Jan. 24, 1967 KENICHI YAMAMOTO ET AL 3,300,127

ROTARY PISTON AND SEAL THEREFOR

Filed Feb. 18, 1965 3 Sheets-Sheet 1

FIG 1

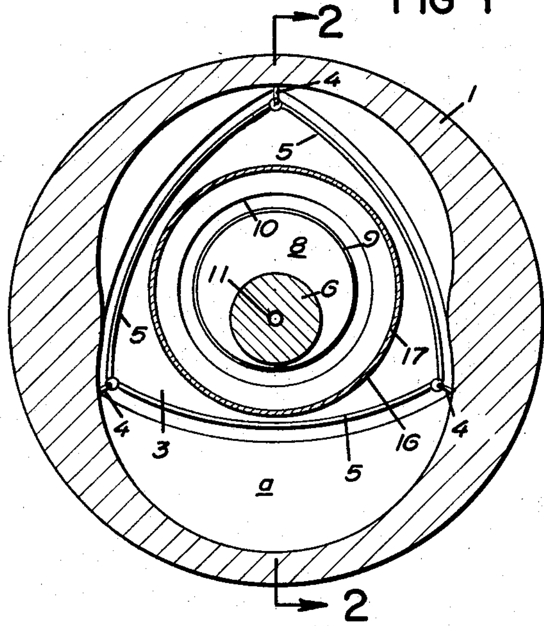


FIG 2

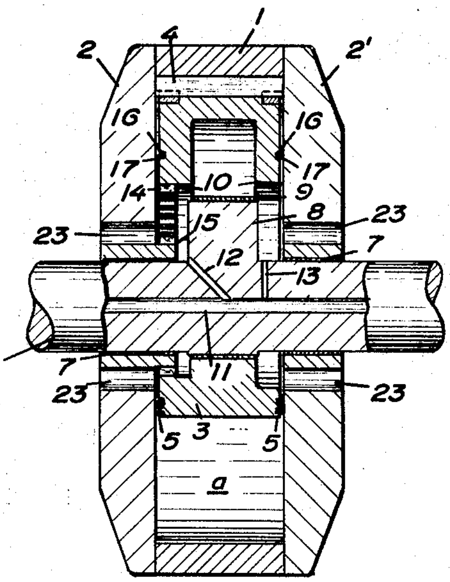


FIG 3

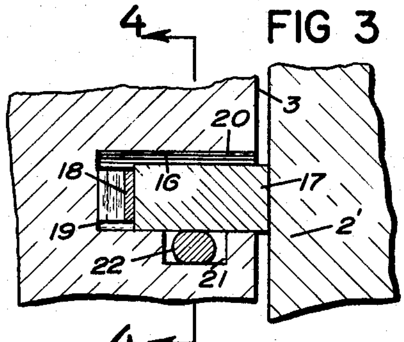


FIG 5

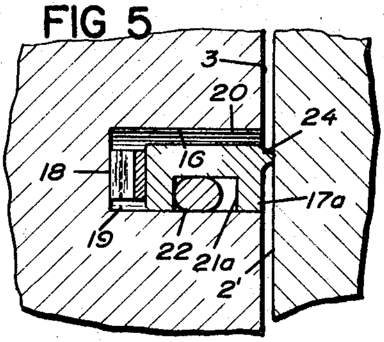
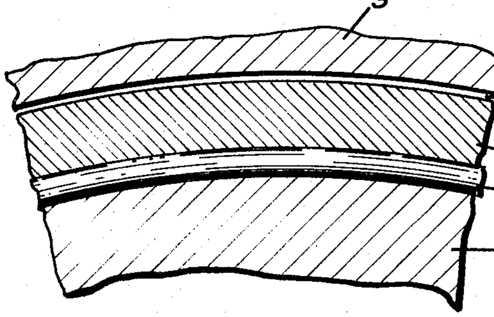


FIG 4



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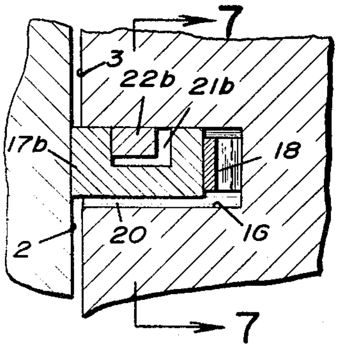

