United States Patent

Okada

[15] **3,636,930**

[45] **Jan. 25, 1972**

[54] ROTARY ENGINE

[72] Inventor: **Fukumatsu Okada,** 4-151 Aza Umemorizaka, Ohaza Ueda, Tenpaku-cho, Showa-ku, Nagoya, Japan

[22] Filed: **Feb. 3, 1970**

[21] Appl. No.: **8,247**

[30] **Foreign Application Priority Data**

Mar. 28, 1969 Japan.....44/23610

[52] **U.S. Cl.**.....**123/8.45,** 123/8.09, 418/233

[51] **Int. Cl.**.....**F02b 55/14**

[58] **Field of Search** 123/8.13, 8.49, 8.07, 8.45, 123/8.47; 418/233, 265, 195, 196

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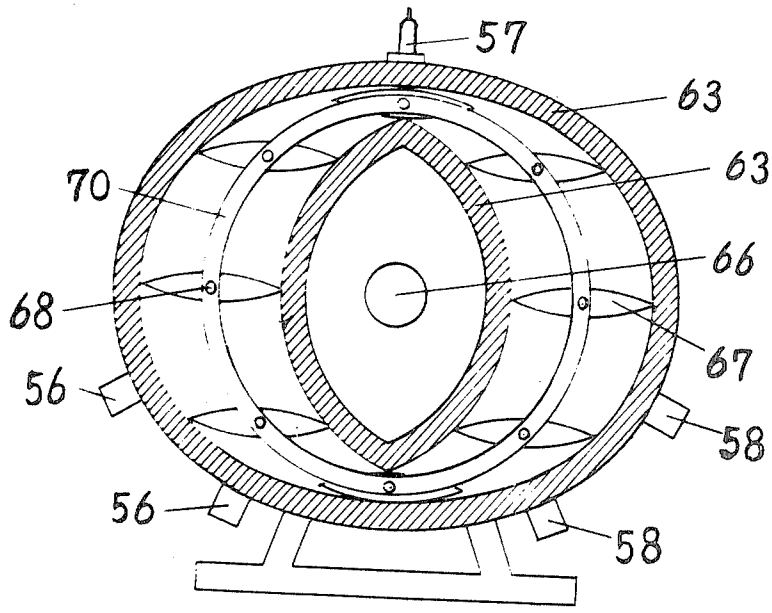
Primary Examiner—Clarence R. Gordon
Attorney—Otto John Munz

[57] **ABSTRACT**

The present invention relates to a rotary engine in which the cylinder is ring shaped and is constructed by an elliptical outer circumferential wall, a leaf-shaped inner circumferential wall, a front wall and rear wall, and the cross section of said cylinder is rectangular and becomes larger at first, smaller next, then larger and smaller at last along the cylinder circumference. Into said ring-shaped cylinder several leaf-shaped pistons are inserted airtightly at equal intervals and the engine has a device to revolve said pistons around the center of said cylinder maintaining their attitudes always in horizontal state. Further the engine has, in the outside of cylinder, the device of connecting the engine output shaft and the piston axes which are fixed to the pistons, whereby the force of explosion gas which acts on the pistons is transmitted smoothly to the output shaft of engine.

