



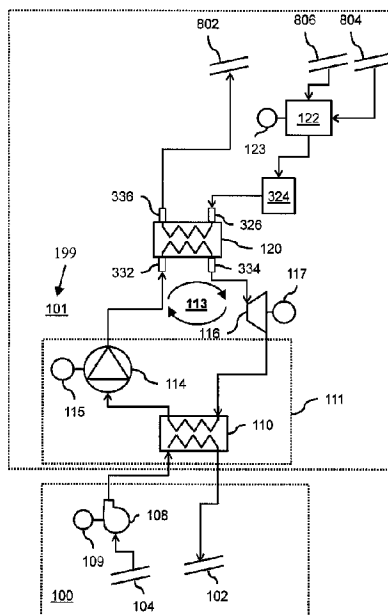
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(71) Demandeur/Applicant:
IGEN TECHNOLOGIES INC., CA
(72) Inventeur/Inventor:
LAI, PATRICK, CA
(74) Agent: INTEGRAL IP

(54) Titre : MODULE DE TRAITEMENT DE L'AIR ET MODULE D'EVAPORATEUR-EXPANSION DESTINES A UNE STRUCTURE DE BATIMENT
(54) Title: AIR-HANDLER MODULE AND EVAPORATOR-EXPANSION MODULE FOR BUILDING STRUCTURE



(57) **Abrégé/Abstract:**

An apparatus includes an evaporator-expansion module configured to (A) provide electric energy to a building structure, and (B) cooperate with an air-handler module configured to provide thermal energy to a building structure. The evaporator-expansion module includes an evaporator assembly including a heated fluid conduit, a refrigerant conduit, and a thermal buffer. The heated fluid conduit is configured to convey a heated fluid. The refrigerant conduit is configured to convey an evaporator refrigerant. The thermal buffer is configured to be positioned relative to the heated fluid conduit and the refrigerant conduit. This is done in such a way that the thermal buffer transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

ABSTRACT

An apparatus includes an evaporator-expansion module configured to (A) provide electric energy to a building structure, and (B) cooperate with an air-handler module configured to provide thermal energy to a building structure. The evaporator-expansion module includes an evaporator assembly including a heated fluid conduit, a refrigerant conduit, and a thermal buffer. The heated fluid conduit is configured to convey a heated fluid. The refrigerant conduit is configured to convey an evaporator refrigerant. The thermal buffer is configured to be positioned relative to the heated fluid conduit and the refrigerant conduit. This is done in such a way that the thermal buffer transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

**AIR-HANDLER MODULE AND EVAPORATOR-EXPANSION MODULE FOR
BUILDING STRUCTURE**

TECHNICAL FIELD

[0001] This document relates to the technical field of (and is not limited to) (A) an apparatus including an evaporator-expansion module and an air-handler module (and method therefor), and/or (B) an apparatus including an evaporator-expansion module configured to cooperate with an air-handler module (and method therefor).

BACKGROUND

[0002] Standalone heating equipment (deployed in or for a building structure) is configured to operate by utilizing a fuel (such as, natural gas, propane, oil, electricity, etc.).

[0003] Standalone power generation equipment (deployed in or for a building structure) is configured to operate by utilizing a fuel (such as, natural gas, propane, oil, solar, wind, etc.).

SUMMARY

[0004] It will be appreciated that there exists a need to mitigate (at least in part) at least one problem associated with the existing heating equipment (also called the existing technology) for a building structure. After much study of the known systems and methods with experimentation, an understanding of the problem and its solution has been identified and is articulated as follows:

[0005] Known heating assemblies or appliances (for utilization with building structures), such as a gas-fired furnace, an electric-driven heat pump, etc., are configured to produce heat while consuming electrical power.

[0006] Known electrical power generators (for utilization with building structures), such as an internal combustion engine, a solar photovoltaic system, etc., are configured to provide electrical power (and do not provide thermal energy usable for heating building structures).

[0007] Known European and Japanese manufacturers provide heating equipment configured to provide heat and electrical power (also called CHP equipment, or Cogeneration or Combined Heat and Power equipment). Known CHP equipment is configured to utilize internal combustion engines, Stirling engines, combustion turbines and fuel cells, etc. Known CHP equipment are also known to: (A) be relatively higher in cost to manufacture, (B) need excessive maintenance, (C) be relatively overly complex, (D) be relatively difficult to install or service, and/or (E) emit a relatively higher noise level and/or relatively higher combustion emission (chemical pollution, etc.). In addition, known CHP equipment are not configured to switch between different types of fuel sources (such as, between cheaper fuel sources and/or

cleaner fuel sources, etc.). Moreover, some known CHP equipment is configured to use a building hydronic distribution loop (also called a hydronic system) as a heat sink. A majority of North American residential building structures (such as homes) utilize air ducts (conduits) and, therefore, are not typically (and conveniently) compatible with known hydronic systems.

[0008] What may be needed, for at least some embodiments, is an apparatus configured to provide (at least in part) a combination of (A) heat (thermal energy) to the building structure (such as, residential buildings, commercial buildings, etc.) and (B) electrical power to the building structure. In this manner, electrical-power consumption savings may be realized for the case where the building structure (such as for the case where the building structure does not receive electric power from an electrical utility grid). In this manner, energy security or independence may be provided.

[0009] What may be needed, for at least some embodiments, is an apparatus configured to (A) deliver relatively higher electrical utility (cost) savings, (B) provide heat (thermal energy), and/or (C) electric power usable to offset an electrical load (electrical consumption demand) associated with the building structure.

[0010] What may be needed, for at least some embodiments, is an apparatus configured to provide (at least in part) lower manufactured cost, a lower installation cost, a lower maintenance cost, and/or a lower operating cost, etc.

[0011] What may be needed, for at least some embodiments, is an apparatus configured to utilize, at least in part, solar thermal energy and/or higher-temperature geothermal energy (instead of fuel combustion or in combination with fuel combustion) to drive a vapor expansion cycle process.

[0012] What may be needed, for at least some embodiments, is an apparatus configured to utilize (at least in part) a building air duct system as the heat sink.

[0013] What may be needed, for at least some embodiments, is an apparatus configured to be installable in building structures (that may have basements) located in northern climates.

[0014] What may be needed, for at least some embodiments, is an apparatus configured to deliver (provide), at least in part, relatively higher electrical utility savings during winter season operation as well as provide heat and electric power for a building structure. The delivered heat (thermal energy) offsets a heating load that the building structure may normally experience during the winter season. The delivered electric power offsets (at least in part) the electric power normally consumed by components (motors and electronics, etc.) of the heating equipment, along with other electrical loads in the building structure.

[0015] What may be needed, for at least some embodiments, is an apparatus configured to have (at least in part) a relatively lower manufactured cost, installation and/or maintenance requirement. In accordance with a preferred embodiment, the apparatus includes (for instance) a premix-fuel burner assembly with a modulating gas valve configured to deliver an appropriate amount of heat to an evaporator coil without the need for dilution of combustion exhaust gases.

[0016] What may be needed, for at least some embodiments, is an apparatus configured to be equipped with an optional evaporator heat exchanger configured to cooperate with a suitable source of renewable energy (such as, solar thermal, geothermal, waste heat, etc., and any equivalent thereof).

[0017] What may be needed, for at least for some embodiments, is an apparatus configured to operate in a North American building structure (such as, a residential building and/or a commercial building, etc.) that has an air duct system. For instance, a combustion and vapor expansion process may be located in a module configured to be utilized with (mounted either outside or inside) the building structure. An air handler module may be is configured to be utilized with (mounted in a basement, attic or closet of) the building structure (preferably, in any given orientation).

[0018] What may be needed, for at least some embodiments, is an apparatus configured to (A) include (at least in part) improved ability to obtain government approval or certification, and/or (B) be relatively easier to install.

[0019] What may be needed, for at least some embodiments, is an apparatus configured to provide a safety and interlock system for the case where a vapor expansion module is located outside of a building structure.

[0020] What may be needed, for at least some embodiments, is an apparatus configured to include an indoor air handler module and an outdoor vapor expansion module, in which case space in a building structure may be preserved for other uses.

[0021] To mitigate, at least in part, at least one problem associated with the existing technology, there is provided (in accordance with a first major aspect) an apparatus. The apparatus includes and is not limited to (comprises) an air-handler module and an evaporator-expansion module. The air-handler module is configured to provide thermal energy to a building structure. The evaporator-expansion module is configured to provide electric energy to the building structure. The evaporator-expansion module is also configured to cooperate with the air-handler module. The evaporator-expansion module includes (and is not limited to)

an evaporator assembly. The evaporator assembly includes (and is not limited to) a heated fluid conduit and a refrigerant conduit. The heated fluid conduit is configured to convey, in use, a heated fluid. The refrigerant conduit is configured to convey, in use, an evaporator refrigerant. The heated fluid conduit is positioned relative to (proximate to) the refrigerant conduit. This is done in such a way that the heated fluid conduit, in use, transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

[0022] To mitigate, at least in part, at least one problem associated with the existing technology, there is provided (in accordance with a second major aspect) an apparatus. The apparatus includes and is not limited to (comprises) an evaporator-expansion module. The evaporator-expansion module is configured to provide electric energy to a building structure. The evaporator-expansion module is also configured to cooperate with an air-handler module. The air-handler module is configured to provide thermal energy to a building structure. The evaporator-expansion module includes (and is not limited to) an evaporator assembly. The evaporator assembly includes (and is not limited to) a heated fluid conduit and a refrigerant conduit. The heated fluid conduit is configured to convey, in use, a heated fluid. The refrigerant conduit is configured to convey, in use, an evaporator refrigerant. The heated fluid conduit is positioned relative to (proximate to) the refrigerant conduit. This is done in such a way that the heated fluid conduit, in use, transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

[0023] Embodiments of the apparatus may be configured to provide relatively constant heat and power to a building structure while providing a source of electrical power to the building structure, thereby providing utility savings (electrical utility savings) and/or energy security (self-sufficiency for the case where the building structure does not rely on the electrical grid for receiving electrical power).

[0024] For the case where a heat source for the apparatus is provided by a renewable energy source (such as, solar thermal, geothermal, hydrogen fuel, etc., and any equivalent thereof), the heat and electrical power that are produced by the apparatus may result in relatively lower (preferably zero) greenhouse gas emissions. Having access to affordable and/or reliable heat and electrical power may be a requirement for the building structure (such as, a residential home, detached home, a town home, an apartment building, a commercial building, etc., and any equivalent thereof).

[0025] Other aspects are identified in the claims. Other aspects and features of the non-limiting embodiments may now become apparent to those skilled in the art upon review of the following detailed description of the non-limiting embodiments with the accompanying drawings. This Summary is provided to introduce concepts in simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the disclosed subject matter, and is not intended to describe each disclosed embodiment or every implementation of the disclosed subject matter. Many other novel advantages, features, and relationships will become apparent as this description proceeds. The figures and the description that follow more particularly exemplify illustrative embodiments.

DETAILED DESCRIPTION OF THE DRAWINGS

[0026] The non-limiting embodiments may be more fully appreciated by reference to the following detailed description of the non-limiting embodiments when taken in conjunction with the accompanying drawings, in which:

[0027] FIG. 1 depicts a schematic view of an apparatus including an evaporator-expansion module configured to cooperate with an air-handler module; and

[0028] FIGS. 2-11 depict schematic views of the evaporator-expansion module of FIG. 1.

[0029] The drawings are not necessarily to scale and may be illustrated by phantom lines, diagrammatic representations and fragmentary views. In certain instances, details unnecessary for an understanding of the embodiments (and/or details that render other details difficult to perceive) may have been omitted. Corresponding reference characters indicate corresponding components throughout the several figures of the drawings. Elements in the several figures are illustrated for simplicity and clarity and have not been drawn to scale. The dimensions of some of the elements in the figures may be emphasized relative to other elements for facilitating an understanding of the various disclosed embodiments. In addition, common, but well-understood, elements that are useful or necessary in commercially feasible embodiments are often not depicted to provide a less obstructed view of the embodiments of the present disclosure.

