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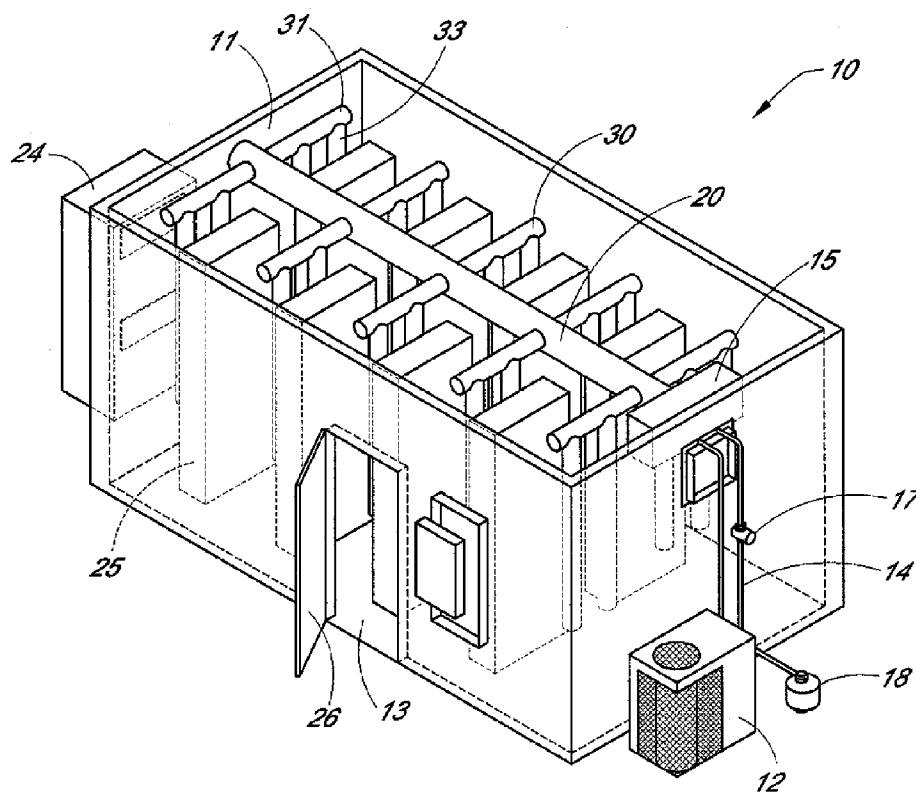
(19) **United States**(12) **Patent Application Publication**
Khalili et al.(10) **Pub. No.: US 2009/0126293 A1**(43) **Pub. Date: May 21, 2009**(54) **TELECOMMUNICATIONS SHELTER WITH
EMERGENCY COOLING AND AIR
DISTRIBUTION ASSEMBLY**(75) Inventors: **Kaveh Khalili**, Boulder City, NV
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E04C 2/52 (2006.01)(52) **U.S. Cl.** **52/220.1**(57) **ABSTRACT**

A telecommunications outdoor shelter having an interior chamber containing one or more vertical racks of telecom-

munications and/or electronic components, and an AC powered air conditioner configured to deliver cooled air to said interior chamber, is characterized by a back-up cooling apparatus comprising: an outdoor refrigeration system exterior to the interior chamber configured for supplying refrigerant or chilled heat transfer fluid to an evaporator mounted in the interior chamber and for rejecting heat to ambient outside air; an air cooling unit comprising an air handler and evaporator mounted in the interior chamber and configured to receive refrigerant or heat transfer fluid from the outdoor refrigeration system and provide cool air to the interior chamber; an air distribution assembly cooperating with the comprising air cooling unit and one or more primary air ducts for directing cooled air from the evaporator and a plurality of secondary air ducts communicating with each of the primary air ducts, wherein each of the secondary air ducts is configured for delivering cooled air to one or more selected vertical racks at one or more vertical levels and wherein the handler includes one or more fans for moving warm air from the interior chamber to the evaporator and forcing cooled air through the one or more primary air ducts and the one or more secondary air ducts; an electric power generating unit configured to provide power for operating the outdoor refrigeration system and the indoor air cooling unit; and a sensor configured to initiate operation of the back-up cooling apparatus in response to AC power outage and/or interior chamber air temperature.



