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(54) **SYSTEM AND A METHOD FOR AIR CONDITIONING AND HEAT EXCHANGER ARRANGEMENT**

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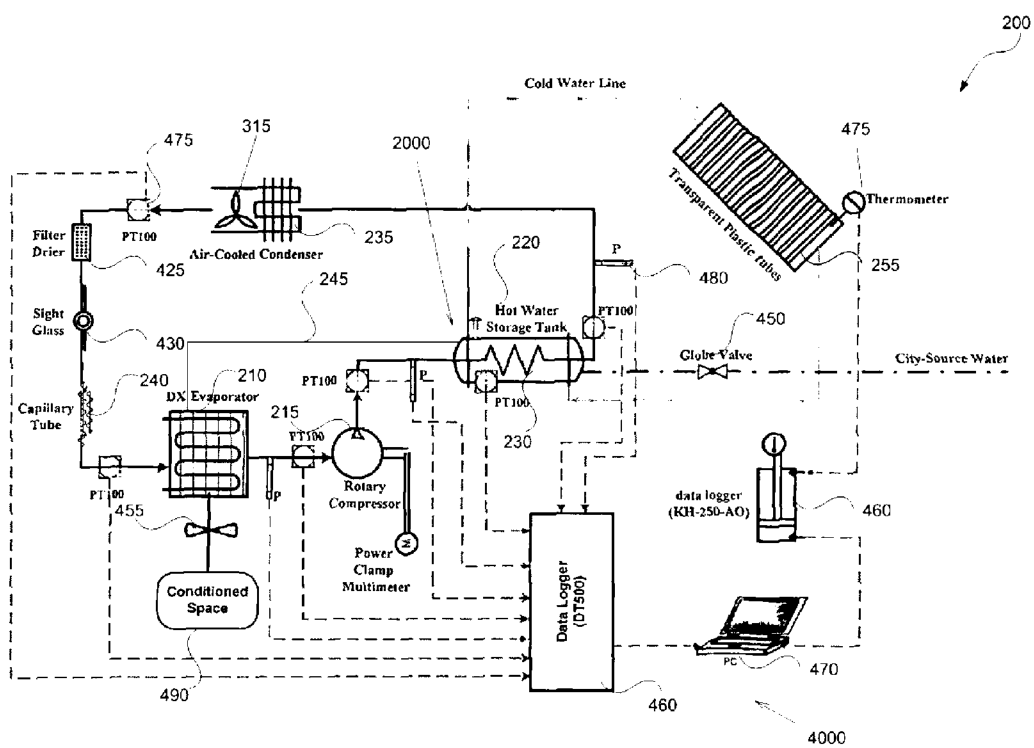
(57) **ABSTRACT**

The present invention relates to an air-conditioning system, and a heat exchanger arrangement for fitting to an air-conditioning system, the heat exchanger arrangement using water condensed on the evaporator as a coolant to cool the refrigerant after it has been compressed by the compressor, and before it is directed to the condenser.



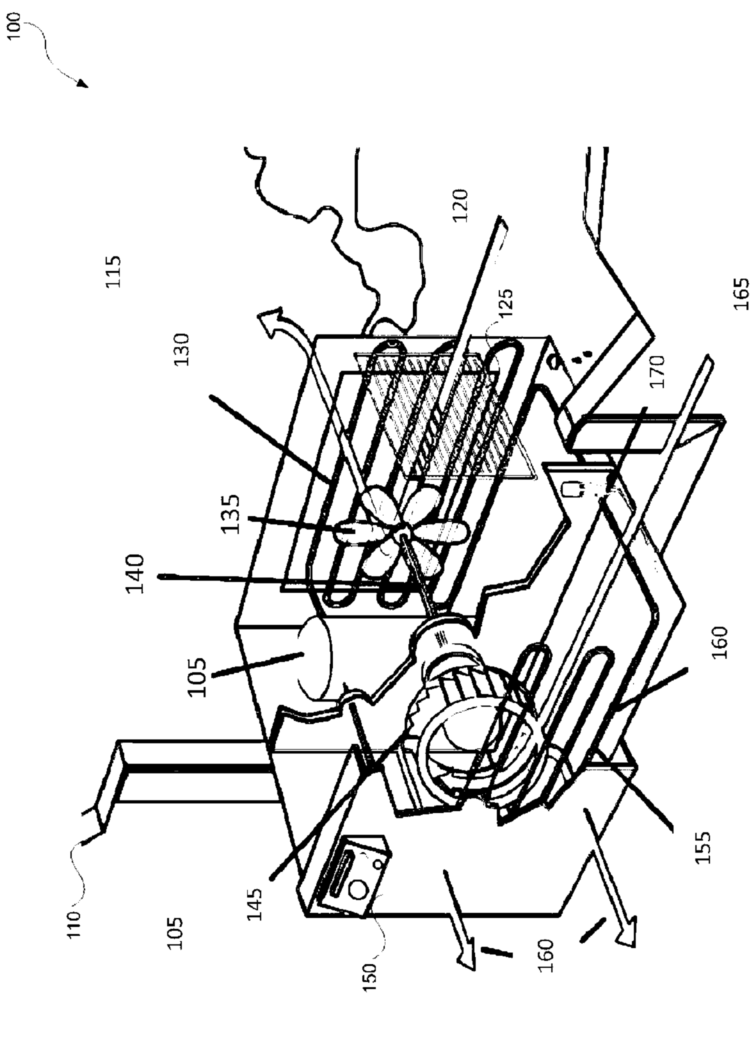


Figure 1 (PRIOR ART)

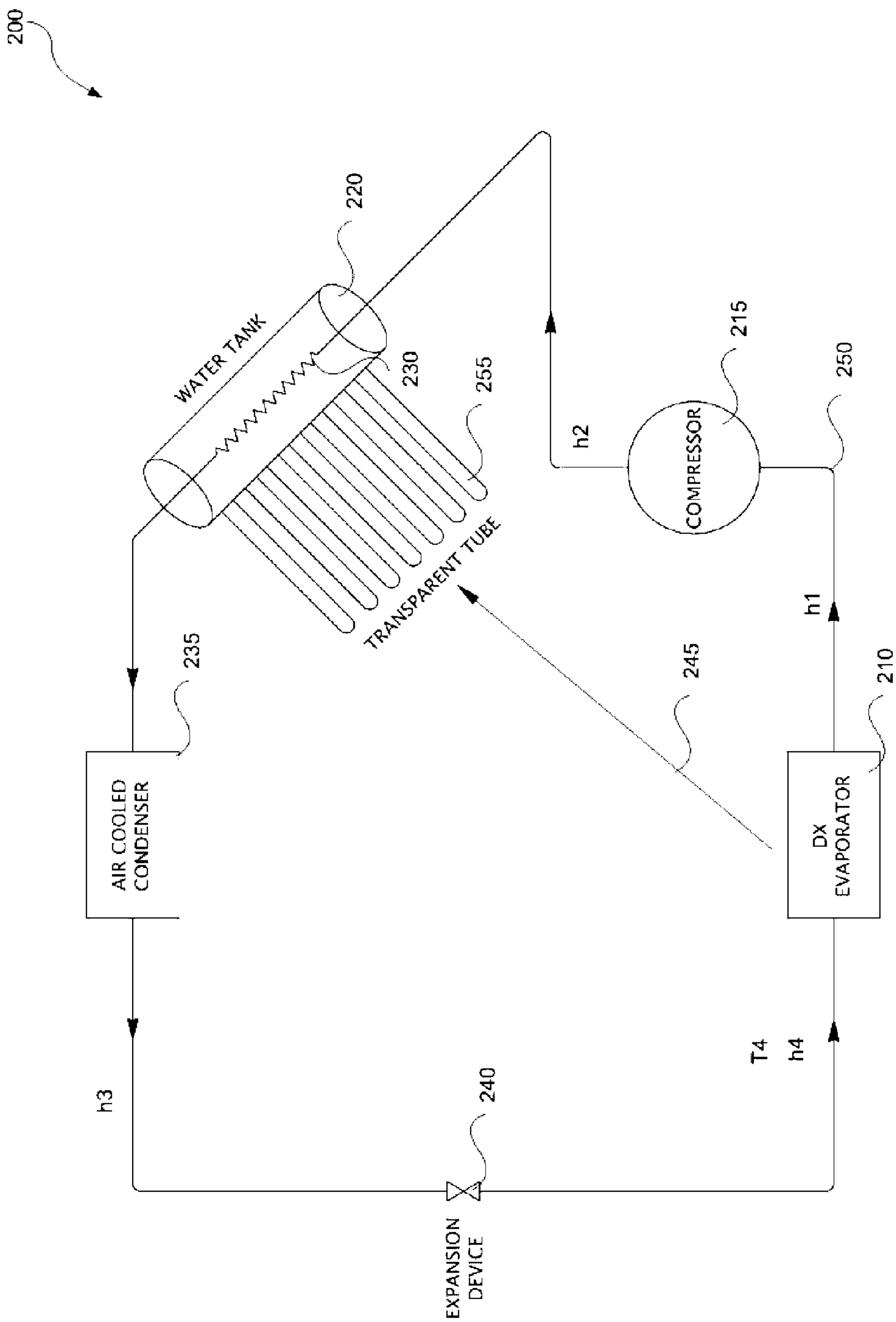

200
220
WATER TANK
230
255
TRANSPARENT TUBE
215
COMPRESSOR
250
h2
h1
245
235
AIR COOLED CONDENSER
210
DX EVAPORATOR
T4
h4
h3
240
EXPANSION DEVICE

