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Malaval

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[54] **ROTARY THERMAL ENGINE**

[76] Inventor: **Claude Malaval,** 39 rue des Coquelicots, 92160 Antony, France

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[52] **U.S. Cl.** **60/669**

[51] **Int. Cl.** **F01k 11/00**

[58] **Field of Search** 60/36, 108, 1, 6, 517, 60/525, 670, 671, 669

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Primary Examiner—Martin P. Schwadron
Assistant Examiner—H. Burks, Sr.
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

Thermal rotating engine in a closed circuit using chambers having a variable volume limited by two successive blades of a flash wheel, two lateral rims connected to the blades and a portion of liquid ring comprised between these two blades.

The drive fluid drawn off from each chamber when the latter takes up the minimum volume, is injected again into the chamber after having been heated up in a hot source.

Application to all cases where a certain power in a small volume proves to be necessary. It is suitable particularly for automatic use, due to its slight pollution.

7 Claims, 3 Drawing Figures

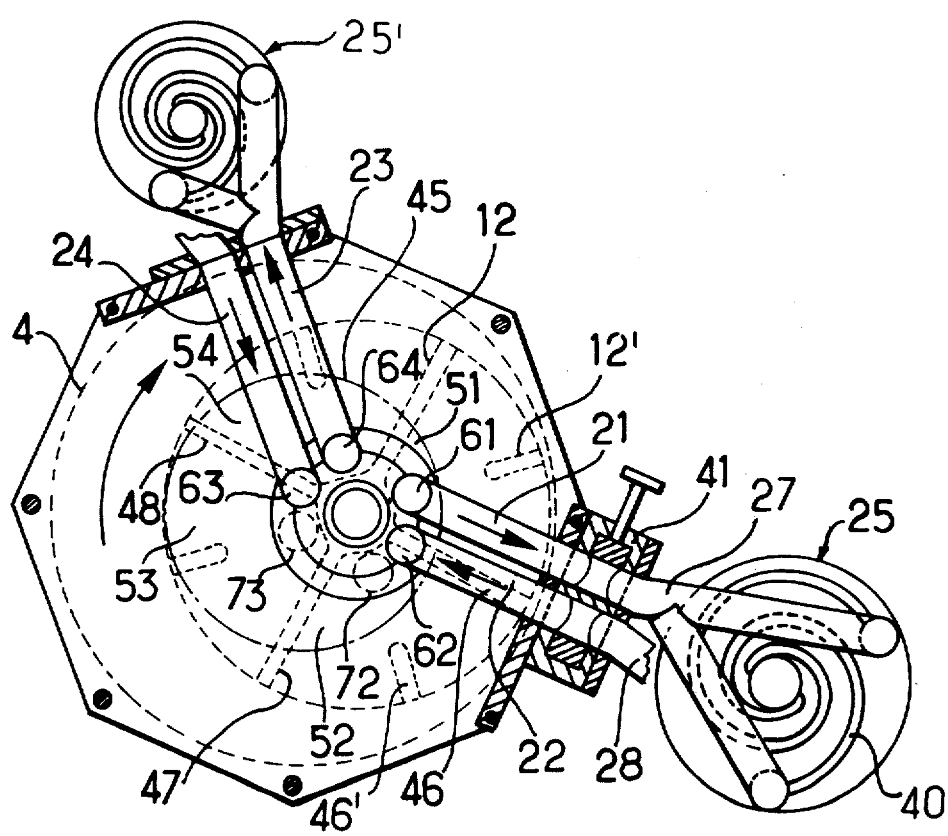
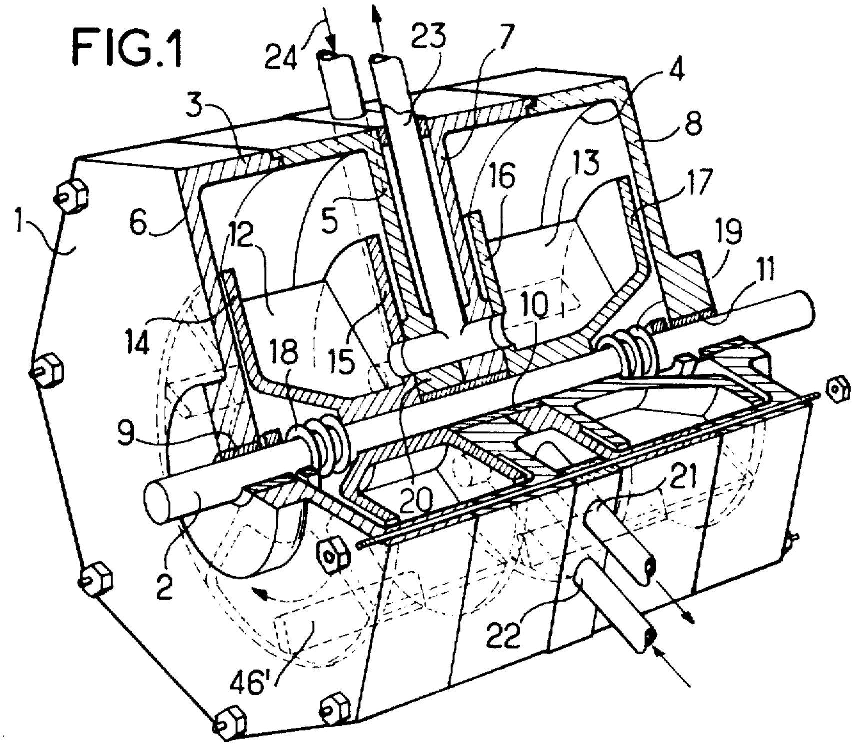


