April 27, 1965 HANNS-DIETER PASCHKE 3,180,323

AIR COOLING SYSTEM FOR ROTARY MECHANISMS

Filed May 31, 1961 3 Sheets-Sheet 1

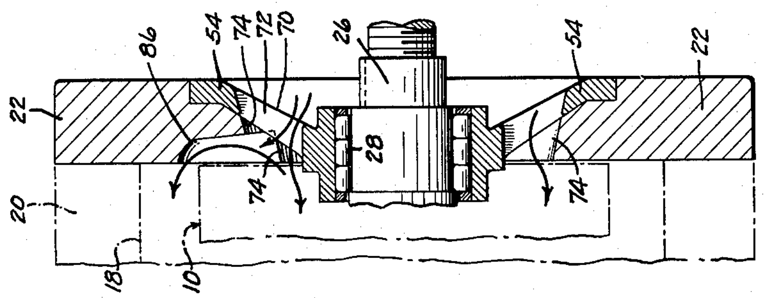

Fig. 5

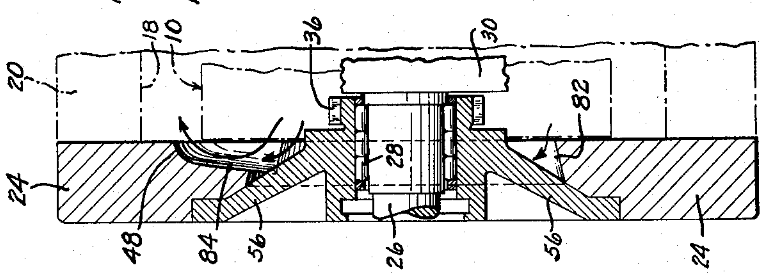

Fig. 4

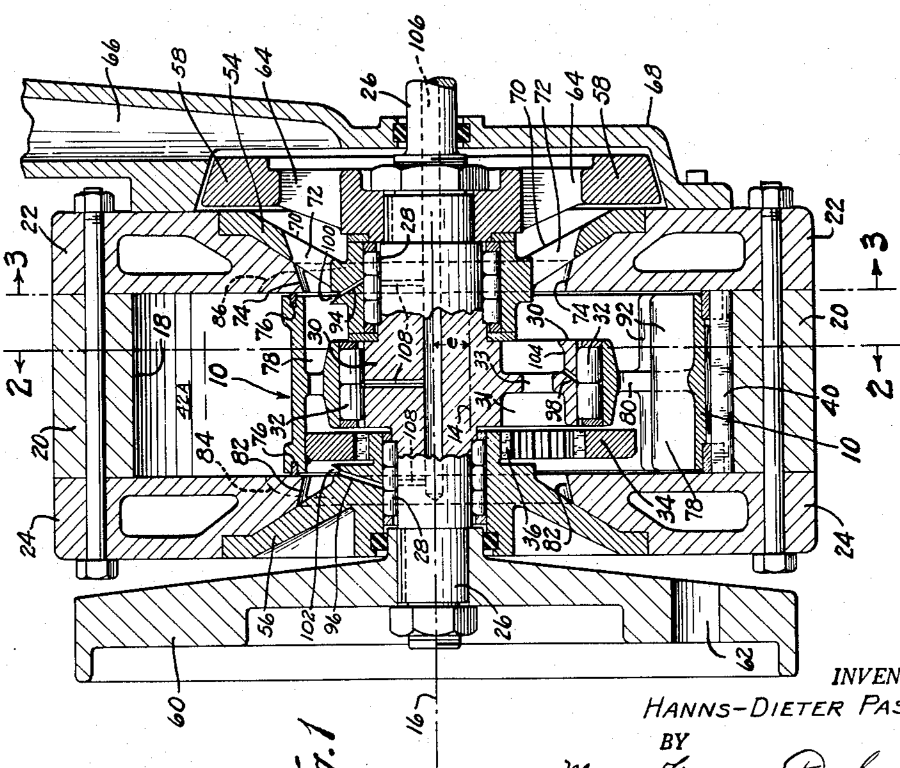

Fig. 1

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AIR COOLING SYSTEM FOR ROTARY MECHANISMS

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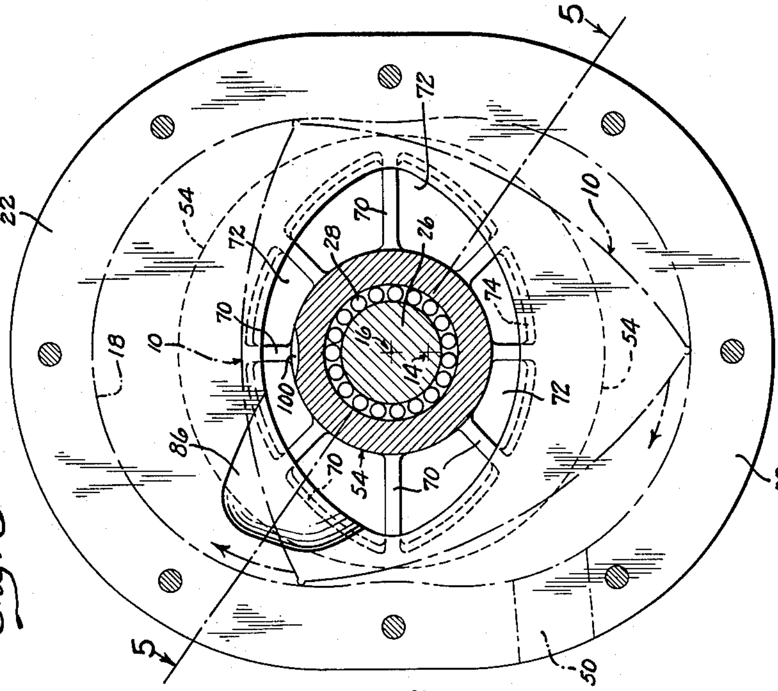

