



US 20080203866A1

(19) **United States**(12) **Patent Application Publication**
Chamberlain(10) **Pub. No.: US 2008/0203866 A1**(43) **Pub. Date: Aug. 28, 2008**(54) **ROOFTOP MODULAR FAN COIL UNIT****Publication Classification**(76) Inventor: **Cliff S. Chamberlain**, Kirkland,
WA (US)(51) **Int. Cl.**
F24F 5/00

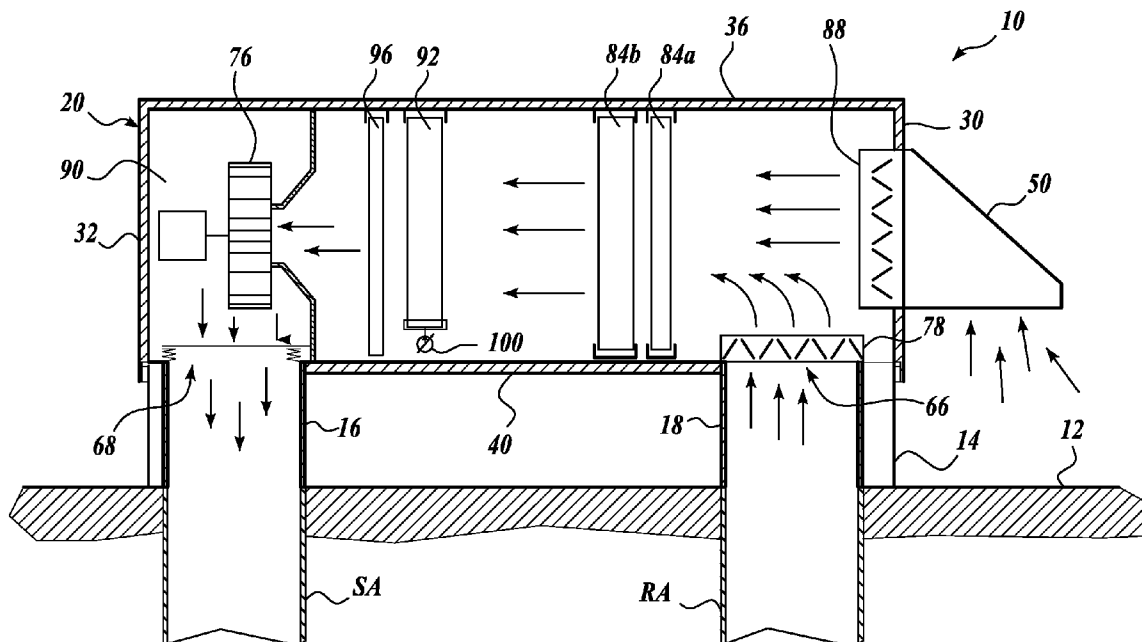
(2006.01)

(52) **U.S. Cl.** **312/236**(57) **ABSTRACT**

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SEATTLE, WA 98101-2347 (US)(21) Appl. No.: **12/021,216**(22) Filed: **Jan. 28, 2008****Related U.S. Application Data**(60) Provisional application No. 60/886,876, filed on Jan.
26, 2007.

A rooftop cooling and/or heating unit may include, but is not limited to, a supply fan and a heating and/or coiling device. The cooling device is preferably one or more chilled water coils suitably mounted within the unit in-line with fresh air delivered via an air intake hood and/or return air supplied from the return air duct. The unit further includes one or more fluid circulation pumps connected in-line with the one or more chilled water coils. Embodiments of the rooftop cooling and/or heating units may further include one or more of the following: pump compartment, controls compartment, power compartment, space for optional features, varying air filter options, mixed air dampers, optional exhaust/relief features, etc. The unit may receive part or all of its power requirements from an associated solar power generator.



