United States Patent [19]

Kantz

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[54] **AUXILIARY WATER PUMP**

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[73] Assignee: **Ford Motor Company,** Dearborn, Mich.

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[52] **U.S. Cl.** **60/524;** 123/41.01; 415/141; 415/182; 60/690

[51] **Int. Cl.²** **F02G 1/04;** F01K 9/00

[58] **Field of Search** 123/41.44, 41.02, 41.01; 60/517, 524, 526, 690, 692; 418/84, 88; 415/141, 182

[56] **References Cited**

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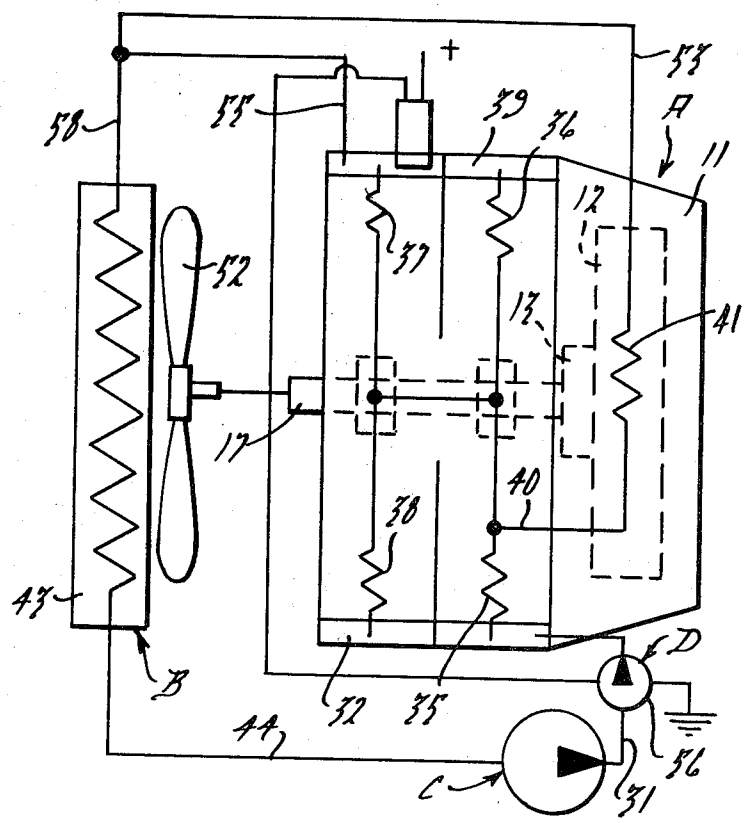
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[57] **ABSTRACT**

An external continuous type combustion engine, of the Stirling type, is disclosed having a cooling circuit modified to permanently receive an auxiliary but independent pumping means in the circuit. The auxiliary pumping means is operative to free wheel with cooling flow when said engine is operating and to drive said cooling fluid after engine shut down. Collapsible blading continuously in the cooling flow is utilized to achieve the different operative conditions of said auxiliary pumping means.

12 Claims, 6 Drawing Figures



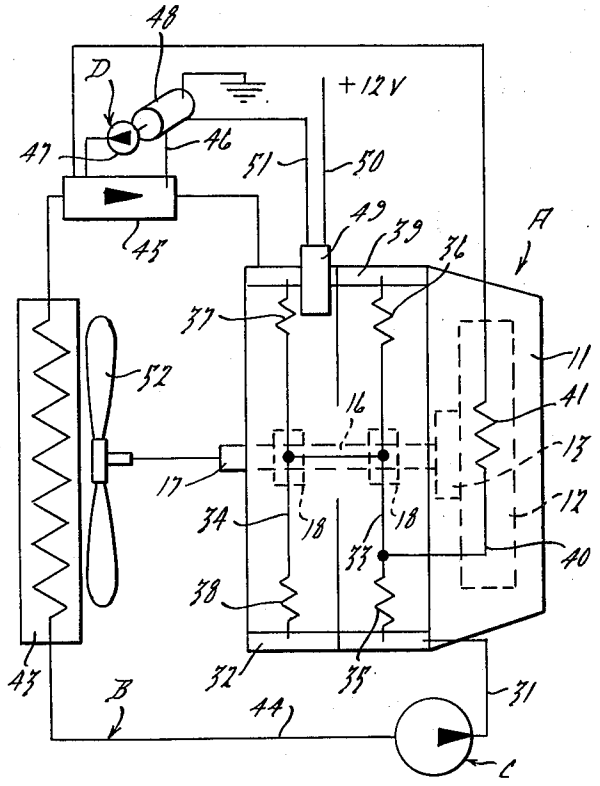


Fig. 1.