Fig. 3

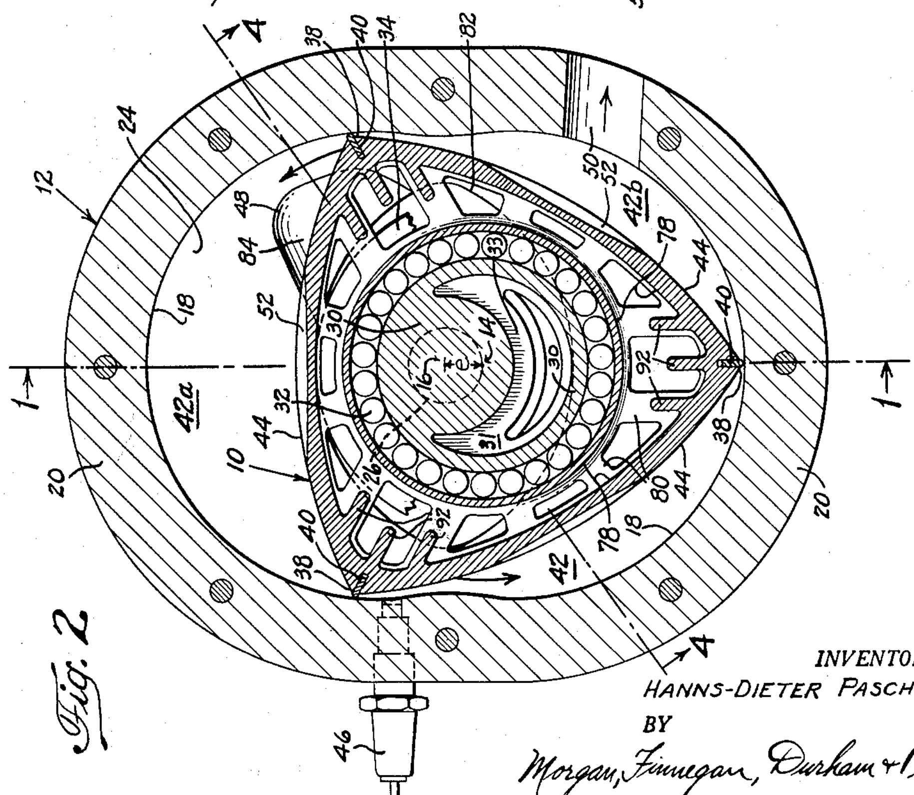

Fig. 2

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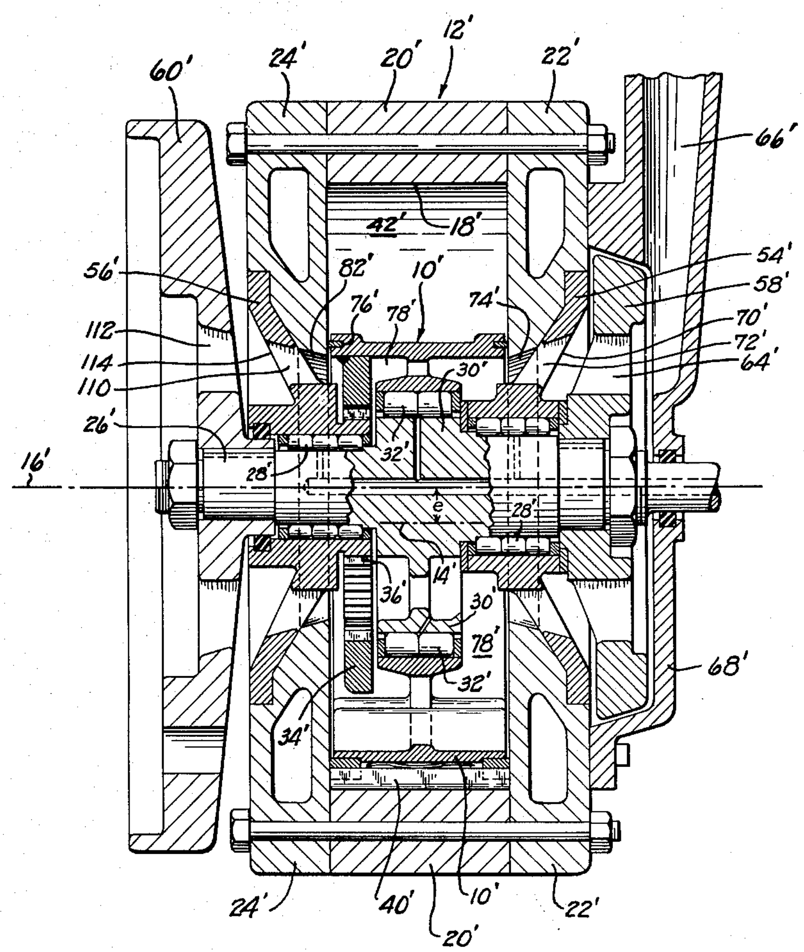
Fig. 6