Figure 2

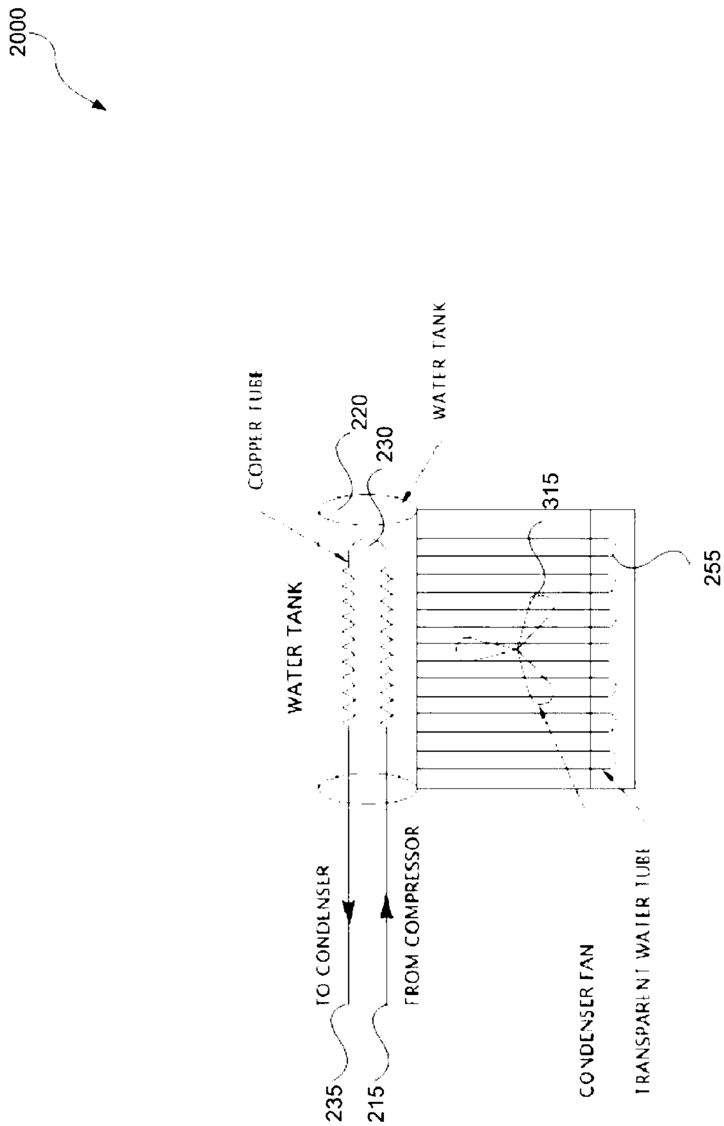

2000
COPPER TUBE
220
230
WATER TANK
WATER TANK
315
255
TO CONDENSER
FROM COMPRESSOR
CONDENSER FAN
TRANSPARENT WATER TUBE
235
215

Figure 3

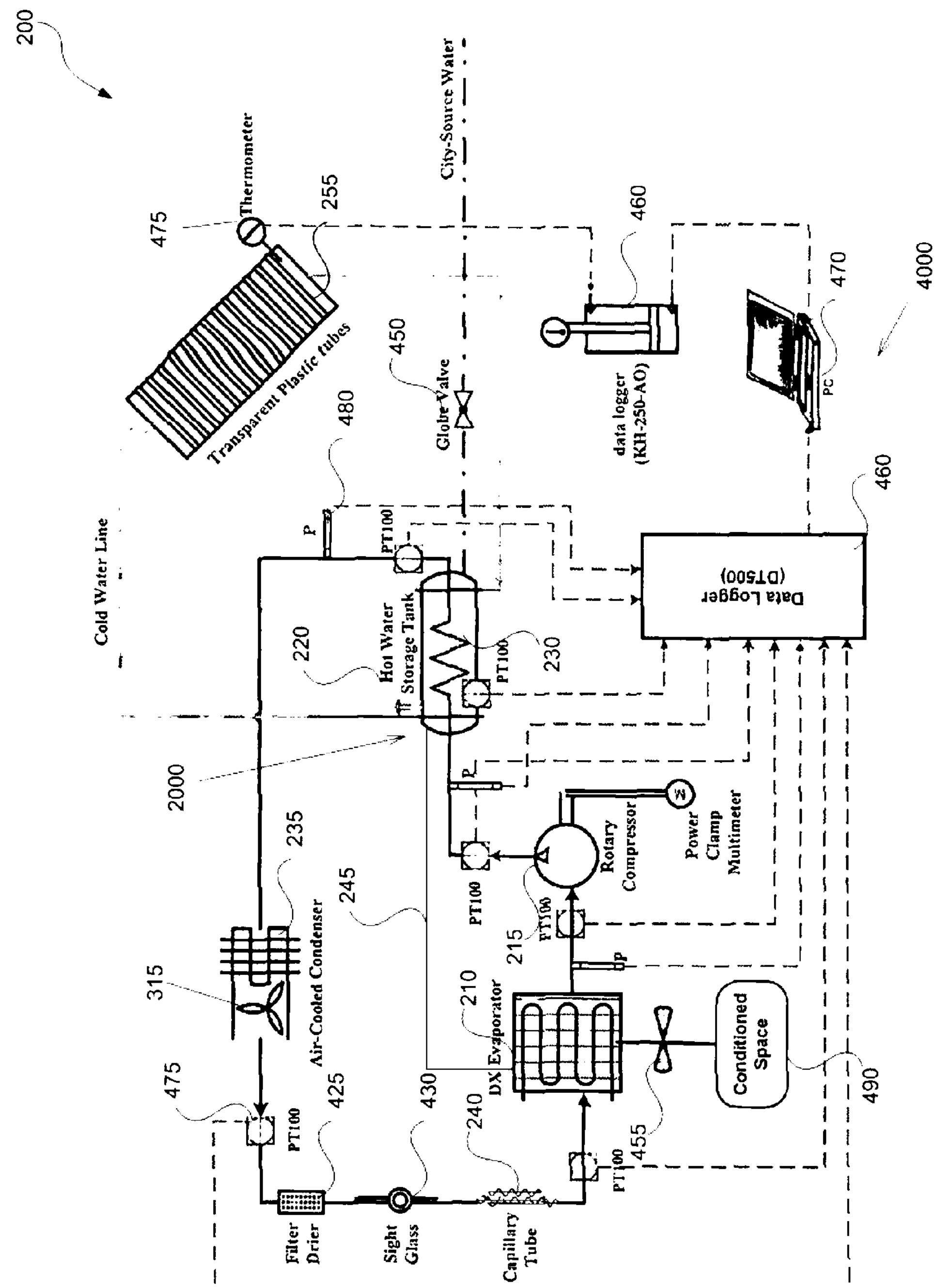

200
Thermometer
475
255
Transparent Plastic tubes
City-Source Water
460
450
Globe Valve
480
data logger
(KH-250-AO)
PC
470
4000
Cold Water Line
P
PT100
Hot Water
Storage Tank
220
230
PT100
Data Logger
(DT500)
460
2000
P
235
Air-Cooled Condenser
315
245
PT100
Rotary
Compressor
Power
Clamp
Multimeter
215
PT100
P
210
DX Evaporator
Conditioned
Space
490
475
PT100
425
430
240
455
PT100
Filter
Drier
Sight
Glass
Capillary
Tube

