Dec. 6, 1949 P. KOLLSMAN 2,490,064

THERMODYNAMIC MACHINE

Filed Jan. 12, 1945 2 Sheets-Sheet 1

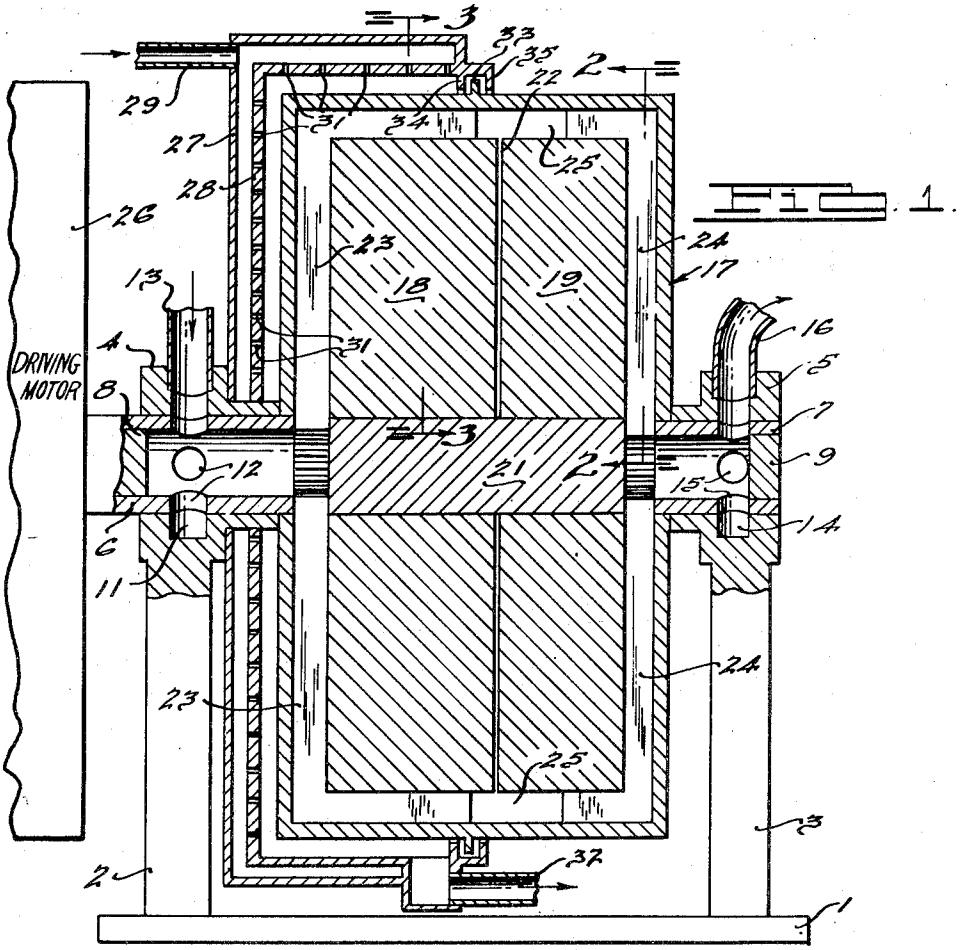


Fig. 1.

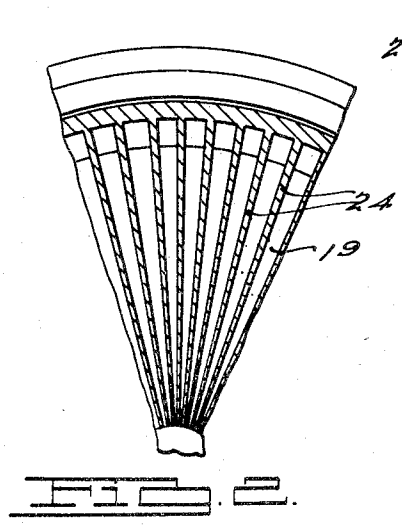


Fig. 2.

