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(54) **HYBRID SPACE AND HOT WATER HEATING HEAT PUMP**

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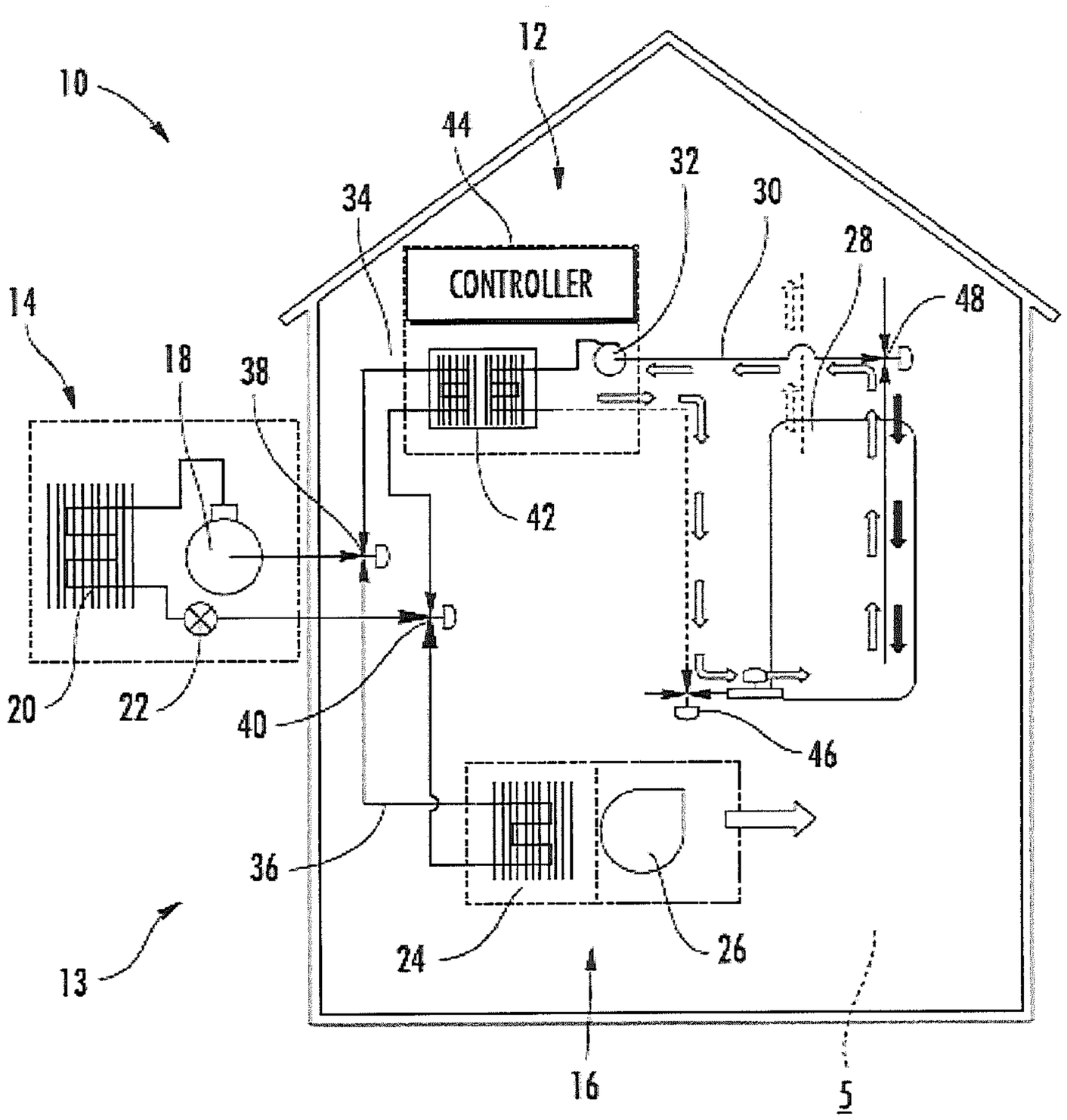
(57) **ABSTRACT**

A hybrid space and water heating heat pump system includes a heat pump including an outdoor assembly and an indoor assembly; a hot water module including a first heat exchanger, a controller, and a water pump connected to a water line, the first heat exchanger being configured for heating water; and a water heater in fluid communication with the hot water module, the water heater configured for receiving heated water from the first heat exchanger; wherein the controller is configured to select between one of conditioning an interior space or heating of the water in the first heat exchanger; and wherein the heat pump is configured for circulating a refrigerant through a first refrigerant circuit in response to the conditioning of the interior space and circulating the refrigerant through a second refrigerant circuit in response to the heating of the water in the first heat exchanger.