6 Claims, 19 Drawing Figures



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SHEET 1 OF 4

FIG. 1

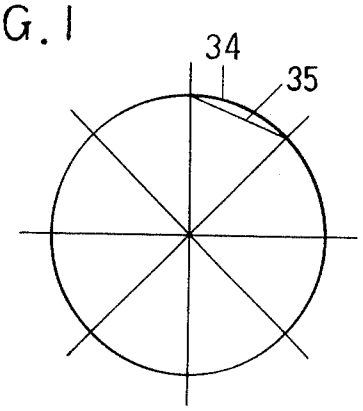

FIG. 2

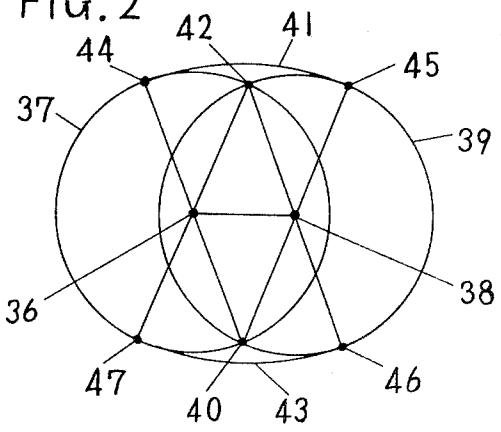

FIG. 3

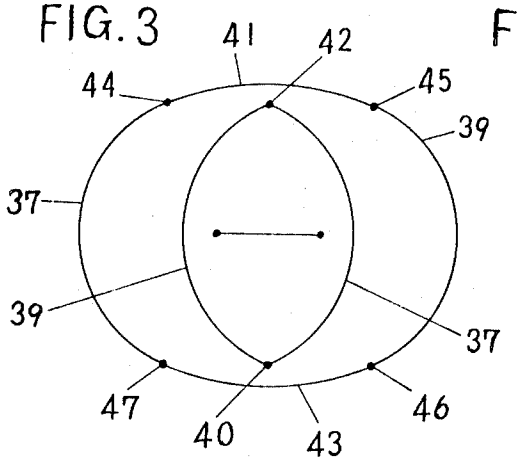

FIG. 4

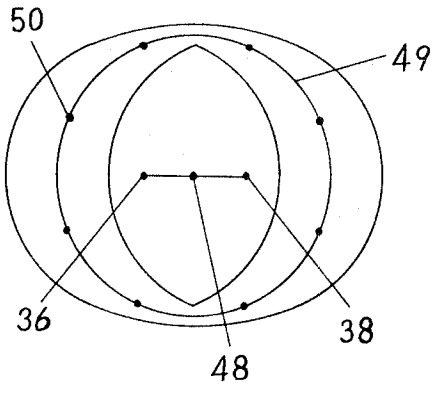

FIG. 5

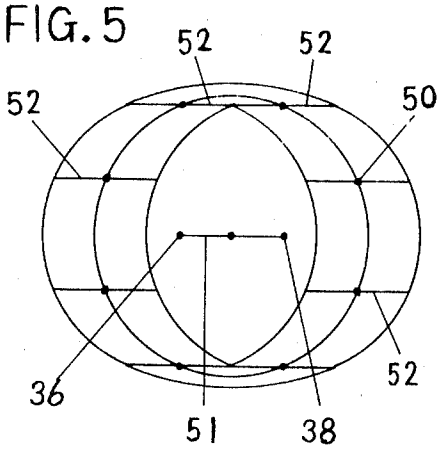

FIG. 6

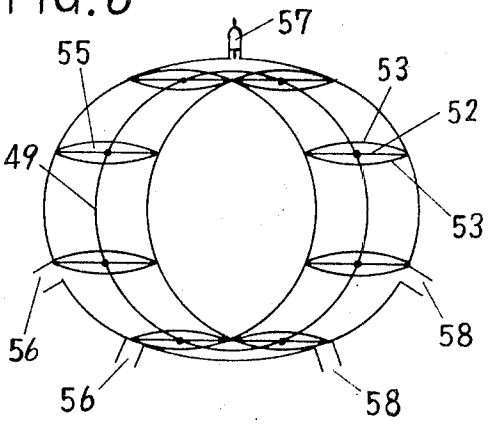

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FIG. 7

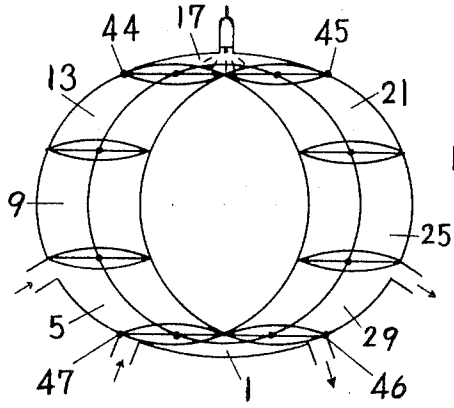

FIG. 8

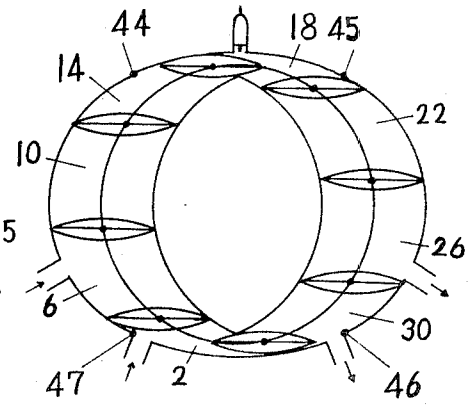

