

[54] ROTARY ENGINE

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[51] Int. Cl. F02b 53/08

[58] Field of Search 123/8.43, 8.25, 8.07

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Flynn

[57] ABSTRACT

A rotary engine comprising both a main and secon-

dary rotor provided with a rotating shaft defined along the central axis thereof and disposed in such a fashion that either of the semi-cylindrically curved outer surfaces of said two rotors is always kept in contact with the outer surface of the central axis portion of the other rotor; a housing including therein two cylindrical hollow portions with a radius equivalent to that of both rotors so as to accommodate therein said two rotors and thereby having a cross-section of cocoon-shape; a gearing mechanism interconnecting both of the rotating shafts projecting out from the cover plates of the housing; a fuel feeding hole positioned in a portion of the housing where the secondary rotor is accommodated; and an ignition plug as well as a exhaust hole positioned in another portion of the housing where the main rotor is accommodated, said two rotors being obtained from dividing a cylindrical member with a suitable height into two cylindrical members by a vertical plane including the central axis thereof and further from cutting away some portions on the both sides of the central axes of said two members lengthwisely along a specific curve.

10 Claims, 16 Drawing Figures

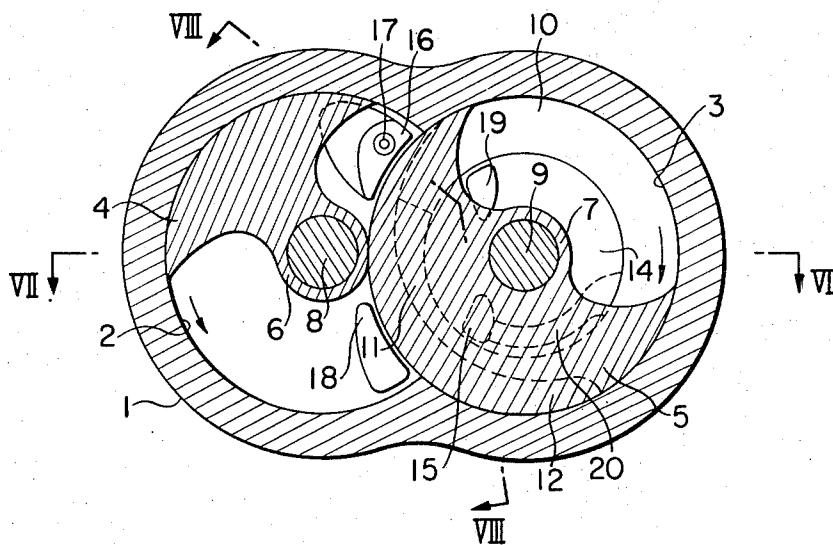


FIG. 1

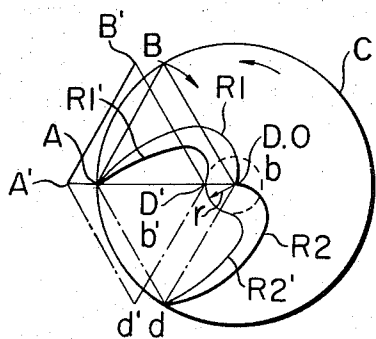


FIG. 2

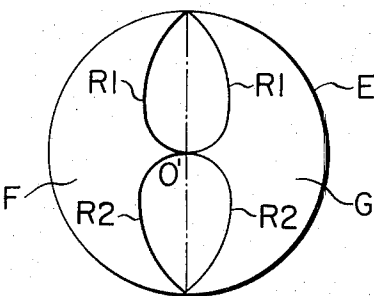


FIG. 3

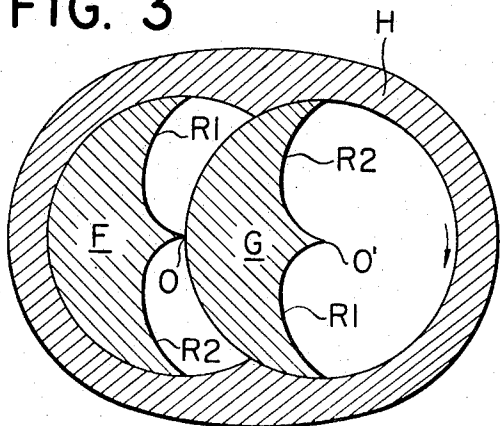


FIG. 4

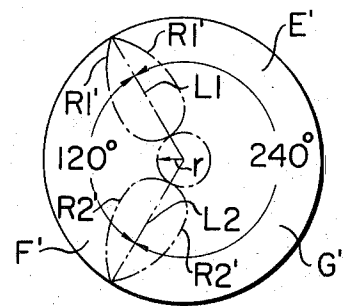


FIG. 5

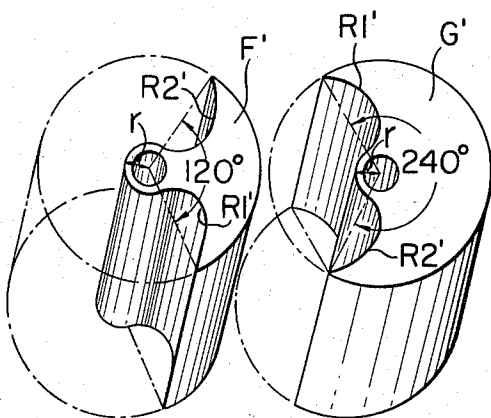


FIG. 6

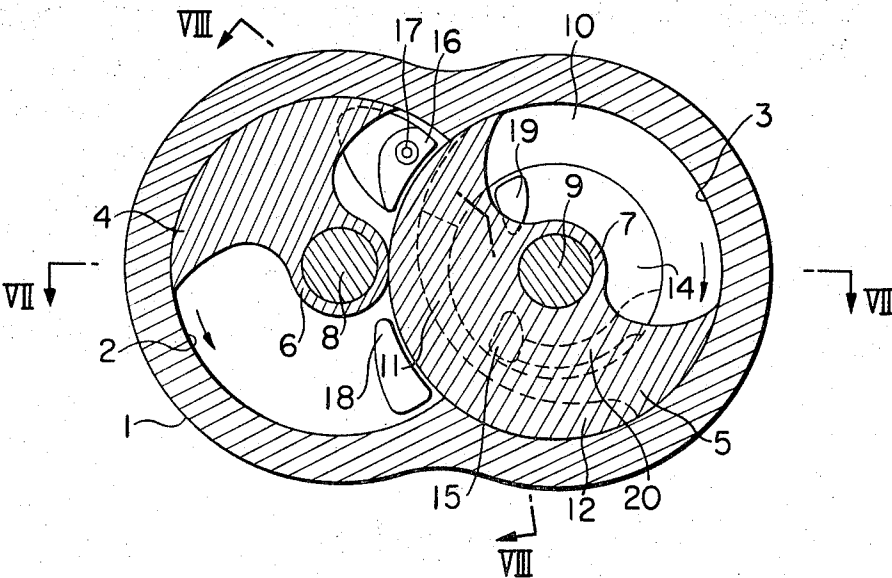


FIG. 7

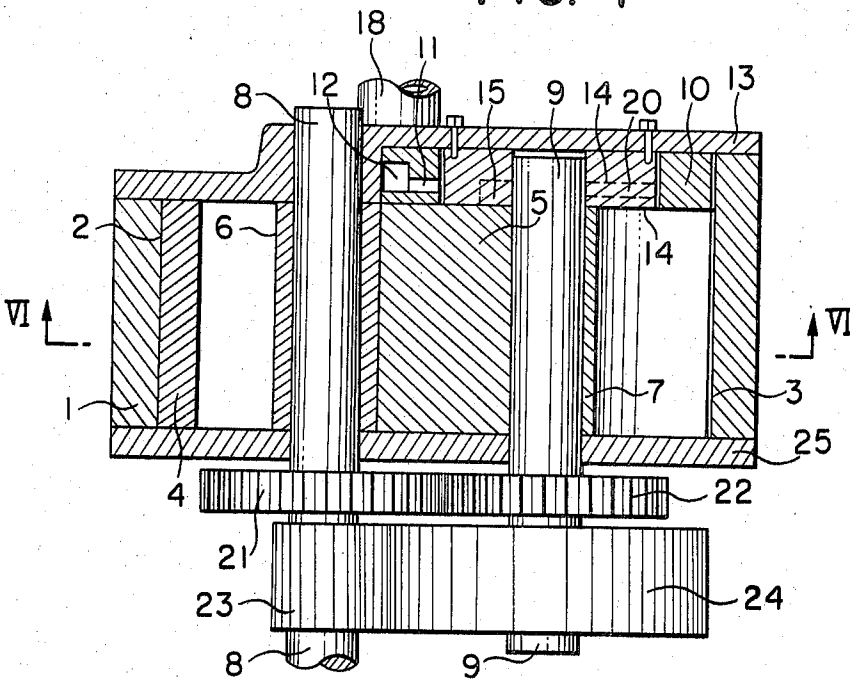


FIG. 8

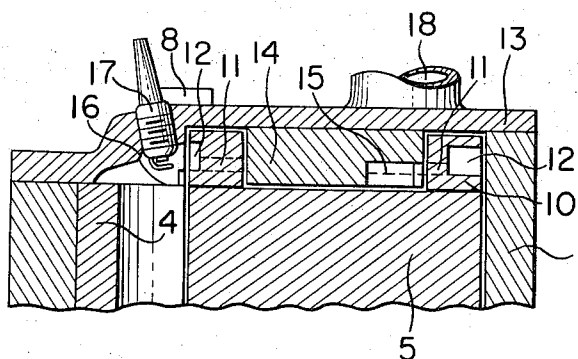
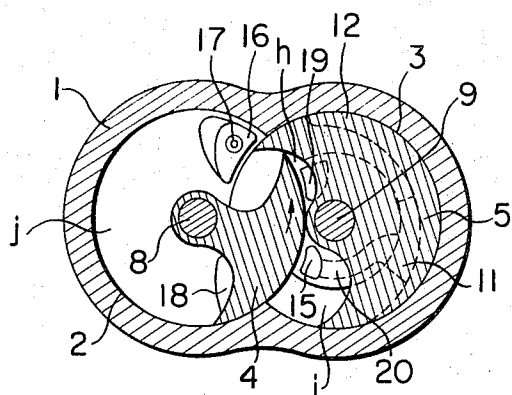
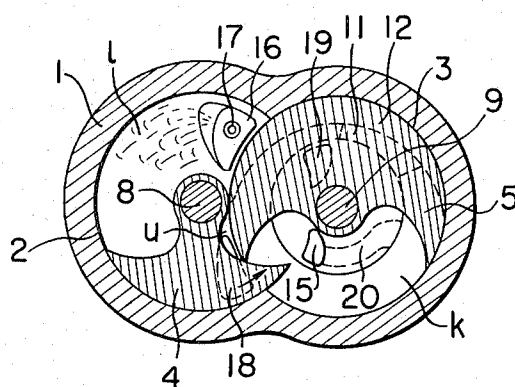


FIG. 9

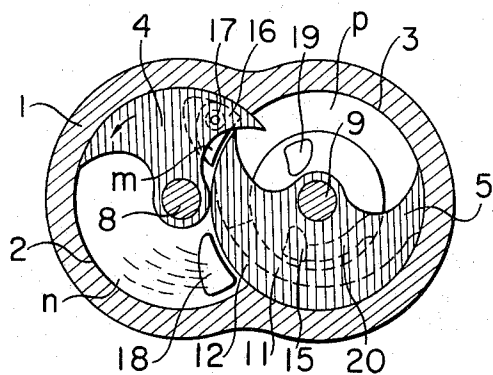
(a)



(b)



(c)



(d)