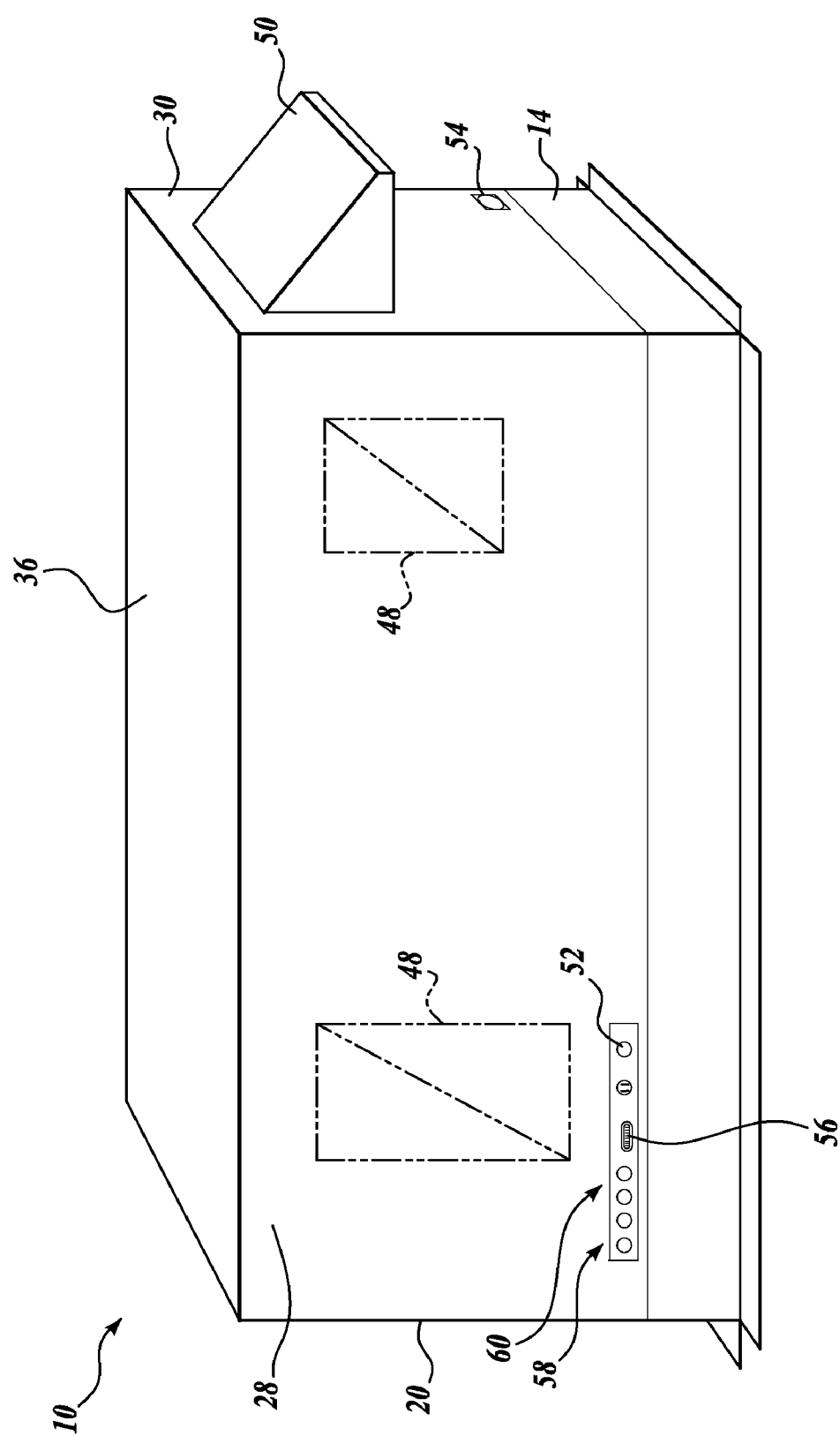


Fig. 1.

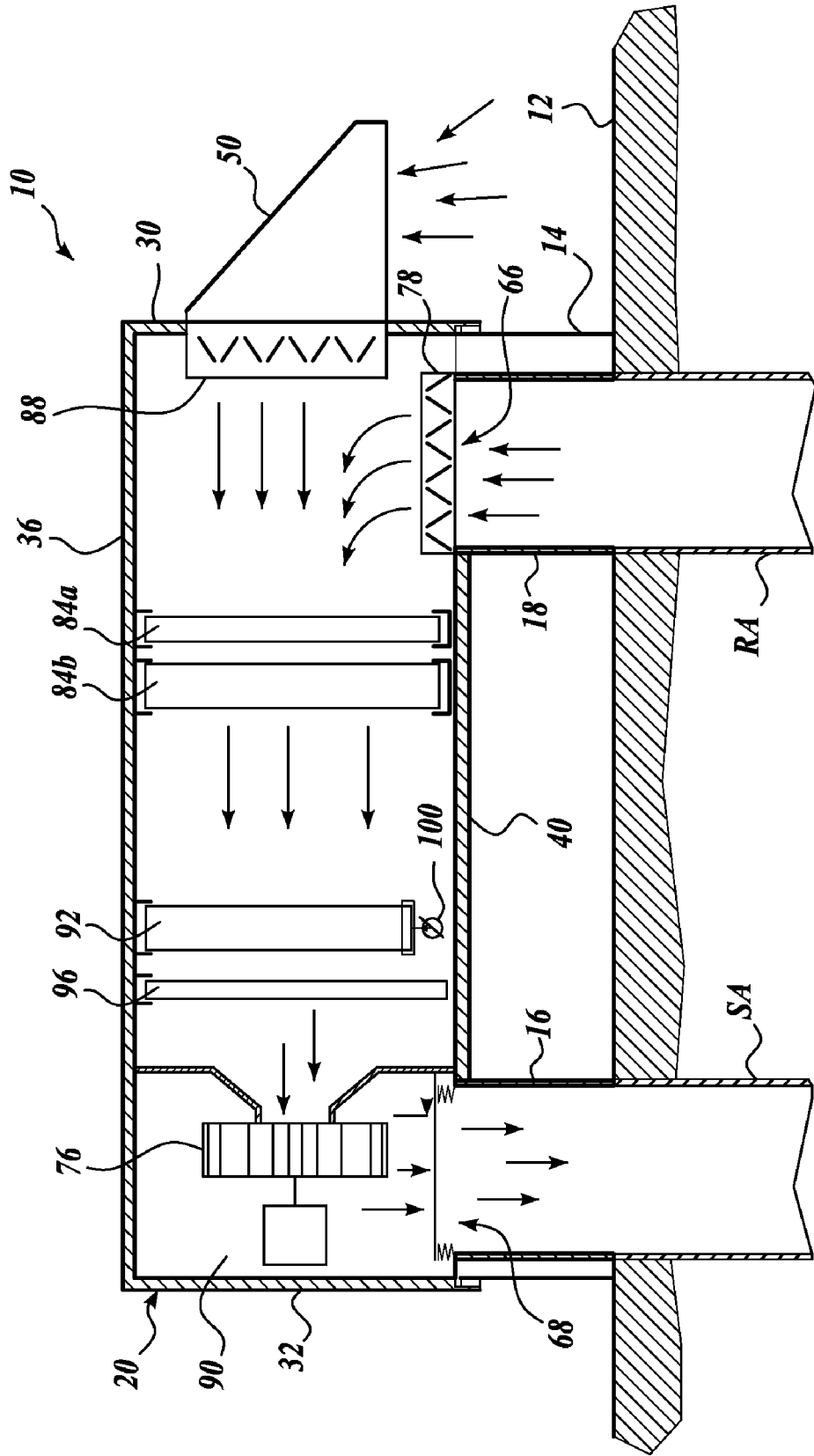


Fig. 2.

