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Method and System of Heat Capture for HVAC

Field of Invention

This invention relates to the use of renewable energy sources to provide refrigeration source. In particular, the invention provides for a refrigeration source that may be used with air conditioning, food storage and other such applications.

Background

Refrigeration, whether for air conditioning, food storage or otherwise is inherently a high energy usage application. Refrigeration is almost inevitably a major draw on electricity and consequently cost, whether for domestic, commercial or industrial use.

It follows, therefore, that providing a refrigeration system that draws on renewable energy is potentially very useful and economically beneficial, but is also a relatively unexplored application.

Summary of Invention

In a first aspect, the invention provides a refrigeration system comprising, a solar energy collector for collecting heat; a vapour generator adapted to use said heat to generate a flow of vapour; a refrigeration unit in communication with a heat source, said refrigeration unit comprising a condenser for receiving said vapour, and an evaporative unit in fluid communication with said condenser via an expansion valve such that the vapour enters the refrigeration unit and exits as liquid, with a resulting refrigeration effect applied to said heat source.

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In a second aspect the invention provides a method of refrigerating a heat source comprising the steps of : collecting heat from a solar energy collector; generating vapour using said collected heat within a vapour generator; passing said vapour through a condenser to form a condensate; passing said condensate through an expansion valve to evaporate said condensate and consequently refrigerating said evaporated condensate; applying said evaporated condensate to a heat source to refrigerate said heat source.

The solar energy collector may take a number of different forms, including forming part of structural and non-structural components. In its most basic form, it may be a panel, such as may be mounted to a roof or the side of a building. Alternatively, it may be fitted to a structural frame, so as to enclose a space. Said frame may be in any number of arrangements so as to optimise exposure to the sun.

In a preferred embodiment, the solar energy collector may be fitted to a frame such that the solar energy collector forms an apex. Such a shape may be wedge shaped, conical, frusto-conical or similar shape. In a preferred embodiment, it may be pyramid in shape, so as to provide an optimum flat surface in key directions, as well as being a convenient arrangement for constructions.

In a preferred embodiment, the absorbent may comprise a Lithium Bromide-water solution or Ammonia-water solution

It should be noted, conventional absorption chiller use natural gas or LPG as the primary source of working energies.

Further, solar assisted cooling may help to maintain load balancing on the power grid. As solar irradiation increases, the need for cooling also increases.

This is offset by the production of hot water at higher temperature that can be used in the absorption chilling cycle.

In a preferred embodiment, the present invention may combine a pyramid like solar energy collector, a vapour generator and a refrigeration unit, such as a condenser unit of an absorption chiller system.

Whilst many arrangements of the solar energy collector are possible, multiple panels converging at an apex may be considered beneficial. To this end, and for construction purposes, a pyramid shape may be a convenient structure.

For example, a pyramid-like structure comprising a base and 3 or more side frames, each side frame forming an angle to the base, the pyramid-like structure having an enclosed space within, the pyramid-like structure having:

- A collector of solar energy;
- An accumulator-conductor of thermal energy;
- An air suction means to take surrounding air into the enclosed space;
- A plurality of wind tunnels at the base to admit in surrounding air;
- A condenser situated within the wind tunnel to effect heat transfer between the heated refrigerant vapour and the induced air;
- A wind turbine;
- A system for storage, circulation and heating of a Heat Transfer Medium from a Main Thermal Reservoir up to a plurality of Day tanks near the top

of the pyramid-like structure and then down through the accumulators and conductors of thermal energy;

- A boiler system; and

- A system of control for working of the solar assisted absorption chiller.

The pyramid-like structure is for the collection of thermal energy by the accumulator-conductor of thermal energy, said thermal energy transferred by the accumulator-conductor to heat the Heat Transfer medium. The high temperature Heat Transfer Medium transfers the thermal energy to the refrigerant absorbent solution to cause desorption of refrigerant from the refrigerant absorbent solution.

In a specific embodiment, the present invention may include a pyramid structure that works as a solar energy collector.

In a preferred embodiment, the invention may further include a set of wind tunnels located near the base of the pyramid structure to admit in pressurized ambient air from the outside. The air may be supplied by a set of induction fans.

In a more preferred embodiment, each wind tunnel may be further equipped with an air-cooled condenser. The vapourised refrigerant produced by the generator unit flows through the pipes in the condenser to undergo condensation and heat exchange with the induced air.

In a more preferred embodiment, each wind tunnel may be further equipped with an air-cooled heat exchanger. Warm water undergoes heat exchange with the induced air to become cooling water. Cooling water flows through pipes in the refrigeration unit to absorb the waste heat generated by the refrigeration unit.

In a more preferred embodiment, the invention may further include a central air duct within the pyramid structure equipped with a wind turbine to recover the thermal and kinetic energy of the heated induced air from the wind tunnel.

To cater for day and night operations, the system may also be equipped with an additional gas burner to supplement the supply of heat needed to sustain the absorption chilling cycle. The gas burner may burn LPG, natural gas or brown gas (a form of oxyhydrogen gas obtained from the electrolysis of water according to the method of US Patent 4,081,656).

A In a more preferred embodiment, the invention may further include a Main Thermal Reservoir for collecting the high temperature heat transfer medium produced either by the solar thermal collector or by the supplementary burning of gas or both. The Main Thermal Reservoir ensures continue supply of high temperature heat transfer medium for indirect heating of the refrigerant solution in the generator unit even when there is insufficient solar insolation.

