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Lamm

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[54] COOLING SYSTEM FOR THE COOLING OF THE HOUSING OF A ROTARY PISTON INTERNAL COMBUSTION ENGINE

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[51] **Int. Cl.²** **F02B 55/10**

[58] **Field of Search** 123/8.01, 41.29; 418/83, 418/61

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[57] **ABSTRACT**

A cooling system with a liquid cooling medium for cooling the housing of a rotary piston internal combustion engine, especially of trochoidal construction, which consists of at least one casing, of end parts and possibly of one or several intermediate parts, in which the cooling system consists of at least two cooling circulations which are completely separated from one another; the cooling media of the two cooling circulations may thereby have different temperatures.

28 Claims, 2 Drawing Figures

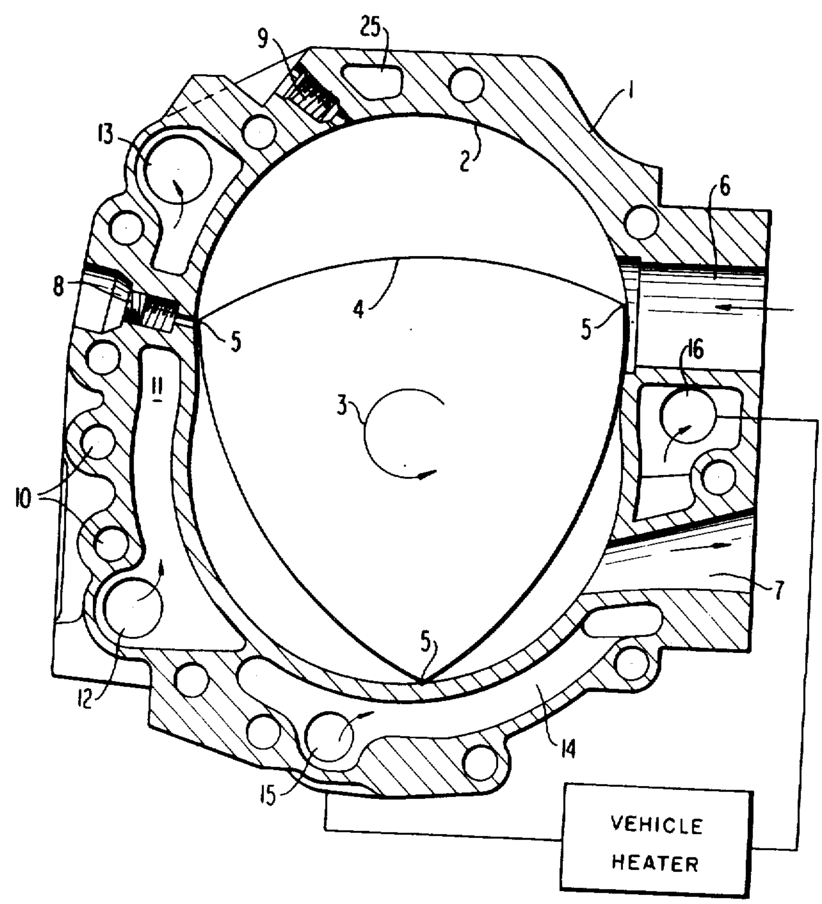

FIG 2

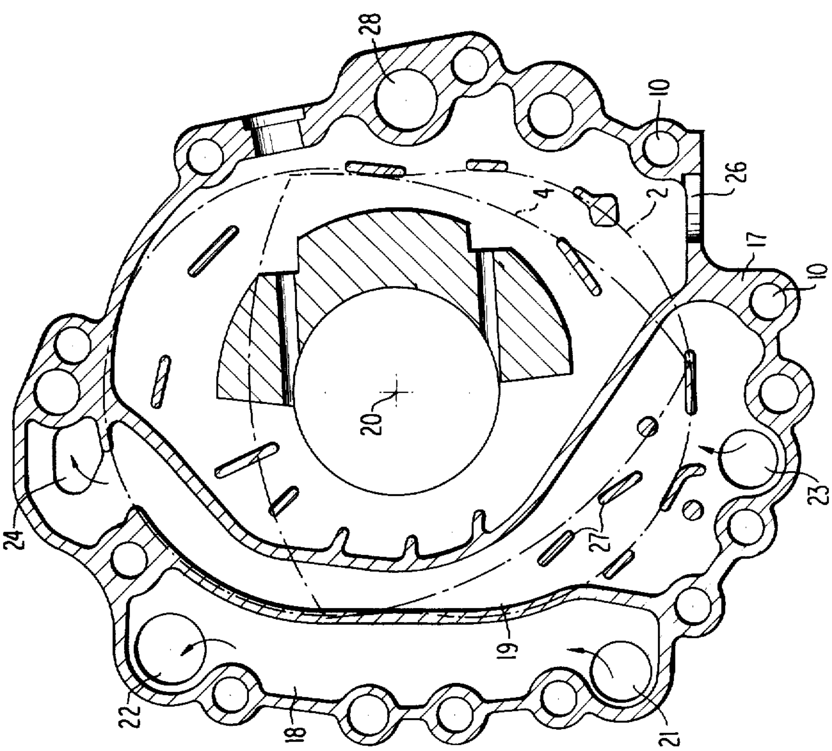
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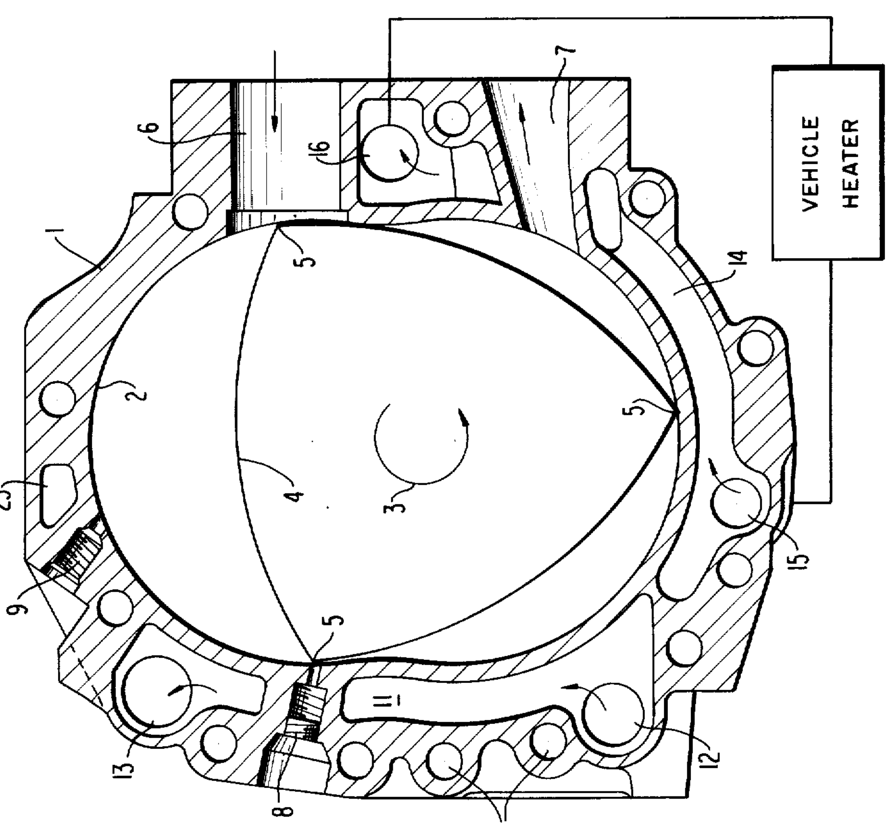
FIG 1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COOLING SYSTEM FOR THE COOLING OF THE HOUSING OF A ROTARY PISTON INTERNAL COMBUSTION ENGINE

The present invention relates to a cooling system with a liquid cooling medium for purposes of cooling a housing consisting at least of a casing, of end parts and possibly of one or several intermediate parts of a rotary piston internal combustion engine, especially of trochoidal type of construction.