FIG.1


24
23
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4
8
3
16
13
17
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5
12
19
11
1
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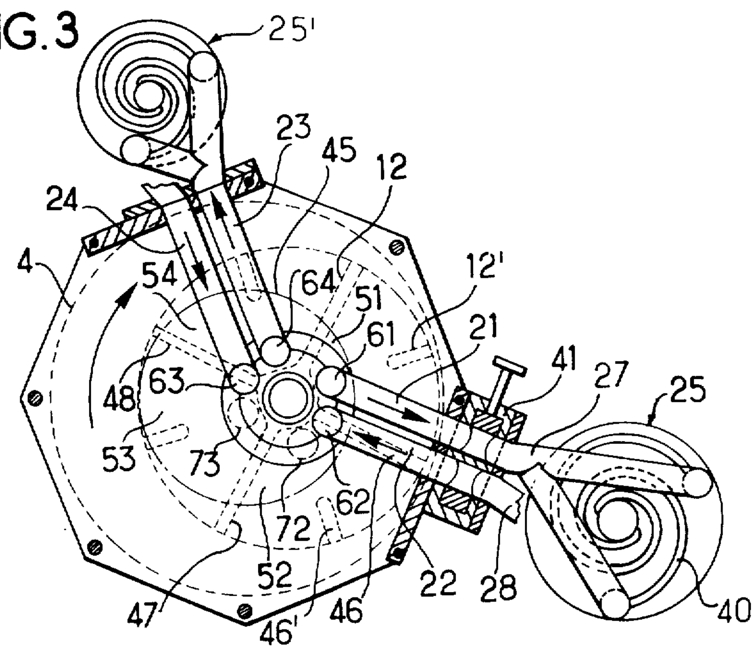
14
18
15
9
21
20
2
22
46'