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United States Patent Office

3,180,323
Patented Apr. 27, 1965



# 3,180,323
# AIR COOLING SYSTEMS FOR ROTARY MECHANISMS

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Filed May 31, 1961, Ser. No. 113,918
Claims priority, application Germany, June 1, 1960, N 18,438
2 Claims. (Cl. 123—8)

The present invention relates to means for cooling rotary mechanisms, and more particularly to an air cooling system for the inner body or rotor of such mechanisms.

Although this invention is applicable to and useful in almost any type of rotary mechanism which presents a cooling requirement, such as 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 which 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, that with slight modifications which would be obvious to a person skilled in the art, the invention is equally applicable to other types of rotary mechanisms.

The present invention is particularly useful in rotary mechanisms of the type that comprise an outer body having an axis, axially-spaced end walls, and a peripheral wall interconnecting the end walls. In such rotary mechanisms the inner surfaces of the peripheral wall and end walls form a cavity, and the mechanism also includes an inner body or rotor that is mounted within the cavity between its end walls.

The axis of the inner body or rotor is eccentric from and parallel to the axis of the cavity of the outer body. The rotor has axially-spaced end faces disposed adjacent to the end walls of the outer body and a plurality of circumferentially-spaced apex portions. The rotor is rotatable relative to the outer body, and its apex protions substantially continuously engage the inner surface of the outer body to form a plurality of working chambers that vary in volume during engine operation, as a result of relative rotation between the rotor and outer body.

The inner surface of the peripheral wall of the outer body has a multi-lobed profile that is preferably an epitrochoid and the number of lobes of this epitrochoid is one less than the number of apex portions of the inner body or rotor.

By suitable arrangement of ports, such rotary mechanisms may be used as fluid motors, compressors, fluid pumps, or internal combustion engines. This invention is of particular importance when employed with a rotary mechanism that is designed for use as a rotary combustion engine, and, accordingly, will be described in combination with such an engine. As the description proceeds, however, it will be apparent that the invention is not limited to this specific application.

When the rotary mechanism is designed for use as a rotary combustion engine, such engines also include an intake passage means for administering a fuel-air mixture to the variable volume working chambers, an exhaust passage means communicating with the working chambers, and suitable ignition means. During engine operation the working chambers of the engine undergo a cycle of operation which includes the four phases of intake, compression, expansion, and exhaust. This cycle of operation is achieved as a result of the relative rotation of the inner body or rotor and outer body and for this purpose both the inner body or rotor and outer body may rotate at different speeds, but preferably the inner body or rotor rotates while the outer body is stationary. Such an engine could obviously also be operated as a diesel engine.



For efficient operation of the engine, its working chambers should be sealed, and therefore an effective seal is provided between each rotor apex portion and the inner surface of the peripheral wall of the outer body, as well as between the end faces of the rotor and the inner surfaces of the end walls of the outer body.

Between the apex portions of its outer surface the rotor has a contour that permits its rotation relative to the outer body free of mechanical interference with the multi-lobed inner surface of the outer body. The maximum profile which the outer surface of the rotor can have between its apex portions and still be free to rotate without interference is known as the "inner envelope" of the multi-lobed inner surface, and the profile of the rotor that is illustrated in the accompanying drawings approximates this "inner envelope."

For purposes of illustration, the following description will be related to the present preferred embodiment of the engine in which the inner surface of the outer body is basically a two-lobed epitrochoid, and in which the rotor or inner body has three apex portions and is generally triangular in cross-section but has curved or arcuate sides.

It is not intended that the invention be limited, however, to the form in which the inner surface of the outer body approximates a two-lobed epitrochoid and the inner body or rotor has only three apex portions. In other embodiments of the invention the inner surface of the outer body may have a different plural number of lobes with a rotor having one more apex portion than the inner surface of the outer body has lobes.

In a rotary combustion engine of the type described above, as the rotor rotates relative to the outer body, each of its three working faces goes through all four phases of the cycle of operation in succession, i.e., intake, compression, expansion, and exhaust. The total heat input to each face of the rotor during the complete cycle of operation can be substantially high, and this is especially true when the engine is operating at a high number of revolutions per minute.

It has been found desirable to use a rotor fabricated from a light weight metal alloy in many applications of the rotary combustion engine. A light weight metal alloy, such as an aluminum alloy, provides the important benefits and advantages of ensuring a great saving of weight in the principal moving parts of the engine, and also provides a rotor having high thermal conductivity. The latter characteristic is particularly beneficial in preventing the formation of hot spots within the rotor, while the former characteristic greatly reduces energy losses the result from inertia forces of the rotor.