Figure 4

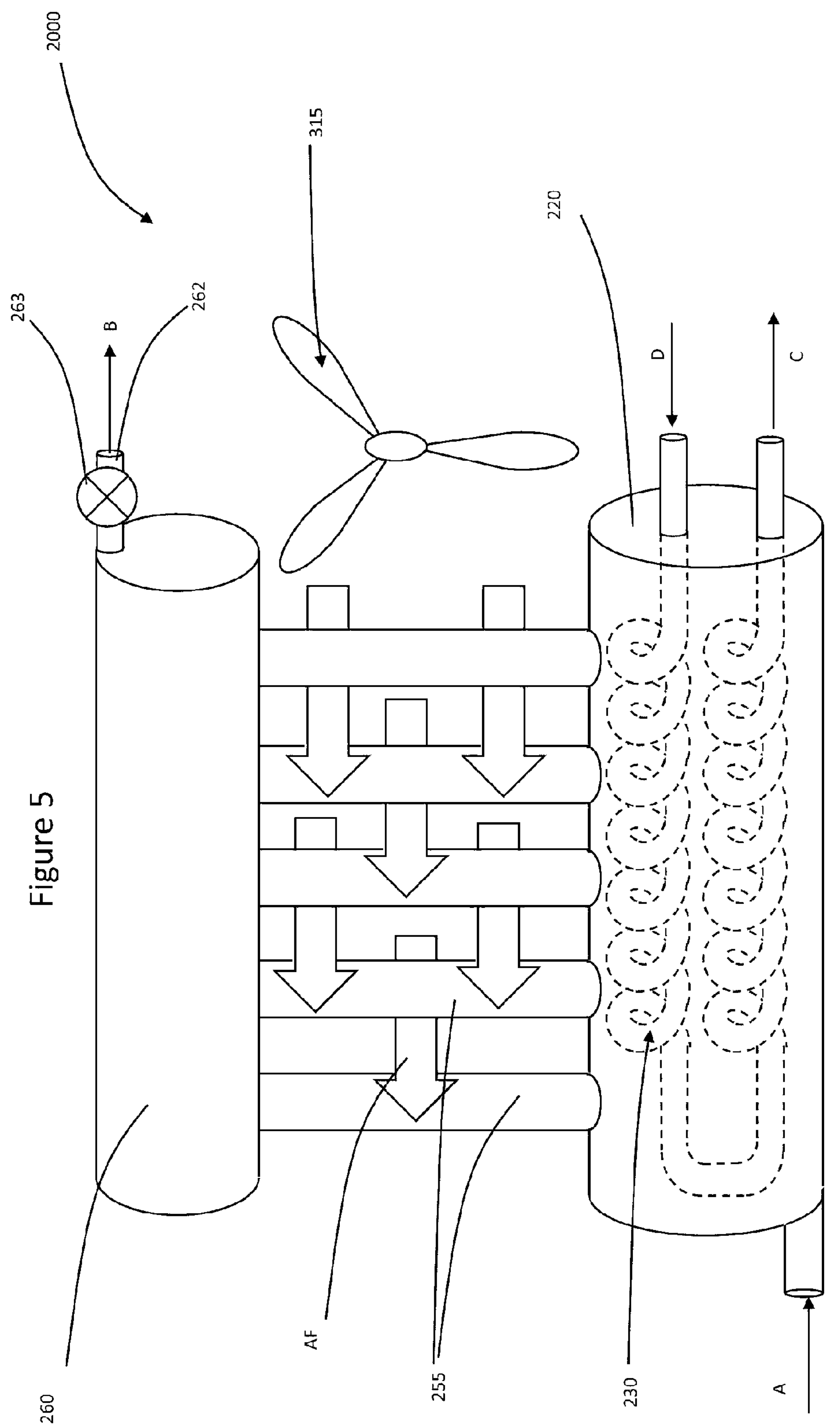


Figure 5

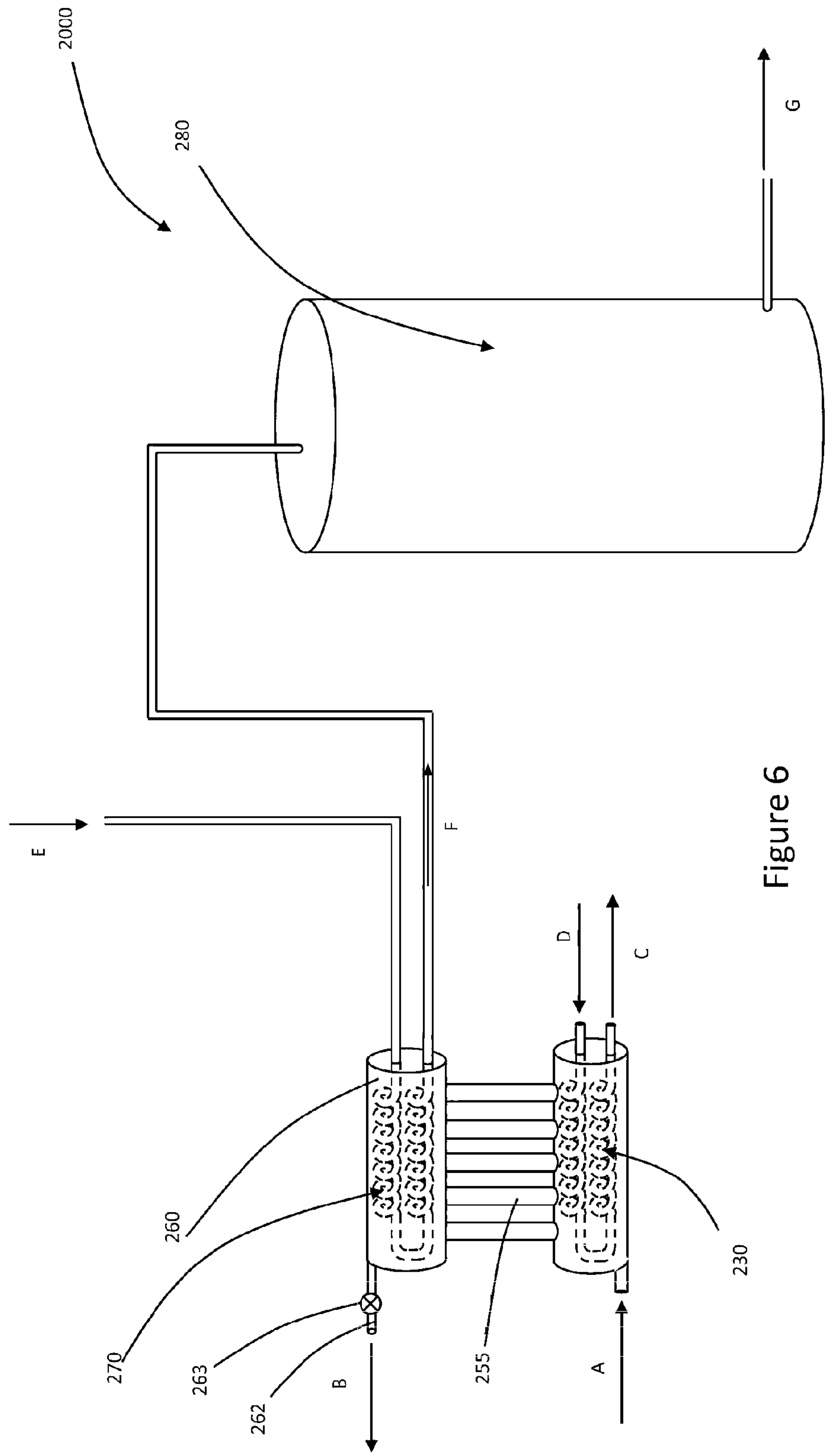


Figure 6

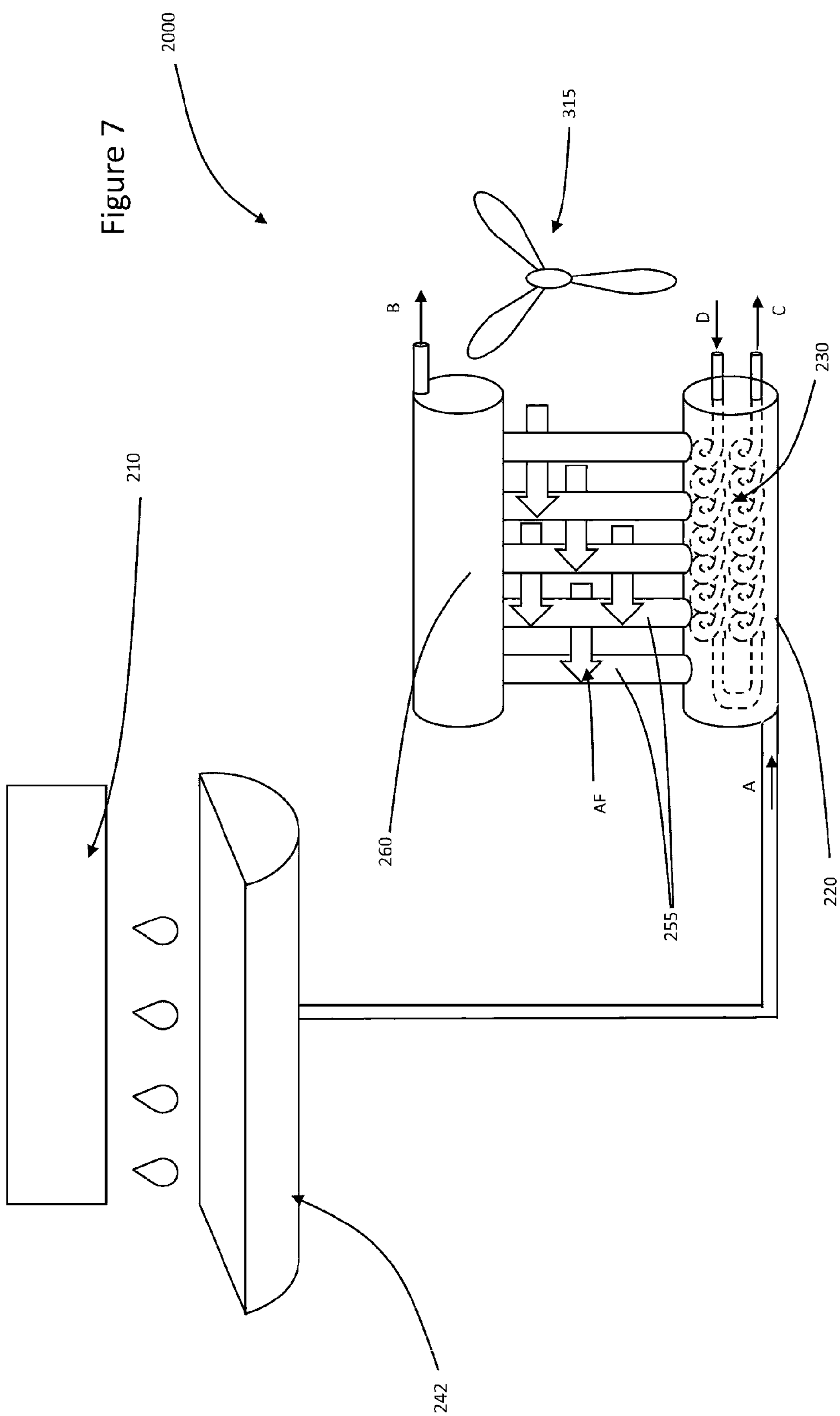


Figure 7

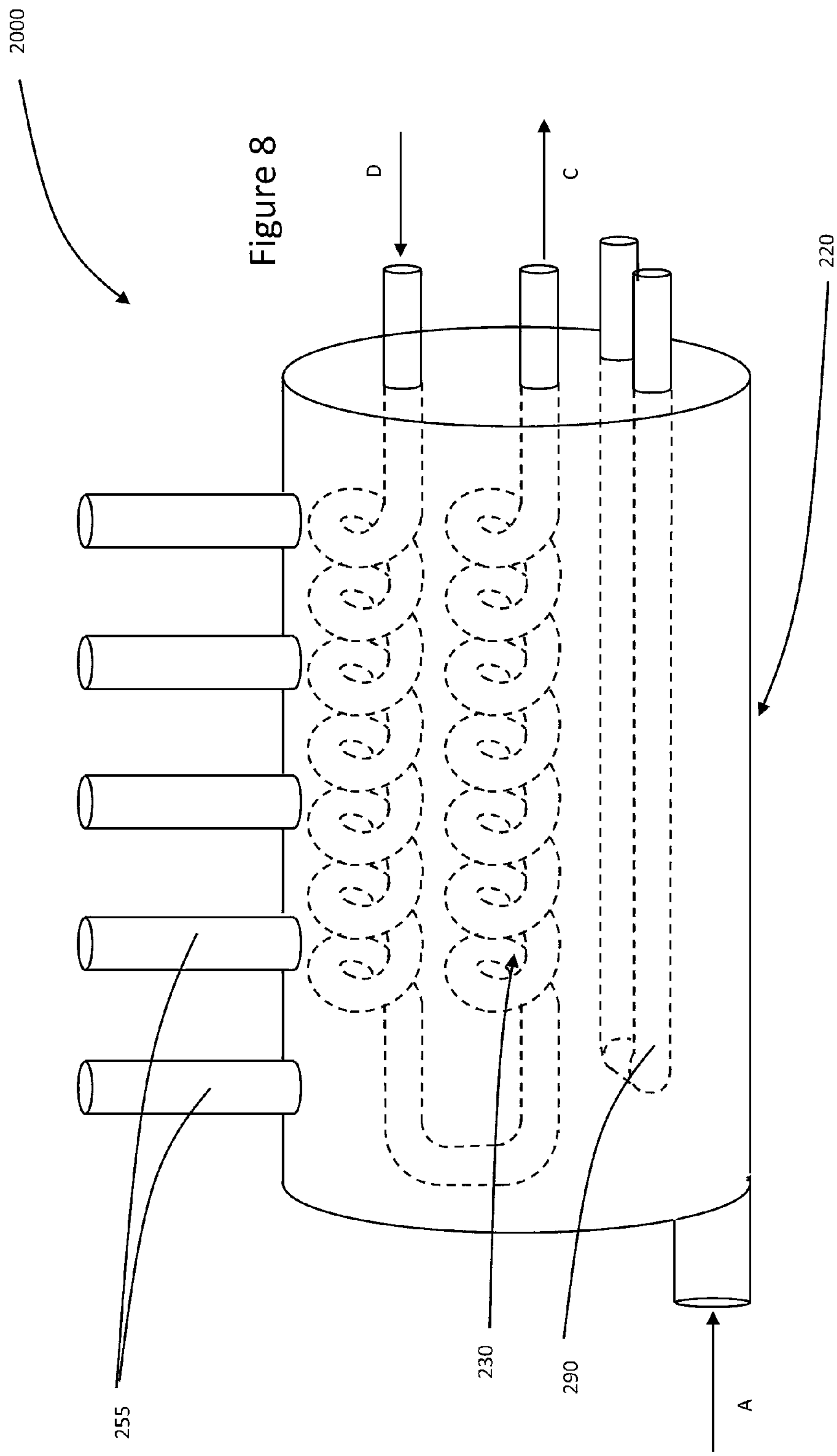


Figure 8

SYSTEM AND A METHOD FOR AIR CONDITIONING AND HEAT EXCHANGER ARRANGEMENT

FIELD OF THE INVENTION

[0001] The present invention relates to cooling, heating, air conditioning and in particular to an improved air-conditioning system.

[0002] The invention has been developed primarily for use in air-conditioning of a premises and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use.

BACKGROUND OF THE INVENTION

[0003] Air-conditioning systems are a major contributor to summer peak electrical demands. They lead to the reduction of the valuable fossil fuel sources while contributing to the very problem of greenhouse gas emission that depletes the ozone layer leading to dire health consequences. Global warming is another major problem attributed by conventional heating, ventilation, and air conditioning (HVAC) systems that increase the average temperature world-wide. HVAC systems typically account for around 40% of total electricity consumption of buildings. Air-conditioning units are least efficient at high ambient temperatures when cooling demand is highest. This leads to increase pollution, excessive investment in standby generation capacity, and poor utilization of peaking assets. The overall attainable reduction in energy consumption and enhancement of human comfort in the buildings are therefore dependent on the performance of HVAC systems.

[0004] FIG. **1** shows an example of a typical prior art air-conditioning system **100**. The prior art air-conditioning system **100** shown in FIG. **1** is installed in a premises with walls dividing indoors **105** and outdoors **115** where part of the air-conditioning system **100** is situated indoors **105** and the other part of the air-conditioning system **100** is situated outdoors **115**. Air-conditioning system **100** in general uses refrigerant that propagates through coils to lower the temperature of indoor air **165** relative to the outdoor air **120**, taking advantage of the fact that during a liquid gas phase conversion, heat energy is absorbed.

[0005] When hot air from outdoors **115** flows over the cold, low-pressure evaporator/cooling coils **155**, the refrigerant inside the cooling coils **155** absorbs heat as the refrigerant changes from a liquid to a gaseous state blown by the blower **145**. The gaseous refrigerant is pressurised and further increased in temperature by the compressor **105**. The extraneously created heat by compressing the gas is then evacuated to the outdoors through airflow vents **125** by a second fan **135** driven by an axle **140**. The refrigerant gas is converted back to a liquid phase again by a second set of coils known as condenser coils **130**, and the cycle repeats. The expansion valve **170** regulates the refrigerant flow into the evaporator coils **155**. The temperature of the air flow is therefore reduced by endless cycles of gas, liquid phase conversions. Instead of expansion valve, other type of expansion devices such as capillary tube can be used. The indoor and outdoor unit can be separated as the split type air conditioning system.

[0006] The extent of the cooling performed by the air-conditioning system **100**, can be controlled by an electrical control system (not shown) via an appropriate user interface installed inside the premises **105** to receive user preferences whether in the analogue or digital form such that the user in the indoors **105** is able to activate and set the temperature of the indoor air **165** measured by a temperature measuring means such as a temperature sensing bulb **160**.

[0007] While a prior art window air-conditioning system **100** has been illustrated in use in a residential premises in FIG. **1**, it will be appreciated by those skilled in the art that the air-conditioning system **100** can be installed internally inside a premises where the premises can take forms of any premises that is not limited to townhouses, factories, retail premises, office buildings and shopping centres. In the event that the air-conditioning system **100** is to be placed wholly inside the premises **100**, the air-conditioning system **100** can be in a portable arrangement as opposed to be installed as long as ducts to diffuse hot air outside are available. Furthermore the distribution of the cooled air does not have to directly into the environment to be cooled. The distribution of cooled airflow can be straight into relevant ducts and vents for ducting of cooled air to a suitable location. Other applications of the air-conditioning system **100** are not limited to residences, but can extend to commercial constructions and buildings.

