Feb. 7, 1967 YASUO TATSUTOMI 3,302,624

ROTARY PISTON AND COOLING MEANS THEREFOR

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Fig. 3

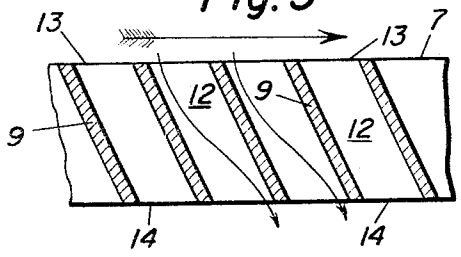


Fig. 1

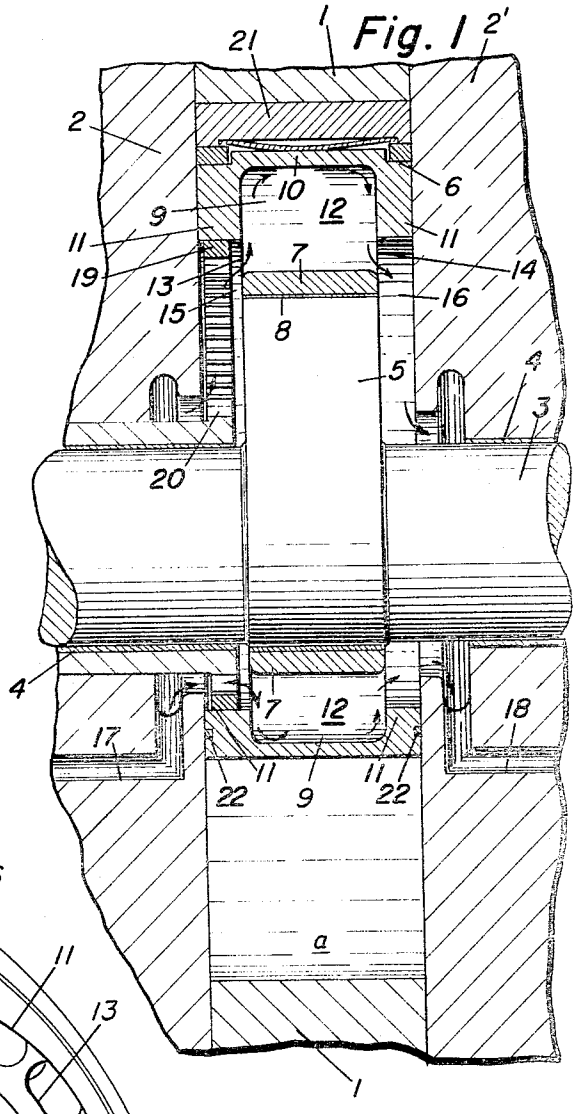
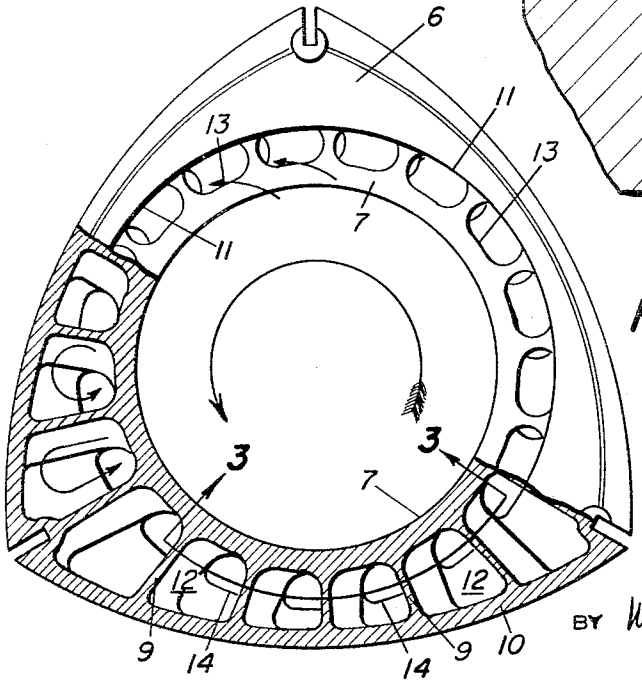


