April 6, 1965 F. P. SOLLINGER 3,176,916

INTERNALLY COOLED ROTOR FOR ROTARY MECHANISM

Filed Nov. 20, 1962 3 Sheets-Sheet 1

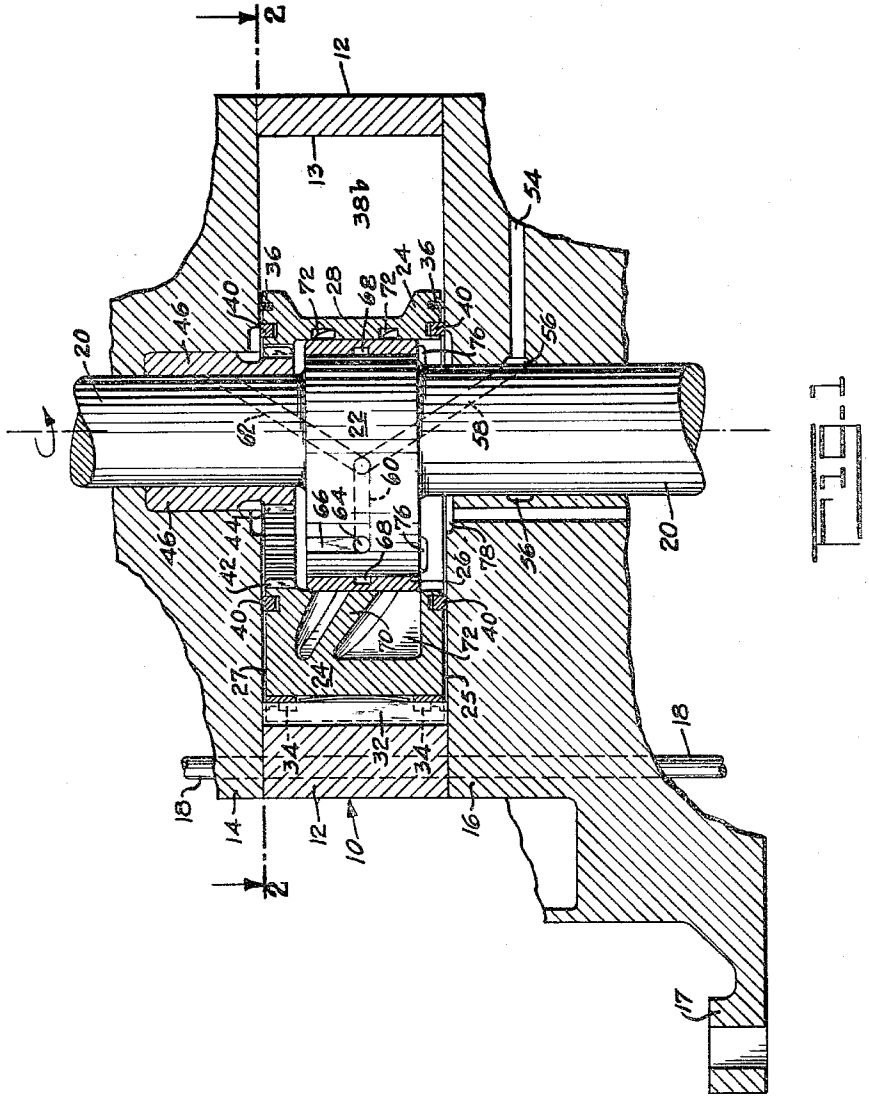


FIG. 1

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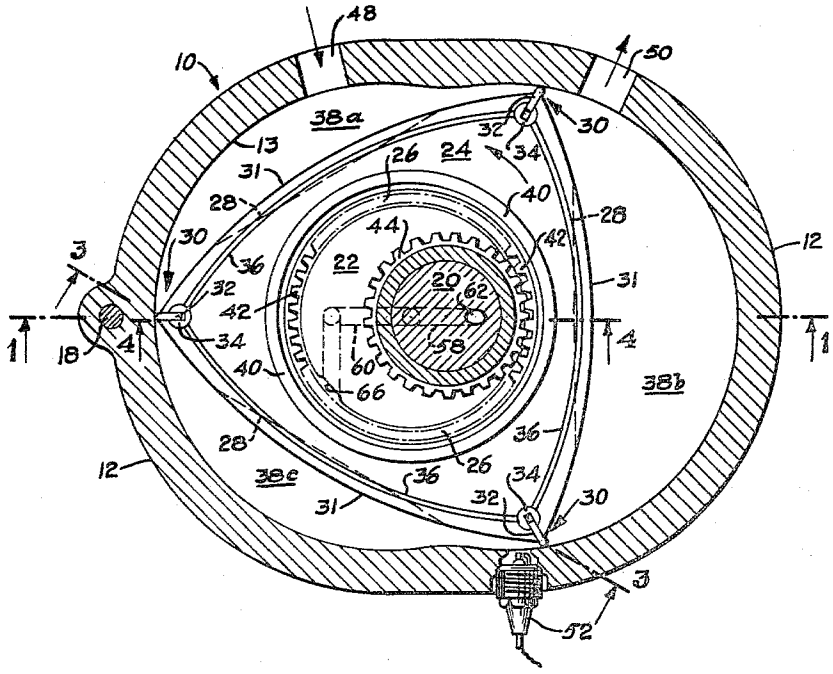