[0008] It is to be understood that, if any prior art information is referred to herein, such reference does not constitute an admission that the information forms part of the common general knowledge in the art, in Australia or any other country.

SUMMARY OF THE INVENTION

[0009] The invention seeks to provide a system and method for air-conditioning, which will overcome or substantially ameliorate at least some of the deficiencies of the prior art, or to at least provide an alternative.

[0010] According to a first aspect of the present invention, there is provided an air conditioning system adapted for augmented heat exchange using an augmenting heat exchange fluid.

[0011] In this manner, the system is advantageously adapted to further reduce the electricity consumption and greenhouse emissions while maintaining low airflow temperature and human comfort levels under any climatic conditions.

[0012] The system may further comprise a refrigerant, where the system is adapted for augmented heat exchange between the augmenting heat exchange fluid, stored in a reservoir, and the refrigerant and also the system is further adapted to evaporate the refrigerant by an evaporator that is adapted to receive the refrigerant from the condenser via an expansion valve. The reservoir is further adapted to receive the augmenting heat exchange fluid from the evaporator.

[0013] The system may comprise a compressor operably adjacent to the reservoir or a condenser operably adjacent to the reservoir, where the condenser is adapted to receive the refrigerant from the reservoir. Further, the reservoir is further adapted for augmented heat exchange between air flow and the augmenting heat exchange fluid using an augmenting heat exchange conductor and the augmenting heat exchange conductor comprises at least one tube and the at least one tube is arranged to receive air flow from the fan such that in use, air flow is substantially perpendicular to an elongated axis of the tube. The at least one tube comprise at least one polymer tube.

[0014] Preferably, the system is adapted to distribute air flow to augment heat exchange, where the system further comprises a fan operably adjacent to the condenser.

[0015] The reservoir may comprises a heat exchanger for receiving the refrigerant from the compressor, where the heat exchanger is adapted for augmented heat exchange between the heat exchange fluid and the refrigerant.

[0016] Preferably, the system further comprises a heater operably coupled to the augmenting heat exchange conductor such that in use, the augmenting heat exchange conductor is heated to heat the augmenting heat exchange fluid.

[0017] Preferably, the augmenting heat exchange fluid is water and the reservoir and the augmenting heat exchange conductor is configured to form an integral unit.

[0018] According to another aspect, there is provided a method for air conditioning, the method comprising using an augmenting heat exchange fluid for augmented heat exchange.

[0019] Preferably, the method further comprises a refrigerant.

[0020] Preferably, the method further comprises the method further comprises adapting the augmenting heat exchange fluid and the refrigerant for augmented heat exchange.

[0021] Yet further, the method comprises a compressor where the method comprises a compressor operably adjacent to the reservoir or the method further comprises a condenser operably adjacent to the reservoir.

[0022] Preferably, the method further comprises adapting the condenser to receive the refrigerant from the reservoir.

[0023] Preferably, the method further comprising further comprises distributing air flow to augment heat exchange.

[0024] Preferably, the method further comprises displacing a fan operably adjacent to the condenser.

[0025] Preferably, the method further comprises receiving the refrigerant from the compressor by a heat exchanger.

[0026] Preferably, the method further comprises adapting the heat exchanger for augmented heat exchange between the heat exchange fluid and the refrigerant.

[0027] Preferably, the method further comprises using an augmenting heat exchange conductor adapted to the reservoir for augmented heat exchange between air flow and the augmenting heat exchange fluid.

[0028] Preferably, the augmenting heat exchange conductor comprises at least one tube.