Fig. 2



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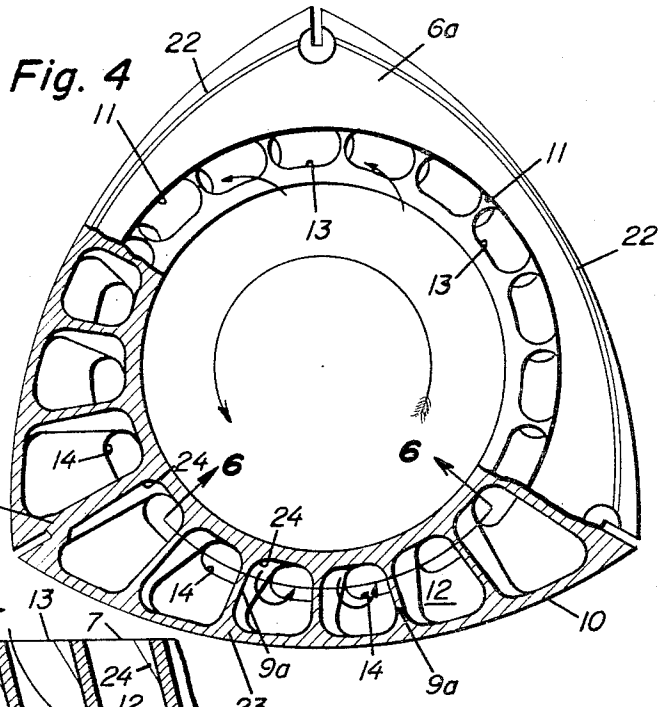
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Fig. 4



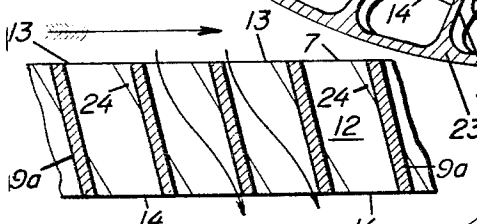
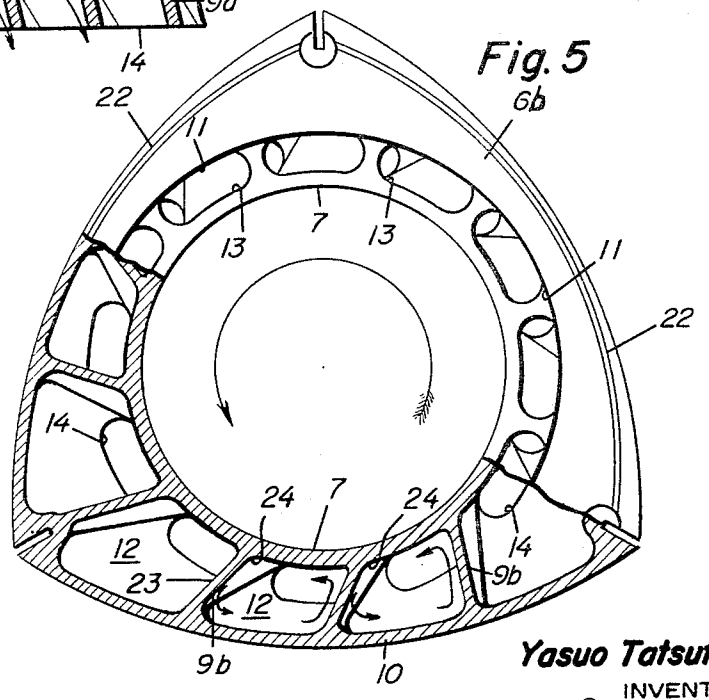


Fig. 6

Fig. 5



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ROTARY PISTON AND COOLING MEANS THEREFOR

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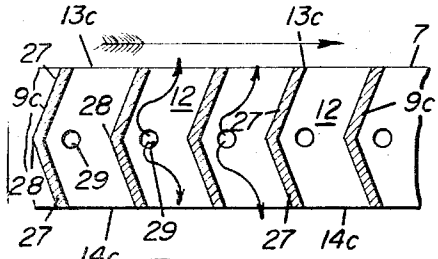