FIG. 2

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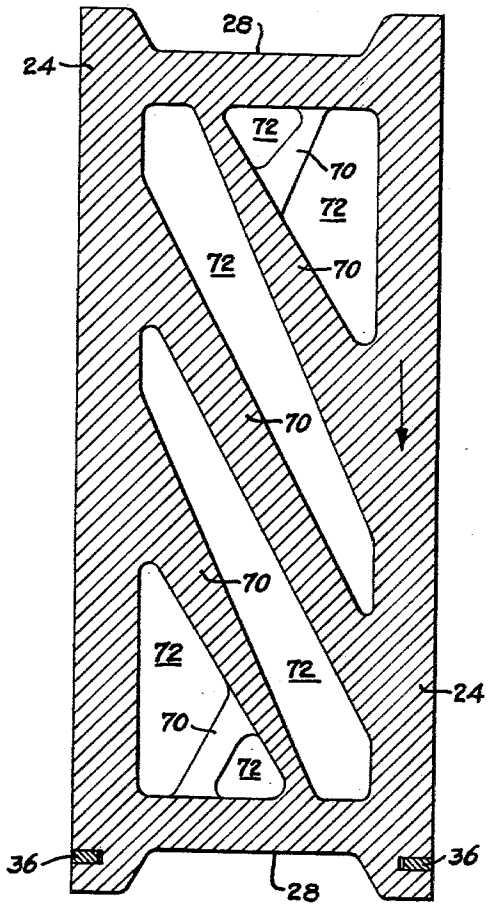


FIG. 3

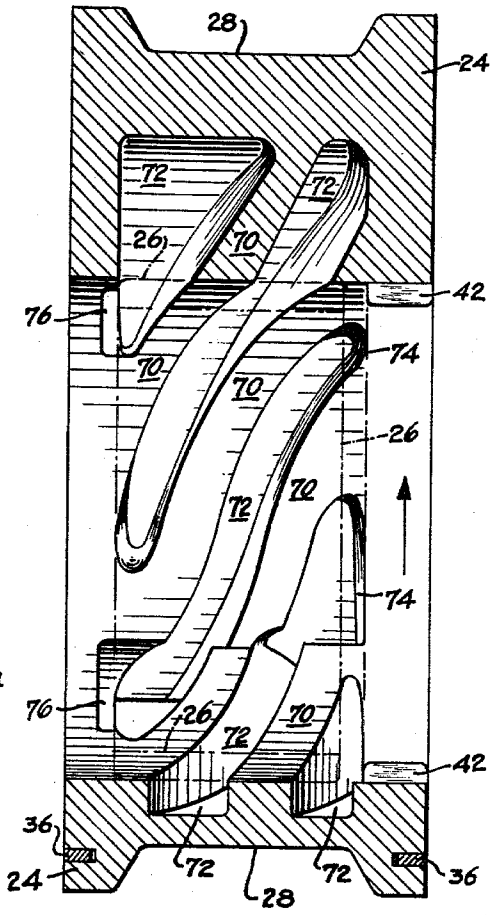


FIG. 4

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3,176,916

INTERNALLY COOLED ROTOR FOR ROTARY MECHANISM

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6 Claims. (Cl. 230—210)

This invention relates to rotary mechanisms such as fluid pumps, fluid motors, combustion engines or the like and more particularly to means for cooling the rotor in a rotary mechanism.