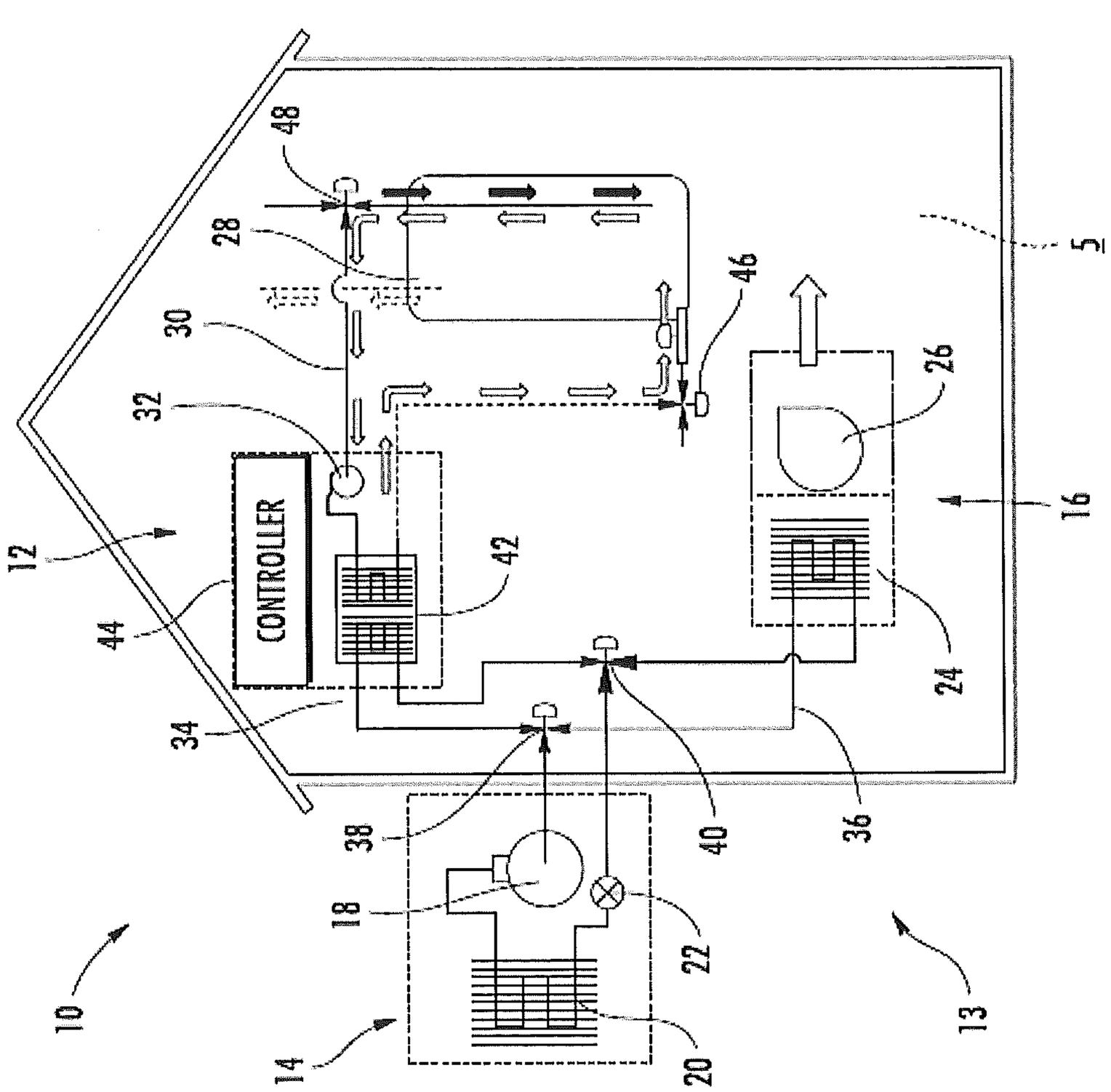

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FIG. 1

FIG. 2

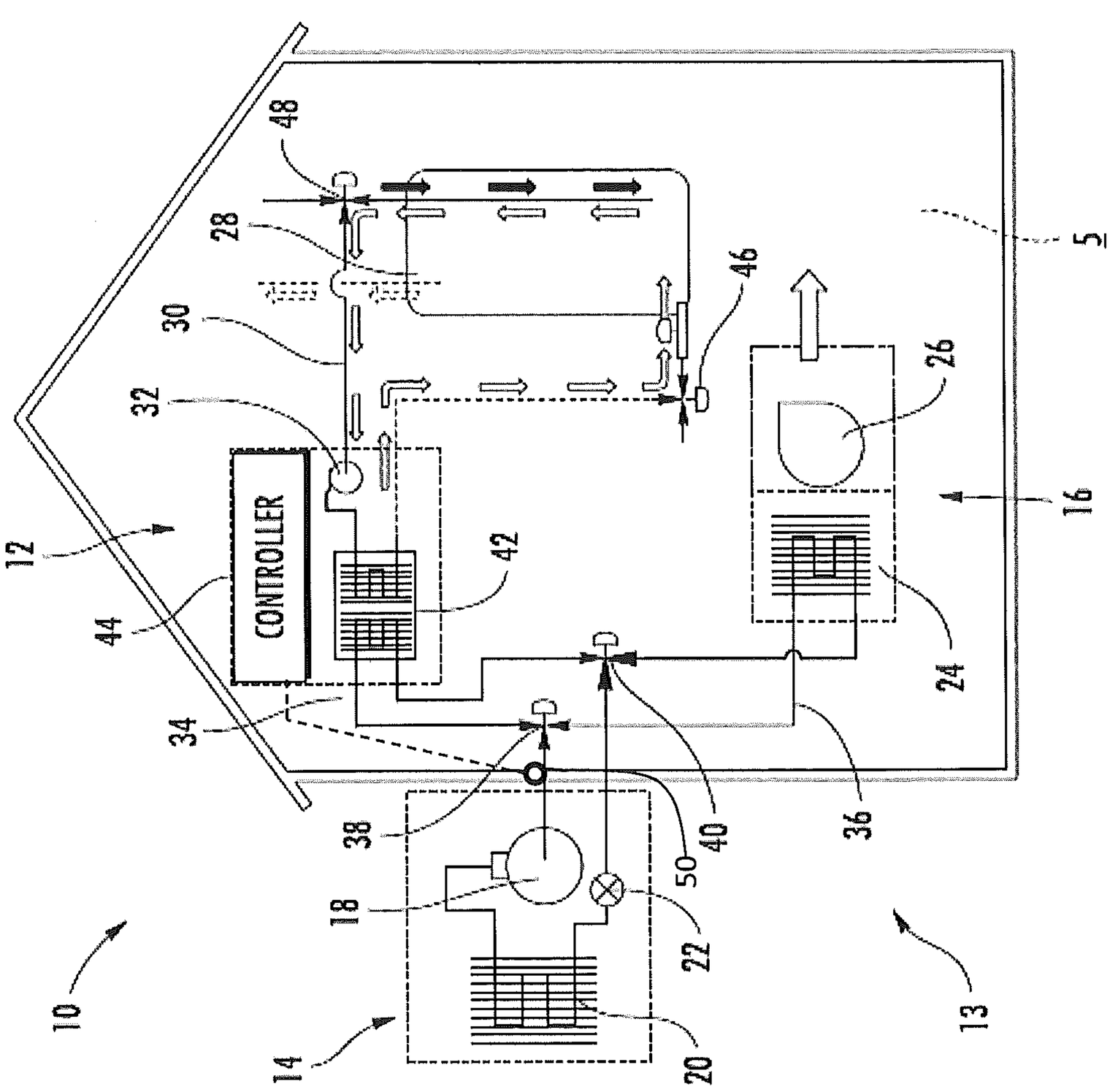