In a more preferred embodiment, the solar energy collector may be a pyramid-like structure with four side frames. Each side frame being angled from 30 to 60 degree as measured from the base, depending on location of the collector and sun's maximum azimuth. The foundation of the structure may comprise mild steel concrete plinths, beams and columns with steel encasing therein, forming the pyramid-like structure.

Each side frame of the pyramid structure may comprise multi-layered panels to accommodate at least the following four layers:

- A heating layer
- A heat transfer layer
- A heat absorption and transfer layer

- A heat retention layer

Water in the heat transfer layer may be carried in metal pipes spiralling from the top of the pyramid structure to the base. Water transfers and absorbs thermal energy from the heating layer for storage in a thermal reservoir at the bottom of the pyramid.

Further, there may be three storage tanks at the bottom of the pyramid. The tanks may be set out in a concentric manner taking reference from the apex of the pyramid. The innermost tank may be a thermal reservoir for the storage of heated water from the heat transfer layer. Adjacent to the thermal reservoir may be a storage tank for Lithium Bromide solutions. The outermost tank may be the cooling water storage tank. The heated water tank and the Lithium Bromide storage tank may be separated by a conducting wall, which serves to preheat the Lithium Bromide solution. Further, the cooling water tank, however, may be insulated from the other tanks.

The drum which collects the refrigerant vapour may be situated near the top of the pyramid. In so doing, the drum may be connected through a series of pipes to the storage tank for Lithium Bromide solution.

There may also be an opening at the top of the drum for the venting of refrigerant vapour to the condenser of the absorption chiller. The pipes carrying the Lithium Bromide solution may be laid close to the surface of the pyramid.

The series of pipes may radiate from the Lithium Bromide solution tank at the base of the pyramid and converge to the drum at the top. When there is sufficient solar insolation at one of the surfaces, refrigerant vapour and diluted Lithium Bromide solution may rise to the top drum due to the thermo-siphon effect. At the top drum further desorption of Lithium Bromide solution may take place and give rise to higher concentration of Lithium Bromide solution.

The heavier concentrated Lithium Bromide solution may flow, by gravity, to the Lithium Bromide storage tank. Some of the concentrated Lithium Bromide solution in the storage tank is piped to the absorber unit of the absorption chiller to absorb back the refrigerant vapour. Diluted Lithium Bromide solution from the absorption chiller may be returned via a pump to the Lithium Bromide storage tank to sustain the operation.

The set of wind tunnels at the base of the pyramid-like structure may be for the forced circulation of surrounding air into the pyramid-like structure. A condenser unit carrying heated refrigerant vapour transfers the thermal energy of the refrigerant vapour to the induced air. Refrigerant vapour condenses as the latent heat of evaporation is imparted to the induced air. A temperature differential is created between the surrounding air and heated air inside the wind tunnel of the pyramid, leading to a continuous flow of heated air that turns the wind turbines to generate electricity to supplement the energy needed to sustain the operation of the solar assisted absorption chiller.

The Accumulator-conductor may comprise at least three layers of heat absorbing materials and a bottom layer of heat retention material, the three layers of heat absorbing materials being a 1st Heat Layer as the outermost layer, a 2nd Heat Transfer Layer below the 1st Heating Layer, a 3rd Absorption and Transfer Layer below the 2nd Heat Transfer Layer, and a bottom layer of heat retention material being a 4th Heat retention Layer.

In a preferred embodiment, the collector of solar energy may comprise the 1st Heating Layer 1 and is a layer of glass panels integrated with solar cells.

In a preferred embodiment, the 1st Heating Layer may be made of glass panels or other transparent material such as transparent polycarbonate, integrated with solar cells.

Alternatively, the 1st Heating Layer is made of glass panels or other transparent material such as transparent polycarbonate, integrated with convex lenses to concentrate light beams.

In a preferred embodiment, the 2nd Heat Transfer Layer may comprise a network of metal pipes, wherein one pipe could be used to carry heat transfer medium and another pipe for carrying other heat transfer fluids.

In a preferred embodiment, the 4th Heat retention Layer may be made of insulation materials to absorb thermal heat transferred from the 1st Heating Layer, 2nd Heat Transfer Layer and 3rd Heat Absorption and Transfer Layer.

In a preferred embodiment, the 1st Heating Layer, the 2nd Heat Transfer Layer, the 3rd Heat Absorption and Transfer Layer and the 4th Heat Retention Layer may form part of the cross section of the side frame.

Air Suction Means may comprise a Vertical Main Air shaft joint by a plurality of wind tunnels. The Vertical Main Air shaft has a top end near the top of the pyramid-like structure and an enlarged circular base, having a large wind turbine. The top end of the Vertical Main Air shaft vented to outside and has automated louvers

The enlarged circular base of the Vertical Main Air Shaft may be connected to a plurality of Wind tunnels. Each Wind tunnel is in the form of a spirally curved, converging nozzle having its discharge end joins to the enlarged circular base of the Vertical Main Air Shafts.

Each Wind tunnel has an air-cooled condenser unit with pipes carrying Refrigerant Vapour to be condensed into liquid form. An air suction means admits in surrounding air to exchange heat with the heated refrigerant vapour in the condenser.

System for Storage, Circulation and Heating of a Heat Transfer Medium may comprise a Main Thermal Reservoir connected to a plurality of Balancing Tank and an intake for Heat Transfer Medium and a pipe and pumps to circulate the Heat Transfer Medium up to a plurality of Generator Units near the top of the pyramid-like structure and down from the Generator Units back to the Main Thermal Reservoir.