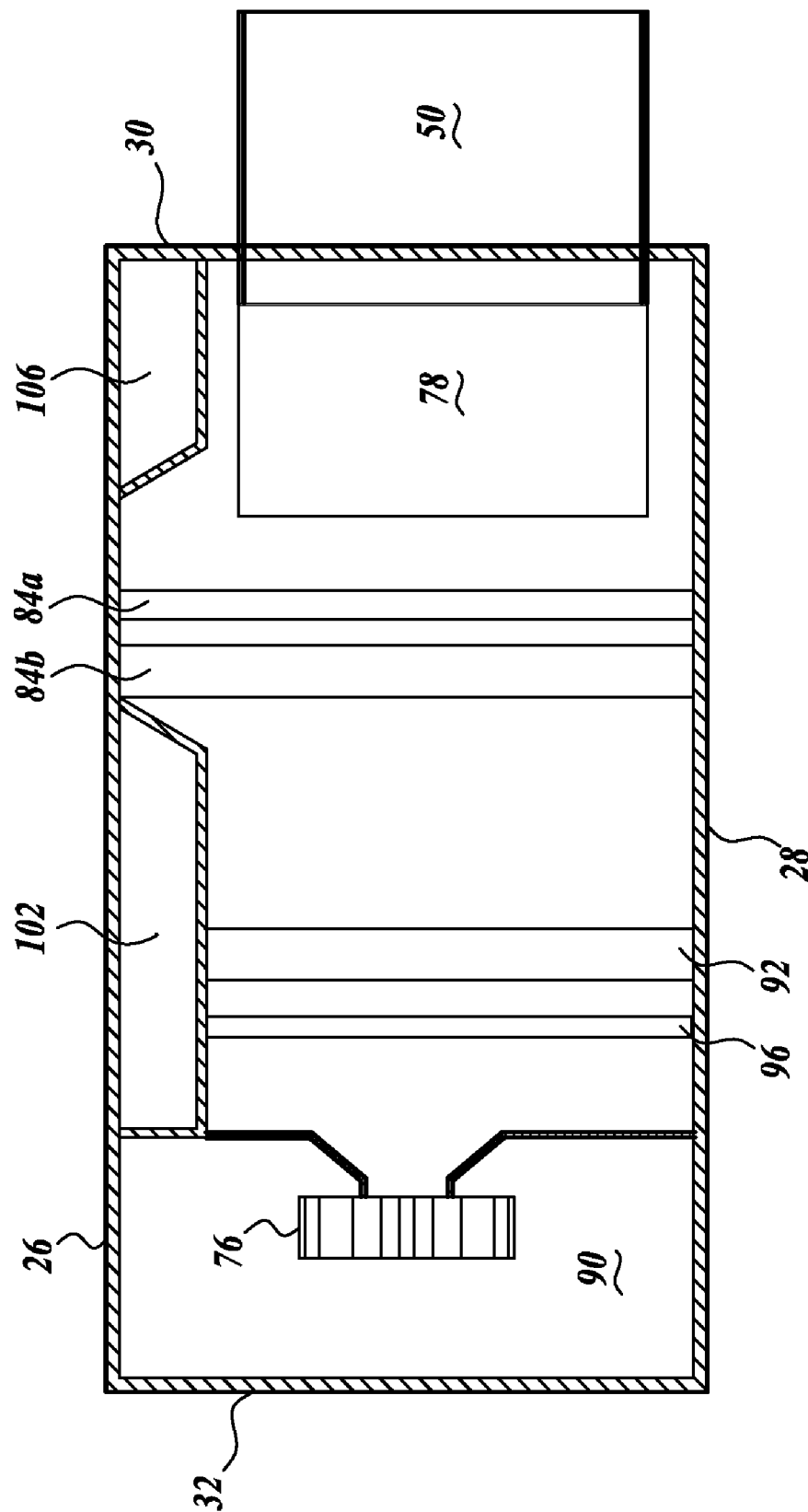


Fig. 3.