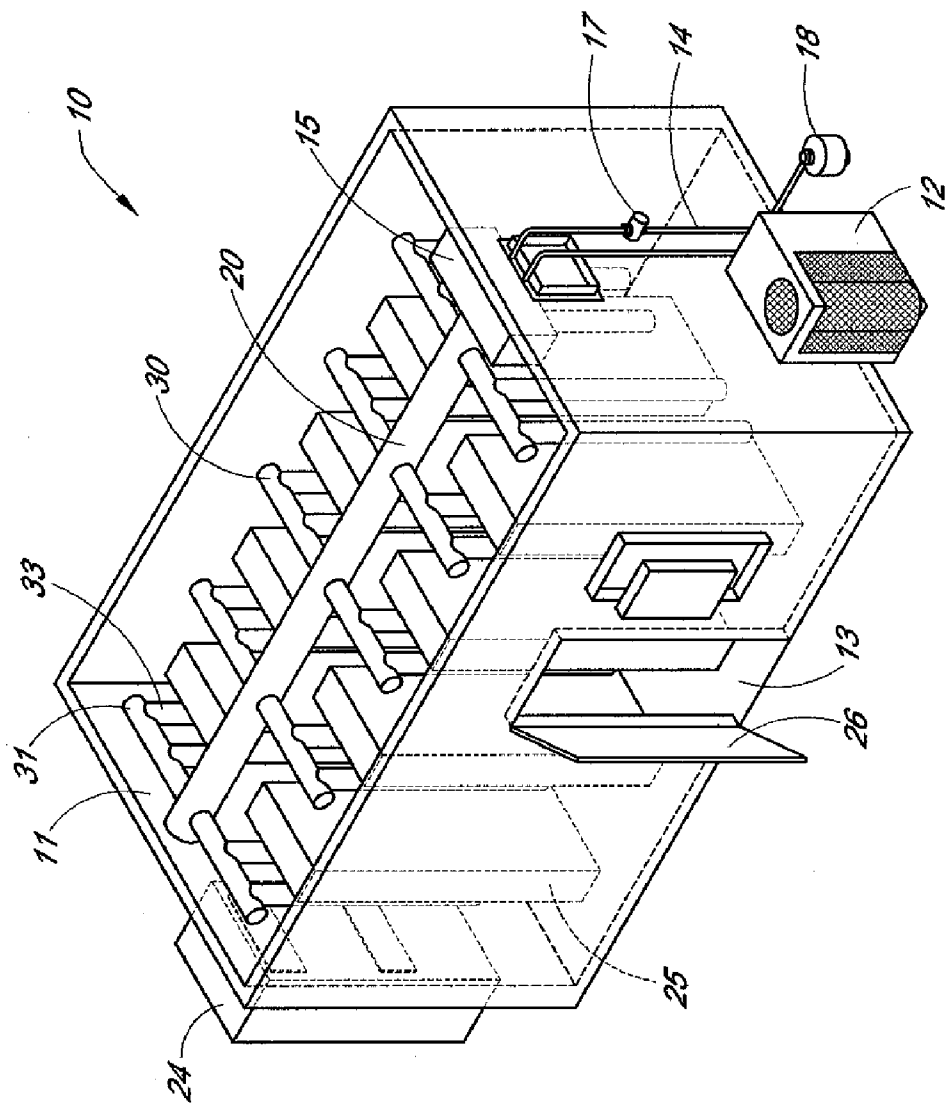
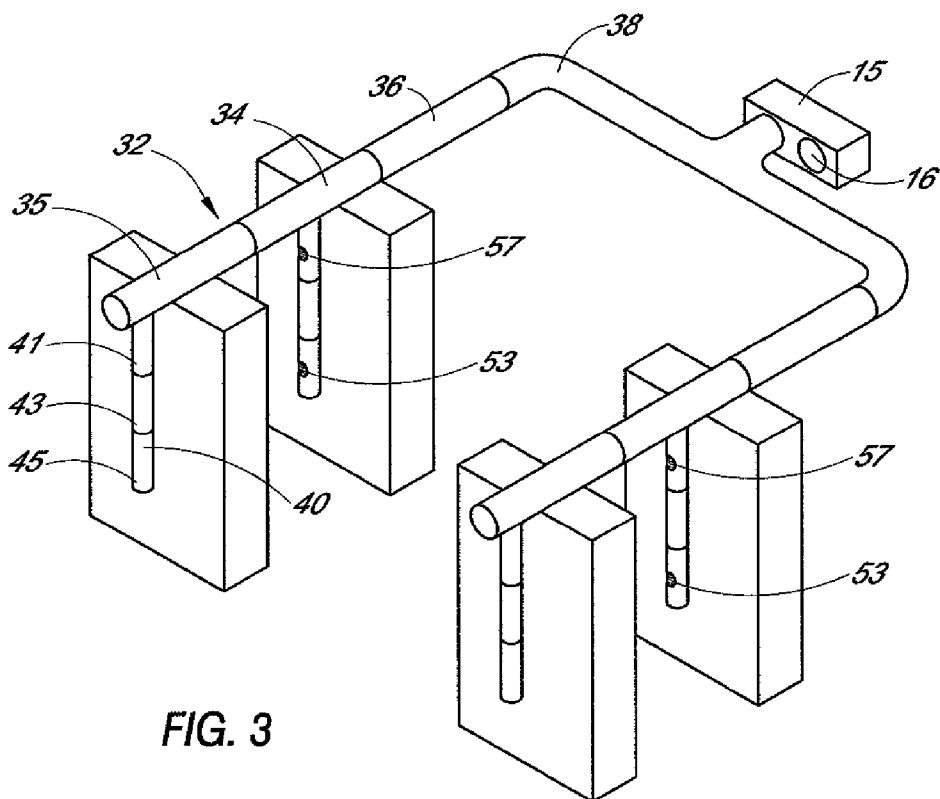