Such types of prior art cooling systems consist of one cooling circulation which especially in rotary piston internal combustion engines with several disks, represents a widely extended and branched system. Since in a rotary piston internal combustion engine, in contrast, for example, to a reciprocating piston internal combustion engine, the heat yield, i.e., the amount of heat produced is very different in the individual areas, the cooling system has to be matched very carefully. Thus, throttling places for the cooling medium are installed in order to supply the individual areas with different quantities of cooling medium. This entails the disadvantage that the cooling medium pump has to be dimensioned very large and that it possesses a very high input power. Notwithstanding a careful matching, however, local overheatings cannot be avoided by reason of an unfavorable distribution of the cooling medium or by reason of inadequate venting.

The present invention is concerned with the task to avoid the aforementioned shortcomings. The underlying problems are solved according to the present invention in that the cooling system consists of at least two completely separate cooling circulatory systems.

By reason of the construction of the cooling system in accordance with the present invention, the cooling medium quantities in each cooling medium circulation are considerably smaller than if only one single cooling circulation were present. Throttling places are not necessary in the cooling system, and the matching of the cooling system is considerably facilitated. Also, the small cooling medium quantity in each cooling circulatory system brings about a very rapid heat-up of the cooling medium after a cold start.

The cooling system is further improved according to an advantageous embodiment of the present invention in that the cooling media of the different cooling circulatory systems have differently high temperatures. The cooling media may thereby consist of different substances depending on the temperature.

The cooling system is further improved according to the present invention in that the cooling media of the different cooling circulatory systems cool different areas of the housing having differing heat yield or heat production. These differing heat quantities can be conducted away either by differing cooling medium quantities or with the aid of different cooling medium temperatures if a cooling circulatory system with lower cooling medium temperature is consequently coordinated to an area of the housing with higher heat yield. In case the temperature of the hottest cooling medium is selected sufficiently high, heat can be given off from the cooling medium to the housing in individual, particularly cool areas of the housing. As a result thereof, the housing assumes everywhere an approximately equal temperature which also signifies a uniform housing expansion. The advantages resulting therefrom are that the form and shape of the running surface of the casing as well as of the intermediate and end parts changes only slightly and that the gas-tightness between the individual housing parts is considerably improved. This gas-tightness cannot be assured in the prior art cooling systems since none of the customary elastic seals can be arranged between the housing parts for thermal reasons and the metallic seal is only very inadequate by reason of non-uniform temperature distribution and local overheating with the elastic and plastic deformation resulting therefrom.

It is furthermore advantageous if the cooling medium of one cooling circulatory system enters the housing at the place of the area to be cooled where the largest heat quantity of this area is produced or in proximity thereof, and leaves at the place with lowest heat yield or in proximity thereof. The temperature of the housing can thus be kept approximately the same also at the individual places of an area since the entering relatively cool cooling water absorbs a larger amount of heat then the already heated discharged cooling water.

In a cooling system for cooling the housing of a rotary piston internal combustion engine of trochoidal type of construction with a two-arched trochoidal running surface arranged in the casing, along which slides a triangular piston with its corners, and with one inlet and one outlet channel each arranged in the casing, the cooling system of this invention may consist of two cooling circulations with differing temperatures, of which the cooler cooling circulation flows through the area of the casing opposite the inlet and outlet channel whereas the hotter cooling medium flows through the adjacent area of the casing adjoining in the direction of the piston up to the area of the inlet channel or therebeyond up to the area in which the combustion gases are present during the beginning of the suction cycle. The cooler cooling medium thus cools the area with the greatest heat yield, therefore that area in which the combustion gases give off heat to the casing at the end of the compression and during the combustion whereas the hotter cooling medium cools the area of the casing inclusive the outlet channel in which the combustion gases give off heat during the expansion and exhaust cycle.

In case in this cooling system of the present invention the cooling media of the two cooling circulations enter into the casing at adjacent places of the two areas, then they cool at first the hottest places of the rotary piston internal combustion engine; namely, the vicinity thereof in which the combustion gases are present at the beginning of the expansion cycle, and then flow toward the coolest places for the respective areas thereof.

