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(54) **HEAT ENGINE**

THERMISCHER MOTOR

MOTEUR THERMIQUE

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EP 1 056 944 B1

Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to a heat driven combustion engine incorporating an air compressor, a combustion chamber, and an expansion chamber.

2. DESCRIPTION OF THE PRIOR ART

[0002] U.S. Pat. No. 5,165,238, issued to Marius A. Paul et al. on November 24, 1992, discloses a combustion engine employing a Wankel type rotor and housing in the capacity of both compressor and expander.

[0003] U.S. Pat. No. 4,912,642, issued to Hals N. Larsen et al. on March 27, 1990, shows an electronic engine control system. Larsen et al. does not show an expander having a selectable expansion ratio.

[0004] U.S. Pat. No. 4,864,814, issued to Albert F. Albert on September 12, 1989, discloses a continuous combustion engine having reciprocating pistons which move radially outwardly from the axis of the combustion chamber. The output of these pistons is captured by respective crankshafts located still further outwardly from the axis.

[0005] U.S. Pat. No. 4,389,173, issued to William C. Kite on June 21, 1983, shows a rotary internal combustion engine having a rotor with pivoted vanes. Kite does not show an engine having a separate compressor and expander. Further, Kite does not show an expander having a selectable expansion ratio.

[0006] U.S. Pat. No. 4,336,686, issued to Kenneth W. Porter on June 29, 1982, shows a rotary vane or piston engine. The rotor is centrally located within a radially asymmetrical chamber, and accommodates chamber dimensional variations by vanes or pistons which periodically project from and retract into the rotor.

[0007] Pistons compress air on one side, and receive pressure from combustion gasses on the other side. Combustion is continuous, occurring in a dedicated combustion chamber. Sensors report data to a microprocessor, which controls fuel delivery to the combustion chamber.

[0008] U.S. Pat. No. 4,134,258, issued to Nobuhito Hobo et al. on January 16, 1979, shows an electronic fuel metering system. Hobo et al. does not show an expander having a selectable expansion ratio.

[0009] U.S. Pat. No. 3,989,011, issued to Minoru Takahashi on November 2, 1976, shows a heat engine having an air compressor, a combustion chamber, and an expansion chamber. Takahashi does not show an expander having a selectable expansion ratio.

[0010] U.S. Pat. No. 2,782,596, issued to Teodor I. Lindhagen et al. on February 26, 1957, discloses an engine having an external combustion chamber and a positive displacement member.

[0011] U.S. Pat. No. 2,435,476, issued to Orran B. Summers on February 3, 1948, shows a rotary internal combustion engine having a rotor with pivoted vanes. Summers does not show an expander having a selectable expansion ratio.

[0012] U.S. Pat. No. 2,382,259, issued to Fred H. Rohr on August 14, 1945, shows a rotary combustion engine having sliding vanes. Rohr does not show an engine having a separate compressor and expander. Further, Rohr does not show an expander having a selectable expansion ratio.

[0013] U.S. Pat. No. 1,324,260, issued to Ralph J. Meyer on December 9, 1919, shows a rotary pump with a rotor having pivoted vanes. Meyer does not show an expander having a selectable expansion ratio.

[0014] U.S. Pat. No. 1,138,481, issued to Friedrich Hupe on May 4, 1915, shows a rotary steam engine having a rotor with pivoted vanes. Hupe does not show an expander having a selectable expansion ratio.

[0015] U.S. Pat. No. 1,042,596, issued to William E. Pearson on October 29, 1912, shows a liquid motor having a rotor with sliding vanes. Pearson does not relate to gas expanders at all, and does not show the selectable expansion ratio feature of the present invention.

[0016] German Pat- Document No. 40 23 299, dated February 21, 1991, describes a continuous internal combustion engine having a rotor of configuration similar to that of a helical screw positive displacement pump.

[0017] German Pat- Document No. 1815711, dated June 25, 1970, shows a heat engine having an air compressor, a combustion chamber, and an expansion chamber. German '711 has a sliding vane type expander with a single passive vacuum relief valve. German '711 does not show an expander whose expansion ratio can be selectively set at a plurality of values.

[0018] Japanese Pat. Document No. 56-113087, dated September 5, 1981, shows a rotary pump or compressor with a rotor having pivoted vanes. Japanese '087 does not show an expander having a selectable expansion ratio.

[0019] Japanese Pat. Document No. 55-78188, dated June 12, 1980, shows a rotary internal combustion engine having a rotor with pivoted vanes. Japanese '188 does not show an engine having a separate compressor and expander. Further, Japanese '188 does not show an expander having a selectable expansion ratio.

[0020] None of the above inventions and patents, taken either singly or in combination, is seen to describe the instant

invention as claimed.

SUMMARY OF THE INVENTION

[0021] The present invention provides a rotary expansible chamber device characterised in that said rotary expansible chamber device has an expansion ratio, and said expansion ratio is setable at a selected one of a plurality of expansion ratio values by opening respective ones of said plurality of valves.

[0022] In most prior art rotary vane expansion and compression devices, the vanes are biased, as by spring or fluid pressure, to contact the inner surface of the housing- This could lead to excessive friction, either between vane edge and housing, or between the vane and its supporting cavity walls, and further threatens to bind the vane against the housing.

[0023] This potentially harmful relation is obviated in the present invention by an arrangement wherein the vanes are controlled by arms having rollers. The rollers roll along a cam or track which is configured to cooperate with the housing cross sectional configuration. The rollers influence the arms, and therefore the vanes, to remain within a predetermined dimension of the housing wall.

[0024] If rapidly fluctuating conditions cause expansion such that pressure in the expander is dropped below ambient pressure, venting valves automatically open to enable atmospheric pressure to compensate for the vacuum.

[0025] The venting valves also provide variation of the dynamic expansion ratio. While the geometry of the rotor and housing are fixed, the mathematical expansion ratio is thus also fixed. Provision of the venting valves allows the expander geometry to be variable, thus allowing the expansion ratio to be set at a value selected from a plurality of values corresponding in number to the number of venting valves.

[0026] Lubrication and cooling are provided by the lubricant, which is slung under great force by centrifugal action, spreading through shaft bearings to the inside of the compressor and expander rotors. A microprocessor and sensor system control fuel supply, so that the engine quickly responds to changes in power demand. The same microprocessor controls the venting valves.

[0027] The compressor and expander are mounted to a common shaft and are of the positive displacement type. Therefore, air supply volume is linear with the volume being expanded. The novel heat engine is able, therefore, to cause the torque curve to be substantially linear, within minor limits imposed by high speed friction and fluid flow characteristics.

[0028] Because air is compressed separately from the fuel, the combustion process is resistant to suppression. The heat engine therefore operates satisfactorily at very low rotational speeds. Separate compression of air also causes less pollution to be produced during the combustion process, since peak temperatures are lower than would occur when fuel and air are compressed as a mixture, thus leading to a lower tendency for nitrogen oxides to form. Furthermore, air mixing is superior to that of other internal combustion engines, and the time allowed for combustion is not limited in the same manner as the time allotted to an Otto or Diesel cycle engine. For these reasons, fuel burns substantially to completion, and hydrocarbon and carbon monoxide emissions are substantially mitigated. Further, because air is compressed separately from the fuel, no knocking or autoignition problems exist with the heat engine of the present invention.

[0029] Accordingly, it is a principal object of the invention to provide a combustion engine of the rotary vane type.

[0030] It is another object of the invention to provide a rotary vane engine wherein frictional contact of the vanes with the rotor and housing is minimized.

[0031] It is a further object of the invention to control vanes by a guide, whereby vanes are not subject to contact with the rotor housing.

[0032] Still another object of the invention is to provide for venting an expansion chamber to the atmosphere, whereby excessive pressure drop during expansion is prevented from reducing engine output.

[0033] It is yet another object of the invention to provide a rotary vane engine wherein conditions favor complete combustion and wherein peak temperatures are limited.

[0034] It is again an object of the invention to provide a rotary vane engine capable of producing nearly maximum torque at low rotational speeds.

[0035] An additional object of the invention is to provide a rotary vane engine having a torque curve which is substantially linear throughout the range of attainable rotational speeds.

[0036] It is an object of the invention to provide improved elements and arrangements thereof in an apparatus for the purposes described which is inexpensive, dependable and fully effective in accomplishing its intended purposes.

[0037] These and other objects of the present invention will become readily apparent upon further review of the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038]

Fig. 1 is a schematic representation of the heat engine and associated control system of the present invention.

Fig. 2 is a cross sectional detail view of the compressor of the present invention.

Fig. 3 is a cross sectional detail view of the expander of the present invention.

Fig. 4 is a diagrammatic, top plan, cross sectional view of the compressor and expander assemblies, showing details of the lubrication system of the present invention.

Fig. 5 is an elevational detail view of a representative vane arm, as used in the compressor and expander of the present invention, shown in isolation.

[0039] Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0040] The heat engine 10 of the present invention is seen in diagrammatic form in Fig. 1. An air intake 12 communicating with the atmosphere or other suitable air source leads to a compressor assembly 14, which discharges compressed air to a combustor 16 having a combustion chamber 18. Hot gaseous products of combustion are conducted to an expander assembly 20. Compressor and expander assemblies 14,20 are mounted to a common shaft 22.

