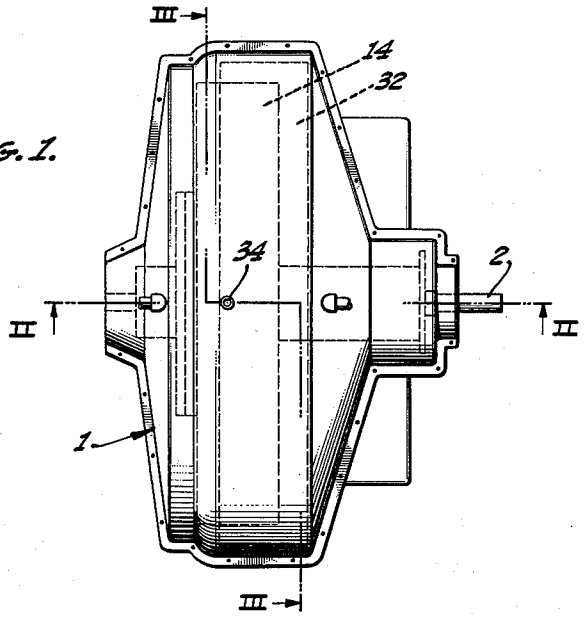
May 20, 1952 P. KOLLSMAN 2,597,249

THERMODYNAMIC ENGINE

Filed April 24, 1945 3 Sheets-Sheet 1

FIG. 1.



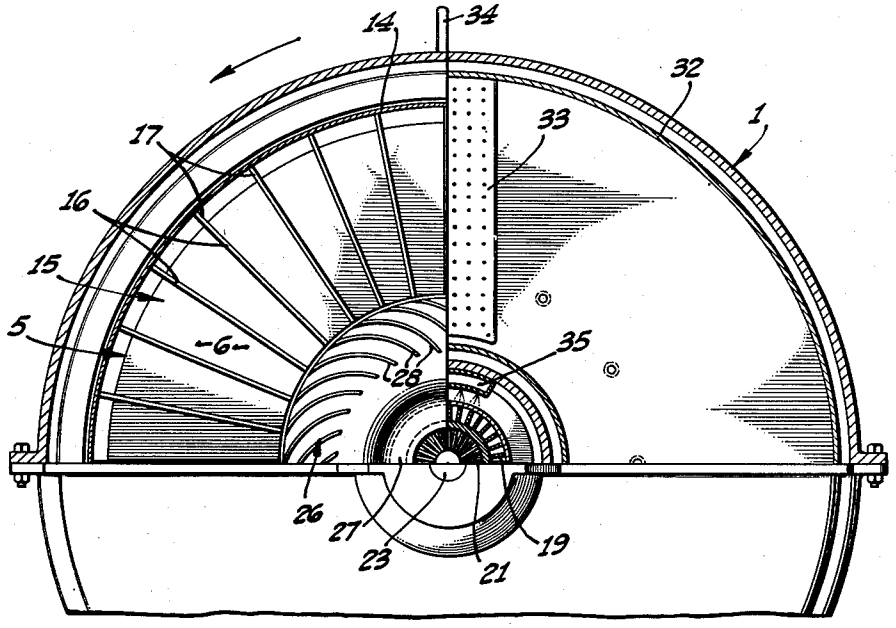


FIG. 3.

