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Eskeli

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[54] **HEAT AND STEAM GENERATOR**

[76] Inventor: **Michael Eskeli,** 6220 Orchid Ln., Dallas, Tex. 75230

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Related U.S. Application Data

[63] Continuation-in-part of Ser. Nos. 216,929, Jan. 11, 1972, Pat. No. 3,748,057, and Ser. No. 243,239, April 12, 1972.

[52] **U.S. Cl.** **122/11,** 122/26, 415/116

[51] **Int. Cl.** **F22b 3/06**

[58] **Field of Search** 122/11, 26; 415/116, 178, 415/180

[56] **References Cited**

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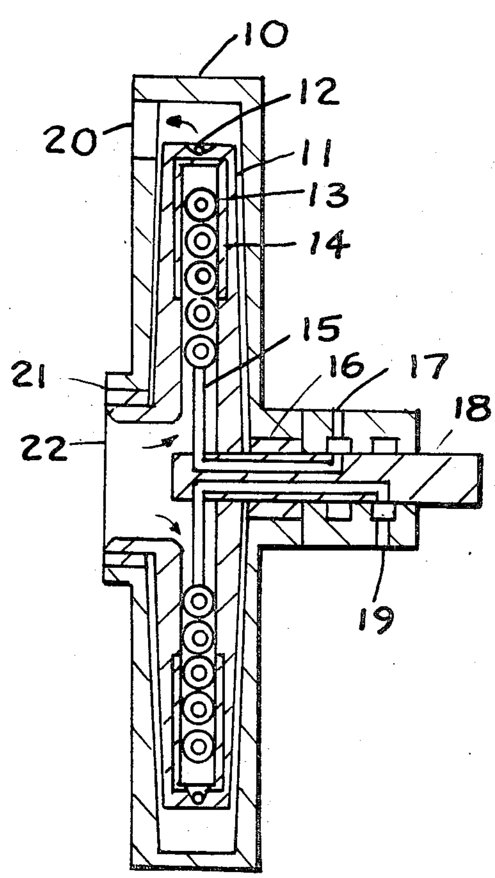
Primary Examiner—Kenneth W. Sprague

[57] **ABSTRACT**

A method and apparatus for the vaporizing of liquids and for generation of steam, wherein a gaseous heating fluid is compressed with accompanying temperature increase, and this temperature increase is employed to provide for heat transfer to a working fluid which is in heat exchange relationship with said heating fluid during said compression. A rotating rotor with a heat exchanger mounted within is used to compress said heating fluid with said working fluid being within said heat exchanger conduits. Said gaseous heating fluid may also be condensed within said rotor with the heat of vaporization of said heating fluid being passed to said working fluid. Various fluids may be used for said heating fluid, such as halogenated hydrocarbons, ammonia, air, nitrogen or sulfur dioxide. For the working fluid, water, halogenated hydrocarbons, hydrocarbons or sulfur dioxide may be used. The fluids are so selected that said heating fluid has a higher temperature increase within said rotor than said working fluid so that heat transfer from said heating fluid to said working fluid may take place. By proper selection of the heating fluid, the work input of the unit rotor can be made to be nearly nil.

16 Claims, 6 Drawing Figures



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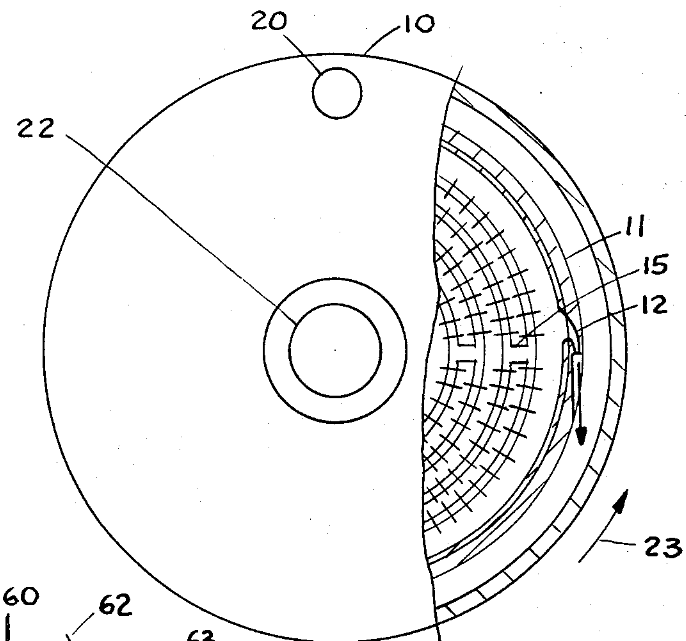

