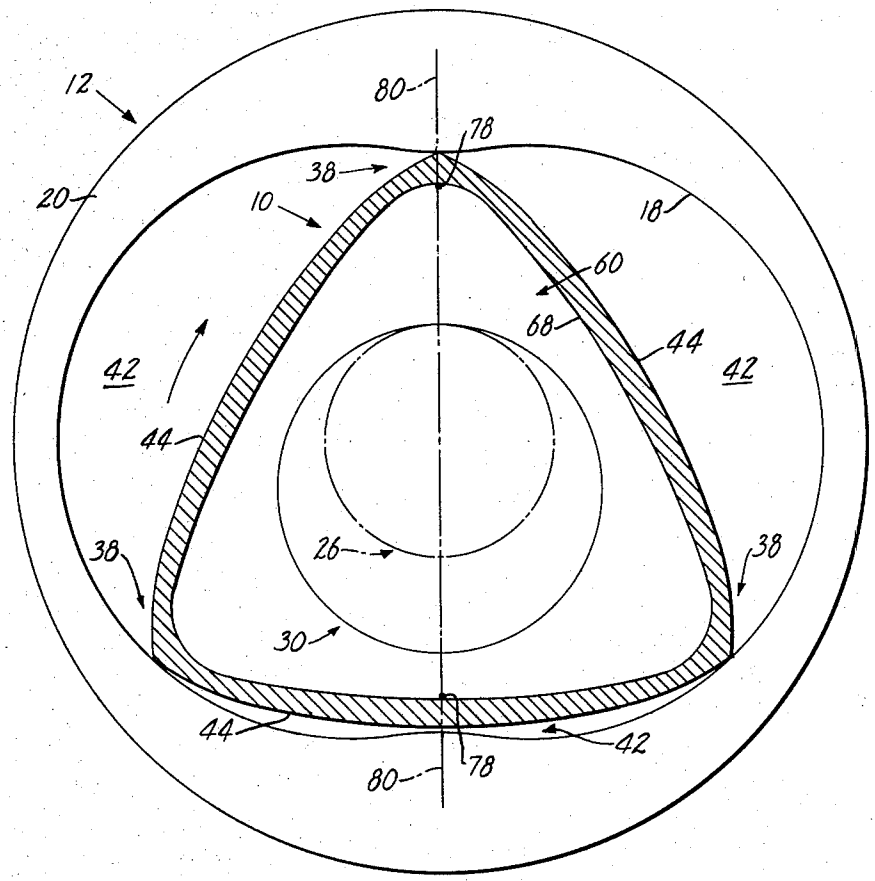
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COOLING SYSTEM FOR ROTARY MECHANISMS

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FIG. 1.

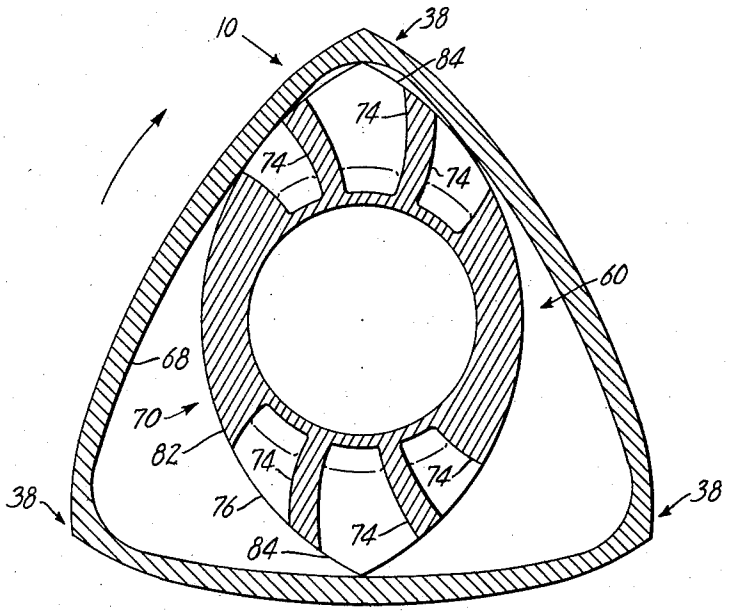


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FIG. 2.