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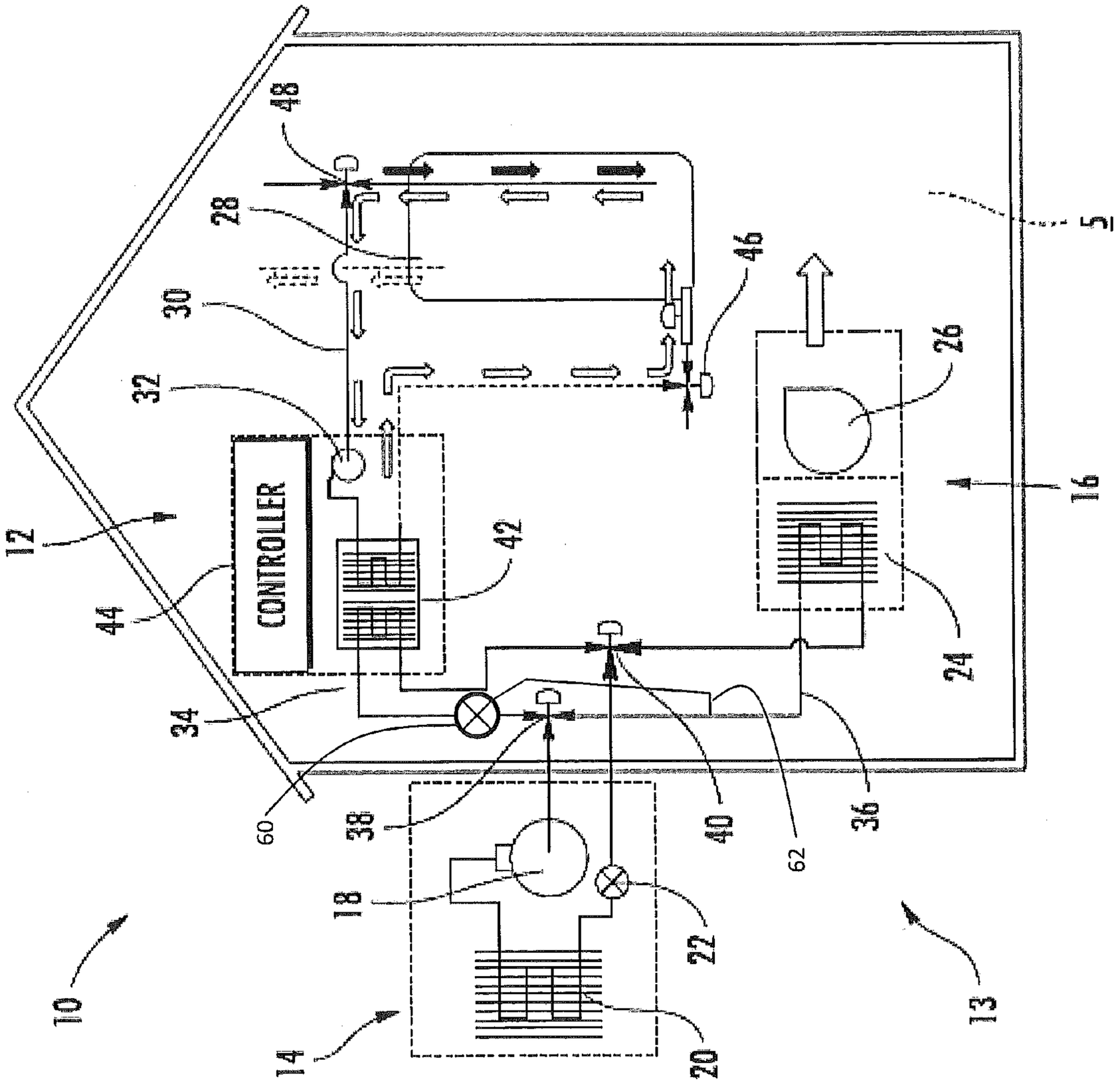
FIG. 3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HYBRID SPACE AND HOT WATER HEATING HEAT PUMP