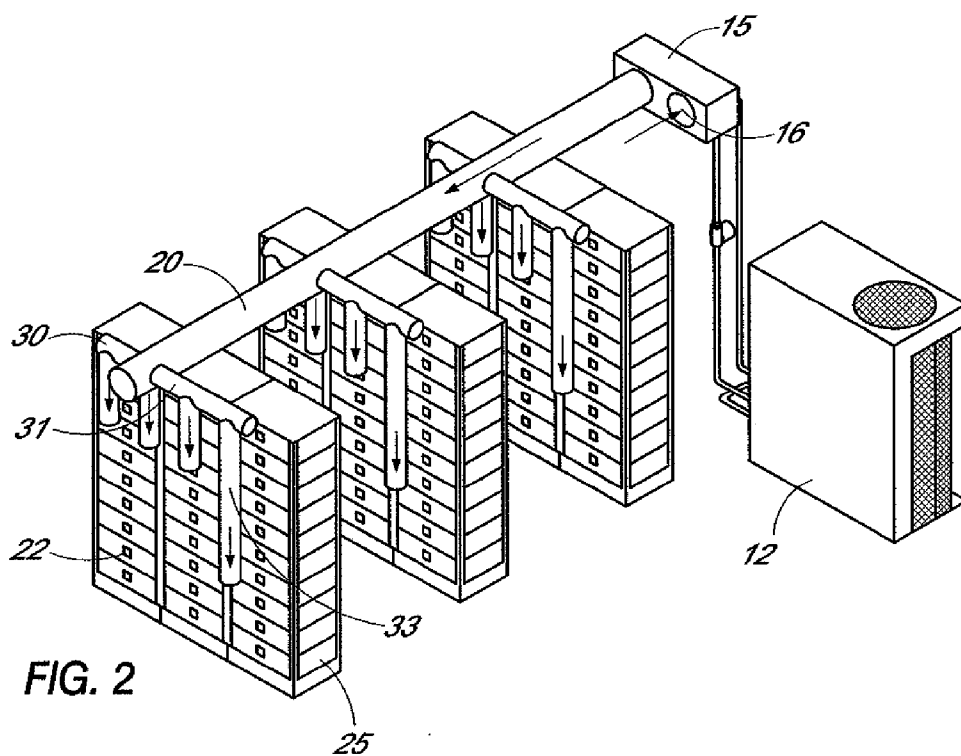


