



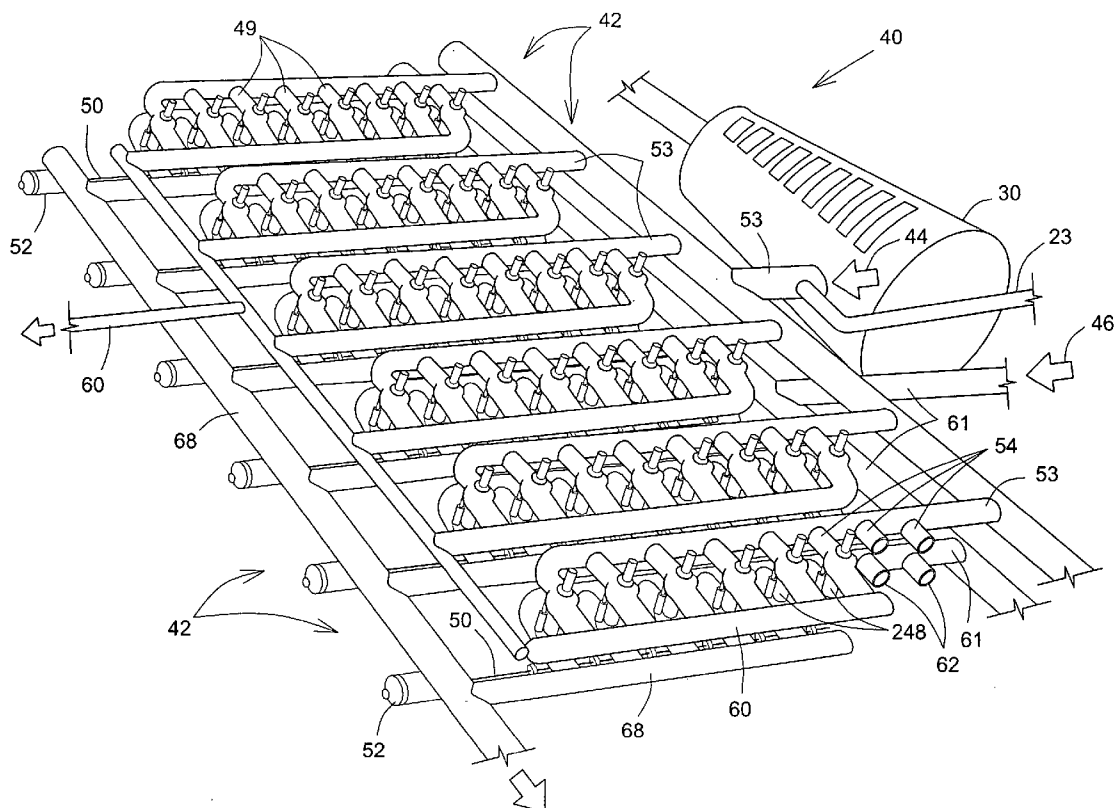
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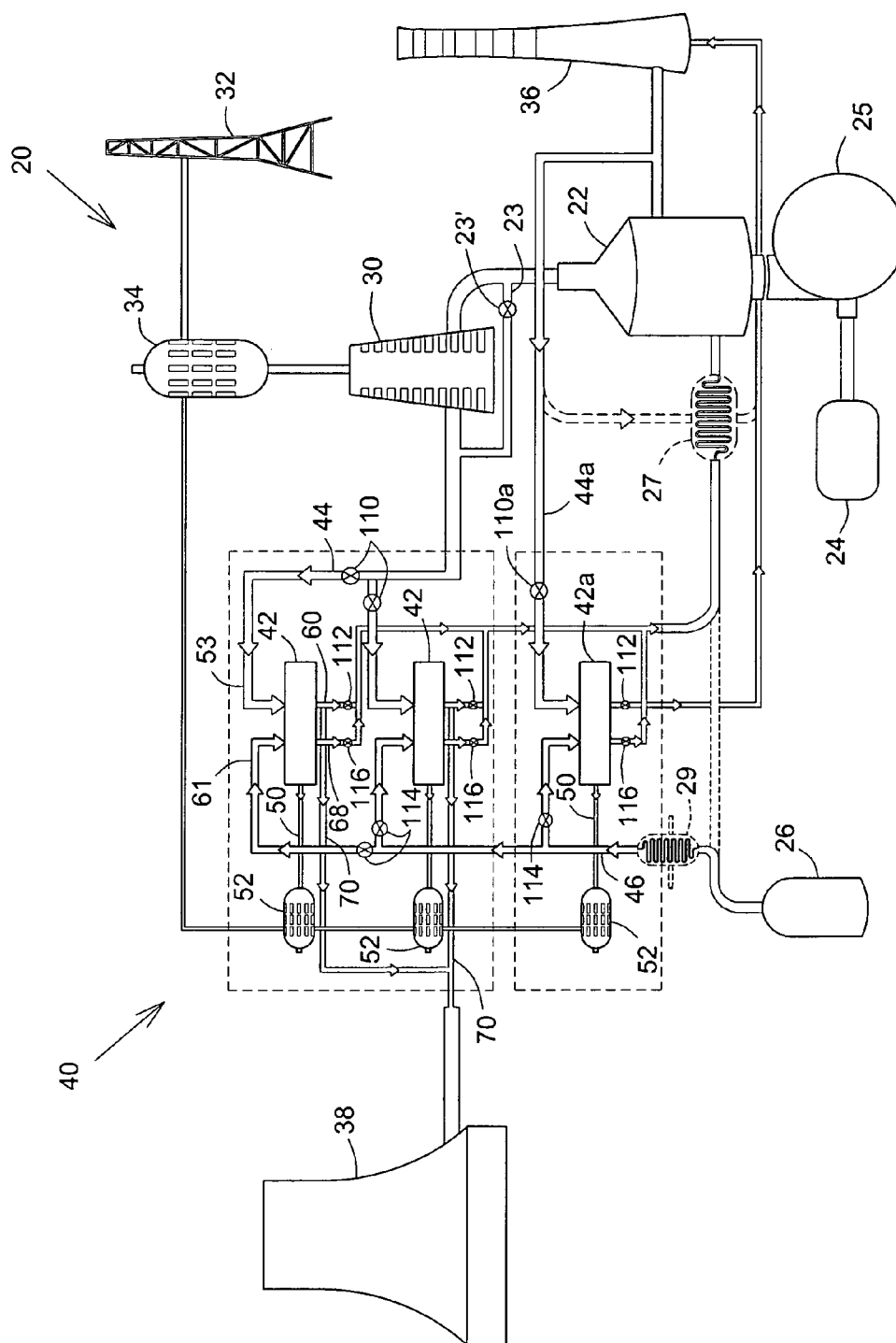
(19) **United States**(12) **Patent Application Publication**
Beaulieu(10) **Pub. No.: US 2007/0101717 A1**(43) **Pub. Date: May 10, 2007**(54) **ENERGY RECUPERATION MACHINE
SYSTEM FOR POWER PLANT AND THE
LIKE**(52) **U.S. Cl. 60/645**(76) **Inventor: Gerald Beaulieu, Mirabel (CA)**(57) **ABSTRACT**

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F01K 13/00 (2006.01)

A heat energy reclaim system and method for providing output power from input latent heat energy of a hot source fluid and including means for capturing the latent heat energy from the hot source fluid, that includes an input distribution pipe network for distributing the hot source fluid along a plurality of paths with reduced flow and flow rate, and a respective external heat motor operatively connected to each reduced flow path to provide a portion of the output power. Each motor has shaped piston heads to improve heat transfer between the internal gas and the cylinder walls exposed to the hot source fluid and a cold source fluid, respectively, as well as small internal gas conduits also exposed to the hot source fluid, and other characteristics; therefore increasing the motor and system efficiency.





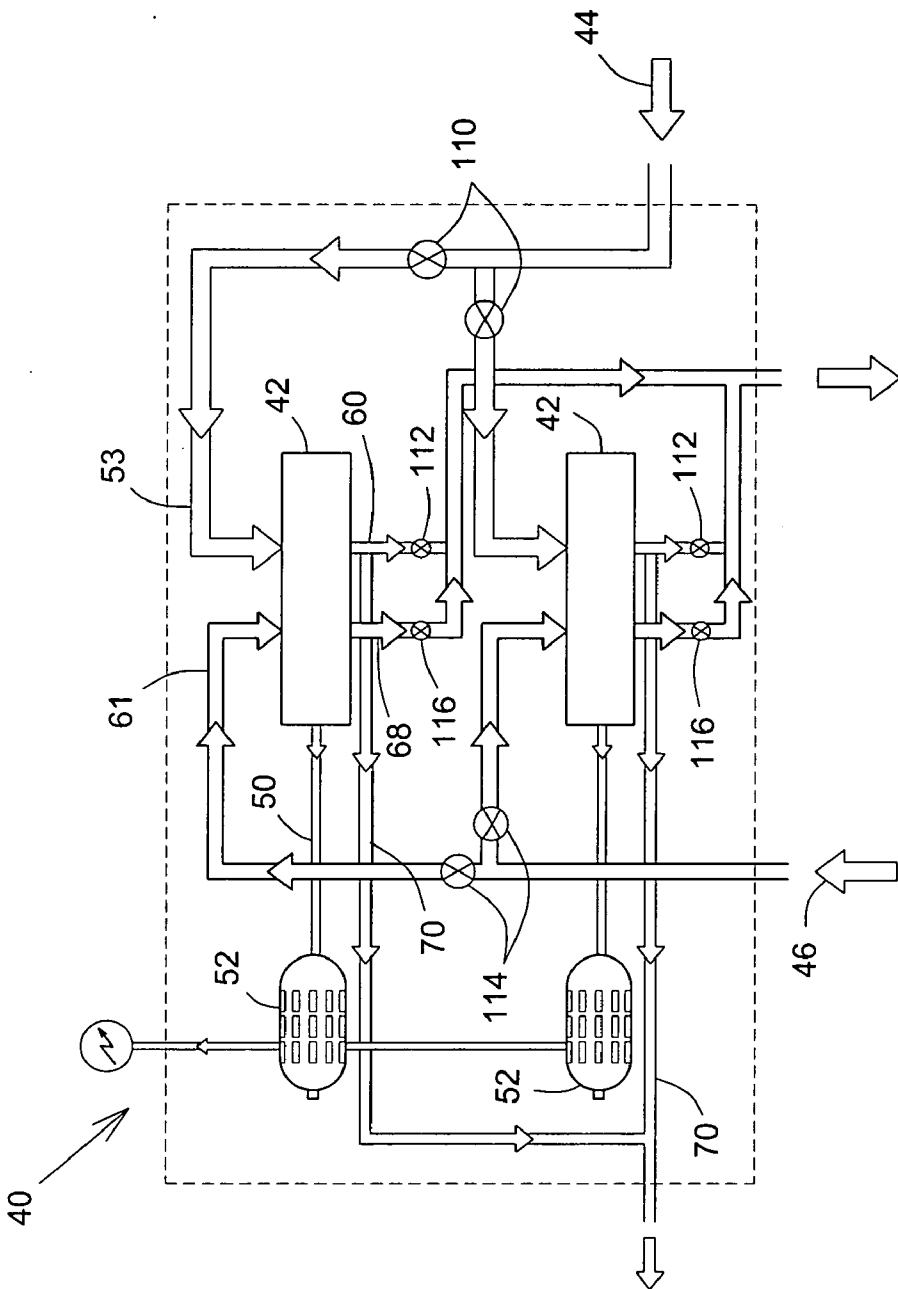
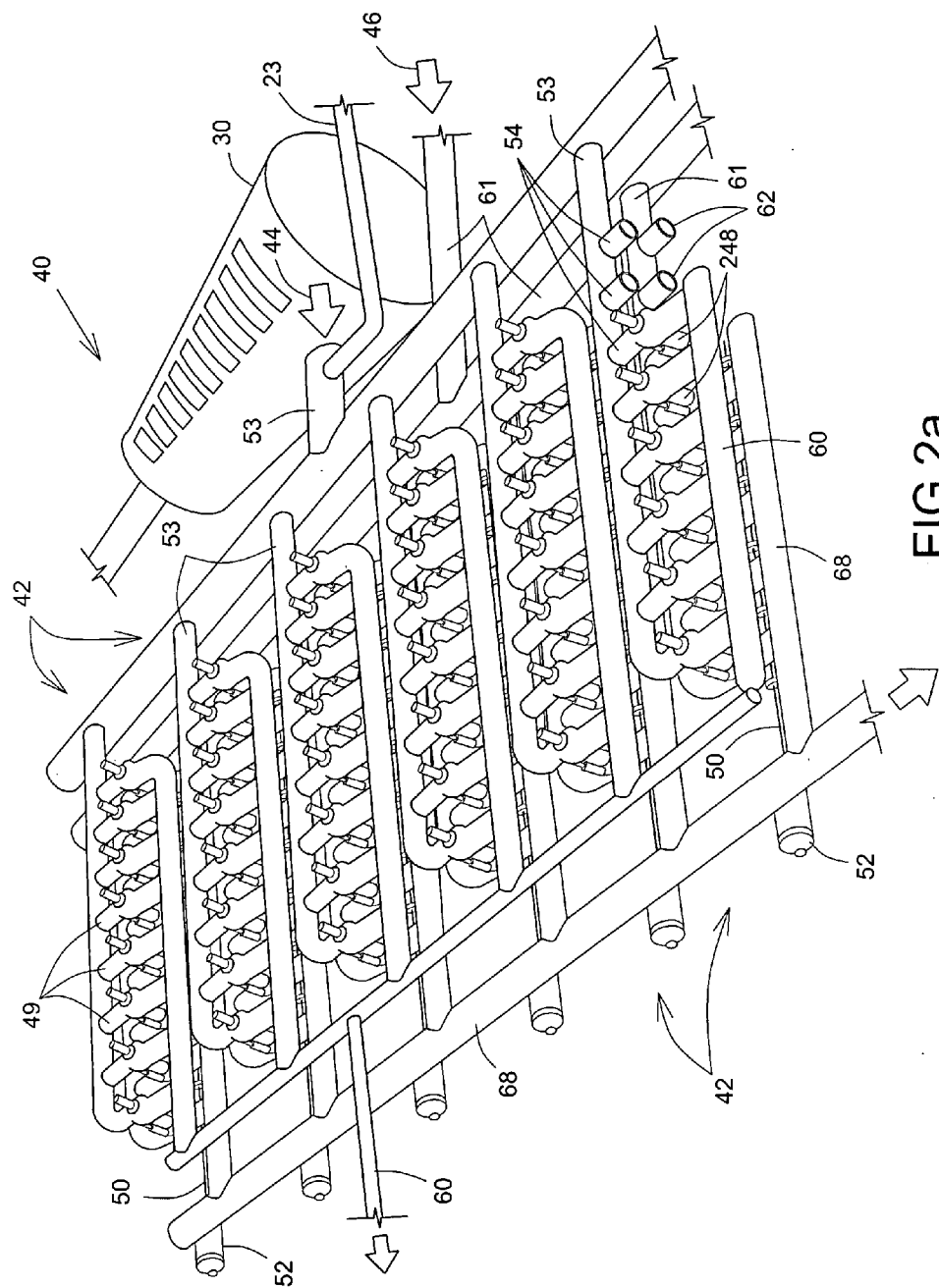