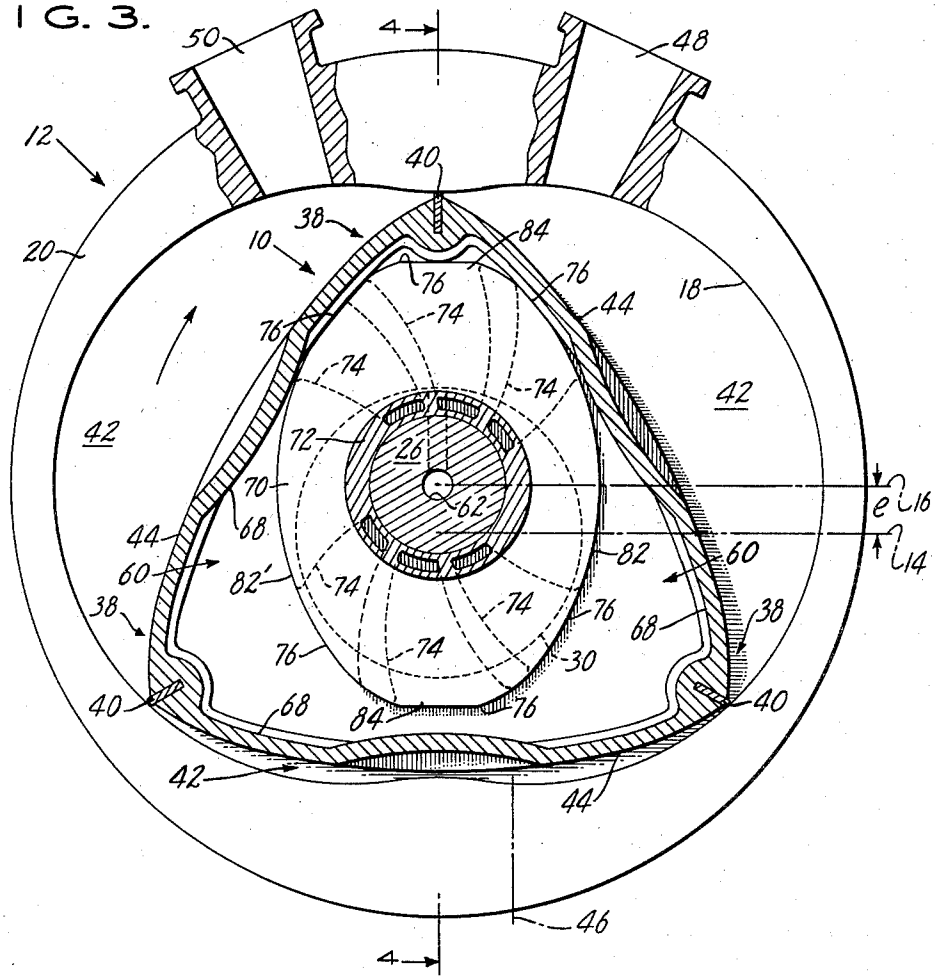
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COOLING SYSTEM FOR ROTARY MECHANISMS

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FIG. 3.