FIG. 1



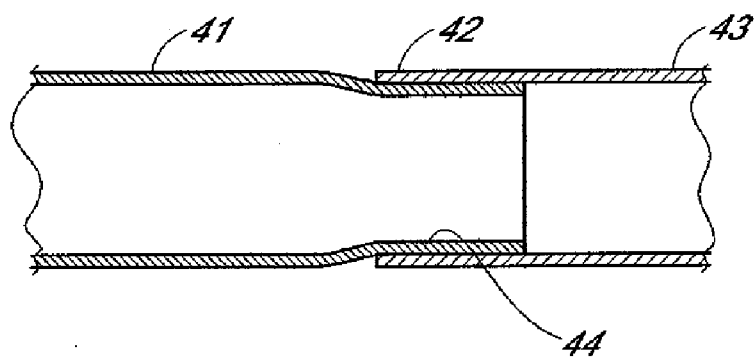


FIG. 4

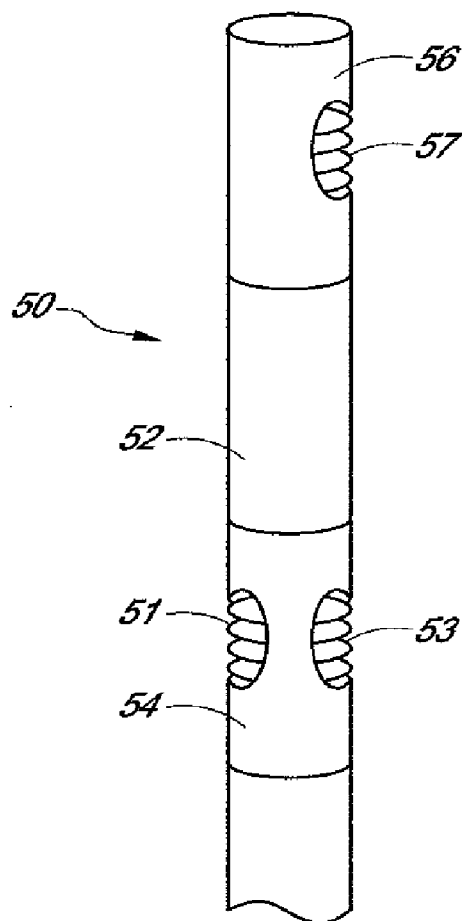


FIG. 5

TELECOMMUNICATIONS SHELTER WITH EMERGENCY COOLING AND AIR DISTRIBUTION ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] There are thousands of telecommunications shelters located throughout the country containing iDen, combined iDen/CDMA or other radio or telecommunications equipment and components. Such a telecommunications shelter is a small building, typically about 8 feet-14 feet long, about 7 feet-8 feet high and enclosing an interior room or chamber providing weather protection and security for the equipment. The shelter is cooled by one or two AC-powered on-site air conditioner(s), typically wall mounted, for maintaining the interior air temperature below that which would cause the telecommunications system to shut down or otherwise fail or compromise reliable operations, typically about 40° C. (104° F). During a power outage in which there is loss of AC power to the on-site air conditioner(s), temperatures within a shelter may rise rapidly since battery back-up continues heat generating operation of the electronics but without operating an air conditioner, leading to an equipment shut-down, often after only a few minutes. The use of back-up Diesel generators to operate the air conditioners during such power outages is undesirable due to pollution, noise and their limited reliability. The use of outside ambient air to cool the shelter interior is also impractical, if ambient temperatures reach or exceed the mid or high 90s (° F). Moreover, the use of outdoor air poses a dust contamination risk, especially at high air flows, which also requires a significant electric power source for operating the fan, especially if filters are partially or fully clogged with dust or debris.