A rotor constructed of a light weight metal alloy, howevery, demands adequate and efficient cooling, as such alloys will fail from overheating at a considerably lower temperature than a material, such as, cast iron or steel. Accordingly, although the present invention is not limited to use with light weight metal alloy rotors, it is particularly useful when used with such rotors.

In accordance with the present invention, means are provided for cooling the rotor of a rotary combustion engine during operation, or more particularly, means are provided for cooling the rotor, with incidental cooling of the outer body, by passing a stream of air or other gaseous medium through the rotor.

It is a primary object of this invention to provide a novel air cooling system for the rotor of a rotary mechanism.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that avoids the need for the use of a liquid coolant to cool the rotor and thereby eliminates the problem of preventing the escape of coolant liquid along the end of the rotor into the working chambers of the engine and also eliminates the energy losses that result from churning and turbulence of cooling liquid within the rotor cavity that result from changing accelerations exerted on the rotor during operation of the engine. The energy losses due to churning and turbulence of a liquid coolant, if not carefully controlled can cause a serious decrease in the efficiency of the engine. Most liquid cooling systems that have been previously proposed for cooling the rotors of rotary mechanisms provide for supply of the cooling liquid to the rotor and its return from the rotor by way of the eccentric or the end walls of the outer body, and these liquid cooling systems for the rotor have generally presented a problem in devising a means to prevent the escape of the cooling liquid along the end face of the rotor into the working chambers of the engine; the present invention overcomes this problem.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that permits the use of a fuel, air, and lubricant mixture as the coolant for the rotor, as well as for the combustible fuel-air mixture that comprises the charge for the engine and the lubricant for the bearings and the gears of the engine. Use of the cooling system of this invention permits the elimination of an oil seal on the end faces of the rotor radially inward from the gas seal.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that uses the cooling air as the air supply for the fuel-air mixture that forms the combustible charge of the engine, when a fuel injection type engine is used. It is also an object of this invention to permit the use of the cooling air as a supply for scavenging air to be used to scavenge the working chambers of the engine in cooperation with the exhaust port.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that uses the air-fuel mixture that forms the combustible charge for the engine as the cooling air for the rotor and obtains additional cooling effect through vaporization of the entrained fuel particles as they come near or into contact with the hot walls of the rotor cavity.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that will draw lubricant through passages provided for this purpose from the lubricant that is fed to the eccentric and shaft bearings by suction of the cooling air passing through the rotor and will deposit this air entrained lubricant on the inner surfaces of the outer body to provide lubrication for the apex seals and side gas seals of the rotor as they move into sliding engagement with the inner surface of the outer body.

Another object of this invention is to provide a novel air-cooling system for the rotor of a rotary mechanism that permits the use of at least one flywheel of the mechanism as the pressure-fan to aid in pushing cooling air through the rotor and that in some embodiments of the invention permit the use of a second flywheel as a suction fan to aid the passage of the cooling air to the rotor by providing a suction force at its exit from the rotor.

Another object of this invention is to provide a novel air cooling system for the rotor of a rotary mechanism that utilizes the negative pressure in a working chamber of the mechanism as an aid in drawing cooling air through the rotor.

Another objective of the present invention is to provide a novel air cooling system for the rotor of a rotary mechanism that is sufficiently effective and efficient to permit the construction of the rotor from light weight metal alloys, such as aluminum, without danger of overheating the thermal distortion of the rotor.

Additional objects of this invention are to provide a



novel air cooling system for the rotor of a rotary mechanism that makes the rotor relatively inexpensive and easy to fabricate, that achieves substantial savings in weight of the mechanism and particularly the rotor, that virtually eliminates the problem of leakage or freezing of the cooling medium, and that requires very little servicing as compared with a liquid cooling system. Cooling fins may be used on the interior of the rotor cavity adjacent to the apex portions of the rotor to prevent excessive heating of the apex portions and possible binding of the apex seals within their slots in the apex portions. The air cooling cavity in the rotor permits reduction of its weight without sacrificing its strength, and a further advantage of the air cooling system for the rotor is that it is the less expensive to manufacture and produce than a liquid cooling system.

To achieve the foregoing objects, and in accordance with its purpose, this invention provides means which, as embodied and broadly described, comprise a rotor having a cavity that is open at least towards one end wall of the outer body, that is passed through by the cooling medium, and that communicates with a cooling air supply port arranged in at least one end wall of the outer body in that region of the inner surface of the end wall that is continuously covered by the rotor during rotation of the rotor relative to the outer body.

When air is used as a cooling medium in this invention, it is advantageous to provide an annular chamber in each end wall that communicates with the cavity in the rotor through large openings in the rotor end faces. The annular chamber in one end wall serves as a delivery channel for supplying air to the rotor cavity. The annular chamber in the other end wall of the outer body, in one embodiment of the invention, serves as a collecting channel for collecting the air from the rotor cavity and delivering it to an appropriate transfer passage for use as the combustible charge, part of the combustible charge, or as scavenging air.