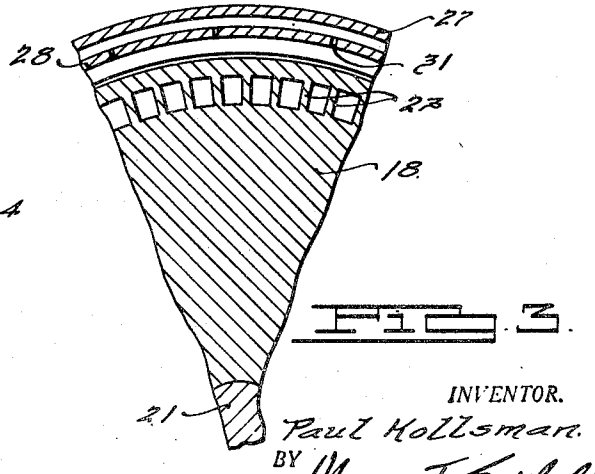


Fig. 3.

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THERMODYNAMIC MACHINE

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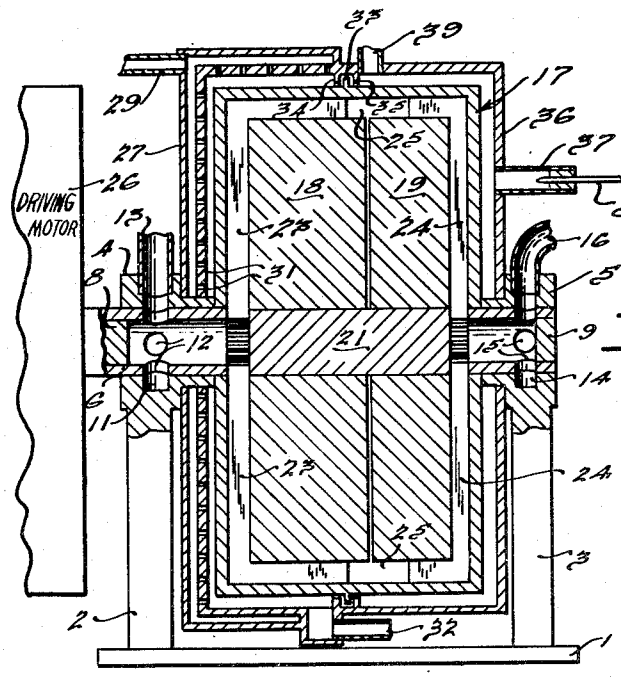


FIG. 4.

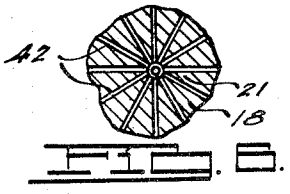
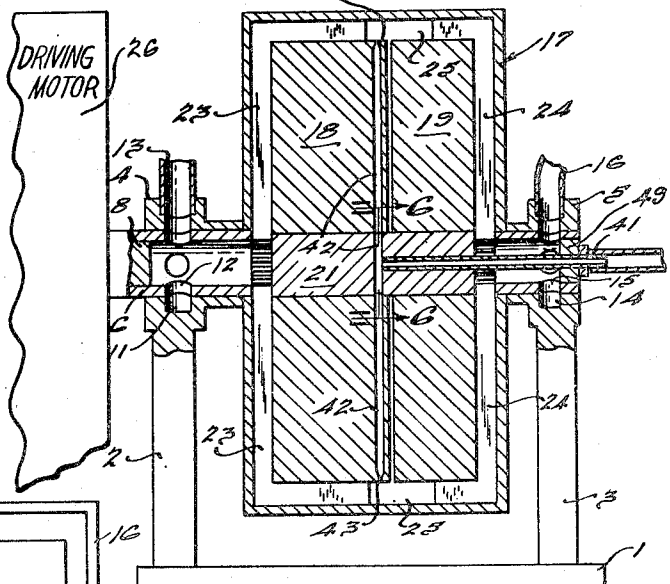


FIG. 5.



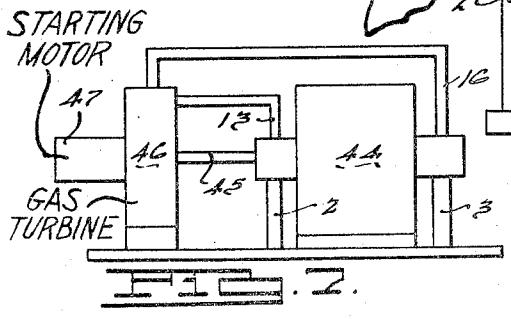


FIG. 2.