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application Ser. No. 61/554,651 filed Nov. 2, 2011, the entire contents of which of incorporating herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates generally to a hybrid heat pump system and, more particularly, to a hot water module coupled to an existing heat pump system and water heater for supplementing the heating needs of the water heater when the heat pump system is not providing space heating or cooling.

DESCRIPTION OF RELATED ART

[0003] Reversible heat pumps are commonly used for cooling and heating a climate controlled comfort zone such as a residence or a building. A conventional heat pump includes a compressor, a suction accumulator, a reversing valve, an outdoor heat exchanger with an associated outdoor fan, an indoor heat exchanger with an associated indoor fan, an expansion device operatively associated with the outdoor heat exchanger and a second expansion device operatively associated with the indoor heat exchanger. The heat pump components are typically arranged in a closed refrigerant circuit pump system employing a refrigerant vapor compression cycle. When operating in the cooling mode, excess heat absorbed by the refrigerant in passing through the indoor heat exchanger is rejected to the environment as the refrigerant passes through the outdoor heat exchanger.

[0004] A typical water heater for residential hot water production and storage is the electric resistance water heater and storage tank, although gas water heaters are also used to heat water in the storage tank. Water heaters typically include a tank defining a chamber for retention of water. A water inlet pipe that is provided with a first connection for interconnection with a cold water supply line that conveys fresh relatively cold water into the chamber. Within the tank there are electric resistance elements that heat the water in the tank in the case of electric resistance water heaters.

[0005] An alternative method of heating a liquid have been provided in the form of a desuperheater heat pump water heater to intercept the superheated hot gas from the compressor to provide the auxiliary heating to the water heater. The desuperheater is provided with a water heater or as an accessory in order to intercept the superheated gas from a compressor during the cooling mode. However, the desuperheater water heater is limited in its capacity to heat water as it only does so while there is a demand for space cooling.

BRIEF SUMMARY

[0006] According to one aspect of the invention, a hybrid space and water heating heat pump system includes a heat pump including an outdoor assembly and an indoor assembly; a hot water module including a first heat exchanger, a controller, and a water pump connected to a water line, the first heat exchanger being configured for heating water; and a water heater in fluid communication with the hot water module, the water heater being configured for receiving the heated water from the first heat exchanger; wherein the controller is configured to select between one of conditioning an interior space or heating of the water in the first heat exchanger; and wherein the heat pump is configured for circulating a refrigerant through a first refrigerant circuit in response to the conditioning of the interior space and configured for circulating the refrigerant through a second refrigerant circuit in response to the heating of the water in the first heat exchanger.