FIG.2



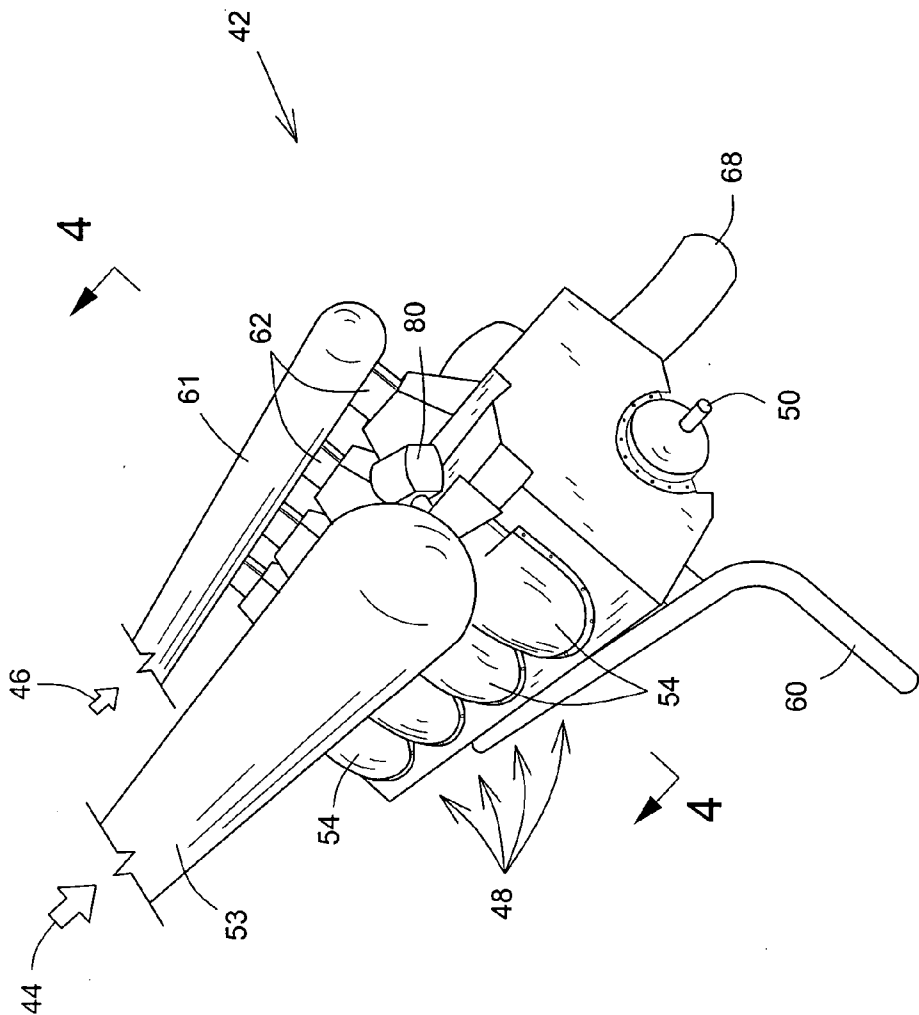


FIG. 3

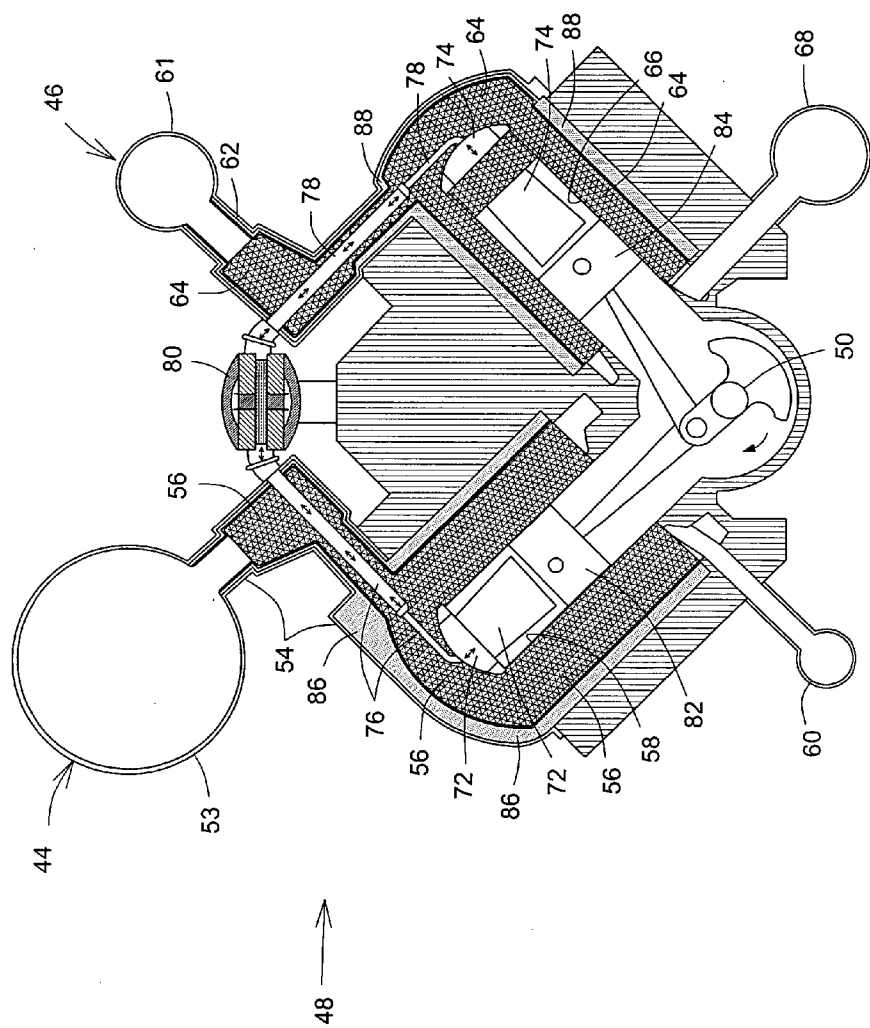


FIG. 4

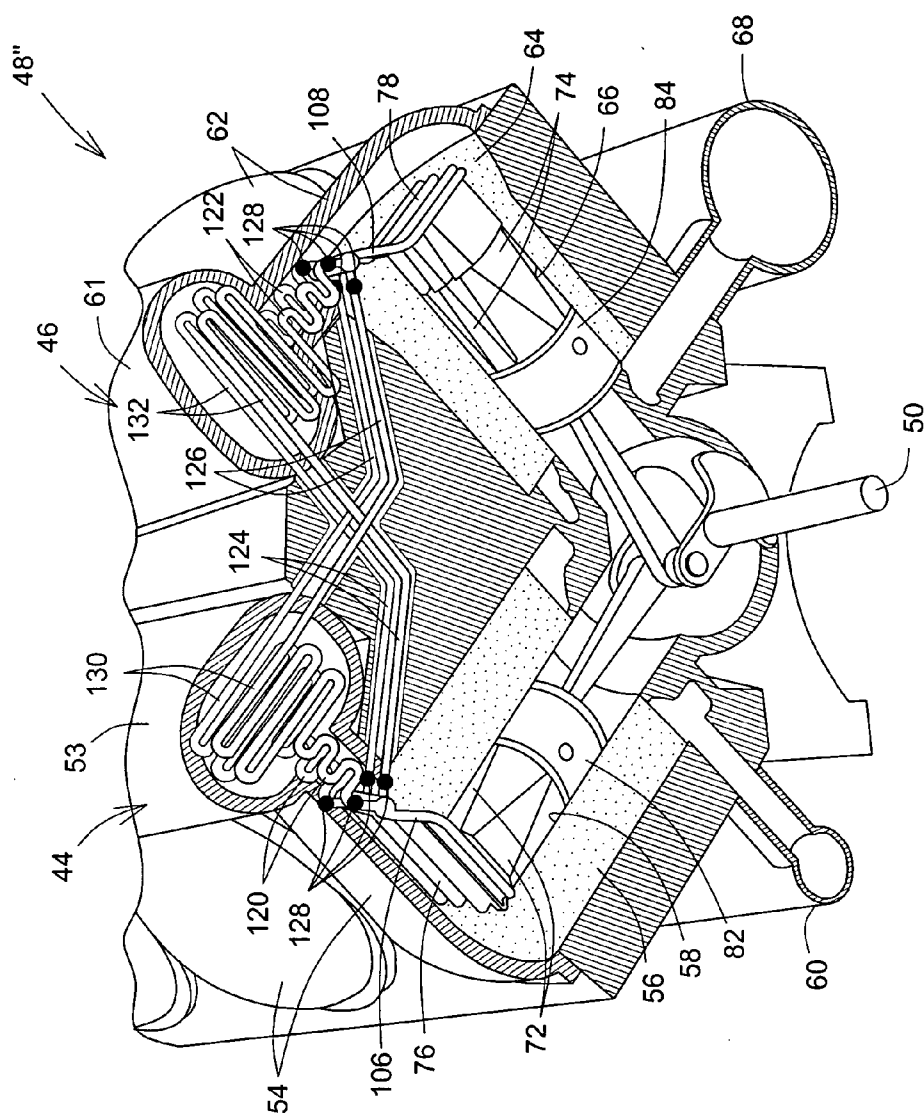


FIG. 4a

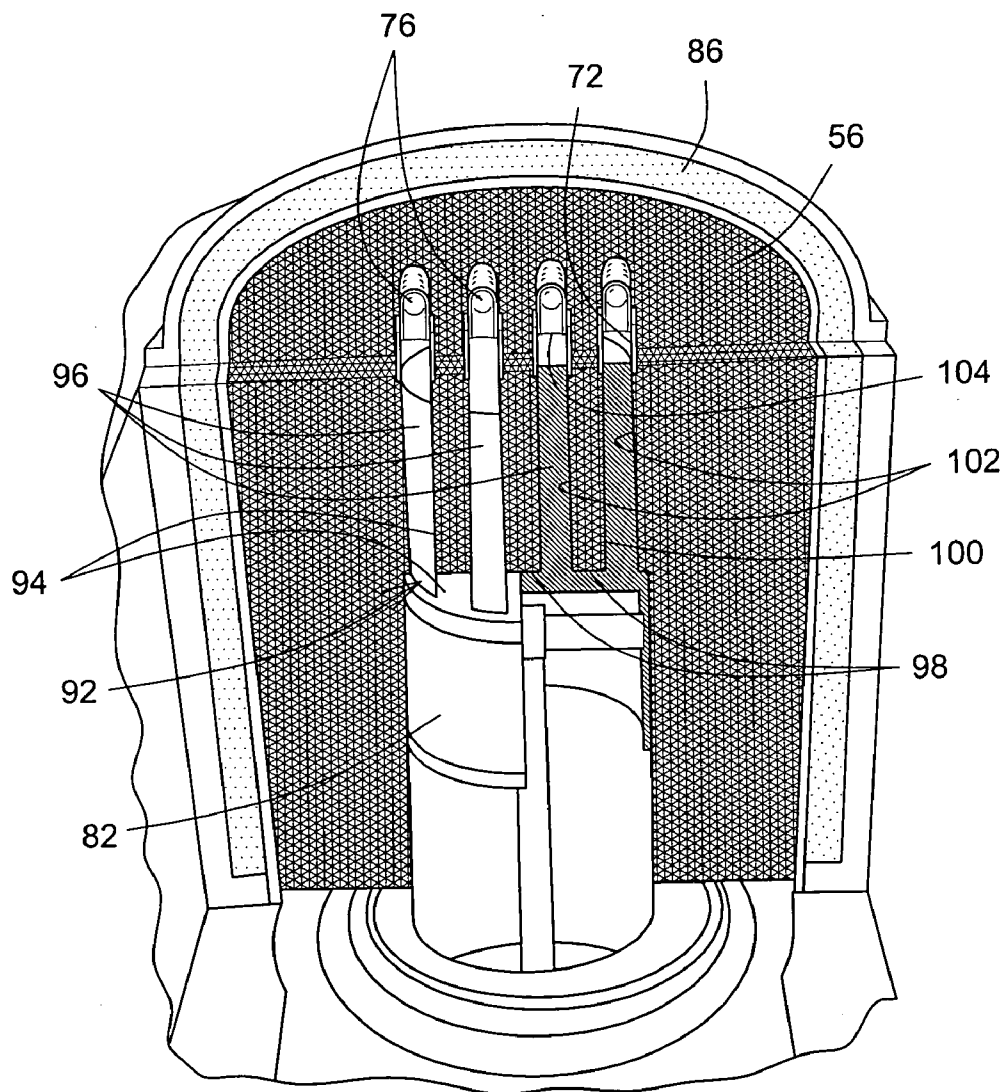


FIG.5

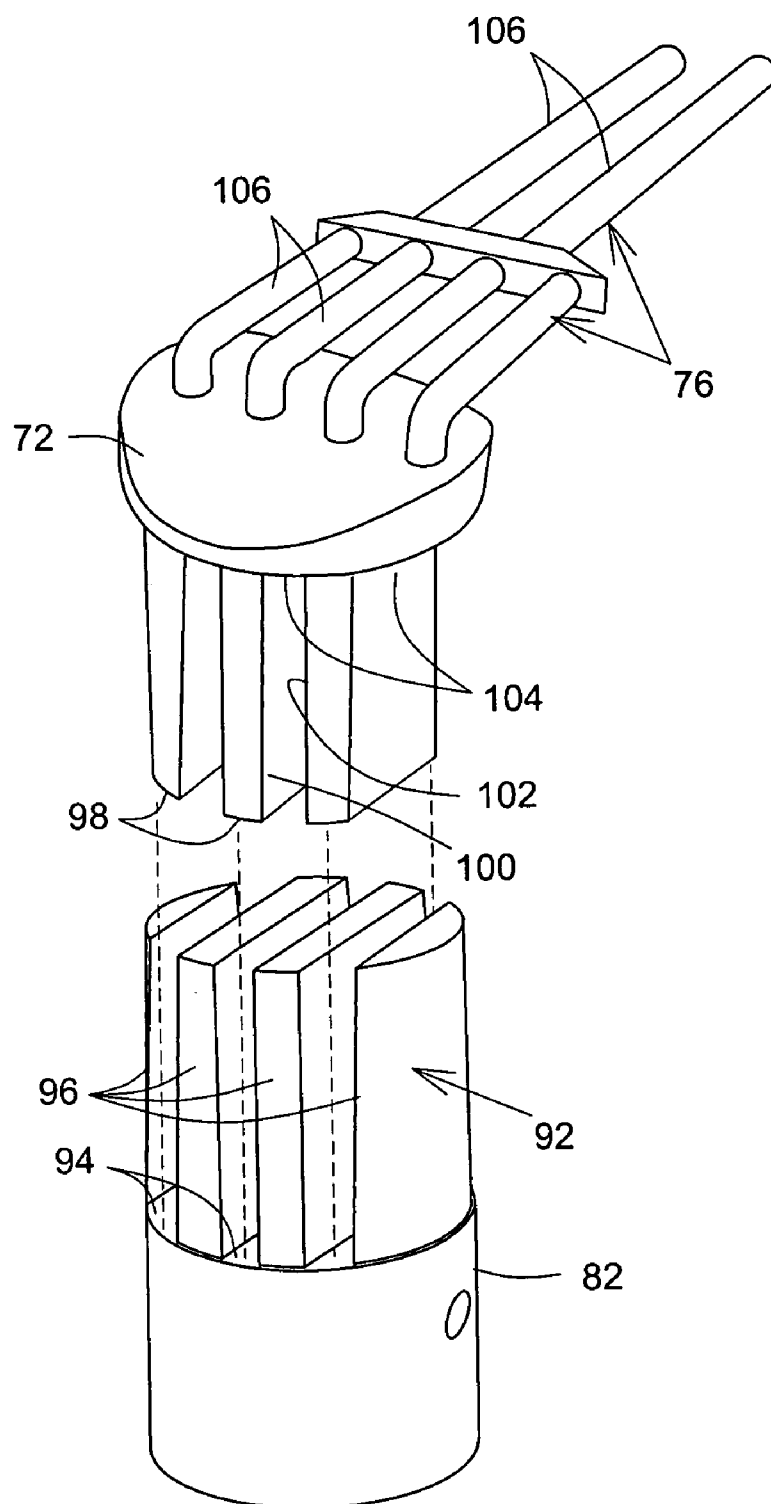


FIG.5a

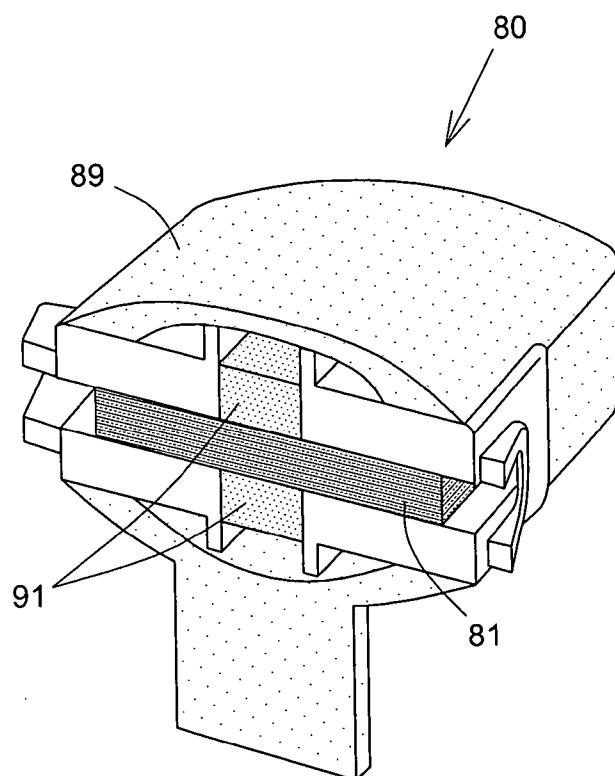


FIG. 6

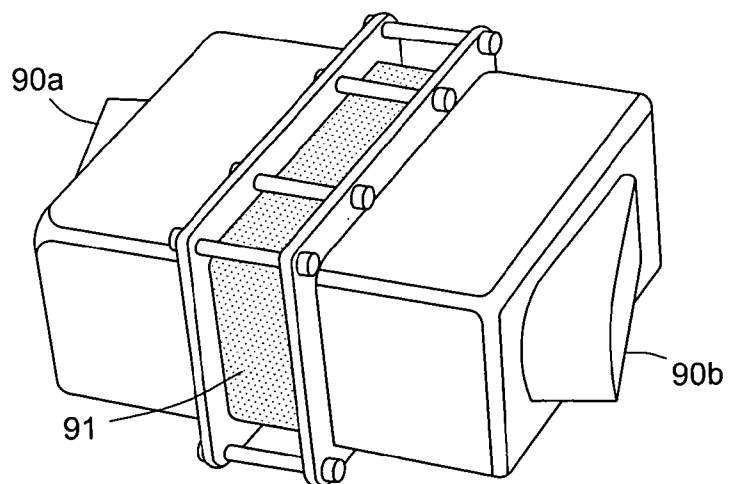


FIG. 6a

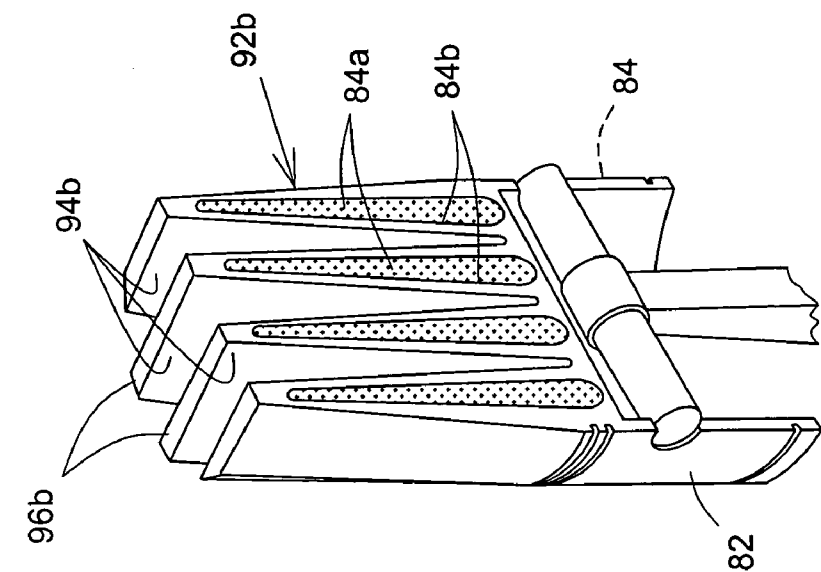


FIG.7

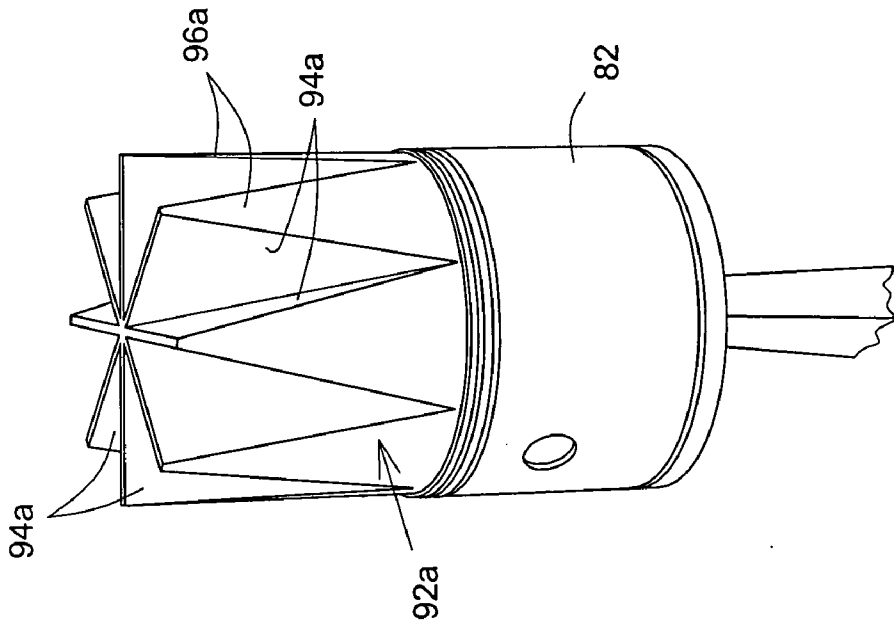


FIG.8

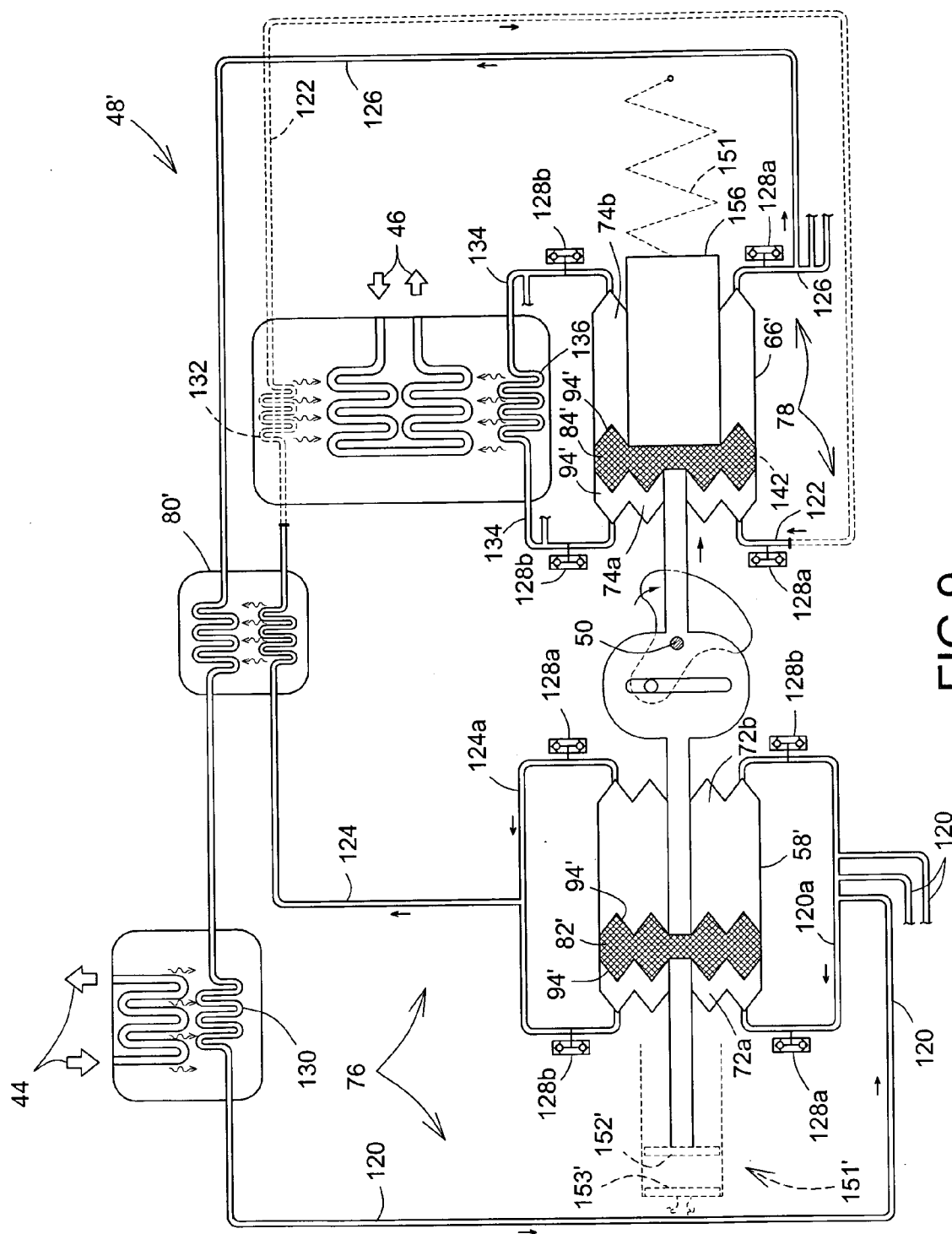


FIG. 9

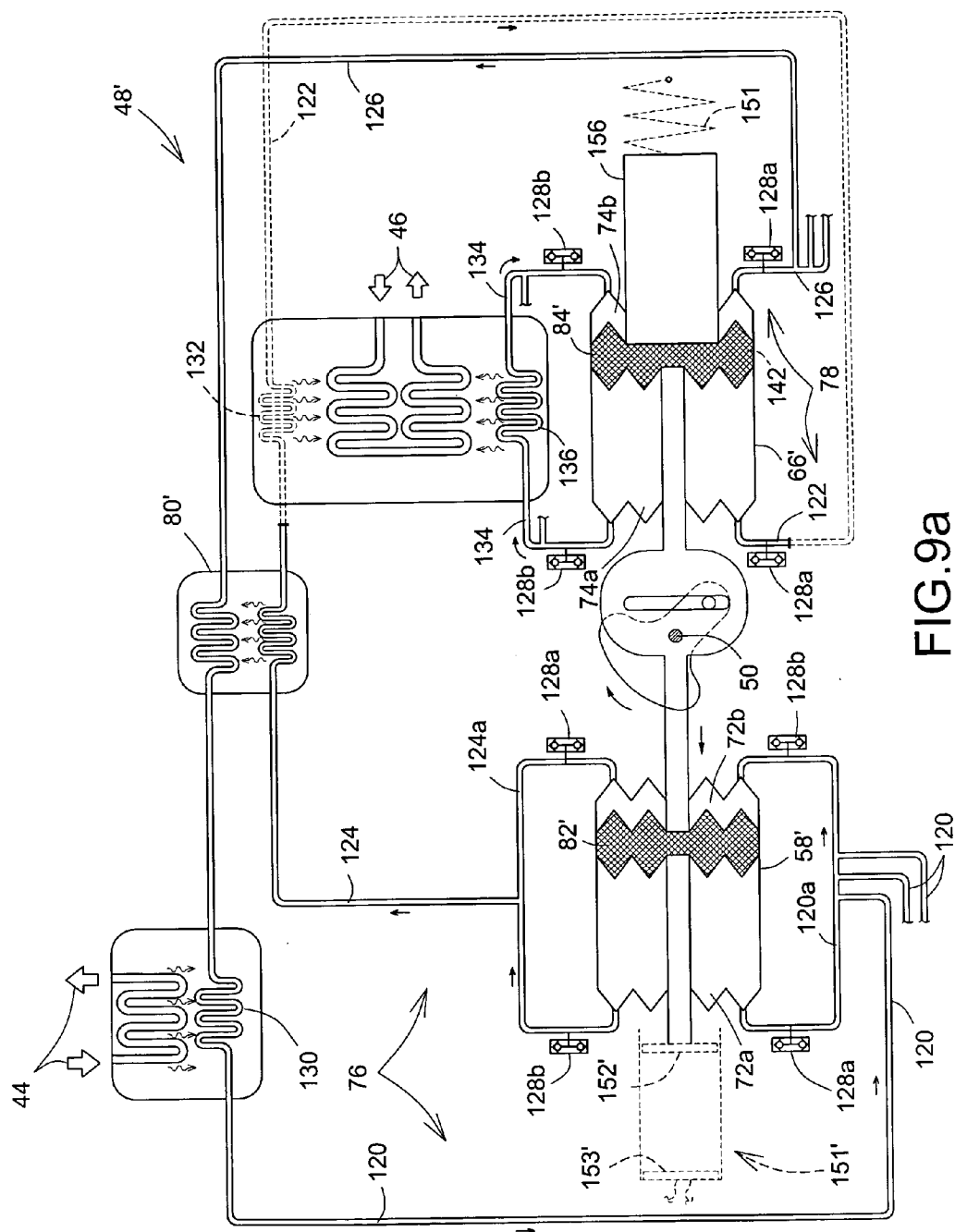


FIG. 9a

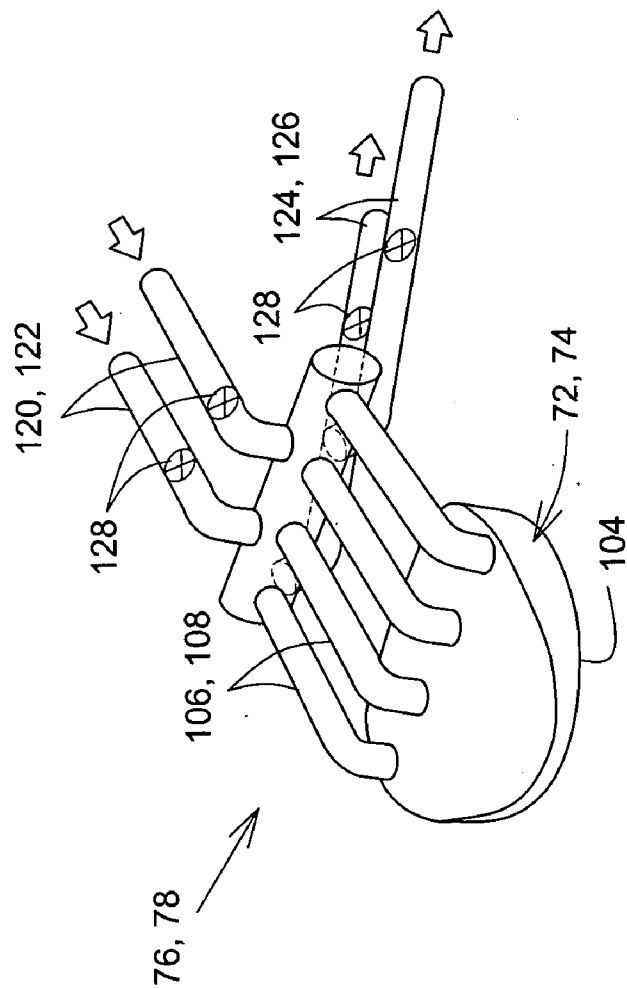


FIG.10

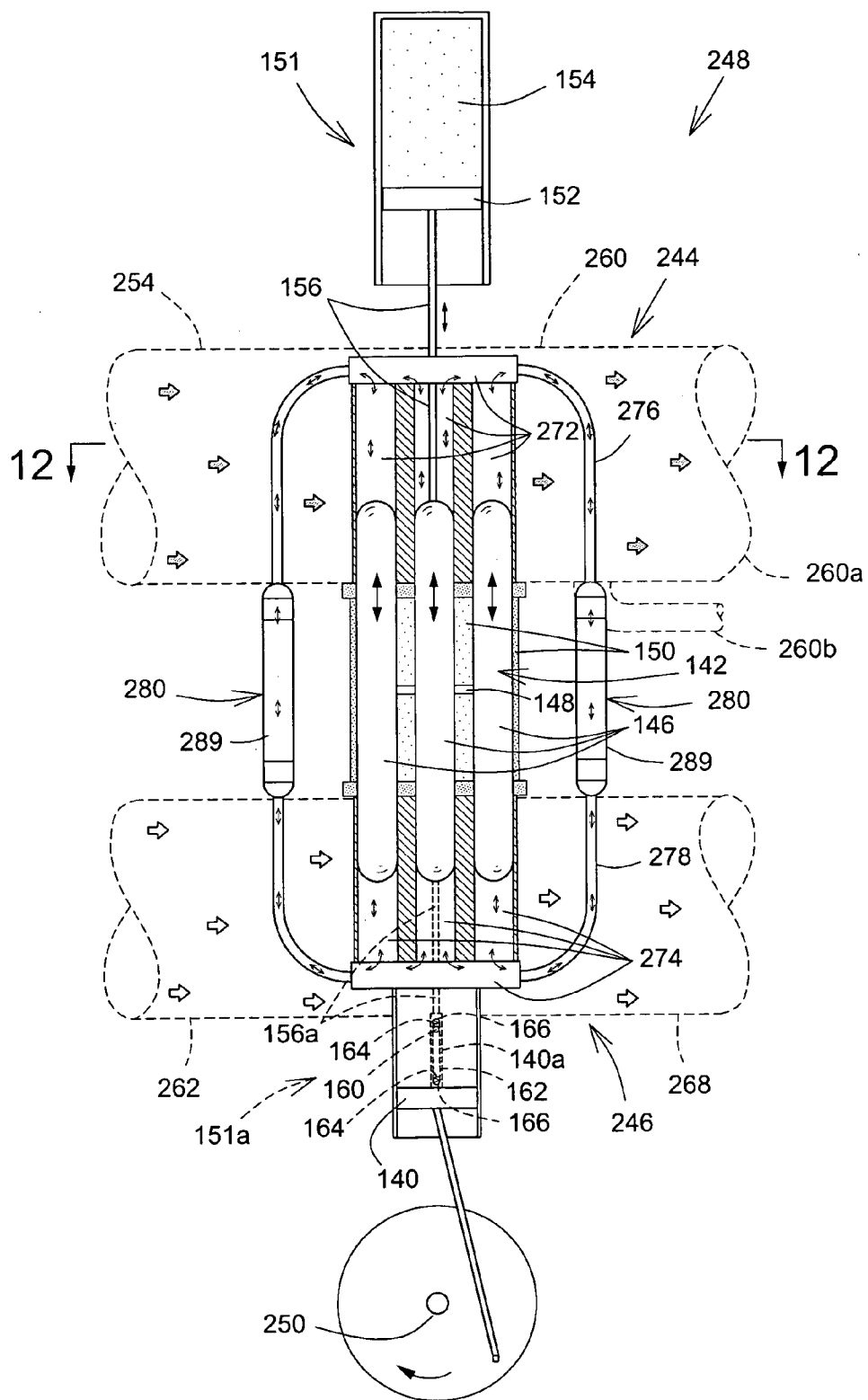


FIG.11

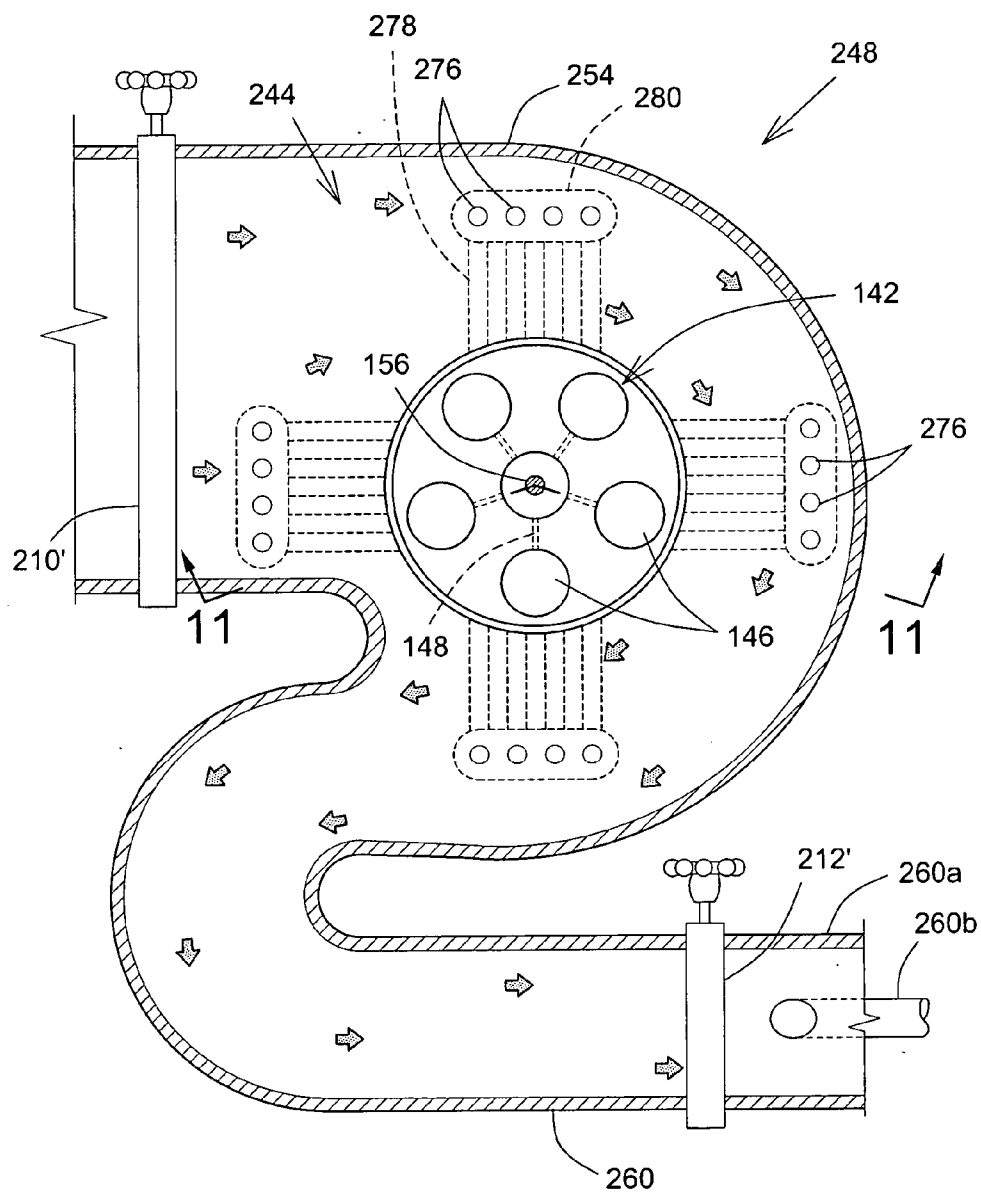


FIG.12

ENERGY RECUPERATION MACHINE SYSTEM FOR POWER PLANT AND THE LIKE

FIELD OF THE INVENTION

[0001] The present invention relates to energy transformation and/or recuperation machines or systems, more particularly to a heat energy system operating from latent heat sources of different nature readily available and external to the system, the system including external heat motors having high heat transfer components therein for improved efficiency.

BACKGROUND OF THE INVENTION

[0002] As an example, it is well known in the art that latent heat is part of output liquids, gas, or fluids from turbines or furnaces of power plants, or even any other fluids found in the nature. Although existing systems try to lower the temperatures of these gas and/or liquids as much as possible, they still come out at temperatures high enough to enable recuperation of a significant amount of useful energy therefrom, although the nature of this latent energy would typically be considered useless relative to the purpose of the machine or system the energy comes from.

[0003] It is also known in the art to use external combustion or hot gas motors or Stirling-type (alpha, beta & gamma types) motors or engines, or any modifications thereof such as Ericsson-, Martini- (generally free piston), Ringbom- (generally free displacer), etc. type motors, to generate power from a temperature differential between hot and cold sources.

[0004] Many documents refer to either these existing systems that typically include additional turbine cycles or the like or Stirling derived motors. Examples of such documents are:

[0005] U.S. Pat. No. 4,077,216 issued to Cook-Yarborough on Mar. 7, 1978 for "Stirling Cycle Thermal Devices";

[0006] U.S. Pat. No. 4,435,959 issued to Mohr on Mar. 13, 1984 for "Hot-Gas Piston-Type Engine and Use Thereof in Heating, Cooling and Power Plants";

[0007] U.S. Pat. No. 5,924,305 issued to Hill on Jul. 20, 1999 for "Thermodynamic System and Process for Producing Heat, Refrigeration, or Work"; and