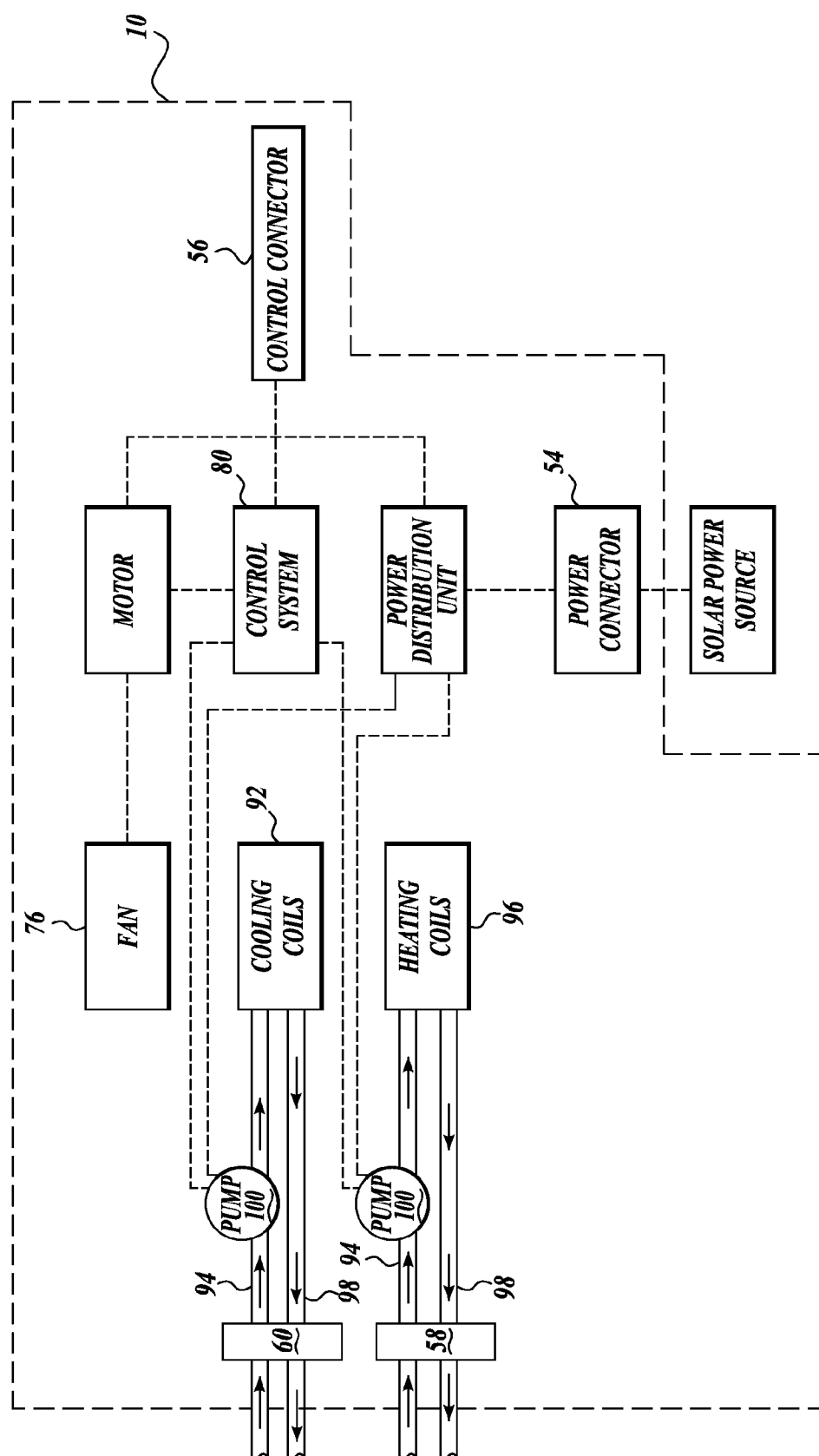


Fig. 4.

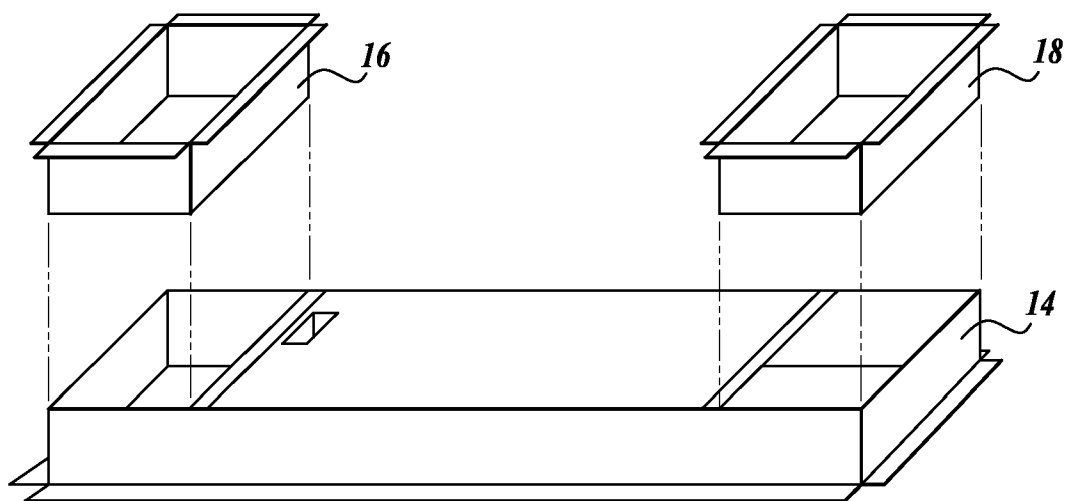


Fig. 5A.

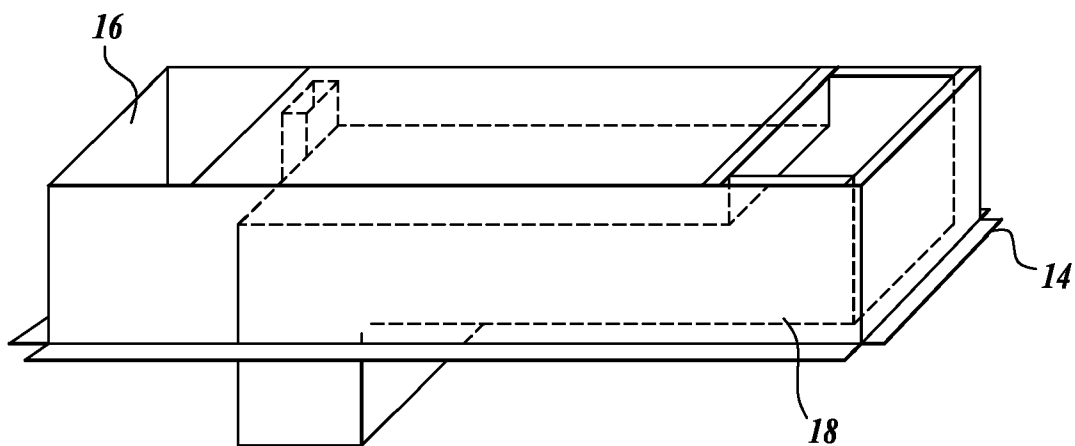


Fig. 5B.