Fig. 9

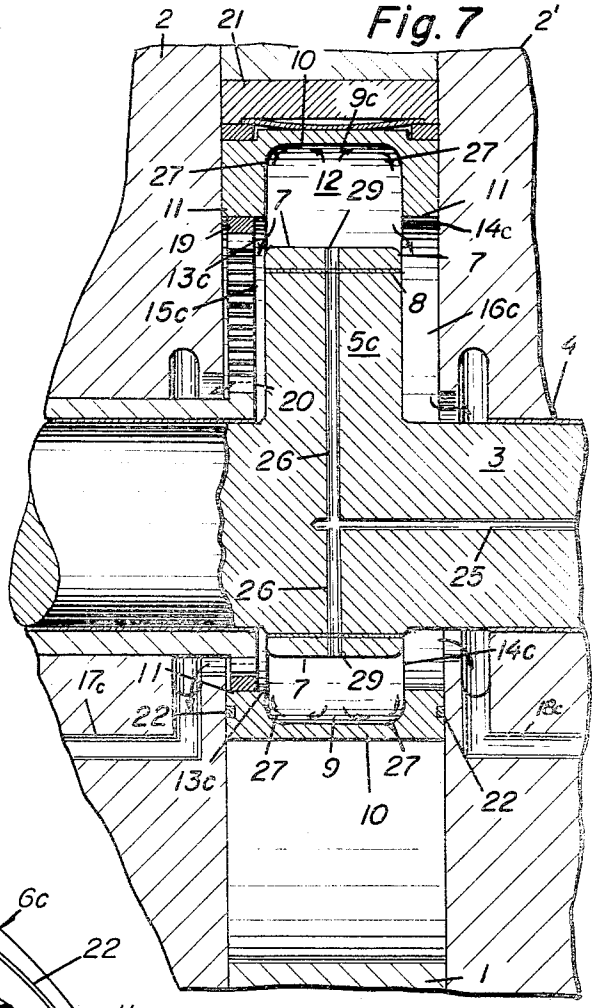
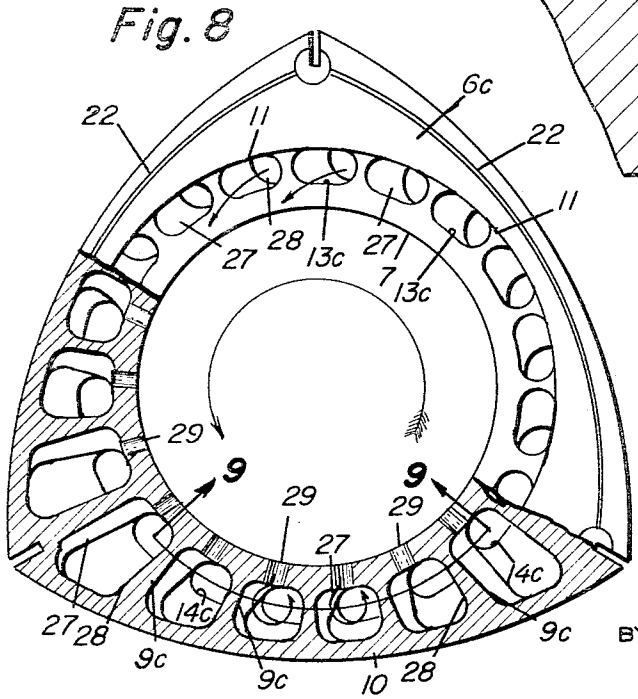


Fig. 7

Fig. 8



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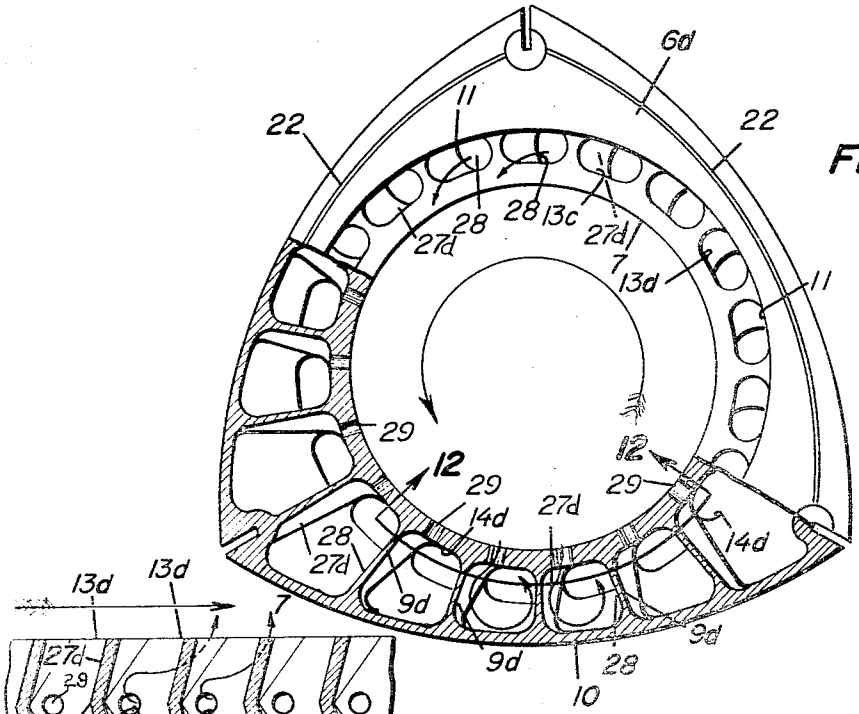