FIG. 10

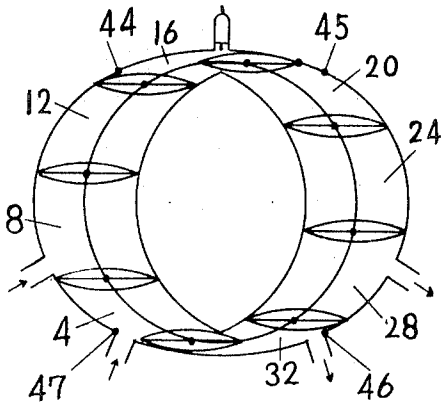

FIG. 9

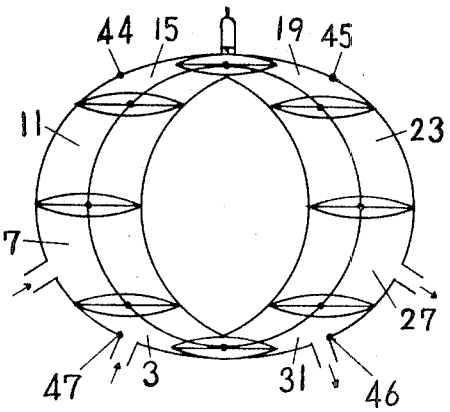

FIG. 11

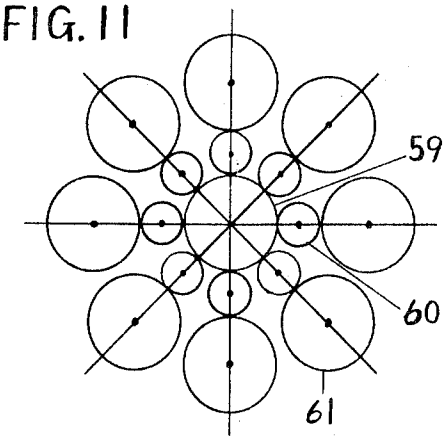

FIG. 12

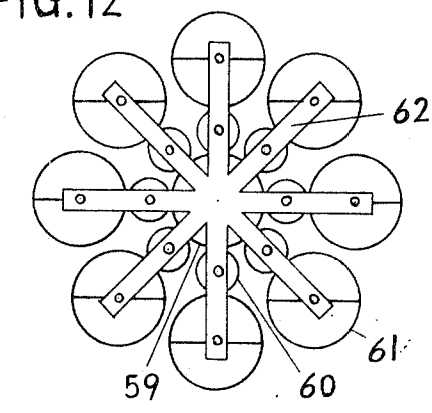

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FIG. 13

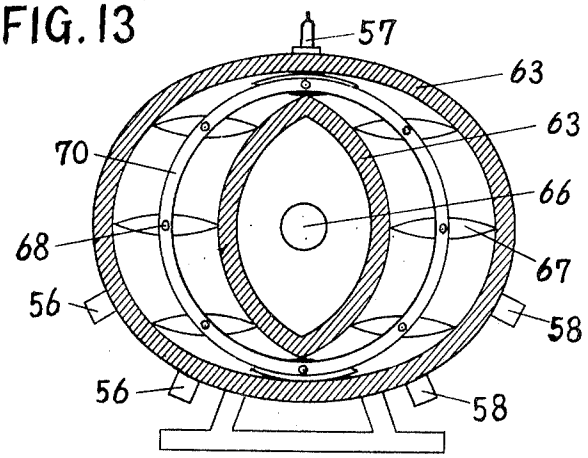

FIG. 14

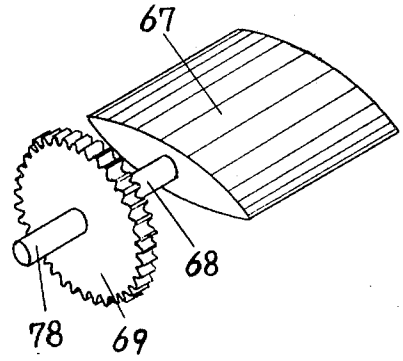

FIG. 15

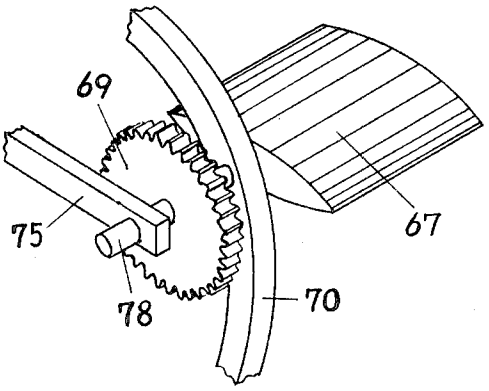

FIG. 16

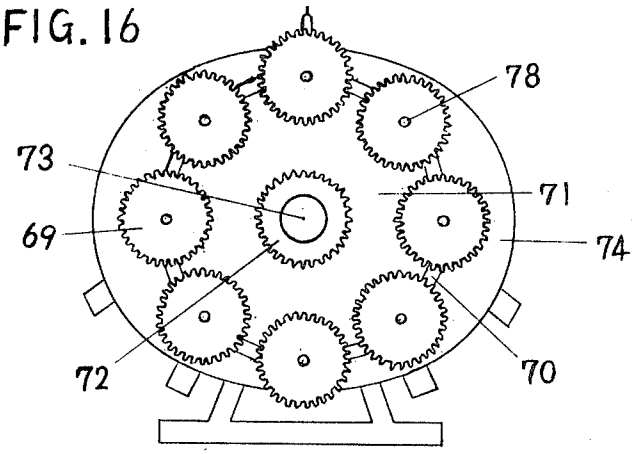

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FIG. 17