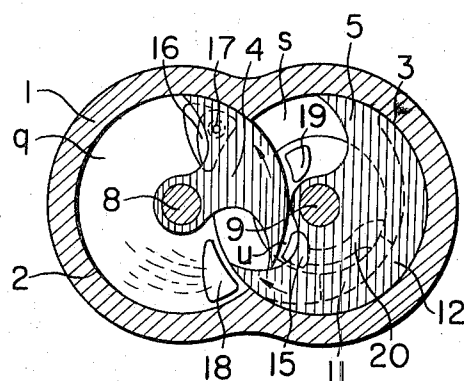


FIG. 10

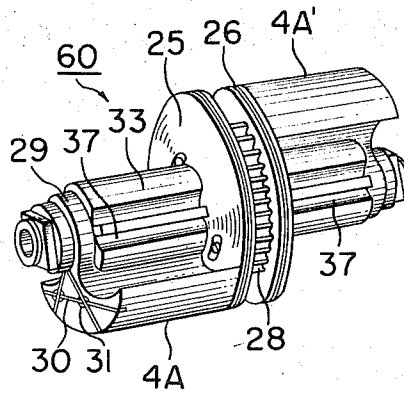


FIG. 11

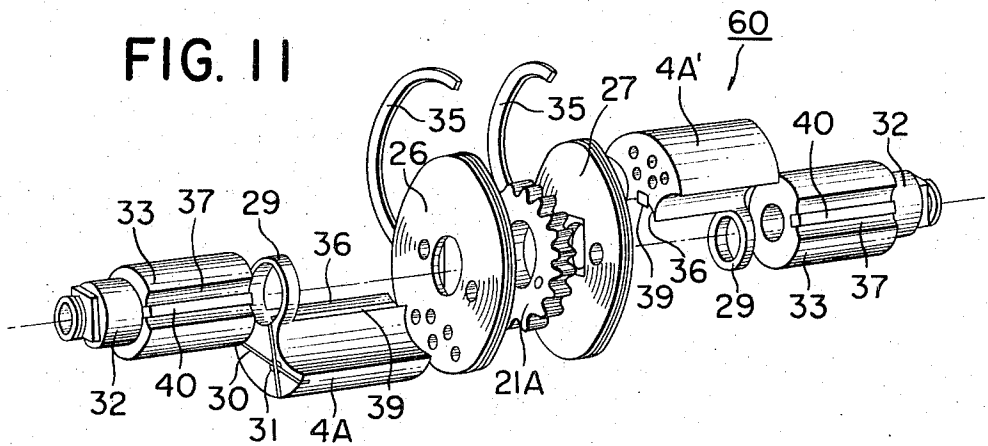


FIG. 12

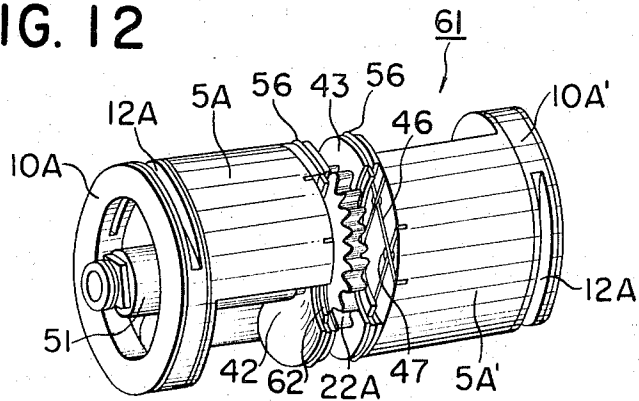


FIG. 13

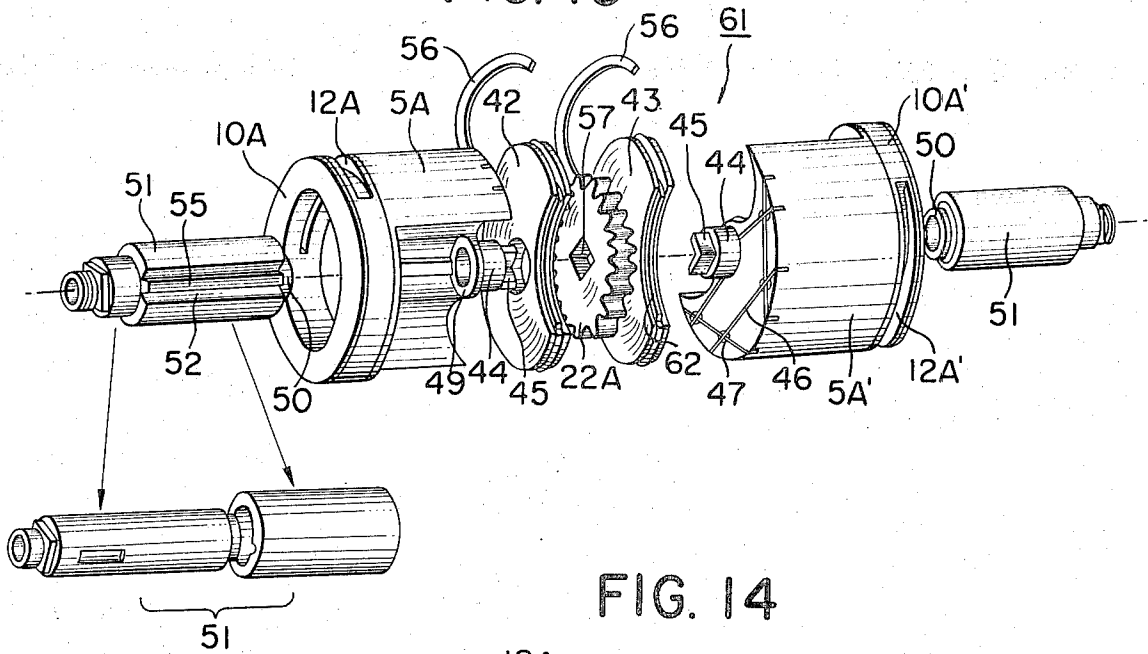


FIG. 14

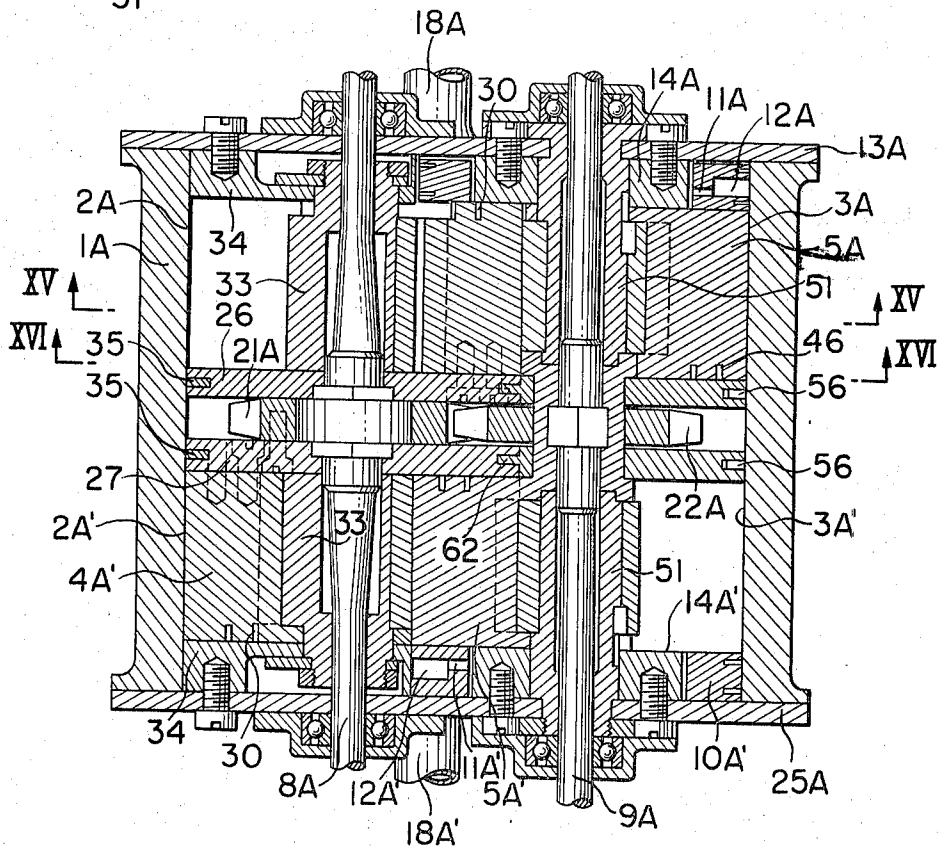


FIG. 15

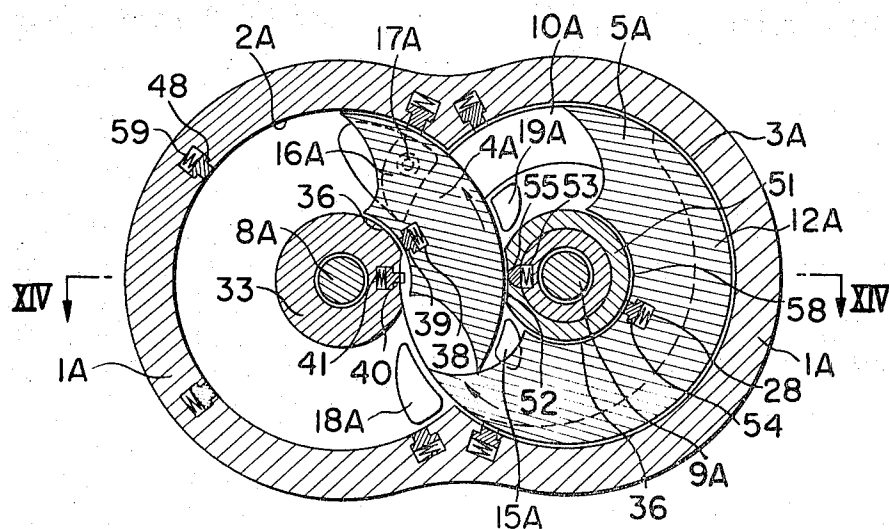
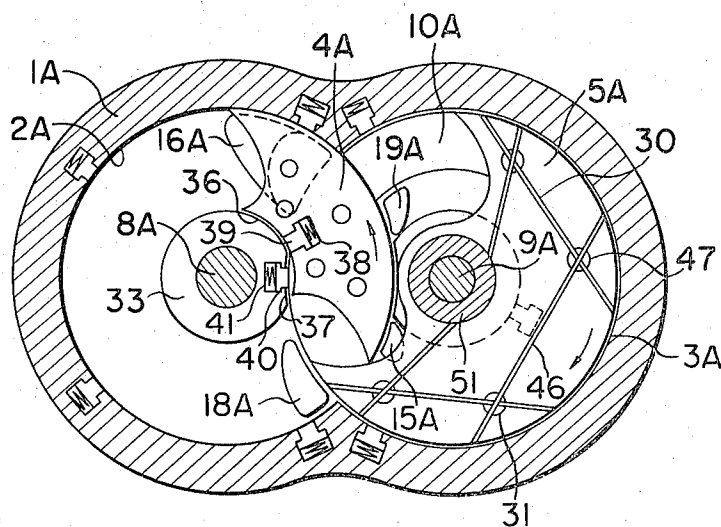


FIG. 16



ROTARY ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a rotary engine comprising a housing including therein two cylindrical hollow portions overlapping each other to a suitable extent to form a cross-section of cocoon-shape and a pair of rotors accommodated in said housing.

2. Description of the Prior Art

The conventional reciprocating engine usually results a noticeable heat loss of fuel; in other words, the energy available for shaft horsepower is as little as about 30 percent of the entire energy generated by fuel combustion, whereby about 70 percent thereof is lost. Then nearly a half of said loss should be taken up as the loss in exhaust gas. Accordingly, the thermal efficiency of the engine is exceedingly low.

To improve such disadvantages as above-mentioned, the Wankel type engine has been developed; however it has proved to have still such disadvantages as that the unstabilized rotation of the rotor thereof exerts uneven pressure onto the inside walls of the housing and further, it is hard to provide a rotor with a large volume capacity, since the rotor is not sustained directly by the housing through a supporting shaft, and thus this engine fails to have the expected thermal efficiency.

SUMMARY OF THE INVENTION

The principal object of the present invention is to provide an improved rotary engine which eliminates the above-mentioned defects of Wankel type rotary engine hitherto used.

Another object of the present invention is to provide a rotary engine having an enhanced thermal efficiency obtained by extending the expansion stroke thereof for minimization of loss in the exhaust gas.

A further object of the present invention is to provide a rotary engine which can be operated with minimized noise by minimizing vibrations which arise during operation, as by decreasing the torque fluctuations during rotation of rotor and by mechanically balancing the rotor.

A still further object of the present invention is to provide a rotary engine having a smaller size than a conventional one, but capable of running to effect an output power even the same as that of a conventional one having a larger size.

A still further object of the present invention is to provide a rotary engine adapted to have the rotating shaft of the rotor sustained by the wall of the housing so as to result in a stabilized rotation of the rotor, whereby it is possible to let the rotor have a larger volume in comparison with the conventional rotary engine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates how to draw the specific curves which is the basis for defining the curved portion of a rotor to be employed by the rotary engine according to the present invention.

FIG. 2 is an illustrative view for forming the curved portion of the rotor by virtue of said specific curves.

FIG. 3 is a cross-sectional view of a prototype according to the present invention and showing the rotors

with a specifically curved surface defined by the curves shown in FIG. 2.