[0007] According to another aspect of the invention, a method for controlling space and hot water heating with a hybrid heat pump system having a heat pump coupled to a hot water module and a hot water heater, includes receiving, via a sensor, a control signal indicative of a call for the hot water heating; determining, via a controller, whether the heat pump is being used for conditioning an interior space; and switching, via the controller, the heat pump to hot water heating, the switching of the heat pump in response to determining whether to disable the heat pump for conditioning the interior space; wherein the heat pump includes an outdoor assembly and an indoor assembly; wherein the hot water module includes a first heat exchanger, the controller, and a water pump connected to a water line, the first heat exchanger being configured for the hot water heating of water in the first heat exchanger; and wherein the hot water heater being configured for receiving heated water from the first heat exchanger.

[0008] Other aspects, features, and techniques of the invention will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0009] Referring now to the drawings wherein like elements are numbered alike in the Figures:

[0010] FIG. **1** illustrates a schematic view of a hybrid hot water and heating heat pump system according to an embodiment of the invention;

[0011] FIG. **2** illustrates a system for controlling compressor discharge pressure in an exemplary embodiment; and

[0012] FIG. **3** illustrates a system for controlling compressor discharge pressure in an exemplary embodiment.

DETAILED DESCRIPTION

[0013] Embodiments of a high efficiency hybrid space and water heating heat pump system includes a hot water module and a water heater operably coupled to a heat pump for providing auxiliary hot water heating to the water heater by switching the heat pump from either the space heating mode or the space cooling mode to a hot water heating mode. During the hot water heating mode, the heat pump is operated in the heating mode for specifically heating hot water. The hot water module includes a controller for executing algorithms for controlling one or more valves that diverts vapor refrigerant from a compressor located in the heat pump in an outside environment to a hot water refrigerant circuit in order to heat cold water diverted from a hot water heater. Additionally, the controller would execute algorithms to determine whether to switch from either the space-heating mode or the space-cooling mode to a hot water heating mode during a call for hot water. Additional algorithms may also determine the duration for operating the heat pump in the hot water heating mode by receiving information regarding various operating conditions in the system. In embodiments, discrete components such as, for example, open/close relays and temperature switches may also be utilized to implement the switching

modes from either the space-heating mode or the space-cooling mode to a hot water heating mode during a call for hot water.

[0014] Referring now to the drawings, FIG. **1** illustrates an example hybrid space and water heating heat pump system **10** for indoor space heating and cooling in addition to providing hot water heating according to an embodiment of the invention. Particularly, the system **10** includes a heat pump **13** having an outdoor assembly **14** and an indoor assembly **16** operably coupled to a hot water module **12** and a water heater **28**. The outdoor assembly **14** is connected to the indoor assembly **16** via a refrigerant line circuit **36** for conditioning an interior space **5** in the heating and cooling modes. The outdoor assembly **14** is also connected to a hot water module **12** via refrigerant line circuit **34** for providing auxiliary hot water heating to a water heater **28** when the heat pump **13** is not being used to condition the interior space **5**. In the space heating mode, the system **10** includes, in an embodiment, the outdoor assembly **14** having a compressor **18** connected to an outdoor heat exchanger, such as an evaporator **20**, and an expansion device **22**, while the indoor assembly **16** includes an air handler having an indoor heat exchanger such as a condenser **24** coupled to an indoor fan **26**. It is to be appreciated that in the space cooling mode, the cycle is reversed with the condenser and evaporator of the heating mode acting as an evaporator and condenser, respectively.

[0015] In an embodiment, a three-way valve **38** is provided to divert the refrigerant from the compressor **18** to the hot water module **12** through refrigerant line circuit **34** during auxiliary water heating and also to divert the refrigerant from the compressor **18** to the indoor assembly **16** through refrigerant line circuit **36** during the heating and cooling modes when conditioning the interior space **5**. Additionally, a three-way valve **40** is provided to couple the return path of the refrigerant from either of the refrigerant line circuits **34**, **36** back to the outdoor assembly **14**. It is to be appreciated that two-way valves may be utilized in lieu of the three-way valves **38**, **40** in order for diverting the refrigerant in the refrigerant line circuits **34**, **36** without departing from the scope of the invention. It is also to be appreciated that the hot water module **12** is connected to the refrigerant line in parallel with the indoor assembly **16** in order to receive the refrigerant from the heat pump **13** during conditioning of the interior space **5** or to receive the refrigerant from the heat pump **13** in order to provide auxiliary heating of the water in the water heater **28** during a call for hot water.

