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(54) SOLAR HEATING AND CENTRAL AIR CONDITIONING WITH HEAT RECOVERY SYSTEM

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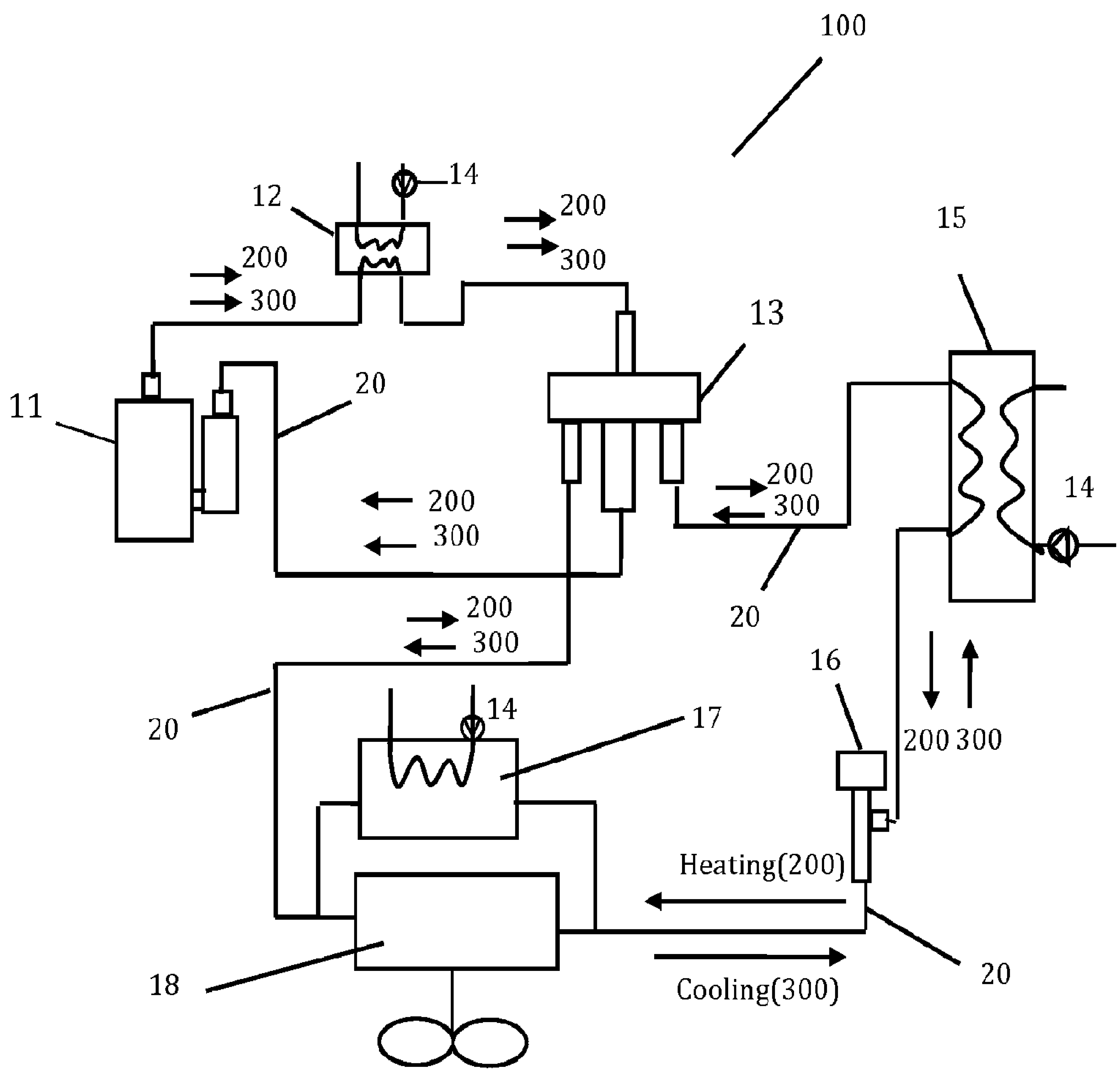
(57) **ABSTRACT**

The present invention discloses a solar heating and cooling central air-conditioning with a heat recovery system. The system includes a solar heating subsystem for providing supplementary energy to a heat pump, a buffer water tank for storing and minimizing energy loss, a domestic water heater for recovering unused heat, and an air handler ventilation and exchanger subsystem. All parts of the system are connected by antifreeze circulation pipes. The present invention combines the solar technology with the heat pump technology, making it work in extreme cold climate. The system is high energy efficient, versatile, safe, reliable, intelligent and flexible in installation.