FIG. 4 is an illustrative view for forming the specifically curved portion of the rotor for use in a preferred embodiment of the present invention.

FIG. 5 is a perspective view of a main and secondary rotors for use in a preferred embodiment of the present invention.

FIG. 6 is a cross-sectional view of the first preferred embodiment as taken along a line VI — VI in FIG. 7.

FIG. 7 is a sectional view taken along the line VII — VII in FIG. 6.

FIG. 8 is a sectional view of the upper portion of what is shown by FIG. 6 as taken along the line VIII — VIII.

FIG. 9 is an illustrative cross-sectional view of the first preferred embodiment of the present invention, wherein the status of operation in each stroke is shown by (a), (b), (c), and (d) respectively.

FIG. 10 is a perspective view of a main rotor assembly for use in a second preferred embodiment of the present invention.

FIG. 11 is a perspective view of the disassembled main rotor assembly shown in FIG. 10.

FIG. 12 is a perspective view of a secondary rotor assembly of the second preferred embodiment of the present invention.

FIG. 13 is a perspective view of the disassembled secondary rotor assembly shown in FIG. 12.

FIG. 14 is a sectional view of the second preferred embodiment of the present invention taken along the line XIV — XIV in FIG. 15.

FIG. 15 is a cross-sectional view taken along the line XV — XV in FIG. 14.

FIG. 16 is a cross-sectional view taken along the line XVI — XVI in FIG. 14.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is based upon a fundamental principle as mentioned below.

To understand this principle, let us consider two of the semi-cylindrical members as well as a housing with a cross-section of cocoon-shape.

Two of the semi-cylindrical members with the same dimension are obtained by dividing a cylindrical member evenly into two members along a vertical plane including the central axis thereof, while for the housing, two hollow cylinders with the same interior dimension as said cylindrical member are joined together in such a fashion that the imaginary central axis of each cylinder is spaced in parallel by a distance equivalent to the radius thereof, that is, they are radially overlapped by a length equivalent to the radius thereof, and the side wall in each overlapped portion is removed so as to form a housing with a cross-section of cocoon-shape, whereby the two chambers interconnected. Then said two semi-cylindrical members are each accommodated within one of the chambers of the housing and are rotated therein on their central axis so as to be kept in union with the imaginary central axis of the chamber with slidable contact between the semi-cylindrical surface of said member and a cylindrical inner wall of the chamber.

During rotation of the semi-cylindrical members, a void is created between the outer surface of the semi-cylindrical members and the surrounding wall of the housing. This void can be utilized as a gas-working room wherein the gas mixture is exploded for expansion.

sion. Thus, the fundamental principle of the present invention depends upon the expansion of the gas mixture to effect rotation of the semi-cylindrical members, so that rotation thereof can be converted into other effective work.

A rotary engine according to the present invention comprises rotors which correspond to the above-mentioned semi-cylindrical members, and a housing, which corresponds to the above-mentioned hollow cylinders, for use in accommodation of said rotors; whereby a gas working room is formed between the wall surface of the housing and the specifically curved surface of the rotor defined along a specific curve to be described below.

Now, in reference to FIG. 1, an elucidation will be made as under, regarding how to form said specific curves.

On circular plate C is placed an equilateral triangle ABD having a side length equivalent to the radius of said circular plate in such a manner that vertexes A and B are positioned on the circumference of the said plate C and vertex D is positioned on the center of said circular plate. Then said circular plate C is turned counter-clockwise in a direction indicated by an arrow and in the meantime, said equilateral triangle is simultaneously turned clock-wise about vertex A in the direction indicated by an arrow at an angular velocity the same as said circular plate while vertex A is maintained its own position without any movement therefrom. When turning of the circular plate as well as the equilateral triangle is stopped after said circular plate has been turned by 60° , vertexes B and D have been shifted to the positions *b* and *d* respectively (position *b* is on the same point as the center of the circular plate C, and position *d* is located on the periphery of the circular plate).

Thus, identical curves R1 and R2 are obtained as locuses defined by shifting vertexes B and D onto the rotating circulating plate. These locuses are designated as specific curves.

FIG. 2 illustrates how to define, by virtue of said specific curves, a specifically curved surface indispensable for the rotor. That is, a cylindrical solid member E is divided into two semi-cylindrical members by a vertical plane including the central axis thereof. Then the point of contact of the curves R1 and R2 shown in FIG. 1 is positioned at the point O', which is a common center for both semi-cylindrical members, and the portions of these members defined within the curves R1 and R2 passing the center O' as shown in FIG. 2 are cut away in order to form two rotors, F and G, each having a specifically curved surface.

In FIG. 3, there are seen two rotors F and G, obtained from such a process as above-described, which are disposed within a housing H. Said housing H is provided therein with two cylindrical chambers, both of which have a radius equivalent to that of the cylindrical member E, and connected to each other in such a fashion that the central axes thereof are disposed in parallel and spaced by a distance equivalent to the radius thereof, for the purpose to accommodate the rotors F and G to let them stay therein respectively. It should be noted that the central axes O and O' of the model rotors F and G are respectively aligned with the imaginary central axes of the cylindrical chambers in the housing.

During the rotation of the rotors, F and G, they are brought into successive contact with each other, for instance, between the lobe running along through the center line of the specifically curved surface of one rotor and the side edge of the specifically curved portion of the other rotor, between the lobe running along through the center line of the specifically curved surface of one rotor and the semi-cylindrical curved outer surface of the other rotor or the surface of the specifically curved portion of the other rotor, and between the side edge of the specifically curved portion of one rotor and the semi-cylindrical curved outer surface or the surface of the specifically curved portion of the other rotor, so that the relation of sliding contact is always kept between both rotors, whenever the two rotors are rotating on their own axes within the housing.

Further, during the rotation of rotors, there is formed a vacancy or space between the inner side of the housing and outer surface of each rotor, F and G, within the area wherein each rotor rotates respectively. That is, while said vacancy is repeatedly formed and then disappears within the respective area wherein each rotor rotates, said vacancy is divided by the semi-cylindrically curved outer surface of the rotating rotors F and G. It is this vacancy that serves as a gas-working chamber of the rotary engine according to the present invention. Thus, it is deemed that FIG. 3 illustrates a prototype of the present invention. The rotary engines developed as the preferred embodiment of the present invention from such a prototype are seen in FIGS. 6 to 16. Now, hereinafter an elucidation will be made with regard to these preferred embodiments.

FIG. 5 is a perspective view of the main and secondary rotors for use in a preferred embodiment of the present invention shown in FIGS. 6 to 16. The two rotors F' and G' are defined from an original solid member of a cylinder-shape E' as shown in FIG. 4.

One rotor F' has a cross-section of a fan-shape having a central angle of 120° , while the other rotor G' is of a shape obtained by cutting away a portion corresponding to said rotor F' from said cylinder E', whereby the central angle of rotor G' is 240° .

Both rotors are provided along the central axes thereof with a lobe of radius *r*, in which a rotating shaft is disposed. On both sides of the lobe, there is provided a specifically curved surface which is made with a wave-like curve consisting of a circular-arc having a radius *r* and a specific curve R1 or R2 connected with each other with a smooth succession therebetween.

A further elucidation will be made hereinafter in respect to how to prepare a specific curve for use in defining the specifically curved portion of a rotor.

As seen in FIG. 1, another equilateral triangle A'B'D' with the same dimension as the equilateral triangle ABD is placed on the radius DA, i.e., the side DA, so as to strictly overlap with said triangle ABD, and then the side A'D' of said triangle A'B'D' is radially slid from the center along the radius AD by a distance equivalent to the radius *r*. Subsequently, in the same manner as in preparation of the specific curves R1 and R2, the circular plate C as well as the triangle A'B'D' is turned around, so that the curves R1' and R2' are defined thereby as the loci of vertexes B' and D' drawn up on the rotating circular plate C.

The prepared curves R1' and R2' are thus connected tangentially with a circular arc *r* with smooth succession.

As seen in FIG. 4, the curves resulted from connecting a circular-arc r with the curve $R1'$ and $R2'$ is applied to and along the lines $L1$ and $L2$, by which the solid cylindrical member E' is divided into two members having the central angle of 120° and 240° respectively so as to obtain the rotors F' and G' as shown in FIG. 5.