The invention is best understood when described with reference to a rotary combustion engine and, although not limited to such use, is so described herein. A rotary combustion engine as described herein may be of the type disclosed in United States Patent 2,988,065, issued on June 13, 1961, to Felix Wankel et al.

The primary purpose of the invention is to provide a novel means for adequately cooling the interior of the rotor of a rotary mechanism with a minimum quantity of cooling medium such as lubricating oil. By keeping the quantity of cooling oil within the rotor at a minimum, said oil does not materially affect the rotor counterbalancing requirements.

The invention is generally carried out by supplying relatively small amounts of oil to one end face of the rotor where it enters openings at one end of a plurality of helical-like passageways formed in the interior of the rotor and running from one end wall of the rotor to the other. Due to the inclination of the passages and the rotary motion of the rotor, the cooling oil is pumped from said one end of the passages to their other ends at the opposite rotor end face from which the oil discharges into the space between the latter rotor end face and the adjacent end wall of the rotor housing from which the cooling oil drains through a suitable drain passageway in the rotary mechanism. Because of the pumping action of the rotor and its inclined passageways, the cooling oil supplied to the rotor interior has a very short residence time within the rotor interior and therefore greater heat transfer is obtained since the heated oil is carried quickly away and then replaced by fresh cooling oil. The present invention permits the rotor to run at sufficiently cool metal temperatures with consequent reduction of thermal distortion, reduction of deposits tending to stick the rotor seals and therefore improving seal operation. Another advantage of the present invention lies in the fact that a smaller oil pump may be used since the rotor runs with very little oil therein and because the rotor itself pumps the cooling oil therethrough. Therefore, overall engine weight will be reduced with consequent reduction in cost.

Accordingly, it is one object of the invention to provide a novel system for circulating a cooling medium through the interior of the rotor in a rotary mechanism.

It is another object of the invention to provide a cooling system for the interior of the rotor wherein a coolant is supplied at one end face of the rotor and is circulated through a plurality of helical-like passageways within the rotor interior with a relatively short residence time therein and discharged from said passageways at the opposite end face of the rotor.

Another object of the invention is to provide a cooling system for the interior of the rotor wherein the rotor interior has a plurality of helical-like passageways therein which aid in pumping the coolant from one side of the rotor to the other.

It is additionally an object of the invention to provide a cooling system for the interior of the rotor wherein the coolant is circulated in close proximity to the region of the rotor bearing the apex seal members.

Other objects and advantages of the invention will become apparent upon reading the following detailed description with the accompanying drawing in which:

FIG. 1 is a sectional view taken along line 1—1 of FIG. 2 showing a rotary combustion engine embodying the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a sectional view of the rotor taken along line 3—3 of FIG. 2,

FIG. 4 is a sectional view of the rotor itself taken along line 4—4 of FIG. 2 with the rotor bearing sleeve shown in dot-dash outline.

In FIG. 1 there is shown a rotary combustion engine having an outer body generally designated at 10. Although the engine of FIG. 1 is shown mounted with its shaft in a vertical position the invention is not limited to vertically mounted engines and is equally applicable to horizontally mounted engines. The outer body 10 is composed of a peripheral wall 12 interconnected with a pair of parallel spaced end walls 14 and 16 by suitable means such as bolts 18. Suitable mounting brackets, for example that shown at 17, may be provided on the end wall 16 through which bolts (not shown) may pass to firmly support the engine in its vertical position. As shown in FIG. 2, the profile of the inner surface 13 of the outer body peripheral wall 12 preferably is basically a two lobed epitrochoid. A shaft 20 is rotatably mounted in the outer body 10 and has an eccentric portion 22 formed thereon upon which there is rotatably mounted a rotor 24. A plain sleeve type bearing 26 is supported by the rotor 24, as will be explained in greater detail below, and serves to position the rotor on the eccentric portion 22. The outer peripheral wall 28 of the rotor 24 has a generally triangular profile to form three circumferentially-spaced apex portions 30 between each pair of which are defined working portions 31 (FIG. 2). Along each of the apex portions 30 there is provided an axial groove in which is mounted a radially movable seal strip 32 for sealing engagement with the inner surface 13 of the peripheral wall 12. Intermediate seal bodies 34 are also provided on each end face of the rotor in sealing cooperation with the apex seals 32 and end face seals 36 in the end faces of the rotor to provide a continuous seal around working chambers 38*a*, 38*b*, and 38*c* formed between the rotor and the outer body. The working chambers 38*a*, 38*b*, and 38*c* vary in volume upon relative rotation of the outer body 10 and rotor 24. Oil seals 40 may also be provided in each side face of the rotor at a radially inward position thereof in order to prevent any oil leakage outwardly into the working chambers.