In another embodiment of the invention the annular chamber in the second end wall acts as a collecting channel for exhausting the cooling air from the rotor cavity so that the cooling air passes through the rotor cavity but is not further used by the engine after it has passed through the cavity.

This invention is especially advantageous as a cooling system when the complete fuel-air mixture that forms the combustible charge is used as the cooling medium. When this is done, an additional cooling effect is obtained by removal of the latent heat of vaporization by the vaporizing of fuel particles entrained in the fuel-air mixture as they approach or come into contact with the hot walls of the rotor cavity.

When the fuel-air mixture is used as a cooling medium in this invention an intake means is provided in one end wall of the outer body and a transfer passage is provided in the other end wall. The intake passage means communicates with the delivery channel, referred to above, and the transfer passage communicates with the collecting channel, also referred to above. The opening and closing of the mouth of the transfer passage that opens into the working chamber of the engine is controlled by the peripheral edge of the rotor.

It is also possible to provide intake passage means in one end wall and a transfer passage in each end wall; one transfer passage communicating with the collecting channel, and the other transfer passage communicating with the delivery channel. The same arrangement can also be used in engines using fuel injection to supply the combustion air, or for use to provide scavenging air only where a scavenging of the working chambers is desired. When scavenging only is desired, the transfer passage is located so that it is open to a working chamber of the engine during the exhaust phase.

A lubricant may be added to the cooling medium to obtain lubrication of these parts of the engine that engage each other in sliding contact, especially the apex seals and the side gas seals carried by the rotor that are in sliding engagement with the inner surface of the outer body. Lubricant entrained in the cooling air will condense on the inner surfaces of the outer body in sufficient quantity to provide the desired lubrication of the rotor seals.

The bearings may also be lubricated, and especially the bearings that support the rotor on the eccentric and the shaft bearings by providing bores that extend from the channels or cavities traversed by the cooling medium to the rotor and shaft bearings. The cooling medium with its entrained lubricant is supplied to the bearings through these bores. The lubrication of these bearings can be improved by providing collecting pockets within the plane of the inner surfaces of the end walls below the intake passage means and the transfer passage; the bores extend from these collecting pockets and the collecting pockets receive lubricant that has condensed on the inner surfaces of the end walls as it is scraped off the end walls by the gas side seals of the rotor.

If entrainment of a lubricant in the cooling medium is not desired, the lubrication of the bearings can be accomplished in the usual way by supplying a lubricant through passages bored in the eccentric shaft. When this arrangement is used, however, it is also possible to obtain a lubrication of the rotor seals as they slide in engagement with the inner surface of the outer body by continuing to provide the bores that extend from the bearings to the channels or cavities of the rotor and the cavities of the outer body that are traversed by the cooling medium. Small amounts of lubricant are admixed or entrained in the cooling medium because of the suction effect that the cooling medium creates as it passes over the outlets of these bores.

A blower can be mounted upon the eccentric shaft in front of the outer orifice that feeds to the delivery channel to increase the mass and rate of flow of the cooling medium through the rotor cavity. This blower can be used as a supercharger if the cooling medium is a fuel-air mixture for combustion air, or as a scavenging fan if the cooling medium is scavenging air. In one embodiment of this invention in which cooling air enters through one end wall of the outer body and leaves through the other end wall after passing through the rotor cavity without being utilized in the working chambers of the engine, a blower can be arranged on each side of the outer body, one designed as a pressure fan, and the other as a suction fan.

The fan wheels are preferably also formed as fly-wheels and include counter-weights to balance the rotor and eccentric. Suitable guide vanes may be provided between the fan wheel and the channels for directing the cooling air in the desired direction.

Since the seals at the apex portions of the rotor must be movable relative to the rotor to function properly it is important that the apex portions of the rotor be cooled well enough to prevent binding of the seals in the apex portions. This invention permits the desired cooling effect to be obtained by providing cooling fins within the rotor cavity in the region of the apex portion such that the fins are swept by the gaseous cooling medium as it passes through the rotor cavity and heat is rapidly removed from the rotor apex portions.

Additional objects and advantages of the invention will be set forth in part in the description which 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, which 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.

Two embodiments of this invention are shown in the accompanying drawings.

Of the drawings:

FIG. 1 is a central vertical section of the mechanism taken along line 1—1 of FIG. 2. FIG. 1 shows an embodiment of the invention in which the cooling medium, after passing through the rotor cavity is introduced into the working chambers of the mechanism;

FIG. 2 is a sectional view of the mechanism taken along the line 2—2 of FIG. 1. The gearing has been omitted from this view for clarity;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1 and showing the inner orifice of the delivery channel that admits the cooling medium to the rotor cavity;

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

FIG. 5 is a sectional view taken along the lines 5—5 of FIG. 3 showing the collecting channel and transfer passage for combustion air;

FIG. 6 is a central vertical section of a modified form of this invention in which the cooling air is exhausted to the atmosphere after passing through the rotor cavity instead of being admitted to one or more of the working chambers of the mechanism.

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 this invention, an example of which is illustrated in the accompanying drawings.

In accordance with the invention, a rotary combustion engine and a means for air cooling its rotor or inner body are provided. As embodied, and as shown in FIGS. 1, 2, and 6, the present preferred embodiment of the invention includes a rotary combustion engine comprising a generally triangular rotor **10** having arcuate sides which 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.