Fig. 10

Fig. 12

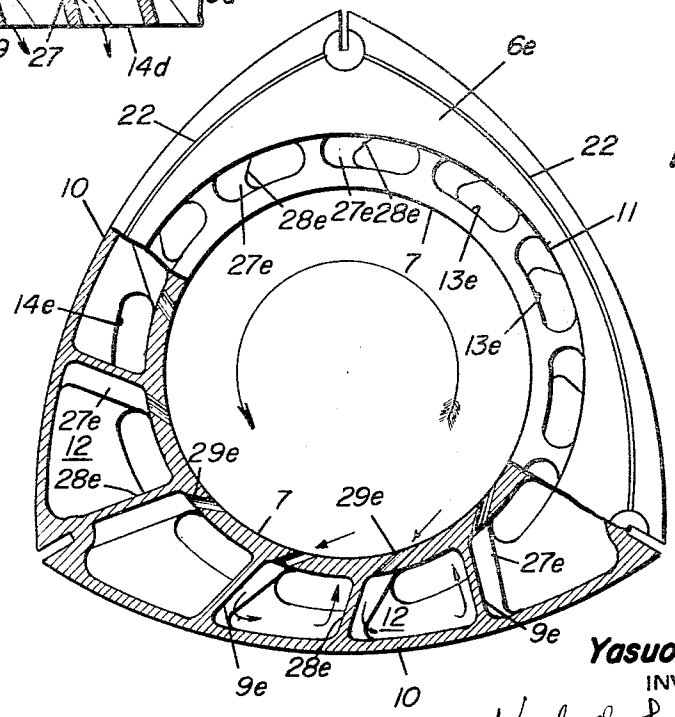


Fig. 11

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United States Patent Office

3,302,624
Patented Feb. 7, 1967

3,302,624
ROTARY PISTON AND COOLING MEANS THEREFOR

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Filed June 22, 1965, Ser. No. 465,845
Claims priority, application Japan, June 24, 1964, 39/35,909; July 21, 1964, 39/41,611, 39/41,612, 39/41,613
7 Claims. (Cl. 123—8)

The present invention relates to a rotary piston internal combustion engine and particularly to a cooling means for cooling the rotary piston thereof by the circulation of the cooling fluid within the piston of the engine.

Generally a rotary piston internal combustion engine comprises a polygonally shaped rotary piston eccentrically rotating within a combustion chamber defined by an annular center casing having a trochoidal shaped internal peripheral wall and end walls on the opposite ends of the annular casing, so as to thereby effect intake, compression of combustible gas for firing within the combustion chamber and exhausting of the product of combustion therefrom. The power is transmitted through a crankshaft which extends through the center of the combustion chamber and the end walls and has the rotary piston eccentrically rotatably mounted on a crank pin eccentrically mounted on the crankshaft. Cooling of the rotary piston during the operation of the above described engine is carried out by supplying cooling fluid to chambers provided within the piston. However, due to the above mentioned specific structure of the engine, exhausting of the fluid from the chambers in the piston must be in the lateral direction though the fluid is under the effect of the centrifugal force due to the rotation of the piston. This causes an impediment to the circulation of the fluid and causes a deterioration of the cooling effect because of the stagnation of the fluid. In view of this problem it has been suggested to provide additional equipment within the fluid chamber in the piston to facilitate exhausting of the fluid, but such a device has proved impractical for the engine because the structure of the device is relatively complicated and causes an increase in the cost of the engine.

An object of the present invention is to provide a simple structural and efficient functional cooling device for the rotary piston of the engine just described.