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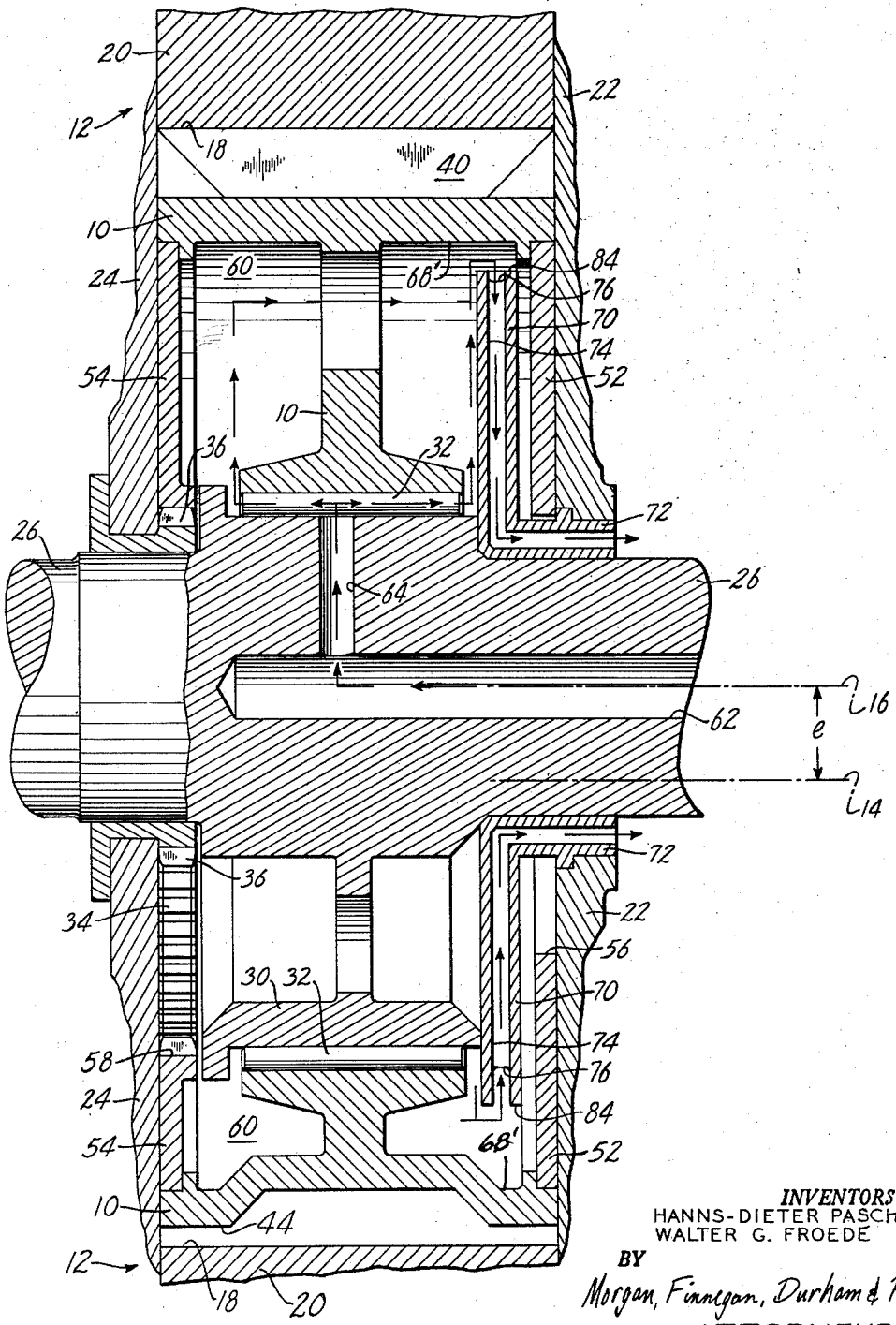
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COOLING SYSTEM FOR ROTARY MECHANISMS

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FIG. 4.



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COOLING SYSTEM FOR ROTARY MECHANISMS

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13 Claims. (Cl. 230—210)

This invention relates to an improved cooling system for rotary mechanisms, and more particularly to a cooling system for the rotor portion of such mechanisms.

This application is a continuation in part of copending application Serial No. 21,989, filed April 13, 1960. The rotary combustion engine that is the preferred embodiment of the type of rotary mechanism with which the cooling system of this invention is to be used is fully described in Patent No. 2,988,065, issued June 13, 1961. That patent may be referred to for a more detailed description of the rotary combustion engine with which the cooling system of this invention will preferably be used.

Although this invention is applicable to and useful in almost any type of rotary mechanism which presents a cooling requirement such as rotary combustion engines, fluid motors, fluid pumps, compressors, and the like, it is particularly useful in rotary combustion engines. To simplify and clarify the explanation of the invention the description that follows, will, for the most part, be restricted to the use of the invention in a rotary combustion engine. It will be apparent from the description, however, that with slight modifications that would be obvious to a person skilled in the art, the invention is equally applicable to other types of rotary mechanisms.

The parent application of this continuation in part application describes a rotary combustion engine comprising a hollow outer body having an axis, axially-spaced end walls and a peripheral wall interconnecting the end walls; the inner surfaces of the peripheral wall and the end walls form a cavity, and a rotor is mounted within the cavity between the end walls on an eccentric portion of a shaft, the axis of which coincides with the axis of the outer body. The rotor has end faces that are disposed adjacent to the end walls of the outer body, and these end faces are provided with openings for accommodating the eccentric portion of the shaft. These openings also accommodate a gearing between the rotor and the outer body comprising an externally-toothed gear fixed to the outer body and an internally-toothed gear fixed to the rotor.