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THERMODYNAMIC MACHINE

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10 Claims. (Cl. 60—44)

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This invention relates to a thermo-dynamic machine for changing the temperature and / or pressure characteristics of gases passed therethrough.

An object of the invention is the provision of a thermo-dynamic machine for changing the temperature and/or pressure characteristics of the gas in which the gas is rotated at high speeds, with the pressure characteristic of the gas changed by the action of centrifugal force acting upon a column thereof, with the gas passing from its compression to its expansion cycle without substantial change in its rotative velocity.

Another object of the invention is the provision of a thermo-dynamic machine according to the previous object in which the gas flow through the machine is radial and transverse, with the energy of rotation of the gas returned to the machine before its exit therefrom.

Other objects of the invention lie in the provision of thermo-dynamic machines in accordance with the previous objects with means for effecting a suitable change in the heat content of the gas employed.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawings illustrating certain preferred embodiments in which:

Figure 1 is a transverse sectional view through one form of thermo-dynamic machine according to the present invention.

Figure 2 is a partial sectional view on the line II—II of Figure 1.

Figure 3 is a partial sectional view on the line III—III of Figure 1.

Figure 4 is a transverse sectional view through a modified form of thermo-dynamic machine according to the present invention.

Figure 5 is a transverse sectional view through a further modified form of the invention.

Figure 6 is a partial sectional view on the line VI—VI of Figure 5.

Figure 7 is a diagrammatic representation of a system in which the thermo-dynamic machine in accordance with Figures 4 and 5 may be utilized.

In the thermo-dynamic machine shown in Figures 1, 2 and 3 there is shown a platform 1 carrying standards 2 and 3 having bearings 4 and 5 in which are journaled hollow shafts 6 and 7 provided with suitable closures 8 and 9. The bearing 4 is provided with an annular chamber 11 communicating with the hollow shaft 6 through the openings 12 there-through. An inlet pipe 13 leads to the annular chamber 11.

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Similarly, the bearing 5 is provided with an annular chamber 14 communicating with the hollow shaft 7 through the openings 15 therein. The chamber 14 communicates with an exit pipe 16.

Upon the shafts 6 and 7 is mounted a drum 17 having disposed within its central portion large rings 18 and 19 secured to a central core or shaft 21 and spaced apart as at 22 for heat insulation. It is, of course, understood that the spacing 22 may be filled with an insulating material if desired. Secured to the rings 18 and 19 and the drum 17 are a plurality of spaced walls or fins 23 and 24 which extend transversely of the peripheral portion of the rings and drum, and which may be continuous if desired but are specifically shown as interrupted at 25 to form a common annular peripheral chamber for the individual chambers formed between the falls or fins 23 and 24. The walls or fins 23 and 24 are also attached to the shafts 6 and 7 and the core or shaft 21 to bind the shafts 6 and 7, drum 17, the rings 18 and 19 and the fins or partition walls themselves into a unitary rotatable structure. The shaft 8 is driven by any suitable motive means indicated diagrammatically at 26 in the drawing. In the modification of Figures 1, 2 and 3, the thermo-dynamic machine according to this invention is provided with means for cooling the gas during its compression cycle so as to produce or approach isothermal compression of the gas. While this may be accomplished by any desired means, it is specifically shown as embodied in a double walled generally cup-shaped stationary structure mounted on the bearing 4 and enclosing the left hand side of the machine as viewed in Figure 1, comprised of an outer wall 27 and inner wall 28 between which is flowed a coolant such as water from the inlet pipe 29. The inner wall 28 is provided with a plurality of openings 31 through which the coolant passes into contact with the exterior of the drum 17. In view of the direct contact of the coolant with the walls of the drum 17 and the relatively large surface afforded by the fins or partition walls 23, ready heat transfer is effected from the gas as it is compressed. Water leaving the surface of the drum is carried away through the exit pipe 32, a simple water seal being provided by the annular projection 33 on the drum 17 and the projections 34 and 35 on the wall 28 which cooperate therewith.