ROOFTOP MODULAR FAN COIL UNIT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 60/886,876, filed Jan. 26, 2007, the disclosure of which is hereby incorporated by reference.

BACKGROUND

[0002] HVAC is an acronym that stands for “heating, ventilating, and air conditioning.” HVAC is sometimes referred to as “climate control” and is particularly important in the design of residential buildings, industrial buildings, and office buildings, where humidity and temperature must all be closely regulated whilst maintaining safe and healthy conditions within.

[0003] Heating, ventilating, and air conditioning is based on the basic principles of thermodynamics, fluid mechanics, and heat transfer. The three functions of heating, ventilating, and air-conditioning are closely interrelated. All seek to provide thermal comfort, acceptable indoor air quality, and reasonable installation, operation, and maintenance costs.

[0004] These functions are typically integrated into one or more HVAC systems in modern buildings. One type of HVAC system is the fan coil unit (FCU). A FCU is a small terminal unit that is often composed of only a blower and a heating and/or cooling coil, and is often used in individual residential units such as single family housing, condominium, hotel, etc. Another type of HVAC system is a standard package rooftop unit (RTU). An RTU is an air-handling unit, defined as either “recirculating” or “once-through” design, made specifically for outdoor “rooftop” installation. RTU’s are popular for small commercial buildings, particularly of the single story type. Conventional RTUs consist of the following components within a pre-engineered package: a cabinet containing a supply fan, mixed air dampers, a direct expansion (DX) refrigerant cooling coil, piping connections to a refrigeration compressor, an air-cooled condenser piped to the refrigeration compressor, one or more temperature control components, and one or a plurality of heating source options (e.g., hot water coil, heat reclaim coil, electric heating coil, etc.).

[0005] While FCU’s, RTU’s, etc. are suitable for many existing applications, they are not without limitations. To that end, the HVAC industry is continually looking for improvements in HVAC systems. As will be described in the Detailed Description below, embodiments of the present invention are directed to HVAC systems with such improvements.

SUMMARY

[0006] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0007] In accordance with aspects of the present invention, a rooftop modular fan coil unit is provided. The unit includes a cabinet defining an interior cavity, an air intake, an air return inlet, and an air supply outlet, wherein the air intake, the air return inlet, and the air supply outlet are disposed in communication with the cavity. The unit also includes a cooling unit mounted within the cabinet, supply and return piping fluidly connected to the cooling unit, a cooling unit connector assembly

bly mounted on the cabinet and fluidly connected to the supply and return piping, and a monoflow pump fluidly connected between the cooling unit and the cooling unit connector assembly. The unit further includes an air supply fan for moving air across the cooling unit and out through the air supply outlet.

[0008] In accordance with another aspect of the present invention, a rooftop modular fan coil unit is provided. The unit includes a cabinet defining an interior cavity, an air intake, an air return inlet, and an air supply outlet, wherein the air intake, the air return inlet, and the air supply outlet are disposed in communication with the cavity. The unit also includes a cooling unit mounted within the cabinet, supply and return piping fluidly connected to the cooling unit, a cooling unit connector assembly mounted on the cabinet and fluidly connected to the supply and return piping, and a monoflow pump fluidly connected between the cooling unit and the cooling unit connector assembly. The unit further includes an air supply fan for moving air across the cooling unit and out through the air supply outlet, an electrical assembly electrically connecting a motor of the air supply fan and the pump to an electrical connector mounted on the cabinet, and a solar power unit positioned external the cabinet and electrically connected to the electrical connector.

DESCRIPTION OF THE DRAWINGS

[0009] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0010] FIG. 1 is a perspective view of one exemplary embodiment of an RMFCU constructed in accordance with aspects of the present invention, wherein the RMFCU is mounted to a roof curb;

[0011] FIG. 2 is a side interior view of the RMFCU of FIG. 1 mounted on a roof via a roof curb;

[0012] FIG. 3 is a top interior view of the RMFCU of FIG. 1;

[0013] FIG. 4 is a schematic diagram of one exemplary embodiment of an RMFCU;

[0014] FIG. 5A is a standard roof curb showing typical supply/return duct connections;

[0015] FIG. 5B is a special high return air roof curb showing typical supply/return duct connections.

DETAILED DESCRIPTION

[0016] Embodiments of the present invention are directed to cooling and/or heating units suitable for use in the heating, ventilation and air-conditioning (HVAC) industry. In particular, embodiments of the present invention are directed to integrated cooling and/or heating units that are typically known in the industry as pre-engineered package HVAC units. Generally described, such package units may be pre-engineered, pre-wired, and include factory piping and optional factory controls so that with connection to the required utilities it is ready to perform as intended per cataloged performance characteristics.

[0017] As will be described in more detail below, embodiments of the cooling and/or heating units are suitable for use in rooftop installations for light industrial, commercial and some unique residential applications. Embodiments of the rooftop cooling and/or heating units may include, but are not

limited to, a supply fan and a heating and/or coiling device. Embodiments of the rooftop cooling and/or heating units may further include one or more of the following: pump compartment, controls compartment, power compartment, space for optional features, varying air filter options, mixed air dampers, optional exhaust/relief features, etc.