As embodied for use with this invention, the rotor is provided with a cavity for the flow of a coolant fluid through the rotor. A stationary member is arranged in the cavity and is provided with a passage means at its radially outer end. The radially outer end of the stationary member is so disposed that it is also radially outward of the openings in the end faces of the rotor. The passage means in the stationary member provides a passage for exit of cooling fluid from the rotor cavity under the influence of centrifugal forces that are exerted on the fluid by the rotary motion of the rotor. By this arrangement the cooling fluid within the rotor cavity is kept at a level that prevents the escape of the cooling fluid through the openings in the end faces of the rotor to any appreciable extent.

In rotary combustion engines of the type described, considerable losses caused by churning and turbulence may be generated in the cooling fluid in the rotor cavity because of the tangential and radial forces of continuously changing direction and magnitude exerted on the fluid as a result of the planetary revolving motion of the rotor.

These churning and turbulence losses deleteriously affect the efficiency of the engine.

The invention described in the parent application greatly and advantageously reduces the churning and turbulence losses in the rotor cavity by decreasing the depth of the ring of fluid around the outer periphery of the rotor cavity to a manageable extent. This invention is an improvement over the invention of the parent application in that it provides means by which the depth of the fluid ring within the rotor cavity can be reduced to an even greater extent than is possible with the parent application.

This invention is also an improvement over the invention of the parent application in that this invention provides means by which the passage means in the stationary member can be made adaptable for use with types of rotary combustion engines in which the contour of the rotor is straight, or even inwardly curved, between apex portions. In the parent application, since the passage means was preferably arranged in a circular disc, that invention was not particularly adaptable to types of rotary combustion engines other than those in which the contour of the rotor is outwardly curved between apex portions. The circular disc could be used with a rotor having an inwardly curved contour, but when used with such a rotor, the disc would have to be made undesirably small in diameter and the depth of the fluid ring would in turn be increased with consequent undesirable increase in churning and turbulence losses and undesirable increase in the weight of the rotor.

Accordingly, it is a primary object of this invention to provide means to keep the radial depth of the cooling liquid in the fluid ring within the rotor cavity at a desired minimum. This invention thus provides means by which cooling fluid may be picked up and pumped out of the outer periphery of the rotor cavity, or the interior contour of the rotor.

The main object of the invention is accomplished by locating the radial outer end of the passage means in the stationary member on the inner envelope curve that is circumscribed by the contour of the outer periphery of the rotor cavity, i.e. the interior contour of the rotor.

The inner envelope curve is generated or circumscribed by the path that is described by the inner contour of the rotor during its planetary rotary motion or in other words, the curve that describes the limit of radially inward travel of the interior contour of the rotor.

As already disclosed in the parent application the passage means is preferably in the form of one or a plurality of channels provided within a stationary disc, and the radial outer ends of said channels lie on the outer periphery of the disc. According to the present invention the stationary disc is then constructed in a shape having as its outer periphery the inner envelope of the interior contour of the rotor.

By the nature of its construction, the stationary member having this inner envelope contour thus touches the interior contour of the rotor at at least one point at all times. This attribute permits the cooling system of the rotor to be designed so that regardless of whether the rotor is outwardly or inwardly curved between apex portions the radial depth of the fluid ring around the outer periphery of the rotor cavity can be controlled to provide any desired depth, and a very slight radial depth for the fluid ring can be easily obtained by having the exit passage means in the stationary member located in the stationary member so that its opening is on the inner envelope curve. There must, however, always be some distance between the outer periphery of the stationary member (inner envelope) and the interior contour of the rotor because of production requirements.

It is preferable to locate the opening of the exit passage means in the stationary member in the zone of the

inner envelope curve that forms the outer periphery of the stationary member at a position on the inner envelope curve that is radially outward the greatest distance from its center. This location of the opening for the exit passage means insures that cooling fluid will be picked up also in the apex zones of the rotor.

In rotary combustion engines in which the contour of the inner surface of the peripheral wall of the outer body is basically a two-lobed epitrochoid the interior contour of the rotor or the outer periphery of the rotor cavity may take the shape of a three-toothed or three-lobed hypotrochoid. When this is so, the corresponding inner envelope curve or contour of the stationary member or disc has an oval shape the apexes of which are in continuous contact with the hypotrochoid. The cooling liquid within the rotor cavity can thus be picked up at two opposite points close to the interior contour of the rotor.