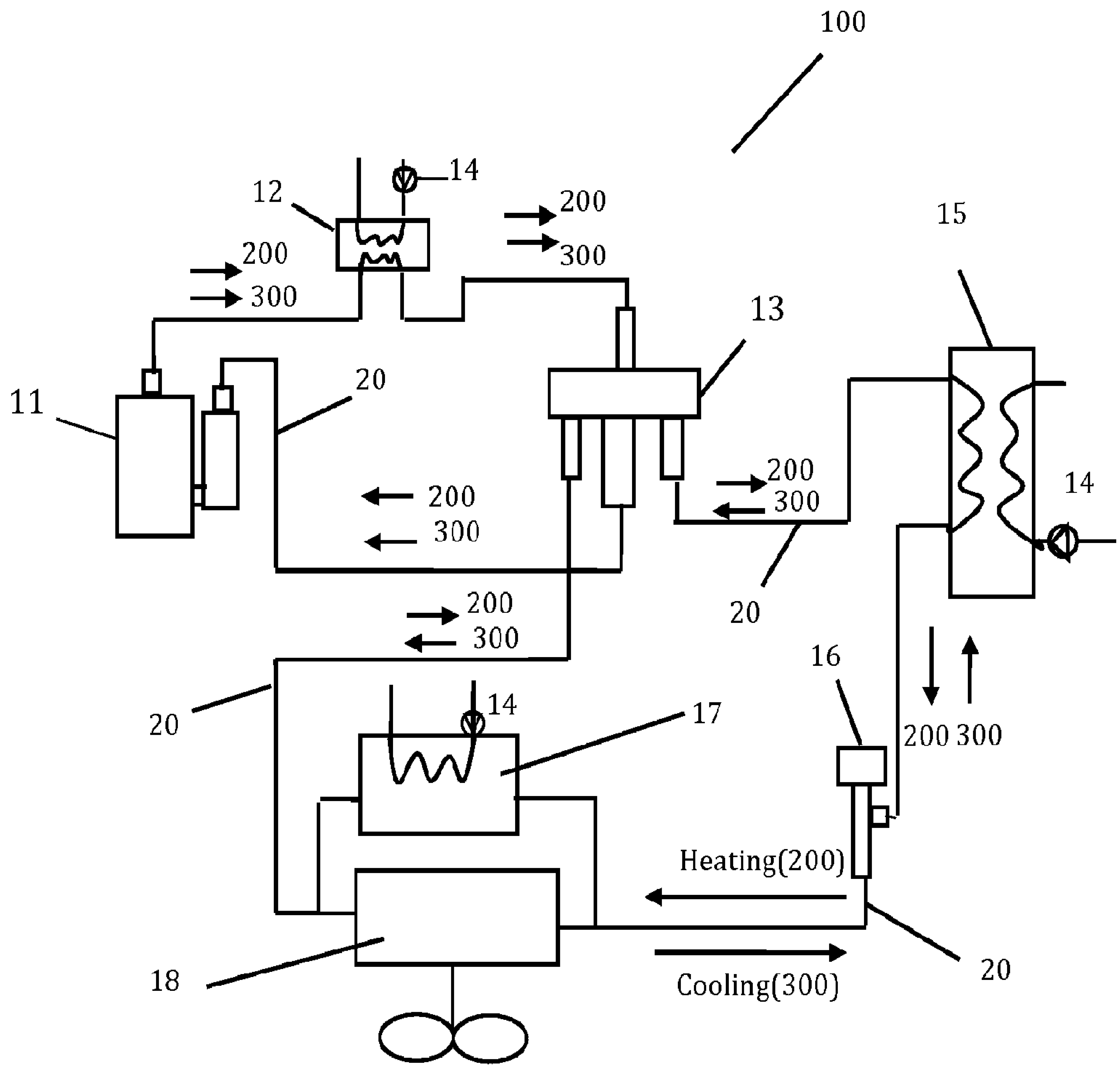

100
12
14
200
300
200
300
15
13
11
20
200
300
14
200
300
20
200
300
16
20
14
17
200 300
Heating(200)
18
Cooling(300)
20