Another object of the invention is to provide a cooling device for the piston of the above described engine which performs cooling by circulation of cooling fluid by the action of alternate acceleration and deceleration of the rotational velocity of the rotary piston.

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 longitudinal sectional view of a rotary piston internal combustion engine according to the present invention;

FIG. 2 is an elevation view, partly in section, of a rotary piston showing the cooling fluid guides provided therein;

FIG. 3 is a fragmentary sectional view taken on the line 3—3 of FIG. 2;

FIGS. 4 and 5 are elevation views, partly in section, of the rotary piston similar to FIG. 2 with modified forms of cooling fluid guides;

FIG. 6 is a fragmentary sectional view taken on the line 6—6 of FIG. 4;

FIG. 7 is a longitudinal sectional view similar to FIG. 1 of a rotary piston engine with a modified cooling fluid circulation system;

FIG. 8 is an elevation view, partly in section, of the rotary piston of FIG. 7;

FIG. 9 is a fragmentary sectional view taken on the line 9—9 of FIG. 8;

FIGS. 10 and 11 are elevation views, partly in section, of a rotary piston similar to FIG. 8 with modified forms of the cooling fluid guides; and

FIG. 12 is a fragmentary sectional view taken on the line 12—12 of FIG. 10.

Referring first to FIGS. 1, 2 and 3, 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 thereof. Extending through the center of the combustion chamber *a* is a crankshaft 3. Essentrically rotatable positions within the crankshaft bushings 4 fixed in the end walls 2 and 2′. Integral with the crankshaft 3 is a crank pin 5 which is eccentrically positioned with respect to the axis of the crankshaft 3. Essentrically rotatable positions within the chamber *a* is a triangular rotary piston 6 having an axial bearing boss 7 concentrically positioned therein. Within said bearing boss 7 the crank pin 5 of the crankshaft 3 is rotatably inserted in a bushing 8 fixed in the boss 7 so as to thereby support the rotary piston eccentrically and rotatably. Extending radially outwardly from the bearing boss 7 are vane-shaped cooling fluid guides 9 which are disposed at an angle to a radial plane through the axis of rotation and at properly spaced intervals around the outer peripheral face of the bearing boss 7. Radially outwardly spaced from the boss 7 and surrounding the radially outer ends of the guides 9 is an annular peripheral wall 10 having a radially inwardly extending brim 11 at the opposite ends thereof for closing the fluid chambers 12 which are radially and obliquely laterally divided by the guides 9 extending between the boss 7 and the wall 10, leaving and radially inward corner openings 13 and 14 in the chambers 12 at the opposite ends thereof. It will be noted that the corner openings 13 at one end of the chambers are offset backwardly relative to the rotational direction from the openings 14 at other end thereof, and the cooling fluid is supplied from said backwardly offset openings 13 and exhausted from the forwardly offset openings 14 by the effect of the deceleration of the rotational velocity of the piston as explained later. The bearing boss 7, fluid guides 9, peripheral wall 10 and brim 11 will preferably being formed integrally with the rotary piston 6.

Encircled by the brim 11 and opening in the opposite direction at the opposite ends of the piston are circular apertures 15 and 16 into which the corner openings 13 and 14 open laterally so that the fluid chambers 12 are connected with the apertures 15 and 16. Provided within the end walls 2 and 2′ are fluid holes 17 and 18 respectively connected to the apertures 15 and 16 and adapted to supply and exhaust cooling fluid to and from the fluid chambers as described later. Fixed in the circular aperture 15 is an internal gear 19 concentric with the piston and which meshes with an external gear 20 which is concentric with the crankshaft 3 and fixed to the end wall 2 so as to thereby effect the regulation of

the rotation of the piston. Numeral 21 designates seals between apexes of the piston and the internal peripheral face of the annular casing 1 and numeral 22 designates seals between each end face of the piston and the internal face of the end walls 2 and 2'.

The engine is operated in the conventional manner by firing the compressed gas compressed within the chamber *a* by the effect of the eccentric rotation of the triangular piston 6. Intake of combustible gas and exhausting of the products of combustion is carried out by means of conventional intake and exhaust ports (not shown). As the circulation of the cooling fluid within chambers 12 is performed by the effect of the deceleration of the rotational velocity of the piston and the inclination of the guides 9 on the boss 7, as described later, the supply of cooling fluid must come from the side towards which the fluid guides 9 are backwardly inclined with respect to the rotation direction of the piston and, through corner openings likewise backwardly offset. Therefore, according to the embodiment shown in FIG. 1, cooling fluid is supplied from a source of fluid (not shown) by conventional means through the hole 17 and received through the aperture 15, into which the fluid is drawn by the centrifugal force due to the rotation of the rotary piston and urged to flow into the chambers 12 through corner openings 13. With the rotation of the rotary piston 6 the crank pin 5 being eccentric to the crankshaft 3 and with the crank pin 5 rotatably positioned within the bearing boss 7, the piston 6 rotates eccentrically and transmission of the rotation movement of the rotary piston is transmitted through the crankshaft 3.