FIG.2

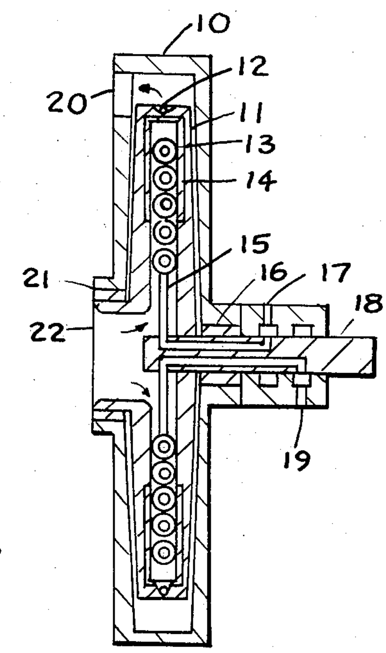

FIG.1

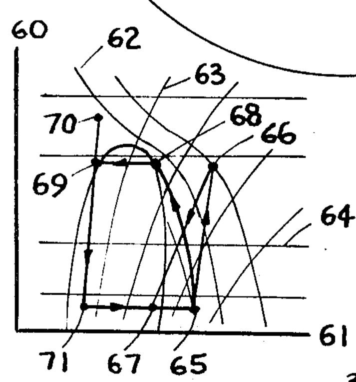

FIG.6

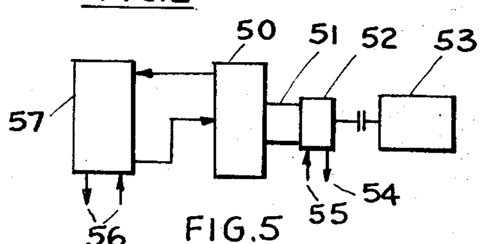

FIG.5

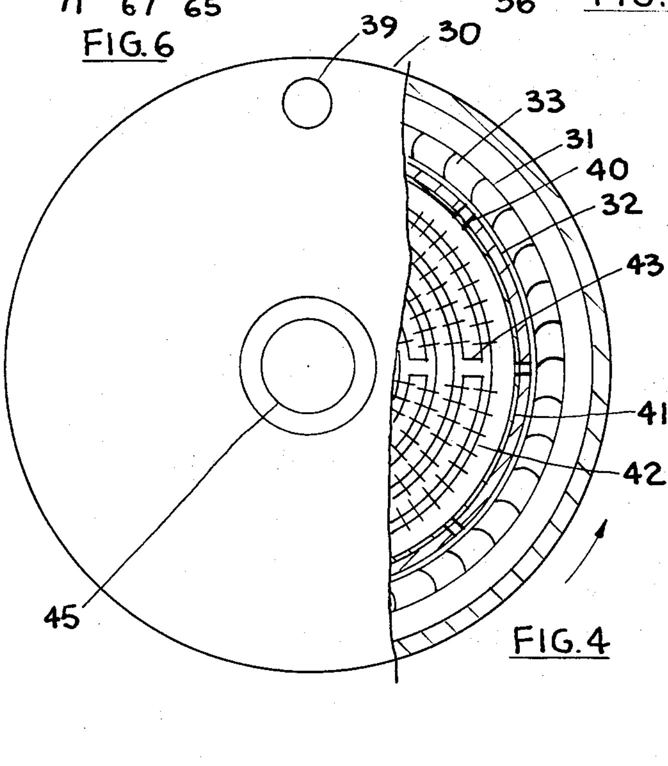

FIG.4

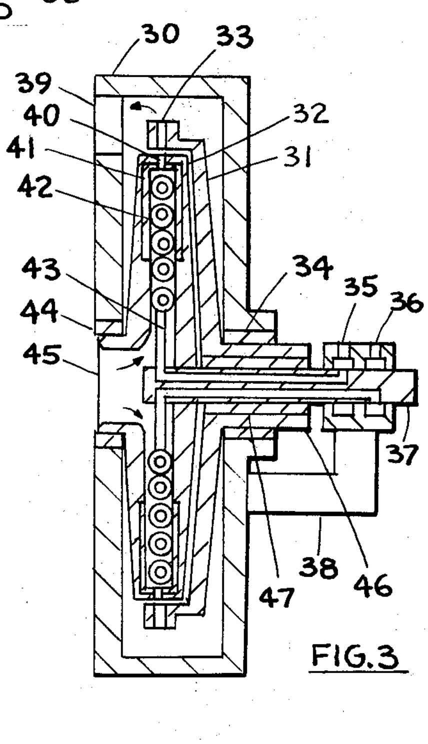

FIG.3

HEAT AND STEAM GENERATOR

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part application of previous application titled "Rotary Compressor with Cooling," filed 1/11/72, Ser. No. 216,929, now U.S. Pat. No. 3,748,057. Claims relating to steam generation were deleted from said application at the request of the Examiner.