The cooling medium may additionally flow through the housing end parts and possibly the housing intermediate parts in those areas which directly adjoin the area disposed within the casing and traversed by the same, whereas the hotter cooling medium flows through the areas of the end parts and possibly of the intermediate parts adjoining these areas in the direction toward the center longitudinal axis of the rotary piston internal combustion engine. The areas traversed by the cooler cooling medium are thus disposed, as viewed in the direction of the longitudinal axis of the rotary piston internal combustion engine, all one behind the other so that the inlet and outlet of the cooling medium is particularly simple. With this cooling system, the areas of the end and lateral housing parts which are thermally loaded particularly highly, are cooled by both cooling media whereas the other areas are cooled by means of oil in a conventional manner.

If at least the hottest cooling medium is heated by the exhaust gases of the rotary piston internal combustion engine, any eventual heat losses can be compensated for which occur when heat is given off to particularly cool parts of the housing. Additionally, the cold starting time is considerably shortened thereby.

In a cooling system for cooling the housing of a rotary piston internal combustion engine which is installed into a motor vehicle with a vehicle heating system, the heating medium of the vehicle heater can be heated up in an advantageous manner by the hottest cooling medium whereby the heating effect commences particularly rapidly and intensively.

Accordingly, it is an object of the present invention to provide a cooling system for cooling the housing of a rotary piston internal combustion engine which avoids by simple means the aforementioned shortcomings and drawbacks encountered in the prior art.

Another object of the present invention resides in a cooling system for cooling the housing of a rotary piston internal combustion engine in which not only the cooling medium pump does not have to be selected very large, but also the difficulties in matching the cooling system to the local, individual requirements is farreachingly dispensed with.

A further object of the present invention resides in a cooling system for cooling the housing of a rotary piston internal combustion engine, particularly of trochoidal construction, which effectively avoids local overheating by the use of at least two completely separate cooling circulations.

Still a further object of the present invention resides in a cooling system for cooling the housing of a rotary piston internal combustion engine which obviates the need for throttling places as well as complicated designs of the passages for the cooling medium.

Still another object of the present invention resides in a cooling system for rotary piston internal combustion engines which also improves the heat-up of the cooling medium after a cold start.

A further object of the present invention resides in a cooling system for rotary piston internal combustion engines in which the different cooling circulations cool different areas of the housing with differing heat yield so as to optimize the cooling effect and match it to the local requirements.

A further object of the present invention resides in a cooling system for a rotary piston internal combustion engine which assures uniform thermal expansion of the housing as well as improved gas-tightness between individual housing parts.

Another object of the present invention resides in a cooling system for rotary piston internal combustion engines which also improves the heating effect of the heater of the motor vehicle.

These and other objects, features and advantages of the present invention will become more apparent from the following description when taken in connection with the accompanying drawing, which shows, for purposes of illustration only, one embodiment in accordance with the present invention, and wherein:

FIG. 1 is a cross-sectional view through the casing of a rotary piston internal combustion engine in accordance with the present invention taken at right angle to the engine axis; and

FIG. 2 is a similar cross-sectional view through an end portion of the same rotary piston internal combustion engine in accordance with the present invention.

Referring now to the drawing wherein like reference numerals are used throughout the two views to designate like parts, the casing **1** of FIG. **1** is delimited toward the inside thereof by a two-arched trochoidal running surface **2**, along which slides the rotating piston **4** with its piston corners **5** in the direction of arrow **3**. An inlet channel **6** and an exhaust channel **7** are arranged in the casing **1** along one longitudinal side. An aperture **8** for a spark plug (not shown) is provided in the casing **1** along the oppositely disposed longitudinal side while an aperture **9** for an injection nozzle (not shown) is provided between the aperture **8** for the spark plug and the inlet channel **6**. Through-passage openings **10** for tie rods are provided distributed over the circumference which hold together the individual housing parts.

The casing **1** is cooled by cooling media of different temperatures flowing in two cooling circulatory systems completely separate from one another. The cooler cooling medium which, for example, has a temperature of 75°C., flows through a cooling chamber **11** disposed in the casing **1** which extends along the entire longitudinal side on which is disposed the spark plug, up to the trochoidal running surface **2**. The opening **8** for the spark plug is surrounded by the cooling chamber **11**. The inlet channel **12** into the cooling chamber **11** is located at the end thereof, as viewed in the direction of rotation **3** of the piston **4**, whereas the outlet channel **13** is disposed at the other end so that the cooling medium flows through the cooling chamber **11** opposite the direction of rotation **3** of the piston **4**.