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THERMODYNAMIC ENGINE

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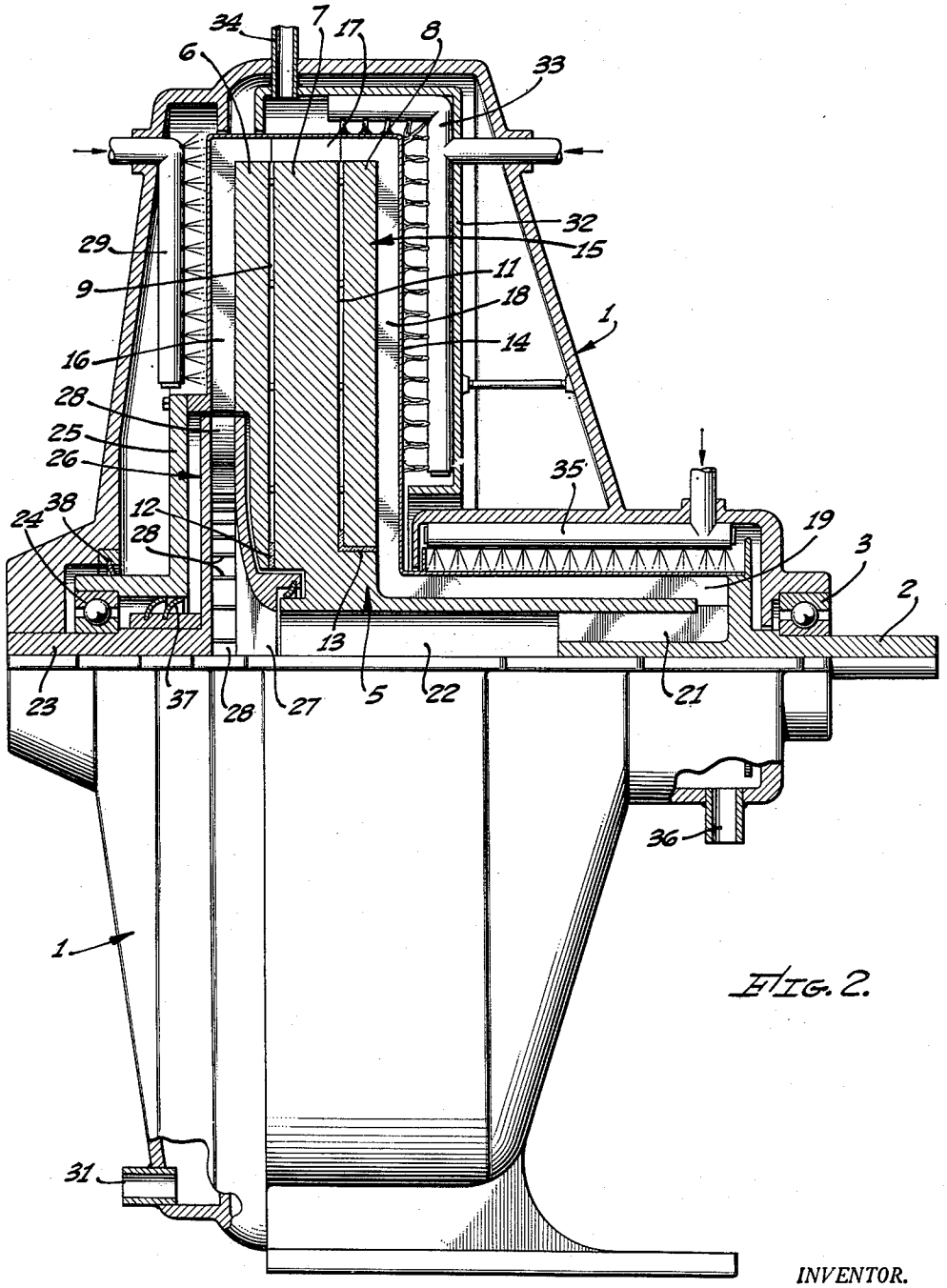


FIG. 2.