[0041] Turning now to Figs. 2 and 3, the structures of compressor assembly 14 and the expander assembly 20 will be described. Compressor and expander assemblies 14,20 are essentially similar in configuration, although expander 20 has venting valves 42. The venting valves 42 will be discussed in greater detail in the context of the detailed description of the expander 20. The compressor 14 has a rotor 44 of circular cross section, mounted eccentrically, with respect to the center of mass of the cross sectional area of the interior of compressor housing 46, within compressor housing 46 and includes vanes 50 which project from the rotor 44. Housing interior surface 54 has a portion parallel to the surface 52 of the rotor 44 from which the vanes 50 project. This surface portion would be projecting out of the plane of the page in the view shown in Fig. 2. The portion of surface 54 parallel to surface 52, is displaced from the surface 52 by a variable amount. This displacement decreases monotonically from a maximum proximate the intake 72 to a minimum proximate the outlet 74. Variable projection enables vanes 50 to seal the displacement, i.e. the dimension, between rotor surface 52 and the portion of the housing interior surface 54 parallel to surface 52. The variable distance existing between rotor surface 52 and the portion of the housing interior surface 54 parallel to surface 52, arises from the eccentricity of rotor 44 with respect to the center of mass of the cross sectional area of the interior of housing 46. Accordingly, the projection of each of the vanes 50 varies monotonically between a maximum projection proximate intake 72 to a minimum projection proximate outlet 74. Thus the projection of each of the vanes 50 varies between a maximum and a minimum projection, and reaches the maximum projection once for every revolution of the rotor 44. The housing interior surface 54, in cross section, may form a modified "figure-8", wherein two circles overlap but do not precisely overlie one another. Of course, other cross sectional configurations, for example, circles and ellipses, would be satisfactory, depending upon the actual application. Additional seals 56,58 seal gaps existing between rotor 44 and vanes 50, and between vanes 50 and housing interior surface 54.

[0042] The rotor 44 is generally cylindrical, and is mounted on shaft 22, which is coaxial therewith. In the preferred embodiment of Fig. 1, shaft 22 is common to both the compressor rotor and the expander rotor. Returning to rotor construction, as illustrated in Fig. 2, each vane 50 is secured at one end to an arm 60, which arm 60 is pivotally attached to rotor 44 about axis 62. Arm 60 is mounted on an end wall 64 of cylindrical rotor 44, and extends into the hollow interior of rotor 44, in order to movably support vane 50 so as to allow vane 50 to move into and out of rotor 44. Vane 50 is preferably arcuate about a radius swung about axis 62, to accommodate projection and retraction. Arm 60 oscillates as rotor 44 rotates, being guided by the following arrangement.

[0043] A rotatable guide bearing 66 is disposed upon arm 60. Guide bearing 66 is located on the opposite side of arm 60 from end wall 64. A groove or track 68 is formed in a housing end wall (not shown), and guide bearing 66 rolls just inside track 68. As depicted in dotted line in the diagrammatic rendition of Fig. 2, track 68 acts as a camming surface controlling the amount of projection of vanes 50 out of the rotor 44. As the rotor 44 rotates the guide bearing 66 travels along track 68. The track 68 passes close to the surface 52 near the intake 72 and farther from the surface 52, and closer to the center of rotor 44, near the outlet 74. Therefore, as the rotor 44 rotates, the guide bearings 66 move close to and away from surface 52, correspondingly causing respective vanes 50 to project a greater amount, near intake 72, and a lesser amount, near outlet 74, from the surface 52.

[0044] Track 68 is configured to cooperate with or parallel the portion, parallel to surface 52, of interior surface 54 of housing 46, in the sense that a tip 70 of vane 50 is maintained spaced from the portion, parallel to surface 52, of interior surface 54 by a gap of predetermined dimension. This is an important feature of the invention, since vanes 50 are not subject to frictional contact with interior surface 54, nor with walls which would otherwise be required to support and guide vanes 50 within rotor 44. The possibility of a vane 50 binding against interior surface 54 is thereby forestalled.

[0045] Guide bearing 66 can be maintained in contact with track 68 by centrifugal force or by springs (not shown) biasing vanes 50 to project from surface 52 of rotor 44. It should be noted that many other means, for maintaining guide

bearing 66 in contact with track 68, will readily be apparent to those skilled in the art and all such means are considered to be within the scope of the present invention.

[0046] An arm 60 and a vane 50 are shown isolated from other components in the detail of Fig. 5. Pivot about axis 62, and arcuate nature of vane 50 are clearly shown. Compressor 14 has inlet 72 and outlet 74 which define the inlet channel and the outlet channel of the compressor respectively. Compressor assembly 14 draws in fresh air, and compresses the same, releasing compressed air at a point of minimal expansible chamber volume 76, to the outlet 74.

[0047] Referring to Fig. 3, the expander 20 is seen. The expander 20 has a rotor 78 of circular cross section, mounted eccentrically, with respect to the center of mass of the cross sectional area of the interior of expander housing 48, within expander housing 48, and includes vanes 80 which project from the rotor 78. Housing interior surface 82 has a portion parallel to the surface 84 of the rotor 78 from which the vanes 80 project. This surface portion would be projecting out of the plane of the page in the view shown in Fig. 3. The portion of surface 82 parallel to surface 84, is displaced from the surface 84 by a variable amount. This displacement increases monotonically from a minimum proximate the intake 86 to a maximum proximate the outlet 88. Variable projection enables vanes 80 to seal the displacement, i.e. the dimension, between rotor surface 84 and the portion of the housing interior surface 82 parallel to surface 84. The variable distance existing between rotor surface 84 and the portion of the housing interior surface 82 parallel to surface 84, arises from the eccentricity of rotor 78 with respect to the center of mass of the cross sectional area of the interior of housing 48. Accordingly, the projection of each of the vanes 80 varies monotonically between a minimum projection proximate intake 86 to a maximum projection proximate outlet 88. Thus each of vanes 80 reaches the maximum projection once for every revolution of the rotor 78. The housing interior surface 82, in cross section, may form a modified "figure-8", wherein two circles overlap but do not precisely overlie one another. Of course, other cross sectional configurations, for example, circles and ellipses, would be satisfactory, depending upon the actual application. Additional seals 90, 92 seal gaps existing between rotor 78 and vanes 80, and between vanes 80 and housing interior surface 82.

[0048] The rotor 78 is generally cylindrical, and is mounted on shaft 22, which is coaxial therewith. As was noted previously, shaft 22 is common to both rotors 44 and 78. Returning to rotor construction, as illustrated in Fig. 3, each vane 80 is secured at one end to an arm 94, which arm 94 is pivotally attached to rotor 78 about axis 96. Arm 94 is mounted on an end wall 98 of cylindrical rotor 78, and extends into the hollow interior of rotor 78, in order to movably support vane 80 so as to allow vane 80 to move into and out of rotor 78. Vane 80 is preferably arcuate about a radius swung about axis 96, to accommodate projection and retraction. Arm 94 oscillates as rotor 78 rotates, being guided by the following arrangement.

[0049] A rotatable guide bearing 100 is disposed upon arm 94. Guide bearing 100 is located on the opposite side of arm 94 from end wall 98. A groove or track 102 is formed in a housing end wall (not shown), and guide bearing 100 rolls just inside track 102. As depicted in dotted line in the diagrammatic rendition of Fig. 3, track 102 acts as a camming surface controlling the amount of projection of vanes 80 out of the rotor 78. As the rotor 78 rotates the guide bearing 100 travels along track 102. The track 102 passes close to the surface 84 near the outlet 88 and farther from the surface 84, and closer to the center of rotor 78, near the inlet 86. Therefore, as the rotor 78 rotates, the guide bearings 100 move close to and away from surface 84, correspondingly causing respective vanes 80 to project a greater amount, near outlet 88, and a lesser amount, near inlet 86, from the surface 84.

[0050] Track 102 is configured to cooperate with or parallel the portion, parallel to surface 84, of interior surface 82 of housing 48, in the sense that a tip 104 of vane 80 is maintained spaced from the portion, parallel to surface 84, of interior surface 82 by a gap of predetermined dimension. This is an important feature of the invention, since vanes 80 are not subject to frictional contact with interior surface 82, nor with walls which would otherwise be required to support and guide vanes 80 within rotor 78. The possibility of a vane 80 binding against interior surface 82 is thereby forestalled.

[0051] Guide bearing 100 can be maintained in contact with track 102 by centrifugal force or by springs (not shown) biasing vanes 80 to project from surface 84 of rotor 78. It should be noted that many other means, for maintaining guide bearing 100 in contact with track 102, will readily be apparent to those skilled in the art and all such means are considered to be within the scope of the present invention.

[0052] The arm 94 and the respective vane 80 are identical in their general configuration to arm 60 and respective vane 50 shown in isolation in the detail of Fig. 5. Pivoting of arm 94 about axis 96 and the arcuate nature of vane 80, would be identical to the pivoting of arm 60 about axis 62 and the arcuate nature of vane 50 as shown in Fig. 5.

