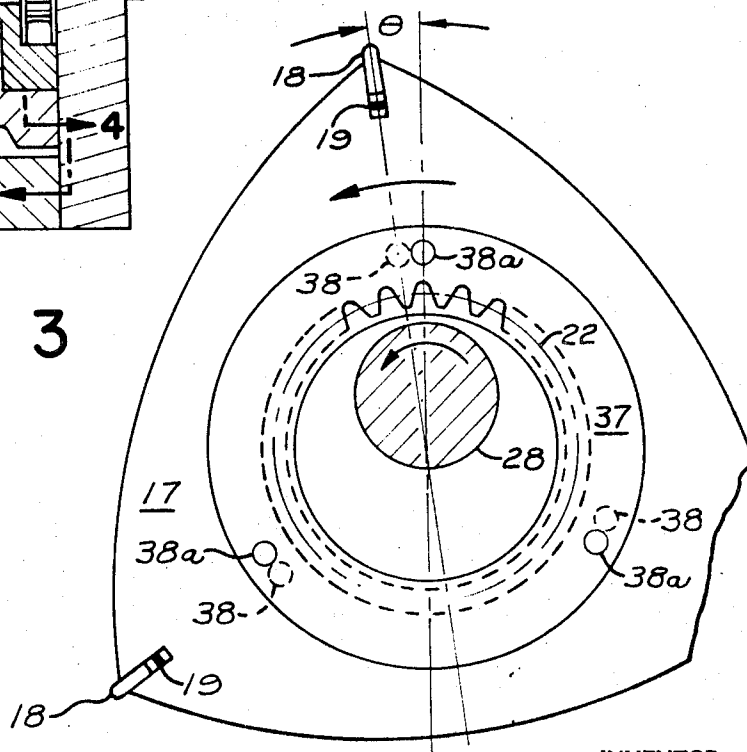


FIG. 5

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1

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ROTARY ENGINE CORRECTED FOR OPERATING
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U.S. Cl. 123—8

8 Claims

ABSTRACT OF THE DISCLOSURE

In a rotary engine of the trochoidal type, bearing clearances and minor deflections of the shaft and rotor parts may cause apex seal wear and loss of pressure at portions of the operating cycle. This condition is corrected by mutually indexing the trochoidal housing and the rotor slightly out of phase.

Background of the invention

This invention relates to rotary combustion engines of the trochoidal type, in which a multi-apexed rotor is mounted for relative rotation within a housing having a basically epitrochoidal profile to form working chambers which vary in volume on such relative rotation and perform the phases of intake, compression, combustion and expansion, and exhaust. Engines of this type are described in U.S. Patents No. 2,988,008 and No. 2,988,065.

Summary of the invention

In an engine of the type described, the main shaft transpierces the end walls of the housing on the longitudinal axis thereof, and has an eccentric portion disposed within the housing cavity, on which eccentric the rotor is mounted. The rotor rotates around the eccentric, the axis of which is displaced from the shaft axis and planetates therearound. Each of the rotor apexes has a longitudinally extending slot in which is disposed an apex seal strip, which seal strips sweep the epitrochoidal inner surface of the peripheral housing in sealing relation thereto, the seal strips being resiliently urged radially into contact with the housing. During the expansion phase the power stroke is transmitted by the rotor to the eccentric, which in turn revolves the shaft. Although the power is transmitted directly from the rotor to the eccentric, the rotor is nevertheless maintained in precise phase with the epitrochoidal housing by a gearing arrangement. A spur gear surrounds the main shaft and is nonrotatably fixed to an end wall of the housing. The rotor bears a ring gear in engagement with the fixed gear, allowing the rotor axis to planetate around the shaft axis while maintaining the rotor in its correct orientation to the housing. In the embodiment herein described, having a two-lobed epitrochoidal housing and a three-apexed rotor, the ring gear has a ratio of 3:2 with the fixed gear, and the shaft turns three revolutions for each revolution of the rotor within the housing, although engines having epitrochoids of a different number of lobes will have other ratios.