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THERMODYNAMIC ENGINE

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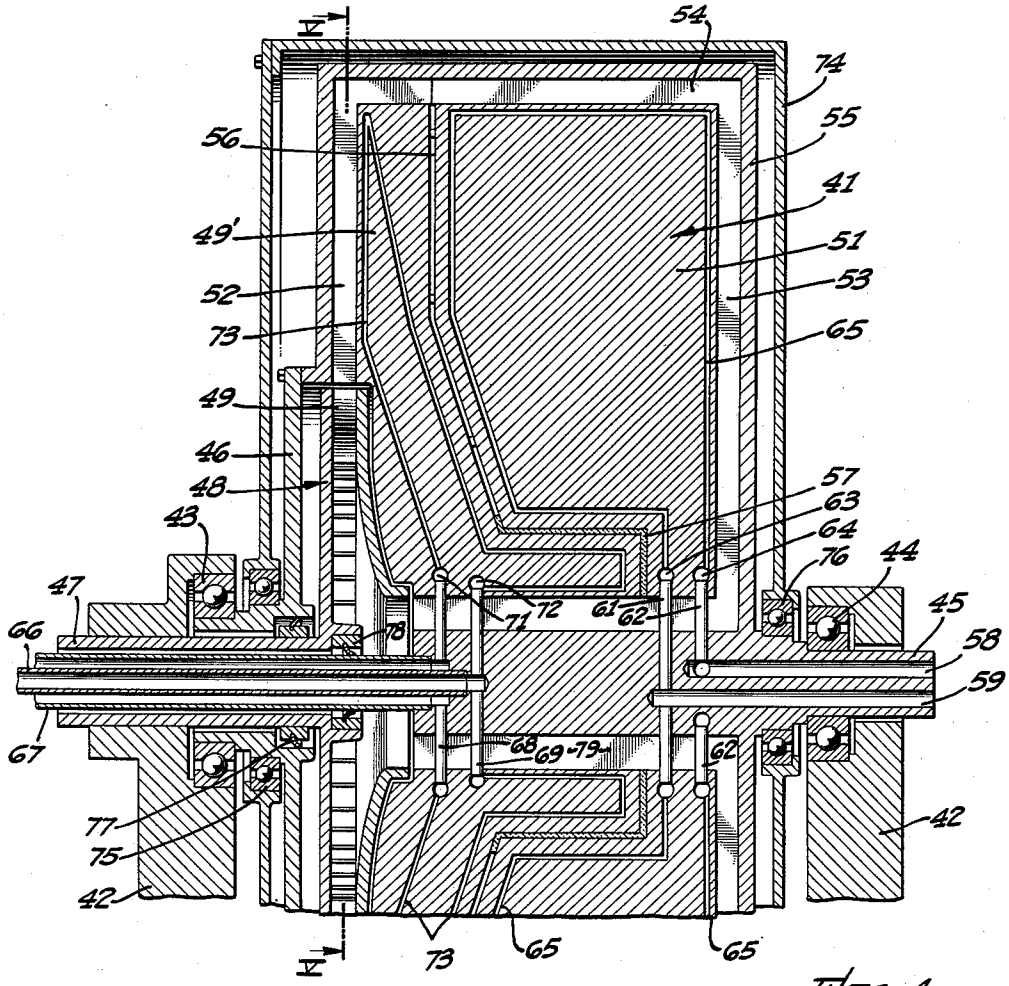


FIG. 4.

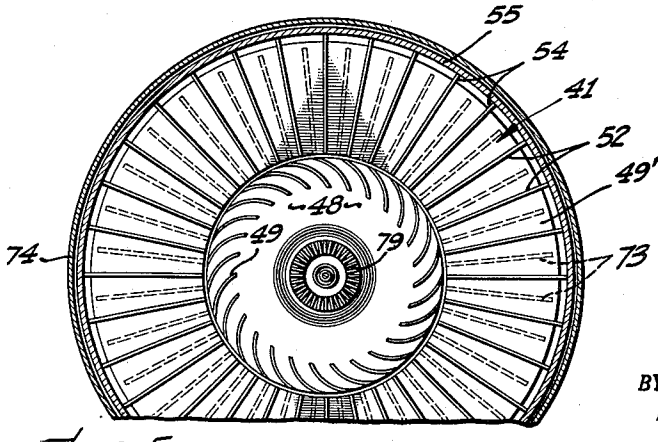


FIG. 5.

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UNITED STATES PATENT OFFICE

2,597,249

THERMODYNAMIC ENGINE

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Application August 24, 1945, Serial No. 612,390

15 Claims. (Cl. 60—59)

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This invention relates to a thermodynamic engine for transferring heat energy into mechanical energy.

One object of the invention is a rotating engine in which a circulating gas is passed through cycles of compression and expansion with the application of heat and cooling to produce rotational energy.

Another object of the invention is a thermodynamic engine in which a gas is rotated at high velocity and circulated in a closed path from the axis toward the periphery and returned, in which the gas is compressed at the periphery by the action of centrifugal force on the radial gas columns, with the application of heat energy to the gas at the periphery and along the return radial leg, the gas in its return toward the axis applying rotational energy to the engine.

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 plan view of the engine according to the present invention.

Figure 2 is a view partly in vertical section and partly in elevation, the section being taken on the line II—II, Figure 1.

Figure 3 is a partial transverse sectional view along the lines III—III of Figure 1.

Figure 4 is a vertical sectional view through a modified form of engine according to the invention. Figure 5 is a reduced transverse sectional view on the line V—V of Figure 4.