Due to the eccentric rotation of the triangular piston and the trochoidal internal face of the casing 1 along which the apexes of the piston move, the rotational velocity of each apex of the piston is subject to alternate acceleration and deceleration dependent on the curvature of the trochoidal face and the radial distance from the eccentric rotation center of the piston and because the eccentric rotation of the piston is effected by the internal gear 19 which meshes with the external gear 20 and rotates eccentrically around said gear 20, acceleration and deceleration of the rotational velocity of the apexes takes place at spaced time intervals in rotational order at all of the apexes according to the rotation of the piston. With above described rotation movement of the piston the centrifugal force due to such rotation is also locally increased and decreased in rotational order. It will be noted therefore, that the action of the above described rotational velocity of the piston and the centrifugal force act on the cooling fluid within each chamber 12 to cause a vortical current in the rotational direction of the piston as shown by the arrows in FIG. 2. This vortical current acts to prevent the stagnation of the fluid and causes the fluid to flow into every corner of the chambers. Assuming now that the peripheral velocity of the piston decelerates at some local portions of the piston during the rotation thereof, the cooling fluid under the effect of the inertia within the chamber 12 is compelled to flow along the guides 9 due to the inclination thereof as shown in FIG. 3 and is exhausted laterally into the circular aperture 16 through the corner openings 14. Such specific local portions at which the rotation velocity decelerates shift along the periphery of the piston during the rotation of the piston, and exhausting of the fluid from all of the chambers 12 is performed in rotational order during the rotation of the piston. The exhausted fluid in the aperture 16 is conveyed away through the fluid hole 18 in the end wall 2'.

According to the present invention the circulation of the cooling fluid through the rotary piston is automatically carried out by the effect of the eccentric rotation of the rotary piston and, since the flow of the fluid is along the inclined guides 9, circulation of the fluid is facilitated and promotes the cooling of the rotor without stagnation of the fluid. Leakage of the fluid between

the opposite ends of the rotary piston and the internal face of the end walls 2 and 2' is blocked by the seals 24.

FIGS. 4 and 6 show a modified form of the piston 6*a* which is similarly mounted on the crank pin 5 within the combustion chamber *a* as shown in FIG. 1. The structure of the bearing boss 7, peripheral wall 10, brim 11 and corner openings 13 and 14 are the same as in the embodiment of FIGS. 1, 2 and 3. Guides 9*a* are also similar to the guides 9 of FIGS. 1 through 3 in that they extend radially outwardly from the bearing boss 7 to the peripheral wall 10 and are disposed obliquely laterally at properly spaced intervals around the outer peripheral face of the boss 7. But they differ from the guides 9 in that each of the guides 9*a* has the radial outer portion 23 twisted with respect to its radial inner portion 24 as in a propeller blade According to this modification the cooling fluid supplied to the fluid chamber 12 is further activated to produce a vortical current by the effect of the twisted curvature of the guide face and which twisted curvature gives the fluid flowing in the exhausting direction a rotational component about the direction of flow. Thereby the circulation of the cooling fluid through the chamber 12 is further facilitated and the partial stagnation of the fluid at the corner of each chamber 12 is avoided.

FIG. 5 shows a further modified form of the rotary piston 6*b* which is the same as shown in FIGS. 1 through 6 except for guides 9*b*. The guides 9*b* are similar to the guides 9*a* of FIGS. 4 and 6 in that they extend radially outwardly from the bearing boss 7 to the peripheral wall 10 and are disposed obliquely laterally at properly spaced intervals around the peripheral face of the boss 7 and also have the radially outer portion 23 twisted with respect to the radially inner portion 24. But they are different from the guides 9*a* of FIGS. 4 and 6 in that the guides 9*b* are inclined in a counter rotational direction of the piston in the form of a backward curved vane. In this modification, when the rotational velocity of the piston decelerates, the fluid within each chamber 12 is affected by the inertia and is guided along the back face of the guides 9*b* without vertical collision therewith because of backward inclination of the guides. The fluid led along said backwardly inclined guide 9*b* is inevitably caused to flow laterally and radially inwardly when the deceleration of the rotational velocity of the piston occurs, and thereby smooth exhausting of the fluid from the corner openings 14 and in a tangential direction with respect to the boss 7 is performed.