[0008] U.S. Pat. No. 6,672,063 issued to Proeschel on Jan. 6, 2004 for "Reciprocating Hot Air Bottom Cycle Engine".

[0009] These Stirling motors or the like, also often called external combustion engines, rely on the transfer of heat energy from an external hot heat source to an internal compressible fluid and from the fluid to an external cold source. Therefore, the efficiency of these motors essentially depends on the rapidity of the heat transfers as well as on the relatively short path of travel of the internal fluid between the external hot and cold sources. Such existing motors lack these characteristics, especially when these motors get larger in size, in which more than hundreds of BTUs (British Thermal Units) per minute output is looked at.

[0010] Accordingly, there is a need for an improved energy recuperation system, and corresponding external

combustion motor, for power plant or the like that would efficiently take advantage of the available temperature differential between existing hot and cold sources.

SUMMARY OF THE INVENTION

[0011] It is therefore a general object of the present invention to provide an improved energy recuperation system, and corresponding external combustion motor, for power plant and the like, as especially applicable in any heavy-type industry, including boat engines, locomotives and the like.

[0012] An advantage of the present invention is that the energy recuperation system is easily customizable to the size, the vapor flow and the respective vapor and water temperatures of the power plant, or even the type of power plant.

[0013] Another advantage of the present invention is that the energy recuperation system is efficient and can recuperate as much as 80% of the heat that would otherwise be rejected and lost in the atmosphere, therefore as much as many megawatts or millions of BTUs (British Thermal Units) per hour or day, with improved heat capture capabilities using reduced-section fluid pipes forming a pipe network or manifold.

[0014] A further advantage of the present invention is that the energy recuperation system can be environmentally-friendly with reduced atmospheric pollution and reduced greenhouse effect, substantially silent and with limited vibrations.

[0015] Another advantage of the present invention is that the energy recuperation system recuperates heat energy that is usually lost and reduces the amount of cooling water required in power plants or the like, and more specifically in nuclear power plants.

[0016] Still another advantage of the present invention is that the energy recuperation system can be highly efficient, depending of the temperature differential between the hot and cold sources; the hot sources can be selected from a very wide variety such as different gas, wood, garbage combustions, solar energy, geothermal energy, enclosed hot/cold air in attics or the like areas, etc.