The Heat Transfer Medium may be slowly pumped up to the Generator Units through the network of pipes of 2nd Heat Transfer Layer, the Heat Transfer Medium absorbing thermal energy and also transferring thermal energy from the 1st Heating Layer to the 3rd Heat Absorption and Transfer Layer. At the Heat Exchanger, the high temperature Heat Transfer Medium further imparts thermal energy to the Refrigerant Absorbent Solution contained in the Generator Units to cause desorption of Refrigerant from the Refrigerant Absorbent Solution and the Heat Transfer Medium flows back to the Main Thermal Reservoir.

Preferably, the Main Thermal Reservoir is located at the base of the pyramid-like structure. The network of pipes comprises pipes for heat transfer medium such as fresh water.

The network of pipes may comprise pipes for heat transfer medium such as fresh water laid within 1st Heating Layer and 3rd Heat Absorption and Transfer Layer inside the side frame.

The network of pipes consisting of pipes for heat transfer medium such as fresh water being laid in a zig-zag pattern within Layer 1 and Layer 3 of the side frame so as to maximize the time taken for the heat transfer medium such as fresh water to flow through the pipes.

System for circulation, heating and cooling of a Refrigerant may comprise a Reservoir for Refrigerant Absorbent Solution connected to an intake for Refrigerant-absorbent solution via a piping network to circulate the Refrigerant absorbent solution up to a plurality of Generator Units near the top of the pyramid-like structure.

The Refrigerant absorbent solution flows to the Generator Units through a pipe and pump. At the Heat Exchanger, the Refrigerant Absorbent Solution absorbing thermal energy from the Heat Transfer Medium to effect evaporation of the Refrigerant. Due to buoyancy force, the Refrigerant Vapour formed in the process will cumulate at the Generator Units together with the Refrigerant absorbent solution desorbed of Refrigerant.

The network of pipes may comprise pipes for Refrigerant absorbent solution such as Lithium Bromide water solution or Ammonia water solution.

Within the Generator Units, the network of pipes may be such that the direction of flow of the Refrigerant is opposite to the direction of flow of the Heat Transfer medium.

Refrigerant vapour cumulated at the Generator Units discharges to a network of heat transfer pipes or heat transfer plates in an air-cooled Condenser Unit. The Condenser Unit may be housed in the middle section of the wind tunnel. Cooled air induced from the surrounding flows through the heat exchanger fins and surface of the Condenser Unit to absorb the latent heat of evaporation from the Refrigerant vapour to effect condensation of the Refrigerant.

Refrigerant condensate discharges further to a low pressure, evaporation chamber of the absorption chiller via a set of expansion valves and nozzles. During which, the condensate evaporates at low temperature and absorbs the latent heat of evaporation from a heat exchanger carrying Heat Transfer fluid to be chilled.

Refrigerant condensate is discharged to the Evaporator Unit of an absorption chiller through a combination of pipes, pump and expansion valve. The Evaporator Unit connects directly to an Absorber Unit. Both the Evaporator Unit and the Absorber Unit are maintained at near vacuum conditions. In particular, the conditions at the Evaporator Unit are as follows: the Evaporator Unit is maintained at a vacuum state to effect evaporation of refrigerant condensate at a lower temperature. For example, the pressure may be about 1 kPa and the temperature may be about 4°C.

The refrigerant condensate from the Condenser Unit flows through pipe which comprises an expansion valve before it forms a refrigerant spray in the Evaporator Unit. The Refrigerant condensate may be sprayed and evaporated onto a bundle of chilled water tubes in the Evaporator Unit. As the refrigerant condensate evaporates under near vacuum condition at the spray, it absorbs the latent heat of evaporation from the warm water flowing in a bundle of chilled water tubes. Consequently, chilled water is discharged from the chilled water tubes. The refrigerant vapour produced in the process is absorbed by the concentrated Absorbent in the Absorber Unit. This rapid absorption of the refrigerant vapour creates a vacuum state at the Evaporator Unit, as the Evaporator Unit and the Absorber Unit are interconnected. In particular, there may be a pump (not shown) connected to the Evaporator Unit and Absorber Unit. The pump creates a high vacuum of less than 1.0% of atmospheric pressure. Concentrated Absorbent is produced in the Generator Unit near the top of the pyramid-like structure. When the Refrigerant from the Generator Unit evaporates, concentrated Absorbent is formed. The concentrated Absorbent

Solution flows to the Absorber Unit through pipe, which comprises an expansion valve, to form an Absorbent spray. The Absorbent Solution from the Absorbent spray may be collected at the bottom of the Absorber Unit to form a pool of Refrigerant Absorbent Solution as it combines with the refrigerant vapour from the Evaporator Unit, which may be recycled back to the Refrigerant Absorbent Solution in the Generator Unit by a pump. Heat may be produced during the absorption of Refrigerant by the Absorbent. A heat exchanger in the Absorber Unit has cooling water of temperature of approximately 25°C being fed an air-cooled heat exchanger located inside the wind tunnel. Water of a slightly higher temperature may be discharged from the heat exchanger and fed back to the air-cooled heat exchanger in the wind tunnel.

According to a further embodiment, the invention may further comprise at least one chamber for producing chilled water. In particular, the at least one chamber may be a part of an absorption chiller unit.