[0016] Also shown in FIG. **1**, hybrid space and water heating heat pump system **10** includes a hot water module **12** connected to hot water heater **28** via a water line **30** for providing auxiliary hot water heating according to an embodiment. Particularly, hot water module **12** includes a refrigerant-to-water heat exchanger **42**, a water pump **32**, a controller **44**, and three-way valves **46**, **48** connected to the water line **30**, and temperature sensors (not shown) for providing signals of temperature sensed by the various components of the system **10** during space heating or cooling and hot water heating in an embodiment. In another embodiment, two-way valves may be utilized for the three-way valves **46**, **48** without departing from the scope of the invention. In an embodiment, the controller **44** includes a microprocessor preprogrammed with software programs stored in nonvolatile memory for executing algorithms to provide the system **10** with a variety of operation modes and control sequences that provides auxiliary water heating to the water heater **28** as well as space heating and cooling of the interior space **5** with desired enhanced operational flexibility and efficiency. Based upon a network of sensory inputs sensing several parameters, the microprocessor may, in embodiments, selectively operate the outdoor assembly **14**, indoor assembly **16**, and hot-water module **12**, as programmed to obtain the most efficient balance between demands placed on the system **10**. In another embodiment, the controller **44** may provide control sequences by opening or closing temperature switches and relays coupled to the system **10**, which provides the system **10** with a variety of operation modes and control sequences without requiring the preprogrammed software programs implemented by the microprocessor. The controller **44** controls each of the three-way valves **46**, **48** to divert water from the water heater **28** through the water line **30** and to the heat exchanger **42**. The heat exchanger **42** effects a heat transfer to the water via the high-pressure vapor refrigerant in the refrigerant line circuit **34** causing the vapor refrigerant to condense into a liquid refrigerant as it releases heat to the water and heats it to a predetermined minimum temperature such as, for example, 120 degrees Fahrenheit. In embodiments, the heat exchanger **42** may be a brazed-plate refrigerant-to-water heat exchanger or a coaxial tube-in-tube heat exchanger for transferring heat to water being circulated between a storage tank in water heater **28** and water module **12**. In embodiments, the water heater **28** may also include electric heating elements or gas heating elements (not shown) to heat the water when the heat pump is not available for auxiliary hot water heating. It is to be appreciated that the system **10** provides auxiliary hot water heating by operating the heat pump in the heating mode and diverting the high-temperature vapor refrigerant through the three-way valve **38** and to the hot water module **12**. It is also to be appreciated that the controller **44** includes algorithms for determining whether to divert vapor refrigerant, from the indoor assembly **16** necessary for the heating- or the cooling modes of interior space **5**, to the hot water module **12** during a call for hot water during the auxiliary heating mode of water in the water heater **28**, as is shown and described below.

[0017] In operation, during the space-heating mode of interior space **5**, the outdoor air passes across evaporator **20** (e.g., via an evaporator fan) causing the low-pressure low-temperature liquid refrigerant to evaporate as it absorbs heat from the outdoor air. The low-pressure refrigerant is delivered to compressor **18** where it is compressed to a high-pressure, high temperature gas. The controller **44** controls the three-way valves **38**, **40** to circulate refrigerant through refrigerant line circuit **36** and prevents the refrigerant from being circulated through the refrigerant line circuit **34**. Specifically, the high-pressure, high temperature refrigerant vapor from compressor **18** diverted through refrigerant line circuit **36** by three-way valve **38** and is delivered to condenser **24** where the indoor air passes across condenser **24** (e.g., via the indoor fan **26**) and condenses the high-pressure vapor refrigerant into a liquid refrigerant as it releases heat to the interior space **5**. The liquid refrigerant exiting indoor heat exchanger **24** is diverted through three-way valve **40** and is delivered to the outdoor heat exchanger **20** through an expansion device **22**. The pressure change caused by the expansion device **22** allows the liquid refrigerant to evaporate at a low temperature outside to achieve a combination of liquid and vapor. In embodiments, the expansion device **22** may be a fixed expansion device such as a piston, or a thermostatic or electronic expansion valve. The refrigerant passes through the expansion device **22** and is

again delivered to the outdoor heat exchanger **20** and compressor **18** where it is compressed to a high-pressure, high temperature gas, and delivered to indoor heat exchanger **24** to start the heating cycle again. It is to be appreciated that while the operation of the hybrid heat pump system **10** is shown in the space heating mode, the hybrid heat pump system **10** may also operate in the space-cooling mode via a reversing valve (not shown). In the space-cooling mode of interior space **5**, the cycle is reversed with the condenser and evaporator of the heating mode acting as an evaporator and condenser respectively.