[0030] LISTING OF REFERENCE NUMERALS USED IN THE DRAWINGS

- 100 air-handler module
- 101 evaporator-expansion module
- 102 supply air assembly
- 104 return air assembly
- 106 supply-fan controller
- 108 supply-fan assembly
- 109 supply-fan motor assembly
- 110 condenser assembly
- 111 pump-condenser module
- 112 filter assembly
- 113 refrigerant flow circuit
- 114 pump assembly
- 115 pump motor
- 116 expander assembly

- 117 generator assembly
- 118 pump controller
- 119 fan-and-burner controller
- 120 evaporator assembly
- 121 refrigerant conduit
- 122 evaporator fan
- 123 evaporator fan motor
- 124 expander controller
- 125 evaporator refrigerant
- 126 battery assembly
- 127 electric heating element
- 128 pipe structure
- 129 electric heating controller
- 132 evaporator heat exchanger
- 133 first three-way valve
- 134 second three-way valve
- 135 third three-way valve
- 136 fourth three-way valve
- 138 condenser heat exchanger
- 140 battery controller
- 142 automatic-disconnect assembly
- 144 electrical-distribution panel
- 146 supply-fan controller
- 148 battery assembly
- 150 power generation system
- 199 apparatus
- 322 mixture
- 324 heat-generating assembly
- 325 heated fluid
- 326 inlet manifold
- 328 heated fluid conduit
- 330 thermal buffer
- 332 inlet

- 334 outlet
- 336 outlet manifold
- 338 water-vapor drain
- 340 pressure vent
- 344 tank assembly
- 346 combustion exhaust-gas vent
- 801 supply air
- 802 exhaust gas
- 803 return air
- 804 fuel
- 806 combustion air
- 808 solar thermal return
- 810 solar thermal supply
- 812 hydronic return
- 814 hydronic supply
- 816 electric utility grid
- 900 building structure

DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENT(S)

[0031] The following detailed description is merely exemplary and is not intended to limit the described embodiments or the application and uses of the described embodiments. As used, the word “exemplary” or “illustrative” means “serving as an example, instance, or illustration.” Any implementation described as “exemplary” or “illustrative” is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to make or use the embodiments of the disclosure and are not intended to limit the scope of the disclosure. The scope of the claim is defined by the claims (in which the claims may be amended during patent examination after filing of this application). For the description, the terms “upper,” “lower,” “left,” “rear,” “right,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the examples as oriented in the drawings. There is no intention to be bound by any expressed or implied theory in the preceding Technical Field, Background, Summary or the following detailed description. It is also to be understood that the devices and processes illustrated in the attached drawings, and described in the following specification, are exemplary embodiments (examples), aspects and/or concepts defined in the appended claims. Hence, dimensions and other physical characteristics relating to the embodiments disclosed are not to be considered as limiting, unless the claims expressly state otherwise. It is understood that the phrase “at least one” is equivalent to “a”. The aspects (examples, alterations, modifications, options, variations, embodiments and any equivalent thereof) are described regarding the drawings. It should be understood that the invention is limited to the subject matter provided by the claims, and that the invention is not limited to the particular aspects depicted and described. It will be appreciated that the scope of the meaning of a device configured to be coupled to an item (that is, to be connected to, to interact with the item, etc.) is to be interpreted as the device being configured to be coupled to the item, either directly or indirectly. Therefore, “configured to” may include the meaning “either directly or indirectly” unless specifically stated otherwise.

[0032] FIG. 1 depicts a schematic view of an apparatus 199 including an evaporator-expansion module 101 configured to cooperate with an air-handler module 100.

[0033] Referring to an embodiment (in accordance with a first major embodiment) as depicted in FIG. 1, there is provided the apparatus 199. The apparatus 199 includes and is not limited to (comprises) a synergistic combination of an air-handler module 100 and an evaporator-expansion module 101.

[0034] The air-handler module 100 is configured to provide thermal energy to a building structure 900 (such as, a residential home). More specifically, the air-handler module 100 is configured to provide (generate) thermal energy (such as heated air), and to move the thermal energy through the building structure 900.

[0035] The evaporator-expansion module 101 is configured to provide (generate and supply) electric power (electric energy) to the building structure 900 (that is, to either provide some of the electric energy or all of the electric energy to be consumed by the building structure 900). The evaporator-expansion module 101 is also configured to cooperate with the air-handler module 100.

[0036] The evaporator-expansion module 101 includes (and is not limited to) an evaporator assembly 120. The evaporator assembly 120 includes (and is not limited to) a heated fluid conduit 328 and a refrigerant conduit 121. The heated fluid conduit 328 is positioned relative to (proximate to) the refrigerant conduit 121. The heated fluid conduit 328 is configured to convey, in use, a heated fluid 325. For instance, the heated fluid conduit 328 is configured to receive the heated fluid 325 from the air-handler module 100. The refrigerant conduit 121 is configured to convey, in use, an evaporator refrigerant 125. This is done in such a way that the heated fluid conduit 328, in use, transfers thermal energy (that is positioned in the heated fluid conduit 328) from the heated fluid 325 to the evaporator refrigerant 125 (that is positioned in the refrigerant conduit 121). For instance, the evaporator refrigerant 125 is usable in an electrical-generating process for generating electrical energy (which may be utilized by the building structure 900), as depicted in the embodiments of FIG. 6 to FIG. 9.

[0037] Referring to the embodiment (in accordance with a preferred embodiment) as depicted in FIG. 1, the evaporator assembly 120 further includes a thermal buffer 330. The thermal buffer 330 is configured to be positioned relative to (proximate to or between) the heated fluid conduit 328 and the refrigerant conduit 121. This is done in such a way that the thermal buffer 330, in use, transfers, at least in part, thermal energy from the heated fluid 325 (that is positioned in the heated fluid conduit 328) to the evaporator refrigerant 125 (that is positioned in the refrigerant conduit 121).

[0038] Referring to an embodiment (in accordance with a second major embodiment) as depicted in FIG. 1, there is provided the apparatus 199. The apparatus 199 includes and is not limited to (comprises) an evaporator-expansion module 101 (for this case, the evaporator-expansion module 101 is configured to be retrofitted to the air-handler module 100). For instance, the evaporator-expansion module 101 is manufactured by a first company, and the

air-handler module 100 is manufactured by a second company. The evaporator-expansion module 101 is configured to provide, at least in part, electric energy to a building structure 900. The evaporator-expansion module 101 is also configured to cooperate with (to be retrofitted to) the air-handler module 100. The air-handler module 100 is configured to provide thermal energy to a building structure 900. The evaporator-expansion module 101 includes (and is not limited to) an evaporator assembly 120. The evaporator assembly 120 includes (and is not limited to) a heated fluid conduit 328 and a refrigerant conduit 121. The heated fluid conduit 328 is configured to convey, in use, a heated fluid 325. The refrigerant conduit 121 is configured to convey, in use, an evaporator refrigerant 125. The heated fluid conduit 328 is positioned relative to (proximate to) the refrigerant conduit 121. This is done in such a way that the heated fluid conduit 328, in use, transfers thermal energy from the heated fluid 325 (that is positioned in the heated fluid conduit 328) to the evaporator refrigerant 125 (that is positioned in the refrigerant conduit 121). In accordance with a preferred embodiment, the evaporator assembly 120 further includes a thermal buffer 330. The thermal buffer 330 is configured to be positioned relative to (proximate to or between) the heated fluid conduit 328 and the refrigerant conduit 121. This is done in such a way that the thermal buffer 330, in use, transfers, at least in part, thermal energy from the heated fluid 325 (that is positioned in the heated fluid conduit 328) to the evaporator refrigerant 125 (that is positioned in the refrigerant conduit 121).

[0039] The thermal buffer 330 is configured to (A) receive (either directly or indirectly) thermal energy (from the heated fluid conduit 328), and (B) release thermal energy (to the refrigerant conduit 121). Preferably, the thermal buffer 330 is configured to limit (A) the amount of heat transferred (provided) to the evaporator refrigerant 125, and (B) the temperature of the evaporator refrigerant 125 positioned in the refrigerant conduit 121. The thermal buffer 330 is configured to physically isolate the heated fluid conduit 328 from the refrigerant conduit 121 (this is done in such a way that the fluids from the heated fluid conduit 328 and the refrigerant conduit 121 do not make contact with each other). Advantageously, for instance, the thermal buffer 330 improves, at least in part, overall safety regarding potential fire hazards. Advantageously, for the case where there is an uncontrolled fire in the heated fluid conduit 328, the thermal buffer 330 is configured to block the passage of the fire from the heated fluid conduit 328 the refrigerant conduit 121. In addition (advantageously), for instance, the thermal buffer 330, in use, prevents thermal degradation of the evaporator refrigerant 125 and the lubrication oil utilized in the evaporator assembly 120.

[0040] In accordance with a preferred embodiment, the thermal buffer 330 is configured to have a predetermined thermal capacity. For instance, the thermal buffer 330 includes, preferably, a thermal heat transfer fluid, such as the DYNALENE (TRADEMARK) Model Number MT synthetic heat transfer fluid. Preferably, the refrigerant conduit 121 includes an evaporator coil (evaporator conduit) and any equivalent thereof (with reference to the embodiment as depicted in FIG. 1). Preferably, the refrigerant conduit 121 is wrapped around (coiled around) the heated fluid conduit 328. The heated fluid 325 is provided by a heat-generating assembly 324 (which is preferably a part of the air-handler module 100) and any equivalent thereof (with reference to the embodiments as depicted in FIGS. 1 to 5). The heat-generating assembly 324 is any type of assembly configured to generate and/or provide thermal energy, heat energy, heat, etc., and any equivalent thereof.

[0041] In accordance with an embodiment as depicted in FIG. 1, the heat-generating assembly 324 includes a premix-fuel burner assembly with a modulating gas valve that is coupled to the evaporator assembly 120 (also called a direct-fired evaporator) without dilution of an air-and-gas mixture (to be consumed by the premix-fuel burner assembly). For instance, the heat-generating assembly 324 includes a premix burner assembly, a catalytic converter, any type of burner, etc., and any equivalent thereof. The heated fluid 325 includes a combusted gas (also called a burner exhaust) and any equivalent thereof. Preferably, the heated fluid conduit 328 is aligned along a linear direction. Preferably, the heated fluid conduit 328 includes a plurality of spaced-apart combustion exhaust-gas tubes aligned along a linear direction (aligned along a longitudinal axis), and any equivalent thereof. In accordance with an alternative, the evaporator assembly 120 includes an indirect fired evaporator assembly, an indirect fired evaporator, etc., and any equivalent thereof.

[0042] In accordance with a preferred embodiment, an evaporator fan 122 is configured to receive a mixture 322 of pre-mixed fuel and air (also called a fuel-and-air pre-mixture). The evaporator fan 122 is fluidly coupled to an inlet manifold 326 (also called a combustion exhaust-gas inlet manifold). The heated fluid conduit 328 is fluidly connected to the inlet manifold 326. Preferably, the heated fluid conduit 328 includes spaced-apart tubes (also called combustion exhaust-gas tubes). Preferably, the heat-generating assembly 324 includes a burner assembly or a pre-mix burner assembly. The refrigerant conduit 121 includes an inlet 334 (also called a refrigerant evaporator coil inlet), and an outlet 332 (also called a refrigerant evaporator coil outlet). The heated fluid conduit 328 is fluidly connected to an outlet manifold 336 (also called a combustion exhaust -as outlet manifold). A water-vapor drain 338 (also

called a combustion exhaust condensate drain) extends downwardly from the outlet manifold 336. A combustion exhaust-gas vent 346 is fluidly connected to the outlet manifold 336. The interior of the evaporator assembly 120 is configured to receive the thermal buffer 330. A pressure vent 340 is coupled to the interior of the evaporator assembly 120. The pressure vent 340 is configured to relieve excessive interior pressure generated in the interior of the evaporator assembly 120. The evaporator assembly 120 includes a tank assembly 344 (also called a heat exchanger tank shell).