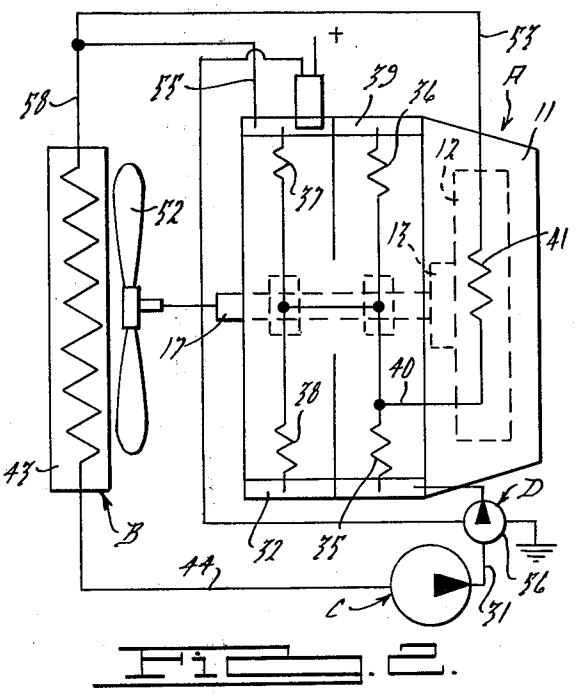


Fig. 2.

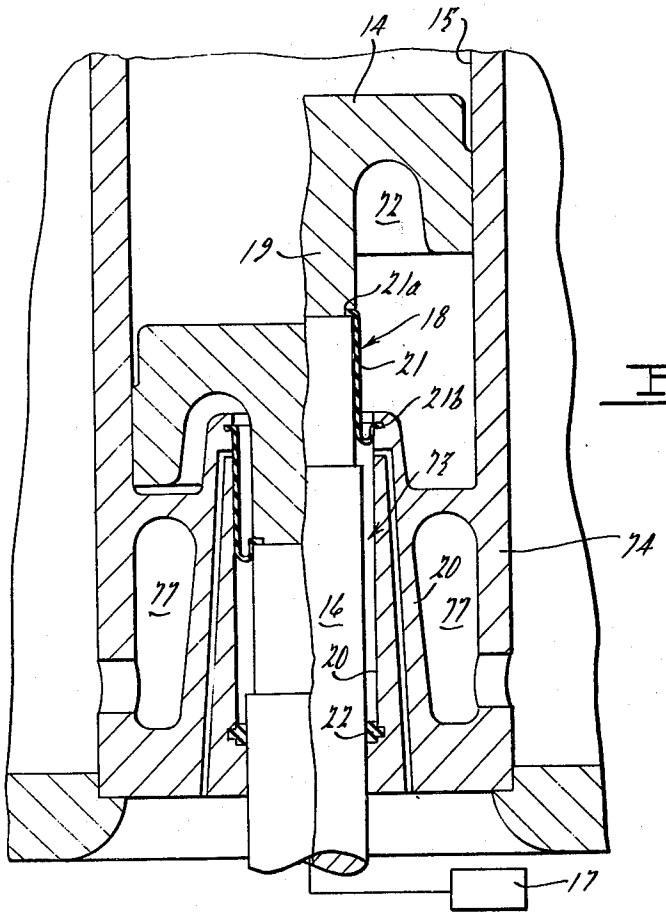


Fig. 3.