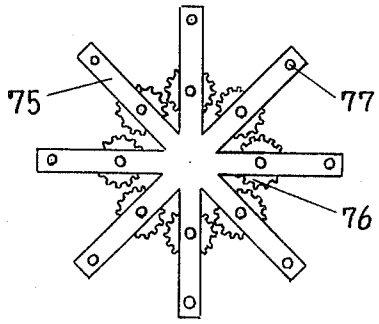


FIG. 18

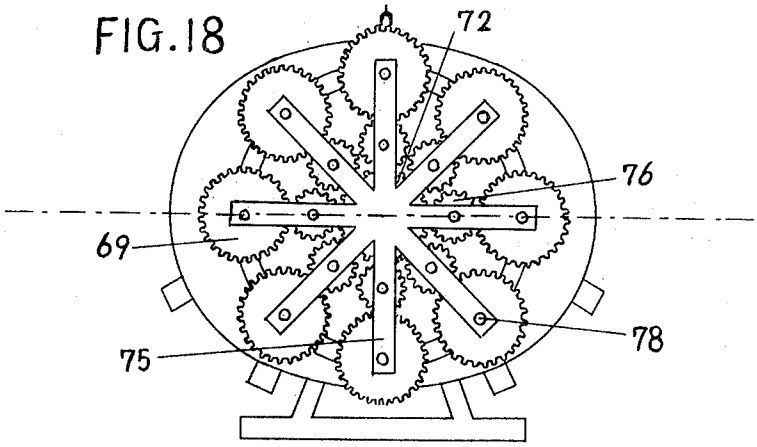
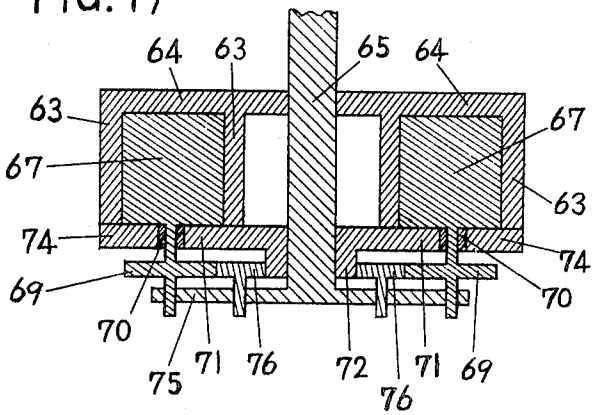


FIG. 19



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ROTARY ENGINE

RELATED APPLICATION

The present application corresponds to an application No. 44–23610 filed Mar. 28, 1969 in Japan.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to a rotary engine which is an internal combustion engine using gasoline and the like, and involves pistons and a cylinder which have special constructions and functions.