The at least one chamber may comprise:

- a first inlet for receiving an absorbent;
- a second inlet for receiving a refrigerant;
- a third inlet for receiving cool water;
- a fourth inlet for receiving warm water;
- a first heat exchanger;
- a second heat exchanger;
- a first outlet for discharging warm water; and
- a second outlet for discharging chilled water produced,

wherein the third inlet and first outlet may be connected to the first heat exchanger, and the fourth inlet and second outlet may be connected to the second heat exchanger.

The absorbent may be Lithium bromide (LiBr), Ammonia (NH_3), and other suitable absorbents such as desiccants or dehumidifiers as would be clear to the skilled addressee. The refrigerant may be water. Other suitable refrigerants may also be used for the purposes of the present invention.

The at least one second chamber may utilise the heat produced from a heat exchanger running hot water from the at least second storage chamber or produced directly from the at least one first chamber from the combustion of Brown gas to vapourise the refrigerant and the absorber to effect a cooling cycle. As a result of the cooling cycle, water from the at least one second chamber may be chilled. The chilled water produced may be stored in at least one third storage chamber. The chilled water may be used for various applications. For example, for space cooling applications. In particular, the chilled water from the at least one third storage chamber may flow into an air handling unit, which comprises a heat exchanger with a blower, to provide space cooling.

The boiler system comprises a boiler on top of a plate or shell of reactive metal element. The boiler provides heat to the Heat Transfer medium when there is insufficient solar insolation to maintain the temperature requirement. For example, the reactive metal element which may be used in the chamber may include, but may be not limited to, any of the following: platinum, steel, nickel-chromium alloy or other high temperature nickel alloys. The reactive metal element may be in the form of a singly curved or doubly curved shell with perforation on the shell surface to maximise the contact area between the metal element and a flame projected by a burner. The reactive metal element may be

placed in the path of the flame produced by a Brown gas burner to effect reactive combustion to further elevate the flame temperature in the boiler.

Heated Heat Transfer medium produced in the boiler circulates to the Main Thermal Reservoir through pipes and circulation pumps.

The System of controls may comprise controls for movement of air, movement of Heat Transfer Medium, Refrigerant absorbent solution and controls for monitoring the operation of the various systems, flow rate and temperature of the Heat Transfer Medium, surrounding air and the Refrigerant absorbent solution.

The control for movement of air may include automated louvers and induction fans. The control for movement of Heat Transfer medium and Refrigerant absorbent solution may include pumps and flow regulators. The system of controls may be operated with instructions from a computer or other electrical/electronic devices.

The wind turbine may be installed at the junction before the enlarge base of the Vertical Air shaft. It may be driven by hot air produced by the Condenser units carrying high temperature Refrigerant Vapour in pipes. The Condenser units may be located in the wind tunnel that admits in cool air from the surrounding.

A set of induction fans installed around the base of the structure sucks in cool air from the surrounding into the wind tunnel. The cool air in the wind tunnel may be heated up by a plurality of Condenser Units. The hot air exists from the wind tunnel converging into the spirally curve wind tunnel that joined to the Vertical Air shaft, creating an air turbulence, hot air exiting from the wind tunnel at an angle into the turbine blades in the Vertical Air shaft, to turn the wind turbine for the generation of electricity.

In a third aspect, the invention provides a system comprising, at least one frame, the or each frame providing an internal chamber, and having a surface exposed to sunlight; said surface comprising an accumulator-conductor of thermal energy, said accumulator-conductor having a solar energy collector, and; a heat transfer circulation system comprising a pipe network for circulating a heat transfer medium in a closed loop arrangement so as to permit the circulation of the heat transfer medium from the surface to receive thermal energy to a thermal reservoir of said heat transfer medium for storing said thermal energy as a thermal mass.

In a preferred embodiment, the solar energy collector may include three layers of heat absorbing materials and a bottom layer of heat retention material. The three layers of heat absorbing materials may include a heating layer as the outermost layer, a heat transfer layer below the heating layer, a heat absorption layer below the heat transfer layer, and a bottom layer of heat retention material being a heat retention layer.

In a preferred embodiment, the heating layer may be made of glass panels or other transparent material such as transparent polycarbonate. Further it may be integrated with photovoltaic cells.

Alternatively, the heating layer is made of glass panels or other transparent material such as transparent polycarbonate, integrated with convex lenses to concentrate light beams.

In a preferred embodiment, the heat transfer layer may comprise a network of metal pipes, wherein one pipe could be used to carry heat transfer medium, another pipe for carrying treated water and another pipe for carrying other heat transfer fluids.

In a preferred embodiment, the heat absorption layer may be made of thermal conductive metal plate, so as to achieve an optimal heat transfer characteristic.

In a preferred embodiment, the heat retention layer may be made of insulation materials to absorb thermal heat transferred from the heating layer, heat transfer layer and heat absorption and transfer layer.

In a preferred embodiment, the heating layer, the heat transfer layer, the heat absorption layer and the heat retention layer may form part of the cross section of the side frame.

In a preferred embodiment, the system for storage, circulation and heating of a heat transfer medium may comprise a main thermal reservoir connected to a plurality of pre-heat side tanks, balancing tank and an intake for heat transfer medium. Further, it may have a pipe network and pumps to circulate the heat transfer medium up to a plurality of day tanks near the top of the structure. From there, the heat transfer medium may be circulated down from the day tanks through the network of pipes of heat transfer layer, the heat transfer medium

absorbing thermal energy and also transferring thermal energy from the heating layer to the heat absorption and transfer layer, before the heat transfer medium flows back to the main thermal reservoir.