A cooling chamber **14** of the second cooling circulatory system, whose cooling medium has a temperature of, for example, 130°C., adjoins the cooling chamber **11** in the direction of rotation **3** of the piston **4** and extends up to the inlet channel **6** whereby it surrounds the exhaust channel **7**. The inlet channel **15** into the cooling chamber **14** is disposed in proximity to the inlet channel **12** of the other cooling chamber **11** whereas the outlet channel **16** is disposed in proximity of the inlet channel **6**. The continuation of this outlet channel **16** is represented by the channel **28** in the end part **17** (FIG. **2**) and possibly in the intermediate parts. The cooling medium of the two cooling circulations thus enter into the cooling chambers **11** and **14** within an area in which the combustion gases have the highest temperature and in which the largest heat quantity is thus produced, and flow in the cooling chambers **11** and **14** toward those places in which the smallest heat quantity for the corresponding areas to be cooled is produced.

In the end part **17** illustrated in FIG. **2** are also provided two cooling chambers **18** and **19** which belong to the same cooling circulations as the cooling chambers **11** and **14**, respectively. The cooling chamber **18** traversed by the cooler cooling medium is disposed directly adjacent the cooling chamber **11** of the casing **1** so that all cooling chambers **11**, **18** belonging to this cooling circulation are arranged approximately aligned one behind the other as viewed in the direction of the center longitudinal axis **20** (FIG. **2**) of the rotary piston internal combustion engine. The same is also true for the inlet channels **21** and outlet channels **22** in relation to the inlet channels **12** and the outlet channels **13** in the casing **1**. A very simple guidance and conduction of the cooling medium stream results therefrom.

The cooling chamber **19** adjoins the cooling chamber **18** in the direction toward the center of the rotary piston internal combustion engine. Ribs **27** arranged therein are to assure a good cooling medium guidance and conduction. The inlet channel **23** is disposed accurately in front or to the rear of the inlet channel **15** within the casing **1** whereas the outlet channel **24** is disposed in proximity of the outlet channel **22**. The continuation of the outlet channel **24** is represented by the channel **25** in the casing **1** (FIG. **1**). The areas of the end part **17** not cooled by the cooling media of the two cooling circulations are cooled by lubricating oil which emerges out of the bearing of the piston **4** and leaves the housing by way of the aperture **26**.

As can be seen from the foregoing, the cooler medium not only flows through the chamber **11** in the casing **1** but additionally flows through the end parts **17** and possibly through intermediate parts of a multi-disk construction by way of chambers **18** located in those areas which directly adjoin the area traversed by the cooler cooling medium in the casing **1** by way of chamber **11**; the hotter cooling medium, in turn, not only flows through the chamber **14** in the casing **1**, but also through the end parts **17** and possibly intermediate parts of a multi-disk construction by way of chambers **19** located in those areas directly adjoining the areas of the chambers **18** in the direction toward the center longitudinal axis **20** of the rotary piston internal combustion engine.

In case the motor vehicle into which the rotary piston internal combustion engine is installed is equipped with a vehicle heater, then the hottest cooling medium which may be heated by the exhaust gases of the rotary piston internal combustion engine can be used to heat the heating medium of the vehicle heater. (See schematic showing of the vehicle heater in FIG. **1**).