In the form of the invention shown in Figures 1, 2, and 3 there is provided an outer casing 1, within which is disposed a rotatable shaft 2 in a bearing 3. Upon the shaft 2 is mounted a rotor portion indicated generally by the numeral 5 and formed of sections 6, 7, and 8, separated by insulating spaces 9 and 11, the lower portion of the spaces 9 and 11 being filled by solid insulation 12 and 13 to prevent gas flow through the spaces. Exterior of the rotor 5 is mounted a rotary casing 14, carried therewith and between rotor 5 and the casing 14 are mounted a plurality of fins dividing the space between the rotor 5 and casing 14 into the plurality of individual generally U-shaped chambers or passageways. These fins are indicated generally by the reference numeral 15 and comprise radial leg 16, a bight 17, and a radial leg 18. From the leg 18, the fins continue to form axial legs 19 and 21 to continue the individual gas chambers. Within the rotor section there is provided an axial cylindrical passage 22.

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Within the casing 1 is rigidly mounted a stationary member 23 on which, through bearing 24, is mounted a rotatable member 25 connected to the casing 14 to complete the support for the rotary parts, it being understood that the fins 15 bind the rotor 5, casing 14, rotatable member 25, and shaft 2 together into a rigid unit rotatable in bearings 3 and 24.

The stationary member 23 carries a stationary gas director 26, having substantially parallel annular walls and an axial opening 27 communicating with passage 22. Adjacent the periphery of the director 26 there are provided a plurality of directional vanes 28, shown more particularly in Figure 3 which incline in the direction of rotation of the rotor 5 to deliver the gas to the chambers formed between the fins 15 in a tangential direction.

In the outer casing 1, at the left hand side of the machine, as shown in Figure 2, is disposed a cooler 29 shown as a means for spraying cooling water upon the surface of the rotary casing 14. It will be noted that the walls of casing 14 are relatively thin for efficient heat transfer and this casing is preferably of a material of high heat conductivity. The water sprayed from the cooler 29 is collected within the casing and discharged through the outlet 31.

Supported in the outer casing 1 is a partial inner casing 32 forming a chamber about the outer and right hand surfaces of the casing 14 and within this chamber there is disposed a heater 33, shown as a plurality of heating jets contacting the surface of the casing 14. The heating medium is discharged through the outlet 34.

Also within the casing 1 there is disposed a second cooler 35, shown as spraying cooling water upon the surface of the rotary casing adjacent to fin legs 19, the water from the cooler 35 being discharged through the outlet 36.

To prevent loss of the gas within the engine, there are provided rotary seals 37 and 38. In the operation of the engine the gas chambers or passages are filled with a gas which passes through a temperature-pressure cycle. While any gas is susceptible of use in the engine, it is preferred to use one of the heavier gases and to introduce it into the engine under pressure so that a greater mechanical energy can be transmitted by an engine of given size.

In the operation of the engine rotation is initiated by any desired exterior means and thereafter with the application of the cooling from the coolers 29 and 35 and of heat by the heater

33 the engine will continue to rotate from the gas energy to deliver power at the shaft 2.

With the rotation of the rotor 5 there is a continuous circulation of gas within the engine produced by the difference in density between the radial legs of the chambers formed between the fins 15. The chamber leg between the fin legs 16, although shorter than the chamber leg between fin legs 18, will have gas therein at a greater mass than in the heated chamber leg due to the difference in temperature of the gas within the legs. As the greater mass will tend to flow toward the periphery of the engine under the action of centrifugal force, a continuous circulation of gas through the chambers is effected.

The gas in the bight of the chambers between fin 17 will be at maximum pressure due to the centrifugal force acting thereon from the gas columns in the radial chamber legs. The gas in passage 22 will be at the lowest pressure and temperature.

The gas in the chamber or passage 22 passes through the opening 27 into director 26 and in passing through the vanes 28 will be delivered in a tangential direction to the individual chambers between the fin legs 16. The vanes 28 are proportioned so that under normal load the gas delivered from the collector will have substantially the same velocity as the interior ends of the fin legs 16.

As the gas passes through the chamber leg between fin 16 toward the periphery it will be progressively compressed and the cooler 29 will extract the heat of compression from the gas so that it will reach the chamber bight under pressure but at substantially cooling water temperature. In the bight of the chamber and along the leg between fins 18 the gas is heated from the heater 33 to greatly increase its energy. As the gas passes through the chamber leg between fins 16 toward the periphery, its rotational energy is increased since it is moving to a greater radius of rotation and will rotate with a higher linear velocity. As the gas returns towards the axis through the chamber leg between fins 18, it moves to a progressively decreasing radius of rotation so that it will return its energy of rotation to the rotor 5. Since the chamber leg between the fins 18 is considerably longer than the chamber leg between the fins 16, a greater rotational energy is returned to the rotor as the gas passes toward the axis than was utilized in the movement of the gas toward the periphery of the engine. The difference, excluding frictional losses, is the energy delivered by the engine.