Shortly after combustion is initiated, pressure builds up very rapidly in the working chamber, causing a pressure shock to the rotor in a direction transverse to the shaft. The engine is assembled with certain operating clearances present in the rotor bearing which is mounted on the eccentric, and in the main shaft bearings which are mounted in the end walls of the housing, and also in intermediate walls in a multi-unit engine. In addition, the shaft itself may be slightly deflectable.

The combination of these clearances and possible deflections, slight though they are, may be sufficient that at

2

the moment of pressure shock one or more of the apex seals is withdrawn from contact with the peripheral housing, resulting in a loss of pressure from the expanding chamber. Further, on the rebound from the pressure shock the withdrawn seal strikes the housing sharply, resulting in excessive wear of the seal strip.

This condition is overcome in the present invention by indexing either the spur gear fixed to the housing, or the ring gear borne by the rotor, in such a manner that the housing is in a slightly angularly retarded position with respect to its theoretical position, or the rotor is slightly angularly advanced. Either type of indexing has the same result with regard to the relative orientation of the rotor and housing, bringing a slightly different portion of the curvature of the housing adjacent to the affected seal, whereby leakage and wear are avoided.

Brief description of the drawings

The invention will be better understood on reading the following specification in conjunction with the annexed drawings, in which

FIG. 1 is an elevational cross-section transverse to the axis of such an engine of the prior art, shown near the beginning of combustion and illustrating the defect;

FIG. 2 is a similar view of the improvement of this invention, taken on line 2—2 of FIG. 3;

FIG. 3 is a cross-section elevation of the improved engine on the axial plane;

FIG. 4 is a fragmentary view of a reoriented spur gear, taken on line 4—4 of FIG. 3; and

FIG. 5 is a view of the rotor taken on line 5—5 of FIG. 3 showing a reoriented rotor gear.

Description of the preferred embodiments

In FIG. 1 there is shown a conventional rotary engine, having a basically epitrochoidal peripheral housing 11 of two lobes, closed by a pair of parallel end walls of which only the rear wall 12 is shown, the front wall being removed. Intake port 13 and exhaust port 14 are shown in the peripheral wall, although such ports may also be provided in one or both end walls. A spark plug 16 is shown mounted on the peripheral wall in the region of one cusp of the epitrochoid, although the spark plug also may be positioned in one or both end walls.

A generally triangular rotor 17 is shown within the housing cavity, having a longitudinally extending slot at each apex, containing apex seal strips 18a, 18b, and 18c. The apex seals are permitted a certain amount of radial movement within their slots, and have springs 19 positioned in the slots under the seals, resiliently urging the seals radially outwardly. Dash-dot line 21 indicates the pitch circle of the spur gear mounted on wall 12, and dash-dot line 22 is the pitch circle of the ring gear borne on the rear face of rotor 17 in mesh with the fixed gear.

The true epitrochoid is shown by the dotted line 23, it being customary in engines of this type for the inner surface 24 of the peripheral wall to have a curvature parallel to the true epitrochoid and spaced outwardly therefrom. Such an arrangement allows the rotor to run with its actual apexes at or near the true epitrochoid, and the protruding apex seals to sweep the inner surface 24 in sealing relation, and also allows for some radial movement of the seals in their slots owing to slight manufacturing tolerances in the engine.

In operation the movement of the rotor takes in fresh gas through the intake port 13. As the rotor turns further (clockwise as shown) the intake port is closed by the trailing seal and compression begins. Full compression is achieved when the rotor face of the compressing chamber reaches top dead center, slightly counter-clockwise from the rotor position shown. Ignition usually takes place a little in advance of top dead center.

Upon ignition, combustion pressure builds up very rapidly in the firing chamber, as shown by the pressure arrows 26 normal to the rotor face in the top chamber shown in the drawing. The sudden pressure build-up occurring by about the time the rotor has reached the position shown causes a shock transverse to the shaft which drives the rotor downward in the housing to the position shown, owing to the bearing clearances and possible shaft deflection previously described. The actual movement of the rotor transversely to the axis is small, amounting only to some thousandths of an inch, but the proportions have been greatly exaggerated in the drawing for clarity of illustration.