[0018] The cooling and/or heating units will be referred to herein as a rooftop modular fan coil unit (RMFCU). It will be appreciated that some embodiments of the RMFCU may include fewer components than described above, or in different combinations. Each RMFCU is intended to replace, or be used in-lieu of, a standard package rooftop unit (RTU) or larger semi-custom variable air volume package unit in some embodiments.

[0019] Turning now to FIG. 1, there is shown an exemplary embodiment of an RMFCU, generally designated 10, constructed in accordance with aspects of the present invention. The purpose of RMFCU 10 is to heat and/or cool the air drawn from a conditioned space by a return air duct (not shown) and/or fresh air drawn in from outside the RMFCU. The conditioned space may be the interior of the building itself, a group of rooms or only one room. The size and capacity of the RMFCU 10 is dependent on heating or cooling loads of the conditioned space. The RMFCU 10 may be designed for both heating and cooling the air to be conditioned, or the RMFCU may only be designed for cooling while others may only be designed for heating.

[0020] As best shown in FIG. 2, the RMFCU 10 is installed on a roof 12. The roof 12 is usually the roof of a building, but may also be the roof of a room enclosed in a larger space. The roof 12 is provided with one or several openings for connecting the RMFCU 10 to the various supply and return air ducts. A rooftop curb 14 ensures proper sealing between the unit 10 and the roof 12. As best shown in FIG. 2, the roof curb 14 includes supply air and return air duct connections 16 and 18 that connect the RMFCU 10 with the supply and return air ducts SA and RA, respectively, of the associated building. A standard roof curb, shown in FIG. 5A, is roughly 12-inches high whereas the optional raised curb, shown in FIG. 5B, is higher to accommodate a return air duct that is provided by the installer.

[0021] Referring now to FIGS. 1-3, the RMFCU 10 includes a weatherproof cabinet 20 for housing any combination of conditioning components. The cabinet 20 is of a conventional construction, which may include a single wall metal exterior that is fully insulated. The cabinet 20 may also use insulated double wall construction. The cabinet 20 is generally rectangular in shape, having its major axis extending generally horizontally. The cabinet 20 includes two side panels 26 and 28 arranged generally parallel to each other and at right angles to end panels 30 and 32. An upper panel or top 36 is affixed to the top edges of the other panels 26, 28, 30, 32 of the cabinet 20. A base panel 40 supports the cabinet panels 26, 28, 30, 32 and provides a bottom to the cabinet 20. The base panel 40 is supported by the roof curb 14. Foam tape or other sealing member (not shown) is preferably interposed between the roof curb 14 and the base panel 40 to create a water-tight seal therebetween.

[0022] The cabinet 20 also includes a plurality of utility connections, one or more access doors 48 for servicing, an intake air hood 50 for supplying fresh air into the cabinet 20, and a condensation drain pipe connection 52. In the embodiment shown in FIG. 1, the utility connections include but are not limited to an electrical power connector 54 located on one

of the vertical panels of the cabinet 20. In this embodiment, an optional control connector 56 may also be provided. Alternatively, the electrical power connector may be located underneath the cabinet 20 at base panel 40 for interfacing with a cooperating connector of the roof curb 14. The utility connections further include heating and/or cooling water supply and return connectors 58 and 60 position on one side or end panel of the cabinet 20. Alternatively, the heating and/or cooling water supply and return connectors 58 and 60 may be located underneath the cabinet at base panel 40 for interfacing with cooperating connectors of the roof curb. It will be appreciated that the electrical and mechanical connectors may be any suitable interface known in the art for interfacing with piping, cabling, electrical wiring, etc., and can be selected for the particular application. As will be described in detail below, the cabinet may further include space, including discrete compartments, for housing pump components, control system components, power components, or other desired features, etc.

[0023] Inside the cabinet 20 is an air circuit along which are located the conditioning components. As best shown in FIG. 2, the air circuit comprises a return air inlet 66 formed in the base panel 40 of the cabinet 20 for connection with the return air duct RA of the conditioned space via the return air duct connection 18 of the roof curb 14. The air circuit also comprises a supply air outlet 68 for connection with the supply air duct SA of the conditioned space via the supply air duct connection 16 of the roof curb 14. At least one electric motor powered air supply fan 76 is mounted in a suitable manner within the cabinet 20 for delivering conditioned air to the conditioned space through the supply air outlet 68 and associated ducting. Air is returned from the conditioned space through the return air duct connection 16 and into the cabinet via the return air inlet 66.

[0024] The volume of this recirculated air may be controlled by an optional recirculation damper 78 mounted in the inlet 66. Return air from the conditioned space mixes with fresh outside air that is drawn in by the fan 76 through the intake air hood 50. The fan 76 and recirculating damper 78 are operated in a well known manner by a control system 80 (see FIG. 4) to provide the proper amount of air to the conditioned space and to recirculate a certain portion of that air. A set of air filters 84, including a pre-filter 84A and a primary filter 84B, may be optionally mounted in the stream of fresh outside air and/or the recirculating air. In one embodiment, a filter rack with a moveable track may be utilized that allows for the installation of, for example, 1-inch to 4-inch thick air filters or the pre-filter 84A and/or primary air filter 84B for improved indoor air quality.

[0025] An optional inlet damper 88 may be mounted over the cabinet entrance of the hood 50 to control the amount of fresh air that passes into the cabinet from the hood 50. The inlet damper 88 is operated by the control system 80. It will be appreciated that other components may be disposed in communication with the air supply fan, such as reclaim devices, ultra violet purification lights, etc.