FIG. 1

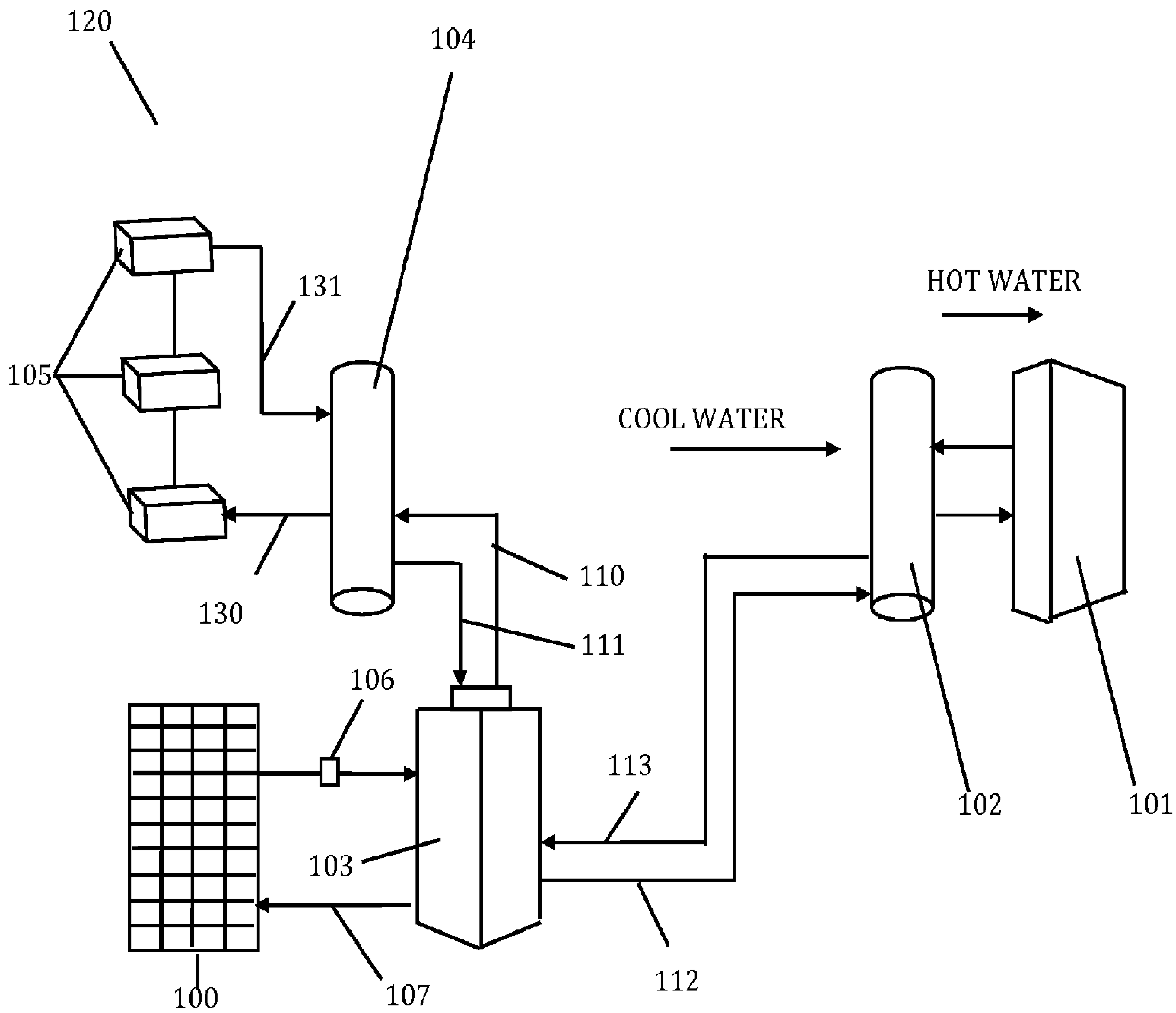

120
104
131
105
HOT WATER
COOL WATER
110
130
111
106
113
102
101
103
100
107
112

FIG. 2

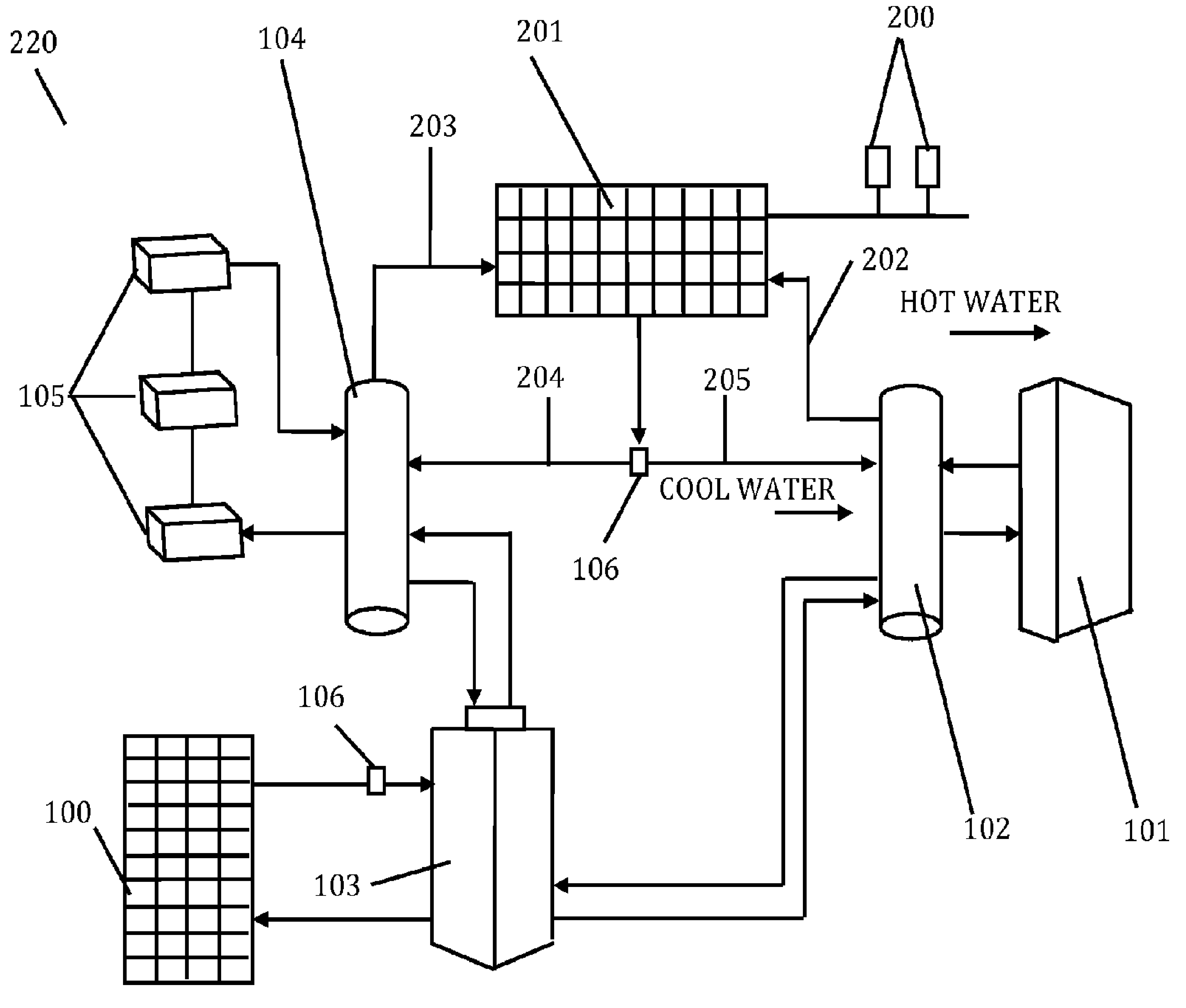

220
104
201
200
203
202
HOT WATER
105
204
205
COOL WATER
106
106
100
103
102
101

FIG. 3

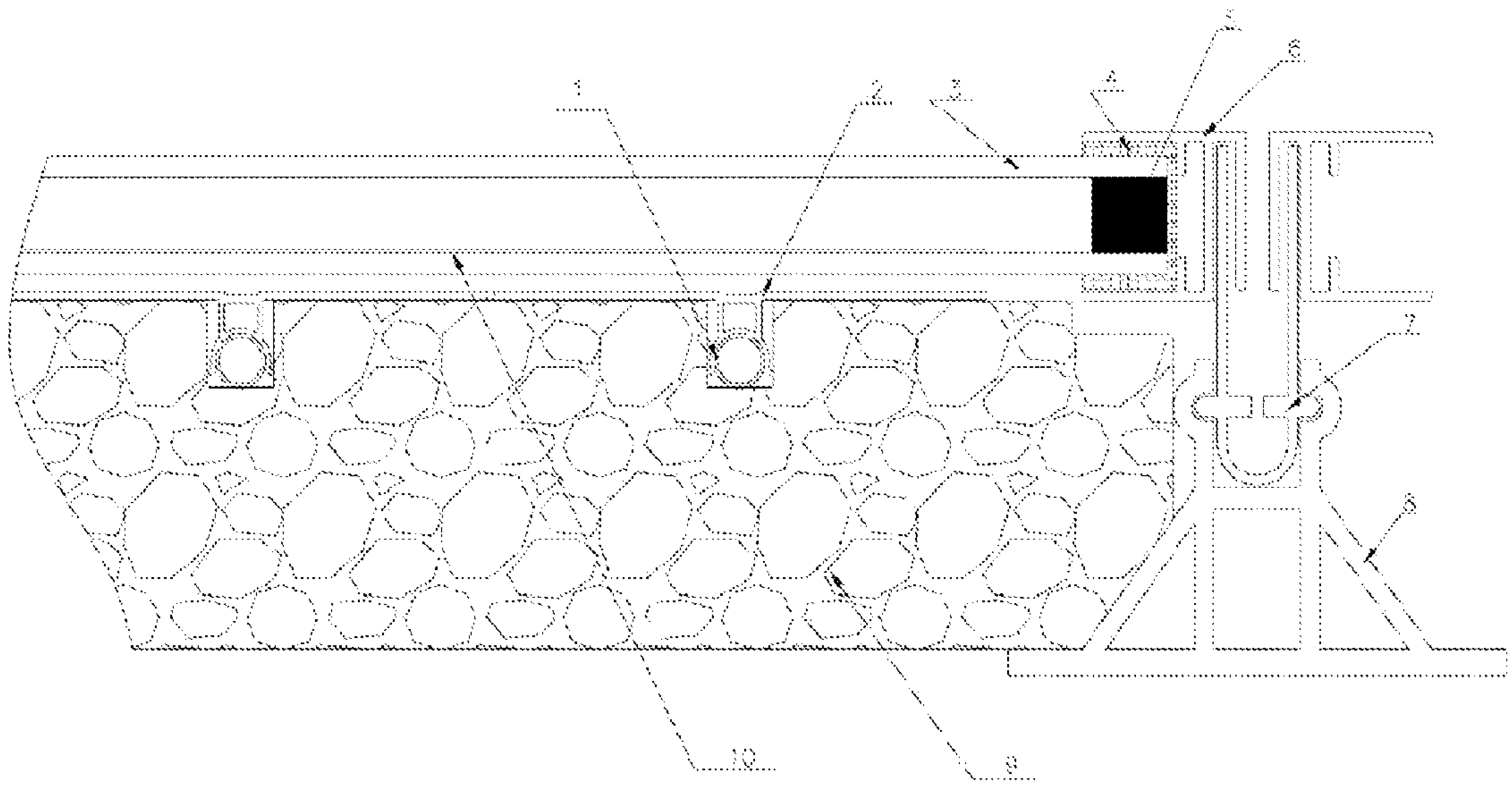


FIG. 4

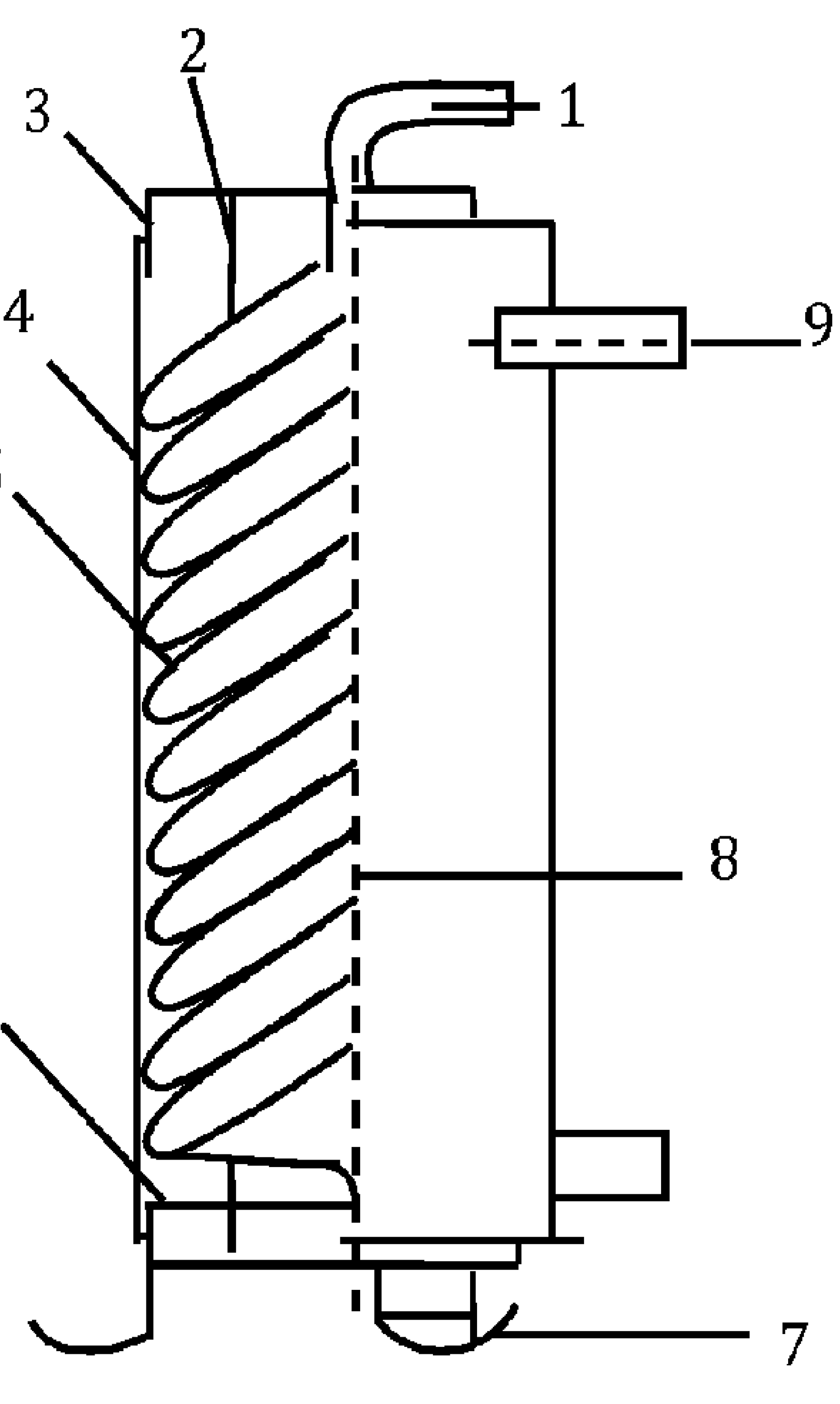


FIG. 5

SOLAR HEATING AND CENTRAL AIR CONDITIONING WITH HEAT RECOVERY SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/771,547, filed on Mar. 1, 2013, which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to heat pump for providing heating and central air conditioning, and specifically relates to solar heating and central air conditioning with heat recovery system.

BACKGROUND OF THE INVENTION

[0003] Heat pumps are commonly used as heating ventilation and air conditioning (HVAC) or heating and cooling systems. A heat pump works as a two-way system, in either heating or cooling mode. It uses the principles of reversed Carnot cycles, and uses a working medium to transfer the energy stored in the environment from outdoor to indoor. This process only consumes a small amount of power in comparing to the power required to heat or cool a place with pure electricity. Therefore, heat pump technology can save a lot of "high-grade" energy, e.g. electricity, in providing heating and cooling needs.

[0004] A heat pump commonly uses outside air as the source. In heating mode, the outdoor coil functions as an evaporator, in which the low pressure medium flowing through carries the thermal energy from the outside air, and is compressed by a compressor, which causes the fluid to turn into highly pressurized vapor. The augmented medium then transfers the energy from the compression and the thermal energy carried from outside to heat inside the building. This is done by a heat exchanger or condenser and pressure-lowing device (e.g. expansion valve), where the high pressured hot vapor cools down and becomes low pressure liquid while releasing heat to the surrounding. It enters into the outdoor coil again and the same process repeats.