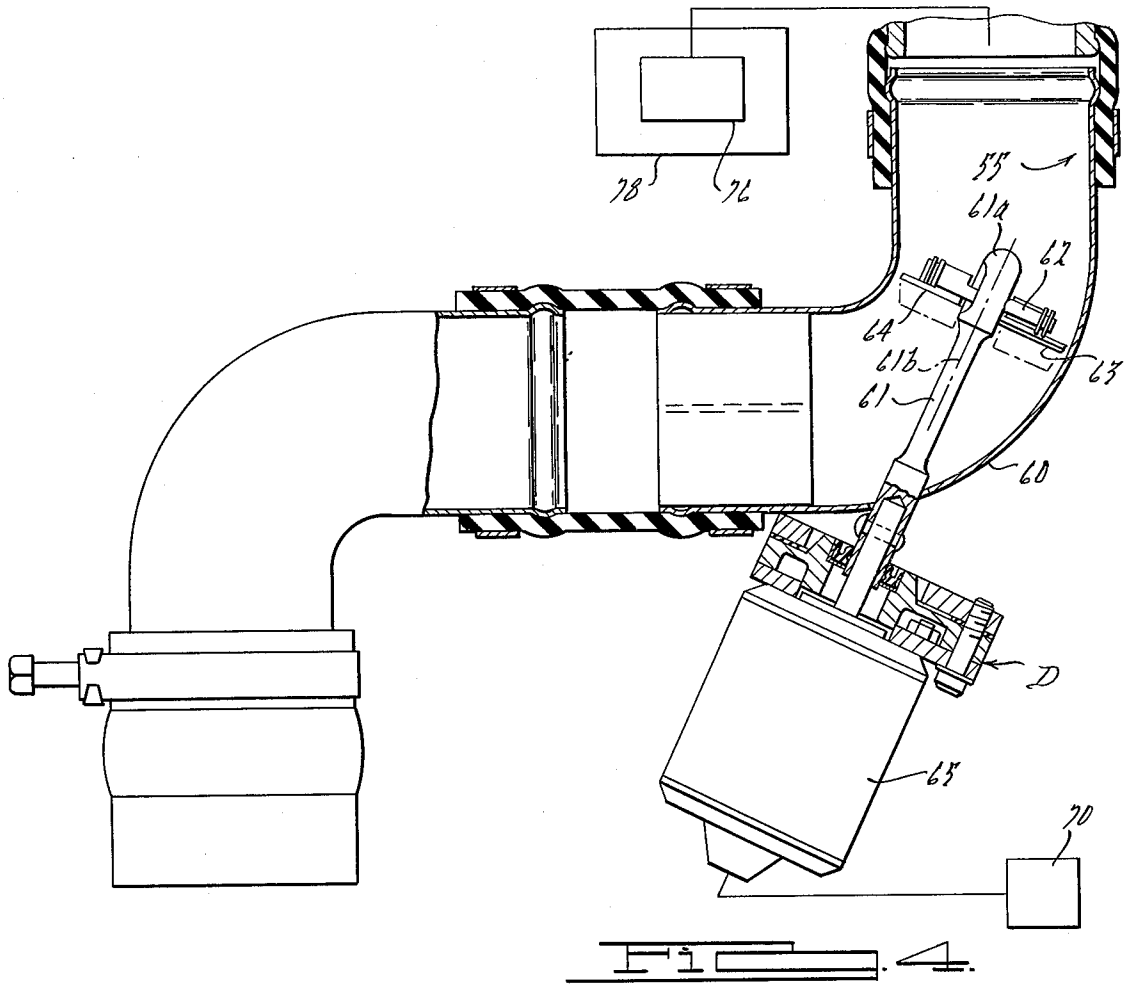


Fig. 4.

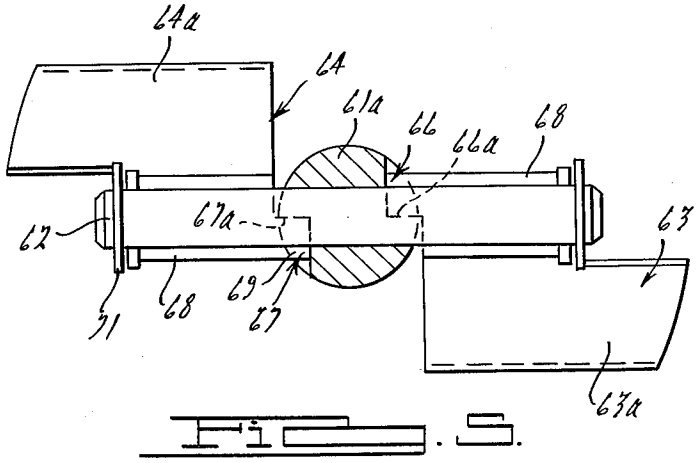


Fig. 5.