[0053] It will be appreciated that expander 20 is substantially similar to compressor 14, however expander 20 operates in reverse sequence to compressor 14. Expander assembly 20 accepts heated combustion gasses within its inlet 86, which gasses are then introduced to a variable volume space defined by surface 84, surface 82, and a neighboring pair of vanes 80, at a point 106. The variable volume space defined by surface 84, surface 82, and a neighboring pair of vanes 80, occupies its minimum volume at the point 106. As rotor 78 rotates, this variable volume space expands, heat energy is converted to mechanical energy, and exhaust is discharged to an exhaust system (not shown in its entirety) through outlet 88.

[0054] The principal structural difference between compressor and expander assemblies 14 and 20 is the presence in the latter of the plurality of valves 42. Valves 42 are actively controlled which means that the valves 42 can be set in

either the open position or the closed position independently of the pressure differential existing across any particular valve 42. Valves 42 are preferably electromagnetically operated, for example by using solenoids, and are biased into the closed position by springs 108. Alternatively, valves 42 may be mechanically actuated as, for example, by a cam arrangement, or the valves 42 may be actuated hydraulically using a hydraulic cylinder. Regardless of the actuating mechanism, most preferably the valves 42 are actively controlled by a microprocessor which selectively opens valves 42 in response to sensor inputs which will be described below. The valves 42 in the rotary expansible chamber device housing 48 are provided to admit atmospheric air to the housing when the pressure in the housing drops below atmospheric pressure. During the expansion of a gas if the pressure in the rotary expansible chamber device housing drops below atmospheric, the rotor will have to do work to discharge the gas to the atmosphere thus losing efficiency. Opening the valves 42, effectively reduces the expansion ratio of the rotary expansible chamber device 20 of the present invention, thereby preventing the pressure inside the housing from falling below atmospheric pressure.

[0055] In the illustrated example, provision of three valves 42 effectively allows the expander 20 to have four actively selectable expansion ratios. With all three valves 42 closed, the expander has its highest expansion ratio. Opening the valve closest to the outlet 88 of the expander, reduces the expansion ratio to the next lower level. Simultaneously opening the two valves closest to the outlet of the expander, further reduces the expansion ratio to the second lowest level. Finally, opening all three valves reduces the expansion ratio of the expander 20 to its lowest value.

[0056] In addition to opening valves 42 in response to low pressure in the expander housing, the valves 42 may be opened in response to a drop in demand for power as detected by sensor 36 which will be described below. Opening valves 42 reduces power output by the expander. This in turn reduces power available to the compressor 14 causing a decrease in the air intake flow rate. Reduced air flow means that less power will be generated from combustion, which leads to an overall reduction in engine rpm. Thus opening valves 42 can effectively act as an engine control mechanism allowing quick braking of the engine.

[0057] Fuel is conducted from a fuel storage tank 24 to combustor 16. Fuel flow is controlled by a valve 26. A microprocessor 28 processes input data generated by sensors, and adjusts fuel valve 26 accordingly.

[0058] There are four principal sensors 30,32,34,36. Sensors 30 and 32 sense temperature and pressure, respectively, existing at the outlet of the combustion chamber 18. Air flow sensor 34, located in the airstream of air intake 12, determines rate of intake of air mass, generating appropriate signals which are communicated to microprocessor 28 by communication cables, generally designated 38. Air flow sensor 34 is of any suitable common type currently in use in automotive applications, and need not be described in greater detail herein. Demand for power is inferred by demand sensor 36, which senses an operator control 40 essentially corresponding to a throttle.

[0059] In response to these inputs, microprocessor 28 generates four control signals. One control signal modulates fuel valve 26 to suit conditions. Temperature and pressure sensors 30,32 indicate excessive or intolerable temperature or pressure, or failure of combustion. Fuel valve 26 is adjusted accordingly. Demand for power is the most significant variable influencing fuel flow under normal circumstances.

[0060] Air flow sensor 34 provides one input to microprocessor 28 enabling, in combination with other inputs, inferred determination of a low pressure condition which may exist within expander assembly 20.

[0061] The pressure within the expander housing can be inferred using well known thermodynamic principles given the pressure and temperature measured by sensors 32 and 30 (see Figure 1) respectively.

[0062] The fundamental relationships used to evaluate the pressure in the expander housing are,

$$PV^\gamma = \text{constant} \quad (1)$$

$$PV = nRT_g \quad (2)$$

$$Q = Ah (T_g - T_h) \quad (3)$$

$$Q = C_p \Delta T_g \quad (4)$$

[0063] Where P is pressure of the gas in the expander, V is volume of the gas in the expander, n is the moles of gas, R is the gas constant, T_g is the gas temperature, T_h is the housing wall temperature, $\gamma = C_p/C_v$, C_p is the constant pressure heat capacity of the gas, C_v is the constant volume heat capacity of the gas, Q is the heat loss from the gas, A is the

heat transfer area, and h is the heat transfer coefficient. These relationships can be found in any introductory text on thermodynamics. Using a well known numerical technique known as zero dimension analysis, one of ordinary skill in the mechanical engineering art could calculate the gas pressure and temperature at any point in the expander housing given the inlet temperature and pressure, and the air flow rate.

[0064] The calculation would begin by calculating the gas pressure after a small increment of time using equation 1. The heat capacity ratio γ is a function of temperature and can be calculated using readily available software. Because in engines of the present type the ratio of air to fuel is on the order of 50 to 1, the gas composition is assumed to be the same as air. Using the air flow rate and the expansion ratio of the expander, which is determined by the expander geometry, the engine rpm can be determined. The volume of an elemental volume of the gas at the beginning and the end of the time interval is determined by the expander geometry and the engine rpm. Using equation 1 the pressure at the end of the time interval can be calculated.

[0065] Given the pressure and volume at the end of the time interval, a new temperature for the gas can be calculated using equation 2. An average of the new temperature and the initial temperature is used in equation 3 to calculate the heat loss from the gas during the time interval. The heat transfer coefficient h is given in the literature as a function of surface type and Reynolds number.

[0066] Using the heat loss calculated above and equation 4, a corrected gas temperature can be calculated. Again, using equation 2 and the corrected temperature a corrected pressure is calculated. The heat capacity ratio γ is evaluated at the corrected temperature, and the whole process is repeated for additional increments of time.

[0067] The above process is continued until the sum of the increments of time equals the time that is required for the elemental volume of gas to move from the expander inlet to the location of the vent valves. This numerical technique can be readily implemented using a microprocessor by one of ordinary skill in the art, and the thermodynamic analysis used would also be within the level of ordinary skill in the art.

[0068] Alternatively, experimental correlations correlating the pressure in the expander housing with the pressure measured by sensor 32, the temperature measured by sensor 30, and the air flow measured by sensor 34, may be programmed into the microprocessor 28 allowing the microprocessor to determine the pressure in the expander housing at the location of the valves 42. The correlations can be determined by routine experimentation using an experimental engine having a pressure sensor provided proximate the location of each of the valves 42, for directly measuring the pressure in the expander housing in the vicinity of each of the valves 42. In addition, production engines may be provided with pressure sensors proximate the location of each of the valves 42, for directly measuring the pressure in the expander housing in the vicinity of each of the valves 42. Thus allowing microprocessor 28 to selectively open valves 42 in response to direct measurement of the pressure in expander housing 48 at the location of each of the valves 42.

[0069] In the embodiment shown herein, three signals control three venting valves 42 communicating between an expansion chamber (see Fig. 3) and the open atmosphere, should microprocessor 28 determine a low pressure condition wherein expansion drops pressure therein below ambient pressure. This provides another adjustment in response to low pressure, should conditions not warrant adjusting fuel flow.

[0070] Lubrication and cooling are provided by forced liquid lubrication, as seen in Fig. 4. Liquid lubricant, such as oil, is stored in an enclosure 110. A conduit 112 leads to an annulus 114 formed between shaft 22 and a shaft housing 116 enclosing shaft 22. Annulus 114 is extended to both ends of shaft 22, and communicates with the cavities 118 and 120, formed by rotors 44 and 78 respectively, via bores 122. Oil is constrained to flow through bores 122 by seals 124. Suitable bearings 126 are located in annulus 114, and are lubricated by oil flow therethrough. A flow path at 128 is then provided by vanes, conduits, or other suitable structure (none shown), so that flow path 128 extends radially outwardly towards circumferential walls 130 and 132 bounding rotors 44 and 78 respectively. When shaft 22 rotates, considerable centrifugal force is imparted to a liquid present in flow path 128. Thus, oil is pressurized, and subsequently completes the circuit being described.

[0071] The oil, pressurized by centrifugal force, continues to flow through passageways 134 and 136 into annular cavities 138 and 140 surrounding housings 46 and 48 respectively. The oil then flows back to storage enclosure 110 via conduits 142 and 144. Storage enclosure 110 is located above the level of shaft 22, and preferably above the highest point of flow path 128, so that there is always oil subject to be pressurized immediately upon shaft rotation.

[0072] As clearly seen in this circuit, oil flows through rotors 44 and 78 and around housings 46,48, thus contacting the major structures that require cooling. Heat may be dissipated from oil as by radiation from enclosure 110, or there may be provided an active heat exchange system (not shown), depending upon the application and cooling load encountered thereby.

[0073] While the best mode of realizing the invention is considered to be the embodiment wherein two rotors 44,78 and housings 46,48 are spaced apart, employing a common shaft 22, the rotors 44,78 and housing assemblies 46,48 could obviously be employed in other arrangements.

[0074] It is to be understood that the present invention is not limited to the sole embodiment described above, but encompasses any and all embodiments within the scope of the following claims.