SUMMARY OF THE DISCLOSURE

[0002] The telecommunications shelter described herein is characterized by a back-up cooling apparatus incorporating an outdoor refrigeration system and an indoor air cooling unit comprising an air handler housing a heat exchanger comprising an evaporator which receives refrigerant or a liquid-air heat exchanger which receives cooled heat transfer fluid from the outdoor refrigeration system. The back-up cooling apparatus also includes an air distribution assembly cooperating with the air cooling unit and comprising one or more primary air ducts for directing cool air from the evaporator and a plurality of secondary air ducts communicating with the primary air ducts. Each of the secondary air ducts are capable of delivering cold air to one or more selected vertical racks at one or more vertical levels within the interior chamber. In a preferred embodiment, the secondary air ducts include one or more air vents or outlet ports configured to selectively direct and/or adjust cold air flow to selected components and heat loads. The air handler incorporates one or more fans for returning warm air from the interior chamber to the evaporator and forcing cool air through the primary and secondary air ducts. The back-up cooling apparatus further comprises an electric power generating unit configured to provide power for operating the outdoor refrigeration system or a fuel supply, such as propane or hydrogen, for operating a thermally activated refrigeration system requiring only minimal power delivery from a supplemental power generation system, e.g., a fuel cell, micro-turbine, gas expansion power cycle, or batteries. The back-up cooling apparatus also comprises the indoor air cooling unit, a sensor for detecting an AC power

outage and a sensor for sensing the interior chamber air temperature, and a thermostat or controller that initiates and controls operation of the back-up cooling apparatus in response to a power outage or air temperature at or above a predetermined limit. Specific details and description of the various components of the back-up cooling apparatus, outdoor refrigeration system, air cooling unit and air distribution assembly are presented in the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 is a perspective view of a telecommunications shelter with roof and two sidewalls removed to show the interior chamber and indoor and outdoor components of the back-up cooling apparatus;

[0004] FIG. 2 is a perspective view illustrating a plurality of vertical racks and telecommunications equipment and another configuration of indoor air distribution assembly components;

[0005] FIG. 3 is a perspective view showing a different configuration of vertical racks for telecommunications equipment and a different air distribution assembly embodiment;

[0006] FIG. 4 is a sectional view of connected air duct segments; and

[0007] FIG. 5 illustrates a portion of a secondary air duct showing connected segments and illustrating examples of a plurality of air distribution outlet ports positioned for delivering air at different selected vertical levels.

DETAILED DESCRIPTION

[0008] In FIG. 1, the front and side walls of the telecommunications shelter 10 are eliminated to show the interior chamber 11 in which there are positioned a plurality of vertical racks 25, each having a number of shelves for supporting various telecommunications and electronic equipment and components. An AC-powered air conditioner 24 is mounted on an exterior wall of the shelter and which normally supplies the cooling for the interior chamber to keep the heat generating electronic telecommunications components within desired operating temperature ranges. A door 26 and doorway 13 allows access to the equipment.

[0009] The back-up cooling apparatus embodiment shown includes an outdoor cooling or refrigeration system 12 which supplies a condensed refrigerant or chilled heat transfer fluid via refrigerant piping 14 and pump 17 to an indoor air cooling unit 15 which comprises an evaporator and air handler. The term "evaporator" as used herein is intended to include any conventional or commercial refrigeration heat exchanger capable of transferring heat from the warm chamber air to cold refrigerant or chilled heat transfer fluid. Conventional evaporator designs include refrigerant tubing, fins, an accumulator, and a capillary inlet tube for refrigerant evaporation. Alternatively, the cooling unit may comprise a cooling coil for circulating cold water or other chilled heat transfer fluid for cooling the indoor air. The air handler includes one or more fans, preferably variable speed, for moving the warm air from the interior chamber to the evaporator and for forcing cooled air from the evaporator through the air distribution assembly. Such an air cooling unit design, configuration and components are well known to those skilled in the art and need not be discussed in further detail.

[0010] The air distribution assembly embodiment shown in FIG. 1 includes a single primary air duct 20, one end of which is in open communication with the air cooling unit whereby

the fan forces the cool air into and along the primary air duct. The opposite end of the primary air duct is closed. Communicating with and extending from primary air duct 20 are a plurality of secondary air ducts 30. The secondary air ducts shown include a horizontal section 31 which communicates with and extends from the primary air duct, and a vertical section 33 extending downwardly from the horizontal portion 31. The diameter of a secondary air duct is smaller than that of the primary air duct. The secondary air ducts preferably are configured with one or more vents which may be adjusted or adapted for directing cold air to selected components and heat loads as needed. The primary air duct is positioned and extends generally horizontally from the air cooling unit 15 at a level above the top of the vertical racks. The primary air duct 20 can be secured by any convenient means such as hangers extending from the interior ceiling of the housing. Other supports or components for securing and maintaining the position of the primary air duct may be used.