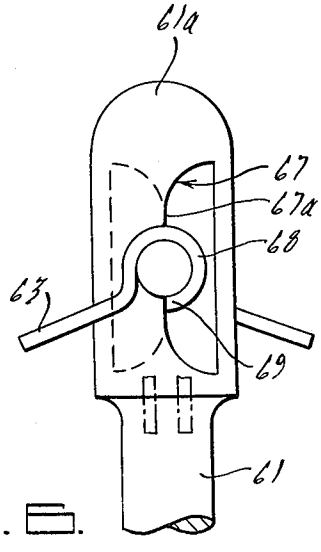


Fig. 6.

AUXILIARY WATER PUMP

BACKGROUND OF THE INVENTION

In an external continuous-type combustion engine, particularly of the Stirling type, some protection must be afforded to certain elements of the engine which are unable to withstand high temperatures. Such elements fall into two general categories: (a) metallic enclosures for the main working walls of the engine and (b) heat sensitive components, such as seals, adjacently positioned to the internal closed gas system of the engine and are usually concerned with the driven or transmission portion of the engine. Since heat input to the main working walls ceases relatively quickly upon engine shut down, the metallic enclosures will not be subjected to unusual thermal stresses since the cooling system, driven by the operation of the engine, is generally coterminous in operation with heat input. However, this does not hold true for the heat sensitive components which are subject to residual or latent heat not quickly dissipated in response to engine shut down. Such components must be protected by continuing the normal cooling function of the cooling system after engine shut down to protect against thermal destruction.

Any solution to this problem must closely consider the expense and materials utilized which should not unduly detract from the available engine energy, and should retain the engine weight and fabricating costs at a minimum level.

SUMMARY OF THE INVENTION

A primary object of this invention is to provide an improved cooling circuit for a continuous external combustion engine of the Stirling type which is effective to retain cooling capability even after the engine has shut down to protect certain heat sensitive parts that are subject to residual engine heat after engine shut down.

Another object of this invention is to provide an unobtrusive auxiliary pumping means which remains in the main cooling circuit during all conditions of operation and nonoperation of the engine; said auxiliary pumping means should free wheel with flow created by engine operation and drive said flow when the engine is inactive. After engine shut down, said auxiliary means should be effective to continue the cooling circuit flow from a separate power source independent from said engine.

Particular features pursuant to the above objects comprise the use of an auxiliary water pump selectively driven by electrical power source, the auxiliary pump has collapsible blading effective to float freely in a limited manner with the normal cooling flow driven by the engine and effective to disalign with the flow through said cooling system for driving said cooling flow after engine shut down in response to rotation of the auxiliary pump shaft, (b) orientation of the auxiliary pump shaft and support for the rotatable blading so that the blading aligned will be aligned with a radius of a curvilinear passage into which the auxiliary pump extends, the shaft should extend substantially downstream of said blading.

SUMMARY OF THE DRAWINGS

FIG. 1 represents a schematic diagram of a Stirling engine employing an early, unimproved developmental cooling circuit which is effective to cool both the working walls of the engine and certain heat sensitive parts;

FIG. 2 is a schematic diagram, similar to FIG. 1, illustrating the improved cooling circuit according to the later developments for this invention;

FIG. 3 is an enlarged sectional view of a portion of the engine illustrating the connecting rod between the driving piston of the Stirling engine and the driven means, the connecting rod is split and shown in two positions for illustrating the action of the roll sock seal about said connecting rod;

FIG. 4 is an enlarged fragmentary view of a portion of the improved cooling circuit illustrating the auxiliary pumping means associated with a curvilinear portion of the passage of said cooling circuit;

FIG. 5 illustrates a still further enlarged view of the blading on said auxiliary pumping means, the blading being shown in a driving position; and

FIG. 6 is a side elevational view of the structure in FIG. 5.