FIG.3


25'
23
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12
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12'
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51
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21
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27
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63
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62
72
52
47
46'
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22
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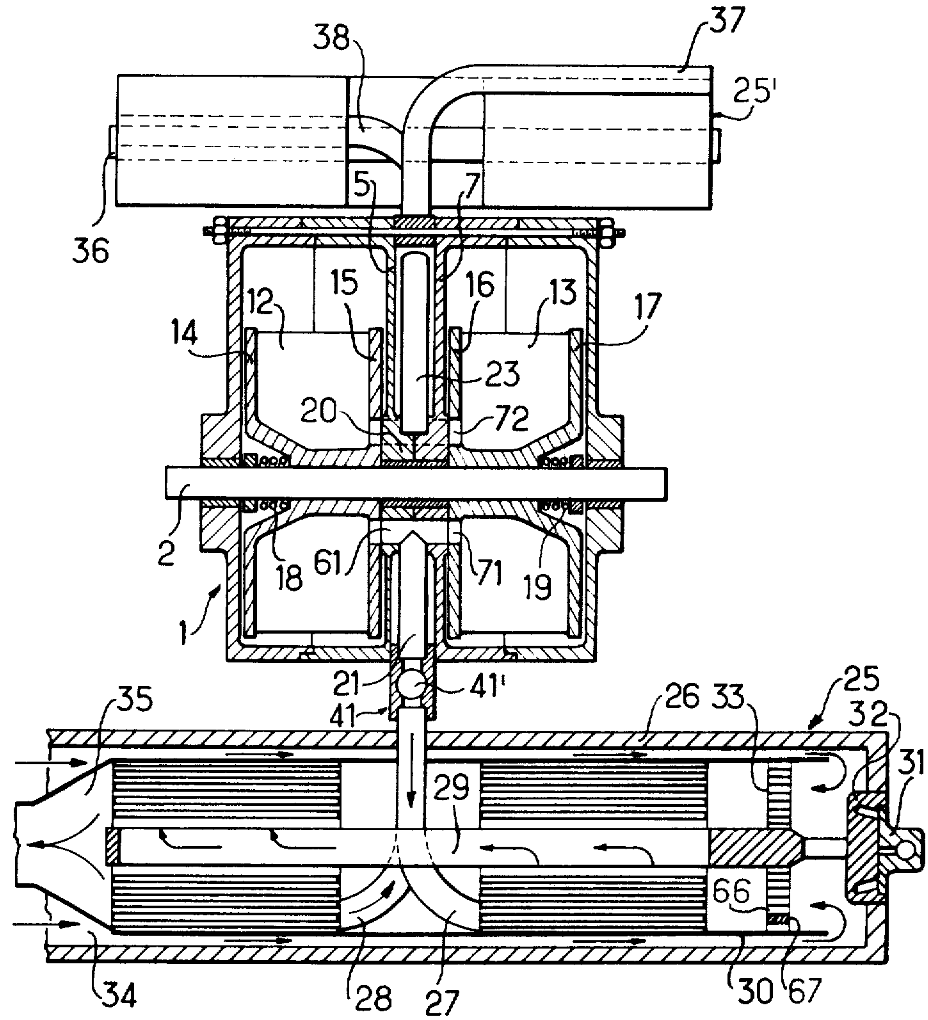
40

FIG. 2


37
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ROTARY THERMAL ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention concerns a rotary thermal engine drawing away a drive fluid, in a closed circuit according to a cycle almost similar to the Stirling cycle.

2. Description of the Prior Art

In engines implementing the Stirling cycle or an almost similar cycle, as present known, drive gases are moved from a hot chamber to a cold chamber by means of the alternating lenear movement of a piston in a cylinder. Expansion is effected in a space comprised between the said piston and another piston placed below the first.

Such a device requires elements for transforming the rectilinear movement of the piston into a rotating movement of the drive shaft leading to an appreciable increase in the weight and the price of the device. Moreover, such an engine implements piston rings operating at high temperature whose reliabiliy is still sometimes haphazard.

It is evidently possible to avoid using chambers having variable volume limited by at least a piston, by using chambers having flexible walls but then, the metal constituting the wall of the chamber would be submitted to particularly severe temperature and fatigue conditions and the problem of transforming the rectilinear movement into a rotating movement remains unsolved.