This is also a continuation-in-part of application titled "Compressing Centrifuge with Cooling," filed 4/12/72, Ser. No. 243,239.

BACKGROUND OF THE INVENTION

This invention relates generally to apparatus for generating steam and to apparatus for providing heating wherein a gaseous heating fluid is compressed with accompanying temperature increase; said temperature increase is then used to provide for heat transfer to a working fluid being in heat exchange relationship with each other within a rotating rotor.

The art of heating and steam generation has seen a variety of devices. In some of these devices, called boilers, heat is generated by burning a fuel; with said heat then being passed to a working fluid being circulated through said boiler.

These devices are inefficient since a large portion of the heat obtained from the fuel is passed to the stack with stack gases. Also, large amounts of costly fuel is required to generate the high temperatures required. Also, the burning of fuel results in pollution of the air.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross section of one form of the device, and FIG. 2 is an end view of the same device with a section removed to show interior details.

FIG. 3 is a cross section of another form of the device, and FIG. 4 is an end view of the unit shown in FIG. 3, with a portion removed to show interior details.

FIG. 5 is a schematic diagram showing typical installation of the device of this invention.

FIG. 6 is a pressure-enthalpy diagram for the heating fluid being circulated through the rotor.

DESCRIPTION OF PREFERRED EMBODIMENTS

It is an object of this invention to provide a method and apparatus for the generation of heat and production of steam using low temperature heat sources to generate said steam. Said heat source may be ambient air, water at its natural temperature, or be a fluid supplied from another process or system. It is also an object of this invention to provide means for generating steam without air pollution.

Referring to FIG. 1, therein is illustrated a form of the device, shown in cross section. The heating fluid enters the rotor 11 via entry 22, and is passed to rotor cavity, where said rotating rotor 11 by centrifugal action will compress said heating fluid with accompanying temperature increase. During said compression of said heating fluid, heat is transferred from said hot heating fluid to working fluid being circulated within heat exchanger 13, and after compression, said heating fluid is discharged via exit nozzles 12 from said rotor; after this, said heating fluid leaves the unit casing space

around said rotor via opening 20. 10 is casing, 14 is thermal insulation within rotor to prevent overheating said rotor 11 wall which could weaken the wall material and cause failure; 15 is working fluid distribution tube; 16 and 21 are rotor bearings and seals, 17 is working fluid inlet to rotor shaft passage and 19 is working fluid outlet from rotor shaft passage, 18 is rotor shaft onto which said rotor is fixed.

In FIG. 2, an end view of the unit shown in FIG. 1, is illustrated. 10 is casing, 11 is rotor, 12 is rotor exit nozzle for said heating fluid, 15 is working fluid distribution conduit, 20 is heating fluid outlet, and 22 is heating fluid inlet. 23 indicates direction of rotation for said rotor 11.

In FIG. 3, another form of the device is shown, in a cross section. This device is provided with two rotors; power is supplied to the first rotor where the compression of the said heating fluid takes place and the heat transfer from said heating fluid to said working fluid occurs; the second rotor is used to convert the kinetic energy of the heating fluid leaving said first rotor, to work, and thus said second rotor will produce work. Usually the said first rotor and said second rotor are connected together through a gear box, so that the work produced by said second rotor is passed to said first rotor, thus reducing the required work input to said device. Heating fluid enters the rotating first rotor 32 via entry opening 45, and is compressed within said rotor 32 by centrifugal action on said fluid with accompanying temperature increase. Heat is transferred to said working fluid being circulated within heat exchanger 42, said working fluid being supplied via hollow rotor shaft 37 through entry 35, and through distribution conduit 43, and then returned through said rotor shaft to exit 36; said heating fluid being discharged from said rotor via nozzles 40 and passed to second rotor 31 vanes 33, where the kinetic energy contained in said high velocity heating fluid is converted to work; said second rotor being supported by shaft 46, and by bearings and seals 34. The first rotor shaft 37 is supported by bearing and seal 47, and by seal 44. Unit casing is 30, heating fluid outlet is 39; 41 is thermal insulation within rotor 32, and 38 is a support for working fluid connections.