In an alternative embodiment of this invention, however, the thickness of the wall of the rotor may be increased at the apex portions to facilitate the providing of sealing members in the apex portions of the rotor when the wall thickness of the rotor might otherwise not be sufficient to accommodate the sealing members.

To provide more efficient return of the cooling liquid through the exit passages, these passages may be made spiral shaped, as is described in the parent application.

Broadly described, this invention provides means for circulating a cooling liquid through the rotor and for maintaining only a minimum radial depth of cooling liquid around the periphery of the rotor cavity.

Additional objects and advantages of the invention will be set forth in part in the description that follows, and in part will be obvious from the description or may be learned by practice of the invention, the objects and advantages being realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

The invention consists in the novel parts, constructions, arrangements, combinations and improvements shown and described.

The accompanying drawings, that are incorporated in and constitute a part of this specification, illustrate one embodiment of the invention, and, together with the description, serve to explain the principles of the invention.

Of the drawings:

FIG. 1 is a diagrammatic transverse sectional view of a rotary combustion engine with a stationary outer body, and with a rotor having an internal cavity embodying the invention;

FIG. 2 is a transverse sectional view of one embodiment of the invention showing a rotor in section and the stationary member that cooperates with the interior contour of the rotor;

FIG. 3 is a view similar to FIG. 2 but illustrating a modified construction of the central vertical section of a rotary combustion engine employing this invention; the passage means within the stationary member being shown partly in diagrammatic form;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory but are not restrictive of the invention.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

In accordance with the invention, a rotary combustion engine and means for cooling its rotor with a coolant fluid are provided. As embodied, and as shown in FIGS. 1 through 4, the present preferred embodiment of the invention includes a rotary combustion engine comprising a generally triangular rotor 10 having arcuate sides

that is eccentrically supported for rotation within an outer body 12.

Although in the illustrative embodiment shown in the drawings, the outer body 12 is fixed or stationary, a practical and useful form of the invention may be constructed in which both the outer body and rotor are rotary; in this latter form of the invention, the power shaft is driven directly by rotation of the outer body and the inner body or rotor rotates relative to the outer body. An embodiment of this latter form of the invention is illustrated in FIGS. 5 and 6 of the parent application (Serial No. 21,989).

As most clearly shown in FIGS. 3 and 4, and as here preferably embodiment, the rotor 10 rotates on an axis 14 that is eccentric from and parallel to the axis 16 of the curved inner surface 18 of the outer body 12. The distance between the axes 14 and 16 is equal to the effective eccentricity of the engine and is designated *e* in the drawings. The curved inner surface 18 of the outer body 12 has basically the form of an epitrochoid in geometric shape and includes two arched lobe-defining portions or lobes.

As embodied, the generally triangular shape of the rotor 10 corresponds in its configuration to the "inner envelope" or the maximum profile of the rotor that will permit interference free rotation of the rotor 10 within the outer body 12.

In the form of the invention illustrated, the outer body 12 comprises a peripheral wall 20 that has for its inner surface the curved inner surface 18 and a pair of axially-spaced end walls 22 and 24 that are disposed on opposite sides of the peripheral wall 20.

The end walls 22 and 24 support a shaft 26, the geometric center of which is coincident with the axis 16 of the outer body 12. This shaft 26 is supported for rotation by the end walls 22 and 24 on bearings 28. An eccentric portion of the shaft or shaft eccentric 30 is rigidly attached to or forms an integral part of the shaft 26, and the rotor 10 is supported for rotation or rotatably mounted upon the shaft eccentric 30 by a bearing 32 which, as illustrated, is a roller type bearing.

As shown in FIG. 4, an internally-toothed or ring gear 34 is rigidly attached to one end face of the rotor 10. The ring gear 34 is in mesh with an externally-toothed gear or pinion 36 that is fixedly secured to the stationary end wall 24 of the outer body 12.

From this construction, it may be observed that the gearing 34 and 36 does not drive or impart torque to the shaft 26 but merely serves to index or register the position of the rotor 10 with respect to the outer body 12 as the rotor rotates relative to the outer body and removes he positioning load that would otherwise be placed upon the apex portions of the rotor 10.