The inventor has preferred to use the principle of the rotating engine, thus avoiding, moreover, the use of intermediate elements for transforming the rectilinear movement into a circular movement. It is indeed a known practice to use a stator having a definite geometrical shape, within which a rotor limiting, with the stator, during its rotation, chambers having a variable volume, is made to rotate ; but all the sealing and cooling problems set by devices of that type are also known. The inventor has overcome these various difficulties by implementing chambers one of whose walls is constituted by a portion of liquid ring obtained by driving in a rotating movement the liquid contained in a cylindrical body having a horizontal axis by means of a flash wheel also having a horizontal axis but excentric in relation to the axis of the cylindrical body in the same way as a compressor or pump of the liquid ring type. In such a structure, the chamber is limited by two blades, by the portion of liquid ring which they determine and by two lateral rims perpendicular to the blades. The chamber is all the smaller as the two blades which limit it on two sides are immersed deeper in the liquid ring. The variation of the volume of the chamber is therefore effected without any seal or friction other than that of the liquid ring driven by the rotation of the blades and remaining very slight. The inventor has constituted a rotating thermal engine by combining a certain number of such cylindrical bodies in which a fluid flows in a closed circuit. That fluid is at least partly put into contact with a hot source and a cold source according to the cycle almost similar to the Stirliing cycle.

The object of the invention is a rotating thermal engine constituted by a hot source, a cold source, a cylindrical volume, several flash wheels fitted with lateral rims and a certain quantity of liquid, the axis of the said flash wheels being parallel and excentric in relation to the axis of the cylindrical volume, the rotation of each flash wheel giving rise to a liquid ring, limiting, with the rims of the said wheel, a cylindrical body which the successive blades divide up into chambers having a variable volume, characterised in that a drive fluid moves in a closed circuit comprising the hot source and the cold source arranged outside the cylindrical bodies.

It is known that at the present time, rotating internal combustion engines have the disadvantage of producing particularly polluting gases when they operate at low speed. In known rotating engines, it is not possible to draw off or inject gases from the vicinity of the centre of the device because of the high temperature of the rotor and of the difficulty in constituting rotating seals impervious to these temperatures so that communications of the chamber with the outside can be made only by the stator, this preventing the drawing off of gases during a cycle to re-inject them after a heat treatment at the most favourable point for obtaining a homogenous mixture. On the contrary, in the device according to the invention, the chamber itself rotates on the axis and only the wall formed by the portion of liquid ring moves forward or backward in a radial direction ; it is therefore easy to choose the place at which the injection is to be made. The very structure of the engine then allows the drive fluid to be brought close to the heat source and to re-inject it in the best output conditions, whatever the speed of rotation of the engine may be and to avoid causing a correlation between the rotation speed of the engine and the combustion rate of the heating gases of the hot source.

The object of the invention is therefore also a rotating thermal engine of the closed circuit type, constituted according to the preceding description, characterised in that communication means enable at least a part of the gases to be drawn off successively from each chamber at the instant when the latter takes up the minimum volume to re-inject them in a chamber having an increasing volume after having put them in contact with the hot source.

In a device according to the invention, due to appropriate means, the drive fluid is therefore drawn off successively from the chambers at an instant when these latter take up the minimum volume to lead it into an exchanger device forming the hot source where the drive fluid is heated then sent back into a chamber whose volume is increasing so that this hot fluid provides drive force during its expansion.

An engine according to the invention operates between a hot source with which the drive fluid drawn off from the chamber taking up the minimum volume is put in contact and a cold source with which the cold fluid drawn off during compression is put in contact to re-inject it into the chamber taking up the maximum volume.

The object of the invention is therefore also a thermal engine constituted according to the preceding descriptions, characterised in that means enable a part of the drive fluid in the chambers in the compression phase to be drawn off, the said fluid to be put in contact with the said cold source and sent back into the following chambers at the instant when the compression is the lowest.