At this portion of the combustion cycle the trailing seal 18a of the firing chamber is pressed firmly against its slot wall by the pressure of expanding gas, which may be sufficient to lock it firmly in place so that its spring 19 may not be strong enough to urge it radially into contact with the peripheral wall. The spring force of springs 19 is kept reasonably light in order to avoid excessive wear of the seals and housing.

In such circumstances the trailing seal 18a may lose contact with the peripheral housing so that gas pressure is lost across the edge of the seal, as shown by the arrow. The same locked condition may also occur in the case of the leading seal 18b, but owing to the angle of its orientation to the peripheral housing surface at this point it is less likely to lose contact. At the same time, the seal 18c at the opposite rotor apex is driven sharply into its slot. In reaction to the pressure shock the rotor then immediately rebounds, whereupon seal 18a strikes the housing surface sharply. There may be a succession of progressively damping rebounds, which causes seal wear and chatter marks in the housing surface.

This condition is corrected by the present invention as shown in FIG. 2, wherein the phasing of the peripheral housing and the rotor is altered by a slight angular amount to bring a differently curved portion of the inner surface of the peripheral housing opposite the seals at the moment of pressure shock, without significant alteration of the timing of the engine. The phase alteration is accomplished by rotating the housing slightly in a direction opposite to the direction of rotor rotation, or by rotating the rotor slightly on the eccentric in the same direction as rotor rotation. These directions will be hereinafter referred to as upstream rotation for the housing and downstream rotation for the rotor.

In the prior art engines the rotor and housing have been phased together so that the rotor turned on the true epitrochoidal path parallel to the outer curve of the peripheral housing. With the rephasing of the present invention, the rotor still turns on an epitrochoidal path, but it is no longer quite parallel to the housing, but is rotated slightly downstream. The amount of displacement is slight, and well within the accommodation provided by the radial travel of the apex seals in their slots. However, it brings the apex seals at the moment of pressure shock adjacent to somewhat differently curved portions of the housing so that in spite of some displacement of the rotor axis the seals will still make proper contact.

In FIG. 2 the rotor is shown at the same period in the combustion cycle as in FIG. 1, that is, at the moment of pressure shock. However, the housing has been rotated upstream, or the rotor downstream, by the means later to be described. Either adjustment produces the same result with regard to the mutual phasing of rotor and housing.

The amount of such relative rotation is indicated by the angle θ between the lines 27 and 27a, showing respectively the minor diameter of the trochoidal profile of the housing and of the trochoidal path traversed by the rotor. Angle θ is preferably about $0^{\circ}35'$, but has a usable range of plus or minus $0^{\circ}25'$ that is, from about $0^{\circ}10'$ to about $0^{\circ}60'$ over-all.

The epitrochoidal path 23a traversed by the motor tips retains the same configuration and dimensions as before,

but it will be observed that it is now displaced angularly downstream with respect to the housing. The trailing seal 18a of the firing chamber has traveled a little closer to the cusp of the epitrochoid, and seal 18c has traveled further beyond the other cusp of the epitrochoid, than is the case in the prior art engine of FIG. 1. Hence, seal 18a is not withdrawn from contact with the housing surface and there is no leakage of pressure, and seal 18c is not driven so far into its slot, obviating the danger of bottoming. The angle of seal 18b to the peripheral housing is not much affected.

FIG. 3 is a cross-sectional elevation of the engine on the axial plane, showing the housing and rotor, shaft 28 having an eccentric portion 29 disposed within the housing on which the rotor turns, and the gears and their mountings by means of which phasing is accomplished. End wall 12 has an axial bore 30 therethrough, in which is positioned the hub 31 of a spur gear 32 surrounding shaft 28. The hub 31 has a flange 33 by which it is mounted on the wall 12 by bolts 34 or other convenient fastening means. The outer diameter of hub 31 has a close fit with bore 30, and the angular position of the gear is established by means of that close fit and a locating dowel 36 through the flange into a bore in the end wall. The rotor bears in a cavity in one end face a ring gear 37, in mesh with spur gear 32. Ring gear 37 is located angularly on the rotor by one or more dowels 38 through the gear body and seated in bores in the rotor.