[0005] In cooling mode, the thermal energy movement is reversed via a reversing valve. The reversing valve switches the direction of medium flow, and the functions of evaporator and condenser swap. The medium arrives at the compressor as a cool, low-pressured gas, is pressurized through the compressor. The resulting hot, high-pressure vapor flows into the outdoor coil that functions as the condenser, through which the medium leaves the condenser as liquid at much lower temperature. The liquid goes into the evaporator through a very tiny hole, through which the liquid's pressure drops. At the low pressure, the liquid begins to evaporate into a gas while extracting heat from the air around it. The resulting low pressure gas returns to the compressor and the cycle repeats.

[0006] There are two major types of heat pumps that use air as outside source: air to air and air to water systems. In an air to air system, heat is directly released to or extracted from surrounding air inside the building. In an air to water system, heat is released to or extracted from a heating coil inside a water tank, which can be used as floor heating, domestic hot water heating to provide shower and hot water taps in the building. A typical heat pump water heater comprises a compressor, evaporator, condenser, heat exchanger, axial fan, insulated water tank, water pump, fluid tank, filter control, electronic expansion valve and electronic automatic controller. After power is on, the axial fan starts running, the outdoor or ambient air exchanges heat with the evaporator and the resulted lower temperature air is discharged by the fan. Meanwhile, the medium inside the evaporator extracts heat from the air and is vaporized into gas. The compressor then compresses this low pressure working medium gas into the high-temperature, high-pressure gas, then feeds the gas into the condenser. Inside the condenser, the water that is circulated by a water pump is heated by the working medium, then stored inside the insulated water tank. Meanwhile, the working fluid going through the condenser is cooled to a liquid, then flows through an expansion valve to become low pressure liquid before going into the evaporator, and the cycle repeats. This process repeats and gradually heats the water in the insulated water tank until it reaches about 131° F., a suitable temperature for shower and household use.