FIG 6

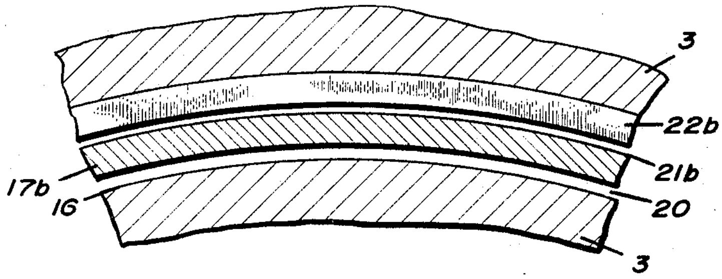

FIG 7

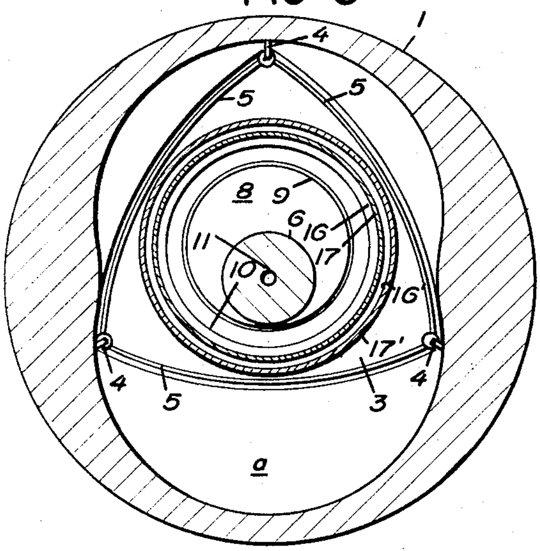

FIG 8

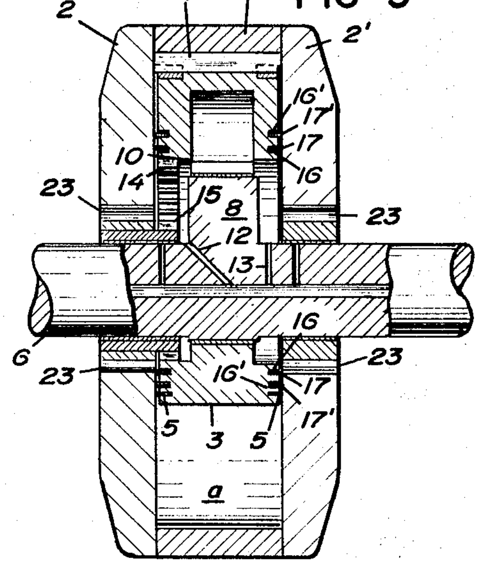

FIG 9

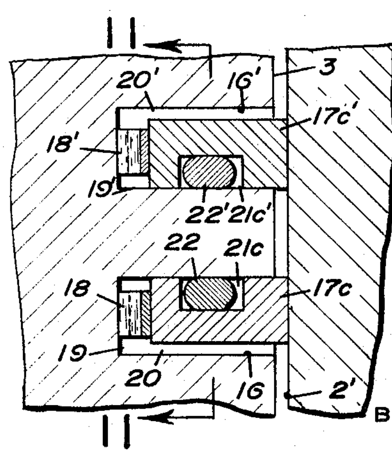

FIG 10

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ROTARY PISTON AND SEAL THEREFOR

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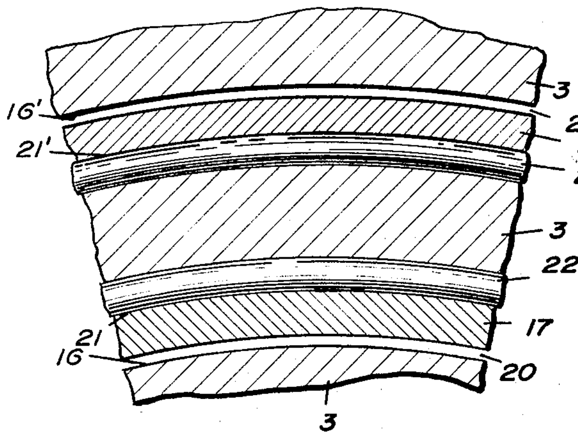