Preferably, the main thermal reservoir is located at the base of the structure. Alternatively, the thermal reservoir may be in the form of a tank located remotely from the frames. In a still further preferred embodiment, the thermal tank may be located at or near to an upper portion of at least one of said frames.

In a preferred embodiment, the network of pipes may comprise pipes for heat transfer medium such as fresh water, saline, Lithium Bromide, treated water or other suitable heat transfer fluid with good thermal retention characteristics.

Preferably, the network of pipes may comprise pipes for the heat transfer medium being laid side by side within heating layer and heat absorption layer inside the frame.

In a preferred embodiment, the boiler system may comprise a boiler on top of a hot plate and a steam chamber for receiving the steam produced by the boiler for further use of the steam by a steam generator, for power production or by a desalination system, for processing of seawater into potable water.

Preferably, the boiler system may have a plurality of external parabolic reflectors near the base of structure positioned so that sunlight is directed towards the hot plate to heat the heat transfer medium in the boiler.

In a preferred embodiment, the hot plate may be a flat horizontal area containing the boiler system and control systems.

Preferably, the controls for movement of heat transfer medium and other heat transfer fluids and water may include pumps and flow regulators.

Preferably, the system of controls is operated with instructions from a computer or other electrical/electronic devices.

Brief Description of Drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are possible, and consequently the particularity of the accompanying drawings is not intended to be limiting of the present invention.

Figure 1 is a schematic view of the refrigeration system according to a first embodiment of the present invention;

Figure 2 is a sectional view of the solar frame according to one embodiment of the present invention;

Figure 3 is a plan of the wind tunnels according to one embodiment of the present invention;

Figure 4 is a schematic view of the full solar radiation cycle of the refrigeration system according to one embodiment of the present invention;

Figure 5 is a schematic view of the partial solar radiation cycle of the refrigeration system according to one embodiment of the present invention;

Figure 6 is a schematic view of the zero solar radiation cycle of the refrigeration system according to one embodiment of the present invention;

Figure 7 is a schematic view of the refrigeration system according to a second embodiment of the present invention;

Figure 8 is an elevation view of frames mounted to a structure according to a further embodiment of the present invention, and;

Figure 9 is an elevation view of frames cooling a structure according to a further embodiment of the present invention.

Description of Preferred Embodiment

Figure 1 shows one embodiment of the present invention providing an integrated arrangement of apparatus in order to provide a chill water supply 126 under a range of environmental conditions.

The embodiment incorporates a structure in the form of a pyramid 5 having at least three solar frames 10 arranged to be inclined so as to receive solar radiation 15. The pyramid 5 stands upon a base having a plurality of wind tunnels 117 receiving air 119 from outside the pyramid 5 and directing the air flow 118 through a wind turbine 114 up through a central vertical shaft 113 so as to expel said air. Air may be driven into the wind tunnels through induction fan 112 which directs air into the wind tunnel 117 so as to pass the air flow 118 pass a condenser and heat exchanger which may be arranged in parallel or in series within the wind tunnel 117. Air exiting the wind tunnels 117 will drive the wind turbine 114 and so using alternator 116 which is connected to a

transformer 121 will generate electricity. The air is expelled through the main air shaft 113 through the apex of the pyramid 5.

With regard to the solar frames 10, within each frame is a network of pipes 30 having a heat transfer medium such as water 50 which is heated by the solar radiation 15 for use later in the process. The heated water is then fed into a vapour generator whereby at least a portion of the heat within the flow of water is exchanged within a second heat transfer medium such as lithium bromide within a vapour generator 22. The water is then fed into a thermal tank 51 located adjacent to the base of the pyramid. From the thermal tank 51 the water is fed back to a day tank 26 located adjacent to the top of the pyramid which acts as a storage area for the water prior to re-circulation through the solar frame 10.

Water vapour 21 is extracted from the vapour generator 22 and fed to the condenser 111 within the wind tunnel 117. The condensate is being further fed through an expansion valve into an evaporator which evaporates the condensate leading to a temperature drop within the evaporator 125. The evaporator further receives a flow of warm water 127 which is passed over coils containing the expanded condensate with the result being the chilled water 126 fed from the evaporator and thus providing a source of refrigeration. The chilled condensate vapour having being warmed by the refrigeration process within the evaporator 125 is then fed into an absorber as low temperature water vapour.

Between the air cooled condenser 110 and the absorber is a closed circulation of water such that the condenser produces warm water which is subsequently cooled in the absorber and recycled back to the condenser 110.

The second heat transfer medium in this case being lithium bromide receives saturated or weak lithium bromide into the vapour generator. Due to the heated water received from the solar frame 10, the water is extracted from the lithium bromide as vapour and exits the vapour generator 22. This results in a more

concentrated lithium bromide which is drained 155 from the vapour generator and fed into a heat exchanger such that the concentrated lithium bromide passes over coils within the heat exchanger 160 such that these coils circulate lithium bromide from the absorber. The heat exchanger cools the concentrated lithium bromide and feeds this into the absorber 140 as a spray which is warmed from the water from the condenser and combined with the water vapour from the evaporator to form a concentration of weak lithium bromide within the absorber 140. This weak lithium bromide is circulated within the coils previously discussed in the heat exchanger and fed back into the vapour generator 22.