[0017] Another advantage of the present invention is that the energy recuperation system has motor(s) that are designed to have efficient and rapid heat transfer capabilities between the hot and cold sources and the internal gas; using different design features such as improved piston/cylinder designs and relatively small diameter of the internal gas conduits.

[0018] Another advantage of the present invention is that the energy recuperation system has motor(s) that are reliable, require relatively low maintenance, therefore have a long life duty-cycle.

[0019] Yet another advantage of the present invention is that the energy recuperation system is substantially autonomous, depending on the type of heat source, and easily adaptable to the nature of the hot (and cold) source.

[0020] A further advantage of the present invention is that the energy recuperation system allows for some adjustment

of the time duration of each cycle or stroke of the motor for better efficiency thereof, depending on the type of motor.

[0021] Still another advantage of the present invention is that the energy recuperation system allows, when installed in a power plant, to preheat the cold water just before it enters the boiler of the power plant to save some fuel energy thereof.

[0022] Yet a further advantage of the present invention is that the energy recuperation system has a motor of which the different cycle durations can be adjusted to improve the overall efficiency of the system, especially to ensure a better transfer of heat from the hot gas or vapor to the closed-loop gas.

[0023] According to an aspect of the present invention, there is provided a heat energy reclaim system for providing output power from input latent heat energy of a hot source fluid, said system comprises: means for capturing the latent heat energy from the hot source fluid, said capturing means including an input distribution pipe network for distributing the hot source fluid along a plurality of paths with reduced flow and flow rate; and a respective external heat motor operatively connected to each one of said reduced flow paths for providing a portion of the output power.

[0024] Conveniently, the network includes a plurality of main input pipes for receiving the hot source fluid therein, each said main input pipe being in fluid communication with a plurality of respective secondary input pipes, all said secondary input pipes connected downstream of one of said main input pipes being said reduced flow paths and having corresponding said external heat motors connected to an output shaft for delivering said output power portions thereto.