[0011] The FIG. 1 embodiment also shows a propane or natural gas fired generator 18 capable of providing power for operating the outdoor refrigeration system and the indoor air cooling unit. Alternatively, photovoltaic (PV) solar panels may be used as may regular back-up batteries, where desired or feasible.

[0012] FIG. 2 shows another view of the air distribution assembly similar to that of FIG. 1 but incorporating a single primary air duct 20 and a plurality of secondary air ducts 30 using horizontal sections 31 and vertical sections 33 for directing air to various different vertical levels along the vertical racks 25. In the FIG. 2 embodiment, the vertical secondary air duct components are of different lengths that provide air flow at different vertical levels. Also shown is a return air duct 16 in the air cooling unit.

[0013] In FIG. 3, the use of segmented air ducts is illustrated. In a preferred embodiment, the lengths of primary and/or—secondary air ducts may be modified, conveniently accomplished by using a plurality of connected and disengagable duct segments. As shown, primary air duct 32 includes a plurality of segments 34, 35, 36 and 38, and is branched to form two horizontal extensions positioned above the top of the vertical racks 25. The secondary air ducts extend vertically downwardly from the primary air duct branches. The secondary air ducts 40 are also segmented; segments 41, 43 and 45 are shown. Any number of segments of the same or different lengths may be used to accomplish the purpose of distributing the air at different vertical levels thereby providing cooling to the equipment along the vertical racks as needed.

[0014] The rack layouts and positions shown in FIGS. 1-3 are by way of example only. Racks may be set up and changed into any configuration including uniform alignment in rows, or staggered, or otherwise randomly positioned, as desired.

[0015] Observing also FIG. 5, different outlet ports or vents 51, 53 and 57 are located at different vertical positions as well as multiple horizontal positions. Thus, a secondary air duct segment may be provided with one or more air vents at selected or needed positions. Segment 54 is provided with two air vents, 51 and 53, whereby air can be directed simultaneously to two vertical racks. Segment 56 is provided with a single air vent, while segment 52 has no air vents and is used simply for extending the length of the secondary air duct 50. The air vents are preferably configured to provide for adjusting the direction and/or the amount of cold air to selected heat loads and equipment components.

[0016] FIG. 4 shows a convenient air duct configuration for connecting and disconnecting air duct segments. As illustrated, one end 44 of air duct segment 41 is of a smaller diameter than the rest of the length of the air duct and is conveniently inserted into the larger end 42 of adjacent air duct 43. The different diameters of the ends of the segments may provide for force-fit connection, or the ends may be threaded for detachably securing the air duct segments. Such a feature allows the user to configure the air duct assembly to distribute air as is needed to different telecommunications shelters having different numbers, sizes and positions of the vertical racks and for designing and tailoring the air distribution to meet any desired needs for one shelter and further modifying the air distribution where different equipment, rack configurations and layouts dictate. Other means for detachably securing the ends of the segments such as using clamps, screws, clips, brackets, etc. may be used as well. The ducting itself may be of any suitable material such as sheet metal, plastic or the like of the type commonly used for air handling and air conditioning ducts. The cross-sectional shape of the tubular ducts, whether circular (cylindrical), rectangular or other shape, is not critical. The use of cylindrical air ducts offers the advantage of making even minor adjustments in air flow direction by simply rotating a duct segment with an air vent as desired.