In FIGS. 6 to 9, the reference numeral 1 denotes a housing having a cross-section of cocoon-shape, wherein a main chamber 2 and a secondary chamber 3 are formed. The main rotor 4 is accommodated within the main chamber and the secondary rotor 5 within the secondary chamber. Both rotors 4 and 5 are formed as seen in FIG. 5, and a rotating shaft 8, 9 runs through the lobe 6 and 7 defined along the center line of the rotor 4, 5 and is fixed thereto. The rotating shafts 8 and 9 are rotatably sustained by the cover plates 13 and 25 disposed on both ends of the housing.

The secondary rotor 5 is provided on an end surface thereof with a ring 10 nonrotatably fixed thereto, and a depressed channel or groove 12 is defined on the outer periphery of said ring 10, extending to cover a half of the peripheral length of said ring 10. Further, an opening 11 running through said ring is provided for communication between a portion of said depressed channel 12 and the inner periphery of the ring 10.

A disc 14 is fixedly secured to the back side of the cover plate 13 adjacent chamber 3. The periphery of the disc 14 is brought into slidable contact with the inner periphery of the ring 10, meanwhile the bottom surface of the disc 14 is also brought into slidable contact with an end wall of the rotor 5. An intake hole 19 extends through both of the cover plate 13 and the disc 14.

An impression 15 is defined on the bottom surface of the disc 14, while a communicating passage 20 is formed in disk 14 and communicates with said impression 15 and said opening 11 during rotation of the rotors.

The cover plate 13 is provided with an ignition chamber 16 positioned within a depressed cavity on the back side of a portion of said cover plate covering the main chamber 2 on the side thereof adjacent to the secondary rotor 5, which chamber 16 is adapted for communication with both the main chamber 2 and the channel 12 as shown in FIG. 8. An ignition plug 17 is inserted within said ignition chamber 16 and an exhaust hole 18 is formed in the corner opposite to said ignition chamber.

The reference numerals 21 and 22 denote the transmission gears fixedly mounted onto the rotating shafts 8 and 9, and the reference numerals 23 and 24 denote the balance weights equivalent to the weight of rotors 4 and 5.

Now referring mainly to FIG. 9 (a) to (d), an elucidation will be made successively with regard to operation of the first preferred embodiment of the present invention having such a structural feature as mentioned above.

As seen in FIG. 9, the main rotor 4 rotates counter-clockwise, while the secondary rotor 5 rotates clockwise. FIG. 9 (a) illustrates an operating status at the moment when the intake stroke is just starting. Let us notice that a gas-working chamber formed on the side of the secondary chamber 3 communicates with the intake hole 19, and then the gas chamber gradually increases in size in accordance with the rotation of the

rotor 5, whereby the gas mixture is drawn in through the intake hole 19. Meanwhile, the gas mixture under compression within the other gas-working chamber i communicates with the depressed channel 12 through the impression 15, the communicating passage 20 and the opening 11 and this gas mixture becomes gradually compressed due to the size of chamber i being decreased.

On the other hand, the gas-working chamber j on the side of the main chamber 2 is filled with burnt gas mixture and a portion thereof begins to flow out the exhaust hole 18. The gas-working chamber j decreases its capacity in accordance with the rotation of the main rotor 4 and thereby the amount of the exhausted gas is increased.

FIG. 9 (b) shows an operating status immediately after the start of compression stroke. On this occasion, on the side of the secondary chamber, an edge portion of the main rotor 4 is coming into the gas-working chamber k and thereby said gas-working chamber gradually decreases its capacity or size, whereby gradual compression is effected to the gas mixture staying in said gas-working chamber k , the impression 15, and the communicating passage 20.

On the other hand, on the side of the main chamber, the gas-working chamber L is increased in capacity by rotation of the main rotor 4 resulted from the combustion of the gas mixture, and meanwhile all of the burnt gas in the gas-working chamber u is discharged through the exhaust hole 18 and in a short while said gas-working chamber u will disappear.

FIG. 9 (c) shows an operating status immediately before the expansion stroke. Under this status, the gas-working chamber m on the side of the main chamber 2 communicates with the depressed channel 12 and the opening 11 of the secondary rotor 5, and the compressed gas mixture staying therein is introduced into the ignition chamber 16 so as to be ignited by the ignition plug 17 to cause the capacity of said gas-working chamber m to increase thereby. Then the burnt gas mixture staying in said gas-working chamber n is discharged through the exhaust hole 18 and said gas-working chamber n gradually decreases its capacity.

On the other hand, the capacity of the gas-working chamber p on the side of the secondary chamber is enlarged to its maximum, as the projecting edge portion of the main rotor moves out from said chamber.

FIG. 9 (d) shows an operating status immediately before the exhaustion stroke. Under this status, the projecting end portion of the rotor 5 begins to penetrate into the gas-working chamber q on the side of main chamber 2, whereby the capacity of said chamber q is gradually decreased and burnt gas mixture is thereby discharged through the exhaust hole 18.

On the other hand, the gas-working chamber s on the side of the chamber 3 gradually increases its capacity in order to take in gas mixture from the intake hole 19, while the other gas-working chamber u is about to disappear. Accordingly, compression of gas mixture staying within the impression 15, the communicating hole 20, the opening 11 and depressed channel 12 is soon completed.

Comparing the prototype shown in FIG. 3 with the first preferred embodiment of the present invention, it is understood from the foregoing descriptions that the former is provided with a main and secondary rotor having a central angle of 180° , since the rotors F and

G are based upon two semi-cylindrical members obtained from dividing a solid cylindrical member by a vertical plane including the center axis thereof, while the latter is provided with a main and secondary rotor having a central angle of 120° and 240° respectively. This is a main difference between the former and the latter.

Therefore, so far as the latter concerns, a gas-working, which appears between the main chamber 2 and the main rotor 4 after gas mixture has been ignited, is larger in capacity thereof when compared with that of the former. In other words, the expansion stroke of the latter is extended by the larger capacity of the gas-working chamber appearing between the main chamber 2 and the main rotor 4, in comparison with the former.

In addition, it can be said that the smaller the central angle of the main rotor is, the larger the capacity of the gas-working chamber on the main rotor side is in comparison with the capacity on the secondary rotor side.

FIGS. 10 and 11 illustrate a second embodiment. Since the majority of the parts of the modified embodiment are identical to the previously described preferred embodiment, said parts will be designated by the same reference numeral used to designate the corresponding parts in the preferred embodiment but with the suffix "A" and "A'" added thereto.

As shown in FIGS. 10 and 11, a main rotor assembly 60 comprises two rotors 4A and 4A' mounted onto a single shaft coaxially in parallel and in symmetry. An end plate 26, 27 is fixedly secured to an opposing end surface of each rotor, and a gear 21a is fixedly installed onto said shaft between said two end plates 26 and 27.

The main rotor 4A and 4A' is provided with a ring 29 in an end portion thereof opposite said end plate 26 and 27 and the inner side of the rotor defines a curved surface 36 FIG. 11 which is brought into contact with the surface of a sleeve 33 to be described later on.

Further, on the end surface of the main rotor are a plurality of crosswise grooves 30 and a plurality of seal members are inlaid in said grooves. A hole 31 is defined at each of the crossing points of the grooves and a pressing spring is inserted into said hole 31 in order that said pressing spring exerts a pressure on said seal member. Furthermore, curved surface 36 is provided with a dovetail groove 38 (FIG. 15) and a seal member 39 is inlaid in the dovetail groove, the seal member projecting out from said dovetail groove by the force of a spring.

Said end plate 26 and 27 each is provided on the periphery thereof with a groove, into which a seal member 35 of circular-arc-shape is inserted slidably. A journal 32 is slidably inserted into the ring 29 of each main rotor 4A and 4A', and a sleeve 33 is fixedly secured at its one end to the supporting plate 34 (see FIG. 14) which is fixed to a cover plate, 13A and 25A, of the housing 1A. Said sleeve 33 is provided with a curved surface 37 which is brought into slidable contact with a surface of the secondary rotor, 5A and 5A'; to be described later on. Said curved surface 37 is provided with a plurality of seal members 40 inserted into a plurality of dovetail grooves 41, just like the foregoing curved surface 36.

In reference to FIGS. 12 and 13, a secondary rotor assembly 61 includes two secondary rotors 5A and 5A' mounted onto the same rotating shaft in parallel and in symmetry.

An opposing end surface of each secondary rotor is provided in the central portion thereof with a ring 49, which is defined to project therefrom and includes a journal 44 and an L-shaped plate 45 connecting said journal. Said journal 44 is to be inserted slidably into the central hole of said end plate 42 and 43. Further, this end surface is provided with a plurality of grooves 46 as well as a plurality of holes 47 so as to inlay and insert seal members and pressing springs therein, just like the end surface of said main rotor 4A and 4A'.