[0007] Commercial systems, however, still suffer from less than ideal performance, measured by coefficient of performance (COP). For example, when used for heating on a mild day (e.g. outside temperature of 10° C.), a typical air-source heat pump achieves COP of 3~4. Generally, a heat pump is more efficient in hotter climate than cooler climate, so when there is a wide temperature differential between the hot and cold (indoor and outdoor) in a cold climate, the COP is lower. Further, as the heat pump extracts heat from outdoor air, moisture in the air may condense and possibly freeze on the outdoor coil. In extreme cold weather, for example, around −18° C., the COP of a heat pump will approach 1, which is less advantage than a simple electric based heater, thus it is not a commercially viable option. In practice, a heat pump in cold climates often uses an electric heater or fossil fuel heating source as a backup system.

[0008] Therefore, there is a need to improve the efficiency of heat pump systems. There is further a need to keep a heat pump system still in a workable condition in extreme cold weather. Still further, there is a need to provide a more efficient heating and cooling heat pump system, as well as a more economical and safer system for household use.

SUMMARY OF THE INVENTION

[0009] A high energy efficient heat pump heating and cooling system, integrated with solar and heat recovery system, is provided. According to the present invention, a heat recovery exchanger and a solar heat exchanger are integrated with the heat pump system. In heating mode, the working medium comes out of the compressor as hot high pressure gas. The heat recovery exchanger cycles some of the heat from the high pressure gas to a domestic water heater providing hot water for normal household use. The medium coming out of the heat recovery exchanger is still warm enough to heat the inside of the building. Further, the solar exchanger uses the heat collected from a solar panel to provide supplementary heat to the system, thus reduce the workload of the heat pump system, making it more energy efficient. In cooling mode, the compressor converts the working medium into hot high pressure gas. This heat is recycled by the heat recovery exchanger to provide a heat source for the domestic water heater, while helping reduce the load of the heat pump by reducing the temperature of the working medium.

[0010] According to another aspect of the present invention, a buffer water tank is integrated with the heat pump system. The buffer water tank is an insulated water tank that contains water or anti-freeze fluid used to store the energy generated from the heat pump. In heating or cooling mode, the water in the tank is heated or cooled by the working medium to a certain temperature and maintains at a steady temperature, delivering heating or cooling to different areas of the building via low-pressure water or anti-freeze economically and safely. Optionally, a water pump system forces the working medium in the entire system or part of the system to constantly circulate thus maintains at a steady temperature. When user demands heating or cooling from the system, the working medium will be brought quickly to its ideal working temperature without the system having to heat or cool from zero-start.

[0011] According to another aspect of the present invention, a whole house solar panel is integrated with the heat pump system to provide additional heat for both the insulated buffer water tank and a domestic water heater, thus making the heat pump system more energy efficient. According to another aspect of the present invention, a whole house solar power and heating integrated system is integrated to the heat pump system to provide additional heat as well electricity for the building.

[0012] According to another aspect of the present invention, the entire heat pump system is automatically controlled with an integrated intelligent controller for controlling various functions such as controlling the direction of medium flow, pressure change valves, water pumps for circulation, thermostat at various points in the system, solar panel and heat exchanger, and fan coil unit at each room of the building. According to another aspect of the present invention, the domestic water heater can use a back up wall mount heat pump. Other applications may also become apparent as utilized by one skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0014] FIG. **1** shows the functional diagram of an exemplary heat pump controller system according to one aspect of the present invention.

[0015] FIG. **2** shows an exemplary configuration of the heat pump heating and cooling system according to one aspect of the present invention.

[0016] FIG. **3** shows an exemplary configuration of the heat pump heating and cooling system according to one aspect of the present invention.

[0017] FIG. **4** shows an exemplary solar power and heating integrated device as a reference.

[0018] FIG. **5** shows an exemplary water heater exchange system according to one aspect of the present invention.

DETAILED DESCRIPTION

[0019] We disclose here a high energy efficient heat pump controller system by means of a design and construction example according to the present invention. This example, however, is not intended to limit the scope of the present invention.

[0020] For purposes of example, we will consider a heat pump system intended to operate in both hot and extreme cold climate, for example at or above 100° F. or below 0° F. outside. With reference to FIG. **1**, a two-way heat pump system (**100**) comprises pipes (**20**) connecting between various components. By way of example, an environmental friendly heat transfer working medium R-410A is used. The medium flows in two directions depending on the working mode of the heat pump. In heating mode, the medium flows in direction **200**; whereas in cooling mode the medium flows in opposite direction (**300**).

[0021] In heating mode, the coil inside the condenser (**15**) works as a heat exchanger, in which the medium releases heat that in turn exchanges the heat with the water or anti-freeze water flowing from/to a buffer water tank (**104** in FIG. **2**). The heat exchange in turn heats the water in the buffer water tank. The medium runs at about 40-60° C. as high pressure gas before entering the condenser/heat exchanger (**15**) and cools down to about 30-45° C. as high pressure liquid. The water in the buffer water tank in return maintains at about 40-45° C. The medium further goes through a throttling expansion valve (**16**) to become low pressure liquid. Because of the expansion, the medium temperature also drops significantly to about −15~10° C. The medium further arrives in low pressure liquid at outdoor coil (**18**), which functions as evaporator in the heating mode. By absorbing heat from the surrounding air, the medium becomes vaporized gas. At the same time, the medium also gets heated in the solar heat exchanger (**17**) via heat collected from a solar heating panel (**100** in FIG. **2**), where its temperature may raise to −15~15° C. depending on the efficiency of the solar panel. The use of the solar heat exchanger **17** thus helps improving the efficiency of the evaporator **18** by providing supplementary heat. The vaporized gas travels through a multi-direction valve (**13**) and is compressed by a compressor (**11**) to become hot high pressure gas, at the temperature of about 70-85° C. The medium then travels through a domestic water heat exchanger (**12**) to heat the water in a domestic hot water tank (**102** in FIG. **2**) for household use, coming out still as high pressure gas at about 40-60° C. before entering the condenser/heat exchanger (**15**). This cycles then repeats.

[0022] In cooling mode, the medium flow is just the opposite (**300**). The medium arriving at the evaporator/heat exchanger coil (**15**) is in the form of low pressure liquid at temperature around 5-15° C. It in turn cools down the water in the buffer water tank (**104** in FIG. **2**) where the water is maintained at about 7-12° C., while the temperature of the medium increases slightly to about 10-15° C. The medium travels through multi-direction valve (**13**) and arrives directly at the compressor (**11**) as cool low pressure liquid. There, the medium becomes hot high pressure gas at the temperature of about 70-80° C. The medium flows through the domestic water heat exchanger (**12**) to heat the domestic living household water while reducing the temperature itself before it reaches the outdoor condenser **18**. This heat recovery process heats the domestic water for household use while lowering the temperature in the working medium to about 40-60° C. The lowered temperature through this heat recovery process will improve the efficiency of the condenser (**18**) thus the efficiency of the entire heat pump system. The more the living water is used, the more heat exchange occurs at the domestic water heat exchange **12**, and the more efficient the heat pump system is. The medium bypasses solar heat exchanger in the cooling mode, this can be realized by an electronically controlled solenoid valve, which is commercially available. The medium then continue through throttling expansion valve (**16**) to become low pressure liquid at the temperature of about 5-15° C. before returning to the evaporator/heat exchange coil (**15**). The cycle repeats.