FIG 11

FIG 12

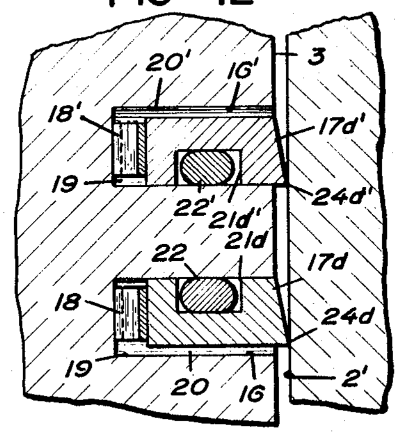
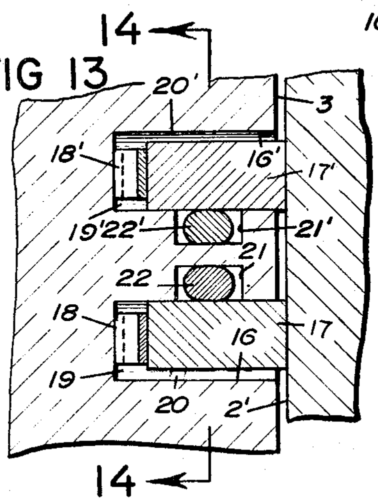


FIG 13



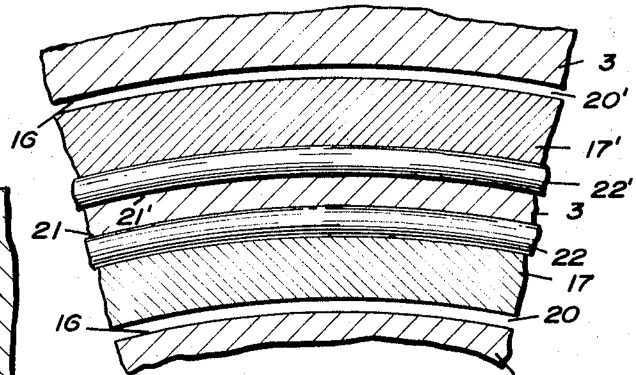


FIG 14

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ROTARY PISTON AND SEAL THEREFOR

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9 Claims. (Cl. 230—145)

The present invention relates to a rotary piston internal combustion engine and particularly to a sealing device for forming a seal between a rotary piston and the end walls of the casing of the engine.

A rotary piston internal combustion engine generally consists of an annular casing having a trochoid-shaped internal peripheral wall and end walls on the opposite ends of the annular casing, which end walls have flat internal faces. A triangular rotary piston is rotatably mounted on a crank pin which is eccentrically mounted on a crankshaft which extends through the center of the combustion chamber defined by the annular casing and the two end walls. At each apex of the rotary piston is a sealing member which forms a seal between the rotary piston and the annular casing and defining combustion chambers between the triangular piston and the trochoid-shaped internal wall of the annular casing. On the flat end face of the triangular piston adjacent the outer edge of the piston is also a sealing member forming a seal between the rotary piston and the end walls of the casing. Cooling of the rotary piston during the operation of the above described engine is carried out by supplying cooling oil through apertures provided around the crank pin within the rotary piston. On the flat faces of the opposite sides of the piston, the apertures through which the cooling oil is supplied, open in the axial direction and surrounding each of the said apertures is an internal sealing ring which also forms a seal between the piston and the side walls of the casing and maintains the cooling oil sealed within the apertures.

The problem in the engine of the above described type is that the leakage of explosive gas past the side seals at the outer edge of the end faces of the rotary piston is inevitable during the operation of the engine, and the inner seal ring surrounding the said cooling oil apertures is affected by the pressure of the leaking explosive gas and deteriorates in its effectiveness as an oil seal. There have been suggestions to install the inner sealing ring around the said cooling oil apertures with a spring means positioned behind the sealing ring within a circular groove on the piston end face to force the sealing ring outwardly against the inner surface of the end walls of the casing, but this arrangement has proved defective for sealing off the cooling oil apertures tightly because the pressure of the leaking gas is very high and the effect of the spring means behind the sealing ring is defeated by the effect of the pressure of the leaking gas during the operation of the engine.