Claims

1. A rotary expansible chamber device (20), comprising:

a housing (48) having an open interior, an interior surface (82), an inlet, and an outlet (88), said housing having a plurality of valve openings communicating between said housing open interior and the atmosphere, said plurality of valve openings being distributed between said inlet and said outlet in order of increasing distance from said outlet with a first one of said plurality of valve openings being positioned closest to said outlet relative to others of said plurality of valve openings, and each subsequent one of said plurality of valve openings being positioned farther from said outlet than a previous one of said plurality of valve openings in said order;

a plurality of valves (42) provided for each of said plurality of valve openings, each of said plurality of valves being selectively movable between a closed and an open position, each of said plurality of valves obstructing fluid communication through a respective one of said plurality of valve openings when in said closed position, and enabling fluid communication through said respective one of said plurality of valve openings when in said open position;

a shaft (22) rotatably supported in said housing, said shaft having an axis (96) of rotation; and

a rotor (78) mounted within said housing and on said shaft, and having a longitudinal dimension disposed within said open interior, said rotor having a plurality of vanes (80) supported therein, said vanes being disposed selectively to move to and from a retracted condition and an extended condition, said vanes sealing a gap existing between said housing interior surface (82) and said rotor (78), the gap extending along said rotor longitudinal dimension, there being one arm (94) for each said vane, each said arm pivotally mounted on said rotor about a pivot axis (96) and controlling a respective said vane to move to the retracted and extended conditions, each said arm (94) having guide bearing means rotatably projecting therefrom and extending from said rotor,

said housing (48) further having track means (102) defining a guiding surface cooperating with said housing interior, said guide bearing means contacting and being guided by said guiding surface, said arms (94) constraining said vanes (80) to project, responsive to said guiding surface, from said rotor (22) for a predetermined dimension between said rotor and said housing interior surface (82),

characterised in that

said rotary expansible chamber device has an expansion ratio, and said expansion ratio is setable at a selected one of a plurality of expansion ratio values by opening respective ones of said plurality of valves (42).

2. A device as claimed in claim 1, wherein said vanes (80) are arcuate about a radius from said arm pivot axis (96).
3. A device as claimed in claims 1 or claim 2, wherein said housing interior surface (82) has a cross sectional configuration having a perimeter formed by two overlapping circles having different center points.
4. A device as claimed in any of claims 1-3, wherein said plurality of valves (42) are electromagnetically operated.
5. A device as claimed in any of claims 1-4, wherein said rotor (78) further includes means defining a space radially distant from said shaft axis of rotation, there further being:
- a shaft housing (116) enclosing said shaft (22), there being an annulus between said shaft and said shaft housing;
- a storage enclosure (110) for containing liquid lubricant disposed above said shaft (22);
- a conduit (112) for conducting liquid lubricant from said storage enclosure to said annulus; and
- means conducting liquid lubricant from said annulus to said radially located space, and restricting liquid lubricant against escape therefrom.
6. A device as claimed in any of claims 1-5, wherein each of said plurality of vanes (80) projects from said rotor (78) between a minimum distance and a maximum distance, and each of said plurality of vanes reaches said maximum distance, for projection from said rotor, once for every revolution of said rotor.
7. A device as claimed in any of claims 1-6, wherein said housing interior surface (82) has a cross sectional configuration having a perimeter formed by two overlapping circles having different center points.
8. A heat engine (10) comprising a second rotary expansible chamber device (20) as claimed in claim 1, and a first rotary expansible chamber device (14), each device having respective first and second inlets and outlets and first

and second housings, said engine further comprising:

a combustion chamber (18) having a third inlet and a third outlet, said third inlet of said combustion chamber (18) communicating with said first outlet of said first rotary expansible chamber device; said third outlet of said combustion chamber communicating with said second inlet of said second rotary expansible chamber device; and

a common shaft (22) being rotatably supported by said first housing and said second housing, respective said first and second rotors of each said first and second rotary expansible chamber devices being mounted on said common shaft (22), whereby air is compressed in said first rotary expansible chamber device, is delivered to and supports combustion in said combustion chamber (18), and products of combustion are conducted to and expanded within said second rotary expansible chamber device, thereby yielding useful energy in rotary form.

9. A heat engine as claimed in claim 8, wherein said plurality of valves are electromagnetically operated.

10. A heat engine as claimed claim 9, wherein each of said first plurality of vanes (80) projects from said first rotor (78) between a first minimum distance and a first maximum distance, and each of said first plurality of vanes reaches said first maximum distance, for projection from said first rotor, once for every revolution of said first rotor, and wherein each of said second plurality of vanes projects from said second rotor between a second minimum distance and a second maximum distance, and each of said second plurality of vanes reaches said second maximum distance, for projection from said second rotor, once for every revolution of said second rotor.

11. A heat engine as claimed in claim 10, further including a fuel supply conducting a fuel to said combustion chamber (18), a fuel valve controlling said fuel supply, a demand sensor (36) sensing demand for power and generating a control signal, and a microprocessor controlling said fuel valve responsive to said control signal; and, optionally further including,

(a) a temperature sensor (30) sensing temperature at said second outlet of said combustion chamber (18) and generating a temperature signal, and said microprocessor reducing fuel supply to said combustion chamber (18) when said temperature signal indicates a temperature value exceeding a predetermined temperature value and/or further including

(b) a pressure sensor (32) sensing pressure at said second outlet of said combustion chamber (18) and generating a pressure signal, and said microprocessor reducing fuel supply to said combustion chamber (18) when said pressure signal indicates a pressure value exceeding a predetermined pressure value.

12. A heat engine as claimed in any of claims 8-11, wherein said first rotor includes means defining a first space radially distant from said common shaft axis of rotation and said second rotor including means defining a second space radially distant from said common shaft axis of rotation, there further being:

a shaft housing enclosing said common shaft (22), there being an annulus between said shaft and said shaft housing;

a storage enclosure for containing liquid lubricant disposed above said common shaft (22);

a conduit for conducting liquid lubricant from said storage enclosure to said annulus; and

means conducting liquid lubricant from said annulus to said first space and said second space, and restricting liquid lubricant against escape therefrom.

13. A heat engine as claimed in any of claims 8-12, wherein said first housing interior surface (82) has a cross sectional configuration having a perimeter formed by first and second overlapping circles having different center points, and said second housing interior surface having a cross sectional configuration having a perimeter formed by third and fourth overlapping circles having different center points.

14. A heat engine as claimed in claim 9, further including a fuel supply conducting a fuel to said combustion chamber (18), a fuel valve controlling said fuel supply, a demand sensor (36) sensing demand for power and generating a control signal, a microprocessor controlling said fuel valve responsive to said control signal, and a temperature sensor (30) sensing temperature at said second outlet of said combustion chamber (18) and generating a temperature signal, said microprocessor reducing fuel supply to said combustion chamber (18) when said temperature signal indicates a temperature value exceeding a predetermined temperature value and, optionally further including a pressure sensor (32) sensing pressure at said second outlet of said combustion chamber and generating a pressure signal, and said microprocessor reducing fuel supply to said combustion chamber (18) when said pressure signal

indicates a pressure value exceeding a predetermined pressure value.

15. A heat engine (10) comprising a second rotary expansible chamber device (20) as claimed in claim 1, and a first rotary expansible chamber device (14), each device having respective first and second inlets and outlets and first and second housings, said engine further comprising:

a combustion chamber (18) having a third inlet and a third outlet, said third inlet of said combustion chamber communicating with said first outlet of said first rotary expansible chamber device (20); said third outlet of said combustion chamber (18) communicating with said second inlet of said second rotary expansible chamber device;

each said valve being electromagnetically operated, and each said valve being selectively opened when a low pressure condition exists within said second rotary expansible chamber device, whereby said low pressure condition is relieved by atmospheric pressure; and

a common shaft (22) being rotatably supported by said first housing and said second housing, respective said first and second rotors of each said first and second rotary expansible chamber devices being mounted on said common shaft (22), whereby air is compressed in said first rotary expansible chamber device, is delivered to and supports combustion in said combustion chamber (18), and products of combustion are conducted to and expanded within said second rotary expansible chamber device, thereby yielding useful energy in rotary form.