[0029] Preferably, the method further comprises arranging at least one tube to receive air flow from the fan such that in use, air flow is substantially perpendicular to an elongated axis of the tube.

[0030] Preferably, the method further comprises operably coupling a heater to the augmenting heat exchange conductor.

[0031] Preferably, the method further comprises heating the augmenting heat exchange conductor to heat the augmenting heat exchange fluid.

[0032] Preferably, the method further comprises evaporating the refrigerant.

[0033] Preferably, the method further comprises an evaporator.

[0034] Preferably, the method further comprises receiving the refrigerant from the condenser via an expansion valve.

[0035] Preferably, the method further comprises receiving the augmenting heat exchange fluid from the evaporator.

[0036] Preferably, the augmenting heat exchange fluid is water.

[0037] Preferably, the at least one tube comprise at least one polymer tube. However, the tube material is not limited to polymer.

[0038] Preferably, the method further comprises configuring the reservoir and the augmenting heat exchange conductor to form an integral unit.

[0039] In another aspect, the invention may be said to consist in a heat exchanger arrangement for use with an air conditioning system comprising a condenser, an expansion device, an evaporator and a compressor connected in a refrigeration circuit, the heat exchanger arrangement comprising:

[0040] a. a coolant reservoir for holding coolant,

[0041] b. a first heat exchanger, the first heat exchanger being configured for receiving heated refrigerant from a compressor in an air conditioning cycle and facilitating the transfer of heat from the refrigerant to the coolant;

[0042] c. an augmenting heat exchanger, the augmenting heat exchanger being configured for facilitating the transfer of heat from the coolant to the environment.

[0043] In one embodiment, the first heat exchanger is contained within the coolant reservoir.

[0044] In one embodiment, the augmenting heat exchange is configured for facilitating the transfer of heat from the coolant to an external air flow.

[0045] In one embodiment, the augmenting heat exchange is configured for mounting adjacent a condenser for receiving airflow from a fan blowing on the condenser, and the external air flow is from a condenser fan mounted on the condenser.

[0046] In one embodiment, the heat exchanger arrangement comprises a water collecting arrangement is configured for collecting liquid water condensed on an evaporator.

[0047] In one embodiment, the heat exchanger arrangement comprises learning water from the water collecting arrangement to the coolant reservoir.

[0048] In one embodiment, the augmenting heat exchanger comprises a plurality of tubes extending from the coolant reservoir.

[0049] In one embodiment, the augmenting heat exchanger comprises a plurality of vanes extending from the coolant reservoir.

[0050] In one embodiment, the coolant reservoir is a tank.

[0051] In one embodiment, the coolant reservoir comprises an overflow outlet.

[0052] In one embodiment, the coolant reservoir is configured for receiving coolant from an external source.

[0053] In one embodiment, the external source is a municipal water supply.

[0054] In one embodiment, the augmenting heat exchanger comprises a storage tank.

[0055] In one embodiment, the heat exchanger arrangement comprises a pump for cycling coolant between the storage tank and the heat exchanger.

[0056] In one embodiment, the heat exchanger arrangement comprises a controller.

[0057] In one embodiment, the controller is configured for receiving signals from one or more selected from:

[0058] a. pressure transducers in the pipes at any location along the refrigeration circuit;

[0059] b. control valves located on the refrigeration circuit;

[0060] c. control valves configured for restricting coolant flow from an external source; and

[0061] d. temperature transducers configured for sensing the temperature of the coolant.

[0062] In one embodiment, the air-conditioning system comprises a condenser fan configured for blowing air onto the condenser, and an evaporator fan configured for blowing air on the evaporator, and the controller is configured for receiving signals from one or more selected from

[0063] In one embodiment, the controller is configured to control one or more selected from

[0064] a. pressure in the pipes at any location along the refrigeration circuit;

[0065] b. actuation of control valves located on the refrigeration circuit;

[0066] c. actuation of control valves configured for restricting coolant flow from an external source;

[0067] d. temperature of the coolant; and

[0068] e. temperature transducers in the condenser airflow from the condenser fan and/or the evaporator airflow from the evaporator fan.

[0069] f. fluid flow rate transducers located in the condenser airflow of the condenser fan and/or the evaporator airflow from the evaporator fan; and

[0070] g. rotational velocity sensors detecting the speed of operation of the condenser fan and/or the evaporator fan.

[0071] h. operation of the pump; and

[0072] i. operation of the heating element.

[0073] In one embodiment the air conditioning system is configured for operation in reverse as a heat pump.

[0074] In one embodiment, the heat exchanger arrangement comprises a heating element configured for heating the coolant when the air conditioning system is operable as a heat pump.

[0075] In one embodiment, the heat exchanger arrangement comprises an isolation valve for isolating the augmenting heat exchanger from the heat exchanger.

[0076] In a further aspect, the invention may be said to consist in an air-conditioning system comprising a heat exchanger arrangement as described.

[0077] In a further aspect, the invention may be said to consist in an air-conditioning system, the air-conditioning system comprising

[0078] a. a condenser,

[0079] b. an expansion device,

[0080] c. an evaporator and

[0081] d. a compressor

[0082] e. wherein the condenser, expansion device, evaporator and compressor are connected by a refrigeration circuit configured for directing refrigerant between them; and

[0083] f. the heat exchanger arrangement, the heat exchanger arrangement comprising

[0084] i. a coolant reservoir for holding coolant,

[0085] ii. a first heat exchanger, the first heat exchanger being configured for receiving heated refrigerant from a compressor in an air conditioning cycle and facilitating the transfer of heat from the refrigerant to the coolant;

[0086] iii. an augmenting heat exchanger, the augmenting heat exchanger being configured for facilitating the transfer of heat from the coolant to the environment.

[0087] In one embodiment, the first heat exchanger of the heat exchanger arrangement is disposed on the refrigeration circuit between the compressor and the condenser.

[0088] In one embodiment, the augmenting heat exchange is configured for facilitating the transfer of heat from the coolant to an external air flow.

[0089] In one embodiment, the augmenting heat exchange is configured for mounting adjacent a condenser for receiving airflow from a fan blowing on the condenser, and the external air flow is from a condenser fan mounted on the condenser.

[0090] In one embodiment, the heat exchanger arrangement comprises a water collecting arrangement is configured for collecting liquid water condensed on an evaporator.

[0091] In one embodiment, the heat exchanger arrangement comprises learning water from the water collecting arrangement to the coolant reservoir.

[0092] In one embodiment, the augmenting heat exchanger comprises a plurality of tubes extending from the coolant reservoir.

[0093] In one embodiment, the augmenting heat exchanger comprises a plurality of vanes extending from the coolant reservoir.

[0094] In one embodiment, the coolant reservoir is a tank.

[0095] In one embodiment, the coolant reservoir comprises an overflow outlet.

[0096] In one embodiment, the coolant reservoir is configured for receiving coolant from an external source.

[0097] In one embodiment, the external source is a municipal water supply.

[0098] In one embodiment, the augmenting heat exchanger comprises a storage tank.

[0099] In one embodiment, the heat exchanger arrangement comprises a pump for cycling coolant between the storage tank and the heat exchanger.

[0100] In one embodiment the air conditioning system is configured for operation in reverse as a heat pump.

[0101] In one embodiment, the heat exchanger arrangement comprises a heating element configured for heating the coolant when the air conditioning system is operable as a heat pump.

[0102] In one embodiment, the heat exchanger arrangement comprises an isolation valve for isolating the augmenting heat exchanger from the heat exchanger.

[0103] In one embodiment, the heat exchanger arrangement comprises a controller.

[0104] In one embodiment, the controller is configured for receiving signals from one or more selected from:

[0105] a. pressure transducers in the pipes at any location along the refrigeration circuit;

[0106] b. control valves located on the refrigeration circuit;

[0107] c. control valves configured for restricting coolant flow from an external source; and

[0108] d. temperature transducers configured for sensing the temperature of the coolant.

[0109] In one embodiment, the air-conditioning system comprises a condenser fan configured for blowing air onto the condenser, and an evaporator fan configured for blowing air on the evaporator, and the controller is configured for receiving signals from one or more selected from

[0110] In one embodiment, the controller is configured to control one or more selected from

[0111] a. pressure in the pipes at any location along the refrigeration circuit;

[0112] b. actuation of control valves located on the refrigeration circuit;

[0113] c. actuation of control valves configured for restricting coolant flow from an external source;

[0114] d. temperature of the coolant; and

[0115] e. temperature transducers in the condenser airflow from the condenser fan and/or the evaporator airflow from the evaporator fan.

[0116] f. fluid flow rate transducers located in the condenser airflow of the condenser fan and/or the evaporator airflow from the evaporator fan; and

[0117] g. rotational velocity sensors detecting the speed of operation of the condenser fan and/or the evaporator fan.

[0118] h. operation of the pump; and

[0119] i. operation of the heating element.

[0120] In a further aspect, the invention may be said to consist in a control system for an air-conditioning system as described, the control system comprising

[0121] a. a controller configured for controlling operation of a heating element of a heat exchanger arrangement as described.

BRIEF DESCRIPTION OF THE DRAWINGS

[0122] Notwithstanding any other forms which may fall within the scope of the present invention, preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0123] FIG. **1** shows an exemplary air-conditioning system in an exemplary premises on which the various embodiments described herein may be implemented in accordance with the present invention;

[0124] FIG. **2** shows a system diagram in accordance with various embodiments described herein of the present invention;

[0125] FIG. **3** shows an exemplary arrangement of the reservoir and the augmenting heat exchange conductor in an air-conditioning system in accordance with various embodiments described herein of the present invention;

[0126] FIG. **4** shows a schematic of the connections in a direct expansion air-conditioning system in accordance with various embodiments described herein of the present invention;

[0127] FIG. **5** shows a heat exchanger arrangement schematic perspective view of a first embodiment of a heat exchanger arrangement;

[0128] FIG. **6** shows a schematic perspective view of a second embodiment of a heat exchanger arrangement;

[0129] FIG. **7** shows a schematic perspective view of a the first embodiment of a heat exchanger arrangement of FIG. **5** connected to a water collecting arrangement; and

[0130] FIG. **8** shows a close up schematic perspective view of the first embodiment of a heat exchanger arrangement of FIG. **7**.