It should be observed that the liquid ring does not heat up permanently and does not have a tendency to become vaporized as circumstances may lead it to be believed. Indeed, the direct contact with the hot gases takes place only during a short fraction of the revolution cycle, moreover by means of the smallest surface, whereas during all the remainder of the revolution cycle, the surface in contact with the gas is greater and the liquid ring remains permanently in contact with the wall of the cylindrical body, itself cooled by a water circulation or by cooling fins.

Lastly, it should be observed that the portion of ring comprised in the chamber where the maximum compression takes place is subjected to a pressure greater than that to which the portion of ring limiting the chamber in which the expansion takes place ; the result of this is a force which tends to make the liquid ring rotate in the direction of rotation of the blades and decreases the drive force of the rotating liquid as well as the corresponding friction.

The invention is described in greater detail in the example herebelow, having no limiting character, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view, partially in section, showing diagrammatically the central part of the engine of the present invention FIG. 2 is a diagrammatic cutaway view showing the connecting of the central part of the engine of FIG. 1 to the two sources. FIG. 3 is a sectional view of the engine of FIGS. 1 and 2 showing the feeding of the chambers with drive fluid.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows diagrammatically the central part of an engine implementing a variant of the invention which comprises two cylindrical bodies having four chambers arranged in a line on the same shaft, arranged in the same cylindrical volume **1**. In FIG. **1**, a cylindrical volume through which a shaft **2** passes may be distinguished at **1**. The cylindrical volume is therefore constituted by two coaxial cylindrical bodies **3** and **4** having the same diameter.

The cylindrical body **3** is limited by the sides **5** and **6**. The cylindrical body **4** is limited by the sides **7** and **8**. Each of the sides supports respectively the bearings **9, 10** and **11** of shaft **2**. The sides **5** and **7** made fast with each other by the bearing **10** constitute a volume containing ducts and the hub **20** of which descriptions are given further on.

Within the cylindrical body **3**, the existence of the blade **12** constituting a wall common to two contiguous chambers and in the cylindrical body **4**, the existence of the blade **13** fulfilling, in the body **4**, the same function as the blade **12**, will be observed. At its lateral ends, the blade **12** bears rims **14** and **15** and the blade **13** bears the rims **16** and **17**. Flexible elements **18** and **19** put the rims **15** and **16** of the blades **12** and **13** in contact respectively with the sides **5** and **7**.

A pipe **21** enabling the drive fluid to be drawn off at the instant when the chamber reaches the minimum volume is arranged between the sides **5** and **7**. A pipe **22** enables the fluid to be re-injected after its pass at the hot source (not shown in this figure).

Likewise, a pipe **23** enabling a part of the fluid to be drawn off towards the cold source (not shown in that figure) and a pipe **24** which enables that fluid to be re-injected after its pass in the cold source may likewise be seen at the top part of the engine.

FIG. **2** shows a diagrammatical cutaway view of the engine assembly. It shows how the central part described previously is connnected up to the hot source

25 and to the cold source **25'**. Two pipes **21** and **22** making the chambers communicate with the hot source **25** by means of the tubes **27** and **28** extending, respectively, the pipes **21** and **22**, are arranged between the sides **5** and **7**. In the hot source **25**, the tubes **27** and **28** are welded along two generating lines to tubes **40** greatly flattened and wound in a spiral. Each flat tube **40** is reinforced by oblique steel wires **40'** arranged in a regular pitch. These wires are fixed to the flat tubes **40**.

The spiral of the flat tubes such as **40** ends at the centre of the hot source in a central tubing **29** whence other flat tubes such as **40** wound in the reverse direction leave. The burner **31** is arranged at one end of the central tubing **29**. The liquid fuel is sent by the sprayer **32** towards a heating grill **33** constituted by a metallic strip **66** insulated by ceramic elements **67**. That spiral coil is heated when the engine is started up by Joule effect by means of a storage cell battery (not shown). When the spiral winding has reached operating temperature, the spiral winding vapourizes the fuel. The air sucked in by the nozzle **34**, flowing between the collar **30** and the casing **26** is heated and burns with the fuel. The combustion gases escape through the tubing **35** after having heated the drive fluid flowing in the flat tubes **27** and **28**.