Patentansprüche

1. Rotationsvorrichtung (20) mit Expansionskammer, umfassend:

ein Gehäuse (48) mit einem offenen Innenraum, einer Innenfläche (82), einem Einlass und einem Auslass (88), wobei das Gehäuse eine Mehrzahl von Ventilöffnungen aufweist, die zwischen dem offenen Gehäuseinnenraum und der Atmosphäre kommunizieren, wobei die Mehrzahl von Ventilöffnungen zwischen dem Einlass und dem Auslass in einer Ordnung von zunehmendem Abstand von dem Auslass verteilt sind, wobei eine erste der Mehrzahl von Ventilöffnungen am dichtesten zu dem Auslass in Bezug zu anderen der Mehrzahl von Ventilöffnungen positioniert ist, und jede nachfolgende der Mehrzahl von Ventilöffnungen weiter von dem Auslass als eine vorhergehende der Mehrzahl von Ventilöffnungen in der Ordnung positioniert ist;

eine Mehrzahl von Ventilen (42), die für jede der Mehrzahl von Ventilöffnungen vorgesehen sind; wobei jedes der Mehrzahl von Ventilen selektiv zwischen einer geschlossenen und einer offenen Position bewegbar ist, und jedes der Mehrzahl von Ventilen Flüssigkeitskommunikation durch eine jeweilige der Mehrzahl von Ventilöffnungen blockiert, wenn es in der geschlossenen Position ist, und Flüssigkeitskommunikation durch die jeweilige eine der Mehrzahl von Ventilöffnungen ermöglicht, wenn es in der offenen Position ist;

eine Welle (22), die drehbar in dem Gehäuse gelagert ist, wobei die Welle eine Drehachse (96) aufweist; und einen Rotor (78), der innerhalb des Gehäuses und an der Welle angebracht ist, und eine Längsabmessung angeordnet innerhalb des offenen Innenraums aufweist, wobei der Rotor eine Mehrzahl von darin gehaltenen Flügeln (80) aufweist, und die Flügel selektiv angeordnet sind, um sich in einen eingezogenen Zustand und einen ausgestreckten Zustand und aus diesen heraus zu bewegen, wobei die Flügel einen zwischen der Gehäuseinnenfläche (82) und dem Rotor (78) vorhandenen Spalt abdichten, und der Spalt sich entlang der Rotorlängsabmessung erstreckt, wobei ein Arm (94) für jeden Flügel vorhanden ist, und jeder Arm um eine Schwenkachse (96) herum schwenkbar an dem Rotor angebracht ist und einen jeweiligen Flügel steuert, um sich in den eingezogenen und ausgestreckten Zustand zu bewegen, wobei jeder Arm (94) Führungslagermittel aufweist, die drehbar von diesem vorstehen und sich von dem Rotor erstrecken,

wobei das Gehäuse (48) ferner Schienenmittel (102) aufweist, die eine mit dem Gehäuseinnenraum zusammenwirkende Führungsoberfläche begrenzen, wobei die Führungslagermittel die Führungsoberfläche berühren und durch diese geführt werden, wobei die Arme (94) die Flügel (80) einschränken, um als Reaktion auf die Führungsoberfläche von dem Rotor (22) für ein vorbestimmtes Ausmaß zwischen dem Rotor und der Gehäuseinnenfläche (82) vorzustehen,

dadurch gekennzeichnet, dass

die Rotationsvorrichtung mit Expansionskammer ein Expansionsverhältnis aufweist, und das Expansionsverhältnis auf einen ausgewählten einer Mehrzahl von Expansionsverhältniswerten durch Öffnen jeweiliger der Mehrzahl von Ventilen (42) einstellbar ist.

2. Vorrichtung nach Anspruch 1, bei der die Flügel (80) um einen Radius von der Armschwenkachse (96) gebogen sind.
3. Vorrichtung nach Anspruch 1 oder Anspruch 2, bei der die Gehäuseinnenfläche (82)
 5 eine Querschnittskonfiguration mit einem Umfang aufweist, der durch zwei überlappende Kreise mit verschiedenen Mittelpunkten gebildet wird.
4. Vorrichtung nach einem der Ansprüche 1-3, bei der die Mehrzahl von Ventilen (42) elektromagnetisch betätigt wird.
5. Vorrichtung nach einem der Ansprüche 1-4, bei der der Rotor (78) weiter Mittel einschließt, die einen radial von der
 10 Wellendrehachse entfernten Raum begrenzen, wobei ferner vorliegt:
 ein Wellengehäuse (116), das die Welle (22) umschließt, wobei ein Ringraum zwischen der Welle und dem Wellengehäuse vorliegt;
 eine Speichereinfassung (110) zum Enthalten von flüssigem Schmiermittel, die über der Welle (22) angeordnet
 15 ist;
 eine Leitung (112) zum Leiten von flüssigem Schmiermittel aus der Speichereinfassung zu dem Ringraum; und
 Mittel, die flüssiges Schmiermittel von dem Ringraum zu dem radial angeordneten Raum leiten und Entweichen von flüssigem Schmiermittel aus demselben beschränken.
- 20 6. Vorrichtung nach einem der Ansprüche 1-5, bei der jeder der Mehrzahl von Flügeln (80) von dem Rotor (78) zwischen einem minimalen Abstand und einem maximalen Abstand vorsteht, und jeder der Mehrzahl von Flügeln den maximalen Abstand zum Vorstehen von dem Rotor einmal für jede Umdrehung des Rotors erreicht.
- 25 7. Vorrichtung nach einem der Ansprüche 1-6, bei der die Gehäuseinnenfläche (82) eine Querschnittskonfiguration mit einem Umfang aufweist, der durch zwei überlappende Kreise mit verschiedenen Mittelpunkten gebildet wird.
- 30 8. Wärmekraftmaschine (10), die eine zweite Rotationsvorrichtung (20) mit Expansionskammer nach Anspruch 1 und eine erste Rotationsvorrichtung (14) mit Expansionskammer aufweist, wobei jede Vorrichtung jeweils einen ersten und zweiten Einlass und Auslass und ein erstes und zweites Gehäuse aufweist, und die Kraftmaschine weiter aufweist:
 eine Brennkammer (18) mit einem dritten Einlass und einem dritten Auslass, wobei der dritte Einlass der Brenn-
 35 kammer (18) mit dem ersten Auslass der ersten Rotationsvorrichtung mit Expansionskammer kommuniziert; und der dritte Auslass der Brennkammer mit dem zweiten Einlass der zweiten Rotationsvorrichtung mit Expansionskammer kommuniziert; und
 eine gemeinsame Welle (22), die drehbar durch das erste Gehäuse und das zweite Gehäuse gehalten wird, wobei jeweils der erste und zweite Rotor jeder der ersten und zweiten Rotationsvorrichtung mit Expansions-
 40 kammer an der gemeinsamen Welle (22) angebracht sind, wodurch Luft in der ersten Rotationsvorrichtung mit Expansionskammer komprimiert wird, in die Brennkammer (18) geliefert wird und dort Verbrennung unterstützt, und Verbrennungsprodukte zu der zweiten Rotationsvorrichtung mit Expansionskammer geleitet und dort expandiert werden, wodurch verwendbare Energie in Rotationsform gewonnen wird.
- 45 9. Wärmekraftmaschine nach Anspruch 8, bei der die Mehrzahl von Ventilen elektromagnetisch betätigt wird.
- 50 10. Wärmekraftmaschine nach Anspruch 9, bei der jeder der ersten Mehrzahl von Flügeln (80) von dem ersten Rotor (78) zwischen einem ersten minimalen Abstand und einem ersten maximalen Abstand vorsteht, und jeder der ersten Mehrzahl von Flügeln den ersten maximalen Abstand zum Vorstehen von dem ersten Rotor einmal für jede Umdrehung des ersten Rotors erreicht, und wobei jeder der zweiten Mehrzahl von Flügeln von dem zweiten Rotor zwischen einem zweiten minimalen Abstand und einem zweiten maximalen Abstand vorsteht, und jeder der zweiten Mehrzahl von Flügeln den zweiten maximalen Abstand zum Vorstehen von dem zweiten Rotor einmal für jede Umdrehung des zweiten Rotors erreicht.
- 55 11. Wärmekraftmaschine nach Anspruch 10, die ferner eine Brennstoffzuführung, welche einen Brennstoff zu der Brennkammer (18) leitet, ein die Brennstoffzuführung steuerndes Brennstoffventil, einen Bedarfssensor (36), der den Energiebedarf abfühlt und ein Steuersignal erzeugt, und einen Mikroprozessor einschließt, der das Brennstoffventil als Reaktion auf das Steuersignal steuert; und die optional weiter einschließt:

(a) einen Temperatursensor (30), der die Temperatur an dem zweiten Auslass der Brennkammer (18) abfühlt und ein Temperatursignal erzeugt, und der Mikroprozessor die Brennstoffzuführung zu der Brennkammer (18) reduziert, wenn das Temperatursignal einen Temperaturwert anzeigt, der einen vorbestimmten Temperaturwert übersteigt, und/oder weiter einschließt:

(b) einen Drucksensor (32), der Druck an dem zweiten Auslass der Brennkammer (18) abfühlt und ein Drucksignal erzeugt, und der Mikroprozessor die Brennstoffzuführung zu der Brennkammer (18) reduziert, wenn das Drucksignal einen Druckwert anzeigt, der einen vorbestimmten Druckwert übersteigt.

12. Wärmekraftmaschine nach einem der Ansprüche 8-11, bei der der erste Rotor Mittel einschließt, die einen radial von der gemeinsamen Wellendrehachse entfernten ersten Raum begrenzen, und der zweite Rotor Mittel einschließt, die einen radial von der gemeinsamen Wellendrehachse entfernten zweiten Raum begrenzen, wobei ferner vorhanden ist:

ein Wellengehäuse, das die gemeinsame Welle (22) umschließt, wobei ein Ringraum zwischen der Welle und dem Wellengehäuse vorliegt;

eine Speichereinfassung zum Enthalten von flüssigem Schmiermittel, die über der gemeinsamen Welle (22) angeordnet ist;

eine Leitung zum Leiten von flüssigem Schmiermittel aus der Speichereinfassung zu dem Ringraum; und Mittel, die flüssiges Schmiermittel von dem Ringraum zu dem ersten Raum und dem zweiten Raum leiten, und Entweichen von flüssigem Schmiermittel aus demselben beschränken.