While I have shown and described only one embodiment in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

What is claimed is:

1. A cooling system for cooling housing means of a rotary piston internal combustion engine of the type having housing means enclosing a combustion space within which a multi-lobed rotary piston rotates, the housing means including a casing means circumferentially surrounding the piston, the casing means having an inwardly facing running surface engageable with outer portions of the lobes of the piston during rotation thereof, the engine including inlet and outlet channels for respectively accommodating entry of combustible materials into the combustion space and exit of exhaust gases from the combustion space, the running surface and piston being so configured and the inlet and outlet channels being so positioned that combustion gases of differing temperatures are in contact with different circumferential portions of the running surface during operation of the engine; said cooling system comprising:

a first cooling circuit for accommodating circulation of a first cooling fluid,

and a second cooling circuit for accommodating circulation of a second cooling fluid,

said first and second circuits being separate from one another,

said first cooling circuit including a first cooling space formed in said casing means and extending adjacent a first portion of the circumference of said running surface with a cooling fluid inlet to said first cooling space positioned adjacent the circumferential portion of the running surface which is in contact with the hottest combustion gases during operation of the engine,

wherein said first cooling space extends around the circumference of said running surface in a direction opposite the rotational direction of the piston from said cooling fluid inlet to a cooling fluid outlet positioned adjacent the circumferential portion of the running surface which is in contact with the coolest combustion gases during operation of the engine.

2. A cooling system according to claim **1**, wherein said second cooling circuit includes a second cooling space formed in said casing means and extending adjacent a second portion of the circumference of said running surface which is circumferentially spaced from said first portion of the running surface.

3. A cooling system according to claim **2**, wherein said second cooling space extends in the direction of rotation of the piston from a cooling fluid inlet thereof located adjacent the cooling fluid inlet of said first cooling space to a cooling fluid outlet thereof.

4. A cooling system according to claim **3**, wherein said running surface includes openings for said inlet and outlet channels and for said ignition means, wherein the openings for said inlet and outlet channels are disposed at the opposite side of said combustion space with respect to said opening for the ignition means, and wherein said inlets for said first and second cooling spaces are positioned intermediate the opening for the ignition means and the opening for the outlet channel as seen in the direction of rotation of the piston.

5. A cooling system according to claim **4**, wherein the opening for the outlet channel, the opening for the inlet channel, and the opening for the ignition means are serially arranged with respect to one another as seen in the direction of rotation of the piston.

6. A cooling system according to claim **5**, wherein the outlet for the first cooling space is disposed between said opening for the ignition means and said opening for the inlet channel.

7. A cooling system according to claim **6**, wherein the outlet for the second cooling space is disposed at the side of the opening for the outlet channel closest to the opening for the ignition means as seen in the direction of rotation of the piston.

8. A cooling system according to claim **7**, wherein said second cooling circuit includes further cooling spaces formed in said casing means between said openings for the inlet and outlet channels and adjacent the outlet for said first cooling space.

9. A cooling system according to claim **4**, wherein said second cooling circuit includes further cooling spaces formed in said casing means between said openings for the inlet and outlet channels and adjacent the outlet for said first cooling space.

10. A cooling system according to claim **5,** wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

11. A cooling system according to claim **1,** wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

12. A cooling system according to claim **9,** wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

13. A cooling system according to claim **12,** wherein the cooling spaces of said second circuit which is located adjacent the outlet of the first cooling space is located adjacent an area of the combustion space where the combustion gases are experiencing the beginning of the suction cycle.

14. A cooling system, for cooling housing means of a rotary piston internal combustion engine of the type having housing means enclosing a combustion space within which a multi-lobed rotary piston rotates, the housing means including a casing means circumferentially surrounding the piston, the casing means having an inwardly facing running surface engageable with outer portions of the lobes of the piston during rotation thereof, the engine including inlet and outlet channels for respectively accommodating entry of combustible materials into the combustion space and exit of exhaust gases from the combustion space, the running surface and piston being so configured and the inlet and outlet channels being so positioned that combustion gases of differing temperatures are in contact with different circumferential portions of the running surface during operation of the engine; said cooling system comprising:

a first cooling circuit for accommodating circulation of a first cooling fluid,

and a second cooling circuit for accommodating circulation of a second cooling fluid,

said first and second circuits being separate from one another,

said first cooling circuit including a first cooling space formed in said casing means and extending adjacent a first portion of the circumference of said running surface with a cooling fluid inlet said first cooling space positioned adjacent the circumferential portion of the running surface which is in contact with the hottest combustion gases during operation of the engine,

wherein said housing means includes an end part adjacent said casing means for laterally closing an axial end of said combustion space, wherein said first cooling circuit includes a cooling space formed in said end part, wherein said second cooling circuit includes a cooling space formed in said end part, and wherein the cooling space in said end part of said first cooling circuit is axially aligned and immediately adjacent the first cooling space.