As shown in FIGS. 1 and 2, and as here preferably embodied, the rotor **10** rotates on an axis **14** that is eccentric from and parallel to the axis **16** of the curved inner surface of the outer body **12**. The distance between the axes **14** and **16** is equal to the 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 which 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**. A 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 rotatively mounted upon the shaft eccentric **30** by rotor bearings **32**.

As shown in FIGS. 1 and 6, an internally-toothed or ring gear 34 is rigidly attached to the rotor 10. The ring gear 34 is in mesh with an externally-toothed gear or pinion 36 that is rigidly attached 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 the positioning load that would otherwise be placed upon the apex portions of the rotor 10.

As shown most clearly in FIG. 2, the rotor 10 includes three apex portions 38 that carry radially 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. 2, the rotation of the rotor relative to the outer body is counter-clockwise and is so indicated by an arrow.

A spark plug 46 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 which, on expansion, drives the rotor in the direction of the arrow. As previously stated, 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. 2, one lobe of the epitrochoid 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.

The working faces 44 of the rotor 10 are provided with cut-out portions or channels 52 that permit combustion gases to pass freely from one lobe of the epitrochoidal inner surface 18 to the other lobe, when the rotor is at or near the dead center of maximum compression position. Also, a desired compression ratio of the engine may be attained by appropriate proportioning of the volume of the channels 52.

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.

In the present preferred embodiment of this invention illustrated in the drawings, the end walls 22, 24 are provided with bearing flanges 54, 56, respectively, that rotatably support the shaft 26 on bearings 28. The shaft 26 in turn carries two fly wheels, fly wheel 58 adjacent to end wall 22, and fly wheel 60 adjacent to end wall 24. The fly wheels 58 and 60 are suitably counterweighted to balance the rotor and eccentric, such as, with lightening holes 62 as shown for fly wheel 60.

Fly wheel 58 is provided with vanes 64 that are canted in a direction to cause them to act as a pressure fan in a direction toward the rotor.

An intake passage means 66 for fresh gases is provided upstream from the fly wheel 58. A carburetor (not shown) may optionally be attached upstream from the intake passage means 66 and would normally be so attached unless fuel injection is to be used with the engine. The intake passage means, as shown in FIG. 1, is formed from the end wall cover 68.

As shown in FIGS. 1 and 3, he bearing flange 54 is provided with ribs 70 and supply passages 72 through which the gaseous cooling medium can flow. The ribs 70 may be canted or shaped to act as guide vanes to guide the gaseous cooling medium in a desired direction.

After flowing through the passages 72 the gaseous cooling medium enters an annular delivery chamber 74 that is open towards the rotor 10 and lies within the region of the inner surface of the end wall 22 that is continuously covered by the rotor or bordered by its gas side seals 76 as the rotor rotates relative to the outer body.

In accordance with the invention means are provided for the flow of the gaseous cooling medium through the rotor. As embodied, this means comprises a cavity 78 within the rotor that is open towards both end walls 22, 24. As shown in FIG. 2, this cavity 78 within the rotor is large and is interrupted only by supporting ribs 80 that support the outer portion of the rotor upon the eccentric 30 through the bearings 32.

In accordance with the invention, means are provided for receiving the gaseous cooling medium after it has passed through the cavity of the rotor. As embodied, and as shown in FIGS. 1 and 5, this means comprises an annular collecting chamber 82 that is similar to and is the counterpart of the annular delivery chamber 74 in the end wall 22. The annular collecting chamber 82 is formed in the end wall 24 and receives the gaseous cooling medium as it leaves the rotor cavity 78. The annular collecting chamber 82 also lies completely within the region that is continuously covered by the rotor and is bordered by its gas side seals 76.

In accordance with the invention means are provided for transferring the gaseous cooling medium from the rotor cavity into a working chamber of the engine. As embodied, and as shown in FIGS. 2 and 5, this means comprises the annular collecting chamber 82 in conjunction with the transfer passage 84. The upper end of the transfer passage 84 forms the intake port 48 for the engine in the embodiment shown in FIGS. 1 through 5. The admission of the gaseous cooling medium to the working chamber of the engine is controlled by the outer periphery of the rotor 10, or working face 44 in a manner such that the working chamber 42 communicates with the rotor cavity 78 only while the working chamber 42*a* is undergoing the intake phase.

If the engine is of the fuel injection type, the gaseous cooling medium will be combustion air, but if the engine is not of the fuel injecton type, then the entire combustible charge constituting the fuel-air mixture will form the gaseous cooling medium and will be introduced into the working chamber 42*a* from the transfer passage 84 and intake port 48 after having passed through the rotor cavity 78.

In operation, the fresh cooling gases are pulled through the rotor cavity 78 by the negative pressure within the working chamber 42*a* and by the pressure fan arrangement of the fan wheel 58. The cooling gases under pressure from the blade 64 of the fan wheel 58 flow through the passages 72 around the guide vanes 70 into the annular delivery chamber 74, through the rotor cavity 78, into the annular collecting chamber 82, and from the chamber 82 into the transfer passage 84 through the intake port 48 and into the working chamber 42*a* as it undergoes its intake phase. The flow of cooling gas into the working chamber 42*a* will be interrupted when the working face 44 of the rotor closes the intake port 48, as shown in FIG. 2. Flow into chamber 42*a* will begin again, however, when the succeeding working face 44 of the rotor uncovers the intake port.