13. Wärmekraftmaschine nach einem der Ansprüche 8-12, bei der die erste Gehäuseinnenfläche (82) eine Querschnittskonfiguration mit einem Umfang aufweist, der durch einen ersten und zweiten überlappenden Kreis mit verschiedenen Mittelpunkten gebildet wird, und die zweite Gehäuseinnenfläche eine Querschnittskonfiguration mit einem Umfang aufweist, der durch einen dritten und vierten überlappenden Kreis mit verschiedenen Mittelpunkten gebildet wird.

14. Wärmekraftmaschine nach Anspruch 9, die ferner eine Brennstoffzuführung, welche einen Brennstoff zu der Brennkammer (18) leitet, ein die Brennstoffzuführung steuerndes Brennstoffventil, einen Bedarfssensor (36), der den Energiebedarf abfühlt und ein Steuersignal erzeugt, einen Mikroprozessor, der das Brennstoffventil als Reaktion auf das Steuersignal steuert; und einen Temperatursensor (30) einschließt, der die Temperatur an dem zweiten Auslass der Brennkammer (18) abfühlt und ein Temperatursignal erzeugt, wobei der Mikroprozessor die Brennstoffzuführung zu der Brennkammer (18) reduziert, wenn das Temperatursignal einen Temperaturwert anzeigt, der einen vorbestimmten Temperaturwert übersteigt, und optional weiter einen Drucksensor (32) einschließt, der Druck an dem zweiten Auslass der Brennkammer (18) abfühlt und ein Drucksignal erzeugt, und der Mikroprozessor die Brennstoffzuführung zu der Brennkammer (18) reduziert, wenn das Drucksignal einen Druckwert anzeigt, der einen vorbestimmten Druckwert übersteigt.

15. Wärmekraftmaschine (10), die eine zweite Rotationsvorrichtung (20) mit Expansionskammer nach Anspruch 1 und eine erste Rotationsvorrichtung (14) mit Expansionskammer aufweist, wobei jede Vorrichtung einen jeweiligen ersten und zweiten Einlass und Auslass und ein erstes und zweites Gehäuse aufweist, und die Kraftmaschine ferner aufweist:

eine Brennkammer (18) mit einem dritten Einlass und einem dritten Auslass, wobei der dritte Einlass der Brennkammer mit dem ersten Auslass der ersten Rotationsvorrichtung (20) mit Expansionskammer kommuniziert; und der dritte Auslass der Brennkammer (18) mit dem zweiten Einlass der zweiten Rotationsvorrichtung mit Expansionskammer kommuniziert;

wobei jedes Ventil elektromagnetisch betrieben wird, und jedes Ventil selektiv geöffnet wird, wenn ein niedriger Druckzustand innerhalb der zweiten Rotationsvorrichtung mit Expansionskammer vorliegt, wodurch der niedrige Druckzustand durch Atmosphärendruck aufgehoben wird; und

eine gemeinsame Welle (22), die drehbar durch das erste Gehäuse und das zweite Gehäuse gehalten wird, wobei jeweils der erste und zweite Rotor jeder der ersten und zweiten Rotationsvorrichtung mit Expansionskammer an der gemeinsamen Welle (22) angebracht sind, wodurch Luft in der ersten Rotationsvorrichtung mit Expansionskammer komprimiert wird, in die Brennkammer (18) geliefert wird und dort Verbrennung unterstützt, und Verbrennungsprodukte zu der zweiten Rotationsvorrichtung mit Expansionskammer geleitet und dort expandiert werden, wodurch verwendbare Energie in Rotationsform gewonnen wird.

Revendications

1. Dispositif rotatif à chambre expansible (20), comprenant
un carter (48) ayant un intérieur ouvert, une surface intérieure (82), une entrée, et une sortie (88), ledit carter ayant
une pluralité d'ouvertures de soupapes communiquant entre ledit intérieur ouvert du carter et l'air libre, ladite pluralité
d'ouvertures de soupapes étant répartie entre ladite entrée et ladite sortie en ordre de distance croissante de ladite
sortie, une première de ladite pluralité d'ouvertures de soupapes étant positionnée le plus près de ladite sortie par
rapport à d'autres ouvertures de ladite pluralité d'ouvertures de soupapes, et chaque ouverture subséquente de
ladite pluralité d'ouvertures de soupapes étant positionnée plus loin de ladite sortie qu'une ouverture précédente
de ladite pluralité d'ouvertures de soupapes dans ledit ordre ;
une pluralité de soupapes (42) prévues pour chacune de ladite pluralité d'ouvertures de soupapes, chacune de
ladite pluralité de soupapes pouvant être bougée sélectivement entre une position fermée et une position ouverte,
chacune de ladite pluralité de soupapes obstruant la communication de fluide à travers une ouverture respective
de ladite pluralité d'ouvertures de soupapes lorsqu'elle est dans ladite position fermée, et permettant la communi-
cation de fluide à travers ladite ouverture respective de ladite pluralité d'ouvertures de soupapes lorsqu'elle est dans
ladite position ouverte ;
un arbre (22) supporté dans ledit carter de manière à pouvoir tourner, ledit arbre ayant un axe (96) de rotation ; et
un rotor (78) monté à l'intérieur dudit carter et sur ledit arbre, et ayant une dimension longitudinale disposée à
l'intérieur dudit intérieur ouvert, ledit rotor ayant une pluralité d'aubes (80) supportées à l'intérieur de celui-ci, lesdites
aubes étant disposées de manière sélective de façon à bouger d'un état rétracté à un état déployé et vice versa,
lesdites aubes fermant de façon étanche un intervalle existant entre ladite surface intérieure du carter (82) et ledit
rotor (78), cet intervalle s'étendant le long de ladite dimension longitudinale du rotor, un bras (94) étant prévu pour
chaque aube, chaque dit bras étant monté, de façon à pivoter, sur ledit rotor autour d'un axe de pivot (96) et
commandant une dite aube respective pour qu'elle se mette dans l'état rétracté et déployé, chaque dit bras (94)
ayant un moyen palier de guidage faisant saillie de celui-ci de manière à pouvoir tourner et s'étendant depuis ledit
rotor,
ledit carter (48) comprenant également un moyen voie (102) définissant une surface de guidage coopérant avec
ledit intérieur du carter, ledit moyen palier de guidage entrant contact avec la surface de guidage et étant guidé par
celle-ci, lesdits bras (94) contraignant lesdites aubes (80) à faire saillie dudit rotor (22), en réponse à ladite surface
de guidage, sur une dimension prédéterminée entre ledit rotor et ladite surface intérieure du carter (82),
caractérisé en ce que
ledit dispositif rotatif à chambre expansible a un taux d'expansion, et ledit taux d'expansion est réglable à une valeur
sélectionnée d'une pluralité de valeurs de taux d'expansion en ouvrant les soupapes respectives de ladite pluralité
de soupapes (42).
2. Dispositif tel que revendiqué dans la revendication 1, lesdites aubes (80) étant arquées autour d'un rayon depuis
ledit axe de pivot du bras (96).
3. Dispositif tel que revendiqué dans la revendication 1 ou la revendication 2, ladite surface intérieure du carter (82) ayant
une configuration de coupe transversale ayant un périmètre formé par deux cercles se chevauchant ayant différents
centres.
4. Dispositif tel que revendiqué dans l'une quelconque des revendications 1 à 3, ladite pluralité de soupapes (42) étant
commandées électromagnétiquement.
5. Dispositif tel que revendiqué dans l'une quelconque des revendications 1 à 4, ledit rotor (78) comprenant également
un moyen définissant un espace radialement distant dudit axe de rotation de l'arbre, dispositif comportant également
un carter d'arbre (116) enfermant ledit arbre (22), un espace annulaire étant prévu entre ledit arbre et ledit carter
d'arbre ;
une enceinte de stockage (110) pour contenir du lubrifiant liquide, disposée au-dessus dudit arbre (22) ;
un conduit (112) pour conduire le lubrifiant liquide de ladite enceinte de stockage audit espace annulaire ; et
un moyen conduisant le lubrifiant liquide dudit espace annulaire audit espace situé radialement, et restreignant le
lubrifiant liquide afin de l'empêcher de s'échapper de celui-ci.
6. Dispositif tel que revendiqué dans l'une quelconque des revendications 1 à 5, chacune de ladite pluralité d'aubes
(80) faisant saillie dudit rotor (78) entre une distance minimum et une distance maximum, et chacune de ladite
pluralité d'aubes atteignant ladite distance maximum, pour faire saillie dudit rotor, une fois pour chaque tour accompli
par ledit rotor.

7. Dispositif tel que revendiqué dans l'une quelconque des revendications 1 à 6, ladite surface intérieure du carter (82) ayant une configuration de coupe transversale ayant un périmètre formé par deux cercles se chevauchant ayant différents centres.