As an auxiliary system, there is further provided a boiler 122 which is in communication across the vapour generator having valves on either side of the water circulation coils within the vapour generator 22. As will be discussed in more detail later, the arrangement is such that water within the boiler 122 is heated through a gas burner 123 and fed upstream of the vapour generator so as to either supplement or replace the supply of heated water to the vapour generator. Further the second valve 24 may be switched such that water exiting the generator 22 instead of entering the thermal tank 51, is directed back to the boiler 122 for reheating. Thus irrespective of the solar radiation 15 received by the pyramid 5, the process can be maintained so as to maintain a flow of chilled water.

Figure 2 is a detailed view of the solar frame 10 through which solar thermal energy is received from the solar radiation 15 and delivered to the aforementioned invention. As can be seen the frame consists of a first layer being a transparent panel on the extreme outside surface of the frame 10 for allowing the transmission of solar radiation 15 into the internal mechanisms of the frame. The first layer 265 covers a cavity within the frame 10 in which are placed a second layer of a pipe network such as metal tubes through which a heat transfer medium such as water will flow. Thus the solar radiation 15 is

transmitted through the first layer and through heat transfer the solar thermal energy is transferred to the circulating water within the metal tubes 30. The network of pipes of the second layer 30 is supported on a black coated conductive metal film constituting the third layer 280. The black coated conductive metal serves two purposes; firstly being to absorb heat not directly absorbed by the second layer and so apply conductive heat to the metal tubing 30. The second purport is to facilitate heat transfer through the third layer to an underlying fourth layer being a heat retention material. The fourth layer 285 further includes metal tubing 270 within which is placed a further liquid, this time not flowing. The purposes of the fourth layer including the metal tubing with the non circulating liquid is to act as a thermal mass such that retained heat is maintained and applies heat to the second layer with the circulating water when the solar radiation 15 diminishes through cloud cover or later in the day. It will have a lesser effect at night but given the construction of the solar frame 10, this will only have a limited effectiveness as heat is lost to the atmosphere. Thus the fourth layer being a heat retention layer is intended to act as a thermal mass to retain heat for short periods only.

Figure 3 shows a plane view of the wind tunnels 117 which directs air flow from outside the pyramid 5 to a central vertical shaft 113 out of which the air is expelled. The wind tunnels are arranged from peripheral edges of the pyramid in a curved orientation to promote a cyclonic flow of air on reaching the central vertical shaft 113. Thus as air enters from the periphery, it is directed in a curved linear direction towards the centre from each of four wind tunnels 117 placed in a rotational symmetric fashion. At the entrance to each wind tunnel 117 is located a pair of induction fans 112 each of which is directed to either a heat exchanger or a condenser, both of which make use of the flow of air so as to be air cooled.

Considering now the function of the structure, Figures 4, 5 and 6 show three different modes of operation subject to the intensity of solar radiation 15 bearing

on the solar frames 10. In Figure 4, the arrangement is for a high solar radiation load such that water 200 flowing through the network of pipes 30 within the solar frame 10 becomes heated prior to exiting the solar frame 10. In this embodiment valves 23 and 24 on either side of the vapour generator are closed so as to isolate the boiler 122. Thus the heated water 205 is directed into the vapour generator to heat the saturated lithium bromide and thus releasing the water vapour 21 from the lithium bromide allowing it to exit the vapour generator 22. The warm water 210 exiting the vapour generator is then stored in a thermal tank 51 which acts as a thermal mass within the pyramid 5. Subject to the requirements of circulating water, water 215 is taken from the thermal tank 51 to a day tank 26 which provides short term storage prior to the warm water 220 circulating from the day tank 26 back to the solar frame 10 for reheating by the high solar radiation mode.

Figure 5 shows the same arrangement when the solar radiation is reduced such as on a winter cycle, overcast day etc. Here the solar radiation 15 still provides a degree of solar thermal energy and so water 225 circulating through the network of pipes 30 within the solar frame 10 is then substituted by a flow of water from the boiler 122. Thus valve 23, 24 are partially opened so as to provide a degree of circulation of water 235 through the vapour generator to supplement the warm water 230 from the solar frame 10. Thus the temperature within vapour generator 22 is maintained and maintaining the flow of water vapour 21. As with the arrangement in Figure 4, water is then fed to the thermal tank 51.

Figure 6 shows a night time cycle whereby there is no solar radiation directed to the solar frame. In this case valves 23 and 24 are arranged so as to isolate the circulation of water through the solar frames such that water passing through the vapour generator 22 flows directly from the boiler 122 and back 260 to the boiler and exiting the vapour generator 22. Thus it can be seen that under a

wide range of conditions the system is maintained irrespective of the solar radiation received by the pyramid 5 so as to provide an optimal solution.

In the cases of Figures 5 and 6 the boiler may be subjected to gassed by the burners whereby the gas may be any one or a combination of propane, natural gas, LPG or brown gas.