As shown in FIG. 3, a second transfer passage **86** may be provided in the end wall **22** so that there will then be a transfer passage in both end walls. The operation of the transfer passage **86** is the same as that for the transfer passage **84**.

As already indicated in the embodiment of FIGS. 1 through 5, either air or a fuel-air mixture may be supplied through the intake passage **66** for flow through the rotor transfer passage **84** (and the transfer passage **86** if provided) into the working chambers (chamber **42**a in FIG. 2) for combustion in this chamber. If only air is so supplied, then instead of using this air for combustion purposes, it may alternatively be used to help scavenge the working chambers of exhaust gases. For this latter purpose the transfer passage **84**, and, if provided, the transfer passage **86**, would be shifted to a position so as to open into the working chambers (chamber **42**b in FIG. 2) adjacent to the exhaust port **50**.

As previously described, the apex seals **40** are radially movable within their mounting grooves in the apex portions **38** of the rotor **10**. In accordance with the invention means are provided to prevent an excessive heating of the apex portions **38** that could result in binding the apex seals **40** within their mounting grooves against radial movement. This means provides for intensive cooling of the apex portions and as embodied, comprises a series of cooling fins **92** arranged within the rotor cavity **78** adjacent to the apex portions of the rotor, as shown in FIG. 2. Also as shown in FIG. 2, the cooling fins **92** extend substantially in an axial direction across the width of the rotor cavity **78**.

In accordance with the invention, a lubricant may be added to the fuel-air mixture or the combustion and scavenging air, respectively, for lubricating both the apex seals **40** and the side gas seals **76**. These rotor seals engage and slide against the inner surfaces of the outer body continuously during operation of the mechanism and it is important that they receive sufficient lubrication to keep friction to a minimum. The desired lubrication can be achieved through inclusion of a lubricant in the cooling; the lubricant is admixed or entrained into the cooling gas as it is fed into the engine through the intake passage means **66**.

In accordance with the invention, means may be provided to lubricate the rotor bearings **32** and shaft bearing **28** by means of a lubricant entrained with the cooling gas. As embodied, the means comprises passage **94** in bearing flange **54**, passage **96** in bearing flange **56**, and passage **98** in the eccentric **30**. These passages extend to the shaft and rotor bearings from their respective annular chambers **74** and **82** and from the rotor cavity **78**.

By means of these passages **94, 96, 98**, the cooling gas with its entrained lubricant can be delivered to the respective bearings **28, 32**. The lubrication of the bearings **28, 32** can be reinforced by the provision of collection pockets **100, 102, 104** at the bearing flanges **54, 56**, and eccentric **30**, respectively. The pockets **100, 102** in the bearing flanges **54, 56** are arranged in the plane of the inner surface of the end walls **22, 24**. Radially inside of the annular chambers **74** and **82** so that these pockets collect the lubricant scraped off of these inner surfaces by the rotor and its gas side seals **76**. The collecting pockets direct the lubricant into the passages **94, 96, 98** and from thence to the bearings.

In accordance with the invention, a lubricant can be omitted from the cooling gas and the lubrication of the shaft bearings **28** and rotor bearings **32** can be achieved by means of axial **106** and radial **108** passages within the eccentric **30** in the shaft **26**, as shown in FIG. 1.

When this type of lubrication is used, lubrication of the rotor seals is achieved by retaining the passages **94, 96, 98**. The suction effect of the cooling gas passing through the rotor cavity **78** is sufficient to draw lubricant up through the passages **94, 96, 98** and admix or entrain this lubricant with the cooling gas. Sufficient of the lubricant then condenses on the inner surfaces of the outer body to provide adequate lubrication of the rotor seals.



In accordance with this invention, an alternative embodiment of the invention is shown in FIG. 6. To simplify and clarify the description of this alternative embodiment of the invention, those parts of the embodiment of FIG. 6 that correspond to similar or almost identical parts of the embodiment shown in FIGS. 1 through 5 will be designated by the same reference numerals, but the reference numerals will be primed.

The embodiment of the invention shown in FIG. 6 is similar in its design to the embodiment shown in FIGS. 1 through 5, with the one outstanding difference, that instead of using a fuel-air mixture, or combustion air, or combustion air and scavenging air for the cooling gas, simple cooling air is used with no purpose other than that of cooling the rotor **10'** and whatever incidental cooling of the outer body **12'** may be obtained in the course of flowing cooling air through the rotor.

In accordance with the invention, the transfer passage **84** (and of course also the transfer passages **86**) are omitted from the construction. Th ebearing flange **56'** of FIG. 6 is modified from the bearing flange **56** of FIG. 1 in that it is ribbed like the bearing flange **54** of FIG. 1 and includes outlet passages **110** that correspond to the inlet passages **72** of FIGS. 1 and 3. The outlet passages **110** extend from the annular collecting chamber **82'** that, similar to the annular collecting chamber **82** in FIG. 1, is arranged in the end wall **24'** in that region of the inner surface of the end wall that is continuously covered by the rotor and is radially inward from the path of travel of the gas side seal **76'** of the rotor.