[0017] Selection of the type of outdoor refrigeration system units may depend on costs, availability as well as technical and/or level of refrigeration needed. Examples of different outdoor refrigeration systems include ammonia-water absorption chillers, complex compound refrigeration systems, vapor compression refrigeration, alone or integrated with ice storage. Ammonia-water absorption systems, and particularly high efficiency GAX systems, have been developed to minimize electric demands. These systems use ammonia-water as the absorption fluid to provide chilled water (or other heat exchange fluid) which is pumped to the indoor air cooling unit. Alternative configurations use refrigerant phase-change coupling. The in-shelter air cooling unit is designed to communicate with the water or refrigerant loop from the outdoor absorption system with the flows and temperatures selected as needed for optimal control and to address the shelter-specific conditions desired. Such ammonia-water, and particularly the high efficiency GAX systems, are described in U.S. Pat. Nos. Re. 36,684 and 6,631,624, the descriptions of which are incorporated herein by reference in their entireties, respectively. Other useful ammonia-water absorption chillers are described in U.S. Pat. Nos. 5,271,235, 5,579,652, and 5,490,393.

[0018] Another useful outdoor refrigeration system requiring low electric power incorporates complex compound technology based on solid-gas absorption of a polar gas refrigerant on metal inorganic sorbents. The preferred cycle uses ammonia refrigerant and all materials are biodegradable with no global warming or ozone depletion potential. Such a system incorporates two or more stationary sorbers that alternately absorb and desorb the refrigerant, a condenser for the refrigerant, an evaporator for cooling water or other heat transfer fluid and a heat transfer fluid loop between the outdoor system and the indoor air cooling unit. The system can be propane or natural gas fired with possible conversion to hydrogen fuel, when commercially available and viable. The advantage of such a system is that there are no moving parts in the internal sorption cycle and the avoidance of a solution pump further reduces electric consumption. Such a system

may be built to reject heat at relatively high ambient temperature, thereby reducing the need for excessive air flow and associated electric fan power. When compared to an ammonia-water system, although the fuel efficiency is not as good, electric power consumption is lower. Examples of such complex compound outdoor refrigeration systems are described in U.S. Pat. Nos. 5,598,721, 6,224,842 and 6,736,194, the descriptions of which are incorporated herein by reference in their respective entireties.

[0019] Another example of useful outdoor refrigeration system utilizes integrated ice storage and vapor compression refrigeration. The outdoor system comprises a unitary vapor compression refrigeration system and a suction temperature tracking chiller. The vapor compression refrigeration system utilizes Freon refrigerant, e.g., RM34a or R410A. Ethylene glycol or propylene glycol may be used as a heat transfer fluid from and to the ice storage tank. Inside shelter air cooling is provided by chilled water from the ice storage tank pumped to the inside air cooling unit. Such a system has very low electric demand during power-out periods, easily fulfilled by PV, solar panels with battery buffer, regular back-up batteries or a small propane generator.

[0020] Yet another outdoor refrigeration system utilizes a conventional vapor compression air conditioner system based on commercially available R134a or R410A refrigerants and a small propane fired generator. Such a system is illustrated in FIG. 1. Use of variable speed compressors further reduce the overall on-site fuel storage requirements.

What is claimed is:

1. A telecommunications outdoor shelter having an interior chamber containing one or more vertical racks of telecommunications and/or electronic components, and an AC powered air conditioner configured to deliver cooled air to said interior chamber, is characterized by a back-up cooling apparatus comprising:

an outdoor refrigeration system exterior to said interior chamber configured for supplying refrigerant or chilled heat transfer fluid to an evaporator mounted in said interior chamber and for rejecting heat to ambient outside air;

an air cooling unit comprising an air handler and evaporator mounted in said interior chamber and configured to receive refrigerant or heat transfer fluid from said outdoor refrigeration system and provide cool air to said interior chamber;

an air distribution assembly cooperating with said air cooling unit and comprising one or more primary air ducts for directing cooled air from said evaporator and a plurality of secondary air ducts communicating with each of said primary air ducts, wherein each of said secondary air ducts is configured for delivering cooled air to one or more selected vertical racks at one or more vertical levels thereof within said interior chamber, and wherein said handler includes one or more fans for moving warm air from the interior chamber to said evaporator and forcing cooled air through said one or more primary air ducts and said one or more secondary air ducts;

an electric power generating unit configured to provide power for operating said outdoor refrigeration system and said indoor air cooling unit; and

a sensor configured to initiate operation of said back-up cooling apparatus in response to AC power outage and/or interior chamber air temperature.