On the inner side of the secondary rotor 5A and 5A', is defined a curved surface 58 for contact with the surface of a sleeve 51 to be described later on. A journal 50 is slidably inserted into a ring 49 of the secondary rotor 5A and 5A'. The sleeve 51, which is fixed at its one end to the cover plate, 13A and 25A, of the housing 1, is provided with a curved surface 52 for slidable contact with the surface of said main rotor, 4A and 4A'.

The respective curved surface, 58 and 52, of said secondary rotor, 5A and 5A', and said sleeve 51 is provided with a dovetail groove 28 and 53 as well as a seal member 54 and 55 inserted therein, just like the curved surface of the main rotor, 4A and 4A', and the sleeve 33.

Each end plate 42 and 43 is cut off so as to not overlap with said end plates 26 and 27, respectively. A groove of circular-arc-shape is defined on the periphery of the end plate and a seal member 56 of circular-arc-shape is inserted in said groove.

Between the end plates 42 and 43 is disposed a gear 22A, which is provided with a square hole 57 for insertion of a hollow square pillar obtained from squarely assembling a pair of L-shaped plates 45 projecting from the ring 49 of the secondary rotors, 5A and 5A'.

FIGS. 14 through 16 show a main rotor assembly and a secondary rotor assembly both of which are accommodated within the housing 1A. The housing 1A is provided with a plurality of dovetail grooves 59 in suitable positions on the inner side surface thereof and a plurality of seal members 48 being pressed outwardly by the force of springs.

So far as this preferred embodiment concerns, the elucidation will be omitted in respect to the operating status in connection with the intake stroke, the compression stroke, the expansion stroke and the exhaust stroke, because they are the same as those of the first preferred embodiment of the present invention. Accordingly, the following elucidation will cover only different points from the first one.

In this preferred embodiment, all the portions of the main rotor, 4A and 4A', as well as the secondary rotor are not constructed integrally, like in the first preferred embodiment. That is, the rotors are constructed with the sleeves 33 and 51 as separate portions.

Once the gas mixture is burst in a gas-working chamber on the side of main chamber 2A for generation of gas pressure, a very large torque is given the rotating shaft 8A of the main rotor 4A and 4A', whereby a larger structural strength is required by the portion to which the main rotor is connected. On the other hand, the rotating shaft of the secondary rotor is given a torque resulting only from compression of the drawn in gas mixture, so that it does not require so large a strength.

Therefore, to satisfy such a requirement as above-mentioned, the main rotor, 4A and 4A', is separated

from the sleeve 33 and is fixedly secured to the rotating shaft 8A' and both main rotors are disposed in symmetry on the opposing sides of a pair of end plates 26 and 27.

As the result, the main rotor, 4A and 4A', the end plates, 26 and 27, the gear 21A, and the rotating shaft 8A can rotate en bloc to provide the required strength for the above-mentioned requirement.

As to the secondary rotor, 5A and 5A', the rotating shaft 9A is provided with only a gear 22A which is incorporated with a pair of opposed L-shaped plates combined together.

In the first preferred embodiment, there is some difficulty in always providing a perfect seal around the boundary of the gas-working chamber. Further fluctuations arise owing to the difference between the masses of the main and the secondary rotors. Accordingly, in this preferred embodiment, a particular effort is made to prevent gas leakage as well as occurrence of fluctuation. Moreover, this preferred embodiment is intended to establish an output as large as could be established by two sets of a rotary engine designed as the first preferred embodiment of the present invention.

With respect to means for preventing gas leakage, it is deemed that the foregoing description could make it clear to some extent for understanding. However, as the foregoing description still has some obscurity, further elucidation will be made as below.

The main rotor, 4A and 4A', rotates on the rotating shaft 8A within the main chamber 2A and 2A' of the housing 1A, meanwhile the end plate, 26 and 27, rotates simultaneously along with the main rotor. Thus, the rotation of said end plate, 26 and 27, is performed within the main chamber and also within the space caused by a portion of the other end plate, 42 and 43, where a sectorial portion thereof is removed. Said end plate, 42 and 43 is positioned non-rotatably within the secondary chamber of the housing and is slidably sustained by the journal 44 of the secondary rotor, 5A and 5A', disposed adjacent thereto.

As the result, the seal member 35 disposed on the periphery of the end plate, 26 and 27, is hindered in its rotation along with the end plate by the projection 62 provided in the cut-away sector of the end plate, 42 and 43, and thereby it slides along the depressed groove so as to stay and adhere closely to the inner wall of the main chamber 2A for sealing thereof. Meanwhile, the seal member 56 disposed on the periphery of the end plate, 42 and 43, stays thereon and adheres closely to the inner side wall of the secondary chamber 3A for sealing thereof.

I claim:

1. A rotary engine, comprising:

first and second rotor means respectively mounted for rotation about first and second parallel axes, each of said rotor means comprising an arcuate sector of selected angular extent so that the sectors of said first and second rotor means complement one another and total approximately 360°;

said first rotor means having the sector thereof defined by a first cylindrical surface which extends through a first arcuate extent, said first cylindrical surface being generated by a first radius defined about said first axis, said sector also being defined by a first curved surface which connects to one end of said first cylindrical surface and extends radially inwardly toward said first axis, said sector being

still further defined by a second curved surface which is connected to the other end of said first cylindrical surface and extends radially inwardly toward said first axis and is interconnected to said first curved surface;

said second rotor means having the sector thereof defined by a second cylindrical surface which extends through a second arcuate extent, said second cylindrical surface being generated by a second radius defined about said second axis, said second radius being equal to said first radius, said sector also being defined by a third curved surface which connects to one end of said second cylindrical surface and extends radially inwardly toward said second axis, said sector being still further defined by a fourth curved surface which is connected to the other end of said second cylindrical surface and extends radially inwardly toward said second axis and is interconnected to said third curved surface;

housing means defining therein a substantially cocoon-shaped chamber, said cocoon-shaped chamber being defined by first and second substantially cylindrical bores which extend parallel to one another, said first and second bores each being defined by a third radius which is substantially equal to said first radius, and the longitudinally extending axes of said bores being spaced apart by a distance less than the diameter of each bore so that the two bores overlap so as to be in open communication with one another;

said housing means including sidewall means surrounding said cocoon-shaped chamber and a pair of end wall means fixed to said sidewall means and closing the opposite ends of said cocoon-shaped chamber;

means rotatably supporting said first and second rotor means in said first and second bores, respectively, whereby the axis of rotation of the respective rotor means is aligned with the longitudinally extending axis of the respective bore;

said first curved surface being generated by providing a disk defined by a radius equal to said first radius, positioning a curve generating line adjacent said disk so that it overlies a reference line on said disk which extends radially outwardly from the center of said disk, said curve generating line having a length equal to said first radius and being positioned to overlie said reference line so that a first point defining the inner end of said generating line is disposed more closely adjacent the center of said disk and a second point defining the outer end of said generating line is disposed more closely adjacent the periphery of said disk, rotating the curve generating line about said second point in a rotational direction which is substantially parallel with said disk and simultaneously therewith rotating the disk about its center in the reverse rotational direction at the same angular velocity as said curve generating line, whereby the first point defines on said disk a curve which extends from said reference line to the periphery of said disk, said curve being the configuration of said first curved surface;

said second curved surface as formed on said first rotor means being a mirror image of said first curved surface;

said third curved surface as formed on said second rotor means being generated in the same manner as

said first curved surface, and said fourth curved surface being the mirror image of said third curved surface;

one of said end wall means having an annular ring-shaped channel formed therein in concentric relationship to said second axis, said ring-shaped channel projecting inwardly from the inner surface of said one end wall means whereby said ring-shaped channel communicates with said cocoon-shaped chamber, said one end wall means having a disk-shaped portion surrounded by said ring-shaped channel and having an end face thereon disposed directly adjacent and opposite to an end face on said second rotor means;

a ring-shaped flow control element fixed to and projecting from one end of said second rotor means and slidably disposed within said ring-shaped channel, said ring-shaped element having an outwardly opening groove formed on the outer periphery thereof and extending angularly along half of said outer periphery, said ring-shaped element further having a flow opening providing communication between said groove and the inner periphery of said element;

said disk-shaped portion having a recess formed in the end face thereof and opening toward said second bore, said disk-shaped portion also having a communication hole formed therein and extending between said recess and the outer periphery of said disk-shaped portion, whereby said opening and said hole intermittently communicate with one another during rotation of said second rotor means; means defining exhaust and intake opening respectively communicating with said first and second bores for permitting discharge of gases from said first bore and supply of gases to said second bore; ignition means associated with said chamber for igniting a combustible gas located therein, said ignition means including an ignition chamber communicating with said first bore and also communicating with said ring-shaped channel, whereby said ignition chamber intermittently communicates with said groove during rotation of said second rotor means; and

means drivably interconnecting said first and second rotor means for synchronous rotation in opposite directions.