In FIG. 4, an end view of the unit shown in FIG. 3, is illustrated. 39 is heating fluid outlet from casing 30, 33 is second rotor vanes, 31 is second rotor, 40 are first rotor exit nozzles for heating fluid, 32 is first rotor, 43 are distribution conduits for working fluid, 41 is a layer of thermal insulation, 42 is heat exchanger, 45 is heating fluid entry.

In FIG. 5, a typical schematic diagram is shown indicating connections for the heat generating device of this invention. 50 is the heat generating device, 51 is a gear box, 52 is a connector for supplying working fluid to the device, 53 is drive unit, 54 and 55 are supply and return for said working fluid, 57 is a heat exchanger for adding heat to said heating fluid, said heat exchanger 57 may be stationary; 56 are supply and return connections for a fluid to be used for adding heat to said heating fluid. Also, said heat exchanger 57 may be an air coil where air is used as the fluid for adding heat to said heating fluid.

In FIG. 6, a typical pressure-enthalpy diagram is shown for the heating fluid being circulated within said rotating rotor. 60 is pressure line, and 61 is an enthalpy line. 62 are constant temperature lines, 63 are constant entropy lines, 64 are constant pressure lines. For the unit shown in FIG. 1, the compression of the heating fluid is indicated by line 65–66, and the expansion of the heating fluid in the rotor exit nozzles is indicated by line 66–67. Heat is being added to the heating fluid from point 67 to point 65.

Also, in FIG. 6, typical cycle diagram is shown for the unit of FIG. 3. The compression within rotor 32 is indicated by line 65–68–69–70, and expansion in first rotor exit nozzles is indicated by line 70–71. Heat is then added to the heating fluid between points 71–65. There is no change in enthalpy in the second rotor vanes.

It should be noted that the compression within said rotating rotor is nearly non-flow, and thus the changes in the condition of the heating fluid can be shown approximately only on an enthalpy diagram during said compression. The expansion within the rotor exit nozzles is a continuous flow process, and the process can be shown on an enthalpy diagram. The radial velocity of the heating fluid within said rotor, is controlled by sizing the rotor exit nozzles to provide for a predetermined flow velocity; said radial flow velocity should be limited to values below 200 feet per second. Higher speeds for the heating fluid radially, will tend to reduce the pressure near the rotor periphery, and thus also reduce the heating fluid temperature.

The rotor exit nozzles for the form of the device shown in FIG. 1, are arranged to discharge the heating fluid in backward direction, preferably tangentially backward. The nozzles are sized and shaped to provide for maximum attainable exit velocity for the fluid leaving said nozzle, relative to said nozzles. The first rotor exit nozzles for the unit shown in FIG. 3, may be arranged to discharge said heating fluid radially, backward or forward, as desired; said nozzles are sized and shaped to provide for highest attainable exit velocity for said heating fluid from said first rotor nozzles.

The unit shown in FIG. 3, is mainly intented to be used when the said heating fluid is being condensed within said first rotor, with the heat of vaporization of said heating fluid being passed to said working fluid. Usually the exit velocity of the said heating fluid leaving said first rotor nozzles in liquid form is low, and the use of said second rotor allows converting the kinetic energy of said heating fluid to work, thus reducing the work input to said heat generating unit. The unit shown in FIG. 3 may also be used when said heating fluid remains a gas. The unit shown in FIG. 1 is mainly intented for use when the heating fluid remains a gas when in rotor; said unit may also be used when the heating fluid is condensed, within said rotor. The main advantage of providing for condensation of said heating fluid within said rotor, is in the amount of heat transferred from said heating fluid to said working fluid, which is much larger. Thus, the size of heating fluid passages for a predetermined amount of heat transfer, is much smaller in a unit where the heating fluid is being condensed within rotor than in a unit where said heating fluid remains a gas.

In operation, power is supplied to the rotor shaft, to provide for rotating said shaft. In the unit of FIG. 1, the heating fluid leaving said rotor nozzles, produces thrust, which will reduce the power required to rotate said rotor shaft. In the unit of FIG. 3, work is produced in said second rotor, which can be used to reduce work input to said unit.

There are numerous applications for this heat and steam generator. The units can be used to provide heat as needed for heating buildings, heating liquids, and producng steam; the heat source normally being at a much lower temperature.