15. A cooling system according to claim **14,** wherein the cooling space in said end part of said second cooling circuit extends circumferentially adjacent to and radially inwardly of said cooling space in said end part of said first cooling circuit such that both of said cooling spaces in said end part are disposed at the same side of the rotational axis of the piston.

16. A cooling system according to claim **15,** wherein the flow of cooling fluid in both of said cooling spaces in said end part is in the same circumferential direction with respect to the direction of rotation of the piston.

17. A cooling system according to claim **16,** wherein the circumferential extent of the cooling space in said end part of said second cooling circuit is greater than the circumferential extent of the cooling space in said end part of said first cooling circuit with the respective inlets and outlets of the cooling space of said second cooling circuit spaced circumferentially outside of the respective inlets and outlets of the cooling space of said first cooling circuit.

18. A cooling system according to claim **17,** wherein said end part includes lubricant accommodating space over portions thereof unoccupied by the cooling spaces of said first and second cooling circuits for accommodating flow of lubricant through said end part, which lubricant communicates with lubricating means for the piston.

19. A cooling system according to claim **15,** wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

20. A cooling system according to claim **10,** further comprising a vehicle heater means, wherein said second cooling circuit includes means for accommodating heat exchange between the second fluid medium and said vehicle heater means, and wherein said second cooling medium is maintained at a higher temperature than is said first cooling medium.

21. A cooling system according to claim **1,** wherein said first fluid medium is maintained cooler than said second fluid medium.

22. A cooling system for cooling housing means of a rotary piston internal combustion engine of the type having housing means enclosing a combustion space within which a multi-lobed rotary piston rotates, the housing means including a casing means circumferentially surrounding the piston and an end part adjacent said casing means for laterally closing an axial end of said combustion space, the casing means having an inwardly facing running surface engageable with outer portions of the lobes of the piston during rotation thereof, the engine including inlet and outlet channels for respectively accommodating entry of combustible materials into the combustion space and exit of exhaust gases from the combustion space, the running surface and piston being so configured and the inlet and outlet channels being so positioned that combustion gases of differing temperatures are in contact with different circumferential portions of the running surface during operation of the engine; said cooling system comprising:

a first cooling circuit for accommodating circulation of a first cooling fluid,

and a second cooling circuit for accommodating circulation of a second cooling fluid,

said first and second circuits being separate from one another,

said first and second cooling circuits including respective separate cooling spaces formed in said end part, the cooling space in said end part of said second cooling circuit extending circumferentially adjacent to and radially inwardly of said cooling space in said end part of said first cooling circuit such that both of said cooling spaces in said end part are disposed at the same side of the rotational axis of the piston.

23. A cooling system according to claim 22, wherein said first cooling circuit includes a first cooling space formed in said casing means and extending adjacent a first portion of the circumference of said running surface, and wherein the cooling space in said end part of said first cooling circuit is axially aligned and immediately adjacent the first cooling space.

24. A cooling system according to claim 22, wherein the flow of cooling fluid in both of said cooling spaces in said end part is in the same circumferential direction with respect to the direction of rotation of the piston.

25. A cooling system according to claim 24, wherein the circumferential extent of the cooling space in said end part of said second cooling circuit is greater than the circumferential extent of the cooling space in said end part of said first cooling circuit with the respective inlets and outlets of the cooling space of said second cooling circuit spaced circumferentially outside of the respective inlets and outlets of the cooling space of said first cooling circuit.

26. A cooling system according to claim 22, wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

27. A cooling system according to claim 25, wherein said end part includes lubricant accommodating space over portions thereof unoccupied by the cooling spaces of said first and second cooling circuits for accommodating flow of lubricant through said end part, which lubricant communicates with lubricating means for the piston.

28. A cooling system according to claim 27, wherein said running surface is of two-arched trochoidal construction, wherein said piston is a three lobed piston, and wherein the first cooling fluid is maintained cooler than the second cooling fluid.

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