Due to the polygonal shape of the rotary piston and its eccentric rotational movement along the trochoidal curve of the inner face of the center casing, cooling fluid within each chamber 12 is affected by the respectively different rotational velocity of the chambers of the piston and the centrifugal force caused thereby and the fluid flows in a different speed and direction within each chamber. In view of this fact the angle of inclination, twisting, etc. of the respective guides will differ so that the most effective fluid circulation condition in each chamber is obtained. Also, in determining the said angle of inclination, twisting, etc. of the guides, viscosity, flow speed, spreading condition of the cooling fluid within chambers and the number of fluid chambers, engine capacity, etc. will be taken into consideration.

The construction shown in FIGS. 7, 8 and 9 is another modification of the invention in which the structure of the annular center casing, end walls, crankshaft, crank pin, rotary piston, internal and external gears, etc. are the same as in the embodiment of FIGS. 1 through 6, but it differs from that shown in FIGS. 1 through 6 in the delivery and the circulation system for the cooling fluid. That is, a crankshaft 3 is provided with a longitudinal center bore 25 which is connected to a source of fluid (not shown). Formed within a crank pin 5*c* are branched radial bores 26 commonly connected with the center bore

25 and extending radially outwardly through a middle portion thereof. Fluid guides 9c are likewise disposed between the bearing boss 7 and the peripheral wall 10 as described with respect to the embodiment shown in FIGS. 1 through 3, but they are different from that of FIGS. 1 through 3 in that they are V-shape in cross section and are disposed so that each inclined blade 27 is inclined respectively in the opposite direction from a center peak 28 and laterally forwardly with respect to the rotational direction of the piston 6c. Extending radially through the bearing boss 7 and the bushing 8 of the piston 6c are fluid ports 29 opening into each fluid chamber 12 at a portion adjacent the center bottom corner of the V-shaped guides. Said fluid ports 29 are connected with the branched radial bores 26 so that at a properly timed interval when the crank pin 5c rotates with respect to the pitson 6c within the boss 7 during rotation of the piston, the cooling fluid is delivered through the ports 29 to each fluid chamber 12 during the operation of the engine. At the opposite ends of the chamber 12 adjacent the bearing boss 7 are laterally opening corner openings 13c and 14c which are the same as those shown in FIGS. 1 through 6 but they are adapted, in this modified embodiment, for exhausting fluid from the chambers 12 in the opposite direction as described later. Circular apertures 15c and 16c, fluid holes 17c and 18c are also adapted for exhausting the fluid.

According to this modification, cooling fluid is supplied in the conventional manner from the source of fluid (not shown) through the center bore 25 and fills the branched holes 26 and is permitted to radiate into each fluid chamber 12 as the holes 26 are connected with fluid ports 29 during rotation of the crank pin 5c with respect to the rotary piston 6c. The eccentric rotation of the piston 6c along the trochoidal face of the annular casing 1 likewise causes the cooling fluid within each chamber 12 to flow in a vortical current in the rotational direction of the piston as shown by the arrows in FIG. 8, which is the same as described with respect to FIGS. 1 through 6. In this modification, however, the fluid is divided at the center peak 28 when the deceleration of the rotational velocity of the piston takes place and is compelled to flow in the opposite directions along each inclined blade 27 towards the corner openings 13c and 14c through which the fluid is simultaneously exhausted in the laterally opposite directions to each circular aperture 15c and 16c. Exhausted fluid received within each aperture 15c and 16c is conveyed away through the fluid holes 17c and 18c provided in each end wall 2 and 2'.