2. A rotary engine according to claim 1, wherein the curve generating line is initially positioned to overlie said reference line so that said first point is spaced a selected distance from the center of said disk, said selected distance defining a small radius which is used to generate a small circle about said center, whereby generation of said curve by said first point results in said curve being tangent to said small circle.

3. A rotary engine according to claim 1, wherein said curve generating line comprises one side of an equilateral triangle so that said first and second points respectively define first and second vertexes of said triangle, said equilateral triangle having a third vertex which is initially positioned adjacent the periphery of said disk in spaced relationship to said reference line, and wherein said equilateral triangle is rotated about said second vertex as the center in a direction such that said first vertex is moved radially outwardly away from the center of the disk simultaneous with the movement of said third vertex radially inwardly toward the center of

said disk, whereby said first and third vertexes simultaneously generate identical curves which define said first and second curved surfaces, respectively.

4. A rotary engine according to claim 1, wherein said housing means includes first and second sleeves respectively mounted on said first and second axes and stationarily positioned with respect to said housing means, and said first and second rotor means being respectively rotatably supported on said first and second sleeves, each of said rotor means having an inwardly facing cylindrical surface of limited arcuate extent extending between the radially inner ends of said curved surfaces and disposed in sliding and sealing engagement with the outer peripheral surface of the respective sleeve, the inner cylindrical surface of the rotor means and the outer surface of the sleeve being provided with seal means thereon for slidable sealing contact with the respective cooperating surface.

5. A rotary engine according to claim 1, wherein said first rotor means includes a pair of identical rotor sectors and means fixedly interconnecting same for rotation about said first axis, said pair of sectors being axially spaced from one another and disposed on diametrically opposite sides of said first axis;

said second rotor means including a pair of identical sectors and means fixedly interconnecting same for rotation about said second axis, said pair of rotor sectors being axially spaced from one another and disposed on diametrically opposite sides of said second axis;

each of the rotor sectors of said first rotor means being positioned directly adjacent and rotatably coacting with one of the rotor sectors of said second rotor means.

6. A rotary engine according to claim 5, wherein said means drivably interconnecting said first and second rotor means for synchronous rotation in opposite directions includes gear means positioned axially between the pair of sectors associated with each rotor means.

7. A rotary engine according to claim 5, wherein said housing means includes stationary sleeve means coaxially aligned with each of said first and second axes and positioned so as to be slidably and sealingly engaged by each of said sectors, each of said sectors having an inwardly directed partial cylindrical surface extending between the inner ends of the respective curved surfaces, said inwardly directed cylindrical surface being disposed in sliding engagement with the outer surface of said sleeve means.

8. An engine according to claim 7, wherein said sleeve means has an arcuate recess formed in the outer periphery thereof adapted to slidably receive therein the outer cylindrical periphery of a respective sector during rotation thereof.

9. A rotary engine according to claim 6, wherein said gear means includes first and second gears disposed in meshing engagement with one another, said first gear being positioned axially between the pair of sectors associated with said first rotor means, and said second gear being axially positioned between the pair of sectors associated with said second rotor means;

said first rotor means including a first pair of circular disklike support plates positioned between said pair of rotor sectors and disposed on opposite sides of said first gear for confining same therebetween, said support plates being fixedly connected to said first gear and to said rotor sectors, said support

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plates having a diameter substantially equal to the diameter of said first bore and having seal means on the outer periphery thereof whereby said first pair of support plates are disposed in rotatable sealing engagement with the surrounding wall which defines said first bore; and
a second pair of support plates stationarily disposed within said second bore and sealingly engaging the housing wall defining said second bore, said second pair of plates being disposed axially between the rotor sectors of said second rotor means and being disposed on opposite sides of said second gear to confine same therebetween, said second pair of plates being positioned directly adjacent first pair

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of plates so that each said first plate has a portion of the periphery thereof disposed in rotatable sealing engagement with one of said second plates, and the rotor sectors of said second rotor means having end faces thereon disposed in rotatable sealing engagement with the side faces of said second pair of plates.

10. A rotary engine according to claim 9, wherein the sector associated with said first rotor means extends through an angle of approximately 120°, and wherein the sector associated with said second rotor means extends through an angle of approximately 240°.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,863,609 Dated February 4, 1975

Inventor(s) Yoshio Ikarashi Page 1 of 5

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

Cover sheet should be canceled and substituted to read per attachment. Figs. 6, 10, 13, 14, 15 and 16 should be canceled to read as per attachments.

Signed and Sealed this

Thirtieth Day of November 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

United States Patent [19]

Ikarashi

[11] 3,863,609

[45] Feb. 4, 1975

[54] ROTARY ENGINE

[76] Inventor: **Yoshio Ikarashi**, No. 3-15,
Otemachi 1-chome, Shibata, Japan

[22] Filed: **Sept. 19, 1972**

[21] Appl. No.: **290,343**

[52] U.S. Cl. **123/8.07, 123/8.25, 123/8.43**

[51] Int. Cl. **F02b 53/08**

[58] Field of Search **123/8.43, 8.25, 8.07**

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Primary Examiner—Clarence R. Gordon

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[57] ABSTRACT

A rotary engine comprising both a main and second

dary rotor provided with a rotating shaft defined along the central axis thereof and disposed in such a fashion that either of the semi-cylindrically curved outer surfaces of said two rotors is always kept in contact with the outer surface of the central axis portion of the other rotor; a housing including therein two cylindrical hollow portions with a radius equivalent to that of both rotors so as to accommodate therein said two rotors and thereby having a cross-section of cocoon-shape; a gearing mechanism interconnecting both of the rotating shafts projecting out from the cover plates of the housing; a fuel feeding hole positioned in a portion of the housing where the secondary rotor is accommodated; and an ignition plug as well as a exhaust hole positioned in another portion of the housing where the main rotor is accommodated, said two rotors being obtained from dividing a cylindrical member with a suitable height into two cylindrical members by a vertical plane including the central axis thereof and further from cutting away some portions on the both sides of the central axes of said two members lengthwisely along a specific curve.