DESCRIPTION OF EMBODIMENTS

[0131] It should be noted in the following description that like or the same reference numerals in different embodiments denote the same or similar features.

System

[0132] With reference to the above drawings, in which similar features are generally indicated by similar numerals, an air-conditioning system according to a first aspect of the invention is generally indicated by the numeral 200, and a heat exchanger arrangement is generally indicated by the 2000.

[0133] To better illustrate the air-conditioning system **200**, FIG. **2** shows a schematic view of a system diagram.

[0134] In a preferred embodiment, the system **200** comprises of various main components of the air-conditioning system **100** that can be used to supply cooled or warmed air to an arbitrary premises.

[0135] The main components of the air-conditioning system **200** includes a direct expansion (DX) evaporator **210**, a compressor **215**, a water tank **220**, an air cooled condenser **235** and an expansion device **240**. These components are connected by suitable pipes **250** for refrigerant conveyance through the air-conditioning system **200** with the direction of flow being annotated by the direction of arrows.

[0136] The expansion device **240** is preferably in the form of a valve (as shown in FIG. **2**) or capillary tubes (as shown in FIG. **4**). The evaporator **210**, the compressor **215**, the condenser **235** and the expansion device are connected to each other by pipes **250** in which a refrigerant is captured as shown in FIG. **2** to form a closed refrigeration circuit.

[0137] In addition to the above, and as shown in FIG. **7**, the air-conditioning system **200** comprises a heat exchanger arrangement **2000** comprising a heat exchanger **230**, and a water tank **220**, which is preferably connected to a water collecting arrangement **242**, and preferably in the form of a trough. The water collecting arrangement is configured in association with the evaporator **210**, to receive cold water that has condensed onto the evaporator **210**, preferably driven by gravity to feed into the water tank **220**. In alternative embodiments, it is envisaged that water from the trough may be pumped by a pump (not shown) to the water tank **220**.

[0138] The heat exchanger **230** can also preferably be configured to receive water from another water source, such as the municipal water supply, or alternatively the heat exchanger **230** can be provided with an inlet for topping up water in the heat exchanger **230**.

[0139] The heat exchanger **230** is configured to be located on the refrigeration circuit to receive relatively hot refrigerant from the compressor at 60° C. to 70° C., to cool the refrigerant by transfer of heat from the refrigerant in the pipes **250** to the water in the water tank **220**. The heat exchanger arrangement **2000** preferably also comprises cooling formations configured for cooling the heated water by transfer of heat from the water to the environment outside of the zone to be cooled (which heat would typically be expelled outdoors).

[0140] In the embodiments shown, the heat exchanger **230** is located inside water tank **220**, although this need not necessarily be the case.

[0141] The refrigerant flow cycle starts with a mixture of liquid and vapour refrigerant entering the DX evaporator

210. Heat from the warm air is absorbed by the refrigerant the DX evaporator coil **210** where the refrigerant boils off and transitions into the gaseous state. In the process, some of the water vapour in the air also condenses resulting in water droplets. The evaporation process results in the reduction of both the air temperature and humidity ratio. The refrigerant used is any refrigerant used in standard air-conditioning system **100**, not limited to R22, R134a, R410A, R407C etc.

[0142] The heated refrigerant vapour then enters the compressor **215** that further elevates and pressurises the refrigerant. Even though a rotary scroll compressor is used in the preferred embodiment, in reality, any other forms of compressor that causes pressure changes such as reciprocating, scroll, screw and rotary compressors can be used.

[0143] The heated high pressure refrigerant then travels through the water storage tank **220** via a heat exchanger **230** to dissipate the heat with water inside the water reservoir or storage tank **220** which is located downstream of the compressor. The heat exchanger **230** inside the water storage tank **220** in general can be made out of any material with high thermal conductivity and characteristics favourable for practical applications. Examples of the materials are not limited to copper, stainless steel, etc.

[0144] While the heat exchanger **230** has been shown as a zigzag line to increase water exposure, in general the heat exchanger **230** can take any arbitrary design, including configuration as a helical coil, a baffle type arrangement, or any other suitable configuration for increasing heat dissipation efficiency inside the water storage tank **220**. Alternative designs include cross flow and parallel flow, shell and tubes, etc. The water storage tank **220** can be fabricated out of any material with favourable physical characteristics under practical cost constraints not limited to aluminium, stainless steel, fibre glass, etc. The heat exchanger **230** can be of any useful configuration. Configurations of heat exchangers are well known, and a more detailed description is considered beyond the scope of this specification.

[0145] Due to the heat transfer process in water storage tank, the water temperature in the water tank **220** will be increased while the temperature of the refrigerant is decreased. To reduce the water temperature in the water tank **220**, an augmenting heat exchanging conductor **255** is provided. In the embodiments shown, the augmenting heat exchanging conductor **255** comprises a plurality of tubes **255**, which are preferably made of suitably heat conductive material with high thermal conductivity. Examples of suitable material include copper, steel, stainless steel, polymer, glass or the like. The tubes **255** are connected to the water storage tank **220** to assist in the transfer of heat between water in the water storage tank, and the environment/ambient air.

[0146] It is further anticipated that the augmenting heat exchange conductor **255** can comprise heat transfer formations (not shown), such as fins or vanes, attached to or extending directly from the water storage tank, for increasing heat flow from the water in the water storage tank **220** to the environment. Preferably such fins or vanes are integrally formed with the water storage tank **222** allow for increased conduction of heat.

[0147] Using the water feed from the water collecting arrangement, it is anticipated that the water in the water storage tank **220** will need to be filled with water initially on installation, but will continue to top itself up with condensate water from the DX evaporator **210** via the or to collecting arrangement and pipe **245**. The temperature and flow rate of the evaporator condensate water is dependent on climatic conditions and indoor conditions, and the amount of heat transferred from the refrigerant to the water may vary.

[0148] Following the cooling from the water storage tank **220**, the temperature of the refrigerant would be significantly less than the refrigerant temperature entering the water storage tank **220**, and typically between 40° C. and 50° C. The high pressure refrigerant moves from the water storage tank **220** to pass through an air-cooled condenser **235** where an additional refrigerant temperature reduction takes place in light of further heat transfer with the ambient air. As the refrigerant has been precooled prior cooling by the air-cooled condenser **235**, the temperature of the refrigerant after the condenser **235** would be considerably less than that in conventional air-conditioning systems **100**. It is anticipated that any types of suitably engineered condensers can be used, including but not limited to surface condensers and direct contact condensers.

[0149] In a preferred embodiment as shown in FIG. **3**, it is anticipated that the airflow used to call the refrigerant moving through the condenser can in addition be used to cool the water in the water tank **220**. In this embodiment, the augmenting heat exchanging conductor **255** is located in the airflow of the condenser fan **315**, preferably downstream of the condenser **235**. In this way, the energy expended in operating the condenser fan is used more efficiently to indirectly pre-cool the hot refrigerant from the compressor, using heat exchanger arrangement **2000**.

[0150] The fan in the preferred embodiment shown in FIG. **3**, uses a forward centrifugal fan **315** that is situated adjacent to the condenser **235** and also the transparent tube **255** such that the direction of airflow would be substantially perpendicular to the elongated axis of the glass tubes **255**. In the event when the capacity of the system is low, an axial fan can be used instead. Even though a centrifugal fan is used, in reality other forms of fans or blowers that is typically driven by an electric or ventilator motor with sheaves may be used in directing the cooled air through the supply air duct either forward or backward depending on the total pressure drop. The fan **315** can subsequently be connected to an inverter and a control system is described below to control the airflow rate based on building requirements.

[0151] The air conditioning system **200** shown in FIG. **3** illustrates an embodiment of the heat exchanger **230** that is preferably composed of copper tube in this example, and which routes the refrigerant inside the water storage tank **220** from the compressor **215** to the condenser **235**. While the condenser fan **315** is used for both cooling the condenser and transparent water tubes **255**, in other embodiments, optional an additional airflow generating means such as a fan, a compressed air supply or other arrangements can be used for cooling the heated water in the exchanger.

[0152] The heat exchanger arrangement **2000** arranged in adjacent to the condenser fan **315** can be formed as an integral unit that is retrofittable to any type of air-cooled direct expansion air condition system such as rooftop packages, chillers etc. Further, the system would be applicable to any climatic conditions independent of levels of humidity and temperature.

[0153] Still in a further preferred embodiment, the air-conditioning system **200** can be set to operate as a heating means to produce airflow with a temperature higher than the temperature of the external fresh air. Under such applications that would make sense in seasons such as autumn and winter, temperature reduction of the refrigerant will no longer be needed. Instead, due to the high thermal conductivity of the heat exchange conductor **230** and the associated design, an additional heater can be coupled to the heat exchange conductor **245** that can act as heat radiator in increasing the temperature of the incoming refrigerant. In general, any standard heating devices or elements can be used to transfer heat to the heat exchange conductor **230** either with or without temperature feedback means. Alternatively, the water can be heated to heat the incoming refrigerant.

[0154] In the preferred embodiment, while water is used as the augmented heat exchange fluid because water has the highest latent heat of vaporization values, in other embodiments other cooling fluid may be used provided they also have the high latent heat of vaporisation value and also provided that it is safe within the regulations of usage and can be well maintained. The relative sizing of the water storage tank **220**, water tubes **255** and the heat exchanger **230** would be dependent on applications taking into considerations of climatic conditions and required system capacity.