It is an object of the present invention to provide a sealing device for a rotary piston engine which effects an air and oil-tight seal between a rotary piston and the end walls of the casing by utilizing either gas or oil pressure applied thereto.

Another object of the present invention is to form an oil-tight seal between the rotary piston and the end walls of the casing by applying the pressure of the cooling oil for the piston which is due to centrifugal force to the sealing ring, whereby the sealing effect is automatically increased in proportion to the amount of the said centrifugal force.

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Other and further objects of the invention will become apparent from the following specification and claims, taken together with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of a rotary piston engine showing a rotary piston provided with a sealing device according to the present invention;

FIG. 2 is a longitudinal sectional view taken on the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view of a portion of FIG. 2 on an enlarged scale and showing the details of the sealing unit;

FIG. 4 is a fragmentary sectional view taken on line 4—4 of FIG. 3;

FIGS. 5 and 6 are cross-sectional views similar to FIG. 3 and showing modified forms of the sealing device of FIG. 3;

FIG. 7 is a fragmentary sectional view taken on line 7—7 of FIG. 6;

FIGS. 8 and 9 are cross-sectional and longitudinal sectional views, respectively, similar to FIGS. 1 and 2 of a rotary piston engine with a modified sealing device according to the invention;

FIGS. 10, 12 and 13 are fragmentary sectional views similar to FIG. 3 and showing details of modified forms of the sealing unit of FIGS. 8 and 9; and

FIGS. 11 and 14 are fragmentary sectional views taken on the lines **11—11** and **14—14** of FIGS. 10 and 13, respectively.

Referring first to FIGS. 1, 2, 3 and 4, a combustion chamber *a* is defined within an annular casing **1** having an internal peripheral wall which is trochoid-shaped and two end walls **2** and **2′** at the opposite ends of the annular casing. Positioned within the combustion chamber *a* is a triangular rotary piston **3** having a plurality of apexes which are moved along the internal peripheral wall of the center casing **1** during rotation of the piston. At the apexes and along the peripheral side edge between each pair of apexes of the piston are sealing members **4** and **5** which form seals between the piston **3** and internal walls of the annular casing **1** and the end walls **2** and **2′**.

Extending through the center of the combustion chamber *a* is a crankshaft **6** which is rotatably mounted in cylindrical crankshaft bushings **7** fixed in the end walls. Integral with the crankshaft **6** is a crank pin **8** which is eccentrically positioned with respect to the axis of the crankshaft **6**, and which is rotatably positioned within a central axial bore in the piston **3** in a bushing **9** fitted within the said central axial bore of the piston. Extending in opposite directions from the said axial central bore of the piston are circular apertures **10**, which may be somewhat larger in diameter than the said axial central bore and which open against the end walls **2** and **2′**. Extending axially through the crankshaft **6** is a longitudinal bore **11** which is connected with a source of rotary piston cooling oil (not shown) by conventional means, and branch holes **12** and **13** connect the longitudinal bore **11** with apertures **10** within the piston **3** to supply the cooling oil for apertures **10**. Fixed in one circular aperture **10** is an internal gear **14** which meshes with an external gear **15** fixed on the crankshaft bushing **7**.

Surrounding apertures **10** on each end face of the piston **3** are circular grooves **16** within which sealing rings **17** are inserted. Sealing rings **17** are axially slidable within but are fixed against rotation with respect to the circular grooves **16**. Behind the sealing rings **17** within the grooves **16** are circular recesses **19** within which are positioned circular springs **18** urging the sealing rings **17** outwardly against the internal faces of the end walls **2** and **2′**. Between ther adially inwardly facing wall of the grooves **16** and the radially outwardly facing surfaces of the sealing rings **17** are circular passages **20** through which the recesses **19** behind the sealing rings are in communication with the combustion chamber *a* when the outer sealing members **5** permit the combustion gas to leak past the sealing members **5**. In the radially outwardly facing surface of the groove is a circular groove **21** within which is an auxiliary sealing ring **22** in tight sealing engagement between the radially inwardly facing surface of the sealing ring **17** and the bottom of the groove **21**. Numeral **23** designates drain ports in the end walls **2** and **2'** to exhaust cooling oil from the aperture **10**.