An internally-toothed gear 42 is secured to one side of the rotor 24, as illustrated in FIG. 1, and meshes with a fixed externally-toothed gear 44 which is shrunk into the end wall 14, the fixed externally-toothed gear 44 having an axially extending shank portion 46 which serves as a bearing support for the shaft 20. The gears 42 and 44 serve to guide the rotor 24 in tracing its epitrochoidal path. In the embodiment illustrated having a two-lobed epitrochoid and a three-lobed rotor the ratio of rotation of the shaft with respect to the rotation of the rotor is 3:1 wherein for each rotation of the rotor about its axis, the shaft rotates three times about its axis.

As shown in FIG. 2, an intake port 48 is provided in one side of the peripheral wall for admitting air or a fuel-air mixture along with an exhaust port 50 for expelling the burnt gases from the outer body and on the opposite side of the peripheral wall spark plug 52 is provided for igniting the fuel-air mixture which of course may be eliminated if the engine is run on diesel cycle. As the rotor 24 and outer body 10 rotate relative to one

another the working fluid in the working chambers undergoes the stages of intake, compression, expansion and exhaust. With reference to the above-mentioned Patent No. 2,988,065, it can be seen that the structure so far described is conventional in rotary combustion engines.

As further shown in FIG. 1, a passageway 54 is provided in the outer body end wall 16 and is connected at one end to a suitable pump (not shown) for supplying a liquid coolant to the interior of the rotor 24. The liquid coolant used in this case is a lubricating oil which serves to lubricate some of the moving parts of the engine as well as acting as a coolant for the interior of the rotor. The passageway 54 terminates in an annular groove 56 cut into the outer body end wall and surrounds the shaft 20, said annulus communicating with one end of a passageway 58 provided in the shaft 20 so that as the shaft rotates oil may be pumped into the shaft passageway 58. The passageway 58 communicates at its other end with a radially extending passageway 60 and also with a shaft passageway 62. The radial passageway 60 extends radially outwardly from passageway 58 through the eccentric portion 22 and terminates in an opening 64 in the outer surface of said eccentric portion. An axially extending flat 66 or groove is cut into the outer surface of the eccentric and communicates with opening 64 in order that a portion of the oil may flow axially outwardly toward one end face of the rotor, as will be explained in greater detail below. Also communicating with opening 64 is an annular groove 68 cut out from the inner surface of bearing 26 so that the oil will flow between the eccentric 22 and the bearing 26 in order to lubricate their engaging surfaces. Some of this oil is also used as the coolant for the interior of the rotor as will also be further explained below.

The rotor 24 has a hollow construction such that its outer wall consists of end wall portions 25 and 27 and a plurality of peripheral wall sections 28, each interconnecting a pair of adjacent apex portions 30 of the rotor. The inner surface of the rotor outer wall has a plurality of inwardly projecting spaced rib members 70 which extend from one end wall of the rotor to the other end wall in a direction inclined to the rotor axis. The rotor rib members 70 thereby have a helical-like configuration and form helical-like passageways 72 therebetween. The bearing sleeve 26 is secured across the inner ends of the rib members 70 thereby forming the inner walls of said helical-like passageways 72. The helical-like configuration of the rib members 70 provides a strong and rigid support for the bearing sleeve 26.

Each of the passageways 72 is open at each end to the space between the adjacent rotor end wall and the outer body end wall. For this purpose a recess is formed at each end of a rotor passageway in the adjacent rotor end wall and adjacent to the rotor bearing sleeve so that the recesses form supply openings 74 on one side of the rotor and discharge openings 76 on the opposite side of the rotor (FIG. 4). When viewing the passageways 72 toward their supply openings, it is apparent that the passageways are inclined toward the direction of rotor rotation and viewed toward their discharge openings, the passageways are inclined opposite to the direction of rotor rotation as shown by the arrows of FIGS. 3 and 4 which indicate the direction of rotor rotation.

In FIGS. 3 and 4 it can be seen that in the apex portions of the rotor, the rib members cross in a lattice-like fashion and the helical passageways 72 are continuous in this region. Due to this construction the coolant may continuously flow through the continuous passageways and pass in close proximity to the region having the radially-movable apex seals 32 and cool this region. Any sticking or jamming of the apex seals is therefore prevented which may result if excess heat is present in this region.