FIGS. 10 and 12 show a further modified form of a rotary piston 6d in which the structural elements are the same as in the embodiment of FIGS. 7, 8 and 9 except for the fluid guides 9d. The guide 9d is different from the guide 9c of FIGS. 7–9 in that each inclined blade 27d is at a steep angle of inclination at its radial innermost portion and the angle of inclination decreases as it extends radially outwardly, so that the exhausting fluid flowing along the blade 27d is caused to flow in a spiral and without resistance due to a vertical collision of the fluid against the guide face. The crankshaft and the crank pin having the center bore 25 and the radial bores 26 as shown in FIG. 7, can be adapted to support the modified piston 6d. The supply of cooling fluid is therefore through the center bore 25, radial bores 26 and the ports 29 and, exhausting the fluid is, as described with respect of FIGS. 7–9, in the lateral opposite directions through the corner openings 13d and 14d and conveying away of the fluid exhausted will be performed in the same manner as recited with respect to the embodiment of FIGS. 7, 8 and 9.

FIG. 11 shows another modified form of a rotary piston 6e in which the structure is the same as that of the embodiments shown in FIGS. 7 through 10 and 12. Guides 9e are also similar to guides 9d of FIGS. 10 and 12 in that they are V-shape in cross section; each inclined blade 27e extends in the opposite direction from a center peak 28e laterally forwardly with respect to the rotational direction of the piston; each blade 27e has the angle of inclination decreased in the radially outwardly direction. But the guides 9e are different from the guides 9d or 9c of FIGS. 8 through 10 and 12 in that the guides 9e are inclined in the counter rotational direction of the rotor in the form of a backwardly curved vane. Ports 29e are also different from the ports 29 of FIGS. 8 and 10 in that they are radially backwardly inclined with respect to the rotational direction of the piston 6e. According to this modification the backward inclination of the guides 9e and the ports 29 cause flow of the cooling fluid into the chamber along the inclined ports 29e and guides 9e without vertical resistance due to the rotation of the piston. Also, when the rotational velocity of the piston decelerates, the fluid within each chamber 12, due to its inertia, is guided along the back face of the said backwardly inclined guides, therefore, there is no confused currents in the exhausting fluid due to the vertical collision of the fluid with the guide face. This modified piston 6e is also supported by the crankshaft having the center bore 25 and the radial bores 26 of FIG. 7 for supplying the cooling fluid therethrough to the chambers 12 via ports 29e. Corner openings 13e and 14e are adapted for exhausting the fluid in the opposite lateral directions and such exhausted fluid is conveyed away in the same manner as described with respect to the embodiment of FIG. 7.

I claim:

1. A rotary internal combustion engine, comprising an annular casing having a trochoidal shaped internal peripheral wall, a crankshaft extending through said annular casing, a triangular rotary piston eccentrically rotatably mounted on said crankshaft for rotation within said casing and defining between said piston and said casing a chamber for combustion of gases, said casing having intake and exhaust means through which the gases to be combusted and the products of combustion are drawn in and exhausted, said triangular piston being hollow and having an internal wall forming a piston bearing boss supporting the piston on the crankshaft, and having an exterior wall and lateral end walls defining the hollow interior of the piston, cooling fluid vanes extending radially outwardly within the hollow interior of said piston from the internal wall to the exterior wall and extending between the lateral end walls at an angle to a radial plane through the axis of rotation of the piston, said lateral end walls having apertures therein between said vanes for the passage of cooling fluid, and said annular casing having lateral end walls with apertures therein opposed to the openings in the lateral piston end walls for the passage of cooling fluid therethrough.

2. A rotary internal combustion engine as claimed in claim 1 in which said vanes extend in the same direction all the way between said lateral end walls of said piston.

3. A rotary internal combustion engine as claimed in claim 2 in which the vanes are each twisted with the outer radial end of the vanes at a greater angle to said plane than the inner radial end.

4. A rotary internal combustion engine as claimed in claim 2 in which the vanes are inclined with the lateral edges at the outlet ends of the vanes leading the lateral edges at the inlet ends of the vanes with respect to the direction of rotation of the piston.

5. A rotary internal combustion engine as claimed in claim 1 in which said vanes have a V-shaped cross section with the apex of the V pointing in the direction opposite the rotation of the piston, and said piston having cooling fluid inlet bores extending through the internal piston wall and opening into the spaces between said V-shaped vanes within the internal angles formed between the vane portions defining said V-shaped vanes.

6. A rotary internal combustion engine as claimed in claim 5 in which the vane portions at the apex of the V

are inclined at an angle to a tangent to the internal piston wall at the inner end of the vane portions.

7. A rotary internal combustion engine as claimed in claim 6 in which said inclination of the vane portions at the apex of the V is opposite to the direction of rotation of the piston.

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