[0043] In accordance with an embodiment as depicted in FIG. 1, the heated fluid 325, in use, transfers thermal energy (indirectly such as via the thermal buffer 330) to the refrigerant conduit 121. More specifically, the heated fluid 325 positioned in the heated fluid conduit 328, in use, transfers thermal energy (directly) to the thermal buffer 330, and the thermal buffer 330, in use, transfers thermal energy (directly) to the evaporator refrigerant 125 positioned in the refrigerant conduit 121. The thermal buffer 330 may be called an intermediate thermal fluid or thermal fluid. The thermal buffer 330 is configured to physically separate (isolate) the heated fluid conduit 328 and the refrigerant conduit 121.

[0044] OPERATION

[0045] With reference to FIG. 1 and FIGS. 6 to 9, for the case where a control system (known and not depicted) receives a call signal (also called a request signal) indicating that heat (thermal energy) is to be provided to (or may be required by) the building structure 900, the control system transmits a turn-on signal to the heat-generating assembly 324. This is done in such a way that the heat-generating assembly 324 is activated to provide thermal energy to the heated fluid 325. An amount of thermal energy is transferred from the heated fluid 325 (such as, the exhaust gas from the burner assembly) to the evaporator refrigerant 125 located in the refrigerant conduit 121 (such as, the evaporator coil) via the thermal buffer 330.

[0046] For the case where the temperature of the heated fluid 325 (such as, the exhaust gas), in use, drops (falls) below its dew point, the formation of water vapor within the heated fluid 325 may condense (within the heated fluid conduit 328) and may liberate additional thermal heat energy.

[0047] The evaporator refrigerant 125, in use, enters the refrigerant conduit 121 in a liquid state and at a relatively higher pressure. The heat (an amount of thermal energy) from the heated fluid 325, in use, is transferred to the evaporator refrigerant 125 and thereby causes a change of state from liquid to vapor (for the evaporator refrigerant 125). The evaporator refrigerant 125, in use, that departs from the refrigerant conduit 121 is in a vapor state and at a

relatively higher pressure. The evaporator refrigerant 125 exits (departs) the evaporator assembly 120 and enters an expander assembly 116 (as depicted in FIGS. 6 to 9) at a relatively higher pressure, in which the evaporator refrigerant 125, in use, imparts mechanical energy to the expander assembly 116 (thereby causing a decrease in pressure in the evaporator refrigerant 125). Through rotation, the expander assembly 116, in use, turns a generator assembly 117 to produce (generate) electricity (electrical power or electrical energy).

[0048] The evaporator refrigerant 125, in use, leaves (departs from) the expander assembly 116 in a vapor state and at a relatively lower pressure. The evaporator refrigerant 125, in use, enters the condenser assembly 110 (also called a condenser coil) in a vapor state and at a relatively lower pressure. The thermal heat energy from the evaporator refrigerant 125 is transferred to the building air (via the supply air assembly 102), thereby causing a change of state of the evaporator refrigerant 125 from a vapor state to a liquid state. The evaporator refrigerant 125, in use, leaves (departs from) the condenser assembly 110 in a liquid state and at a relatively lower pressure. The evaporator refrigerant 125, in use, enters the pump assembly 114 at a relatively lower pressure. A pump motor 115 is configured to consume electricity to turn the pump assembly 114 through rotation. The pump assembly 114, in use, imparts mechanical energy to the evaporator refrigerant 125 and thereby causes an increase in pressure of the evaporator refrigerant 125. The evaporator refrigerant 125, in use, leaves (departs from) the pump assembly 114 in a liquid state and at relatively higher pressure. The evaporator refrigerant 125 exits (departs) from the pump assembly 114 and enters the evaporator assembly 120 (and into the refrigerant conduit 121, as depicted in FIG. 1) to repeat the operating cycle. The supply-fan assembly 108 in the air-handler module 100 induces a building air flow through a side of the condenser assembly 110.

[0049] THERMAL BREAKDOWN

[0050] A potential concern with deployment of the evaporator refrigerant 125 in the evaporator assembly 120 is that the thermal breakdown temperature of the evaporator refrigerant 125 and/or a lubrication oil may be exceeded (if not properly addressed and mitigated). To mitigate such a possibility, a thermal-control device (known and not depicted) is provided, in which the thermal-control device is configured to control the temperature of the heated fluid 325 impinging on the evaporator assembly 120. Preferably, the thermal-control device (for protecting against the overheating of the heated fluid 325) includes a temperature switch configured to open in response to a predetermined temperature to shut-off the heat-generating assembly 324 (such as, a burner circuit). The temperature switch includes the

THERMODISC (TRADEMARK) Model 49T temperature switch. THERMODISC is headquartered in Ohio, U.S.A.

[0051] For instance, an option for mitigating the thermal breakdown temperature of the evaporator refrigerant 125 is to utilize an indirect heating process configured to transfer energy from the heated fluid conduit 328 (having the heated fluid 325, such as to be provided by a combustion process, etc.) to the refrigerant conduit 121 having the evaporator refrigerant 125. The combustion gases are utilized to heat a fluid (such as steam, pressurized water, thermal oil, etc.) within a closed piping loop. With an internal pump, the heated fluid is transferred from the fluid to the evaporator assembly 120 (also called a refrigerant heat exchanger), which may then evaporate the evaporator refrigerant 125. The advantage is that the fluid temperatures in contact with the evaporator assembly 120 are limited. The disadvantage is that the system may be more complex with an additional pump assembly, piping and/or fluid.

[0052] Another option for mitigating the thermal breakdown temperature of the evaporator refrigerant 125 is to utilize a catalytic burner to evaporate the evaporator refrigerant 125. A catalytic burner relies on the use of an exotic metal to enable a flameless chemical reaction between the fuel and oxygen to liberate heat energy. The advantage of the catalytic burner is that the exhaust-gas temperatures are relatively lower to the point where recirculated dilution gases may not be needed (and thus may be expelled). A disadvantage of the catalytic burner may be that the catalytic burner takes up a very large surface area.

[0053] Referring to an option of the embodiment as depicted in FIG. 1, the evaporator fan 122 in the external module is located either upstream or downstream from the refrigerant conduit 121 (also called the evaporator coil). The thermal buffer 330 within the tank of the evaporator assembly 120 (the indirect-fired evaporator) may be stationary or may be agitated by a mechanical means (also called a mixer device) to increase the rate of heat transfer.

[0054] Referring to an option of the embodiment as depicted in FIG. 1, the evaporator assembly 120 is configured to be direct fired, with a premix-fuel burner assembly and a modulating gas valve. For instance, the evaporator assembly 120 is configured to be indirect fired with a tank assembly 344 (also called a thermal fluid tank or tank shell) and a premix-fuel burner assembly with a modulating gas valve.

[0055] FIG. 2 and FIG. 3 depict schematic views (side views) of the evaporator-expansion module 101 of FIG. 1.

[0056] Referring to the embodiments as depicted in FIG. 2 and FIG. 3, the air-handler module 100 and the evaporator-expansion module 101 are both positioned (located) within the

interior of the building structure 900. Referring to the embodiment as depicted in FIG. 2, the evaporator-expansion module 101 has a left-hand return air (return air assembly 104). Referring to the embodiment as depicted in FIG. 3, the evaporator-expansion module 101 has a right-hand return air (return air assembly 104). The air-handler module 100 includes a supply-fan controller 106 configured to control the operation of a heating assembly (such as a natural-gas burner), which is known and not depicted. The heating assembly is configured to generate heat to be fluidly provided to the interior of the building structure 900. A supply-fan assembly 108 is configured to move air (fresh cooler air) from a return air assembly 104 (such as an air intake or return air 801 either from an interior or exterior (or both) of the building structure 900) to the heating assembly that is positioned in the air-handler module 100. The heating assembly is configured to provide heat to the return air received from the return air assembly 104 (as a result of the operation of the supply-fan assembly 108). The supply-fan assembly 108 is also configured to move air (heated air) from the heating assembly of the evaporator-expansion module 101 towards the air-handler module 100, and then towards a supply air assembly 102 (such as the air outtake or supply air 803 to the interior of the building structure 900); in this manner, heated air is provided to the interior of the building structure 900 and also to the air-handler module 100.

[0057] The evaporator-expansion module 101 includes (and is not limited to) a condenser assembly 110 (also called the condenser coil), a filter assembly 112, a pump assembly 114, an expander assembly 116, a pump controller 118, an evaporator assembly 120 (also called an indirect fired evaporator section), an evaporator fan 122, and an expander controller 124. As an option, a battery assembly 126 is provided. The details for the evaporator-expansion module 101 are depicted in FIGS. 6 to 9.

[0058] FIG. 4 and FIG. 5 depict schematic views of the evaporator-expansion module 101 of FIG. 1.

[0059] Referring to the embodiments as depicted in FIG. 4 and FIG. 5, the evaporator-expansion module 101 is configured to be deployed (positioned) outside (the exterior of) the building structure 900, and the air-handler module 100 is configured to be deployed (positioned) inside (the interior of) the building structure 900. Referring to the embodiment as depicted in FIG. 4, the air-handler module 100 has a left-hand return air. Referring to the embodiment as depicted in FIG. 5, the air-handler module 100 has a right-hand return air. A pipe structure 128 (field-installed pipes) is configured to fluidly connect the air-handler module 100 with the evaporator-expansion module 101.

[0060] FIG. 6 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0061] Referring to the embodiment as depicted in FIG. 6, and for the case where the combination of the air-handler module 100 and the evaporator-expansion module 101 is installed (positioned) inside the building structure 900, the evaporator-expansion module 101 includes a refrigerant flow circuit 113. The refrigerant flow circuit 113 includes an evaporator assembly 120 (that is fluidly connected to the pump assembly 114), an expander assembly 116 (that is fluidly connected to the evaporator assembly 120), a condenser assembly 110 (that is fluidly connected to the expander assembly 116), and a pump assembly 114 (that is fluidly connected to the condenser assembly 110). The evaporator refrigerant 125 (as depicted in FIG. 1) is made to flow through the refrigerant flow circuit 113 (as depicted in FIG. 6). A pump-condenser module 111 includes the pump assembly 114 and the condenser assembly 110. A pump motor 115 is configured to operate the pump assembly 114. The expander assembly 116 is configured to rotate a generator assembly 117. A supply-fan motor assembly 109 is configured to operate the supply-fan assembly 108. An evaporator fan motor 123 is configured to operate the evaporator fan 122. A heat-generating assembly 324 is fluidly coupled to the evaporator assembly 120. The evaporator assembly 120 is fluidly coupled to the exhaust gas 802. A fuel 804 is configured to be fluidly connected to the heat-generating assembly 324. A combustion air 806 is configured to be fluidly connected to the heat-generating assembly 324.

[0062] Referring to a variation of the embodiment as depicted in FIG. 6, and for the case where the evaporator-expansion module 101 is to be installed (positioned) outside of the building structure 900, the evaporator assembly 120 and the expander assembly 116 are located within the evaporator-expansion module 101, while the condenser assembly 110 and the pump assembly 114 are located (positioned) within the air-handler module 100 (which is located in the building structure 900).

[0063] The evaporator-expansion module 101 includes a refrigerant flow circuit 113 configured to circulate the evaporator refrigerant 125. The evaporator assembly 120 is configured to be indirect fired. The condenser assembly 110 is configured to be air cooled. The evaporator-expansion module 101 may be located inside or outside the building structure 900. The pump-condenser module 111 may be located within the air-handler module 100, in which the air-handler module 100 is positioned or located inside the building structure 900. The supply-fan assembly 108 may be located downstream of the condenser assembly 110.