In the operation of the thermo-dynamic machine of Figures 1, 2 and 3, the rotary elements are rotated at relatively high speed by the mo-

tor 26. Gas is forced into the inlet 13 and cooling water is supplied through the inlet 29. The gas passes through the pipe 13, annular chamber 11. openings 12 and the hollow shaft 6 into the space between walls or fins 23. The gas within the chambers formed between the fins 23 will be rotated within the drum 17 and in its movement toward the periphery of the drum will be progressively compressed by the centrifugal force exerted on the column of the gas itself in the chambers between the fins. As the gas is being compressed, its heat of compression will be absorbed by the coolant passing through the openings 31 into contact with the drum 17 so that its compression will be accompanied by a loss in heat energy and the compression will be effected substantially isothermally. In the machine specifically illustrated the gas will pass transversely of the periphery of the machine and enter the chambers between the spaced walls or fins 24. As the gas passes radially inwardly from the periphery, the pressure thereof decreases due to the lessening of the column of gas acting thereon by centrifugal force and the gas will expand adiabatically to lower its temperature so that the gas leaving the outlet 16 after passing through the hollow shaft 7, opening 15, and annular chamber 14 will be refrigerated to a lower temperature than the gas entering the inlet 13. It is to be noted that the energy of rotation imparted to the gas as it enters the thermo-dynamic machine is substantially returned thereto, as the gas leaves the machine at a small diameter thereof, so that the energy loss in the rotation of the machine, other than that required to rotate the parts mechanically, is the small loss due to frictional resistance to the transverse flow of the gas, which flow may be of relatively low velocity. The machine illustrated in Figures 1, 2 and 3 thus operates at high efficiency to carry out a refrigerating cycle in which gas is compressed while being cooled to absorb its heat of compression and is thereafter expanded adiabatically to produce a lowering of temperature. It is to be noted that the gas in passing through its compression and expansion cycles returns its energy of rotation to the machine, completes the cycles without contact with stationary parts, and passes from its compression to its expansion cycle without substantial change in its rotative energy.

The modification of the machine illustrated in Figure 4 is quite similar to that shown in Figure 1 through its major operating parts and like reference numerals have been given to like parts. However, the machine of Figure 4 adds to that of Figure 1 means for imparting energy to the gas after its compression cycle. As specifically shown, this embodies a cup-shaped casing 36 mounted upon the bearing 5 and provided with an intake at 37 into which a burner nozzle or other means 38 may be provided for introducing a heating medium into contact with the drum 17. The products of combustion of the heating medium may be vented from the chamber formed between the drum 17 and the casing 36 through the outlet 39. In the operation of the machine of Figure 4, the gas after passing through the compression cycle will be heated to increase its energy. In the operation of this machine, the gas may be forced through its passage between the inlet 13 and outlet 16 as described in connection with Figure 1, or the flow may be a natural one produced by the difference in density between the columns of the gas between the walls or partitions 23 and between the walls or partitions 24. Since the temperature of the gas in the chambers between the walls 23 will be lower than the temperature between the walls 24, it is apparent that the density in the first case will be greater and, hence, the centrifugal force exerted by these columns will be greater than that exerted by the columns in the chambers between the walls of the fins 24. Accordingly, a pressure differential will be produced between the inlet 13 and the outlet 16.

The modification of the thermo-dynamic machine according to this invention illustrated in Figures 5 and 6 incorporates the heating of the gas by direct products of combustion within the gas chambers. In this arrangement, the gas utilized in the machine must be capable of supporting the combustion of fuel used, the most common example being the use of air as the gas to which energy is to be imparted. In this arrangement, a fuel inlet pipe is shown at 41 which passes through a closure 49 and a portion of the central core shaft 21 and communicates adjacent a mid part thereof with a plurality of passageways 42 leading to the periphery of the ring 18 where they terminate in nozzles 43 through which the fuel will be ejected, by the centrifugal action imposed thereon by the rotation of the parts, into the common chamber 25 where it may be burned to impart energy to the gas within the machine by increasing its temperature.