An Exemplary Embodiment I

[0023] By way of example, FIG. **2** shows an exemplary heat pump system using the principle aforementioned. According to one aspect of the present invention, the exemplary system (**120**), as shown in FIG. **2**, comprises a heat pump control subsystem (**103**), a solar heating subsystem (**100**), anti-freeze circulation pipes (**106-113**, **130**, **131**), a domestic hot water tank (**102**), a buffer water tank (**104**), an indoor fan coil subsystem (**105**) and optionally a wall-mounted heat pump (**101**). The heat pump control subsystem (**103**) is connected with a solar panel (**100**) that provides supplemental heat energy to the heat pump, making it more efficient. The heat pump control subsystem (**103**) also connects with the buffer water tank (**104**) that stores heated (in the heating mode) or cooled (in the cooling mode) water, to be ready to provide heating or cooling to the house on demand. Further, the heat pump control subsystem (**103**) connects to the indoor fan coil subsystem (**105**) that ventilates hot or cool air to inside the building on demand. The heat pump control subsystem (**103**) further connects to the domestic water heater (**102**) to provide additional heat for providing tap hot water to inside the building. Optionally, another supplementary heat pump or water heater (e.g. a wall mounted unit) is attached to the water heater (**102**) as a backup source to provide continued hot water supply to the house.

[0024] Heating Mode.

[0025] According to one aspect of the present invention, if the outside weather is adequate, the solar subsystem (**100**) silicon photocell array assembly produces heat energy through heating the antifreeze liquid inside the pipes. The heated liquid flows to the heat exchanger (**17** in FIG. **1**) to provide supplementary heat to the heat pump, thus reducing the burden on the heat pump and making the system more efficient. For example, when the outside temperature is −13° F., there is very few heat energy in the air. The use of solar will improve the efficiency of the traditional heat pump system as if it was working under a 50° F. air temperature, and the COP of the system can reach 3.0, which can not be achieved by traditional heat pump.

[0026] The heat produced by the heat pump control subsystem (**103**) is transported to the buffer water tank (**104**) through the water or anti-freeze fluid inside the pipes (**110** and **111**), where the water inside the buffer water tank maintains at a pre-set temperature, for example, in the range of 40-55° C. The temperature control is entirely automatic. Only when the temperature in the buffer water tank falls below a pre-set threshold (e.g. 38° C.) will the cycle of the heat pump control subsystem (**103**) start. Similarly, when the temperature in the buffer water tank reaches a preset threshold (e.g. 56° C.), the heat pump will become standby.

[0027] According to another aspect of the invention, the heat produced by the heat pump control subsystem (**103**) is transported to a domestic hot water tank (**102**) to provide hot water for use inside the house. The domestic hot water tank (**102**) is different from traditional hot water heater that uses electric coils or gas hot water that uses gas burner. The water heated by the heat pump system may reach lukewarm that is sufficient for hand washing, laundry, dish washing or even shower. However, from a practical standpoint, the domestic hot water tank is also connected to a backup heating system or a secondary water heater to provide high temperature hot water for household use. Alternatively, the heat pump system can be integrated with a whole house solar system as a primary source of heating for domestic hot water (FIG. **3**). The domestic hot water tank (**102**) for heat pump use is simple in construction in that it does not have any electric coils or gas burners. According to one aspect of the present invention, the heating exchanger (**12** in FIG. **1**) is built into the heat pump system thus all pipes containing the heat transfer working medium are reduced to minimum length, which can be made to be contained in a heat pump unit.

[0028] According to another aspect of the present invention, the heat exchanger can be made inside the domestic hot water tank, where the working medium of the heat pump system flows through. With reference to FIG. **5**, the water heater comprises of an insulated tank (**4**), working medium inlet (**1**), coils (**5**) containing the working medium, fixtures (**2**, **6**) for fixing the coils to the tank (**4**), the working medium outlet (**9**), and the base (**7**). Filled in the tank is household tap water flowing in and out the water tank in regular home pluming pipes. Coils (**5**) containing the working medium are made from copper or other materials as commercially available. Optionally, a water pump for circulating the working medium can be installed at inlet or outlet of the coil (**1** or **9**) or other section of the pipe systems. The cost associated with building such water heater is minimal, and is outweighed by the benefits in energy saving.

[0029] Cooling Mode.

[0030] According to another aspect of the invention, and with reference to FIG. **2**, the heat pump control subsystem (**103**) can work in a cooling mode whereas the working medium inside the pipes flows in the opposite direction. When the medium comes out of the throttling expansion valve (**16** in FIG. **1**), the low temperature 5~15° C. arrives at the evaporator/heat exchanger (**15** in FIG. **1**) to lower the water temperature inside the buffer water tank (**104**), which is maintained at a predefined temperature range, for example, 7~12° C. Similar to heating mode, the cycle of heat pump control subsystem (**103**) is entirely automatically controlled depending on water temperature inside the buffer water tank (**104**). When the water temperatures drops to a predefined threshold, e.g. 5° C., the heat pump system will become standby. When the water temperature reaches a predefined threshold, e.g. 12° C., the heat pump system will start the cooling cycle. In cooling mode, according to one aspect of the present invention, the solar subsystem **17** will be shut off. Instead, the condenser (**18** in FIG. **1**) is used to cool down the medium in the pipe before the medium reaches the throttling expansion valve (**16** in FIG. **1**).

[0031] The structure of buffer water tank (**104**) is similar to that of the domestic water heat (**102**) except that the buffer water tank is a concealed unit such that the water (or other medium) cycles completely in a concealed loop to various fan coil units inside the building. The heat exchange coil for heating or cooling the buffer water tank (**104**) can be placed inside the heat pump system or inside the buffer water tank depending on the location of the buffer water tank.

[0032] Throttling expansion valves are readily commercially available, such as model AAE5 manufactured by AMS Electronics in Shenzhen, China. Water pumps and valves aforementioned are also readily commercially available, which are commonly used in heating systems.

[0033] According to one aspect of the invention, and with reference to FIG. **2**, a fan coil subsystem is installed inside the house, which is advantageous to traditional forced air HVAC system that requires high initial cost on installing duct pipes inside the house. Instead, the fan coil subsystem comprises ventilation fan and coils (**105**) installed at each room or heating/cooling area inside the building, and PVC pipes (**130**, **131**) connecting therefrom to the buffer water tank. While much of the heating/cooling and heat exchanging elements can be contained inside a heat pump control subsystem (**103**), the connection to in-house fan coil subsystem is made by low cost PVC pipes containing water or anti-freeze medium at low pressure. This provides safe and environmental friendly configuration as well as low installation cost inside the house in comparison to traditional forced air HVAC system. The PVC pipes for connecting to fan coil subsystem are typically 0.5-1" in diameter, making them much easier and economical to install inside a building than traditional duct system. Fan coil units are commercially made in various configurations such as vertical exposed, or concealed inside a wall or ceiling. Such example is Trane's HFCA/XA, VFCA/XA fan coil unit that provides air flow of 300 m^3/h~2280 m^3/h.