In reciprocating engine in which the conventional internal combustion engine is involved, the inertia force of pistons and the like which do not move in circular motion gives a harmful vibration on the engine body in vertical and transverse directions. Especially, the vibration becomes large during high-speed operation of engine. Moreover, this harmful vibration of engine causes the loss of engine energy and the drop of engine efficiency because of capturing vibration energy from engine revolution energy.

The primary object of this invention is to provide a rotary engine which does not involve the above-mentioned defects as seen in the conventional internal combustion engine and makes all of its moving parts engaged in circular motion.

The second object of this invention is to provide a rotary engine which lowers the engine vibration and raises the combustion efficiency as much as possible during engine operation.

The third object of this invention is to provide a rotary engine in which the suction of mixed gas and the discharge of combustion gas are conducted smoothly.

The fourth object of this invention is to provide a rotary engine which improves the airtightness of combustion chamber, revolves the pistons smoothly in the cylinder around the cylinder center and lowers the friction between the pistons and the cylinder during engine operation.

The last object of this invention is to provide a rotary engine which makes smooth the mutual action between its pistons and output shaft and consequently the revolution of output shaft.

The invention will now be described by way of example with reference to the accompanying drawings wherein

FIGS. 1–12 show the principle of this invention and a process of producing this rotary engine;

FIG. 13 is a front view of this engine in which front portion of the engine is removed to show the inner part of this engine;

FIGS. 14 and 15 show mainly the perspective views of piston;

FIG. 16 is a front view of this engine in which some front portion of the engine is removed;

FIG. 17 shows mainly a radial lever of the engine which is fixed to engine output shaft;

FIG. 18 shows a front view of this engine; and

FIG. 19 is a sectional view of the portion defined by a one point dotted line in FIG. 18.

With reference to FIG. 1–12, the principle of this invention will be described.

As shown in FIG. 1, arcs 34, to which chords 35 correspond, are taken to divide a circle 33 in FIG. 1 which has a predetermined radius into several equal parts (in this example a circle is divided into eight equal parts).

FIG. 2 shows that a circle 37, the center of which is 36, has an equal radius to that of said circle 33 of FIG. 1 which is divided into eight equal parts, and a circle 39, the center of which is 38 and which has an equal radius to that of said circle 37, is apart from the circle 37 by the distance of chord 35 shown in FIG. 1. Arc 41 has its center at the point 40 which is one of the intersection points of circles 37 and 39 and its radius is equal to the diameter of circle 37. The arc 41 touches the circles 37 and 39 at the points of tangency 44 and 45 respectively. Similarly arc 43 has its center at the point 42 which is the other intersection point of circles 37 and 39 and its radius is equal to the diameter of circle 37, and it touches

the circles 37 and 39 at the points of tangency 47 and 46 respectively.

As shown in FIG. 3, an elliptical outer circumferential wall is made by the arc 41 between the two contact points 44 and 45, the arc portion of circle 39 between two contact points 45 and 46, the arc 43 between the two contact points 46 and 47 and the arc portion of circle 37 between two contact points 47 and 44. Moreover a leaf-shaped inner circumferential wall is made by two arc portions between the intersection points 40 and 42 of the two circles 37 and 39. Inner wall of the ring-shaped cylinder is made by the inner surface of said elliptical outer circumferential wall and the outer surface of said leaf-shaped inner circumferential wall.

As shown in FIG. 4, points 50 divided the circumference of a circle 49 into eight equal arcs, said circle 49 having an equal radius to that of circle 37 of FIG. 2 and its center 48 at the middle point of the distance 51 of FIG. 4 between the center 36 of circle 37 and the center 38 of circle 39.