[0155] Various ancillary components may be used as part of the optimisation and realistic implementation and monitoring of the present system. In a preferred embodiment as shown in FIG. **4**, various sensors and data acquisition systems have been installed to track refrigerant flow throughout the system **200** and also water storage tank **220**. The sensors, platinum resistant thermometer PT100 **475** and pressure transmitter P **480** are used for sensing refrigerant flow temperature and pressure respectively. Refrigerant is converted from liquid to gaseous phase by the DX evaporator **210** with the aid of the fan **450** to produce cooled airflow into the conditioned space **490**. Refrigerant in the gaseous state undergoes pressurisation and temperature increase in the rotary compressor **215** before being cooled by the water storage tank **220**, as the refrigerant travels through a heat exchanger **230**. The pre-cooled refrigerant is further cooled by an air cooled condenser **235** before the pressure is regulated by an expansion device that is implemented as capillary tubes **435**. The addition of optional components like filter drier **425** and sight glass **430** are for the general protection of the system **200**. Specifically, the filter drier **425** is used to isolate and filter out any particulates formed from the refrigerant in the refrigerant flow. In contrast, the sight glass **430** is to allow for visual identification of the level of refrigerant inside the system **200**. As an example, where there are the presence of bubbles observed through the sight glass **430**, it may be an indicator for insufficient refrigerant leading actions to refill the refrigerant. The expansion valve **435** reduces pressure of the refrigerant prior evaporation and in general be of any type of devices not limited to capillary tubes and electrostatic expansion valves etc. It can be appreciated by a person skilled in the art that in general, any arrangements of these components may be possible and the components can take various forms.

[0156] In general, the coils or pipes used as part of the interconnects for conveying the refrigerant are commonly made of polyvinyl chloride, ductile iron, steel, cast iron, polypropylene, polyethylene, copper, or (formerly) lead, that carry pressurized fluid at short distances within the air conditioning system **200**. In applications of long distance between evaporator **210** and condenser **235**, suitable pumping means can be deployed to convey the condensate water to the water storage tank **220**.

[0157] To alleviate the temperature increase inside the water storage tank **410**, transparent glass tubes **255** where the water flows are installed for heat transfer between the water and ambient air. It will be appreciated that the tubes **255** can be composed of any suitable material, however material that allows for high conduction of heat and low material cost is preferable, such as glass, copper, metal or plastic. The water in the water storage tank **220** can be topped up from the municipal or city source water by controlling operation of the global valve **450**. Similarly, condensate water due to heat transfer in the evaporation process is conveyed to the water storage tank **235** via suitable interconnecting means for water flow **245**.

[0158] It will be appreciated by those skilled in the art that the heat transfer arrangement **2000** can be used to cool refrigerant coming from the condenser before it is directed to the expansion device **240**. However, the temperature of refrigerant coming from the condenser in typical prior art air-conditioning systems is at between 30° C. and 40° C.

[0159] It is anticipated that by, using the present invention, which directs relatively cold, recently condensed, water (at about 15° C.) from the evaporator to the heat exchanger **230**, where it exchanges heat with refrigerant coming directly from the compressor at between 60° C. and 70° C., the larger temperature difference will allow for increased efficiency of heat exchange. Further, by providing water as the heat exchange fluid, rate of conduction of heat from the heat exchanger **230** is increased. The cooled refrigerant is then directed to the condenser, where it is further cooled by heat transfer to the air flow created by the condenser fan. This means that the airflow being blown through the condenser by the condenser fan **315** will be relatively lower in temperature than the heated water in the heat exchanger arrangement **2000**, and can be used to cool the heated water more efficiently.

[0160] The increased temperature difference between the heated water in the heat exchanger arrangement **2000** and the air flow created by the condenser fan **315** means that more effective cooling of the water will happen while using the same, or a similar, amount of power in the condenser fan **315**.

[0161] In addition, by cooling the refrigerant more effectively (by exchanging heat more effectively with the drainage water before the condenser), the mass flow rate of the refrigerant required for cooling can be further reduced because the density of the refrigerant is reduced.

[0162] A reduced mass flow rate requirement (in kilograms per second) of the refrigerant means that the compressor is required to do less work for the same amount of refrigeration capacity. This, in reduces power consumption by the compressor.

[0163] The coefficient of performance of an air-conditioner can typically be described as

$$\frac{(h4-h1)}{(h2-h1)}$$

[0164] Wherein:

[0165] a. h1 is the enthalpy of the refrigerant immediately after the evaporator;

[0166] b. h2 is the enthalpy of the refrigerant immediately after the compressor;

[0167] c. h3 is the enthalpy of the refrigerant immediately after the condenser; and

[0168] d. h4 is the enthalpy of the refrigerant immediately after the expansion device.

[0169] Using the air-conditioning system **200** is described, the numerator of the above equation is increased, while the denominator of the above equation is decreased. Further, in using the heat exchanger arrangement **2000**, the temperature of the refrigerant in the refrigeration circuit just before it reaches the evaporator (shown as T**4** in FIG. **2**) is reduced with respect to known common air-conditioning systems by about 10° C.

[0170] In most air-conditioning systems, when the airflow over the evaporator reaches its control temperature, the compressor is controlled to stop compressing the refrigerant. However, the evaporator fan **455** typically continues operating to cycle air around in the air-conditioned space **490**. By reducing T**4**, the cooling effect of the airflow caused by the evaporator fan **455** remains even when the compressor **215** is turned off and the refrigerant is not being evaporated. This means that effective air-conditioning continues for longer even when the compressor is switched off. This further means that, for example over an extended time period of air-conditioning in which the compressor is cycled on and off many times, the compressor would be running for a significantly less proportion of the extended time period, thereby saving power costs.

[0171] If the hot refrigerant from the compressor were passed through the condenser first before being cooled, the air flow from the condenser fan **315** would be much hotter, and would not be able to cool the heated water in the heat exchanger arrangement as effectively. However, the result of more efficient cooling of the refrigerant before it passes into the condenser is that the heated water in the heat exchanger arrangement gets hotter (at about 40° C.), and needs to be dealt with.

[0172] In another preferred embodiment as shown in FIG. **5**, the heat exchanger **230** in the water tank **220** is preferably located operationally at a lower level than the tubes **255**. In this preferred embodiment, the water is fed from the water collecting arrangement at the evaporator downwardly to the water tank **220** and heat exchanger **230**. The coolant water will then be heated by a heat transfer from the refrigerant to the water via the heat exchanger **230**. Water heated in this way will rise upwardly by natural convection into the tubes **255** for cooling by air flow over the tubes (the airflow shown as large arrows AF which is preferably created by condenser fan **315**), and into a storage tank **260**. It is further anticipated that the heat exchanger arrangement can comprise an overflow outlet **262** located at the top of the tubes **255** that will allow excess heated water to flow out of the heat exchanger (shown as arrow B), preferably to be replaced by cold water feeding in from the evaporator. The overflow outlet **262** could include a one-way overflow valve **263** that requires a threshold pressure to be applied before it opens. In this way, the required amount of replacement water must be available as head from the evaporator before the overflow valve opens. It is envisaged that the coolant water can be forcibly moved around the coolant circuit formed by the water tank **220**, the tubes **255** and the storage tank **260**, for example by a pump (not shown) located on this circuit.

[0173] In this configuration, when there is increased condensation of water on the evaporator, the water flow to the heat exchanger **230** is increased, and creates a one-way flow path from the trough **242** at the evaporator **210** (shown as arrow A), through the heat exchanger **230**, through the tubes **255**, and out of the overflow outlet, in a manner that allows for the effective cooling of the water in the heat exchanger arrangement **2000** without the requirement for moving parts.

[0174] Refrigerant enters the heat exchanger through an inlet into the water tank **220** (shown as arrow D), and is cooled by conduction of heat from the refrigerant to the cold water through the heat exchanger before exiting the water tank **220** at an outlet (shown as arrow C).

[0175] It is further envisaged that the heated water in the heat exchanger arrangement **2000** can have alternative uses.

[0176] In one preferred embodiment shown in FIG. **6**, the heated water in the heat exchanger arrangement **2000** can be fed via a heating circuit (comprising the transparent tubes **255** in this embodiment) to a second heat exchanger **270** (shown located in the storage tank **260** in the embodiment) where the heat from the water in the heat exchanger arrangement **2000** can be used to preheat water (for example from the household mains water supply shown as arrow E) to be supplied to a geyser **280** (shown as arrow F), water heater, boiler or the like for use downstream in a household hot water supply (shown as arrow G).

[0177] By preheating water that is then sent on to heating devices such as a geyser, water heater, calorifier or boiler, less electricity is required by the geezer to heat the water to a required temperature in the hot water supply, thereby saving on power costs.

[0178] In another embodiment (not shown), it is envisaged that the heated water from the heat exchanger can alternatively be fed to a (preferably larger size) storage tank for natural cooling and then pumped back to the water tank **220** once it is cooled. To this extent, a pump (not shown) can be provided for this purpose. The storage tank can be provided with a level sensing transducer (not shown) for detecting the water level in the storage tank. Operation of the pump can be controlled by a control system as will be discussed in more detail below.

[0179] It is further envisaged that a turbulence creating device (not shown) such as an impeller can be included in the water tank **220** and/or the storage tank for increasing convection heat transfer to the water tank **220** and/or the storage tank, and onward to the environment. However, this option is not preferred, as it increases the cost and complexity of the apparatus.

Data Logging and Control

[0180] Information on the temperature and pressure of the refrigerant throughout the system **200** are acquired by a data logger **460** for real-time analysis and control or off-line modelling and hence optimisation by a PC **470**. It can also be appreciated by a person skilled in the art that in general, any arrangements of these components may be possible and the components can take various forms.

[0181] In addition it is anticipated that the operation of the heat exchanger system can be controlled by a controller. It is anticipated that the controller will preferably be the same controller that controls operation of the air conditioning system **200**.