The modification of Figure 4 has been shown with the cooling jacket and that of Figure 5 without the cooling jacket, but it is to be understood that the cooling arrangement may or may not be used with either of the modifications shown, depending upon the specific cycle through which the gas is to be passed. The cooling jacket may be utilized, as in a heat pump, to extract heat from the gas at a high temperature level to be utilized exteriorly for heating purposes. In such an arrangement the heat supplied adjacent the expansion side of the machine will be at a low temperature level as from a natural source.

In the closed arrangements of Figures 1 and 4, any desired gas or vapor at any desired pressure may be utilized for the compression-expansion cycle; for example, one of the monatomic gases or one of the heavy gases, depending upon the specific cycle desired. In the modification of Figure 5 where the direct products of combustion are used, the gas must be one which will support combustion of the fuel.

In Figure 7 is diagrammatically illustrated a system in which the product of the machine of Figures 4 and 5 may be utilized for the attainment of mechanical power. In this system, the thermo-dynamic machine is illustrated at 44 and is driven through shaft 45 by any desired gas turbine 46. The apparatus may be started in rotation by any desired starting motor 47 which may thereafter be deenergized. After being brought up to speed, the gas passing from the outlet 16 enters the gas turbine 46 and is thereafter either exhausted to the atmosphere in the case of Figure 5, or returned to the inlet 13 in the modification of Figure 4. The useful mechanical output of the turbine 46 will be the difference between the energy developed therein and that required to rotate the thermo-dynamic machine 44, according to this invention.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpre-

tation within the terms of the following claims.

What is claimed is:

1. In a device of the class described, a rotary member comprising a massive internal supporting core, a thin shell exterior of said core and spaced therefrom, a plurality of walls extending between said shell and core and joining them into a rigid unitary structure, said walls dividing the space between said shell and core into a plurality of passages extending from the axis toward the periphery and in return toward the axis of said member, means for passing a gas through said passages, means for rotating said member to place a gas within said passage under compression due to the action of centrifugal force on the gas columns in the passages, means for absorbing the heat of compression of the entering gas during its passage from the axis toward the periphery through said exterior shell, and means for heating the gas by heat transfer through said exterior shell during its return passage from the periphery toward the axis.

2. In a device of the class described, a rotary member comprising a massive internal supporting core, a thin shell exterior of said core and spaced therefrom, a plurality of walls extending between said shell and core and joining them into a rigid unitary structure, said walls dividing the space between said shell and core into a plurality of passages extending from the axis toward the periphery and in return toward the axis of said member, means for passing a gas through said passages, means for rotating said member to place a gas within said passage under compression due to the action of centrifugal force on the gas columns in the passages, and means for heating the gas in its return passage from the periphery toward the axis by heat transfer through said exterior shell.

3. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped individual passages therein, each passage comprising a first compression portion extending radially outward from the axis of rotor and constituting one leg of the U, a second portion extending substantially parallel with the rotor axis and constituting the bight of the U, and a third expansion portion extending substantially radially inward from the second portion toward the axis and constituting the other leg of the U, said passages lying immediately below the outer surface of the rotor for ready transfer of heat through the outer surface of the rotor; means for supporting the rotor for rotation about its axis including means for admitting a gas into said first leg adjacent the axis and means providing a discharge passage from said second leg adjacent the axis; a stationary shell surrounding the rotor adjacent said second passage portion including an inlet duct and an outlet duct for a heat transferring fluid flowing through the space between said shell and said rotor, said fluid being in heat transferring relation with the outer surface of the rotor, the transfer of heat to the rotor being promoted by rotation of the rotor relatively to the shell in addition to the flow of heating fluid through said shell from the inlet duct to the outlet duct.

4. A thermodynamic machine as set forth in claim 3 in which the rotor body comprises two body portions, one body portion including said first leg and a portion of the bight of the U-passage, the other body portion including the remainder of the bight and the second leg of the U-passage, said first body portion being separated from said second body portion by a zone of reduced heat conductivity to retard the transfer of heat from one body portion to the other.

5. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped individual passages therein, each passage comprising a first compression portion extending radially outward from the axis of the rotor and constituting one leg of the U, a second portion extending substantially parallel with the rotor axis and constituting the bight of the U, and a third expansion portion extending substantially radially inward from the second portion toward the axis and constituting the other leg of the U, said passages lying immediately below the outer surface of the rotor for ready transfer of heat through the outer surface of the rotor; means for supporting the rotor for rotation about its axis including means for admitting a gas into said first leg adjacent the axis and means providing a discharge passage from said second leg adjacent the axis; a stationary shell surrounding the rotor adjacent said second passage portion and said third passage portion including an inlet duct and an outlet duct for a heating fluid flowing through the space between said shell and said rotor, said fluid being in heat transferring relation with the outer surface of the rotor to heat compressed gas in said second passage portion and in said third passage portion during expansion of the gas, the transfer of heat to the rotor being promoted by rotation of the rotor relatively to the shell in addition to the flow of heating fluid through said shell from the inlet duct to the outlet duct.

6. A thermodynamic machine as set forth in claim 5 in which the rotor body comprises two body portions, one body portion including the said first leg and a portion of the bight of the U-passage, the other body portion including the remainder of the bight and the second leg of the U-passage, said first body portion being separated from said second body portion by a zone of reduced heat conductivity to retard the transfer of heat from one body portion to the other.

7. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped individual passages therein, each passage comprising a first compression portion extending radially outward from the axis of rotor and constituting one leg of the U, a second portion extending substantially parallel with the rotor axis and constituting the bight of the U, and a third expansion portion extending substantially radially inward from the second portion toward the axis and constituting the other leg of the U, said passages lying immediately below the outer surface of the rotor for ready transfer of heat through the outer surface of the rotor; means for supporting the rotor for rotation about its axis including means for admitting a gas into said first leg adjacent the axis and means providing a discharge passage from said second leg adjacent the axis; means forming a stationary first outer chamber surrounding said rotor adjacent said first passage portion, said last named means including an inlet duct and an outlet duct for a cooling fluid flowing through said first chamber about said rotor; means forming a stationary second outer chamber surrounding said rotor adjacent said second passage portion and said third passage portion, said last named means including an inlet duct and an outlet duct for a heating fluid flowing through said second chamber about said rotor, said fluids being in heat transferring

relation with the outer surface of the rotor, the transfer of heat from and to said rotor being promoted by rotation of the rotor relatively to said chamber in addition to the flow of fluids through said chambers from the respective inlet ducts to the outlet ducts.

8. A thermodynamic machine as set forth in claim 7 in which the rotor body comprises two body portions, one body portion including the said first leg and a portion of the bight of the U-passage, the other body portion including the remainder of the bight and the second leg of the U-passage, said first body portion being separated from said second body portion by a zone of reduced heat conductivity to retard the transfer of heat from one body portion to the other.

9. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped individual passages therein, each passage comprising a first compression portion extending radially outward from the axis of rotor and constituting one leg of the U, a second portion extending substantially parallel with the rotor axis and constituting the bight of the U, and a third expansion portion extending substantially radially inward from the second portion toward the axis and constituting the other leg of the U, said passages lying immediately below the outer surface of the rotor for ready transfer of heat through the outer surface of the rotor; means for supporting the rotor for rotation about its axis including means for admitting a gas into said first leg adjacent the axis and means providing a discharge passage from said second leg adjacent the axis; a stationary shell surrounding the rotor adjacent said first passage portion including an inlet duct and an outlet duct for a cooling fluid flowing through the space between said shell and said rotor, said fluid being in heat transferring relation with the outer surface of the rotor adjacent said first passage portion, the withdrawal of heat from the rotor surface being accelerated

by the rotation of the rotor relatively to the shell in addition to the flow of the cooling fluid through said shell from the inlet duct to the outlet duc.

10. A thermodynamic machine as set forth in claim 9 in which the rotor body comprises two body portions, one body portion including the said first leg and a portion of the bight of the U-passage, the other body portion including the remainder of the bight and the second leg of the U-passage, said first body portion being separated from said second body portion by a zone of reduced heat conductivity to retard the transfer of heat from one body portion to the other.

PAUL KOLLSMAN.

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