As shown in FIG. 5, eight segments of line 52 which pass through said eight points 50 on the circumference of circle 49 respectively are parallel with the segment of line 51 and consequently the length of each segment of line 52 is equal to that of the segment of line 51 and each of said points 50 is the middle center point of each of said segments of line 52 respectively. Hereinafter, any line parallel with the segment of line 51 will be called a horizontal line.

As shown in FIG. 6, a leaf-shaped body 55 in section is formed by two oppositely facing arcs 53, said arc 53 being the same with that which is cut off as a horizontal segment of line 52 from the circle 49. These eight leaf-shaped bodies 55 are called pistons of this engine, which revolve in the ring-shaped cylinder maintaining always equal intervals between themselves and their horizontal attitudes.

Inlets 56 are provided on the portion of ring-shaped cylinder where the cross section of said cylinder becomes larger at first, ignition plugs 57 are installed on the cylinder portion where the cross section of said cylinder becomes smaller at first and outlets 58 are provided on the cylinder portion where the cross section of said cylinder becomes smaller at last.

As shown in FIG. 7, 8, 9 and 10, pistons move in said cylinder keeping both of their ends in touch with the inner surfaces of said cylinder when they are between two contact points 45 and 46 and between two contact points 47 and 44 during their revolution around the center of said cylinder. Moreover, the pistons have a portion of one of their arcs and a portion of the other arc contact the opposite inner surfaces of said cylinder when they are moving between two contact points 44 and 45 and between two contact points 46 and 47. Thus the inner space of said ring-shaped cylinder is divided into eight airtight chambers by the eight pistons and said eight airtight chambers revolve around the center of said cylinder. The volume of each airtight chamber changes as the chamber revolves around the center of said cylinder, for example, an airtight chamber moves from position 1 in FIG. 7 to position 5 in FIG. 7 in said cylinder through position 2 in FIG. 8, position 3 in FIG. 9 and position 4 in FIG. 10. Then the chamber moves from position 5 in FIG. 7 to position 6 in FIG. 8 and finally returns to position 1 in FIG. 7 through position 32 in FIG. 10 and after that this motion is repeated.

The volume of an airtight chamber becomes smaller as the cross-sectional area of said cylinder becomes smaller and becomes larger as that cross-sectional area becomes larger during one complete revolution of the airtight chamber in said ring-shaped cylinder. Consequently the volume of an airtight chamber becomes larger at first, smaller next, then larger and smaller at last during one complete revolution of pistons in said cylinder.

With reference to the accompanying drawings, the gas mixture is sucked through inlets 56 of FIG. 6 into the airtight chamber which is located at the position from 1 to 8 in the cylinder 63 (see FIG. 13), compressed in the airtight chamber at the position from 9 to 17 in FIG. 7, ignited at the position

17, expands in the airtight chamber at the position from 17 to 25 of FIG. 7 and is discharged, through outlets 58 (see FIGS. 6 and 13), from the airtight chamber at the position from 26 (FIG. 8) to 32 (FIG. 10).

This engine conducts the above-described strokes continuously as pistons revolve in the ring-shaped cylinder around the center thereof. Thus this engine is a rotary engine which has a special cylinder and pistons.

As shown in FIG. 11, a circle 59, which will hereinafter be called a fixed circle has an appropriate radius and is surrounded by eight smaller circles of equal diameters provided at equal intervals, which will hereinafter be called secondary circles 60. Eight circles, which will hereinafter be called third circles 61, have the same radius with that of fixed circle 59 and touch the respective secondary circles 60 at the outside thereof and their centers are located respectively on eight radial lines passing the center of fixed circle 59 and the centers of eight secondary circles 60.

I call said fixed circle 59 as fixed gear, said secondary circles 60 as intermediate gears and said third circles 61 as driven gears.

As shown in FIG. 12, the fixed gear is fixed at the center of inner front wall of said ring-shaped cylinder and the driven gears, which are attached rotatably to the arms of radial lever 62 respectively, revolve around the fixed gear through the intermediate gears, which are also attached rotatably to the arms of the radial lever 62 respectively, when said radial lever 62 rotates with engine output shaft.