[0034] Inside the PVC pipes is the water or anti-freeze that circulates from the buffer water tank (**104**) through the fan coil subsystem and back to the buffer water tank (**104**) in a concealed loop. According to one aspect of the invention, a water pump is installed in the pipe system and adapted to cause the water in certain zones of frequent demand to circulate constantly at a relative stable temperature, even there is no demand for heating or cooling. Each ventilation fan inside the building can be turned on independently, heating or cooling only the specific room/area on demand. When a ventilation fan is turned on, the water or anti-freeze will circulate through the coil inside the fan coil unit and the fan blows out warm or cold air to the area. Each fan unit can be controlled by a thermostat controller, allowing user to set a desired temperature in individual room or a zone inside the building. Once a room or zone is set to a desired temperature, the water or anti-freeze in that area circulates to/from the buffer water tank to bring heating or cooling to the desired area, and the operation of the fan coil unit will operate automatically until the desired temperature is reached.

[0035] According to one aspect of the present invention, the thermostat for each room can have other functions such as timer, program setting and so on. While a fan unit is turned on, more energy is drawn to that particular room/area. First, the working medium inside the circulation pipe (**130**, **131**) will bring needed energy to each living area through respective fan coil units (**105**) and bring the temperature of the area to a comfortable desired setting T**1**. At the same time, the automatic control system (as part of the heat pump control subsystem) also monitors the temperature inside the buffer water tank (**104**). If the temperature reaches above T**2** in cooling mode or below T**3** in heating mode, the cycle of the heat pump subsystem (**103**) starts to bring the water inside the buffer water tank (**104**) to the desired preset temperature. Normally, in heating mode, T**1** is around 40° C. and T**3** is around 45° C., whereas in cooling mode T**1** is around 7° C. and T**2** is around 12° C.

[0036] According to another aspect of the invention, when the water temperature inside the buffer water tank exceeds a normal range, e.g. falls outside the 2° C.~60° C., it is indicative of a malfunction of the system and the heat pump is going into shut-off mode and user should be alerted of the situation.

[0037] According to one aspect of the present invention, the layout of the pipes (**130**, **131** in FIG. **2**) can vary and can be designed for the system to work at its best performance with minimum loss of energy. For example, pipes can be laid out by zones. Instead of a single pipe coming out of the buffer water tank, multiple pipes come out of and return to the buffer water tank, each serving a different zone.

[0038] According to another aspect of the invention, a water pump is installed in the pipes for each zone to provide circulation of the working medium. Depending on the living style, the patterns of circulation of working medium inside each zone can differ. For zones that demand heating or cooling more frequently, the working medium can be circulated more frequently or constantly, whereas for zones of lower demand the working medium can circulate infrequently or circulate only when it is needed. This would minimize the loss of energy when a zone is not in demand completely.

[0039] According to another aspect of the present invention, an intelligent energy saving control subsystem can be installed to moderate the operation of the system according to user's usage of energy. For example, the intelligent energy saving subsystem automatically monitor user's setting in each area, frequency of use, duration of each demand, timing etc. According to one aspect of the present invention, if a demand for a particular zone can be predicted based on the past usage, and the system may prepare such demand by starting circulating the working medium in that zone at a predetermined time (e.g. 5 minutes, 30 minutes, 1 hour etc.) before such demand is expected. Once the demand is requested, the temperature of the area in demand can be brought to the desired level effectively in a short time.

[0040] The primary energy consumption is from the operation of the heat pump control subsystem to run the compressor, evaporator, condenser etc. This power consumption can be reduced by various components according to the present invention. For example, the integration of solar heating system will provide supplementary heat energy to raise the temperature of the working medium, thus reduce the burden of the heat pump system. Further, the integration of the domestic water heating system also helps recover wasted energy from the heat pump system while helping cooling down the temperature of the working medium in the summer, thus again reducing the burden of the heat pump system. Still further, the integration of the buffer water tank and careful design of the fan coil subsystem help reduce the energy loss to minimum thus reduce the power consumption of the system. Various electronic controls and the operation of water pumps are all low power consumption, needing only about 200 Watts for a system serving a moderate size home.

An Exemplary Embodiment II

[0041] By way of example, FIG. **3** shows another exemplary heat pump system according to one aspect of the present invention. With reference to FIG. **3**, a whole house solar power and heating system is integrated.

[0042] The use of solar energy can be divided into four categories, including light to heat (thermal use), light to electricity, light to chemical utilization, and light to bio-utilization. In these four types of solar energy uses, light to thermal conversion technology is the most mature, and many products are made at relatively low cost. For example, solar water heaters, solar water boilers, solar dryers, solar cookers, solar greenhouse, solar house, solar desalination unit and solar heating and are seen in commercial use. Within this category, perhaps solar water heaters have the most extensive use due to their mature technologies and economy. The solar light to heat system mainly converts collected solar radiation into heat. A typical solar collection device includes solar collector, vacuum tube collectors and focusing collectors.

[0043] In converting solar into electricity power, there are mainly two methods: one is light-heat-electricity conversion, namely generating the electric power by solar radiation, in which process solar collectors convert thermal energy into steam of a working fluid and generate power by steam-driven generators. This method is a combination of light to thermal conversion and heat to electricity conversion. The second method is light to electricity conversion. The basic principle is to exchange solar radiation directly into electricity with photovoltaic effect, using solar cells as the basic unit.

[0044] Integrated solar heating and power generation at the same time have higher solar conversion efficiency than traditional photovoltaic power generation. For example, the U.S. patent application 2013/0269755 titled "Solar Glass Thermoelectric Integrated Device" to Songshun Xu teaches an integrated solar heating and power generation device, which patent is incorporated by reference. A cross section of the device taught by Xu is also shown in FIG. **4**.

[0045] With reference to FIG. **3**, a whole house solar power and heating integrated board (SPHIB) system (**201**) is integrated into the heat pump system according to one aspect of the present invention. The SPHIB system generates electricity that is used by home appliances and other devices (**200**). The SPHIB system is connected to both the buffered water tank (**104**) through pipes (**203**, **204**), where the pipes go through the solar device (e.g. heat collecting tube **1** in FIG. **4**). The heat generated by SPHIB system is used to heat the water in the buffer water tank (**104**). Again, the medium circulating between the buffer water tank (**104**) and SPHIB system (**201**) and flowing through connecting pipes (**203**, **204**) is water or anti-freeze fluid, operating in low pressure. Other medium may be used as well. The SPHIB system (**201**) can be used as the primary source of heating the water in the buffer water tank as it works more effectively and quickly in a sunny day even in the winter. In return, this significantly reduces the work load of the heat pump subsystem (**103**), thus making the heat pump subsystem secondary because it does not have to work as hard to heat the water in the buffer water tank. Depending on the number of solar panels used in the SPHIB system (**201**), the efficiency of the heat pump system varies. The more solar panels the SPHIB uses, the more efficient the heat pump system is.