[0182] The controller is preferably connected to receive signals from one or more selected from:

[0183] a. pressure transducers in the pipes at any location along the refrigeration circuit;

[0184] b. temperature transducers in the pipes at any location in the heat exchanger arrangement **2000**, and in particular and the water tank **220**;

[0185] c. temperature transducers in the condenser airflow from the condenser fan **315** and/or the evaporator airflow from the evaporator fan **455**;

[0186] d. fluid flow rate transducers located in the condenser airflow of the condenser fan **315** and/or the evaporator airflow from the evaporator fan **455**;

[0187] e. rotational velocity sensors detecting the speed of operation of the condenser fan **315** and/or the evaporator fan **455**.

[0188] The controller will also preferably act as the data logger **460**, since it will be connected to receive signals from the same transducers.

[0189] In addition, it is envisaged that the controller will be connected to the expansion device **240** and configured to control and/or actuate operation of the expansion device **240**. It is further envisaged that the controller will be connected to any one or more of the control valves on the pipes **250** in the refrigeration circuit and on the pipes **245** in the heat exchanger arrangement **2000**. Such valves include the global feed valve **450**. In this way, temperatures, pressures and flow rates, as well is the actuation of valves can be detected, and controlled according to variables such as outside temperature, inside control temperature settings, or the like.

[0190] In particular, it is envisaged that the controller will be configured to ensure that the water level of the heat exchanger arrangement remains topped up from an alternative water supply, such as the municipal water supply if condensed water from the evaporator is not sufficient to top up water levels.

[0191] In addition, it is envisaged that the controller will be configured to control operation of the condenser fan **315** in a manner that allows for the speed of the condenser fan to be increased or decreased as required for increased or reduced cooling of the water in the heat exchanger arrangement **2000** according to requirements. In this way, it is envisaged that the controller will be configured to increase the efficiency of energy usage of the air-conditioning system **200**.

[0192] Further, the controller can be configured for controlling operation of a pump for pumping cooled water from the storage tank back to the heat exchanger **230**. Further, the controller can be configured for controlling operation of an impeller located in one or both of the water tank **220** and the storage tank, to thereby increase convection heat transferred to the tanks.

[0193] In winter it is envisaged that the air conditioner will operate in reverse, with the external unit (previously used as a condenser) now operating as an evaporator, and the internal unit (previously used as an evaporator) now being used as a condenser. The operation of such reversible heat pumps is well known and will not be discussed in detail in this specification.

[0194] In another embodiment shown in FIG. **8**, for use in such conditions, it is envisaged that heat exchanger arrangement **2000** can include a heating element **290** for heating the water in the water tank **220**. Such an arrangement would for example be used in winter when the outside temperature is cold, and the inside temperature of the environment is required to be heated instead of cooled.

[0195] Using such an arrangement, the heated water will now be used to heat the refrigerant using the heat exchanger **230**, pre-heating the refrigerant before it is directed to the compressor **215**. Compression of already pre-heated refrigerant will increase the temperature of refrigerant that is directed to the inside unit (previously described as the evaporator **210**, but now operating as a condenser. This increased temperature will increase the ability of the air conditioning system **200** heat the inside environment.

[0196] In such an arrangement, it is also anticipated that the fan **315** operable on the outside unit (which in summer is the condenser, but will now be operating as an evaporator) can be controlled to operate in reverse, drawing air from the tubes (which will be heated by warm water which is in turn heated by the heating element) to draw heated air over the evaporator, thereby heating the refrigerant.

[0197] However, in an alternative arrangement, it is envisaged that the water tank can instead be provided with an isolation valve (not shown) to prevent flow of heated water from the heat exchanger into the augmenting heat exchanger tubes **255**, so that heat loss into the outside environment is reduced.

[0198] An another alternative, it is envisaged that the heat exchanger **230** and/or water tank **220** and/or augmenting heat exchanger (tubes **255**) can be provided with a removable insulating housing for use in winter, which will reduce heat loss to the outside environment from the heated water.

[0199] It is anticipated that the controller can further control the temperature of the water in the heat exchanger arrangement **2000** by controlling operation of the heating element **290**.

Interpretation

Additional Embodiments

[0200] Thus, one embodiment of each of the methods described herein is in the form of a computer-readable carrier medium carrying a set of instructions, e.g., a computer program that are for execution on one or more processors. Thus, as will be appreciated by those skilled in the art, embodiments of the present invention may be embodied as a method, an apparatus such as a special purpose apparatus, an apparatus such as a data processing system, or a computer-readable carrier medium. The computer-readable carrier medium carries computer readable code including a set of instructions that when executed on one or more processors cause a processor or processors to implement a method. Accordingly, aspects of the present invention may take the form of a method, an entirely hardware embodiment, an entirely software embodiment or an embodiment combining software and hardware aspects. Furthermore, the present invention may take the form of carrier medium (e.g., a computer program product on a computer-readable storage medium) carrying computer-readable program code embodied in the medium.

Means for Carrying Out a Method or Function

[0201] Furthermore, some of the embodiments are described herein as a method or combination of elements of a method that can be implemented by a processor of a processor device, computer system, or by other means of carrying out the function. Thus, a processor with the necessary instructions for carrying out such a method or element of a method forms a means for carrying out the method or element of a method. Furthermore, an element described herein of an apparatus embodiment is an example of a means for carrying out the function performed by the element for the purpose of carrying out the invention.

Connected

[0202] Similarly, it is to be noticed that the term connected, when used in the claims, should not be interpreted as being limitative to direct connections only. Thus, the scope of the expression a device A connected to a device B should not be limited to devices or systems wherein an output of device A is directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. “Connected” may mean that two or more elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-operate or interact with each other.

Embodiments

[0203] Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

[0204] Similarly it should be appreciated that in the above description of example embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the Detailed Description of Specific Embodiments are hereby expressly incorporated into this Detailed Description of Specific Embodiments, with each claim standing on its own as a separate embodiment of this invention.

[0205] Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

Different Instances of Objects

[0206] As used herein, unless otherwise specified the use of the ordinal adjectives “first”, “second”, “third”, etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

Specific Details

[0207] In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description.

Terminology

[0208] In describing the preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar technical purpose. Terms such as “forward”, “rearward”, “radially”, “peripherally”, “upwardly”, “downwardly”, and the like are used as words of convenience to provide reference points and are not to be construed as limiting terms.

[0209] For the purposes of this specification, the term “plastic” shall be construed to mean a general term for a wide range of synthetic or semisynthetic polymerization products, and generally consisting of a hydrocarbon-based polymer.

[0210] For the purpose of this specification, the term “fan” shall be construed to mean a general term for any mechanism capable of moving air in an air flow.

Comprising and Including

[0211] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” are used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

[0212] Any one of the terms: including or which includes or that includes as used herein is also an open term that also means including at least the elements/features that follow the term, but not excluding others. Thus, including is synonymous with and means comprising.

SCOPE OF INVENTION

[0213] Thus, while there has been described what are believed to be the preferred embodiments of the invention, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such changes and modifications as fall within the scope of the invention. For example, any formulas given above are merely representative of procedures that may be used. Functionality may be added or deleted from the block diagrams and operations may be interchanged among functional blocks. Steps may be added or deleted to methods described within the scope of the present invention.

[0214] Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

INDUSTRIAL APPLICABILITY

[0215] It is apparent from the above, that the arrangements described are applicable to the air-conditioning industries.

1. An air conditioning system adapted for augmented heat exchange using an augmenting heat exchange fluid.

2. A system as claimed in claim **1**, wherein the system further comprises a refrigerant.

3. A system as claimed in claim **2**, wherein the system is adapted for augmented heat exchange between the augmenting heat exchange fluid and the refrigerant.

4. A system as claimed in claim **1**, wherein the augmenting heat exchange fluid is stored in a reservoir.

5. A system as claimed in claim **4**, wherein the system further comprises a compressor operably adjacent to the reservoir.

6. A system as claimed in claim **1**, wherein the system further comprises a condenser operably adjacent to the reservoir.

7. A system as claimed in claim **6**, wherein the condenser is adapted to receive the refrigerant from the reservoir.

8. A system as claimed in claim **1**, wherein the system is adapted to distribute air flow to augment heat exchange.

9. A system as claimed in claim **8**, wherein the system further comprises a fan operably adjacent to the condenser.

10. A system as claimed in claim **5**, wherein the reservoir comprises a heat exchanger configured for receiving the refrigerant from the compressor.

11. A system as claimed in claim **10**, wherein the heat exchanger is adapted for augmented heat exchange between the heat exchange fluid and the refrigerant.

12. A system as claimed in claim **5**, wherein the reservoir is further adapted for augmented heat exchange between air flow and the augmenting heat exchange fluid using an augmenting heat exchange conductor.

13. A system as claimed in claim **12**, wherein the augmenting heat exchange conductor comprises at least one tube.

14. A system as claimed claim **13**, wherein the at least one tube is arranged to receive air flow from the fan such that in use, air flow is substantially perpendicular to an elongated axis of the tube.

15. A system as claimed in claim **1**, wherein the system further comprises a heater operably coupled to the augmenting heat exchange conductor.

16. A system as claimed in claim **12**, wherein in use, the augmenting heat exchange conductor is heated to heat the augmenting heat exchange fluid.

17. A system as claimed in claim **1**, wherein in use, the system is further adapted to evaporate the refrigerant.

18. A system as claimed in claim **1**, wherein the system further comprises an evaporator.

19. A system as claimed in claim **18**, wherein the evaporator is adapted to receive the refrigerant from the condenser via an expansion device.

20. A system as claimed in claim **18**, wherein the reservoir is further adapted to receive the augmenting heat exchange fluid from the evaporator.

21-22. (canceled)

23. A system as claimed in claim **12**, wherein the augmenting heat exchange conductor is located at least partly inside the reservoir.

24-65. (canceled)

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