During operation of the engine, oil will be pumped through the passageway 54 in end wall 16 into passageway 58 and also around annulus 56 to the shaft passageway 58 as the shaft rotates. From the passageway 58 a portion of the oil will flow into shaft passageway 62 where it will flow between the shank portion 46 of the gear 44 and shaft 20 to lubricate the bearing surfaces therebetween. Another portion of the oil from shaft passageway 58 will flow radially outwardly through the radial passageway 60 in the eccentric 22 where some of this oil will flow into the annulus 68 in the bearing 26 to lubricate the bearing surfaces between the bearing 26 and the eccentric 22. The remainder of the oil from radial passageway 60 will flow into the axially extending flat 66 provided in the eccentric 22 where the oil will feed out into the region on the gear side of the rotor between the eccentric and the adjacent rotor end wall 27. Due to the fact that the rotary motion of the rotor and shaft produces a loading and unloading effect on the bearing surfaces of bearing 26 and shank portion 46 of gear 44, these bearing surfaces will be slightly spread away from their respective bearing surfaces on the eccentric 22 and shaft 20 on their unloaded side. Therefore, at these unloaded sides, the oil supplied thereto may flow axially outwardly from between the bearing surfaces where some of this oil will also discharge into the region between the eccentric and the adjacent rotor end wall 27 on the gear side of the rotor.

The rotary motion of the rotor produces centrifugal forces. In response to these forces, the oil discharged between the eccentric and the adjacent rotor end wall will be thrown radially outwardly. Hence, as the rotor rotates with respect to the shaft 20 and eccentric 22, the openings 74 in each of the helical passageways 72 will be successively fed with the radially outwardly directed oil. With the orientation of the helical passageways 72 and the direction of rotation of the rotor 24, shown in FIG. 4 the oil upon entering the helical passageways 72 at the gear side end face of the rotor is relatively rapidly pumped through the passageways to their opposite ends or to the discharge openings 76 in each of the passageways 72 where the oil will be discharged in a manner to be discussed more fully below.

At the location of the passageways in the region of the apex portions, the oil is pumped relatively close to the peripheral surface of these portions and, because these passageways are continuous in these regions, as shown in FIGS. 3 and 4, the oil is then pumped from the lobe portion of the rotor from which it entered the passageways 72 to an adjacent lobe portion from which it is then pumped to the openings 76.

As the rotor rotates, each point on the rotor traces an epitrochoidal path and each point thereon has an acceleration force actong on it which may be shown to be at any instant the same as a force produced by the rotor that would result from the rotational motion of the rotor about a point which may be referred to as the instantaneous center of acceleration of the rotor. It may be further shown that as the rotor rotates the direction of the acceleration force acting on any particular point on the rotor will periodically reverse so that at one instant the acceleration force may be directly radially outward and at the next instant the acceleration force will be directed radially inward. Reference may be made to copending application Serial No. 206,753, filed July 2, 1962, wherein the action of the acceleration forces acting on the rotor is clearly described and illustrated.

As explained in said copending application, each particle of oil within the rotor is subject to the same acceleration force as that acting on an adjacent wall portion of the rotor. So it can be seen, that as the oil enters the passageways 72 in the rotor 24 it will also be transferred through the rotor by the varying acceleration forces produced during rotation of the rotor, as well as the pumping action produced by the inclination of the passageways and relative direction of rotation of the rotor, as described

above. As the oil reaches the recessed openings 76 at the opposite side of the rotor from which the oil was supplied, the acceleration forces acting radially inwardly at a particular instant of rotor rotation will throw the oil out of said openings 76 and discharge the oil into the region between the eccentric 22 and the adjacent rotor end wall 25 where it may be collected and drained through a drain outlet 78 in outer body end wall 16. The oil may then be recirculated back through the pump (not shown) and used over again. Of course, it should be realized that the invention is not limited to the oil supply means illustrated and any suitable oil supply means may be substituted which will provide fresh cooling oil for the interior of the rotor.