8. Moteur thermique (10) comprenant un deuxième dispositif rotatif à chambre expansible (20) tel que revendiqué dans la revendication 1, et un premier dispositif rotatif à chambre expansible (14), chaque dispositif ayant une première et une deuxième entrée et sortie respective et un premier et un deuxième carter, ledit moteur comprenant également :

une chambre de combustion (18) ayant une troisième entrée et une troisième sortie, ladite troisième entrée de ladite chambre de combustion (18) communiquant avec ladite première sortie dudit premier dispositif rotatif à chambre expansible ; ladite troisième sortie de ladite chambre de combustion communiquant avec ladite deuxième entrée dudit deuxième dispositif rotatif à chambre expansible ; et

un arbre commun (22) étant supporté par ledit premier carter et ledit deuxième carter de manière à pouvoir tourner, lesdits premier et deuxième rotors respectifs de chacun desdits premier et deuxième dispositifs rotatifs à chambre expansible étant montés sur ledit arbre commun (22), ce qui fait que l'air est comprimé dans ledit premier dispositif rotatif à chambre expansible, qu'il est refoulé dans ladite chambre de combustion (18) et soutient la combustion dans celle-ci, et que les produits de la combustion sont conduits audit deuxième dispositif rotatif à chambre expansible et détendus à l'intérieur de celui-ci, fournissant ainsi une énergie utile de forme rotative.

9. Moteur thermique tel que revendiqué dans la revendication 8, ladite pluralité de soupapes étant commandées électromagnétiquement.

10. Moteur thermique tel que revendiqué dans la revendication 9, chacune de ladite première pluralité d'aubes (80) faisant saillie dudit premier rotor (78) entre une première distance minimum et une première distance maximum, et chacune de ladite première pluralité d'aubes atteignant ladite première distance maximum, pour faire saillie dudit premier rotor, une fois pour chaque tour accompli par ledit premier rotor, et chacune de ladite deuxième pluralité d'aubes faisant saillie dudit deuxième rotor entre une deuxième distance minimum et une deuxième distance maximum, et chacune de ladite deuxième pluralité d'aubes atteignant ladite deuxième distance maximum, pour faire saillie dudit deuxième rotor, une fois pour chaque tour accompli par ledit deuxième rotor.

11. Moteur thermique tel que revendiqué dans la revendication 10, comprenant également une alimentation en carburant, conduisant un carburant à ladite chambre de combustion (18), une soupape à carburant contrôlant ladite alimentation en carburant, un capteur de demande (36) détectant la demande de puissance et produisant un signal de commande, et un microprocesseur commandant ladite soupape à carburant en réponse audit signal de commande ; et comprenant aussi facultativement,

(a) un capteur de température (30) détectant la température à ladite deuxième sortie de ladite chambre de combustion (18) et produisant un signal de température, et ledit microprocesseur réduisant l'alimentation en carburant à ladite chambre de combustion (18) lorsque ledit signal de température indique une valeur de température dépassant une valeur de température prédéterminée et/ou comprenant également

(b) un capteur de pression (32) détectant la pression à ladite deuxième sortie de ladite chambre de combustion (18) et produisant un signal de pression, et ledit microprocesseur réduisant l'alimentation en carburant à ladite chambre de combustion (18) lorsque ledit signal de pression indique une valeur de pression dépassant une valeur de pression prédéterminée.

12. Moteur thermique tel que revendiqué dans l'une quelconque des revendications 8 à 11, ledit premier rotor comprenant un moyen définissant un premier espace distant radialement de l'axe de rotation dudit arbre commun et ledit deuxième rotor comprenant un moyen définissant un deuxième espace distant radialement de l'axe de rotation dudit arbre commun, ce moteur comportant également :

un carter d'arbre enfermant ledit arbre commun (22), un espace annulaire existant entre ledit arbre et ledit carter d'arbre ;

une enceinte de stockage pour contenir du lubrifiant liquide, disposée au-dessus dudit arbre (22) ;

un conduit pour conduire le lubrifiant liquide de ladite enceinte de stockage audit espace annulaire ; et

un moyen conduisant le lubrifiant liquide dudit espace annulaire audit premier espace et audit deuxième espace,

et restreignant le lubrifiant liquide pour l'empêcher de s'échapper de celui-ci.

5 13. Moteur thermique tel que revendiqué dans l'une quelconque des revendications 8 à 12, ladite surface intérieure du premier carter (82) ayant une configuration de coupe transversale ayant un périmètre formé par un premier et un deuxième cercle se chevauchant ayant différents centres, et ladite surface intérieure du deuxième carter ayant une configuration de coupe transversale ayant un périmètre formé par un troisième et un quatrième cercle se chevauchant ayant différents centres.

10 14. Moteur thermique tel que revendiqué dans la revendication 9, comprenant également une alimentation en carburant conduisant un carburant à ladite chambre de combustion (18), une soupape à carburant contrôlant ladite alimentation en carburant, un capteur de demande (36) détectant la demande de puissance et produisant un signal de commande, un microprocesseur commandant ladite soupape à carburant en réponse audit signal de commande ; et un capteur de température (30) détectant la température à ladite deuxième sortie de ladite chambre de combustion (18) et produisant un signal de température, ledit microprocesseur réduisant l'alimentation en carburant à ladite chambre de combustion (18) lorsque ledit signal de température indique une valeur de température dépassant une valeur de température prédéterminée et comprenant aussi facultativement un capteur de pression (32) détectant la pression à ladite deuxième sortie de ladite chambre de combustion et produisant un signal de pression, et ledit microprocesseur réduisant l'alimentation en carburant à ladite chambre de combustion (18) lorsque ledit signal de pression indique une valeur de pression dépassant une valeur de pression prédéterminée.

20 15. Moteur thermique (10) comprenant un deuxième dispositif rotatif à chambre expansible (20) tel que revendiqué dans la revendication 1, et un premier dispositif rotatif à chambre expansible (14), chaque dispositif ayant une première et une deuxième entrée et sortie respectives et un premier et un deuxième carter, ledit moteur comprenant également :

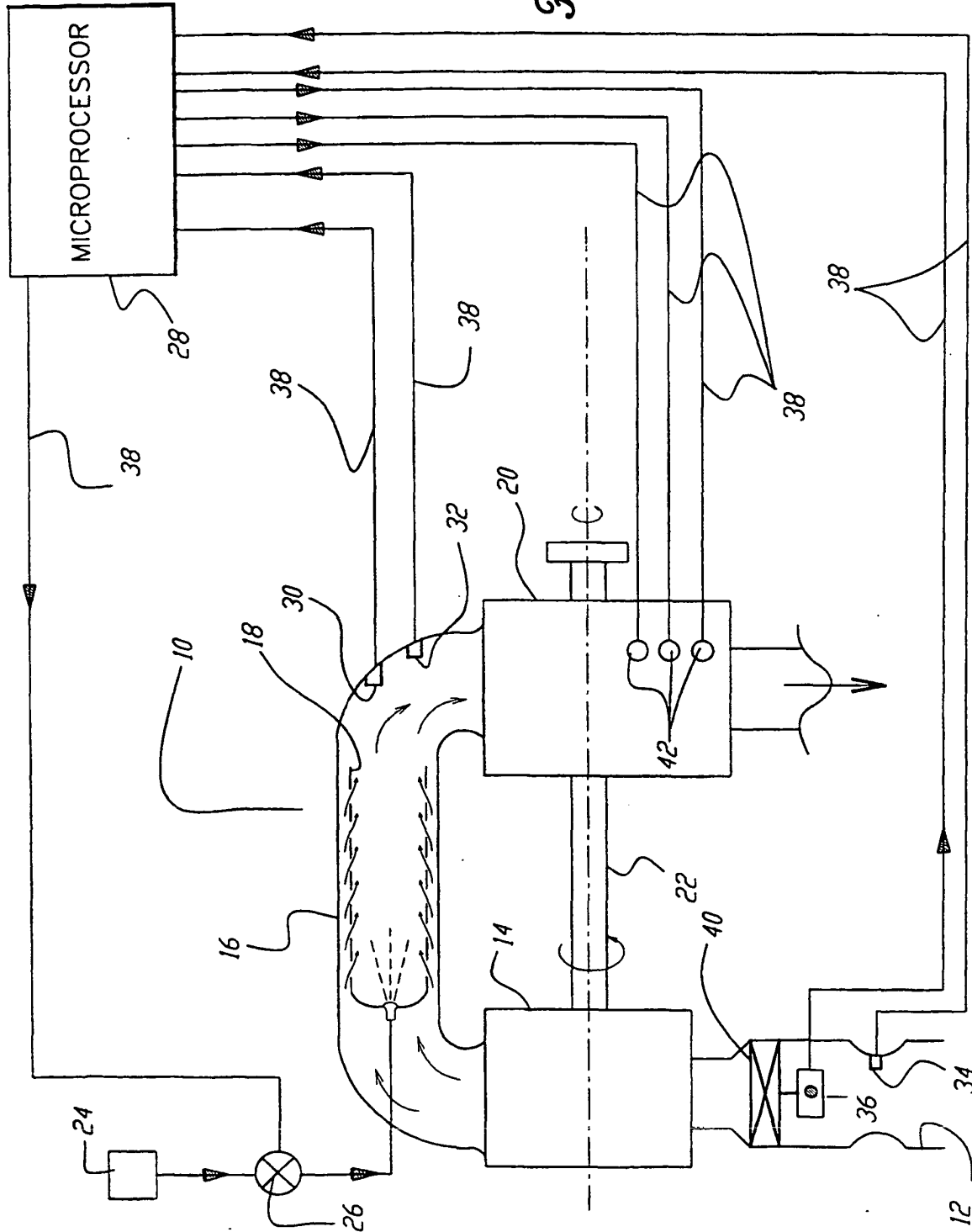
25 une chambre de combustion (18) ayant une troisième entrée et une troisième sortie, ladite troisième entrée de ladite chambre de combustion communiquant avec ladite première sortie dudit premier dispositif rotatif à chambre expansible (20) ; ladite troisième sortie de ladite chambre de combustion (18) communiquant avec ladite deuxième entrée dudit deuxième dispositif rotatif à chambre expansible ;