The fluids being used with the devices of this invention, are a gaseous fluid as the heating fluid which may be condensed and leave the unit as a liquid; and a normally liquid working fluid, which may be vaporized and turned to steam. Said steam may be formed within said heat exchanger of said rotor, or may be formed in a flash tank after said working fluid leaves said rotor. Further, both fluids may be gases, where the two fluids are so selected that the temperature increase for said heating fluid is greater than for said working fluid, within the centrifugal force field of said rotor, so that heat transfer may take place from said heating fluid to said working fluid.

The work input to said rotor is low, since the heating fluid provides during 147 its exit from the rotor, thrust to help rotate said rotor, in the form of FIG. 1. The working fluid enters and leaves said rotor via shaft, and thus the work input for said working fluid is nearly nil, within said rotor. Thus, the work input required to rotate the rotor of the unit of FIG. 1, when the heating fluid is properly selected, and the amount of heat removed is properly controlled, may approach zero; this is due to pressure increase of the the said heating fluid during compression within rotor due to cooling of said heating fluid during said compression; this increased pressure will normally also result in increased exit velocity for said heating fluid from said rotor exit nozzles. Therefore, the device of this invention may be also used to provide steam or pressurized vapor, as required for power generation, while using low temperature heat sources to generate said steam or vapor.

Further, it is possible, by proper selection of the heating fluid, to provide a unit capable of producing high pressure water steam as required by modern steam turbines in power plants. Such heating fluids include many of the halogenated hydrocarbons, such as Freon 12, Freon 13B1, and others; also fluids such as Bromine. For these applications, said heating fluid must have a low ratio of specific heat at constant pressure divided by specific heat at constant volume, and also low value of specific heat at constant pressure; above mentioned fluids meet these requirements. Since the maximum tangential speed for most materials of construction of the rotor is about 1650 feet per second, the use of the types of fluids mentioned above as said heating fluid is required, to provide for sufficiently high temperatures to provide water steam to modern power turbines.

The thermal insulation layer 14 in FIG. 1, is provided to prevent excessive heating of the rotor wall near the rotor periphery where the heating fluid temperature is high. The heat exchanger is in contact with the rotor wall near the shaft, thus providing cooling for said wall, and helping to maintain rotor strength; said working fluid being relatively cold near the shaft, and also said heating fluid being cooler near said shaft.

The heat exchanger within the rotor is shown to be constructed from finned tubing, with the heating fluid passing through the fins; also, the fins provide needed obstructions so that said heating fluid will rotate with said rotor. Other types of heat exchanger construction may be used to obtain the same effect. The working fluid is arranged normally to be in parallel flow with said heating fluid, with said working fluid entering said heat exchanger nearest to the shaft, and then progressing outward toward rotor periphery; then passing back to the said shaft and from there to exit. This type flow pattern is necessary to obtain highest working fluid temperatures. For heating water, for example, any suitable flow pattern may be employed, since the final temperature is not very high.

The rotor sides may be closely fitted to the unit casing to provide for reduced fluid friction on said rotor at high speeds. Alternate methods, such as friction discs, may be also employed to reduce said fluid friction, on outside surfaces of the rotor.

The rotor may be constructed of any suitable material; high strength steel would be normal. The rotor walls are made thick at center, and taper toward periphery to provide for necessary strength for high speeds, as shown.

The work input to the rotor to rotate said rotor, is composed of the work required to accelerate said heating fluid, and said working fluid to rotor speed, to overcome friction on bearings and seals, to overcome fluid friction on rotor external surfaces. Since the working fluid is returned to the rotor center, work is reclaimed from said working fluid, and the work demand by working fluid is nil. The heating fluid leaves the rotor at a high velocity producing thrust on the rotor nozzles, thus producing work; therefore, by proper selection of said heating fluid, and with controlled heat removal from said heating fluid, the work output by the heating fluid can be made to approach the work input for said heating fluid to accelerate said fluid; also, in some situations, the work output by the heating fluid may exceed the work input required for said heating fluid. The fluid friction on the outer surfaces of the rotor can be reduced by fitting closely the rotor walls to the casing as illustrated in FIG. 1, and by centrifugal action the space between the rotor and casing can be evacuated thus reducing the friction loss. The friction loss in bearings and seals is normally very low, when expressed per pound of steam generated. Thus, the work input to generate a pound of steam by using this device, can approach very low value, and can be considered to be negligible, while a low temperature heat source is used to make said steam. Also, it should be noted that the work demand by this device is independent of the amount of heat transferred, as described herein. Further, by proper selection of the heating fluid, and by arranging the heat transfer amount, the work output by the heating fluid can be made larger than the total work input to the rotor so that steam generator accessories may be driven by said rotor; these accessories including for example feed water pump, and other items as needed.