So it can be seen that a system is provided which will supply a liquid coolant to the interior of the rotor and the coolant will have a relatively short residence time in the rotor. The coolant is pumped through the rotor by the rotary motion of the rotor itself and the novel cooling passageways provided therein. As the coolant flows through the rotor, heat is transferred from the heated surfaces of the rotor to the coolant which is quickly removed and then replaced by fresh coolant so that the heat from the rotor walls is quickly carried away and the rotor wall temperature adequately stabilized. Further, it can be seen that only a relatively small amount of oil need be used to cool the rotor interior and the amount of weight added due to the presence of the oil in the rotor is not significant and counterbalancing is not required. Also, due to the fact that only a relatively small amount of oil is used, a smaller oil pump may be used, than that in the case where the rotor must be kept full of oil, which also adds to a total overall reduction in weight of the engine. Consequently, the costs of the engine will be reduced and the performance made more efficient since weight is an important factor in combustion engine both from a cost and performance standpoint.

While the invention has been specifically set forth in detail in the above description the invention is not to be intended to be so limited thereby and various modifications and alterations may be made by those skilled in the art without departing from the spirit and scope of the invention defined in the following claims.

I claim:

1. In a rotary mechanism comprising an outer body having a cavity therein, a rotatable shaft mounted in said outer body co-axial with said cavity and having an eccentric portion thereon, a rotor journaled on said eccentric portion, said rotor having a multi-lobed peripheral surface forming a plurality of circumferentially-spaced apex portions for sealing engagement with the inner peripheral surface of said outer body thereby forming working chambers between the rotor peripheral surface and the inner peripheral surface of said outer body which upon relative rotation of said rotor and said outer body vary in volume, said rotor having a hollow interior with a plurality of spaced ribs projecting inwardly from the outer wall of the hollow rotor with each of said ribs running from one end face of the rotor to the other in a direction inclined to the rotor axis to form separating walls of a plurality of open-end passageways inclined to the rotor axis, said rotor also having an inner annular wall portion secured across said ribs to form the inner walls of said passageways; means for supplying a liquid coolant to one end face of the rotor for flow of the coolant into adjacent open ends of said rotor passageways, the inclination of said rotor passageway separating walls being such, relative to the direction of rotor rotation, to function as a pump during rotor rotation to pump the liquid coolant through said rotor inclined passageways from said one rotor end face to the other rotor end face.

2. In a rotary mechanism as recited in claim 1 in which said rotor passageways interconnect in the vicinity of each apex portion such that the liquid coolant upon being pumped through said passageways will flow in close proximity to the inner surface of each of said apex portions.

3. In a rotary mechanism as recited in claim 1 wherein said inner annular wall portion comprises a plain sleeve type bearing supported by said ribs.

4. In a rotary mechanism as recited in claim 1 wherein said means for supplying a liquid coolant includes at least one coolant supply passageway in said shaft, a radially-extending coolant supply passageway in said eccentric portion communicating at one end with said coolant supply passageway in said shaft and at its opposite end with the outer surface of said eccentric portion and an axially extending coolant supply passageway in said eccentric portion extending axially from said radially-extending coolant supply passageway to the side of said eccentric portion adjacent to said one end face of the rotor.

5. In a rotary mechanism as recited in claim 4 wherein said inner annular wall portion comprises a plain sleeve type bearing supported by said rib members and said liquid coolant supply means further comprises an annulus formed in the radially inner surface of said bearing in communication with said radially-extending coolant supply passageway in said eccentric portion so that a portion of said liquid coolant flows out from between said bearing, and its shaft eccentric portion adjacent to said one end face of the rotor for flow therefrom into the adjacent open ends of the rotor passageways.

6. A rotor for a rotary mechanism having an outer body defining a cavity and a rotatable shaft mounted in said outer body co-axial with said cavity, said shaft having an eccentric portion thereon, said rotor being journaled on said shaft eccentric portion for rotation relative to said outer body and said rotor being in sealing engagement with the inner peripheral surface of said outer body, and said rotor having a peripheral wall interconnected with a pair of spaced end walls defining a cavity, a plurality of spaced rib members projecting from the inner surface of said rotor peripheral wall defining a plurality of passageways therebetween, each of said rib members extending from a portion of one end wall of said rotor to a portion of the opposite end wall of said rotor circumferentially-spaced from the portion of said one end wall and said rib members forming the walls of a plurality of spaced liquid coolant conducting passageways with each of said passageways having an opening in said one rotor end wall for receiving a liquid coolant therein and an opening in said opposite rotor end wall for discharge of said liquid coolant from said passageway, and said rib members being disposed relative to the direction of rotation of said rotor such that said rib members and said passageways function as a pump during rotation of said rotor to pump the liquid coolant from the opening in said one rotor end wall to the discharge opening in said opposite rotor end wall.

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