DETAILED DESCRIPTION

Turning now to the drawings, and particularly to FIG. 1, there is illustrated a schematic drawing of an external continuous type combustion engine A. The engine is particularly of the Stirling type, more particularly disclosed in U.S. Patent Application Ser. No. 466,653 (commonly assigned to the assignee of this invention), the disclosure of which is incorporated herein by reference. The engine has a cooling system B effective to maintain predetermined maximum temperatures in certain major zones of the engine; a primary pumping means C is employed to move fluid along said cooling system during normal engine operation and an auxiliary pumping means D is employed to move fluid along said system when the engine is shut down.

The engine A has an enclosed hot gas circuit 12 which is thermally cycled to receive heat from an external combustion circuit (not shown) and reject heat to either the cooling system B or an independent cooling system. Working walls 13 of the engine are exposed to the hot gases with said circuit 12 and operate responsively to provide mechanical movement; particularly, the working walls comprise in part a piston 14 and surrounding chamber walls 15, as best seen in FIG. 3. A connecting rod is employed to connect the piston 14 with a driven means 17.

A seal construction 18 is employed to separate and close the portion 72 of the hot gas circuit from the zone 73 which surrounds said connecting rod. To this end, the piston has a neck 19 depending downwardly for moving along and into the mouth of a cylindrical chamber 20, the latter chamber being defined in a housing 74 for receiving the connecting rod 16 therethrough. A flexible annular sealing boot 21 is employed to provide said gas tight seat, one end 21*a* of said seal being secured to the extremity of said neck 19 and another end 21*b* being secured to the extremity of the extension 20. The boot is typically referred to as roll sock seal. When the piston neck 19 is nested within the extension 20, the roll sock seal is arranged with end 21*a* above end 21*b*. However, in the opposite position of the connecting rod, end 21*a* is reversed to be beneath end 21*b*. This reversal requires that the seal actually roll, very much like a sock is rolled onto or off of a member. The boot or roll sock is typically made of a material that cannot be as heat resistant as other metallic or ceramic portions of the engine. With this in mind, the heat sensitive components must be carefully guarded after engine

shut down from latent heat. To this end, cooling fluid is passed about the roll sock seal by way of annular passage 77. This passage is one of the heat absorption zones 35–38 of the cooling system to be described.

The cooling system B has a passage 31 downstream of the primary pumping means C connecting to a fluid entrance header 32 for the engine; parallel connected passages 33 and 34 extend from said header 32 and have portions thereof acting as heat absorbing zones (such as 35 and 36 for passage 33 and zones 37 and 38 for passage 34). The parallel connected passages join to an exit header 39 which in turn has a downstream passage 42 ultimately connecting with a heat release or heat extraction zone such as provided by the radiator 43. Surrounding air is moved past the radiator by fan 52 driven by the engine. The cooled fluid is then returned by passage 44 to the primary pumping means C.

A branch circuit is provided comprising a passage 40 connecting with one of the parllel connected passages; passage 40 leads to a primary heat absorption zone 41, typically surrounding the primary working walls of the engine. Passage 40 connects with a downstream passage 53 rejoining with passage 42.

In FIG. 1 an unimproved version or phase of the development program that lead to the present invention is schematically shown for auxiliary means D. A flow diverter 45 is employed in passage 40 to normally permit unrestrained fluid flow to radiator 43 during normal engine operation. However, in response to an elevated temperature, sensed in the exit header 39, particularly after engine shut down, the flow diverter 45 is shifted so that fluid flow is caused to move through a shunt by-pass wherein is disposed an auxiliary pump 47; pump 47 is thus normally out of the cooling system during engine operation. Activation of the auxiliary pumping means D for FIG. 1 involves use of device 49 which senses an unwanted temperature to start electric motor 48 by way of electrical leads 50 and 51 in communication with a suitable electrical supply such as a battery. The auxiliary pump may be any suitable fix blade type driven by an electric motor effective to move fluid through the shunt by-pass. The principal drawbacks of this early phase of development is the considerable expense and lack of reliability required by a flow diverter, control, and auxiliary pumping passages normally independent from the primary circuit.