[0026] The mixed air that is moved through the cabinet 20 is then urged through temperature conditioning means for varying the temperature thereof. As aforesaid, the RMFCU 10 may be configured for cooling and/or heating the air depending on the intended application. Once the air travels through the temperature varying means, it enters a plenum chamber 90 fluidly communicating with the supply air outlet 68 for

connection with the supply air duct SA for providing the conditioned air to the conditioned space.

[0027] As best shown in FIG. 2, the temperature conditioning means of the RMFCU may include an air cooling device 92 for cooling the air passed through the cabinet 20. In one embodiment, the air cooling device 92 includes one or more chilled water coils suitably mounted within the cabinet in-line with the fresh air delivered via the air intake hood 50 and/or return air supplied from the return air duct RA. The chilled water coil(s) are fluidly connected in a conventional manner via piping 94 (see FIG. 4) to the cooling return and supply connectors 60 mounted to the cabinet 20 for job site utility connections. The chilled water coil(s) provide the RMFCU's cooling capacity and can be matched to any brand of chiller or type of chilled water system (e.g., campus chilled water or local package air-cooled chiller).

[0028] Multiple cooling coil sizes are available within each nominal cabinet size so the HVAC designer can more easily provide a precise match to the building load than previously available with conventional package air-cooled RTU equipment. The number of RMFCU cooling coil variations possible within each cabinet size is a unique cooling capacity feature for the RMFCU unit as compared to the package RTU equipment. This cooling flexibility means the RMFCU can be custom matched to the climate and the building's sensible, latent and grand total cooling load. In several embodiments, an optional 2 or 3-inch high by cooling coil width by-pass air damper may be included for simple dehumidification control. A cooling coil drain pan may be provided that is double sloped for improved condensate removal.

[0029] The temperature conditioning means of the RMFCU 10 may additionally or alternatively include a heating device 96 for supplying heat to the air stream to be distributed throughout the conditioned space via the supply air duct SA. In the embodiment shown in FIG. 2, the heating device 96 may include one or more heating coils in the form of hot water coils suitably mounted within the cabinet 20 in-line with the fresh air delivered via the intake hood 50 and/or the return air supplied via the return duct connection 18. The hot water coil(s) are fluidly connected in a conventional manner via piping 98 to the heating return and supply connectors 58 mounted to the cabinet 20 for job site utility connections. The hot water coil(s) provide the RMFCU's heating capacity. The RMFCU may offer several heating hot water coil options within each cabinet size. The hot water coils are compatible with any type of hot water source (i.e., low or high temperature hot water). Alternatively, other heating coils or heating components may be used, such as heat reclaim coils, electric heating coils, etc., to supply the thermal energy for heating the fresh or recirculating air supplied to the conditioned space.

[0030] The RMFCU 10 further includes one or more fluid circulation pumps 100 connected in-line between the return or supply connectors of the cabinet and the chilled water coils and/or heating coils. In the embodiment shown, the pumps 100 are connected to the supply side of the coils as opposed to the return side of the coils, but both configurations are contemplated to be within the scope of the present invention, as claimed. As described briefly above, the pumps 100 and associated accessories may be housed in the cabinet pump compartment 102. In embodiments of the present invention, any heating or cooling water coil can be matched to the coil circulation pumps. In accordance with aspects of the present invention, the circulation pumps are of what is known in the

industry as the monoflow type. One type of monoflow pump that may be practiced with the embodiments of the present invention is commercially available from Taco, Inc., Cranston, R.I., and sold under the trademark LoadMatch™. The pump may be one of many sizes with varying gpm flow rates for each cabinet size, depending on its intended application. In one embodiment, the pump may be sized to offset the internal losses for piping, coil and any piping accessories.

[0031] In several embodiments of the present invention, the pump motors are operatively connected to a variable speed drive (VSD) motor control located within the cabinet 20 as part of the control system 80. As such, the VSD control provides the water coil's capacity control in-lieu of conventional control valves. Thus, the RMFCU is capable of replacing either a single zone air-cooled package RTU or a RTU intended for application with what the HVAC industry calls VVT or VAV zone control terminals. VVT is an industry acronym for an HVAC system using variable air temperature and variable air volume zone temperature control terminals. VAV is an industry acronym for an HVAC system using variable air volume zone temperature control terminals. Embodiments of the present invention include control options for single zone, VVT and VAV applications. As described briefly above, the control system 80 may be housed in the cabinet 20, such as a discrete area or part of another compartment, such as the power compartment 106.

[0032] The RMFCU 10 may include other components known in the HVAC industry. For example, the RMFCU 10 may include return air fan(s), powered exhaust/relief fan(s), relief air outlets, etc., not shown for ease of illustration but well known in the art.

[0033] In accordance with aspects of the present invention, embodiments of the RMFCU 10 includes supply air supply fan(s) and cooling coil combinations that are capable of providing, for example, from 250 to 500-cfm per nominal ton of capacity. In several embodiments, the RMFCU supply fans and fan motors can operate at higher external static pressure for improved performance on VVT and VAV applications compared to most conventional package RTU equipment. The RMFCU cabinet can be supplied in several incremental sizes from 2 to 40 tons and 400-cfm to 15,000-cfm. A preliminary sample of cabinet sizing is as follows: 1 to 5 tons (or 400 to 2,000-cfm), 6 to 9.4 tons (or 2,400 to 3,750-cfm), 10 to 18.75 tons (or 4,000 to 7,500-cfm), 20 to 25 tons (or 8,000 to 10,000-cfm), 0.27.5 to 37.5 tons (or 11,000 to 15,000-cfm).