The engine is operated in the conventional manner by firing the compressed gas compressed within the chamber *a* by rotation of the triangular piston **3**. Intake of combustible gas and exhausting of the products of combustion is carried out by means of conventional intake and exhaust ports (not shown). Leakage of the compressed gas and products of combustion past the side sealing member **5** causes gas to flow along the gap between the end face of the rotary piston **3** and end walls **2** and **2'** and into the circular passages **20**, and thus into the circular recesses **19**. The pressure of the gas which has thus leaked past the sealing member **5** and reached the recess **19** forces the sealing rings **17** against the internal face of the end walls **2** and **2'**, and increases the sealing effect between the rotary piston and the end walls in proportion to the pressure of the thus leaked gas. Accordingly the sealing rings **17** automatically adjust the sealing effect in proportion to the pressure of the leaking gas which is applied thereto. And because the leaked gas is led along the passage **20** into the recess **19**, concentrated action of the pressure against the contact area between the sealing ring and the end wall, which causes deterioration of the sealing effect, is avoided.

During the operation of the engine, cooling of the rotary piston is carried out by supplying cooling oil to the space within the apertures **10** provided in the rotary piston, from a source of cooling oil (not shown) through the longitudinal bore **11** and the branch holes **12** and **13** in the crankshaft **6**. Depending on the speed of rotation of the rotary piston, the cooling oil supplied to the apertures **10** is affected by the centrifugal force, due to the revolution of the piston **3**, and is forced radially against the circular wall of the apertures **10**. This causes, during the operation of the engine, leaking of the cooling oil past the sealing rings **17**. According to the present invention, the sealing effect between the sealing rings **17** and the end walls of the casing is increased in proportion to the pressure of the gas leaking from the combustion chamber *a*, and the auxiliary sealing ring **22** maintains a tight seal between the radially outwardly facing wall of the grooves **16** and the radially inwardly facing surface of the sealing rings **17**. Thus the leaking of the cooling oil past the sealing ring **17** from the apertures **10** is also entirely prevented.

The springs **18** behind the rings **17** act to compensate the positioning of the rings **17** when wear occurs at the contact face between the rings **17** and the end walls **2** and **2'**.

FIG. 5 shows a modified form of sealing ring **17*a*** which is similar to the sealing ring **17** of FIGS. 1–4 in that it is similarly mounted in a circular groove **16** in the end face of a rotary piston **3** such that a space **20** is left between the radially outwardly facing face of the sealing ring **17*a*** and the radially inwardly facing surface of the groove **16** and a recess **19** is left behind the sealing ring. However, it differs from the sealing ring **17** in that a projecting circular lip **24** is provided on the face of the sealing ring opposed to the internal face of the end walls **2** and **2'** which wipes the oil leaking along the inner face of the end wall off said face of the end wall. In addition, instead of having a circular groove **21** in the radially outwardly facing surface of the groove **16**, a circular groove **21*a*** is provided in the radially inwardly facing surface of the sealing ring **17*a*** in which is positioned an auxiliary sealing ring **22** identical to the sealing ring **22** of the embodiments of FIGS. 1–4, and which functions in the same way. The function of the embodiment of FIG. 5 is the same as that of FIGS. 1–4.

FIGS. 6 and 7 show a modified form of the invention in which structure of the casing, rotor, etc., are the same as in the embodiment of FIGS. 1–4, but in which the sealing ring is modified so that the circular passages **20** are provided between the radially outwardly facing wall of the grooves **16** and the radially inwardly facing surface of the sealing rings **17*b***, so that the circular recesses **19** are in communication with the apertures **10**. The cooling oil under the effect of centrifugal force, which is due to the rotation of the piston **3**, is led along the passages **20** and received within the recesses **19**, and the sealing rings **17*b*** are forced outwardly against the inner face of the end walls by the pressure of the cooling oil, and increase the sealing effect in proportion to the amount of centrifugal force. The auxiliary sealing rings **22*b*** in this modified form are positioned within circular grooves **21*b*** provided on the radially outwardly facing circumferential surface of the sealing rings **17*b*** and maintain a tight seal between the sealing rings **17*b*** and the radially inwardly facing circular wall of the grooves **16**. The groove and auxiliary sealing ring can also be provided in the radially inwardly facing wall of the groove **16**.