[0046] According to one aspect of the present invention, the integrated solar heating subsystem (**100**) can still be used standalone for the heat pump control subsystem (**103**) as a supplementary source of energy. The solar heating subsystem (**100**) does not need to be of large size and it can be versatile and portable without requiring to install a whole house solar system. In a typical configuration, the solar heating subsystem (**100**) can be 2 square meters in area (with about 1.85 square meters of heat collecting area). According to another aspect of the present invention, the solar heating subsystem (**100**) can be substituted by the whole house solar system SPHIB (**201**). This is particular desirable if the whole house solar system is already installed. In this case, pipes can be installed to connect the heat pump control subsystem (**103**) and the whole house solar system SPHIB heating pipes in the similar fashion as the buffer water heater (**104**).

[0047] According to another aspect of the present invention, the whole house solar system (**201**) is connected to the domestic water heater (**102**), where the heat collected from the solar system is carried by the working medium flowing in the pipes (**202**, **205**) to the water heater (**102**), where it heats the tap water for household use. This works for both heating and cooling mode, similar to the embodiment as shown in FIG. **2**, with the difference that the SPHIB can work as a primary heating source for the domestic water heater.

[0048] The solar heating and cooling system and various embodiments are disclosed here only to show various aspects of the present invention. Extensions, variations as may be clear to one skilled in the art shall not depart from the scope of the present invention. For example, the working medium used in the pipes can be different from R401A as required by the demand. Other medium such as R-744 or more environment friendly medium, such as R600A or other medium to be later developed, may also be used.

[0049] Further, as different medium may require different working pressure, different pipes may be used to accommodate this requirement. According to one aspect of the present invention, PVC pipes with copper or stainless steel core, which are commercially available, are used. Although all PVC pipes that are exposed to outdoor climate are insulated to prevent freezing inside, PVC pipes with copper or stainless core gives special advantages to withstanding cold or hot, e.g. −40° F.~204° F., and prevents pipe burst from freezing. Other pipes may also be used as justified by their cost and requirement.

[0050] Further, to withstand extreme cold weather, other than the condenser (**18** in FIG. **1**), all components can be place indoors. In this way, the system can still work under −25° C. Still further, the medium inside the buffer water can be water or other anti-freeze fluid, and the heat exchange coil can be inside the tank (**104** in FIG. **2**) or inside the heat pump subsystem (**103** in FIG. **2**). If the heat exchange coil (**15** in FIG. **1**) is installed inside the heat pump subsystem, then the buffer water tank will be structured as an empty tank and functions as a water storage only, reducing the cost of the tank even further.

[0051] Still further variations, including combinations and/or alternative implementations, of the embodiments described herein can be readily obtained by one skilled in the art without burdensome and/or undue experimentation. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

1. A heat pump heating and cooling system for working in a heating or cooling mode comprising:

a first heat transfer medium;

a heat pump control subsystem comprising a compressor, an evaporator, a condenser and an expansion valve, containing the first heat transfer medium therein and adapted to operate in a heating or cooling mode;

a first heat exchanger connected to a buffer water tank for transferring heat between the first heat transfer medium contained in the heat pump control subsystem and a second heat transfer medium contained in the buffer water tank;

a second heat exchanger connected to a solar heat subsystem and adapted for providing supplementary heat to said heat pump control subsystem in the heating mode; and

a third heat exchanger connected to a domestic water heater and adapted for transferring heat produced from the said heat pump control subsystem to the domestic water heater;

whereby said buffer water tank containing an inlet and an outlet adapted to connect to one or more fan coil units carrying a flow of the second heat transfer medium for heat delivery.

2. The system of claim **1**, wherein the first heat transfer medium is one of the R-410A, R-744 and R600.

3. The system of claim **1**, wherein the second heat transfer medium is water or anti-freeze fluid.

4. The system of claim **1**, wherein the first heat exchanger is adapted to be installed inside the buffer water tank.

5. The system of claim **1**, wherein the first heat exchanger is adapted to be installed inside the heat pump control subsystem.

6. The system of claim **1**, wherein the solar heat subsystem is a solar heat collecting panel or a whole house solar heating system.

7. The system of claim **1**, wherein the solar heat subsystem is a whole house solar thermoelectric integrated system.

8. The system of claim **1**, wherein the solar heat subsystem is connected to the buffer water tank and adapted to provide supplementary heat to said heat pump control subsystem.

9. The system of claim **1** further comprising a control circuit is adapted to maintain the temperature of the second heat transfer medium contained in the buffer water tank within a first preset range.

10. The system of claim **9**, wherein the control circuit is adapted to control operation of one or more fan coil units to maintain interior temperature within a second preset range.

11. The system of claim **9**, wherein the control circuit is adapted to estimate a start time based on past usage of the system and kick-start the heat pump control subsystem at a predefined interval time before said estimated start time.

12. A heat pump heating and cooling system for working in a heating or cooling mode comprising:

a first heat transfer medium;

a heat pump control subsystem comprising a compressor, an evaporator, a condenser and an expansion valve, containing the first heat transfer medium therein and adapted to operate in a heating or cooling mode;

a first heat exchanger connected to a buffer water tank for transferring heat between the first heat transfer medium contained in the heat pump control subsystem and a second heat transfer medium contained in the buffer water tank;

a second heat exchanger connected to a domestic water heater and adapted for transferring heat produced from said heat pump control subsystem to the domestic water heater;

whereby said buffer water tank containing an inlet and an outlet adapted to connect to one or more fan coil units carrying a flow of the second heat transfer medium for heat delivery.

13. The system of claim **12**, wherein the first heat transfer medium is one of the R-410A, R-744 and R600.

14. The system of claim **12**, wherein the second heat transfer medium is water or anti-freeze fluid.

15. The system of claim **12**, wherein the first heat exchanger is adapted to be installed inside the heat pump control subsystem.

16. The system of claim **12** further comprising a solar heat subsystem adapted to provide supplementary heat to the heat pump control subsystem in the heating mode.

17. The system of claim **12** further comprising a solar heat subsystem connected to the buffer water tank and adapted to provide supplementary heat to the second heat transfer medium contained therein.

18. The system of claim **12** further comprising a control circuit is adapted to maintain the temperature of the second heat transfer medium contained in the buffer water tank within a first preset range.

19. The system of claim **18**, wherein the control circuit is adapted to control operation of one or more fan coil units to maintain interior temperature within a second preset range.

20. The system of claim **18**, wherein the control circuit is adapted to estimate a start time based on past usage of the system and kick-start the system at a predefined interval time before said estimated start time.

21. The system of claim **12** further comprising a plurality of pipes carrying flow of the second heat transfer medium, wherein at least one of the plurality of pipes is made of PVC/copper or PVC/stainless steel composite material.

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