2. A telecommunications shelter of claim 1 wherein said one or more primary air ducts are mounted in said interior chamber and extend generally horizontally above said one or more vertical racks, and wherein each of said one or more secondary air ducts comprises one or more distribution outlet ports positioned below a primary air duct at a vertical level above the upper end of an adjacent vertical rack.

3. A telecommunications shelter of claim 1 wherein said one or more primary air ducts comprises a plurality of detachably connected duct segments.

4. A telecommunications shelter of claim 2 wherein the length of one or more of said secondary air ducts is adjustable for changing or selecting a vertical level and/or horizontal location of said one or more outlet ports.

5. A telecommunications shelter of claim 4 wherein said one or more secondary air ducts comprises a plurality of disengagable connected duct segments.

6. A telecommunications shelter of claim 2 wherein at least one of said secondary air ducts comprises a plurality of outlet ports and is configured to direct cool air simultaneously in two or more different lateral directions from said secondary air duct.

7. A telecommunications shelter of claim 4 wherein at least one of said secondary air ducts comprises a plurality of outlet ports and is configured to direct cool air simultaneously in two or more different lateral directions from said secondary air duct.

8. A telecommunications shelter of claim 2 wherein at least one of said secondary air ducts comprises a plurality of outlet ports and is configured to direct cool air simultaneously to two or more different vertical levels.

9. A telecommunications shelter of claim 5 wherein one or more of said secondary air duct segments includes an outlet port for venting cool air therefrom.

10. A telecommunications shelter of claim 9 wherein said one or more primary air ducts comprises a plurality of detachably connected duct segments.

11. A telecommunications shelter of claim 2 comprising two or more said vertical racks having telecommunications and electronic components mounted at different vertical levels thereon, and wherein one of said secondary air ducts is configured to direct air toward two or more of said vertical racks,

12. A telecommunications shelter of claim 2 comprising two or more of said vertical racks having telecommunications and electronic components mounted thereon at different vertical levels, and wherein one or more of said secondary air ducts comprises a plurality of detachably connected duct segments whereby the length of a said secondary air duct is adjustable for delivering cool air at selected vertical levels and/or selected horizontal locations.

13. A telecommunications shelter of claim 12 wherein one or more of said secondary air duct segments includes an outlet port for venting cool air therefrom.

14. A telecommunications shelter of claim 13 wherein said one or more primary air ducts comprises a plurality of detachably connected duct segments.

15. A telecommunications shelter of claim 11 wherein at least one of said secondary air ducts comprises one or more direction and/or air flow adjustable air vents.

16. A telecommunications shelter of claim 11 wherein at least one of said secondary air ducts comprises a plurality of outlet ports and is configured to direct cool air simultaneously to two or more different vertical levels.

17. A telecommunications shelter of claim 12 wherein at least one of said secondary air ducts comprises a plurality of outlet ports and is configured to direct cool air simultaneously to two or more different vertical levels.

18. A telecommunications shelter of claim 1 wherein said refrigeration system comprises an ammonia-water absorption chiller, and a heat transfer loop for directing chilled heat transfer fluid between said chiller and said indoor air cooling unit.

19. A telecommunications shelter of claim 1 wherein said refrigeration system comprises an ammonia-water GAX chiller, and a heat transfer loop for directing heat transfer fluid between said GAX chiller and said indoor air cooling unit.

20. A telecommunications shelter of claim 1 wherein said refrigeration system comprises a complex compound absorp-

tion system, and a heat transfer loop for directing heat transfer fluid between said absorption system and said indoor air cooling unit.

21. A telecommunications shelter of claim 1 wherein said refrigeration system comprises a vapor compression refrigeration unit configured for cooling a heat transfer fluid, a heat transfer loop for directing a heat transfer fluid between said refrigeration unit and an ice storage tank and a cold water loop to said indoor air cooling unit.

22. A telecommunications shelter of claim 1 wherein said refrigeration system comprises a refrigerant vapor compression apparatus, and a heat transfer loop for directing refrigerant between said refrigeration system and said indoor air cooling unit, and wherein said electric power generating unit comprises a gas fired generator.

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