FIGS. 8, 9, 10 and 11 show a further modified form of the invention, in which the piston **3** in a motor the same as that shown in FIGS. 1 and 2 has, in addition to the inner circular grooves **16** which surround the apertures **10** and which are provided on both end faces of the piston **3**, additional outer circular grooves **16'** which are positioned radially outwardly of grooves **16** surround the grooves **16**. The sealing ring **17*c*** is provided in the radially inwardly positioned groove and is arranged in a manner similar to the embodiment of FIGS. 6 and 7 so that a circular passage **20** is left between radially outwardly facing wall of the grooves **16** and the radially inwardly facing surface of the sealing rings **17*c***, and the sealing ring **17*c'*** is provided in the outer groove and is arranged in a manner similar to embodiment of FIGS. 3 and 4 so that a passage **20'** is left between the radially inwardly facing wall of the groove **16'** and the radially outwardly facing surface of the sealing ring **17*c'***. Thus the recesses **19** behind the sealing rings **17*c*** are connected with the apertures **10** in the piston **3**, and the recesses **19'** behind the sealing rings **17*c'*** are connected with the combustion chamber *a* through the gap between the outer sealing members **5** and the inner surface of walls **2** and **2'** during operation of the engine. During the operation of this modified embodiment, the cooling oil under the effect of centrifugal force is led along the circular passages **20** from the apertures **10** in the piston **3** and into the recesses **19**, and at the same time the gas leaking from the combustion chamber past the outer sealing member **5** is led along the circular passages **20'** and into the recesses **19'**, and the sealing effect of sealing rings **17*c*** and **17*c'*** is increased with the increasing pressure applied thereto as the speed of the engine increases. If the cooling oil should leak past the rings **17*c***, it will be blocked by the outer sealing rings **17*c'***, and if the gas from the chamber *a* should leak past the outer sealing ring **17*c'***, it will be blocked by the inner sealing ring **17*c***, so that the seal between the piston and the end walls is complete. The auxiliary seal rings **22** are positioned within the grooves **21*c*** provided on the radially outwardly facing circumferential face of the inner sealing rings **17*c*** and effect sealing between the inner sealing rings **17*c*** and the radially inwardly facing circular wall of the grooves **16** similar to the embodiment of FIG. 6. Additional auxiliary sealing rings **22'** are positioned within the grooves **21*c'*** provided on the radially inwardly facing circumferential face of the outer sealing rings **17*c'*** and likewise effect sealing between the outer sealing ring **17c'** and the radially outwardly facing circular wall of the grooves **16'**. The sealing rings **17c** and **17c'** are maintained in contact with the inner face of the end walls by means of springs **18** and **18'** installed behind the sealing rings.

FIG. 12 shows a modified form of the sealing rings **17d** and **17d'** which are each provided with a projecting circular lip **24d** and **24d'** respectively at the point where they contact the inner face of the end wall, whereby the oil leaking along the inner face of the end walls is scraped off by the projecting lips **24d** and **24d'**. FIGS. 13 and 14 also show a modified form of the sealing unit similar to the embodiment of FIG. 4 and in which the auxiliary seal rings **22** and **22'** are installed within circular grooves **21e** and **21e'** which are provided in the walls of the grooves **16** and **16'** and form a seal between the wall of the grooves and the sealing rings.