[0018] During hot-water heating in the auxiliary heating mode, the controller **44** executes algorithms for providing hot water heating to the water heater **28** through the refrigerant-to-water heat exchanger **42** while forgoing both the space heating and space cooling modes. The controller **44** forgoes these space conditioning modes in order to maximize the time available for hot water heating without adversely affecting comfort when the space-heating and space-cooling modes are not being used. Particularly, in an example, the controller **44** controls the three-way valves **38**, **40** to circulate refrigerant through the refrigerant line circuit **34** and prevents the refrigerant from being circulated to the condenser through the refrigerant line circuit **36** when a request for hot water is received by controller during a demand for hot water heating. As such, the controller **44**, during a call for hot water, activates the heat pump **13** for operating in a heating mode and controls the three-way valves **38**, **40** in order to direct the flow of high-pressure high-temperature refrigerant from compressor **18** to the refrigerant-to-water heat exchanger **42** within refrigerant line circuit **34**, while preventing refrigerant from flowing through the refrigerant circuit **36** heating interior space **5**. Also, the controller **44** activates water pump **32** to divert cold water from the tank in water heater **28** to the heat exchanger **42** via valve **48**. In embodiments, when a call for hot water is received by controller **44** during operation of the heat pump **13** in either the space-heating or space cooling modes, the controller **44** will execute algorithms to determine whether to shut-off space-heating or space cooling while diverting the system in order to provide auxiliary hot water heating to the water heater **28** thereby enhancing the operational efficiency of the system **10**. Additional algorithms determine whether to select the space-heating or space cooling modes and the hot water heating mode utilizing a timer to alternate between space-heating or space cooling and hot water heating utilizing, in embodiments, the electric or gas heating elements of the water heater **28** to supplement the hot water demand during. In embodiments, the controller **44** senses the temperature of the interior space **5** and may maintain hot water heating for a predetermined time in order to heat the water to a predetermined minimum temperature if the controller **44** determines that the change in temperature of interior space **5** for the predetermined time may not significantly affect the comfort while the hot water is being heated.

[0019] When operating in the hot water heating mode, recirculating water in refrigerant-to-water heat exchanger **42** increases in temperature. The warmer water in turn causes the refrigerant temperature and pressure to increase as it interacts in the refrigerant-to-water heat exchanger **42**. The increased system pressure drives up the compressor **18** discharge pressure which is a concern for compressor reliability. The increasing discharge pressure can negatively impact the efficiency of the system by causing the compressor **18** to be shut down due to high discharge pressure prior to the water being fully heated. This is especially true when the outdoor ambient temperature (OAT) is approximately 80° F. or higher.

[0020] The heat pump hot water heating mode is shut off at a compressor discharge pressure limit (e.g., 600 psi) which may correspond to manufacturer's recommended maximum compressor discharge pressure. When the heat pump hot water heating mode is shut off, the remaining water heating must be done by backup heaters. Utilizing the backup heaters due to high compressor discharge pressures significantly degrades the overall heating cycle efficiency.

[0021] FIG. **2** illustrates a system for controlling compressor discharge pressure in an exemplary embodiment. To avoid heat pump hot water heating mode shut off, a sensor **50** monitors compressor discharge pressure during heat pump hot water heating mode. When the compressor discharge pressure reaches a discharge pressure limit, some of the refrigerant is allowed to migrate from refrigerant line circuit **34** to the indoor heat exchanger **24**. Controller **44** controls three way valve **38** to allow a small amount of refrigerant vapor to flow to indoor heat exchanger **24** via refrigerant line circuit **36**. This reduces the effective charge level of the hot water heating system and thus reduces the compressor discharge pressure and avoids a compressor shut off. This refrigerant added to the indoor heat exchanger **24** drops in temperature and condenses into liquid, reducing its pressure so that additional refrigerant can be dumped into the indoor heat exchanger **24** if required.

[0022] FIG. **3** illustrates a system for controlling compressor discharge pressure in an exemplary embodiment. The system of FIG. **3** employs a pressure regulating valve **60** at the refrigerant inlet of the refrigerant-to-water heat exchanger **42**. The pressure regulating valve is coupled to a bypass line **62** that connects to an inlet of the indoor heat exchanger **24**. The pressure regulating valve **60** may be set to vent refrigerant to the bypass line **62** when a certain refrigerant pressure is present (e.g., 600 psi) to prevent shut down of compressor **18**. As noted with reference to FIG. **2**, an amount of vapor refrigerant is directed to indoor heat exchanger **24**. This reduces the effective charge level of the hot water heating system and thus reduces the compressor discharge pressure and avoids a compressor shut off.