As shown most clearly in FIGS. 1, 2, and 3, the rotor 10 includes three apex portions 38 and as shown in FIG. 3, these apex portions 38 carry radial movable sealing members 40. The sealing members 40 are in substantially continuous gas-sealing engagement with the inner surface 18 of the outer body 12 as the rotor 10 rotates within and relative to the outer body 12.

By means of the rotation of the rotor 10 relative to the outer body 12, three variable volume working chambers 42 are formed between the peripheral working faces 44 of the rotor 10 and the inner surface 18 of the outer body 12. As embodied in FIG. 3, the rotation of the rotor relative to the outer body is clockwise and is so indicated by an arrow.

A spark plug 46 (indicated schematically in FIG. 3) is mounted in the peripheral wall 20 of the outer body 12, and at the appropriate time in the engine cycle the spark plug 46 provides ignition for a compressed combustible mixture that, on expansion, drives the rotor in the direction of the arrow. The rotary combustion engine may also be operated as a diesel, and when it is operated

as a diesel, the spark plug 46 is not required, since ignition of the fuel is initiated by the temperature reached through high compression of the working air.

Also as shown in FIG. 3, one lobe of the epitrochoidal surface 18 is provided with an intake port 48, and the other lobe is provided with an exhaust port 50. As the rotor 10 rotates a fresh charge is drawn into the appropriate working chamber 42 through the intake port 48. This charge is then successively compressed, ignited, expanded, and finally exhausted through the exhaust port 50.

All four successive phases of the engine cycle: intake, compression, expansion, and exhaust, take place within each one of the variable volume working chambers 42, each time the rotor 10 completes one revolution within the outer body, and for each revolution of the rotor, the engine completes a cycle.

Since the gear ratio between the rotor ring gear 34 and the outer body gear or pinion 36 is 3:2, each time the rotor 10 completes one revolution about its own axis 14, the shaft 26 rotates three times about its axis 16. The gearing, having a ratio of 3:2, thus enforces a speed ratio between the shaft and the rotor of 3:1.

The end faces 52 and 54 of the rotor 10 are provided with openings at 56 and 58 through which the shaft 26 extends.

The rotor 10 is provided with an internal cavity 60, as shown in FIGS. 1 through 4. This internal cavity 60 is supplied with cooling liquid, such as lubricating oil, through a central bore 62 (as shown in FIGS. 3 and 4) within the shaft 26 and a radial passage 64 that extends radially to the periphery of the eccentric 30 at the midpoint of the roller bearing 32. The coolant flows between the rollers of the bearing 32 and out from the ends of this bearing into the internal cavity 60, where centrifugal forces distribute the cooling fluid around the outer periphery of the internal cavity or interior contour 68 of the rotor.

For return conveyance and to aid in circulation of the cooling fluid, a stationary disc 70 is arranged within the cavity 60 of the rotor 10. As shown in FIG. 4, the disc 70 is continued or extended by a tubular hub 72 that extends axially beyond the rotor and is fixed to the end wall 22 of the outer body 12. Radially extending channels 74 are provided in the disc 70, and these channels communicate at their radially outer ends at the periphery of the disc 70 with the cavity 60 and are continued at their radially inner ends in an axial direction through the tubular hub 72.

If the fluid level or depth of the fluid ring that forms within the cavity 60 due to centrifugal force as the rotor rotates, reaches a depth such that the openings of some of the channels 74 dip into the fluid ring, the cooling liquid will be conveyed by centrifugal pressure through these channels 74. The fluid will then flow under centrifugal pressure through the tubular hub 72 and may either be taken out of the engine at this point or circulated by appropriate passage means (not shown) through the outer body. After leaving the engine, the cooling fluid may be conveyed to a cooling radiator (not shown), and when cooled, can be recirculated through the rotor after being reintroduced into the engine through the central bore 60.

From the foregoing description, it is apparent that the return passages 74 act as a pump to limit the quantity of cooling fluid within the internal cavity 60 by pumping excess fluid out of the cavity through the passages 74.

Preferably, the stationary disc 70 extends radially outward beyond the openings 56 and 53 in the end faces 52 and 54 of the rotor 10 in every position of the rotor, so that the return passages 74 communicate with the cavity 60 at a point in the relative movement between the rotor and outer body that is always radially beyond the openings 56 and 58, the rotor bearing 32, and the gears 34 and 36 between the rotor and the outer body.