In that case, each driven gear rotates oppositely against the direction of the rotation of radial lever 62 and its number of rotation is equal to that of radial lever 62. Consequently the horizontal line marked on each driven gear 69 shown in FIG. 16 remains horizontal, and each piston revolves maintaining its horizontal attitude in the ring-shaped cylinder because each shaft 78 (FIG. 16) to which each piston axis 68 (see FIG. 14) is connected in alignment with it holds said driven gear 69 (see FIG. 14) on it.

As shown in FIG. 13, the ring-shaped cylinder 63 is comprised of an elliptical outer circumferential wall, a leaf-shaped inner circumferential wall, a front wall and a rear wall 64; the cross section of said cylinder 63 is rectangular and a hole 66 for mounting the output shaft of the engine is opened at the center of rear wall 64. Moreover, inlets 56, (FIG. 13), ignition plug 57 (FIG. 13) and outlets 58 (FIG. 13) are provided on the cylinder portion at which the sectional area of the cylinder becomes larger at first, smaller next and smaller at last respectively. The pistons 67 which are inserted airtightly into the said cylinder 63 at equal intervals are formed like leaves in section by two oppositely facing arcs and have same breadth with that of the chamber of the said cylinder 63. Eight piston axes 68 and 78, which are fixed to eight pistons respectively, are rotatably mounted respectively in the eight holes made at equal intervals on a rotational ring 70 and fixed to the axes 78 of driven gears 69 in alignment therewith.

A circular inner front wall 71 holds pistons 67 in the ring-shaped cylinder 63 and closes the said cylinder at the inside of rotational ring 70, and has a hole 73, through which the output shaft 65 is rotatably mounted, and mounts a fixed gear 72 having the same number of teeth as driven gears 69 at the boss of its center portion.

The elliptical outer front wall 74 closes the said cylinder at the outside of rotational ring 70 which is inserted airtightly and rotatably into the slit between the inner and outer front walls.

The output shaft 65, which is rotatably mounted in the hole 70 of inner front wall 71 and the hole 66 of rear wall 64, holds a radial lever 62 (FIG. 12) at the outside of said cylinder, which carries eight arms 75 radially extending from its center portion at equal angles. Each arm 75 mounts rotatably an intermediate gear 76 at its middle portion and has a hole 77, in which axis 78 of a driven gear 69 is rotatably mounted, at its end portion. Each driven gear 69 rotates oppositely against the fixed gear 72 with the aid of intermediate gear 76.

In operation, each piston 55 (FIG. 6) always holds its horizontal attitude in the ring-shaped cylinder 63 with the help of fixed gear 72, intermediate gear 76 and driven gear 69 when it revolves around the center of said cylinder 63. In that case, the inner space of said cylinder 63 is divided into eight airtight chambers and the airtightness of the chambers is never lost during engine operation. The volume of each airtight chamber becomes larger at first, smaller next, then larger and smaller at last as it completes one revolution.

Each airtight chamber sucks mixed gas into it through inlet 56 when it grows larger at the first step, then compresses the gas in it when it becomes smaller at the second step, then the gas expands strongly by combustion when said chamber becomes larger at the third step and the exhaust gas is discharged from said chamber through outlets 58 when the chamber becomes smaller at the last step. Thus, in this rotary engine, a stroke of suction, compression, ignition, expansion and discharge of mixed gas is repeated continuously and smoothly and an even torque is generated by the transmission of force acting on each piston to the output shaft of engine through piston axis fixed to the piston and radial lever fixed to output shaft.

The rotary engine of this invention has the following characteristics:

a. The pistons and other parts of the engine revolve in a true circle and the engine hardly vibrates either vertically or laterally. Therefore, the loss of energy due to vibration is minimized, and the engine has an improved combustion efficiency.

b. An even torque is generated on the engine shaft because there exist a plurality of airtight chambers under expansion following the ignition of the engine.

c. As the paths of pistons are defined by rotational ring, it is enough to have the pistons contact softly with the cylinder wall for maintaining airtightness between pistons and cylinder inner wall and the revolution of pistons is very smooth. Consequently, the wear of pistons and cylinder wall is very small.

d. Driven gears which are fixed to the piston axes, and intermediate gears are mounted rotatably on the arms of the radial lever fixed to the output shaft and the driven gears are engaged with the fixed gear which is fixed to the boss of inner front wall of the cylinder, with the aid of said intermediate gears respectively, whereby the force acting on pistons is transmitted smoothly to output shaft of this engine and an even torque is generated on that output shaft.