10 Claims, 16 Drawing Figures

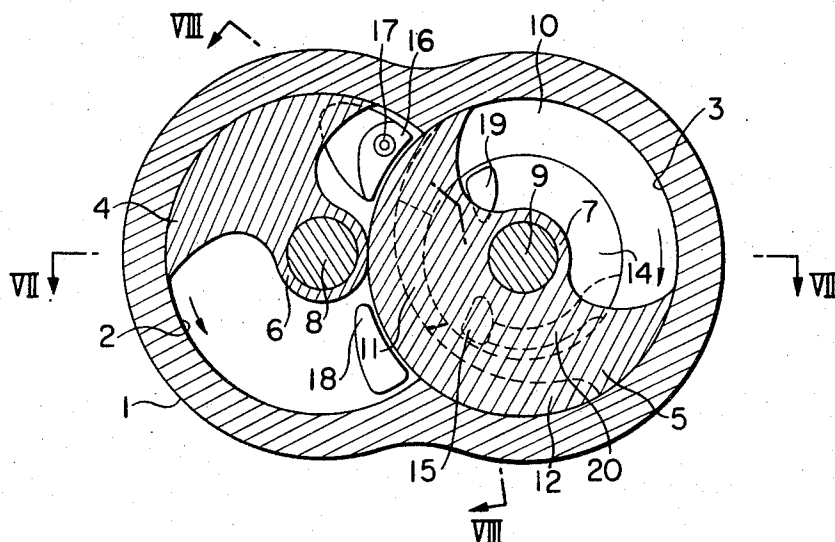


FIG. 6

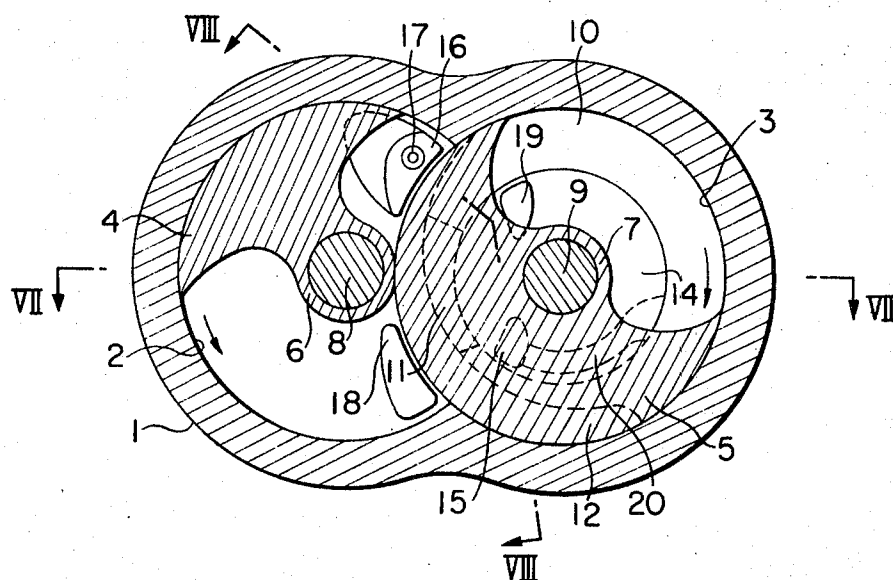


FIG. 10

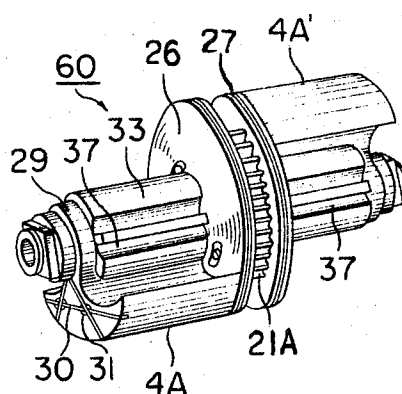


FIG. 13

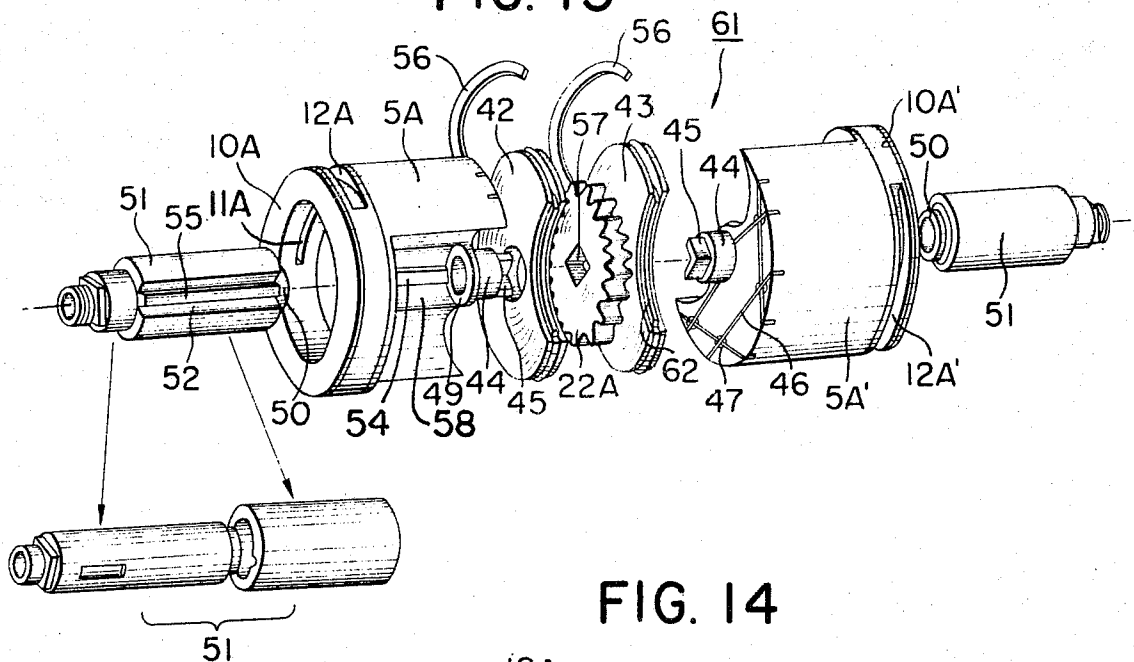


FIG. 14

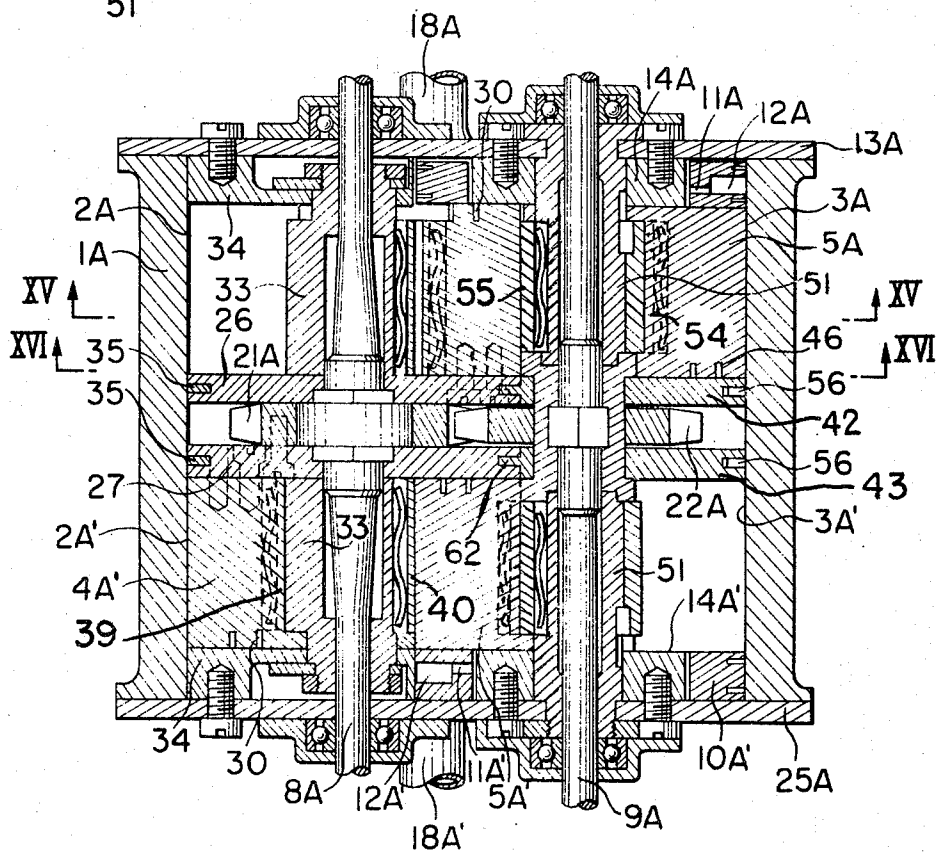


FIG. 15

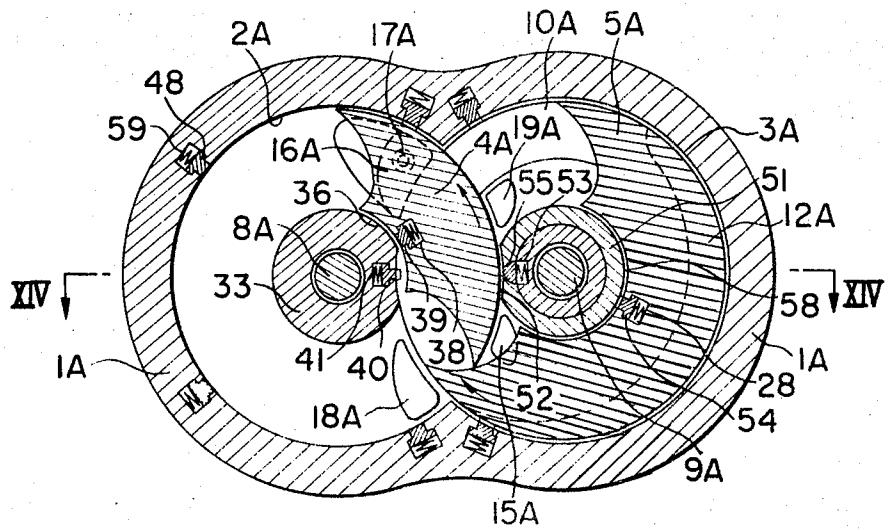


FIG. 16