What is claimed is:

1. A rotary piston and sealing means for a rotary piston internal combustion engine having an annular casing with a trochoidal shaped internal peripheral wall and a crankshaft within said casing for eccentrically rotating a rotary piston within the casing, and the crankshaft having cooling oil bores therethrough for supplying cooling oil to a rotary piston, and the casing having end walls on the ends thereof with substantially flat internal faces, said rotary piston and sealing means comprising a triangular shaped rotary piston having substantially flat end faces adapted to be eccentrically mounted on the crankshaft for rotation within the annular casing, sealing means at the apexes of said rotary piston and along the outer edges of the piston end faces adapted to seal against the internal peripheral wall of the annular casing and the flat internal faces of the end walls for sealing off the combustion chambers and compressing chambers from the space between the end faces of the piston and the end walls, said piston having annular chambers around the crankshaft and opening out of each of the end faces of the piston and adapted to receive cooling oil from the bores in the crankshaft, and said piston having two circular grooves in each end face intermediate the annular oil chamber and the sealing means, said grooves each being defined by opposed radially facing surfaces and a laterally facing bottom surface, a sealing ring in each said circular groove, the sealing ring in the outermost circular groove being in sealing engagement with the outwardly radially facing surface of said groove and being spaced from the inwardly radially facing surface and bottom surface of said outermost groove, and the sealing ring in the innermost circular groove being in sealing engagement with the inwardly radially facing surface of said groove and being spaced from the outwardly radially facing surface and bottom surface of said innermost groove, and spring means in each of the spaces between the circular sealing rings and the bottom surfaces of said grooves and urging said rings out of said grooves against the internal face of the end wall adjacent the end face of the piston.

2. A rotary piston and sealing means as claimed in claim **1** in which there is an auxiliary groove in one of the radially facing surfaces of each of the sealing rings and grooves which are in sealing engagement, and an auxiliary sealing ring in each auxiliary groove for providing the sealing engagement between the groove face and the sealing ring face.

3. A rotary piston and sealing means as claimed in claim **2** in which the auxiliary grooves are in the sealing rings.

4. A rotary piston and sealing means as claimed in claim **2** in which the auxiliary grooves are in the radially facing surfaces of the grooves.

5. A rotary piston and sealing means as claimed in claim **1** in which each sealing ring has a projection on the face thereof opposed to the internal face of the end wall for engagement with the end wall.

6. A rotary piston and oil sealing means for a rotary piston internal combustion engine having an annular casing with a trochoidal shaped internal peripheral wall; a crankshaft rotatably supported within said casing and having a crank pin portion located in the said casing; said crankshaft having cooling oil bores therethrough for supplying cooling oil to a rotary piston; a triangular rotary piston having substantially flat end faces and eccentrically rotatably journaled on the said crank pin portion; sealing means at the apexes of said rotary piston and along the outer edges of the piston end faces sealingly defining working chambers between the casing and the rotary piston; and said rotary piston having annular chambers around the crankshaft and opening out of each of the end faces of the piston and into which said oil bores open to receive cooling oil from said bores; said rotary piston and oil seal means comprising at least one circular groove in each end face of the rotary piston intermediate the annular cooling oil chamber and the sealing means; each circular groove being defined by spaced opposed radially facing surfaces which are parallel and coaxial and a laterally facing bottom surface; a wear-resistant and substantially rectangular cross-section metal oil seal ring axially slidably inserted within each of the said circular grooves; a wave spring means disposed in the space between each sealing ring and the bottom face of the groove so that the said sealing ring is urged axially out of the groove and resiliently and sealingly engaged with the internal face of the end wall; and said sealing ring being in sealing engagement with the radially inwardly facing surface of said circular groove and spaced from the radially outwardly facing surface of said groove and from the bottom surface of the groove, whereby cooling oil under pressure can pass between the sealing ring and the radially outwardly facing surface of said circular groove and act on the sealing ring in combination with the said wave spring to urge it against the inner face of the end wall so that the sealing effect is increased responsive to the oil pressure applied thereto; one of the radially facing surfaces of the sealing ring and theg roove which are in sealing engagement having an auxiliary annular groove therein; and an auxiliary sealing ring in each auxiliary annular groove for assuring sealing engagement of the radially inwardly facing surface of the circular groove with the sealing ring.

7. A rotary piston and oil sealing means as claimed in claim **6** in which the auxiliary annular groove is in the radially outwardly facing surface of the sealing ring.

8. A rotary piston and oil sealing means as claimed in claim **6** in which the auxiliary annular groove is in the radially inwardly facing surface of the groove.

9. A rotary piston and oil sealing means as claimed in claim **6** in which the sealing ring has a projection on the face thereof opposed to the internal face of the end wall for engagement with the end wall.

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