As the return passages 74 prevent the radial depth of

the cooling fluid in the fluid ring around the interior contour 68 of the cavity 70 from increasing radially inward substantially beyond the radial outer ends 76 of the passages 74, the escape of cooling fluid through the openings 56 and 58 and along the end faces 52 and 54 of the rotor 10 to the working chambers 42 is prevented. Also, with this arrangement of the cooling system neither the rotor bearing 32 nor the rotor gear 34 and stationary gear 36 run immersed in the cooling fluid and churning and turbulence of the cooling fluid that would otherwise result through the action of these bearings and gears is thus prevented.

The foregoing description of the rotary combustion engine and its cooling system is also, in general, applicable to the invention disclosed in the parent application (Serial No. 21,989).

In accordance with the present invention, however, means are also provided that permit the depth of the fluid ring on the interior contour 68 of the rotor cavity 60 to be controlled down to any desired minimal depth through the provision of a combination of contours for the interior contour 68 and the contour of the stationary disc 70 that ensures the desired spacing between the radially outer-most point on the stationary disc 70 with at least one point on the interior contour 68 at all times. The means provided by the present invention also ensures the combination of a disc and interior contour of the rotor that will achieve the objects of the invention for any suitable shape of rotor including a rotor that is inwardly curved or straight between apex portions as well as one that is outwardly curved between apex portions.

As here preferably embodied, and as shown in FIGS. 1 and 2, this means comprises a rotor 10 in which the internal cavity 60 has an interior contour 68 that is in the shape of a three-toothed or three-lobed hypotrochoid. This hypotrochoidal interior contour 68 is traced on the rotor 10 by the points 78 fixed with respect to the outer body and located on the minor axis 80 of the epitrochoid that forms the contour of the inner surface 18 of the outer body 12. The tracing points 78 describe the hypotrochoidal interior contour 68 of the rotor 10 when they remain stationary with respect to the outer body 12 as the rotor 10 rotates relative to the outer body.

As shown in FIG. 2, the outer contour 82 of the stationary disc 70 is the inner envelope that is circumscribed by the hypotrochoidal interior contuor 68 during revolution of the rotor 10 within the outer body 12. The outer contour 82 of the disc 70 is thus the inner envelope of the hypotrochoid 70, and in this respect the relationship is similar to the relationship between the epitrochoid 18 or inner surface of the outer body 12, and the general configuration of the outer contour of the rotor 10 that is the "inner envelope" of the epitrochoid 18.

The outer or "envelope" contour 82 of the disc 70 provides a periphery for the disc 70 that has its apex portions 84 disposed adjacent to the interior contour 68 of the rotor in all relative positions of the rotor 10 and disc 70. Accordingly, since the return passages 74 are located adjacent the apex portions 84 of the disc 70 and the radial outer opening 76 of the passages 74 lie on the periphery or outer contour 82 of the disc 70 the radial depth of the liquid coolant at the outer periphery 68 of the rotor cavity 60 can be kept quite small.

As shown in FIG. 2, the use of a hypotrochoidal interior contour 68 of the rotor 10 results in a relatively small thickness for the wall of the rotor in the zone of the rotor apex portions 38 if the thickness of the rotor wall between apex portions is made as small as possible to decrease the weight or mass or the rotor. This small thickness of the rotor wall in the zone of the apex portion 38 prevents the proper arrangement of the sealing members 40 that are necessary if the rotary mechanism is designed as a rotary combustion engine. If the thickness of the rotor wall in the zone of the apex portions 38 is made large enough to accommodate the sealing mem-

bers 40, however, the wall thickness in the remaining portion of the rotor could become larger than desired for a particular design and could make the rotor heavier than desired. Also, if the walls of the rotor are permitted to become excessively thick, heat transfer becomes more difficult.

An alternative embodiment of the present invention is shown in FIGS. 3 and 4. As shown in FIG. 3, the interior contour 68 of the rotor 10 has been modified at the apex portions 38 of the rotor so that this contour is no longer strictly in the shape of a three-lobed hypotrochoid. This modification in the shape of the interior contour 68' also leads to a modification of the shape of the outer contour 82 of the disc 70, because the outer contour 82' remains as the inner envelope curve of the new interior contour 68'.

The new outer contour 82' no longer is in engagement with the interior contour 68' at two opposite points as the outer contour 82 was in contact with the interior contact 68 in the embodiment of FIG. 1. But the outer contour 82' of the disc 70 does remain in engagement with the interior contour 68' at one relative spot through rotation of the rotor 10, and the location of this spot varies during rotation of the rotor.