[0034] Embodiments of the RMFCUs described and shown herein provide many advantages over conventional package RTUs, some of which will now be described. First, because the RMFCU cabinet has no condenser or compressor sections (like a conventional air-cooled RTU). Therefore, that portion of the cabinet dedicated to fan and coil components can be slightly larger. This added space provides improved performance and the availability of unique options that are not available with (or do not fit within) the typical air-cooled RTU product.

[0035] Secondly, because the RMFCU may use a full face chilled-water cooling coil, the application of variable airflow does not require the external addition of a supply to return air duct by-pass damper as is recommended for most air-cooled package RTUs in a VVT or VAV application. Thirdly, a greater number of cooling capacity options for each cabinet size are available due to the more simple use of chilled-water cooling. Fourthly, the application of chilled water cooling provides improved energy performance due to closely

matched sensible and latent capacity. Other advantages that can be realized may include the option for dehumidification control, the inclusion of variable flow pumping for temperature control and compatibility with a monoflow piping design, cabinet space for improved air filtration and purification options, and factory installation and wiring of a supply fan variable speed drive (VSD) for VAV and VVT applications for providing energy conservation not obtainable with most small package air-cooled RTUs.

[0036] Other embodiments of the RMFCU may include the use of a battery and/or electrical power components compatible with a local or unit mounted photovoltaic solar panel for providing all, or a portion of, the fan, pump and control power requirements. To this end, as described briefly above, the power components may be housed in the cabinet power compartment **106** and electrically connected to the electrical power connector mounted on the cabinet. The power compartment, or other available space within the cabinet, may house rechargeable batteries or the like for power back-up and/or as a solar power accessory. It will be appreciated that the power components may include any device that provides power distribution, conditioning, surge protection, etc., and may include a standard 120 AC interface for providing power requirements to any tools used by a serviceman.

[0037] Embodiments of the RMFCU may also improve service access compared to some traditional air-cooled package RTU units of the same tonnage and size. Also, the use of chilled water cooling translates into longer equipment life and cooling diversity that allows the installation of fewer total compressor tons when compared to multiple air-cooled RTUs on a single building. Finally, the total connected electrical load for the RMFCUs is lower with reduced annual energy consumption. With the inclusion of optional photovoltaic power generation, the RMFCU should qualify for a LEED or green building design credit.

[0038] It will be appreciated that other components and/or features may be included within or use with the RMFCUs. For example, direct drive plug fans may be used by the RMFCUs. The advantage of a direct drive plug fan is no motor/belt efficiency losses, lower operating costs, quieter supply fan operation, and easy conversion from down flow to horizontal supply air discharge. Also, barometric relief may be provided with either a fabric or a balanced back draft damper, as well as powered exhaust fans. The RMFCU can be provided without controls (for field installation of controls) or with factory wired controls. Standard factory controls may be direct digital controls (DDC) with BACNet, LonWorks or modbus ports for remote monitoring and a control interface. These control ports and open protocol can minimize the need for factory installed controls as provided by national manufactures such as Johnson, Siemens, Alerton, Trane, Carrier, etc.

[0039] While illustrative embodiments have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

- 1.** A rooftop modular fan coil unit, comprising:
a cabinet defining an interior cavity, an air intake, an air return inlet, and an air supply outlet, wherein the air intake, the air return inlet, and the air supply outlet are disposed in communication with the cavity;
a cooling unit mounted within the cabinet;
supply and return piping fluidly connected to the cooling unit;
a cooling unit connector assembly mounted on the cabinet and fluidly connected to the supply and return piping;
a monoflow pump fluidly connected between the cooling unit and the cooling unit connector assembly; and
an air supply fan for moving air across the cooling unit and out through the air supply outlet.
- 2.** The unit of claim **1**, further comprising a power connector mounted on the cabinet.
- 3.** The unit of claim **2**, wherein the power connector is electrically connected to the pump and the fan.
- 4.** The unit of claim **1**, further comprising space within the cabinet for housing at least one device selected from a group of devices consisting of batteries, power components, and control components.
- 5.** The unit of claim **1**, further comprising a heating unit mounted within the cabinet.
- 6.** The unit of claim **5**, wherein the heating unit is selecting from a group consisting of a hot water coil, a heat reclaim coil, and an electric heating coil.
- 7.** The unit of claim **5**, further comprising supply and return piping fluidly connected to the heating unit and a heating device connector assembly mounted on the cabinet.
- 8.** The unit of claim **1**, further comprising at least one device selected from a group of devices consisting of dampers, reclaim devices, UV purification lights, and filters.
- 9.** The unit of claim **1**, further comprising a control communicatively connected to the pump and/or the fan.
- 10.** The unit of claim **1**, further comprising a solar power connector mounted on the cabinet for connecting to an associated solar power generator.
- 11.** A rooftop modular fan coil unit, comprising:
a cabinet defining an interior cavity, an air intake, an air return inlet, and an air supply outlet, wherein the air intake, the air return inlet, and the air supply outlet being disposed in communication with the cavity;
a cooling unit mounted within the cabinet;
supply and return piping fluidly connected to the cooling unit;
a cooling unit connector assembly mounted on the cabinet and fluidly connected to the supply and return piping;
a monoflow pump fluidly connected between the cooling unit and the cooling unit connector assembly;
an air supply fan for moving air across the cooling unit and out through the air supply outlet;
an electrical assembly electrically connecting a motor of the air supply fan and the pump to an electrical connector mounted on the cabinet; and
a solar power unit positioned external the cabinet and electrically connected to the electrical connector.

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