[0064] Referring to the embodiment as depicted in FIG. 6, the supply-fan assembly 108 in the internal module may be located either upstream or downstream from the condenser coil of the condenser assembly 110.

[0065] FIG. 7 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0066] Referring to the embodiment as depicted in FIG. 7, an evaporator heat exchanger 132 is configured to utilize solar thermal and/or or geothermal energy in conjunction with the evaporator assembly 120 (direct-fired evaporator using fuel combustion). The evaporator heat exchanger 132 (also called a liquid-to-refrigerant heat exchanger) may be provided in parallel with the evaporator assembly 120 (such as an indirect fired evaporator) to take advantage of solar thermal and/or geothermal energy. The evaporator heat exchanger 132 is configured to be fluidly coupled to a renewable thermal energy source. The evaporator heat exchanger 132 is fluidly connected to a solar thermal return 808 and a solar thermal supply 810. The evaporator heat exchanger 132 is configured to operate in cooperation with the evaporator assembly 120. A second three-way valve 134 and a fourth three-way valve 136 are configured to fluidly interface the evaporator heat exchanger 132 with the evaporator assembly 120.

[0067] The evaporator assembly 120 is configured to be indirect fired. The condenser assembly 110 is configured to be air cooled. The evaporator heat exchanger 132 is solar thermal heated. The evaporator-expansion module 101 may be located inside or outside the building structure 900. The pump-condenser module 111 may be located within the air-handler module 100, in which the air-handler module 100 is positioned or located inside the building structure 900. The supply-fan assembly 108 may be located downstream of the condenser assembly 110.

[0068] FIG. 8 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0069] Referring to the embodiment as depicted in FIG. 8, a condenser heat exchanger 138 is configured to utilize hydronic water, domestic water or pool water. The condenser heat exchanger 138 (also called a liquid-to-refrigerant heat exchanger) may be provided in parallel with the condenser assembly 110 (configured to be air cooled) to take advantage of a hydronic loop, a domestic water loop and/or a pool water loop. The condenser heat exchanger 138 is configured to fluidly cooperate with the condenser assembly 110. The condenser heat exchanger 138 is configured to fluidly connect with a hydronic return 812 and a hydronic supply 814. A first three-way valve 133 and a third three-way valve 135 are configured to fluidly interface the condenser assembly 110 with the condenser heat exchanger 138.

[0070] The evaporator assembly 120 is configured to be indirect fired. The condenser assembly 110 is configured to be air cooled. The condenser heat exchanger 138 is configured to be hydronic cooled. The evaporator-expansion module 101 may be located inside or outside the building structure 900. The pump-condenser module 111 includes the pump assembly 114 and the condenser assembly 110. Alternatively, the pump-condenser module 111 may be located within the air-handler module 100, in which the air-handler module 100 is positioned or located inside the building structure 900. Alternatively, the supply-fan assembly 108 may be located downstream of the condenser assembly 110.

[0071] FIG. 9 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0072] Referring to the embodiment as depicted in FIG. 9, the condenser heat exchanger 138 and the evaporator heat exchanger 132 are deployed with the evaporator assembly 120. The evaporator assembly 120 is configured to be indirect fired. The evaporator heat exchanger 132 is solar thermal heated. The condenser assembly 110 is configured to be air cooled. The condenser heat exchanger 138 is configured to be hydronic cooled. The evaporator-expansion module 101 may be located inside or outside the building structure 900. The pump-condenser module 111 includes the pump assembly 114 and the condenser assembly 110. The pump-condenser module 111 may be located within the air-handler module 100, in which the air-handler module 100 is positioned or located inside the building structure 900. The supply-fan assembly 108 may be located downstream of the condenser assembly 110.

[0073] FIG. 10 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0074] In accordance with an embodiment as depicted in FIG. 10, a battery assembly 148 (also called an on-board battery, or a battery storage system) and the expander controller 124 (also called a grid-independent expander controller or an inverter-and-charging assembly) is configured to allow the apparatus 199 to operate in the event of outage of the electric utility grid 816.

[0075] A battery controller 140 is electrically connected to an electrical-distribution panel 144 (also called a breaker panel). An automatic-disconnect assembly 142 electrically connects the electrical-distribution panel 144 (breaker panel) to the electric utility grid 816. A supply-fan controller 146 is electrically connected to the electrical-distribution panel 144.

[0076] The generator assembly 117 is configured to output AC (Alternating Current) power (preferably, three-phase AC power) that may be rectified to DC (Direct Current) power. The DC power may be converted to single phase AC power through an inverter that is compatible

with the electric grid. Alternatively, the DC power can also be left as is to charge a battery that may operate independently of the electric grid.

[0077] The pump motor 115 of the pump assembly 114 may utilize AC power from the electric utility grid 816 through a controller that rectifies AC power (provided by the electric utility grid 816) to DC power before inverting to AC power (or three-phase AC power) that is input to the pump motor 115.

[0078] For the case where the evaporator-expansion module 101 is to be deployed as a grid-connected system, the power output from the generator assembly 117 is exported to the building structure 900 or to the electric utility grid 816 via an expander controller 124.

[0079] Power input for the internal loads of the apparatus 199 may be imported from the building structure 900 or from the electric utility grid 816 (through other controllers). The building structure 900 has the option to install a battery storage system that has the ability to run the apparatus 199 along with other electrical loads in the event of an electric utility grid 816 outage. A main disconnect switch may be required to be activated in order to prevent the electric utility grid 816 from being energized in an outage situation.

[0080] The generator assembly 117 is configured to provide electrical output to the electrical-distribution panel 144 (breaker panel or utility grid connection) via the expander controller 124.

[0081] The battery assembly 126 (the on-board battery) is not provided (in accordance with an option). The expander controller 124 is a utility grid-connected unit, and includes an anti-islanding unit (known). The automatic-disconnect assembly 142 is optional (known and may be provided by a third party). The automatic-disconnect assembly 142 may be required for the case where a battery assembly 148 is present, in which the battery assembly 148 is configured to prevent the electric utility grid 816 from being energized in the event of the electric utility grid 816 is not operational (also called a grid outage condition). The battery assembly 126 (also called a battery storage system) is optional. The battery assembly 126 may be configured to charge and/or discharge depending on a control and management algorithm, etc.

[0082] In accordance with a preferred embodiment, the evaporator fan motor 123 and/or the heat-generating assembly 324 (also called the burner assembly) are configured to be controlled by a fan-and-burner controller 119.

[0083] In accordance with an embodiment, the air-handler module 100 also includes an electric heating element 127, and an electric heating controller 129 configured to operate the electric heating element 127.

[0084] The electric heating element 127 is configured to selectively not provide thermal energy (heat) for heating the building structure 900 for the case where natural gas rates (fuel costs) are relatively less expensive than electric rates (electrical costs) associated with the electric utility grid 816. For this case, heating of the building structure 900 is provided by utilizing (consuming) natural gas, and the generation of electric power may be provided by the generator assembly 117.

[0085] The electric heating element 127 is also configured to selectively provide, in use, thermal energy (heat) for heating the building structure 900 (by consuming electric power provided by the electric utility grid 816) for the case where the electric rates (costs) are relatively less expensive than the natural gas rates (fuel costs). For this case, electric power is not produced by the generator assembly 117.

[0086] The selection between the two heating modes (the operation of the electric heating element 127) may occur by operation of a thermostat (not shown and known), a controller (not shown and known), and any equivalent thereof.

[0087] FIG. 11 depicts a schematic view of the evaporator-expansion module 101 of FIG. 1.

[0088] Referring to the embodiment as depicted in FIG. 11, a battery assembly 148 is configured to operate independently of the electric utility grid 816 (the electric grid), in which case the battery may be used to provide the DC power that is inverted to three-phase AC power for usage by the pump motor 115 of the pump assembly 114. The battery assembly 148 (also called an on-board battery bank) is configured to allow for grid independent operation for the evaporator-expansion module 101 (that is, for the vapor expansion cycle utilized in the evaporator assembly 120, as depicted in FIG. 1). For the case where the evaporator-expansion module 101 is deployed as a grid-independent system, the power output from the generator assembly 117 is utilized to either (A) charge the battery assembly 148 via a battery controller 140, and/or (B) power other electrical loads directly connected to the evaporator-expansion module 101. Power input for the internal loads may always be obtained from the battery assembly 148 through the battery controller 140 (upon start-up, etc.). The generator assembly 117 is provided with no output to the electrical-distribution panel 144 (breaker panel or utility grid connection). The power generation system 150 is utility grid independent (that is, the power generation system 150 is not electrically connected to the electric utility grid 816). The evaporator-expansion module 101 and the air-handler module 100 may initialize operations from (and obtain electrical power from) the battery assembly 148.

[0089] The following is offered as further description of the embodiments, in which any one or more of any technical feature (described in the detailed description, the summary and the claims) may be combinable with any another one or more of any technical feature (described in the detailed description, the summary and the claims). It is understood that each claim in the claims section is an open ended claim unless stated otherwise. Unless otherwise specified, relational terms used in these specifications should be construed to include certain tolerances that the person skilled in the art would recognize as providing equivalent functionality. By way of example, the term perpendicular is not necessarily limited to 90.0 degrees, and may include a variation thereof that the person skilled in the art would recognize as providing equivalent functionality for the purposes described for the relevant member or element. Terms such as “about” and “substantially”, in the context of configuration, relate generally to disposition, location, or configuration that are either exact or sufficiently close to the location, disposition, or configuration of the relevant element to preserve operability of the element within the invention which does not materially modify the invention. Similarly, unless specifically made clear from its context, numerical values should be construed to include certain tolerances that the person skilled in the art would recognize as having negligible importance as they do not materially change the operability of the invention. It will be appreciated that the description and/or drawings identify and describe embodiments of the apparatus 199 (either explicitly or inherently). The apparatus 199 may include any suitable combination and/or permutation of the technical features as identified in the detailed description, as may be required and/or desired to suit a particular technical purpose and/or technical function. It will be appreciated that, where possible and suitable, any one or more of the technical features of the apparatus 199 may be combined with any other one or more of the technical features of the apparatus 199 (in any combination and/or permutation). It will be appreciated that persons skilled in the art would know that the technical features of each embodiment may be deployed (where possible) in other embodiments even if not expressly stated as such above. It will be appreciated that persons skilled in the art would know that other options may be possible for the configuration of the components of the apparatus 199 to adjust to manufacturing requirements and still remain within the scope as described in at least one or more of the claims. This written description provides embodiments, including the best mode, and also enables the person skilled in the art to make and use the embodiments. The patentable scope may be defined by the claims. The written description and/or drawings may help to understand the scope of the claims. It is believed that all the crucial aspects of the

disclosed subject matter have been provided in this document. It is understood, for this document, that the word “includes” is equivalent to the word “comprising” in that both words are used to signify an open-ended listing of assemblies, components, parts, etc. The term “comprising”, which is synonymous with the terms “including,” “containing,” or “characterized by,” is inclusive or open-ended and does not exclude additional, unrecited elements or method steps. Comprising (comprised of) is an “open” phrase and allows coverage of technologies that employ additional, unrecited elements. When used in a claim, the word “comprising” is the transitory verb (transitional term) that separates the preamble of the claim from the technical features of the invention. The foregoing has outlined the non-limiting embodiments (examples). The description is made for particular non-limiting embodiments (examples). It is understood that the non-limiting embodiments are merely illustrative as examples.

CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus, comprising:

an air-handler module configured to provide thermal energy to a building structure; and

an evaporator-expansion module configured to provide electric energy to the building structure; and

the evaporator-expansion module also configured to cooperate with the air-handler module; and

the evaporator-expansion module including:

an evaporator assembly, including:

a heated fluid conduit configured to convey, in use, a heated fluid; and

a refrigerant conduit configured to convey, in use, an evaporator refrigerant; and

the heated fluid conduit being positioned relative to the refrigerant conduit in such a way that the heated fluid conduit, in use, transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

2. The apparatus of claim 1, wherein:

the heated fluid conduit is configured to receive the heated fluid from a heat-generating assembly.