30 chacune desdites soupapes étant commandée électromécaniquement, et chacune desdites soupapes étant ouverte sélectivement lorsqu'une condition de basse pression existe à l'intérieur dudit deuxième dispositif rotatif à chambre expansible, ce qui fait que ladite condition de basse pression est soulagée par la pression atmosphérique ; et

35 un arbre commun (22) étant supporté par ledit premier carter et ledit deuxième carter, de façon à pouvoir tourner, lesdits premier et deuxième rotors respectifs de chacun desdits premier et deuxième dispositifs rotatifs à chambre expansible étant montés sur ledit arbre commun (22), ce qui fait que l'air est comprimé dans ledit premier dispositif rotatif à chambre expansible, qu'il est refoulé dans ladite chambre de combustion (18) et soutient la combustion dans celle-ci, et que les produits de la combustion sont conduits jusqu'audit deuxième dispositif rotatif à chambre expansible à l'intérieur duquel ils sont détendus, produisant ainsi une énergie utile sous forme

40 rotative.

Fig. 1



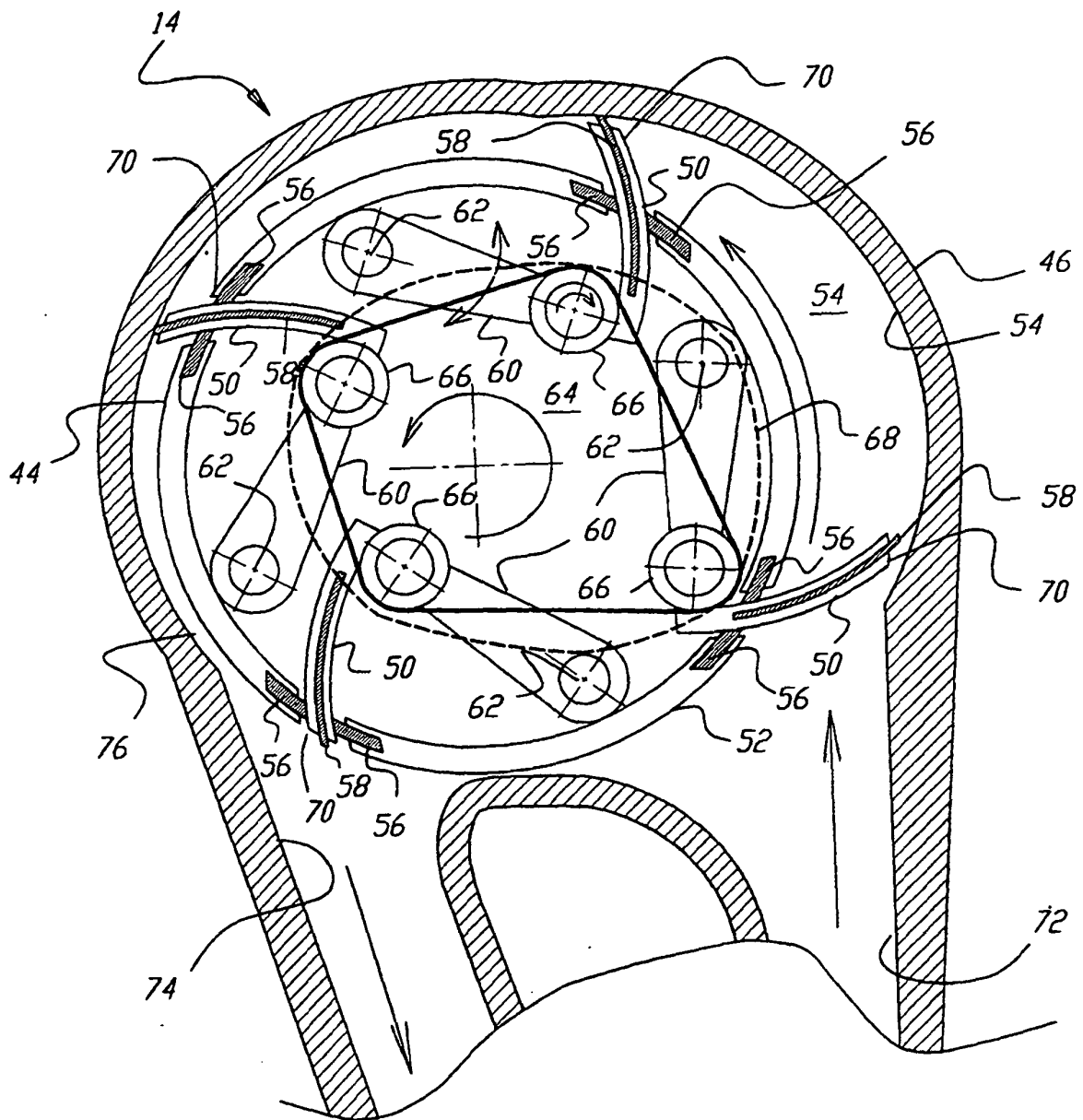


Fig. 2

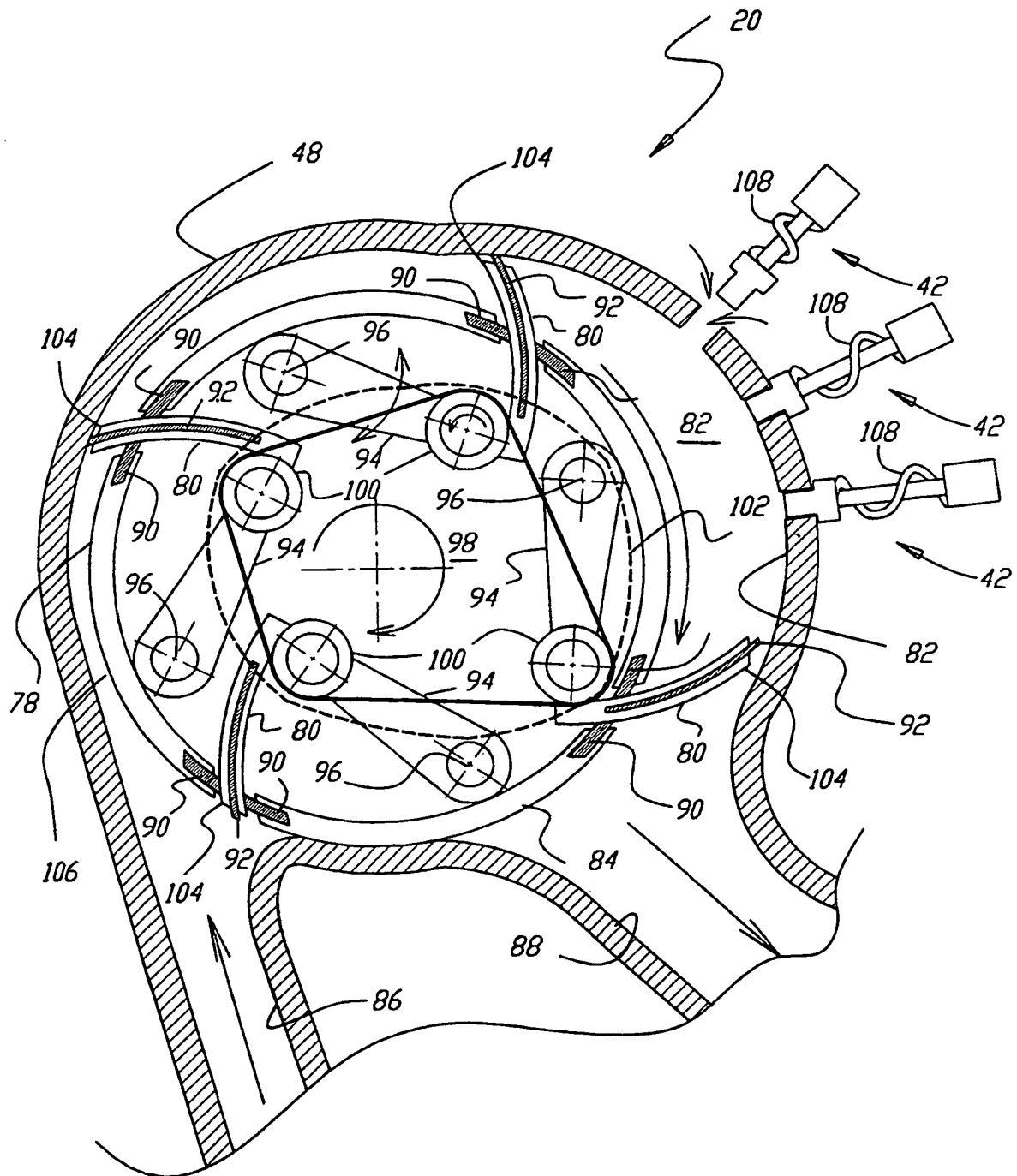


Fig. 3