[0025] In one embodiment, the external heat motor includes: a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber with a first volume therebetween and a retracted position in which said gas chamber has a second volume less than said first volume, said piston having a head partially defining said gas chamber and generally axially facing said cylinder, said piston head having a shaped head surface with a plurality of head protrusions extending substantially outwardly axially therefrom so as to enable increased turbulences of a gas located within said gas chamber when said piston is being displaced relative to said cylinder; said cylinder being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the turbulent gas inside the gas chamber for actuation of said piston; and an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

[0026] In one embodiment, the external heat motor includes: a piston axially slidably and reciprocally axially engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber therebetween; a displacer dividing said gas chamber into first and second chamber sections being located adjacent and away from said piston, respectively, said displacer being axially displaceable within said gas chamber for selectively controlling volumes of said first and second chamber sections, said displacer including a plurality of rod

spaced and parallel from one another, said plurality of rod connecting to each other for simultaneous displacement thereof in respective gas chamber portions of reduced cross-section area for increased heat exchange between said cylinder and the gas inside said gas chamber portions; a gas conduit being in fluid communication with said first and second chamber sections to allow an internal gas to flow therethrough between first and second chamber sections; a section of said cylinder adjacent one of said first and second chamber sections being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the gas inside gas chamber portions of corresponding said chamber section with increased heat exchange therebetween for displacement thereof and actuation of said piston; and an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

[0027] According to another aspect of the present invention, there is provided a method for providing output power from input latent heat energy of a hot source fluid, said method comprises the steps of: a) distributing a flow of the hot source fluid through an input distribution pipe network into a plurality of paths with reduced flow and flow rate; and b) operatively connecting a respective external heat motor to each one of said reduced flow paths for providing a portion of the output power.