3. The apparatus of any one of claim 1 and claim 2, wherein:

the heated fluid conduit includes a plurality of combustion exhaust-gas tubes aligned along a linear direction.

4. The apparatus of any one of claim 1 to claim 3, wherein:

an amount of thermal energy from the heated fluid, in use, is transferred to the evaporator refrigerant; and

the evaporator refrigerant, in use, departs from the evaporator assembly and enters an expander assembly, in which the evaporator refrigerant, in use, imparts mechanical energy to the expander assembly, and the expander assembly, in use, turns a generator assembly to produce electricity; and

the evaporator refrigerant departs from the generator assembly and enters a condenser assembly in such a way that thermal energy from the evaporator refrigerant is transferred, at least in part, to an supply air assembly; and

the evaporator refrigerant, in use, departs from the condenser assembly and enters a pump assembly, in which the pump assembly, in use, imparts mechanical energy to the evaporator refrigerant; and

the evaporator refrigerant, in use, departs from the pump assembly and enters the evaporator assembly.

5. The apparatus of any one of claim 1 to claim 4, wherein:

the evaporator assembly further includes:

a thermal buffer; and

the thermal buffer is configured to be positioned relative to the heated fluid conduit and the refrigerant conduit in such a way that the thermal buffer, in use, transfers, at least in part, thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

6. The apparatus of any one of claim 1 to claim 5, wherein:

the thermal buffer is configured to:

limit an amount of heat transfer to the evaporator refrigerant; and

limit a temperature of the evaporator refrigerant positioned in the refrigerant conduit; and

physically isolate the heated fluid conduit from the refrigerant conduit.

7. The apparatus of any one of claim 1 to claim 6, wherein:

an interior of the evaporator assembly is configured to receive the thermal buffer; and

the heated fluid conduit includes spaced-apart tubes configured to extend through the thermal buffer.

8. The apparatus of any one of claim 1 to claim 7, wherein:

an evaporator fan is configured to receive a mixture of pre-mixed fuel and air; and

the evaporator fan is configured to be fluidly coupled to an inlet manifold; and

the heated fluid conduit is configured to be fluidly connectable to the inlet manifold; and

the heated fluid conduit is fluidly connected to an outlet manifold.

9. The apparatus of any one of claim 1 to claim 8, wherein:

a combustion exhaust-gas vent is configured to be fluidly connectable to the outlet manifold.

10. The apparatus of any one of claim 1 to claim 10, wherein:

a water-vapor drain is configured to extend from the outlet manifold; and

a pressure vent is configured to be coupled to an interior of the evaporator assembly, and the pressure vent is configured to relieve excessive interior pressure of the evaporator assembly.

11. An apparatus, comprising:

an evaporator-expansion module configured to provide electric energy to a building structure; and

the evaporator-expansion module also configured to cooperate with an air-handler module, in which the air-handler module is configured to provide thermal energy to the building structure; and

the evaporator-expansion module including:

an evaporator assembly, including:

a heated fluid conduit configured to convey, in use, a heated fluid; and

a refrigerant conduit configured to convey, in use, an evaporator refrigerant; and

the heated fluid conduit being positioned relative to the refrigerant conduit in such a way that the heated fluid conduit, in use, transfers thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

12. The apparatus of claim 11, wherein:

the heated fluid conduit is configured to receive the heated fluid from a heat-generating assembly.

13. The apparatus of any one of claim 11 and claim 12, wherein:

the heated fluid conduit includes a plurality of combustion exhaust-gas tubes aligned along a linear direction.

14. The apparatus of any one of claim 11 to claim 13, wherein:

an amount of thermal energy from the heated fluid, in use, is transferred to the evaporator refrigerant; and

the evaporator refrigerant, in use, departs from the evaporator assembly and enters an expander assembly, in which the evaporator refrigerant, in use, imparts mechanical energy to the expander assembly, and the expander assembly, in use, turns a generator assembly to produce electricity; and

the evaporator refrigerant departs from the expander assembly and enters a condenser assembly in such a way that thermal energy from the evaporator refrigerant is transferred, at least in part, to an supply air assembly; and

the evaporator refrigerant, in use, departs from the condenser assembly and enters a pump assembly, in which the pump assembly, in use, imparts mechanical energy to the evaporator refrigerant; and

the evaporator refrigerant, in use, departs from the pump assembly and enters the evaporator assembly.

15. The apparatus of any one of claim 11 to claim 14, wherein:

the evaporator assembly further includes:

a thermal buffer; and

the thermal buffer is configured to be positioned relative to the heated fluid conduit and the refrigerant conduit in such a way that the thermal buffer, in use, transfers, at least in part, thermal energy from the heated fluid that is positioned in the heated fluid conduit to the evaporator refrigerant that is positioned in the refrigerant conduit.

16. The apparatus of any one of claim 11 to claim 15, wherein:

the thermal buffer is configured to:

limit an amount of heat transfer to the evaporator refrigerant; and

limit a temperature of the evaporator refrigerant positioned in the refrigerant conduit; and

physically isolate the heated fluid conduit from the refrigerant conduit.

17. The apparatus of any one of claim 11 to claim 16, wherein:

an interior of the evaporator assembly is configured to receive the thermal buffer; and

the heated fluid conduit includes spaced-apart tubes configured to extend through the thermal buffer.

18. The apparatus of any one of claim 11 to claim 17, wherein:

an evaporator fan is configured to receive a mixture of pre-mixed fuel and air;

and

the evaporator fan is configured to be fluidly coupled to an inlet manifold; and

the heated fluid conduit is configured to be fluidly connectable to the inlet manifold; and

the heated fluid conduit is fluidly connected to an outlet manifold.

19. The apparatus of any one of claim 11 to claim 18, wherein:

a combustion exhaust-gas vent is configured to be fluidly connectable to the outlet manifold.

20. The apparatus of any one of claim 11 to claim 19, wherein:

a water-vapor drain is configured to extend from the outlet manifold; and

a pressure vent is configured to be coupled to an interior of the evaporator assembly, and the pressure vent is configured to relieve excessive interior pressure of the evaporator assembly.