The improved cooling system of the present invention, as shown in FIG. 2, employs again the primary pumping means C which, of course, can be any typical fluid pump as now utilized in commercial engines of this type. The passage 31, downstream of the primary pumping means leads again to an entrance header 32 having parallel connected passages 33 and 34 with portions thereof defining heat absorption zones about apparatus, such as the roll sock seals 18. Again, a branch circuit has passage 40 carrying cooling fluid to the working walls adjacent the hot gas closed circuit 13; passage 53 connects the branch circuit with the passage 55 so that both bodies of cooling fluid may proceed commonly through passage 58 to the radiator 43.

The fundamental difference of the improved cooling system is in the simplification of the passage 55 downstream of the exit header 39 and the use and orientation of a novel auxiliary pumping means D in the single passage 31 upstream from the entrance header 32. However the thermal sensing unit 49 is still placed in the exit header 39 for controlling the on and off operation of means D in FIG. 2.

In FIG. 4, the improved auxiliary pumping means comprises a shaft 61 selectively driven by an electric motor 65 receiving power from a source 70 and extending on a unique orientation path into the passage 55. The passage is here shown as having a curvilinear portion 60 which receives fluid from a cooling circuit 76 within engine 78. At the extremity 61*a* of the shaft, a transverse axis or arm 62 is supported for rotation with the shaft 61. The arm 62 extends symmetrically outwardly from opposite sides of the shaft and carries a pair of limited movable fluid moving members 63 and 64 (bladed elements).

Each of the fluid moving members have a substantially flat contoured portion 63a and a journal 68 commonly formed from a single metallic stamping. The journal is adapted to have an interior radius fitting snugly about the exterior cylindrical surface of the arm 62; the fluid moving members are retained on the arm by suitable stop members, such as at 70. Each fluid moving member has an extension 69, here shown as a finger extending from the journal 68, which is effective to engage a stop defined on the shaft 61. The stop is particularly shown as comprising a recess 67, one provided on each side of the shaft and located adjacent the extremity 61*a*. The recesses define flat stop surfaces 67*a* and each are complimentary to other laying on opposite sides of the shaft.

In operation, when the external continuous combustion engine is operating, the primary pumping means C is effective to carry an adequate fluid flow through passage 55 to cool working walls as well as heat sensitive components, as shown in FIG. 4. Under this condition, fluid forces impinge upon the backside of each of the fluid moving members 63 and 64 causing them to rotate about the arm 62 and align with the fluid flow, such as shown in dotted outline in FIG. 6. When the engine undergoes shut down, fluid flow through passage 55 ceases to have a driving force from the primary pumping means. A sensing mechanism will selectively engergize the electric motor 65 causing shaft 51 to rotate about the longitudinal axis 61b. Such rotation would tend to provide a degree of centrifugal force causing the fluid moving members 63 and 64 to move away from shaft 61 and disalign with the centerline of the passage 55. Reaction forces of the fluid against the forward side of each of the blades 63*a* and 64*a*, will cause the fluid moving members to move to a position with the blades extended almost perpendicular to the shaft 61. The fluid moving members are prevented from assuming a totally perpendicular relationship because fingers (or extensions) 67 on each of the fluid moving members engage the stops defined upon the shaft. This promotes a predetermined angular orientation of the fluid moving members with the shaft. This predetermined positioning is designed to provide an optimum ability to stimulate continuous fluid flow through passage 55. The operation of the auxiliary pumping means may be programmed to cease upon the cooling fluid reaching a reduced temperature condition in the sensitive areas or to continue until such time as the primary pumping means is reactivated.

I claim as my invention:

1. In an external continuous combustion engine, a cooling system for said engine, comprising:

a. circuit means for positively conveying a cooling fluid between a heat absorbing zone and a heat extraction zone, said circuit means having a fluid passage,

b. primary pumping means driven by said engine for moving said fluid through said fluid passage during normal operation of said engine, said primary means permitting fluid flow therethrough when deactivated, and

c. auxiliary means for moving said cooling fluid along said passage when said primary means is deactivated, said auxiliary means having a projection normally extending into said passageway during all conditions of flow through said passage, said projection having a shaft driven for rotation about the shaft axis and having at least one fluid moving member supported on said shaft for limited free rotation about an axis transverse to said shaft whereby said fluid moving member may free wheel with fluid flow when said primary means is active and positively move said fluid in response to said shaft being driven when said primary means is deactivated.