In accordance with the invention, the fly wheel **60'** is designed as a suction fan with vanes **112** canted or oriented to provide a suction force to assist the pressure force provided by fan wheel **58'** to flow the cooling gas through the rotor cavity **78'**. The outlet passages **110** in the embodiment of FIG. 6 may be provided with guide vanes through the shaping or canting of the ribs **114** of the bearing flange **56'** similar to the manner in which the guide vanes **70** of the bearing flange **54** in FIG. 1 were shaped to aid the flow of the cooling gas.

The intake of the fuel-air mixture or the combustion air for the embodiment shown in FIG. 6 is effected in the ordinary manner by means of a suitably arranged intake port and exhaust port. In this embodiment both a peripheral intake port and exhaust port are preferably used. If a side intake port were to be used, the intake area would have to be quite small as compared to conventional side intake port rotary combustion engines. Because of the large opening that leads into the rotor cavity **78'** in this invention, unless a side intake port is made quite small the cooling air and the charge in the combustion chamber would mix; this would make the engine inoperative. Accordingly, with the embodiment of FIG. 6 the use of an intake port in the peripheral wall is preferred to a side intake port. Similarly, the exhaust port is preferably also located in the peripheral wall.

As best shown in FIGS. 1 and 3 the eccentric **30** in this invention includes a half-moon opening in its end faces that provides a cavity **31** directly through the eccentric. This cavity **31** permits the cooling gas to flow through the eccentric as well as through the rotor cavities **78**. The cavity **31** also makes the eccentric lighter in weight and contributes to the overall balance of the engine. A strengthening rib **33** is provided in the center of the eccentric cavity **31**.

This invention provides the means for achieving an efficient and effective air cooling system for a rotary combustion engine or other type of rotary mechanism. By using the means of the present invention to achieve an air cooling system, it is possible to effect significant economies in the manufacture and operation of rotary mechanisms. The cooling cavities in the rotor and eccentric lighten these parts and reduce inertia losses without the accompanying disadvantages that are introduced when a liquid coolant is used. When a liquid is directed into the rotor to cool it, problems of churning and turbulence of the liquid are introduced as well as an inertia loss caused by the weight of the liquid itself.

The air cooling system of the present invention is relatively simple, easy, and economical to construct and trouble free in operation. Unlike a liquid cooling system, the air cooling system provided by this invention avoids any necessity for a multiplicity of fittings, conduits, channels, and passages for transferring cooling liquid from one point to another in the system with consequent danger of leakage, breakage, and failure through loss of cooling liquid.

Another advantage of the present invention is that the cooling air flow may be routed through the outer body 12, 12′ of the engine in a manner such that the cooling air will cool the outer body as well as the rotor in the course of its passage through the engine. The arrangement of air cooling passages within the outer body to achieve this object presents no unusually difficult problems to be overcome and is considered to be within the skill of a person trained in the art.

From the foregoing detailed description of the present preferred embodiment, it is apparent that this particular embodiment is restricted to mechanisms in which the outer bodies are stationary and the rotors and eccentrics are rotary, but it is no intended to limit the scope of the invention to such a mechanism. It is apparent that with mechanical changes that would be obvious to a person skilled in the art, alternative embodiments using the principles of this invention could be constructed in which both the outer body and rotor are rotary and the eccentric is stationary with a power shaft taken off the outer body.

Accordingly, 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 which do not sacrifice its chief advantages.

What is claimed is:

1. In a rotary mechanism having a hollow outer body comprising two spaced-apart end walls and a peripheral wall interconnecting the end walls, a rotatable shaft journaled in the end walls on the axis of the outer body and having an eccentric portion disposed within the outer



body, and a rotor disposed within the outer body having a plurality of portions sweeping the inner surface of the peripheral wall in sealing relation therewith, the rotor being mounted on the eccentric for rotation relative to the outer body and to the eccentric; the improvement of a cooling system comprising the rotor having an internal cavity for the flow of a gaseous cooling medium through the rotor, the cavity being open toward at least one of the end walls, the end wall adjacent to the rotor opening having a port for supplying cooling medium therethrough to the rotor opening, the port being located in that portion of the end wall which is at all rotor positions radially inward of the outer periphery of the rotor, the rotor being mounted on the eccentric on rotor bearings to permit relative rotation between the eccentric and the rotor, the shaft being supported by the end walls of the outer body on shaft bearings, the mechanism including passages connecting the rotor cavity with the shaft bearings and the rotor bearings, whereby lubricant admixed with the cooling gas can be carried by the cooling gas to the bearings through said passages.

2. The invention as defined in claim 1, in which the rotary mechanism has collecting pockets adjacent to the rotor cavity ends of the passages and in the plane of the inner surface of the end wall to receive lubricant scraped off the end walls by the movement of the rotor adjacent to the end walls during rotation of the rotor relative to the outer body.


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