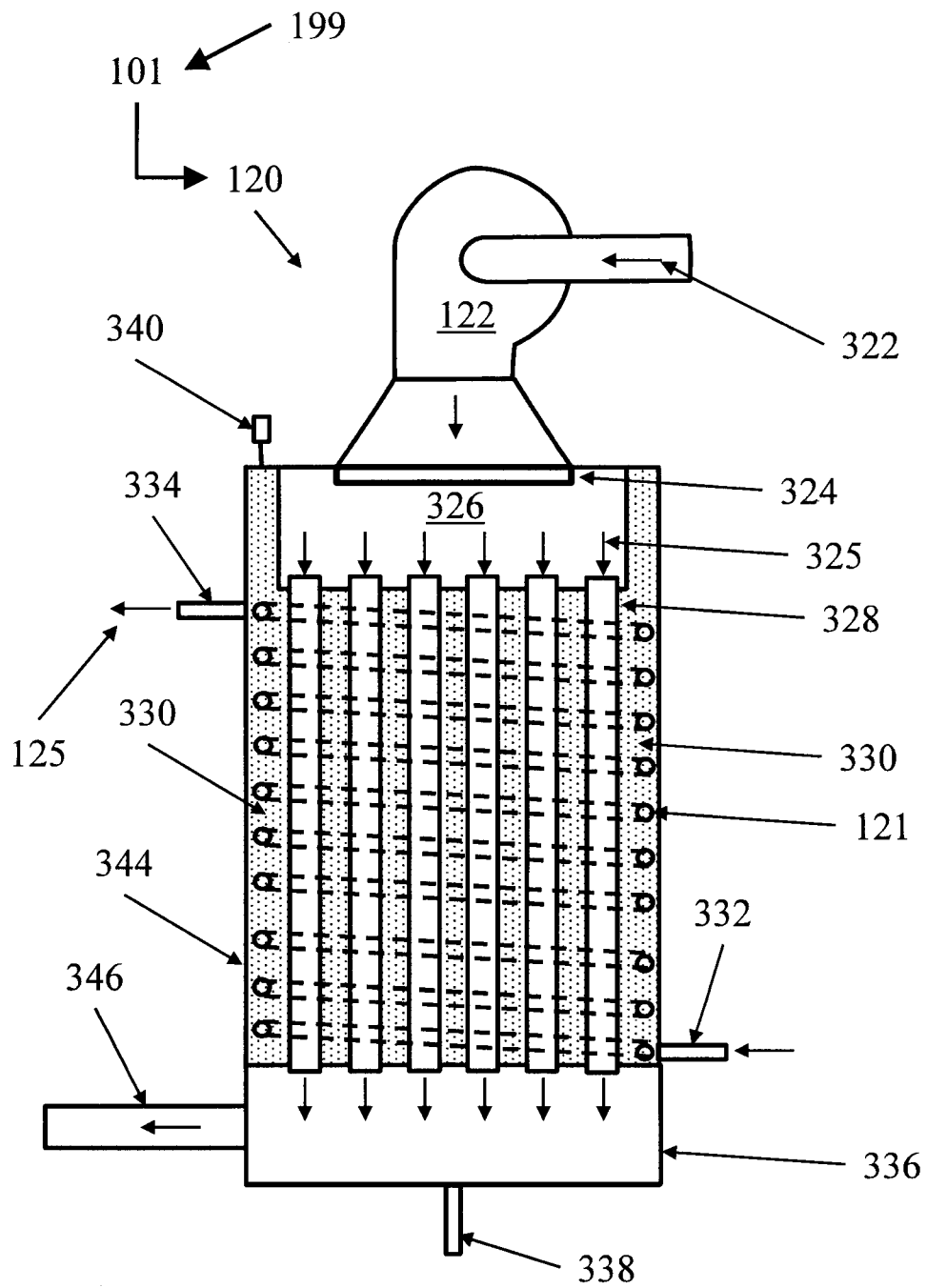


FIG. 1

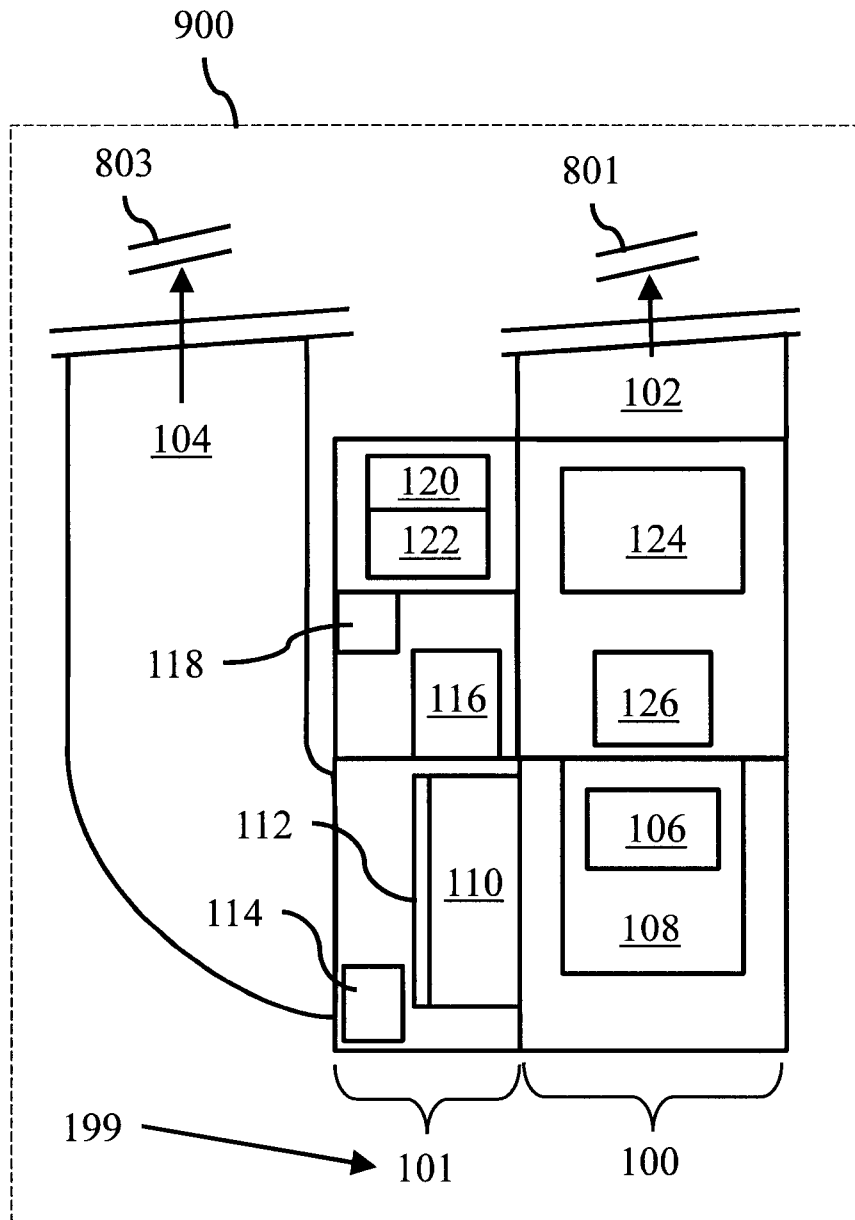


FIG. 2

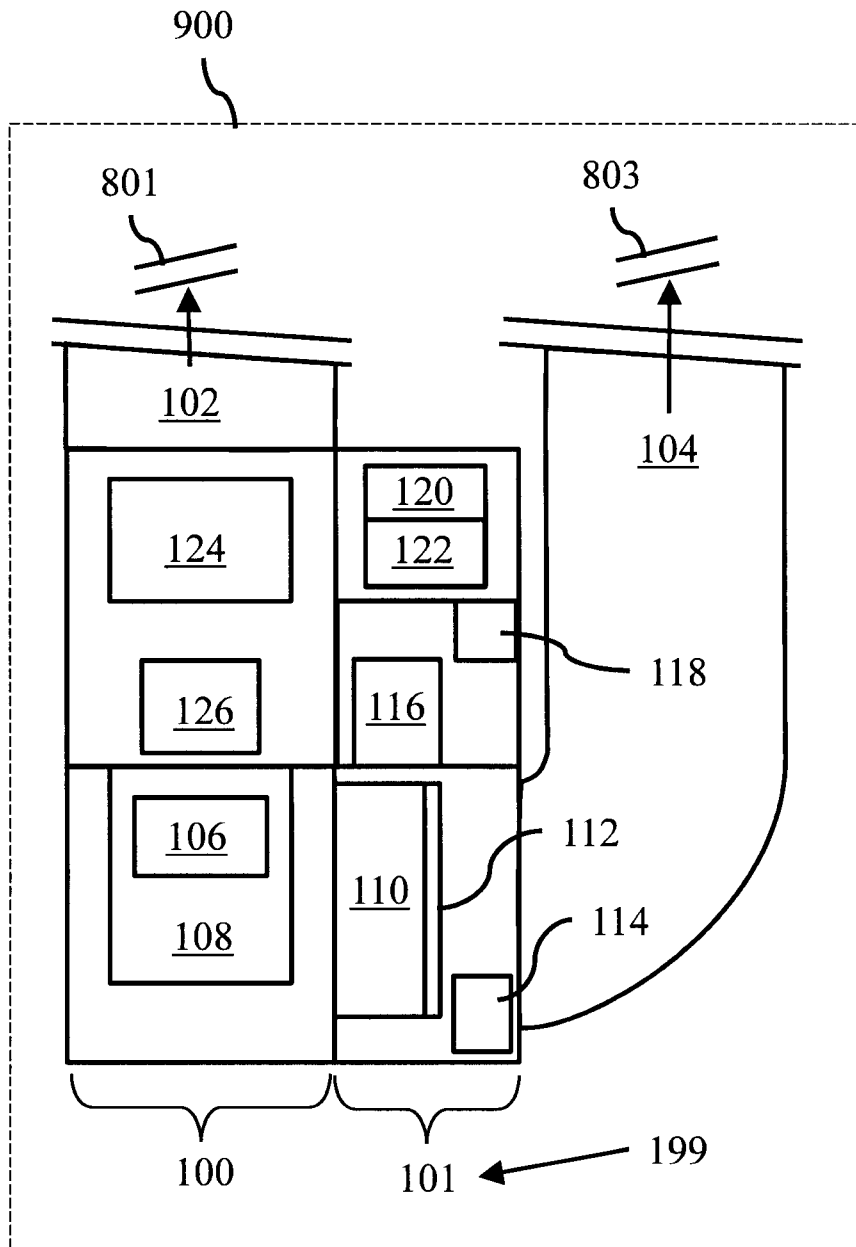


FIG. 3

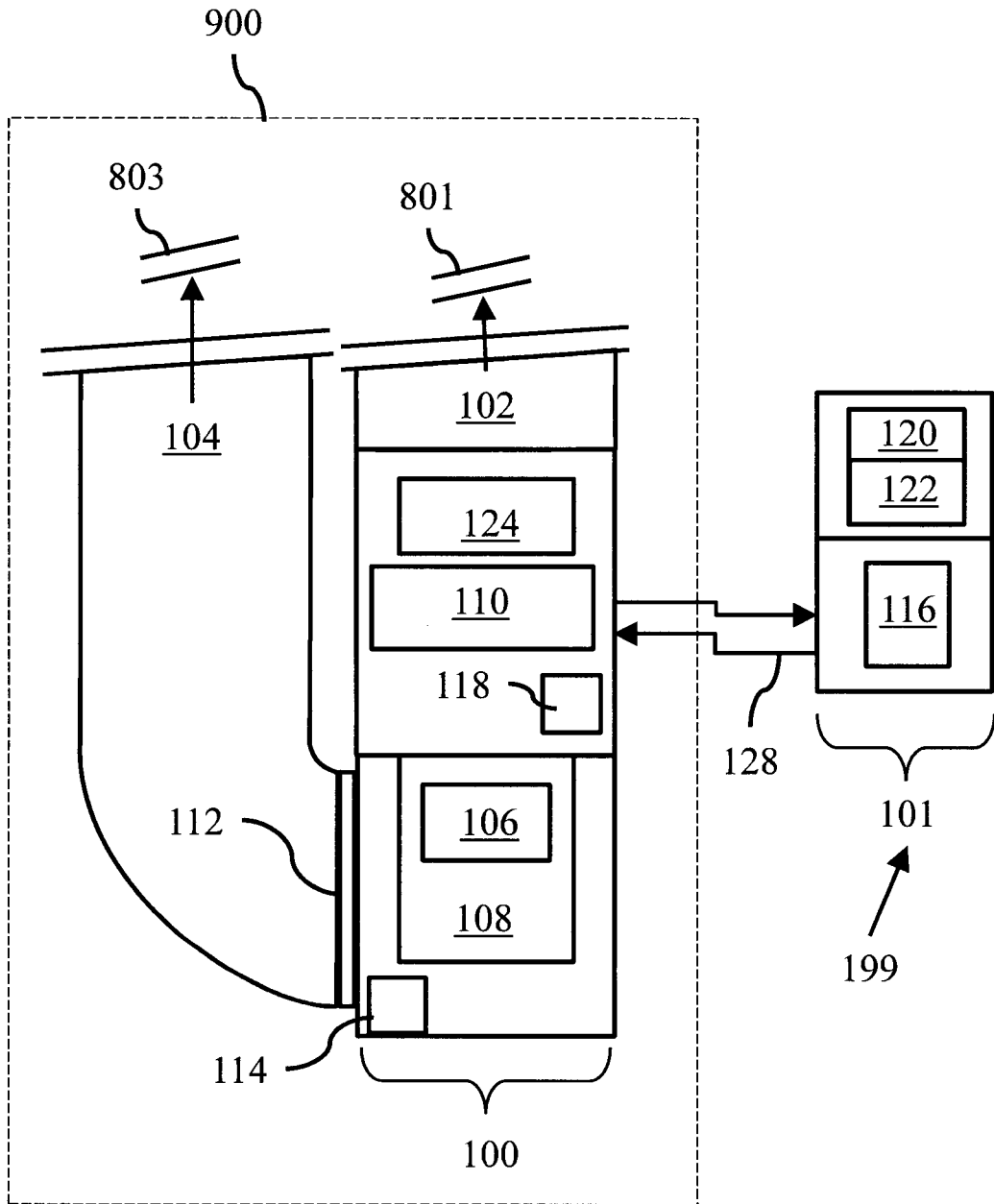