[0028] According to a further aspect of the present invention, there is provided an external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprises: a piston axially slidably and reciprocally engaging a corresponding cylinder, said cylinder defining a plurality of generally cylindrical gas chambers spaced apart from one another and extending generally axially and in a generally parallel relationship relative to one another, said piston having a plurality of piston heads generally spaced apart from one another and extending generally axially and in a generally parallel relationship relative to one another, each said piston heads axially slidably and reciprocally engaging a corresponding said gas chambers; said cylinder being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the gas inside the gas chambers for displacement of respective said piston heads and said piston relative to said cylinder; and an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

[0029] According to another aspect of the present invention, there is provided an external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprises: a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber with a first volume therebetween and a retracted position in which said gas chamber has a second volume less than said first volume, said piston having a head partially defining said gas chamber and generally axially facing said cylinder, said piston head having a shaped head surface with a plurality of head protrusions extending substantially outwardly axially therefrom so as to enable increased turbulences of a gas located within said gas chamber when said piston is being displaced relative to said cylinder; said cylinder being exposable to the

hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the turbulent gas inside the gas chamber for actuation of said piston; and an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

[0030] According to another aspect of the present invention, there is provided an external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprises: a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber therebetween, said cylinder having an internal chamber wall partially defining said gas chamber, said internal chamber wall having a fin network extending outwardly therefrom, said fin network being exposable to the hot source fluid for receiving latent heat therefrom and conductively transmitting the received latent heat to the internal chamber wall for transfer to the gas inside the gas chamber so as to displace said piston relative to said cylinder; and an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

[0031] Other objects and advantages of the present invention will become apparent from a careful reading of the detailed description provided herein, with appropriate reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] Further aspects and advantages of the present invention will become better understood with reference to the description in association with the following Figures, in which similar references used in different Figures denote similar components, wherein:

[0033] FIG. 1 is a simplified schematic diagrammatic layout of a typical power plant with a heat energy recuperation system in accordance with an embodiment of the present invention;

[0034] FIG. 2 is an enlarged view of a heat energy recuperation system similar to the one of FIG. 1 that could be used with any other application producing available latent heat source;

[0035] FIG. 2a is an enlarged perspective view of a heat energy recuperation system of FIG. 1, showing the fluid pipe network or manifold distributing the flow of hot fluid to individual external heat motors for efficient capture or transfer of the latent heat energy from the fluid;

[0036] FIG. 3 is a simplified top perspective view of a motor, namely an alpha-type Stirling motor with regenerator, of the embodiment of FIG. 1 for recuperation of heat energy;

[0037] FIG. 4 is a simplified enlarged section view taken along line 4-4 of FIG. 3;

[0038] FIG. 4a is a simplified enlarged sectioned top perspective view similar to FIG. 4, showing an embodiment of a motor with multi-conduit heat exchangers inside hot and cold source fluid pipes;

[0039] FIG. 5 is a simplified broken top perspective section view of a piston head region of the block engine of the embodiment of FIG. 2;

[0040] FIG. 5a is a simplified top perspective section view of a piston head with corresponding gas circulation pipes of the embodiment of FIG. 2;

[0041] FIG. 6 is a simplified top perspective section view of a regenerator of the motor of FIG. 3;

[0042] FIG. 6a is a simplified broken top perspective section view of the regenerator of FIG. 6 with its insulating cover;

[0043] FIG. 7 is a view similar to FIG. 5a, showing a second embodiment of a piston head;

[0044] FIG. 8 is a simplified top perspective section view of a third embodiment of a piston head;

[0045] FIGS. 9 and 9a are simplified schematic layouts of another embodiment of a motor in accordance with the present invention, namely an Ericsson-type motor, showing one-way gas circulation pipes and corresponding heat exchanger arrangement between hot and cold double-acting cylinders shown in a back-to-back configuration, being displaced in the opposite first and second displacement directions;

[0046] FIG. 10 is a view similar to FIG. 5a, showing the one-way gas circulation conduits;

[0047] FIG. 11 is a simplified front elevation section view, taken along line 11-11 of FIG. 12, of an embodiment of the motor shown in FIG. 2a with some parts taken away, namely a beta-type Stirling motor, with a displacer restraint mechanism used in the energy recuperation system of FIG. 2a; and

[0048] FIG. 12 is a simplified top plan section view taken along line 12-12 of FIG. 11 with some parts taken away.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] With reference to the annexed drawings the preferred embodiments of the present invention will be herein described for indicative purpose and by no means as of limitation.

[0050] Referring to FIG. 1, there is shown a schematic layout of a conventional power plant 20 in which a boiler 22 fed with some combustibles 24 burned through a burner 25 is used to heat up cold input water 26 into vapor 28 that feed a turbine 30 and generate electrical power 32 from alternators 34. Hot gas outputs from the combustion and rejected into the atmosphere via chimneys 36 while output vapors from the turbine 30 enter a condenser (not shown). From the condenser, water returns back and mix with the cold input water 26 while residual vapor is also rejected into the atmosphere via cooling towers 38. The rejections from both the chimneys 36 and the towers 38 have temperatures high enough such that useful latent heat energy could still be recuperated there from.

[0051] In addition, there is shown a heat energy recuperation or reclaim system 40 in accordance with an embodiment of the present invention for use with a conventional power plant 20 or the like. The system 40 of the present invention essentially replaces the condenser to recuperate a large amount of latent heat energy from the power plant vapor and hot gas rejections via a means for capturing the latent heat energy there from.

[0052] The energy recuperation system 40 includes two groups of motor 42, typically external combustion motors such as Stirling-type motors or the like, in which the heat or hot source 44 is provided by the hot pressurized vapor coming out from the turbine 30 and the cold source 46 or sink is provided by the cold input water 26 or the like of the power plant 20. A similar additional motor group 42a has its heat source 44a provided from the hot gases coming out from the boiler 22. Each motor group 42, 42a includes a plurality, four being shown in FIG. 3, of simple motors 48 connected to a same output shaft 50 connected to a corresponding alternator 52 (see FIG. 1) to generate additional electrical power. In order to better control the temperature of the hot source 44, a portion of the vapor exiting the boiler 22 could flow through a turbine bypass conduit 23, the access of which being controlled by a flow control valve 23' or the like, and mix with the vapor coming out of the turbine 30 before entering the energy recuperation system 40, as shown in FIGS. 1 and 2a.

[0053] As shown in FIG. 2, the system 40 could be installed in any other type of locations adjacent any hot source 44 and cold source 46 which could simply be the ambient air or the like, and could ultimately include only one motor 48, depending on the available amount of heat and the specific application. For example, the hot source 44 could be heat generated by an internal combustion engine or boiler, hot air found in the attics of domestic housings, solar energy, air heated by underground pipes in winter time, hot surface water of oceans, etc. while the cold source 46 could be the ambient air (especially in winter time), ocean deep water, etc.

[0054] FIG. 2a refers to a typical system 40 of the present invention in which the fluid of the hot source 44 is directed to the different motor groups 42, each having eight motors 248 of a different embodiment as shown, as an example. In order to efficiently capture the latent heat energy from the hot source 44, which is a key feature of the present invention, the system 40 includes a means for capturing the latent heat energy from the hot source fluid 44. This capturing means is typically located in each one of the motor groups 42 and includes an input distribution pipe network 41 (or manifold) to distribute the hot source fluid 44 along a plurality of paths 49 with reduced flow and flow rate to maximize the amount of heat transferred from the hot source 44 to the motors 248 (as further described hereinbelow in relation with FIGS. 11 and 12). A reduced flow and flow rate of hot source fluid 44 is one of the best way to increase the heat capture efficiency by capturing as much heat energy as possible there from since the heat energy is located at every location of the hot source fluid 44. A respective external heat motor 248 is operatively connected to each reduced flow path 49 to provide a portion of the output power of the system 40.

[0055] Typically, the pipe network 41 includes a plurality of main hot input pipes 53, one per motor group 42, to receive the hot source fluid 44 therein that are in fluid communication with a plurality of respective secondary hot input pipes 54 located downstream thereof and forming the different reduced flow paths 49. Each secondary hot input pipe 54 is connected to a corresponding external heat motor 248. In opposite, using large hot input pipes connecting to

large motors would not enable efficient heat recuperation and would be too costly in relation to the amount of energy that would be recuperated.

[0056] Now referring more specifically to the embodiment of the motor 48 shown in FIGS. 3 and 4, the vapor of the hot side of all motors 48 is fed via a hot input pipe 54 through hot sleeves or jackets 56 surrounding and connecting to the respective hot cylinder 58 and to a hot output pipe 60. Similarly, the cold water of the cold side of all motors 48 is fed via a cold input pipe 62 through cold sleeves or jackets 64 surrounding and connecting to the respective cold cylinder 66 and to a cold output pipe 68, as also shown in FIG. 2a in which the main cold input pipe 61 feeds the secondary cold input pipes 62. Ultimately, the water from both the hot and cold output pipes 60, 68 could be mixed together before returning to the boiler 22, as partially shown in FIGS. 11 and 12. At the same time, some residual low temperature vapor from the hot output pipe 60 is redirected toward the cooling towers 38 via the vapor output pipe 70, as shown in FIG. 1. The hot and cold jackets 56, 64, typically made out of a network or trellis of highly efficiently designed fins or the like and made out of a highly heat conductive material and coarsely represented with a specific hashed pattern for pictorial purposes only, are used to rapidly heat up and cool down the temperature of the respective hot and cold cylinders 58, 66 exposed to the hot and cold sources 44, 46 by efficient heat transfer such that the internal gas inside the hot 72 and cold 74 gas chambers is quickly and better uniformly heated up and cooled down respectively.

[0057] In each simple motor 48, the internal gas circulating between the hot and cold gas chambers 72, 74 flows through respective hot 76 and cold 78 gas pipes that typically at least partially extend through the respective jacket 56, 64 and a regenerator 80 located there between. The regenerator 80 (see FIGS. 6 and 6a) is typically a sort of highly efficient heat exchanger 81, typically made out of a metallic mesh or the like, used to further cool down the gas flowing from the hot gas chamber 72 to the cold gas chamber 74 and heat up the gas when flowing in the opposite direction from the cold 74 to the hot gas chamber 72. Obviously, the amount of dead gas volume flowing inside the hot and cold gas pipes 76, 78 located between the two hot and cold jackets 56, 64 (and outside the regenerator 80 if present) is kept to a minimum since the internal gas is not being warmed or cooled when flowing therein therefore being thermally inefficient pipe sections that unnecessarily further increase the head loss inside the internal gas conduits 76, 78.

[0058] As it is for an alpha-type Stirling motor/engine 48, both the hot 82 and cold 84 pistons are connected to the same output shaft 50 with a cycle delay between the two typically varying between about thirty and about hundred-and-twenty degrees (30°-120°) depending on the specific use, and preferably about ninety degrees (90°). Accordingly, there is a detent (expansion) phase (at essentially constant temperature) of the closed-loop or internal gas just after the heating phase (at essentially constant volume), then a cooling phase (at essentially constant volume) of the gas occurs followed by a compression phase (at essentially constant temperature) thereof. Although an alpha-type Stirling motor/engine 48 is illustrated herein, it would be obvious to one skilled in the

art to consider any other type of external combustion or hot gas engine/motor without departing from the scope of the present invention.

[0059] In order to minimize heat losses and to isolate the hot and cold cylinders **58**, **66** from one another, both the hot and cold jackets **56**, **64** are externally insulated by a respective hot **86** and cold **88** insulation sleeve. Similarly, the regenerator **80** is typically well externally covered by a good temperature insulator **89**, as shown in FIG. **6a**, as well as having the hot **90a** and cold **90b** gas inputs insulated from each other by an insulating interface **91** (see FIGS. **6** and **6a**). Typically, the insulating material is ceramic or the like.

[0060] As shown in FIGS. **4**, **5** and **5a**, each piston **82**, **84** includes a piston head **92** having a shaped head surface **94** with a plurality of head protrusions **96** extending substantially outwardly axially there from to enable increased turbulences of the internal gas located within the gas chamber **72**, **74** when the piston **82**, **84** is in movement relative to the cylinder **58**, **66**, for increased heat transfer between the gas and the cylinder **58**, **66**. In the opposite, each cylinder **58**, **66** has a bottom wall **98**, generally axially facing the piston head **92**, that has a shaped wall surface **100** with a plurality of wall recesses **102** extending substantially inwardly axially therein such that each head protrusion **96** selectively engages a respective wall recess **102** when the piston **82**, **84** moves from an extended position in which the piston **82**, **84** and the cylinder **58**, **66** define the gas chamber **72**, **74** with a first volume there between toward a contracted position in which the gas chamber **72**, **74** has a second volume less than the first volume. Typically, the shaped cylinder wall surface **100** is substantially a complementary image of the shaped piston head surface **94** such that the head protrusions **96** almost entirely fill the corresponding wall recesses **102** when the piston **82**, **84** is in the contracted position, with a second volume substantially null. In the latter configuration, the cylinder wall recesses **102** define respective gas chamber portions **72a** spaced apart, typically equally, and generally parallel relative to one another such that they form a plurality of individual sub-cylinders **58a** of reduced cross-section area for increased heat exchange between cylinder wall **98** and the gas inside the gas chamber portions **72a**.

[0061] Furthermore, each cylinder wall recess **102** defines a bottom region **104** thereof, via which the wall recess **102** is in fluid communication with at least one, typically all, of the adjacent wall recesses **102**.

[0062] Now referring more specifically to FIGS. **5** and **5a**, there is shown the hot piston head protrusions **96** typically having a blade shape to maximize the overall chamber surface area over volume ratio and enable a relatively rapid heating up of the gas filling the hot gas chamber **72**, including the space between the blades **96**, from the hot vapor flowing inside the jacket **56**, through the cylinder wall **98**. To improve a relatively uniform flow distribution of the gas between the hot gas chamber **72** and the corresponding hot gas pipes **76** and to facilitate the heating (heat transfer) of the gas flowing therethrough from vapor inside the jacket **56**, the hot gas pipes **76** includes a plurality of generally parallel hot gas conduits **106** of a smaller diameter. Although the hot side has been described hereinabove, the description, including cold gas conduits **108**, also applies to the cold side which might be different in size and configuration depending

on the required heat transfer between the internal gas and the respective hot source **44** or cold sink **46**.

[0063] As shown in FIGS. **1** and **2**, in order to control the flow of hot vapor or gas **44** flowing into the hot jackets **56** of a same motor group **42**, **42a** and coming out there from, input **110**, **110a** and output **112** hot valves connected to the corresponding pipes **53**, **60**. Similarly, the flow of cold water flowing into the cold jackets **64** of a same motor group **42**, **42a** and coming out there from is controlled with input **114** and output **116** cold valves connected to the corresponding pipes **61**, **68**. The input and output hot and cold valves **110**, **110a**, **112**, **114**, **116** are also used to isolate any motor group **42**, **42a** from the others for maintenance thereof or the like.