The device acting as a heat source enables the use of very thin tubes **27** and **28** making thermal exchanges with the hot source easier. Indeed, the pressures brought into play are retransmitted by means of the steel wires up to the outside collar **30** made of a metal which is sufficiently thick to bear the whole of the pressure obtained in the tubing by means of the hot source.

The cold source **25'**, constituted in the same way as the hot source **25**, is fed with cooling fluid. The pipes **23** and **24** widen out respectively into the tubes **37** and **38** to form, subsequently, flat spiral tubes as in the hot source. They are connected up by the central duct **36**.

To enable the slowing down of the rotating speed of the thermal engine, a by-pass valve **41** whose shutter **41'** is linked with the adjusting of the combustion discharge is arranged between the tubes **21** and **22**. That arrangement enables the hot source **25** to be maintained at a high temperature when the burner and the engine operate at low speed and cancels, simultaneously, the effects of thermal inertia.

Lastly, FIG. **2** makes it possible to understand the principle of the feeding of the chambers by the hot source **25** and the cold source **25'**.

The lateral rim **15** does not bear with all its surface against the left-hand face of the side **5**. A certain gap appears on the peripherical part although the spring **18** may tend to press the blade wheel against the wall **7**. Indeed, the wall **5** has, at its central part, a hub **20** drilled at certain places with circular ports **61**. Each of the circular ports such as **61** is in relation with one of the pipes such as **21, 22, 23** or **24** (FIG. **1** or **2**). When a port such as **71** of the lateral rim comes opposite a port of a boss such as **61**, a communication between the source and the chamber of the engine is established. At the instant in question in FIG. **2**, a port such as **72** in the rim **16** does not establish any contact with a source.

FIG. **3** shows a cross-section of the engine; a profile of one of the blades **12** driving the liquid contained in the cylindrical body limited by a circle **4** shown in dotted lines may be seen therein. The liquid forms, in its turn, a cylindrical wall whose inside face is limited by the dotted line 45. The blades 12, 46, 47 and 48 limit, with the wall of the liquid ring 45, four chambers 51, 52, 53 and 54, the two lateral faces of these chambers being limited by rims such as 14 and 15 (FIG. 1 or FIG. 2).

Circular ports formed in the boss 20, connected up respectively to the pipes 21 and 22 feeding the hot source have been shown at 61 and 62. Ports formed in the boss 20, connected up respectively to the pipes 23 and 24 have been shown at 63 and 64.

Lastly, the circular port 72 drilled in the lateral rim is seen in the chamber 52. One such feed port exists per chamber, the chamber 53 being provided with the opening 73.

In actual fact, four circular ports are drilled in the boss 20, in constant communication with one of the four feed pipes of the two sources. Likewise, four circular ports are drilled in the lateral rims in contact with the central sides 5 and 7, each port in turn putting the chamber to which it corresponds in communication, during a short period, with the hot gas inlet, the cold gas outlet, the cold gas inlet, the hot gas outlet.

The result of this is that in the case of the figure where the number of chambers having variable volumes per cylindrical body is four, the drive fluid is drawn off by the port 61 in the chamber during the quarter of a cycle corresponding to the minimum volume (chamber 51) and pointed towards the hot source at the following quarter of a cycle corresponding, in FIG. 3, to the chamber 52, the fluid coming from the hot source is injected by the port 62. The hot gas then expands, providing a drive force.

At a following quarter of a cycle, the chamber having a variable volume receives, by the port 63, a certain quantity of fluid cooled by the cold source 25'. During the last quarter of a cycle, a part of the fluid is drawn off by the port 64 in the chamber having a variable volume is pointed towards the cold source by the pipe 23.