From the radial chambers between the fins 18 the gas enters the axially extending chambers between fins 19 and is cooled by the cooler 35 so that it returns to the axial passage 22 at substantial cooling water temperature.

In the modification of the invention shown in Figures 4 and 5 provision is made for an outer follower casing to reduce air frictional resistance to the rotation of the engine rotor and interior application of heating and cooling is provided for.

There is shown a rotor 41 supported in standards 42 by bearings 43 and 44; in bearing 43 by an integral hub 45 and in bearing 44 through a rotary member 46 connected to the side of the rotor 41. Within the standard 42 is mounted stationary hub 47 carrying the stationary director 48 having directional vanes 49, the director 48 corresponding to the director 46 of Figure 2.

The rotor 41 is again formed in two sections 49 and 51 and there are provided the individual rotary gas chambers with radial legs 52 and 53 and connecting axially extending peripheral bights 54. The exterior 55 of the rotor has been shown integral for the sake of simplicity but it is understood that the mechanical structure may be assembled in any desired way, as by soldering or welding, with the chamber passages formed of fins, as in the preferred form of the invention, connecting the interior and the outer casing of the rotor. Between rotor sections 49' and 51 there is an insulating space 56 and solid insulation 57. Rotary gas seals are provided at 77 and 78.

Through the hub 45 are passages for the transfer of a heating medium with the inlet at 58 and the outlet at 59, these passages leading to any conventional form of stuffing box to permit their rotation. From the passages 58 and 59 there extend tubes 61 and 62 leading to annular chambers 63 and 64 with which communicate a plurality of heating passages 65 extending radially and axially with respect to the rotor section 51. Through the stationary hub 47 extend concentric cooling water tubes 66 and 67 leading to the rotor 41 and communicating through tubes 68 and 69 with annular chambers 71 and 72 with which communicate cooling water passages 73 in the rotor section 49, the cooling water entering through tube 67 to pass through chamber 71 through cooling passage 73, to chamber 72 and thence discharging through tube 66. It will be understood that any desired stuffing box arrangement will be connected to the tubes 66 and 67 to permit their rotation. The cooling passages 73 and heating passages 65 extend closely adjacent with the surface of the rotor sections where the heat exchange is to be effected to facilitate heat transfer. It will be understood that a large number of heating and cooling passages are provided within the rotor sections, preferably one to each of the individual gas chambers.

About the rotor 41 there is provided a drum 74 mounted in bearings 75 and 76 and free to rotate as a follower about the rotor 41. The follower drum 74 will rotate at substantially half the speed of the rotor 41 with a resultant theoretical reduction in the frictional loss due to air resistance to substantial one-fourth.

The gas passages include axially extending portions 79 adjacent to the axis of the rotor 41 leading from chamber legs 53 to director 48. Cooling of the gas is effected along the chamber leg 52 and heating of the gas is effected over the major portion of the chamber leg 54 and the radical chamber leg 53. Cooling is also effected in the axially extending chambers 79.

The operation of the engine shown in Figures 4 and 5 is similar with that described in connection with the description of the preferred embodiment of the invention. The engine is initially rotated by exterior means and with the application of cooling through passages 73 and heating through passages 65, the engine will continue its rotation to deliver power.

Again it is preferred to use a heavy gas under pressure to secure the maximum power output for the size of the machine and the gas circulation is effected through difference in density of the gas in chamber legs 52 and 53. The chamber leg 53 is again longer than leg 52 and the rotational energy of the axially moving gas is returned to the machine to deliver energy at the

shaft. The gas before entering the chamber legs 52 is given a tangential velocity by the vanes 49.

While the legs of the gas passages have been referred to herein and in the appended claims as being radial it will be understood that they may have any direction from the axis toward the periphery which has a radial component.

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 interpretation within the terms of the following claims.

What is claimed is:

1. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped 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 one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake, and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis, including means providing a stationary passage from the outlet to the intake; means associated with the rotor for supplying heat to the rotor adjacent the second passage portion, whereby gas circulating through said passages and compressed by centrifugal force in said first passage portion is heated by transfer of heat through the body of the rotor within the area of greatest compression, the heated gas expanding in its flow through the said third passage portion and transmitting rotative energy to the rotor.