[0064] Many types of gas or refrigerant could be used as a compressible working fluid inside the closed-loop or internal gas network between the hot and cold gas chambers **72**, **74** and through the regenerator **80** depending on the heat requirements of the specific application, such as the thermodynamics characteristic of the gas, safety (toxicity, explosiveness, etc.), and environmental, technical and economic considerations. For examples, the gas categories could include CFCs (chlorofluorocarbons), HCFCs (hydro-chlorofluorocarbons), HFCs (hydro-fluorocarbons), low greenhouse-effect gas such as ammonia (NH₃), HCs (hydrocarbons), CO₂ (carbon dioxide), and water (vapor), as well as typical efficient gases such as helium, hydrogen, nitrogen or simply air. In order to increase the temperature difference between the hot and cold sources **44**, **46**, and/or to improve the efficiency of the motor group **42**, **42a**, one could consider the use of artifices of external devices, such as the use of cold ambient air (in winter, when and where applicable) to further cool down the cold source **46** (as illustrated in FIG. **2** with heat exchanger **29**), or the use of a sodium based solution or mixture **84a** (schematically represented in FIG. **8**) inside weight relief chambers **84b** of the cold piston **84** to increase the piston capacity to dissipate the heat extracted from the internal gas, etc.

[0065] Inside the regenerator **80**, it would be preferable to have a phase change material (PCM), such as ammonia (NH₃) or carbon dioxide (CO₂), to increase its heat capacity and heat transfer efficiency.

Operation

[0066] Although the following example specifically refers to a power plant with hot pressurized vapor, any other type of heat source (especially the hot one) from any other location could be considered for the system of the present invention as long as there is sufficient temperature difference between the hot and cold sources **44**, **46** as further detailed hereinafter.

[0067] In a typical power plant application wherein turbines are activated with vapor, that vapor, when at substantially zero relative pressure at the outlet of the turbines, is at the temperature range between about 200° C. (390° F.) and about 250° C. (480° F.), being the temperature of the hot source **44**. After the heat has been transferred to the gas inside the hot gas chamber **72** and hot gas pipes **76** while flowing through the hot jacket **56**, the vapor temperature drops down to about 95-100° C. (203-212° F.) in the hot output pipe **60**, essentially in water state. For the cold source **46**, the water is typically available at about 15° C. (60° F.) to enter the cold input pipe **62**. After the heat has been

transferred from the gas inside the cold gas chamber 74 and cold gas pipes 78 while flowing through the cold jacket 64, the water temperature increases up to about 80-90° C. (176-194° F.) in the cold output pipe 68. The water from both hot and cold output pipes 60, 68 are mixed together before going to the boiler 22 where it is vaporized again, and therefore saving the amount of energy that would have been required to heat it up from 15° C. (60° F.) to that temperature of about 95° C. (203° F.). As seen in dotted lines in FIG. 1, when the ambient outside temperature is below 15° C. (60° F.), the cold water 26 can even be further cooled down via the cold ambient atmospheric air via a heat exchanger 29; this would further increase the efficiency of the system 40.

[0068] As mentioned hereinabove, other types of hot and cold sources 44, 46 could also be considered as well as any other temperature ranges. For example, the hot vapor temperature could vary between about 50° C. (122° F.) and about 550° C. (1020° F.) while a hot gas temperature could be as high as about 750° C. (1380° F.). In any case, and without limitation, a hot-cold temperature difference (between the hot and cold source temperatures) as low as about 30° C. (54° F.) could typically be considered as sufficient to generate a significant amount of power therefrom for power plants or the like, and even as low as about 10° C. (18° F.) for domestic size applications in which smaller size external heat motors would be considered.

Alternatives

[0069] In the example hereinabove described, instead of having a motor group 42a fed with the hot gas coming out from the boiler 22 and/or the burner 25, there simply could be a heat exchanger 27 (as shown in dotted lines in FIG. 1) between these hot gases and the cold input water 26 to cool down the hot gases before rejection thereof and pre-warm-up of the water 26 before entering the boiler 22.

[0070] In order to increase the uniformity of the heating or cooling of the gas inside the respective hot or cold gas chamber 72, 74, by inducing vortex motion to the gas during firing thereof, the piston heads 92a, 92b could have surfaces 94a, 94b with protrusions 96 of different shapes such as radial pyramids 96a of a tapered star-shaped head 92a or tapered blades 96b, as shown in FIGS. 7 and 8 respectively.

[0071] Now referring more specifically to FIGS. 4a and 10, the hot and cold gas conduits 106, 108 of the motor 48" could follow different paths between the gas chambers 72, 74 and therefore would typically include a plurality of respective inlet gas conduits 120, 122 and a plurality of respective outlet gas conduits 124, 126 to allow the gas to enter and exit the corresponding gas chamber 72, 74 there through, respectively. Each inlet and outlet gas conduit 120, 122, 124, 126 typically has a one-way flow control valve 128 for controlling the flow of gas there through, the valves 128 being typically electronically controlled valves or spring-loaded type, or simple one-way flaps to prevent backflow of the internal gas.

[0072] In order to improve the heat transfer between the hot or cold source 44, 46 and the gas inside the inlet gas conduits 120, 122, a conduit heat exchanger 130, 132, typically a serpentine or the like, in fluid connection with a respective inlet gas conduit 120, 122. Typically, the conduit heat exchangers 130, 132 are exposable to the respective hot and cold source 44, 46 either for receiving latent heat from

the hot source 44 and transmitting the received latent heat to the gas inside the conduit heat exchangers 130 for heating the gas flowing therein or for receiving latent heat from the gas flowing inside the conduit heat exchangers 132 and transmitting the received latent heat to the cold source 46 for heating the same.

[0073] Typically, the fin network of the jackets 56, 64 extend outwardly around the bottom region 104 of the cylinder recesses 102, the hot and cold gas conduits 106, 108 there around and typically the inlet gas conduits 120, 122 with their serpentines 130, 132 such that the latter are all exposed to the respective hot and cold sources 44, 46 for further increased heat transfer efficiency of the system 40 with the internal gas.

[0074] As schematically shown in FIGS. 9 and 9a, to further enhance efficiency of the system 40, the hot and cold circulation gas pipes 76, 78 of an Ericsson-type motor 48' as illustrated herein typically includes multiple parallel small gas conduits 120, 122, 124, 126 with respective one-way flow control valves 128, as partially illustrated between the two cylinders 58', 66'. The motor 48' shown in FIGS. 9 and 9a includes double-acting pistons 82', 84' typically assembled in a back-to-back configuration with shaped head surfaces 94' on both sides thereof. During the displacement of the pistons 82', 84' in a first direction of the reciprocation movement illustrated in FIG. 9, the internal gas, with one-way flow valves 128a opened and one-way flow valves 128b closed, flows via the hot serpentines 130 and the hot inlet small gas conduits 120, 120a, all typically exposed to the hot source 44, into the first hot gas chamber 72a, and from the second hot gas chamber 72b into the hot outlet small gas conduits 124, 124a. Then the hot gas could enter a heat exchanger 80' such as a regenerator or the like and preferably cold serpentines 132 to get cooler by the cold source 46. Thereafter, the cold internal gas flows via the cold inlet small gas conduits 122, typically exposed to the cold source 46, into the first cold gas chamber 74a, and from the second cold gas chamber 74b into the cold outlet small gas conduits 126.

[0075] During the displacement of the pistons 82', 84' in an opposite second direction of the reciprocation movement illustrated in FIG. 9a, the internal gas, with one-way flow valves 128a closed and one-way flow valves 128b opened, flows via the hot serpentines 130 and the hot inlet small gas conduits 120, 120b, all typically exposed to the hot source 44, into the second hot gas chamber 72b, and from the first hot gas chamber 72a into the hot outlet small gas conduits 124, 124b. Then the hot gas could similarly enter the heat exchanger 80' and preferably cold serpentines 132 and the cold inlet small gas conduits 122 to get cooler by the cold source 46. At the cold end of the engine 48', to further cool the compressed internal gas before it gets redirected towards the hot cylinder 58' in the following phase (first displacement direction of the pistons 82', 84'), the cold internal gas flows from the first cold gas chamber 74a into the second cold gas chamber 74b via cold by-pass conduits 134, with one-way valves 128b, that include by-pass heat exchanger 136 or serpentines exposed to the cold source 46. The second cold gas chamber 74b is smaller than the first cold gas chamber 74a because the internal gas is further compressed due to its colder temperature.

[0076] The cold inlet small gas conduits 122 and the cold serpentines are shown in dotted lines in FIGS. 9 and 9a

because instead of having a closed-loop internal gas, the latter could eventually be rejected out from the hot outlet small conduits 124 of the motor 48' after actuation of the hot piston 82', and have new cold gas (such as air or the like) entering the cold cylinder 66' of the motor 48' via the cold inlet small gas conduits 122.

[0077] In FIGS. 9 and 9a, although both the hot and cold pistons 82', 84' are connected to the output shaft 50, the cold piston 84' could be disconnected there from and acting as a displacer 142 which displacement could be controlled by a displacer actuating means 151, shown in dotted lines in FIGS. 9 and 9a, as further explained hereinbelow with reference to FIGS. 11 and 12. The same approach could eventually be considered with the motor 48 of FIG. 4 without departing from the scope of the present invention. The hot piston 82' could have its displacement helped or operated by a typically magnetic displacer actuating means 151' that would have at least one controllable electromagnet 153' acting on a magnetic piston 152' or the like connected to the hot piston 82'.

[0078] The large quantity (only duplication shown in FIG. 4a) of small gas conduits 120, 122, 124, 126 as well as heat exchangers 130, 132 enable to keep them relatively small to increase the heat exchange all along their respective path. Such increased heat transfer capability of the motor of the present invention is further enhanced by the shaped gas chambers 72, 72a, 72b, 74, 74a, 74b as explained hereinabove. The heat exchangers 130, 132 could also be any type of heating or cooling mechanism such as an electrical heating coil or a liquid nitrogen cooling coil, respectively. Obviously, having the outlet small conduits 124, 126 running outside of the respective jacket 56, 64 could also apply even if the small conduits 124, 126 are free of one-way valves 128, 128a, 128b or the like.

[0079] The motor 48' of FIGS. 9 and 9a is obviously well suited for Bourke and Wiseman type engines in which single-acting pistons with fixed connecting rods would run at approximately in opposed cycles (compression/expansion), namely at about one-hundred-and-eighty degrees (180°) from each other in a back-to-back relationship. Although not specifically illustrated herein, it would be obvious to one skilled in the art to have the motor 48' be modified into a motor with a rotary piston having multiple gas chambers there around without departing from the scope of the present invention.

[0080] Referring now more specifically to FIGS. 11 and 12, instead of using an alpha-type Stirling motor 48 shown in FIGS. 3, 4 and 5 to 6a, the system 40 could also use a plurality of beta-type Stirling motors 248 in connection with both hot and cold sources 244, 246. The beta (as well as gamma-type) motor 248 has only one piston 140 and a displacer 142 located inside the gas chamber and in-between the hot and cold gas chamber sections 272, 274 divided thereby that forces the closed-loop internal gas to be alternately displaced between the hot and cold gas chamber sections 272, 274 via the hot and cold gas pipes 276, 278 and the regenerators 280 which are also covered with insulating ceramic material 289 or the like, upon axial displacement of the displacer 142 that selectively control the volumes of the two chamber sections 272, 274 exposed to the hot and cold sources 244, 246.

[0081] The hot and cold gas chamber sections 272, 274 and their respective hot and cold gas conduits 276, 278 are

located inside the hot and cold fluid input pipes 254, 262, upstream of respective hot and cold fluid output pipes 260, 268; the hot output pipe 260 being subdivided into a main vapor pipe 260a or gas output pipe and a smaller water pipe 260b or liquid output pipe collecting condensed vapor. In order to maximize the heat transfer, the hot and cold gas chamber sections 272, 274 are preferably composed of a plurality of parallel gas chamber cylinder portions 144 of a smaller diameter (reduced cross-section area). Accordingly, the displacer 142 includes a plurality of generally cylindrical rods 146 generally equally spaced apart and parallel from each other and adapted to axially tightly and reciprocatingly slide into the respective cylinder hot and cold chamber portions 144. The cylindrical rods 146 are secured to one another via link bars 148 that reciprocatingly slide inside an insulating spacer 150, typically made out of ceramic material or the like. Obviously, both longitudinal ends of each cylindrical rod 146 could have a different shape such as a hemispherical end or any other shape to increase the turbulences of the gas flowing inside the portions 144 of the hot and cold chamber sections 272, 274.