Figure 7 shows a further embodiment of the present invention. In brief, this shows a direct method of heat transfer. Rather than water being heated and this heat transferred to the second heat transfer medium, such as LiBr, LiBr is heated directly, and so saving on any heat losses occurring as a result of the intermediate step of heat transfer. Specifically, Figure 7 shows a pyramid-like solar energy collector 315 that raises temperature of a heat transfer medium 335, a generator 305 that uses the high temperature heat transfer medium for the desorption of refrigerant from an absorbent. Not shown is a wind tunnel with heat exchanger that condenses refrigerant vapour. The surface of the pyramid-like solar energy collector 315 may be covered with photovoltaic cells, so as to maximise the energy rating of the system, beyond that covered by the present invention. Further, there may be a series of evacuated heat pipes 320, or a series of water pipes coated with heat absorption and retention materials. The function of the pyramid-like solar energy collector is to produce hot water for evaporating the refrigerant from an absorbent. Excess hot water from the solar energy collector may be stored for use at night within an insulated reservoir below the structure, which acts as a thermal mass to ensure the flow of vapour around the system does not stall when heat from the solar energy collector diminishes.

The evaporated refrigerant undergoes condensation in a condenser 110, which may be that housed within a wind tunnel so as to provide a cooling source to condense the water vapour. In this case, the wind tunnel may be equipped with a set of induction fans that draw in cool air from the surrounding. Accordingly,

cool air flows through the condenser in the wind tunnel to absorb the latent heat of evaporation of the refrigerant.

Heated air, due to buoyancy and force induction, escapes to a Main Vertical Air Shaft. Further a wind turbine installed at the entrance to the Main Vertical Air Shaft may recover the thermal and kinetic energies of the raising hot air to produce electricity to supplement the power needed to operate the auxiliary systems such as pumps and induction fans.

Refrigerant condensate from the condenser 110 is pumped through an expansion valve 120 into the evaporator 125 to produce chilled water. The evaporator 125 is connected to an absorber 140, into which is sprayed high concentration absorbent from the generator and a heat recovery unit. The high concentration absorbent from the generator passes through a heat recovery unit to undergo heat exchange with the diluted absorbent from the absorber. The high affinity of absorbent has for the refrigerant helps to extract the low temperature refrigerant vapour in the evaporator to form diluted absorbent that can be pumped to the generator again to repeat the refrigeration cycle. The solar assisted absorption chiller also comprises a main thermal reservoir to take in and hold heat transfer medium, which is heated by the pyramid-like solar energy collector. If desired, the heat transfer medium can be heated by supplementary burning of Brown gas when there is insufficient energy from solar insolation.

Further, in this embodiment the pyramid-like structure includes liquid storage tanks 330, a drum 26 which collects the refrigerant vapour 355, pipes for the flow of heat exchange fluid and pipes for the flow of absorbent.

The system may be equipped with a gas burner unit to provide the heat needed to operate the system during a prolonged absence of sunlight.

In a further embodiment of the present invention, key components of the invention may be arranged for greater flexibility in both purpose of the system and orientation of the frames. Figure 8 shows a system 400 whereby a structure 410 such as a building or other permanent fixture is used to support a plurality of frames 405 having solar collectors according to the present invention. The means of mounting of the frames may be any conventional method which will be apparent to the skilled person. These frames 405 may be individual frames aligned on portions of the structure 410 or form a unitary assembly around the structure 410 as required. The frames 405 may be placed directly in contact with this structure 401 or as is shown in Figure 8, a cavity 425 may also be formed. In this orientation the system 400 is intended to develop thermal energy from the frames 405. The heat transfer fluid in pipes within the solar collector of the frames 405 are heated by sunlight and subsequently the heat transfer fluid is pumped to a thermal reservoir 415, in this case a thermal tank located adjacent to upper portions of the frames 405. By using water as the heat transfer medium, this embodiment may provide a direct supply of hot water. It will be appreciated that any appropriate heat transfer fluid will be applicable. In this embodiment, the flexibility of the system 400 allows the thermal tank 415 to be located remotely from the frames 405. In further embodiments, the thermal tank may be located convenient to the purpose for the thermal tank and have the heat transfer fluid pumped to it from a range of different frames located accordingly. For instance, a single thermal tank may be in fluid communication with an array of frames arranged to maximize exposure to sunlight analogous to a photovoltaic farm.

In the case shown in Figure 8, the tank 415 is located at a point which the heat transfer fluid may be extracted 430 from the tank for use for heating or as a supply of hot water for an absorption chiller for instance, an absorption chiller in accordance with the present invention. At an elevated height, the fluid may also be gravity fed to the desired location.

The frames 405 may include transparent upper panels for receiving the sunlight and further still, said panels may include lenses so as to focus the sunlight onto the solar collector. In the case shown in Figure 8 where the capture of solar thermal energy is to be optimised, said lenses will maximize the production of thermal energy applied to the heat transfer fluid.

Figure 9 shows a further embodiment of the present invention whereby an envelope 440 of frames has been formed around a structure 445 for the purposes of cooling said structure. The structure may be a range of different types including buildings, plant or equipment or in fact any such structure whereby a benefit is to be gained from cooling.

In this case the frames according to the present invention, may make up all or a portion of the envelope 440 for production of thermal energy transferred to a heat transfer fluid. Of particular interest for the envelope of 440 is the intent to encapsulate the structure to be cooled 445 and so creating a cavity 450. Thus, rather than exposing the structure 445 to sunlight, the frames 440 not only shield the structure from sunlight but also provide a means of capturing solar thermal energy. To further enhance the cooling effect, the cavity 450 may be ventilated using a device 455 such as a ventilation fan or other means of pumping or removing heated air from the cavity 450 and so providing a further means of cooling the structure 445.