2. A thermodynamic machine as set forth in claim 1 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 other 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.

3. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped 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 one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake, and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis, including means providing a stationary passage from the outlet to the intake; cooling means associated with the rotor for withdrawing heat adjacent said first compression portion; heating means associated with the rotor for supplying heat to the rotor adjacent the second passage portion, whereby gas circulating through said passages and compressed by centrifugal force in said first passage portion is cooled during compression and then heated by transfer of heat through the body of the rotor within the area of greatest compression, the heated gas expanding in its flow through the said third passage portion and transmitting rotative energy to the rotor.

4. 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake; means associated with the rotor for supplying heat to the surface of the rotor at the second passage portion, whereby gas circulating through said passages and compressed by centrifugal force is heated by transfer of heat through the rotor surface within the area of greatest compression, the heated gas expanding in its flow through the third passage portion, giving up its rotative energy to the rotor to drive it.

5. A thermodynamic machine as set forth in claim 4 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 other 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.

6. 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake; means associated with the rotor for supplying heat to the surface of the rotor at the second and at the third passage portion, whereby gas circulating through said passages and compress-

ed by centrifugal force is heated by transfer of heat through the rotor surface within the area of greatest compression and during expansion, the heated gas in its flow through the third passage portion giving up its rotative energy to the rotor to drive it.

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 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake; cooling means associated with the rotor for withdrawing heat from the surface of the rotor adjacent said first compression portion; heating means associated with the rotor for supplying heat to the rotor surface adjacent said second passage portion, whereby gas circulating through said passages and compressed by centrifugal force in said first passage portion is cooled during compression through the rotor surface and then heated by transfer of heat through the rotor surface, the heated gas expanding in its flow through the third passage portion giving up its rotative energy to the rotor to drive it.

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 other 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 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 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake; cooling means associated with the rotor for withdrawing heat from the surface of the rotor adjacent said first compression portion; heating means associated with the rotor for supplying heat to the rotor surface adjacent said second passage portion and said third passage portion whereby gas circulating through said passages and compressed by centrifugal force in said first passage portion is cooled during compression through the rotor surface and then heated by transfer of heat through the rotor surface, the heated gas expanding in its flow through the third passage portion giving up its rotative energy to the rotor to drive it.

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 outer 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.

11. 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake, and means for directing the gas into the intake with a tangential component of movement; 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.

12. 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis includ-

ing means providing a stationary return passage from the outlet to the intake, and means for directing the gas into the intake with a tangential component of movement; 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.

13. 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, said one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis including means providing a stationary return passage from the outlet to the intake, and means for directing the gas into the intake with a tangential component of movement; a stationary shell enclosing the rotor, said shell providing a first outer chamber surrounding said rotor adjacent said first passage portion, said chamber including an inlet duct and an outlet duct for a cooling fluid flowing through said first chamber about said rotor, said shell further providing a second outer chamber surrounding said rotor adjacent said second portion and said third passage portion, said last named chamber including an inlet duct and an outlet duct for heating fluid flowing through said second chamber about said rotor, said fluids being in heat transferring relation with the outer surface of the rotor transfer of heat from and to said rotor being promoted by rotation of the rotor relatively to said chambers in addition to the flow of fluids through said chambers from the respective inlet ducts to the outlet ducts.

14. A thermodynamic machine as set forth in claim 13 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 other 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.

15. A thermodynamic machine comprising, a rotor body having a plurality of peripherally spaced U-shaped 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 one leg of the U being shorter than the other leg of the U, the end of the shorter leg constituting an intake, and the end of the longer leg constituting an outlet located closer to the axis than the intake; means for supporting the rotor for rotation about its axis, including means providing a stationary passage from the outlet to the intake; cooling means associated with the rotor for withdrawing heat adjacent said first compression portion; heating means associated with the rotor for supplying heat to the rotor adjacent the second passage portion, whereby gas circulating through said passages and compressed by centrifugal force in said first passage portion is cooled during compression and then heated by transfer of heat through the body of the rotor within the area of greatest compression, the heated gas expanding in its flow through the third passage portion and transmitting rotative energy to the rotor; and an outer shell enclosing the rotor, said shell being mounted for free rotation about the rotor axis.

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