[0082] As known in the art and not shown, although the displacer 142 could be either free or connected to the shaft 250, freely extending through the piston 140, with any angle a ninety-degree (90°) cycle delay relative to the piston varying between about thirty and about hundred-and-twenty degrees (30°-120°) depending on the specific use, it could also have its displacement being controlled and actuated by a displacer actuating means 151 such as an external actuator (electric, magnetic 151', electromagnetic, pneumatic, hydraulic, etc.) or a passively resisting pressure mechanism including a piston 152 displaced by a pressurized volume 154 and connected to the displacer 142 by a connecting rod 156, as schematically shown in FIG. 11, or as a helical spring as represented in FIGS. 9 and 9a. As the hot vapor lost most of its heat to the closed-loop gas before entering the reduced diameter hot output pipe 260, it is mostly transformed into hot water by condensation; accordingly, the hot output pipe 260 is slightly angled, although not specifically shown, to ensure the flow of water away from the motor 248, through the water pipe 260b.

[0083] From FIG. 12, it can be seen that the hot source 244 surrounds the hot gas chamber 272 and the corresponding hot gas pipes 276. To ensure a good heat transfer, the hot input pipe 254 typically forms a generally 180° curve or spiral shape (not shown) to force formation of turbulences in the hot vapor flow. To control the flow of hot vapor thereto and to allow maintenance of each motor 248, independently of each other, the motor 248 is typically isolable from the others with input and output control and purge valves 210', 212' or the like, the latter output valve 212' being typically located upstream of the hot output pipe 260 split into vapor and water pipes 260a, 260b; similar valves (not shown) are mounted on the cold side of the motor 248.

[0084] Now referring more specifically to FIG. 11, the motor 248 could alternatively have the displacer 142 movably linked to a piston extension 140a, as shown in dotted lines, such that the displacer actuating means 151 is a displacer retarding mechanism 151a connecting the displacer 142 to the piston 140. The displacer connecting rod 156a, or displacer bar, has a pin end 160 slidably and reciprocatingly mounted into a corresponding slot 162 of the piston extension 140a. Coil springs 164 or the like are

mounted at both ends **166** of the slot **162**, or limit positions of the displacer connecting rod **156a** relative to the piston extension **140a**, to damper the contact abutment of the pin end **160** with the piston extension **140a** at the respective slot end **166**. This displacer retarding mechanism **151a** allow the displacer **142** to be substantially free while allowing slightly longer detent and compression cycle durations which increase the heat transfer efficiency, up to two or three times more heat transfer, especially in the hot source **244** side.

[0085] As it would be obvious to one skilled in the art, it could be possible to control the flow of the working gas flowing through the regenerator **80** by adding control valves or the like (not shown) to the hot and/or cold gas pipes **76**, **78** without departing from the scope of the present invention.

[0086] Furthermore, one skilled in the art would easily understand that any type (alpha, beta, gamma) of Stirling motor/engine, variation thereof or the like could be considered for use with the system of the present invention without departing from the scope of the present invention.

[0087] The present invention also refers to a method for providing output power from input latent heat energy of a hot source fluid **44**. The method comprises the steps of:

[0088] a) distributing (or networking) a flow of the hot source fluid **44** through an input distribution pipe network **41** into a plurality of paths **49** with reduced flow and flow rate; and

[0089] b) operatively connecting a respective external heat motor **48** to each one of the reduced flow paths **49** for providing a portion of the output power.

[0090] Typically, the method further comprises the step of:

[0091] c) connecting the external heat motors **48** corresponding to all secondary input pipes **54** connected downstream of one of the main input pipes **53** to an output shaft **50** for delivering the output power portions thereto.

[0092] Conveniently, above step b) further includes controlling a flow of the hot source fluid flowing through each secondary input pipe **54** with a corresponding flow control valve **110**.

[0093] Furthermore, the method comprises the step of:

[0094] d) subdividing each secondary input pipe **54**, downstream of its respective motor **48**, into a gas output secondary pipe **260a** and a liquid output secondary pipe **260b** for receiving a gas portion and a liquid portion of the hot source fluid **44** therein, respectively.

[0095] Although the present invention has been described with a certain degree of particularity, it is to be understood that the disclosure has been made by way of example only and that the present invention is not limited to the features of the embodiments described and illustrated herein, but includes all variations and modifications within the scope and spirit of the invention as hereinabove described.

I claim:

1. A heat energy reclaim system for providing output power from input latent heat energy of a hot source fluid, said system comprising:

means for capturing the latent heat energy from the hot source fluid, said capturing means including an input distribution pipe network for distributing the hot source fluid along a plurality of paths with reduced flow and flow rate; and

a respective external heat motor operatively connected to each one of said reduced flow paths for providing a portion of the output power.

2. The system of claim 1, wherein said network includes a plurality of main input pipes for receiving the hot source fluid therein, each said main input pipe being in fluid communication with a plurality of respective secondary input pipes, all said secondary input pipes connected downstream of one of said main input pipes being said reduced flow paths and having corresponding said external heat motors connected to an output shaft for delivering said output power portions thereto.

3. The system of claim 2, wherein each said secondary input pipe includes a flow control valve for controlling a flow of the hot source fluid flowing therethrough.

4. The system of claim 2, wherein each said secondary input pipe, downstream of respective said motor, is subdivided into a gas output secondary pipe and a liquid output secondary pipe for receiving a gas portion and a liquid portion of the hot source fluid therein, respectively.

5. The system of claim 2, wherein said external heat motor includes:

a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber with a first volume therebetween and a retracted position in which said gas chamber has a second volume less than said first volume, said piston having a head partially defining said gas chamber and generally axially facing said cylinder, said piston head having a shaped head surface with a plurality of head protrusions extending substantially outwardly axially therefrom so as to enable increased turbulences of a gas located within said gas chamber when said piston is being displaced relative to said cylinder;

said cylinder being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the turbulent gas inside the gas chamber for actuation of said piston; and

an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

6. The system of claim 5, wherein said cylinder has a bottom wall partially defining said gas chamber and generally axially facing said piston head, said bottom wall having a shaped wall surface with a plurality of wall recesses extending substantially inwardly therein, each said head protrusion selectively engaging a respective said wall recesses when said piston moves from said extended position toward said contracted position.

7. The system of claim 6, wherein said cylinder shaped wall surface is substantially a complementary image of said piston shaped head surface.

8. The system of claim 6, wherein said cylinder wall recesses define respective gas chamber portions spaced apart and generally parallel relative to one another so as to form a plurality of individual sub-cylinders of reduced cross-

section area for increased heat exchange between said cylinder wall and the gas inside said gas chamber portions.

9. The system of claim 6, wherein each said cylinder wall recess defines a bottom region thereof, each said wall recess being in fluid communication with at least one adjacent of said wall recesses at respective said bottom region.

10. The system of claim 9, wherein said wall recesses is in fluid communication with each other at respective said bottom region, thereby forming a cylinder bottom head in fluid communication with each said wall recess.

11. The system of claim 10, further including a plurality of gas conduits being in fluid communication with said cylinder bottom head for allowing the gas to enter and exit said gas chamber therethrough.

12. The system of claim 11, wherein said gas conduits include a plurality of inlet gas conduits and a plurality of outlet gas conduits for allowing the gas to enter and exit said gas chamber therethrough, respectively, each said inlet and outlet gas conduit having a one-way flow control valve for controlling the flow of gas therethrough.

13. The system of claim 12, further including a conduit heat exchanger in fluid connection with respective said inlet gas conduits, said conduit heat exchanger being exposable to the hot source for receiving latent heat therefrom and transmitting the received latent heat to the gas inside the conduit heat exchanger for heating the gas flowing therein.

14. The system of claim 12, further including at least one conduit heat exchanger in fluid connection with said inlet gas conduits, said conduit heat exchanger being exposable to the hot source for receiving latent heat therefrom and transmitting the received latent heat to the gas inside the conduit heat exchanger for heating the gas flowing therein.

15. The system of claim 14, wherein said conduit heat exchanger includes serpentine in fluid connection with respective said inlet gas conduit.

16. The system of claim 14, wherein said cylinder bottom wall includes a fin network extending outwardly therefrom, said fin network being exposable to the hot source fluid for receiving latent heat therefrom and conductively transmitting the received latent heat to the cylinder bottom wall for transfer to the gas inside the gas chamber.

17. The system of claim 16, wherein said fin network further extends outwardly from said outlet gas conduits, said fin network being exposable to the hot source fluid for receiving latent heat therefrom and conductively transmitting the received latent heat to the cylinder bottom wall and the inlet gas conduits for transfer to the gas flowing therein.

18. The system of claim 2, wherein said external heat motor includes:

- a piston axially slidably and reciprocally axially engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber therebetween;

- a displacer dividing said gas chamber into first and second chamber sections being located adjacent and away from said piston, respectively, said displacer being axially displaceable within said gas chamber for selectively controlling volumes of said first and second chamber sections, said displacer including a plurality of rod spaced and parallel from one another, said plurality of rod connecting to each other for simultaneous displacement thereof in respective gas chamber portions of

- reduced cross-section area for increased heat exchange between said cylinder and the gas inside said gas chamber portions;

- a gas conduit being in fluid communication with said first and second chamber sections to allow an internal gas to flow therethrough between first and second chamber sections;

- a section of said cylinder adjacent one of said first and second chamber sections being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the gas inside gas chamber portions of corresponding said chamber section with increased heat exchange therebetween for displacement thereof and actuation of said piston; and

- an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

19. The system of claim 18, wherein said external heat motor includes a means for actuating said displacer within said cylinder so as to selectively control motor cycles durations for selective increased heat transfer between said cylinder and the gas inside said gas chamber portions.

20. The system of claim 19, wherein said displacer actuating means is a connecting rod connecting said displacer to said output shaft.

21. The system of claim 18, wherein said displacer actuating means is a displacer retarding mechanism connecting said displacer to said piston.

22. The system of claim 21, wherein said displacer retarding mechanism includes a displacer bar having a first longitudinal bar end mounted on said displacer and a second longitudinal bar end axially slidably connected to said piston between first and second limit positions relative thereto for free displacement of said second bar end relative to said piston between said first and second limit positions.

23. The system of claim 22, wherein said displacer retarding mechanism includes dampers located at said first and second limit positions for damping displacement of said bar second end relative to said piston at corresponding said limit position.

24. The system of claim 18, wherein each one of said plurality of rods is generally cylindrical and is axially displaceable within a corresponding axial cylindrical portion of said gas chamber.

25. The system of claim 24, wherein each one of said plurality of rods has shaped opposed longitudinal rods ends for increasing turbulences of the internal gas inside said first and second chamber sections upon axial displacement of said rods within said gas chamber.

26. A method for providing output power from input latent heat energy of a hot source fluid, said method comprising the steps of:

- a) distributing a flow of the hot source fluid through an input distribution pipe network into a plurality of paths with reduced flow and flow rate; and

- b) operatively connecting a respective external heat motor to each one of said reduced flow paths for providing a portion of the output power.

27. An external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprising:

a piston axially slidably and reciprocally engaging a corresponding cylinder, said cylinder defining a plurality of generally cylindrical gas chambers spaced apart from one another and extending generally axially and in a generally parallel relationship relative to one another, said piston having a plurality of piston heads generally spaced apart from one another and extending generally axially and in a generally parallel relationship relative to one another, each said piston heads axially slidably and reciprocally engaging a corresponding said gas chambers;

said cylinder being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the gas inside the gas chambers for displacement of respective said piston heads and said piston relative to said cylinder; and

an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

28. The motor of claim 27, wherein each said gas chambers has a bottom wall thereof, each said gas chambers being in fluid communication with at least one adjacent of said gas chambers at respective said bottom walls.

29. The motor of claim 27, wherein each said gas chambers has a bottom wall thereof, said gas chambers being in fluid communication with one another at respective said bottom walls.

30. An external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprising:

a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber with a first volume therebetween and a retracted position in which said gas chamber has a

second volume less than said first volume, said piston having a head partially defining said gas chamber and generally axially facing said cylinder, said piston head having a shaped head surface with a plurality of head protrusions extending substantially outwardly axially therefrom so as to enable increased turbulences of a gas located within said gas chamber when said piston is being displaced relative to said cylinder;

said cylinder being exposable to the hot source fluid for receiving latent heat therefrom and transmitting the received latent heat to the turbulent gas inside the gas chamber for actuation of said piston; and

an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

31. An external heat motor for providing output power from input latent heat energy of a hot source fluid connected thereto, said motor comprising:

a piston axially slidably and reciprocally engaging a corresponding cylinder between an extended position in which said piston and said cylinder define a gas chamber therebetween, said cylinder having an internal chamber wall partially defining said gas chamber, said internal chamber wall having a fin network extending outwardly therefrom, said fin network being exposable to the hot source fluid for receiving latent heat therefrom and conductively transmitting the received latent heat to the internal chamber wall for transfer to the gas inside the gas chamber so as to displace said piston relative to said cylinder; and

an output shaft operatively connected to said piston for transmitting said displacement thereof, thereby providing the motor output power.

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