[0023] The technical effects and benefits of embodiments relate to a high efficiency hybrid space and water heating heat pump system including a hot water module and a water heater operably coupled to the heat pump for providing auxiliary hot water heating to the water heater during operation of the heat pump in the heating mode while forgoing space heating or space cooling of an interior space. The hot water module includes a controller for executing algorithms for controlling one or more valves that diverts vapor refrigerant from a compressor located in the heat pump in an outside environment to a hot water refrigerant circuit in order to heat cold water diverted from the hot water heater.

[0024] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. While the description of the present invention has been presented for purposes of illustration and description, it is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications, variations, alterations, substitutions, or equivalent arrangement not hereto described will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. Additionally, while various embodiment of the invention have been described, it is to be under-

stood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

1. A hybrid space and water heating heat pump system, comprising:

a heat pump including an outdoor assembly and an indoor assembly;

a hot water module including a first heat exchanger, a controller, and a water pump connected to a water line, the first heat exchanger being configured for heating water; and

a water heater in fluid communication with the hot water module, the water heater being configured for receiving the heated water from the first heat exchanger;

wherein the controller is configured to select between one of conditioning an interior space or heating of the water in the first heat exchanger; and

wherein the heat pump is configured for circulating a refrigerant through a first refrigerant circuit in response to the conditioning of the interior space and configured for circulating the refrigerant through a second refrigerant circuit in response to the heating of the water in the first heat exchanger.

2. The system of claim **1**, wherein the heat pump operates in a heating mode in response to the heating of the water in the first heat exchanger.

3. The system of claim **1**, further comprising at least one valve for switching the refrigerant between the first refrigerant circuit and the second refrigerant circuit.

4. The system of claim **1**, wherein the controller controls the flow of the refrigerant between the first refrigerant circuit and the second refrigerant circuit.

5. The system of claim **1**, wherein the first heat exchanger is a refrigerant-to-water heat exchanger for transferring heat from the second refrigerant circuit to water from the water line.

6. The system of claim **1**, wherein the outdoor assembly includes a second heat exchanger, a compressor, an outdoor fan, and an expansion device.

7. The system of claim **6**, wherein the indoor assembly includes a third heat exchanger and an indoor fan.

8. The system of claim **7**, wherein a discharge line of the compressor is coupled to one of the third heat exchanger in response to the conditioning of the interior space or to the first heat exchanger in response to the heating of the water.

9. The system of claim **1**, wherein the controller is configured to disable the conditioning of the interior space in response to the heating of the water.

10. The system of claim **1**, wherein the controller is configured to detect a compressor discharge pressure and divert a portion of the refrigerant from the second refrigerant circuit to the indoor assembly in response to the compressor discharge pressure.

11. The system of claim **1**, further comprising:

a pressure regulating valve at a refrigerant inlet of the first heat exchanger; and

a bypass line connecting the pressure regulating valve to the indoor assembly.

12. A method for controlling space and hot water heating with a hybrid heat pump system including a heat pump coupled to a hot water module and a hot water heater, comprising:

receiving, via a sensor, a control signal indicative of a call for the hot water heating;

determining, via a controller, whether the heat pump is being used for conditioning an interior space; and

switching, via the controller, the heat pump to hot water heating, the switching of the heat pump in response to determining whether to disable the heat pump for conditioning the interior space;

wherein the heat pump includes an outdoor assembly and an indoor assembly;

wherein the hot water module includes a first heat exchanger, the controller, and a water pump connected to a water line, the first heat exchanger being configured for the hot water heating of water in the first heat exchanger; and

wherein the hot water heater being configured for receiving heated water from the first heat exchanger.

13. The method of claim **12**, further comprising selecting between one of conditioning the interior space or the hot water heating of the water in the first heat exchanger.

14. The method of claim **12**, further comprising circulating a refrigerant through a first refrigerant circuit in response to the conditioning of the interior space and circulating the refrigerant through a second refrigerant circuit in response to the hot water heating in the first heat exchanger.

15. The method of claim **14**, further comprising switching, via at least one valve, between the first refrigerant circuit and the second refrigerant circuit.

16. The method of claim **14**, wherein the controller controls flow of the refrigerant between the first refrigerant circuit and the second refrigerant circuit.

17. The method of claim **12**, further comprising configuring the heat pump for a heating mode in response to the hot water heating.

18. The method of claim **12**, wherein the hot water heater includes a hot water retention tank in fluid communication with the hot water module via the water line.

19. The method of claim **18**, wherein the hot water retention tank includes one of electric resistance heating elements or gas heating elements for heating the water contained therein.

20. The method of claim **12**, further comprising diverting refrigerant from a refrigerant inlet of the first heat exchanger to the indoor assembly in response to a pressure of the refrigerant.

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