Claims :

1. A refrigeration system comprising,
a solar energy collector for collecting heat;
a vapour generator adapted to use said heat to generate a flow of vapour;
a refrigeration unit in communication with a heat source, said refrigeration unit comprising a condenser for receiving said vapour, and an evaporative unit in fluid communication with said condenser via an expansion valve such that the vapour enters the refrigeration unit and exits as liquid, with a resulting refrigeration effect applied to said heat source.

2. The system according to claim 1, wherein the solar energy collector includes a least one surface for receiving solar heat and transferring said heat to a fluid heat transfer medium.

3. The system according to claim 2, wherein the heat transfer medium is water.

4. The system according to claim 2, wherein the heat transfer medium includes LiBr or NH_3.

5. The system according to any one of the preceding claims, wherein the generator is in heat transfer communication with the solar energy collector.

6. The system according to any one of the preceding claims, wherein the generator generates vapour through the heating of an absorbent in a reservoir of said generator.

7. The system according to any one of the preceding claims, wherein said vapour is water vapour desorped from the absorbent.

8. The system according to any one of the preceding claims, wherein the absorbent includes LiBr or NH_3.

9. The system according to any one of claims 6 to 8, wherein the reservoir includes a column having a vertical temperature gradient, such that diluted absorbent ascends the column, and concentrated absorbent descends the column.

10. The system according to claim 9, wherein the column further includes a zone at the top of said column where desorped water vapour is collected.

11. The system according to claim 10, wherein the condenser is connected to the generator through a pipe from the zone to the condenser to permit the flow of vapour from the generator to the condenser.

12. The system according to claim 11, wherein the vapour the flow of vapour is biased by an increase in pressure in the zone as a result of the desorption of the vapour from the absorbent.

13. The system according to any one of the preceding claims, wherein the condenser comprises a cooling source applied to said vapour for forming a condensate from said vapour.

14. The system according to claim 13, wherein the cooling source includes a cooling tower in communication with the condenser to dissipate heat.

15. The system according to claim 13, wherein the condenser is positioned within a wind tunnel, such that the cooling source includes air flow in the wind tunnel and subsequently passing over the condenser to dissipates heat.

16. The system according to any one of the preceding claims, wherein the heat source comprises conduits having liquid flowing from an external source, said pipes having a portion within the evaporator such that evaporated condensate is applied to said conduits, and consequently refrigerating the liquid within said conduits.

17. The system according to any one of claims 9 to 16, further including an absorber unit for receiving the evaporated condensate from the evaporator, and concentrated absorbent from the reservoir, said absorber unit adapted to combine the condensate with the absorbent, to output diluted absorbent to the reservoir.

18. The system according to claim 17, further including a heat exchanger, intermediate the absorber unit and reservoir, for dissipating heat from the diluted absorbent.

19. The system according to claim 3, further including heat transfer pipes for circulating water from the solar energy collector to the reservoir, said heat transfer pipes arranged to receive within the solar energy collector, and dissipated heat within the reservoir, said the water in the heat transfer pipes and the absorbent in the reservoir remaining isolated.

20. The system according to claim 19, wherein the heat transfer pipes dissipate heat to an upper portion of the reservoir.

21. The system according to claim 19 or 20, wherein the heat transfer pipes circulate the water from a warm water tank located contiguous with a central portion of the reservoir, to the solar energy collector, to the reservoir and back to the warm water tank.

22. The system according to any one of claims 19 to 21, further including a cool water tank insulated from the warm water tank and contiguous with a lower portion of the reservoir.

23. The system according to any one of claims 20 to 22, wherein the heat transfer pipes, the warm water tank and cool water tank form the vertical temperature gradient within said reservoir.

24. A method of refrigerating a heat source comprising the steps of :
collecting heat from a solar energy collector;
generating vapour using said collected heat within a vapour generator;
passing said vapour through a condenser to form a condensate;
passing said condensate through an expansion valve to evaporate said condensate and consequently refrigerating said evaporated condensate;
applying said evaporated condensate to a heat source to refrigerate said heat source.

25. A system comprising,
at least one frame, the or each frame providing an internal chamber, and having a surface exposed to sunlight;

said surface comprising an accumulator-conductor of thermal energy, said accumulator-conductor having a solar energy collector, and;

a heat transfer circulation system comprising a pipe network for circulating a heat transfer medium in a closed loop arrangement so as to permit the circulation of the heat transfer medium from the surface to receive thermal energy to a thermal reservoir of said heat transfer medium for storing said thermal energy as a thermal mass.

26. The system according to claim 25 wherein said heat transfer medium is selectively pumped through the pipe network so as to maintain circulation.

27. The system according to claim 25 or 26, wherein the or each frame is engaged with a structure such that at least a portion of said structure is shielded from the sunlight by said frame.

28. The system according to any one of claims 25 to 27 wherein said surface is inclined from the vertical.

29. The system according to any one of claims 25 to 28 wherein said frame includes a plurality of surfaces.

30. The system according to any one of claims 27 to 30 wherein said at least one frame includes a plurality of frames encapsulating said structure so as to define a cavity intermediate said frames and structure.

31. The system according to any one of claims 25 to 30 wherein said thermal reservoir includes a tank located near or at an upper portion of said at least one frame.

32. The system according to claim 30 or 31 further including a ventilation device for removing heated air from said cavity.

33. The system according to claim 32 wherein said ventilation device includes an exhaust fan.

34. The system according to claim 32 or 33 wherein said ventilation device is located adjacent top an upper portion of said frames.