2. The apparatus as in claim **1**, in which said transverse axis carries at least one fluid moving member on opposite sides of said shaft, each of said fluid moving members being free to align with fluid flow when said flow is driven by said primary means and effective to align transverse to said flow for imparting fluid movement when said fluid moving members are positively rotated by said shaft.

3. The apparatus as in claim **1**, in which the engine has an internal closed circuit for heat exchange, and heat sensitive flexible engine components exposed to said closed circuit, said heat absorbing zone being arranged to affect cooling of heat sensitive flexible engine components.

4. In a Stirling engine having at least one driving piston exposed to the force of an enclosed gas which is thermally cycled, a driven member and a rod connecting said driving piston and driven member, a flexible seal about said connecting rod for dividing said enclosed gas from the driven member, an apparatus combination, comprising:

a. a cooling circuit having a passage surrounding said seal for effectively maintaining a predetermined maximum temperature of said seal,

b. first pumping means for normally driving a cooling fluid through said passageway when said engine is operating, said pump being normally and continuously disposed in the circuit for said passage, and

c. auxiliary means for driving said coolant flow through said passage when said engine and said first pumping means is inactive, said auxiliary means having at least one fluid moving member disposed continuously in said passage, said fluid moving member being carried on said auxiliary pumping means in a manner for aligning with the flow of said fluid when said first pumping means is operative and for positively disaligning with fluid flow to impart a positive force to said fluid when said first means is inactive.

5. The apparatus combination as in claim **4**, in which said circuit has a fluid entrance header, a fluid exit header, and a plurality of passageways connecting said headers and surrounding said seals for providing temperature protection, said auxiliary means being located in said passage downstream in said circuit from said exit header.

6. The apparatus combination as in claim **1**, in which the auxiliary means comprises a selectively rotatable shaft provided with a stop thereon, said shaft rigidly carrying a cross member for rotary movement therewith, said fluid moving member being pivotally carried on said cross member for limited free rotation, said fluid moving member having an extension effective to engage said stop on said shaft after experiencing a predetermined degree of rotation about said arm for providing limitation of said free rotation.

7. The apparatus combination as in claim **6**, in which said stop is defined by a recess in said shaft, said recess providing a surface laying in a plane including said shaft axis, said surface serving as said stop.

8. The apparatus combination as in claim **4**, in which said first pumping means is driven by said engine and said auxiliary means has an independent source of electrical energy for operating an electric motor to rotate the shaft of said auxiliary means.

9. The system as in claim **1**, in which said fluid moving member normally moves between two positions, one position normally aligned with fluid flow coincident with the axis of said shaft, and a position less than **90°** from said first position.

10. The system as in claim **1**, in which said limited rotation of said fluid moving member about said transverse axis is provided by cooperation between an extension of said member and a stop on said shaft, said extension being arranged to contact said stop upon reaching a predetermined degree of rotation about said transverse axis.

11. The system as in claim **1**, in which the passage is curvilinear and said shaft is arranged to extend into said curvilinear passage in a manner to carry said transverse axis coincident with a radius of said curvilinear passage.

12. For use in a Stirling engine having at least one driving piston exposed to the force of an enclosed gas which is thermally cycled, a driven member and a rod connecting said driving piston and driven member, and having a flexible seal about said connecting rod for dividing said enclosed gas from the driven member, and having a cooling circuit with a passage surrounding said seal for effectively maintaining a predetermined maximum temperature of said seal during engine operation, an auxiliary fluid pump for maintaining said temperature after engine shut down, comprising:

a. a rotatable shaft extending into said passage,

b. electrical means for rotating said shaft about the longitudinal axis of said shaft,

c. an arm carried at and extending across the extremity of said shaft and transverse to the shaft axis, and

d. at least one fluid moving member journalled on said arm for limited rotation transverse to said shaft, said member being rotatably movable in response to flow created by said engine to align with said flow, said member being rotatably movable in response to rotation of said shaft and to the reaction force of fluid in said passage to extend transverse to said shaft for imparting thrust to said fluid in said passage, the member having an extension effective to engage said shaft to limit rotatable movement in response to rotation of said shaft so that said member assumes an optimum position for imparting thrust to said fluid.

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