FIG. 4 shows one method of rephasing the housing and rotor, by rotating or displacing the housing angularly upstream relative to the spur gear 32, or by rotating the gear angularly downstream in its position on the end wall 12, which amounts to the same thing. The locating dowel 36a is shown in its new position, the former position being indicated by the dotted circle at 36, angularly displaced from the new position by the amount of angle θ . Such relocation may be achieved either by retaining the dowel bore through flange 33 in its original position with respect to the gear teeth and relocating the dowel bore in end wall 12, or by retaining the seating bore in the end wall and relocating the dowel bore through the flange, so that the gear teeth are angularly repositioned with regard to the housing.

FIG. 5 shows another method of rephasing, by rotating the rotor in the downstream direction with respect to the teeth of its ring gear 37. That is, the gear is pinned to the rotor with the teeth slightly upstream from their former position. Dowels 38a are shown in their new position, with the former position indicated by the dotted circles 38, separated from the new position by the angular amount θ . Here again, the dowel seats in the rotor may be relocated and the dowel bores in the gear retained, or the dowel seats may be the same as before and the bores in the gear relocated, which has the effect of repositioning the rotor in a downstream direction with regard to its gear teeth and hence in regard to the peripheral housing.

The same over-all result may be achieved by rotating both the housing and the rotor as shown in FIGS. 4 and 5, the desired total angle θ being divided between housing rotation and rotor rotation. In both FIGS. 4 and 5 the effect is much exaggerated in the drawings, the actual amount of angular displacement being the selected angle θ between centerlines, as previously set forth.

Although the invention has been described above in preferred embodiments, it is not intended to limit the invention to those precise embodiments shown and described. It will be understood that various modifications may be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A rotary engine having a peripheral housing with an inner surface having a basically epitrochoidal profile, the peripheral housing being closed by a pair of parallel end

5

walls to form a cavity therein, a shaft transpiercing the end walls on the axis of the epitrochoid and having an eccentric portion disposed within the cavity, the eccentric having a longitudinal axis parallel to the housing axis and displaced therefrom and planetating therearound, a rotor having a plurality of apexes rotatably mounted on the eccentric, the rotor tracing an epitrochoidal path within the housing, the rotor path being of the same general form as the housing profile but angularly displaced therefrom.

2. The combination recited in claim 1, wherein the rotor path is angularly displaced downstream from about $0^{\circ}10'$ to about $0^{\circ}60'$.

3. The combination recited in claim 2 wherein the rotor path is angularly displaced downstream about $0^{\circ}35'$.

4. The combination recited in claim 1, wherein one end wall bears a spur gear rigidly mounted thereon and coaxial with the shaft, the rotor bears a ring gear rigidly mounted thereon and coaxial with the eccentric, the mounting of at least one of the gears being positioned to cause the rotor to trace an epitrochoidal path out of parallel to the peripheral housing.

5. The combination recited in claim 4, wherein the mounting of the spur gear is positioned to cause the rotor

6

to trace an epitrochoidal path out of parallel with the peripheral housing.

6. The combination recited in claim 5, wherein the mounting of the ring gear is positioned to cause the rotor to trace an epitrochoidal path out of parallel with the peripheral housing.

7. The combination recited in claim 4, wherein the epitrochoidal path of the rotor is angularly displaced downstream from the peripheral housing profile about $0^{\circ}10'$ to about $0^{\circ}60'$.

8. The combination recited in claim 7, wherein the epitrochoidal path of the rotor is angularly displaced downstream from the peripheral housing profile about $0^{\circ}35'$.

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C. J. HUSAR, Primary Examiner

U.S. Cl. X.R.

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