What I claim is:

1. A rotary engine comprising an elliptically symmetrically ring-shaped cylinder having at least one suction inlet, exhaust outlets and ignition plug; a plurality of pistons which revolve around the center of said cylinder holding their attitude in parallel relation in said cylinder and a device outside of said cylinder which holds said pistons in parallel relation and transmits the force acting on the pistons to output shaft mounted in the center of said cylinder at the outside thereof; wherein said ring-shaped cylinder is comprised of an elliptical outer circumferential wall with a given breadth; a leaf-shaped inner circumferential wall cross-sectionally shaped as opposing intersection segmental arcs of equal radius coaxial with, and having the same breadth as said outer circumferential wall; a front wall and a rear wall parallel with each other and perpendicular to the axis of rotation, the cross section of said cylinder in the plane of rotation being rectangular and its sectional area increases at first, decreases next, then increases, then decreases along the cylinder circumference during a 360° revolution; where in said engine said several pistons which revolve are spaced at equal intervals in said cylinder divide the cylinder into several airtight chambers, are mounted on a rotational ring for them to be held at equal intervals and are shaped like foils in section; inlets are provided on the portion of said cylinder where the cross section of said cylinder increases at first, ignition plugs are mounted on the next decreasing portion of said cylinder and outlets are provided on the portion where the cross section of said cylinder increases again; a radi-

al spider lever carrying arms extending radially at equal angles from its center is fixed to the output shaft at the outside of said cylinder, said output shaft being rotatably mounted on the center portions of front and rear walls, and piston axes with pistons fixed thereto are rotatably mounted on the end portion of said arms respectively, whereby the force acting on said pistons is transmitted smoothly to said output shaft; said front wall having a circular slit, whereby said front wall is divided into an inner front wall and an outer front wall; the front wall of said ring-shaped cylinder journaling said rotational ring in said circular slit airtightly and rotatably and said piston axes passing through said rotational ring at equal intervals and are supported rotatably thereby.

2. A rotary engine as claimed in claim 1,

each of said pistons having a foillike cross section formed by two oppositely facing arcs;

said arcs being of the same radius as the radius locating the axis of rotation of said pistons;

the thickness of said piston being equal to half of the difference between the narrowest width between the inner faces of said elliptical outer circumferential wall of said cylinder and the largest dimension across the high points of the said leaf-shaped inner circumferential wall;

whereby said pistons are capable of a regular circular movement around said shaft of said engine, while maintaining their parallel position in relation to each other and their sliding contact clearance with the inner surfaces of said cylinder.

3. A rotary engine as claimed in claim 1, wherein a fixed gear is fixedly exteriorly mounted to said inner front wall of said cylinder, said piston axes which are rotatably mounted in said rotational ring and on the end portion of arms of said radial lever respectively, said driven gears fixedly mounted on said axis having the same number of teeth as said fixed gear and intermediate gears are mounted rotatably on the arms of said radial lever between the fixed gear and the driven gears, and engage with both the fixed gear and the driven gears, whereby the pistons are held in a parallel position in relation to each other during their revolution in said cylinder, said fixed gear, said intermediate gears and said driven gears forming a planetary gear system.

4. A rotary engine defined in claim 1, wherein the inner circumferential wall forms a leaf-shaped contour formed by the intersection of two circles of same radius.

5. A rotary engine defined in claim 1, wherein the outer circumferential wall forms an elliptical contour which is composed by two arcs of two intersecting circles of same radius and two arcs which touch the two arcs of said two circles and has a radius equal to the diameter of said circles, and the centers of which coincide with the intersection points of said two circles.

6. A rotary engine defined in claim 1, wherein the length of pistons having a leaf-shaped section is equal to the distance between the centers of said two circles and said shape of pistons is formed by two oppositely facing arcs which are cut off from said circle by the chord length which is equal to that of said piston.

* * * * *