FIG. 4

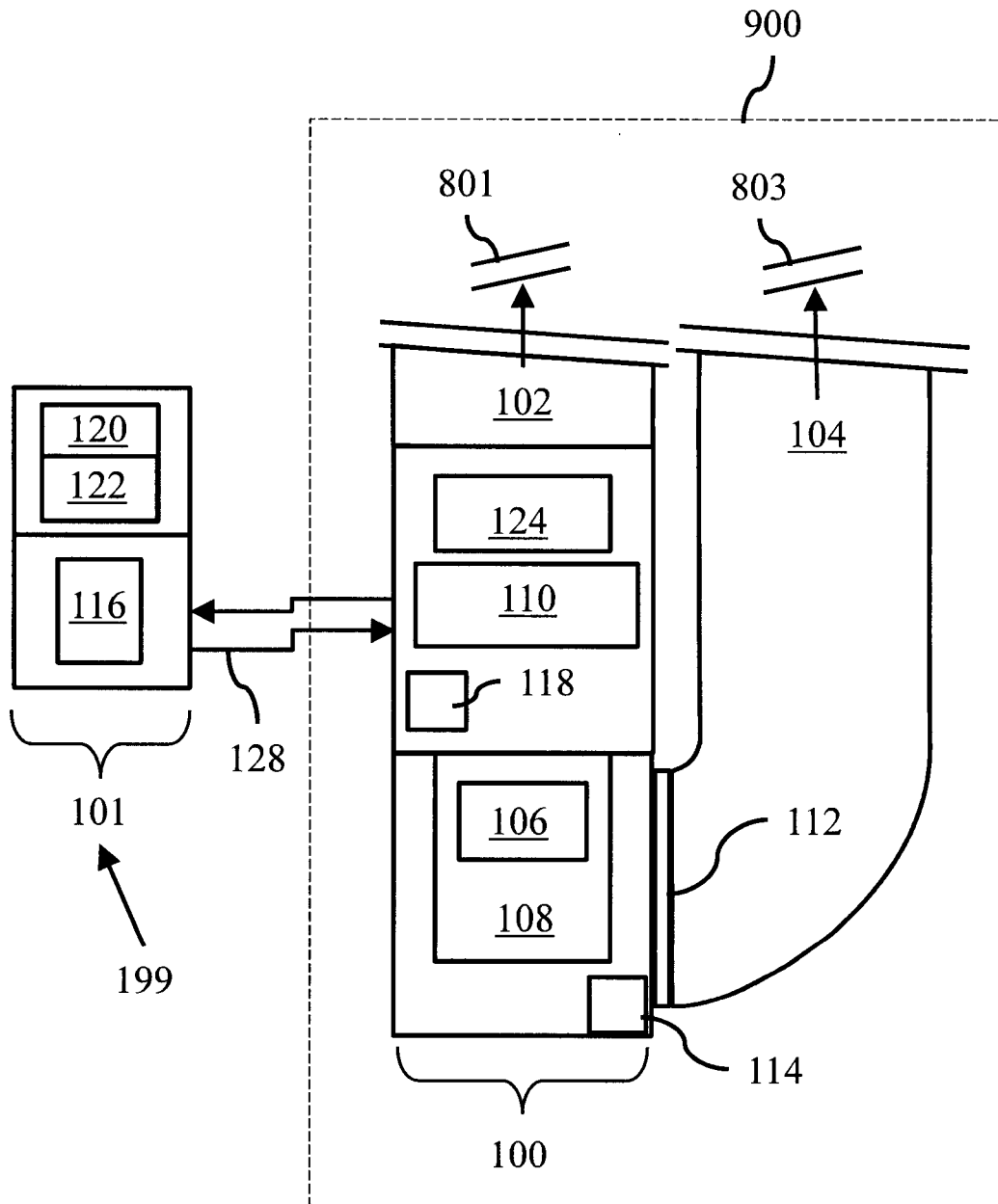


FIG. 5

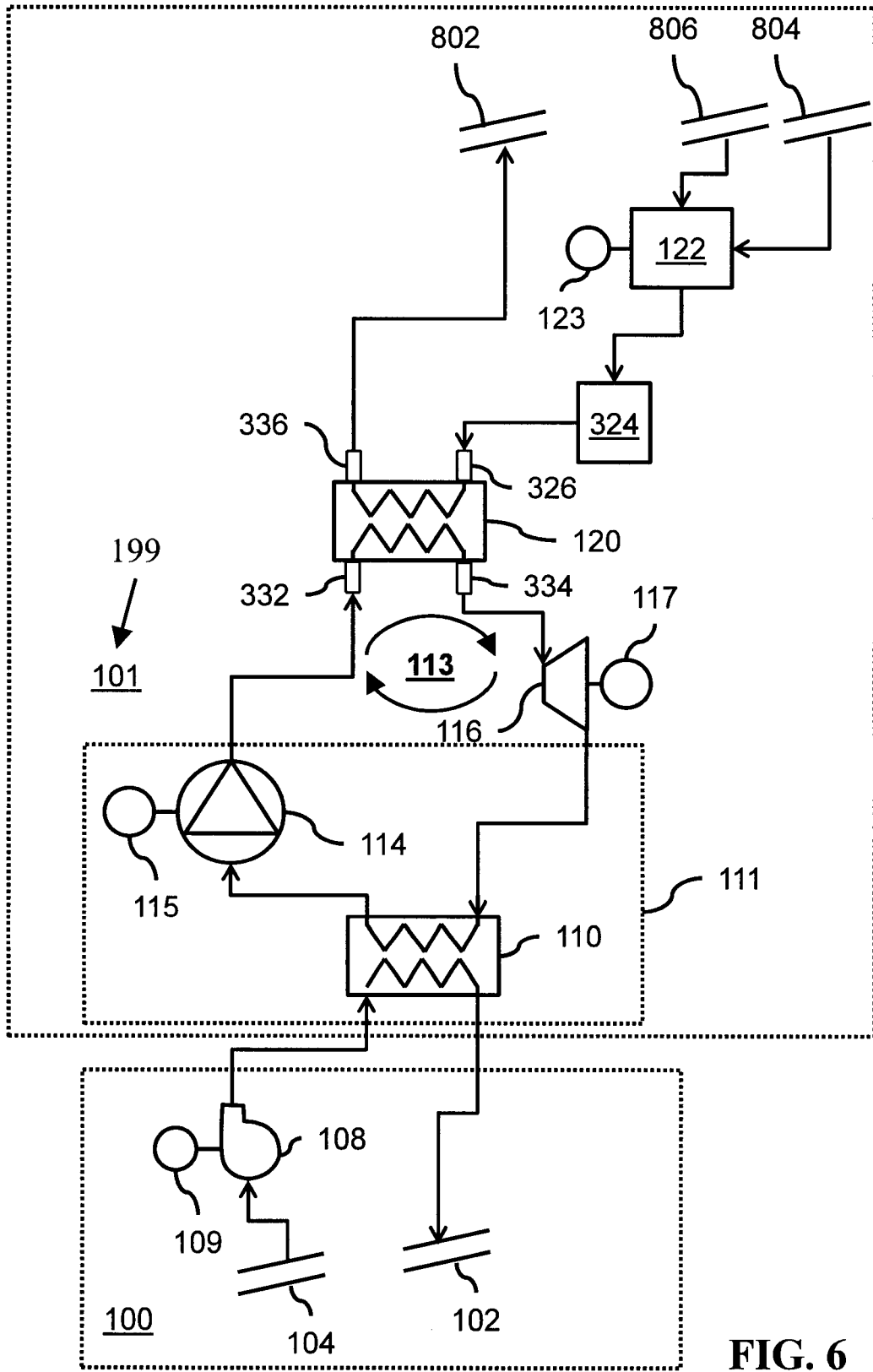


FIG. 6

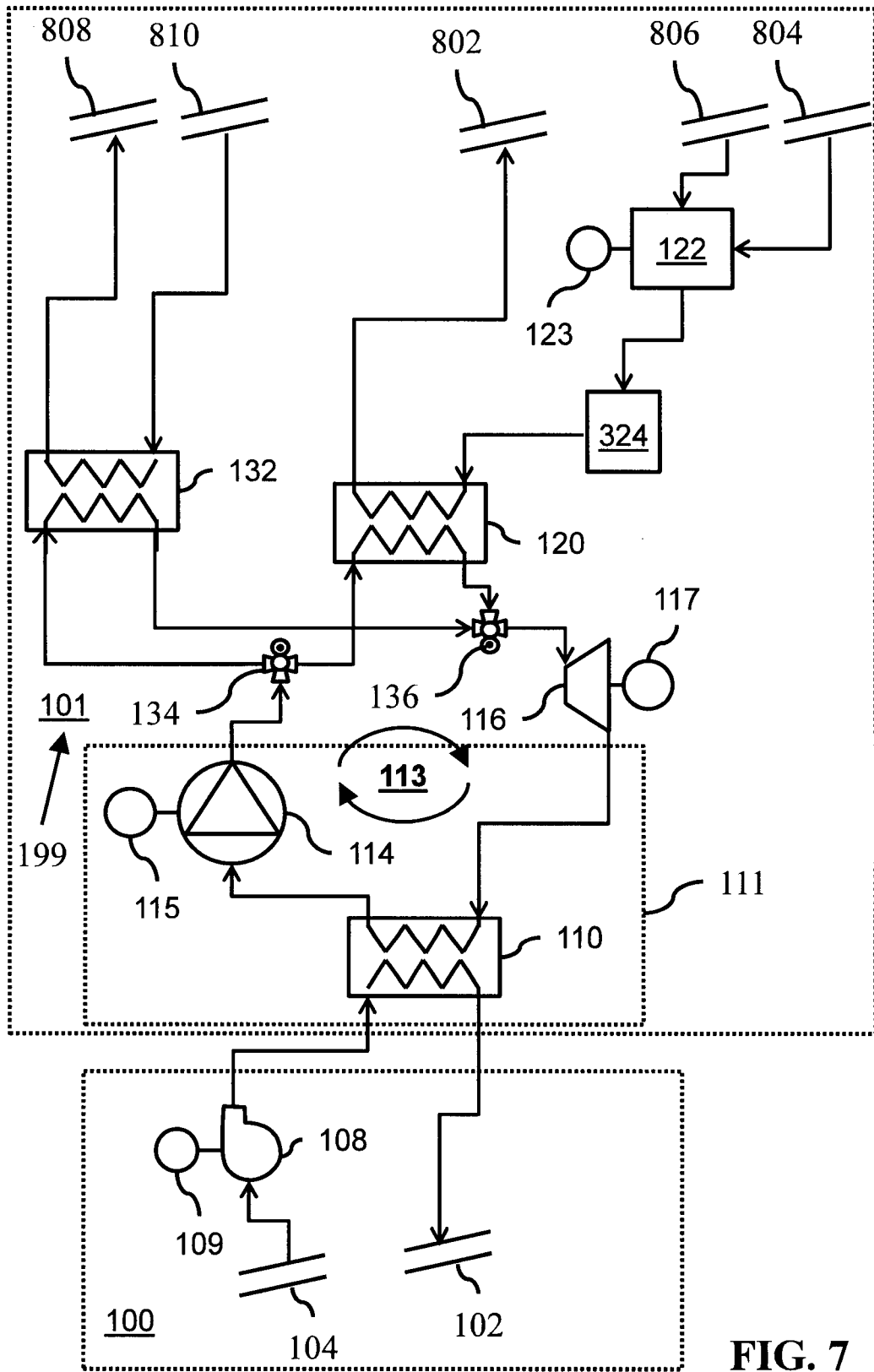


FIG. 7