The fluid supplies, in each chamber having a variable volume, a drive force during the whole of the expansion of the fluid, that is, from the pressing of the port of the chamber in front of the fixed port 62 until it passes in front of the fixed port 63. During the expansion, the pressure in the chamber is higher than in the chamber which preceeds it ; the result of this is an action on the wall of the liquid ring which tends to move the latter in the rotating direction of the engine. A part of the energy thus supplied is recuperated by means of fins such as 12' (FIG. 3) or 46' (FIGS. 1 and 3) which produce a drive of the wheel in the direction of its rotation.

The device according to the invention has been described hereinabove with two cylindrical bodies installed on the same shaft. It is self-evident that it is also possible to install only one or more than two, for example, four, six or eight, without going beyond the scope of the invention. Likewise, bodies comprising four blades limiting four chambers have been described. The inventor has also made experiments on cylindrical bodies containing six and eight chambers, which could be a greater advantage if it is required to drive a device having low inertia which must nevertheless be actuated with a very regular movement. Applications for such an engine are particularly numerous. This engine gives high power for a low volume ; moreover, it adapts itself very well to a variable speed rate. It is recommended more particularly for traction, more particularly on automobiles, tractors, dinghies, etc. As a fixed unit, it may be combined with an alternator or a compressor. Moreover, that engine has the advantage of using the most diverse liquid or gaseous fuels.

I claim:

1. A cylindrical rotating thermal engine comprising:
   a cylindrical casing,
   a quantity of liquid within said casing,
   a source of heat exterior of said cylindrical casing,
   a source of cold exterior of said cylindrical casing,
   a plurality of wheels inside said casing mounted for rotation therein,
   each of said wheels bearing radial vanes fitted with lateral rims, the axis of said wheels being parallel and eccentric in relation to the axis of the cylindrical casing,
   a cylindrical ring of said liquid formed by rotation of each wheel, the lateral rims and the successive vanes of said wheels defining successive chambers having variable volume,
   a propellant contained in said successive chambers, and
   means for displacing said propellant in a closed circuit along a path including said chambers for successive compression, placement in contact with a source of heat, expansion to provide power, partial exhaustion from one of said chambers submitted to compression, and placement into contact with the cold source before rejection into the chamber taking up the maximum volume.

2. The rotating thermal engine according to claim 1, wherein said propellant directing means includes first means communicating said chambers with the source of heat during a predetermined interval of time.

3. The rotating thermal engine according to claim 2, wherein said propellant directing means includes a second communication means for placing a fraction of the propellant in communication with the cold source during a predetermined time interval.

4. The rotating thermal engine of the closed circuit type according to claim 2, wherein the heat source communicating means includes means for drawing off at least a part of the gases from each chamber at the instant when the latter takes up minimum volume and putting said gases into contact with the source of heat and reinjecting them into a chamber whose volume is increasing.

5. The rotating thermal engine of the closed circuit type according to claim 3, wherein said second communication means includes means for drawing off a part of the gases from the chambers having a variable volume during compression and putting them into contact with said cold source and means for reinjecting said gases into a chamber whose volume at that moment is maximum.

6. The rotating thermal engine of the closed circuit type according to claim 2, in which the propellent directing means enabling a part of the gas system to be drawn off from or injected into chambers having a variable volume, comprises: a hub, four bores formed in the casing sides in the vicinity of the hub, heat exchangers external to the casing forming said hot and cold sources and ducts communicating the heat exchangers with said bores, and wherein a lateral rim of each chamber is provided in the vicinity of the hub with a circular portion communicating said chambers with said heat exchangers when the circular port comes in alignment with a corresponding bore formed within the side of the cylindrical casing.

7. The rotating thermal engine of the closed circuit type, according to claim 1, wherein the communication means between each chamber and the source of heat is provided with a bypass valve.

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