What is claimed is:

1. A heat and steam generator comprising:

a. a rotor for generating said heat and steam by compressing a compressible heating fluid within said rotor by centrifugal action on said fluid by said rotating rotor with accompanying temperature increase of said heating fluid; said rotor having an entry opening for said heating fluid near the center of rotation; said rotor having a cavity to contain said heating fluid during said compression, and having exit nozzles mounted near the rotor periphery for discharging said heating fluid after said heating fluid has been compressed within said rotor; said rotor having vanes or other obstructions within said rotor cavity to assure that the said heating fluid will rotate with said rotor with approximately the same tangential velocity as said rotor; said rotor having a heat exchanger within said rotor cavity; within said heat exchanger a working fluid is being circulated in heat exchange relationship with said heating fluid; said working fluid being supplied to said rotor heat exchanger via suitable passages within the rotor shaft and returned back to passages within said shaft; said rotor being fixed to said rotor shaft and said shaft being rotatably mounted on bearings; power being supplied from an external source to said rotor shaft at least initially to rotate said shaft; said working fluid receiving heat from said heating fluid within said rotor;

b. a casing to support said rotor and its shaft;

c. a heating fluid being circulated within said rotor and being a compressible fluid and being a gas at least initially when entering said rotor;

d. a working fluid being circulated through said rotor heat exchanger and being a fluid that is less compressible than said heating fluid with lower temperature increase within said rotor than for said heating fluid.

2. The device of claim 1 wherein said rotor exit nozzles are arranged to discharge tangentially backward and said nozzles are sized and shaped to provide for highest attainable exit velocity from said nozzles for said heating fluid, for the pressure differential between the entry and exit ends of said nozzles.

3. The device of claim 1 wherein said rotor exit nozzles arranged to discharge said heating fluid at highest attainable exit velocity for the pressure differential available between the entry and exit ends of said nozzles; and wherein a secondary rotor is provided with suitable vanes to convert the kinetic energy available in the heating fluid stream to power; with said secondary rotor being supported by shaft and bearings and being rotatably mounted and with means for passing said power to external load.

4. The device of claim 1 wherein said heating fluid radial velocity within said rotor cavity is maintained at less than 200 feet per second.

5. The device of claim 1 wherein said heating fluid enters said rotor as a gas, and wherein said heating fluid is condensed within said rotor cavity with the heat of vaporization of said heating fluid being passed to said working fluid being circulated within said heat exchanger.

6. The device of claim 1 wherein said heating fluid enters said rotor as a gas and wherein said heating fluid leaves said rotor nozzles as a gas, with minor amounts of liquid, if any.

7. The device of claim 1 wherein said heating fluid is a gaseous fluid with a low specific heat at constant pressure; with said specific heat being less than 1.2 British thermal units per pound.

8. The device of claim 1 wherein said heating fluid a halogenated hydrocarbon.

9. The device of claim 1 wherein said working fluid is water.

10. The device of claim 1 wherein said working fluid is a halogenated hydrocarbon.

11. The device of claim 1 wherein said rotor is provided with thermal insulation within said rotor near the periphery of said rotor, and wherein said rotor walls are in cantact with said heating fluid in the areas near the rotor center; the thermal insulation to reduce the loss of strength of said rotor construction material due to high temperatures.

12. The device of claim **1** wherein said heating fluid is supplied to said rotor from an external stationary heat exchanger, and is also passed from said device back to said external heat exchanger for the purpose of adding heat to said heating fluid, with said heating fluid being circulated in a closed loop.

13. The device of claim **1** wherein said heating fluid is ambient air.

14. The device of claim **1** wherein said heating fluid is provided with means, external to said device, for adding heat from water, at its natural temperature, to said heating fluid, with said heating fluid being circulated through said means.

15. The device of claim **1** wherein said flow of said working fluid is arranged within said heat exchanger to be outward from the center of said rotor toward rotor periphery thus having the said working fluid in parallel flow with said heating fluid during the period when heat is transferred from said heating fluid to said working fluid; said working fluid then being returned back to said rotor center directly from said rotor periphery.

16. The device of claim **1** wherein said heating fluid and the amount of heat removed from said heating fluid is selected to provide for a sufficiently high exit velocity from said rotor exit nozzles to generate sufficient work to overcome all rotor work losses and to make the work input to said rotor shaft during normal operation nil.

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