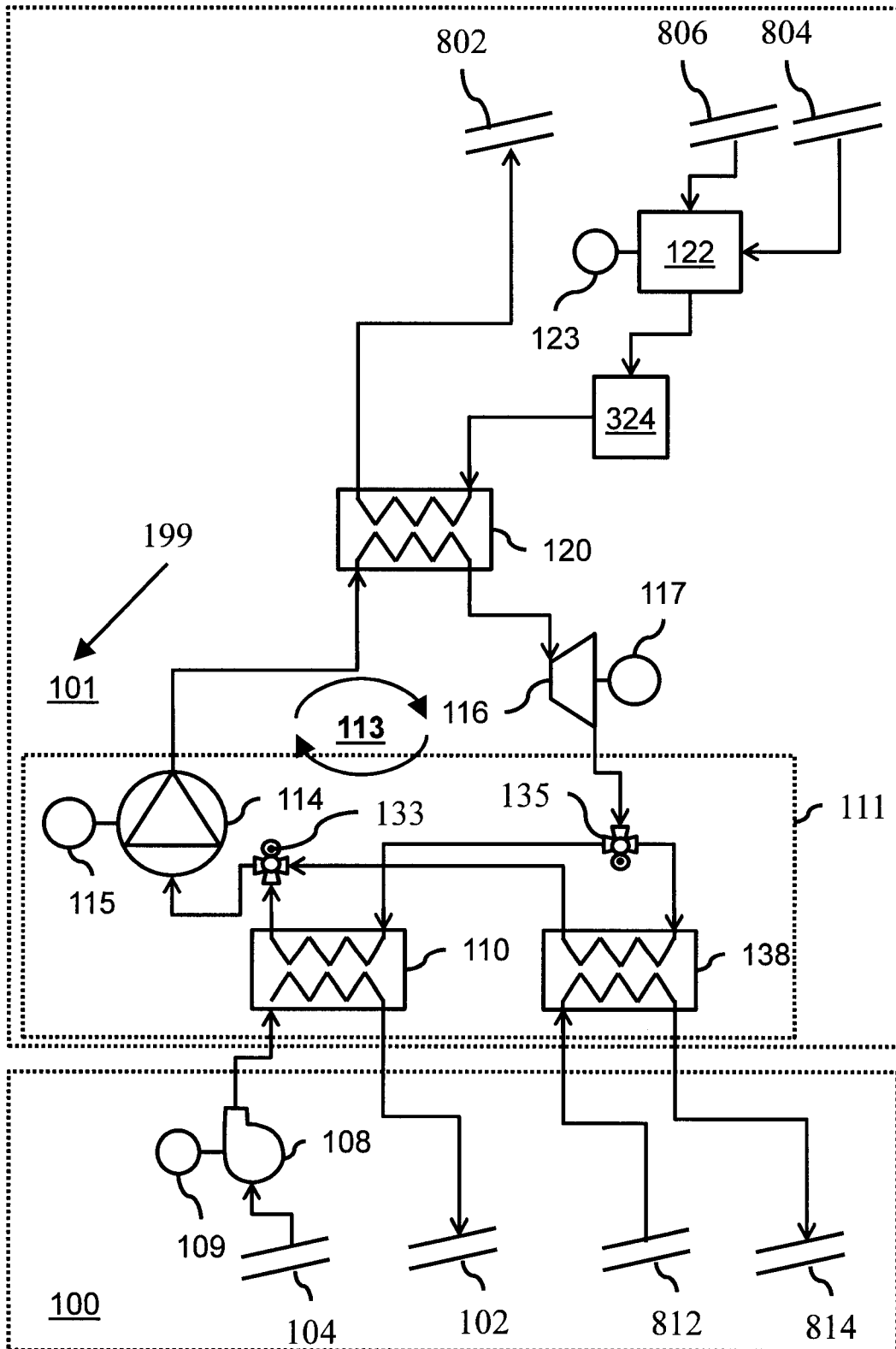


FIG. 8

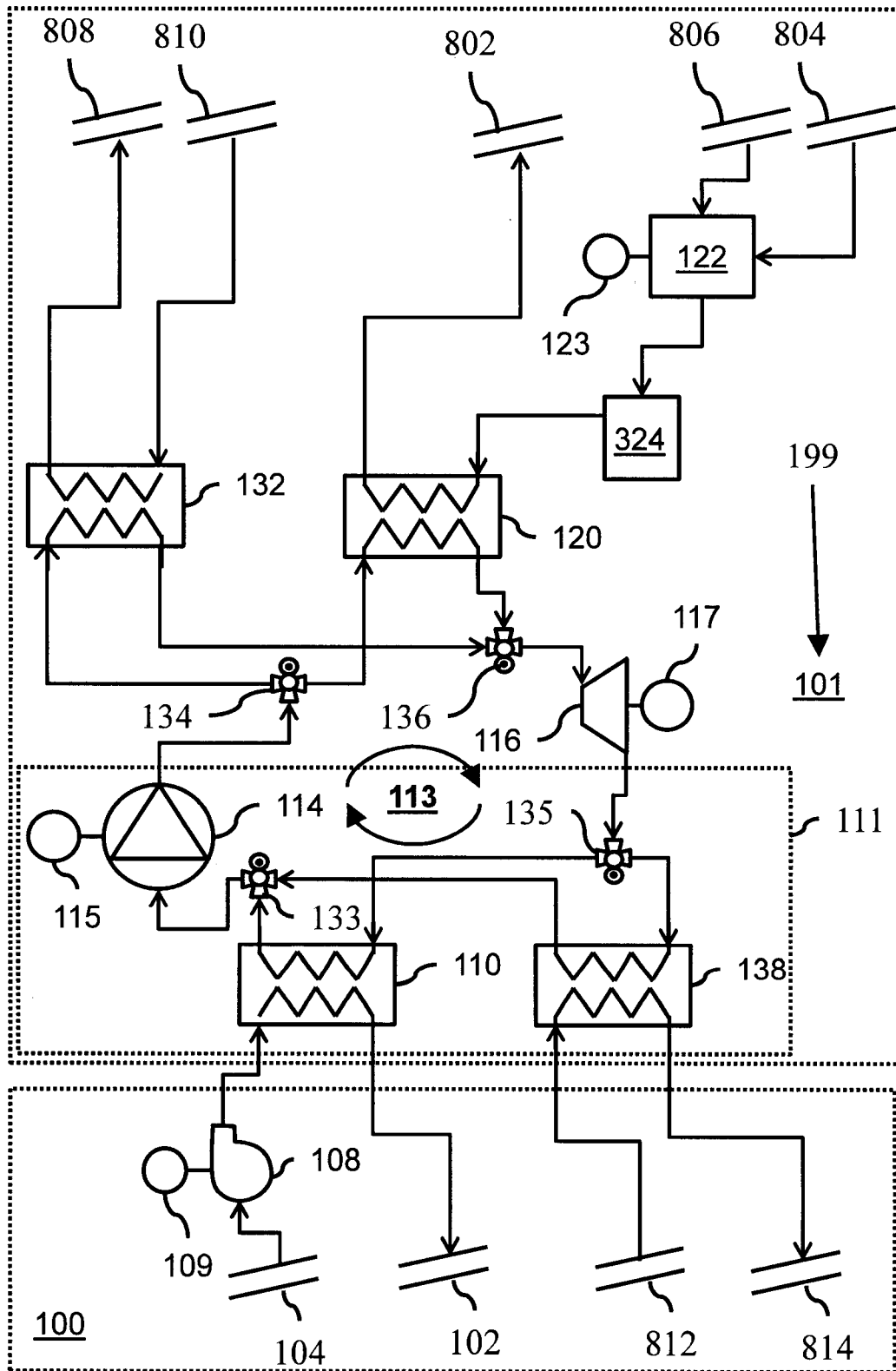


FIG. 9

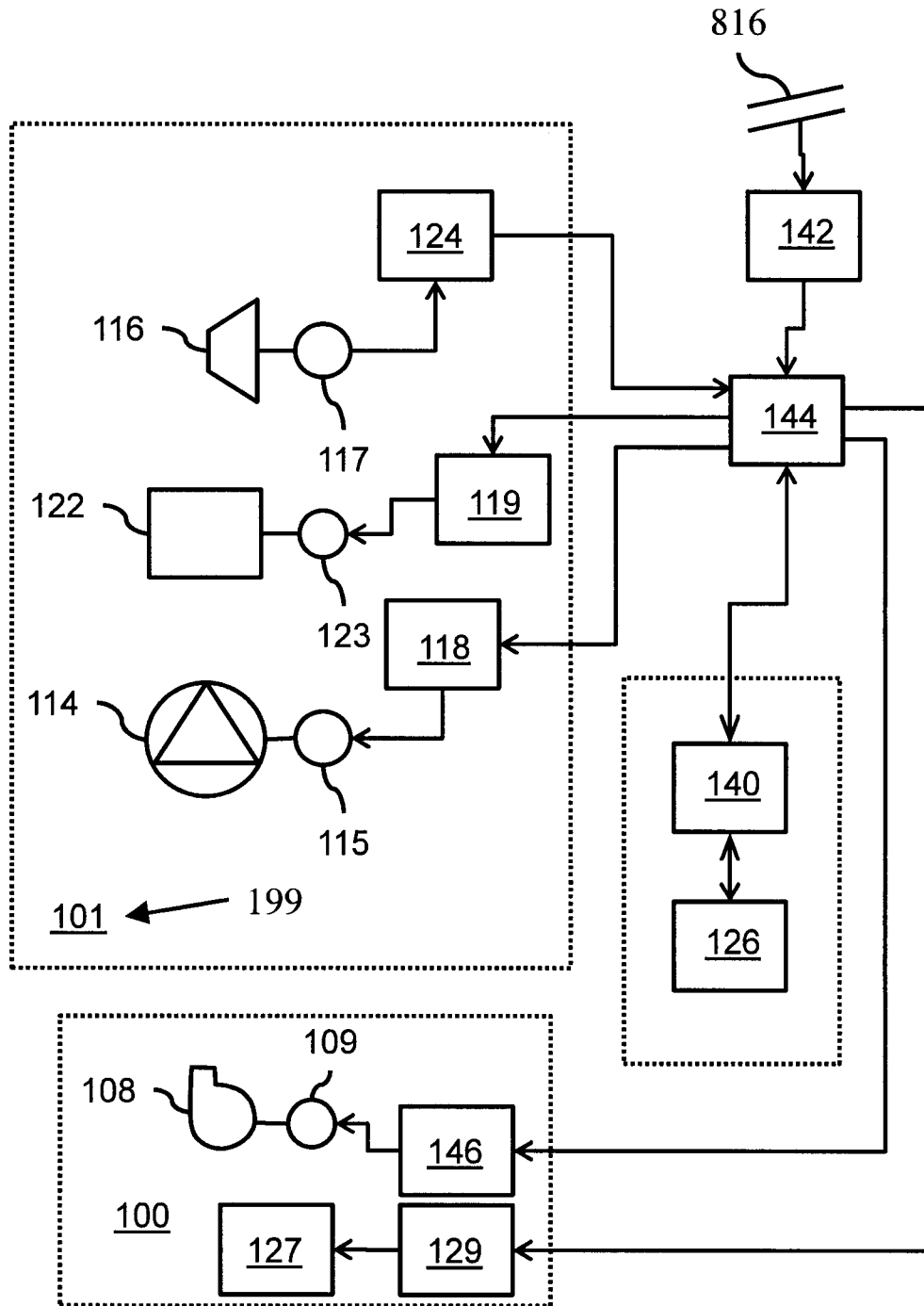


FIG. 10

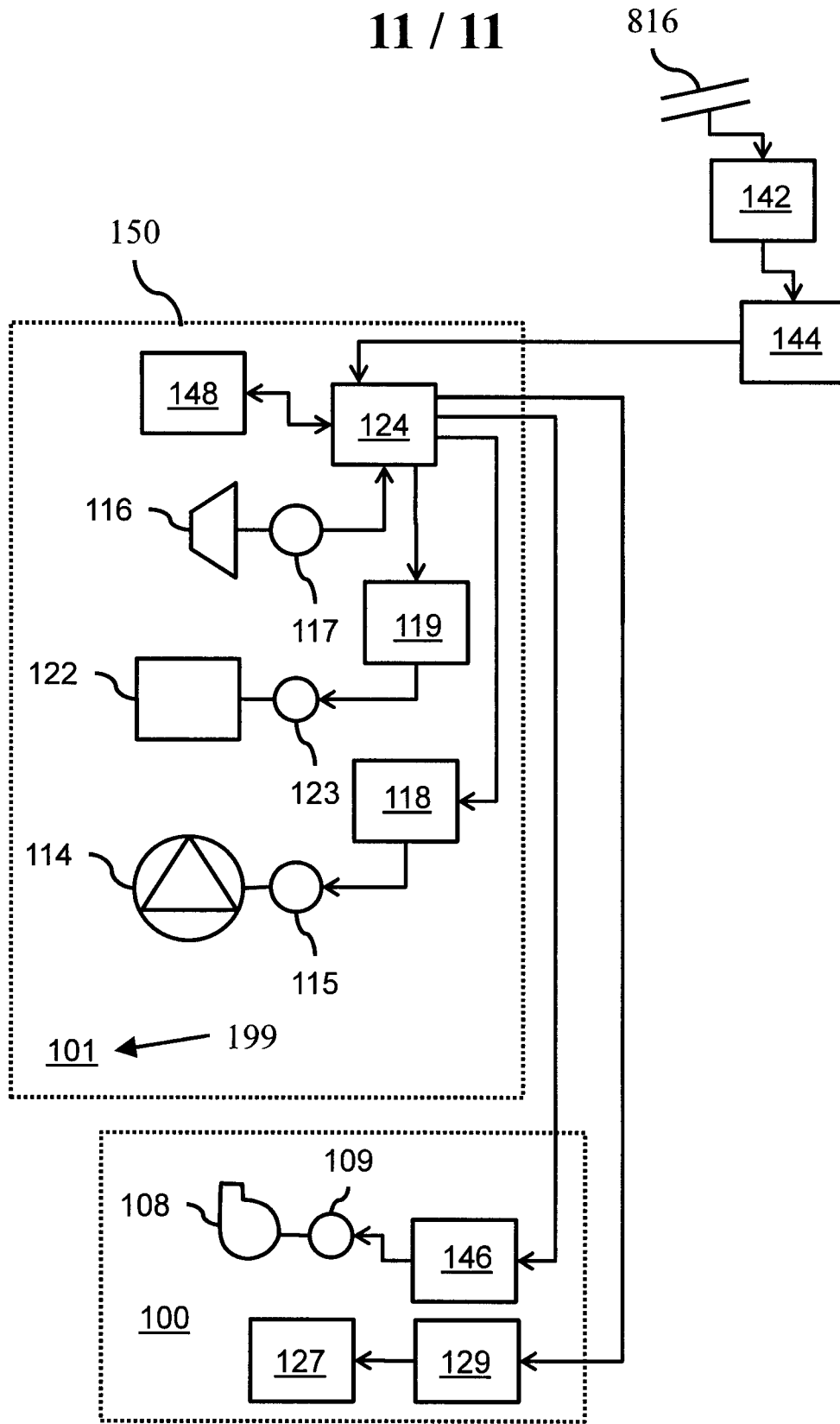


FIG. 11