This alternative embodiment, however, also effectively achieves the objects of the present invention, and the cooling system continues to function in the same way as previously described.

In both embodiments illustrated in the drawings, the passages 74 are spiral-shaped and are inclined into the direction of rotation of the rotor as shown by the arrows on the drawings to improve the pickup and return of the cooling fluid from the rotor cavity 60.

The cooling fluid used in the instant invention preferably also has lubricating properties. A low viscosity lubricant, such as diesel oil works well. The present invention thus makes possible the use of a single fluid to accomplish two functions for the rotary mechanism or engine: cooling and lubrication.

The rotary mechanism can be constructed so that the bearings for the rotor, outer body, and shaft and the gearing between the rotor and outer body, can all be lubricated by the same fluid that is used to cool the mechanism.

This invention in its broader aspects is not limited to the specific mechanisms shown and described, but also includes within the scope of the accompanying claims any departures made from such mechanisms that do not sacrifice its chief advantages.

What is claimed is:

1. A rotary mechanism comprising a hollow outer body having an axis, axially-spaced end walls and a peripheral wall interconnecting the end walls, a rotor mounted within the outer body for rotation relative to the outer body on an axis eccentric from and parallel to the axis of the outer body, the rotor being symmetrical about its axis, having end faces disposed adjacent to the end walls and a plurality of circumferentially-spaced apex portions in sealing engagement with the inner surface of the peripheral wall to form a plurality of working chambers between the rotor and the peripheral wall that vary in volume upon relative rotation of the rotor within the outer body, the rotor having an internal cavity for the flow of a cooling fluid through the rotor, a stationary member extending radially outward into the internal cavity of the rotor, the stationary member having a plurality of passages open at their radially outer ends so that when these outer ends are immersed in fluid within the rotor the centrifugal pressure on the fluid is effective to force the fluid to flow out of the rotor through the stationary passages, the internal cavity of the rotor being symmetrical about the rotor axis and having a non-circular shape that is generally symmetrical to the shape of the rotor itself, the stationary member having a periphery that has substantially the shape of the inner envelope curve that is circumscribed by the outer contour of the rotor cavity during rotation of the rotor relative to the outer body, and the radially outer ends of the passages being located on the periphery of the stationary member.

2. The invention as defined in claim 1, in which the distance between the outer surface of the rotor and the internal cavity is substantially uniform about the periphery of the rotor.

3. The invention as defined in claim 1, in which the inner surface of the outer body has basically the contour of a multi-lobed epitrochoid, and in which the internal cavity of the rotor has basically the shape of a multi-lobed hypotrochoid, the hypotrochoid having one more lobe than the epitrochoid.

4. The invention as defined in claim 1, in which the radially outer end of at least one of the passages is located in the region of the envelope outer contour of the stationary member that is radially most remote from the center of the stationary member.

5. The invention as defined in claim 1, in which the inner surface of the outer body has basically the contour of a two-lobed epitrochoid, and in which the interior contour of the rotor has basically the shape of a three-lobed hypotrochoid.

6. The invention as defined in claim 5, in which the periphery of stationary member has the shape of the inner envelope curve circumscribed by the three-lobed hypotrochoid when the rotor revolves within the outer body.

7. The invention as defined in claim 1, in which the rotor has a greater wall thickness at its apex portions than between apex portions so that the rotor walls between apex portions may be thin but will have sufficient thickness at the apex portions to accommodate sealing members.

8. The invention as defined in claim 1, in which the outer body is stationary; and in which the rotary mechanism includes a rotatable shaft having an eccentric portion, the rotor being rotatably mounted upon this eccentric portion.

9. The invention as defined in claim 1, in which the radially outer end of the passage is inclined into the direction of rotation of the fluid within the internal cavity.

10. The invention as defined in claim 9, in which the passage is spiral-shaped.

11. The invention as defined in claim 1, in which the radially inner end of the stationary passage extends substantially in an axial direction with respect to the axis of rotation of the rotor and away from the rotor.

12. The invention as defined in claim 1, in which both the outer body and rotor are rotatable simultaneously.

13. The invention as defined in claim 12, including a stationary eccentric upon which the rotor is mounted for rotation; the stationary member being fixed to the stationary eccentric.

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