

An Air Conditioning System and Method of Operation Thereof

TECHNICAL FIELD

5 Embodiments of the invention relate to air conditioning systems and more particularly, to an air conditioning unit which may operate in cooperation with an air circulation system.

BACKGROUND

10 Many buildings employ central air conditioning system in which supply and distribution of cooled air to various areas or rooms within the buildings are centrally controlled. Operation hours of the central conditioning system may be established according to typical usage pattern of the tenants within a building. For example, in a typical office building environment, a central air
15 conditioning system may be set to operate daily from 8 a.m. to 6.30 p.m. By and large, there would be a handful of tenants working beyond their normal working hours. As such, these tenants would require the central air conditioning system to operate beyond the usual operating hours to cool their offices. The extra operating hours for a handful of tenants may require
20 switching on the centrally controlled air conditioning system, thus resulting in a disproportionately large increase in energy bills for low usage. However, if the centrally controlled air conditioning system were not switched on, the air temperature within the building would rise to uncomfortable levels if no other ventilation is available.

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 In view of the above-mentioned and other problems with existing air conditioning systems, improved air conditioning systems are desired.

SUMMARY

30 Embodiments of the invention provide an air conditioning unit which operates in cooperation with an air circulation system, e.g. Air Handling Unit (AHU) to cool air at selected or occupied areas without necessarily having to switch on a central or other existing air conditioning system.

An air conditioning unit may comprise a compressor, condenser coils, evaporator coils, and a reservoir of heat absorbent material disposed in thermal communication with the condenser coils to absorb heat dissipation from the condenser coils. The evaporator coils, the condenser coils and the
5 reservoir of absorbent material are disposable to operate indoors or within an interior of a building.

In some embodiments, the compressor may be fabricated or procured as a separate modular unit. In certain other embodiments, the compressor
10 may be fabricated or installed with other components of the air conditioning unit in a single modular unit.

In operation, an air circulation system, e.g. AHU, passes an incoming air flow over evaporator coils of an air conditioning unit. The cooled
15 (outgoing) air flow is then transferred to a designated area which is to be cooled. Meanwhile, heat from the incoming air flow is transferred to condenser coils of the air conditioning unit and dissipated to a reservoir of heat absorbent material. As the heat from condenser coils is substantially absorbed by the reservoir of absorbent material, minimal or no heat is
20 dissipated to the ambient air, and therefore the condenser coils and the reservoir of heat absorbent material may be disposed indoors or within an interior of a building without increasing the overall load of the air conditioning unit.

25 In some embodiments, the air conditioning unit may operate in cooperation with an AHU while a central or other existing air conditioning system is switched off. In certain other embodiments, the air conditioning unit may operate in cooperation with an AHU while a central or existing air conditioning system is switched on, to provide further cooling of the air without
30 increasing the overall load of the central or other existing air conditioning system.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be readily understood by the following detailed description in conjunction with the accompanying drawings.

Figure 1A is an isometric view of an air conditioning unit installed in cooperation with an Air Handling Unit (AHU) according to one embodiment of the invention.

Figure 1B is a close-up view of a portion of the air conditioning unit as marked in Figure 1A.

Figure 1C is a side cross-sectional view of the air conditioning unit and AHU of Figure 1A.

Figure 1D is a side view of the air conditioning unit and AHU of Figure 1A.

Figure 2 is a schematic diagram of an air conditioning unit according to one embodiment of the invention.

Figure 3A shows an example layout of evaporator coils in the air conditioning unit of Figure 1A.

Figure 3B shows an example layout of condensation fins in the air conditioning unit of Figure 1A.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the invention. It will be understood, however, to one skilled in the art, that embodiments of the invention may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure pertinent aspects of embodiments being described.

Reference is made to Figure 1A which shows an isometric view of an air conditioning unit 100 installed in cooperation with an air circulation system, e.g. air handling unit (AHU) 200. The AHU 200 is disposed in fluid communication with a ventilation duct 250 which provides a passage for transferring air (or an incoming air flow) into the AHU 200. The incoming air

flow is passed through the air conditioning unit 100 to be cooled before the cooled air (or outgoing air flow) is transferred to a designated area.

5 The air conditioning unit 100 may include a compressor 10, a plurality of condenser coils 20, a plurality of evaporator coils 30, and a reservoir of heat absorbent material 40. The functions and operation of the above-mentioned components will be described with reference to Figure 2. While Figure 2 shows one schematic arrangement of the above-mentioned and other possible components of an air conditioning unit 100, it is to be
10 appreciated that suitable modifications to the illustrated schematic arrangement may be made in certain other embodiments, and other arrangements may be possible.

The compressor 10 is operable to compress a cool refrigerant gas (e.g. Freon gas) into a hot high pressure refrigerant gas. The hot refrigerant gas,
15 supplied by the compressor 10, is transferable to flow or run through the condenser coils 20 so that the hot refrigerant gas can dissipate its heat and condense into a refrigerant liquid (e.g. liquid Freon). To this purpose, the condenser coils 20 may be disposed in thermal communication with a
20 reservoir of heat absorbent material 40 or cooling reservoir to absorb the dissipated or rejected heat from the condenser coils 20. This obviates the use of conventional motor fan to dissipate heat from condenser coils. Examples of heat absorbent materials 40 include, but are not limited to, hydrophilic macromolecule water-gel (carbon bomber).

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In one embodiment, the condenser coils 20 may be submerged in the reservoir of heat absorbent material 40 (see Figures 1A, 1C). This way, dissipated heat from the condenser coils 20 may be more efficiently absorbed by the heat absorbent material 40 and thereby preventing or minimizing heat
30 dissipation to an ambient air. Hence, the condenser coils 20 may be placed or disposed indoors or within an interior of a building without increasing temperature of the ambient air around the air conditioning unit 100 or substantially increasing load to the air conditioning unit 100. Accordingly, a

conventional outdoor condenser unit would not be required in embodiments of the invention.

5 A liquid receiver 22 may be interposed between the condenser coils 20 and the evaporator coils 30 for condensing the hot refrigerant gas into a high pressure refrigerant liquid. The high pressure refrigerant liquid may be transferred through an expansion valve 24 to the evaporator coils 30 to be vaporised. The high pressure refrigerant liquid leaving the liquid receiver 22 may be protected by a safety relief pressure valve 26 to prevent building up of
10 high pressure along the pipes or circuitry connecting the condenser coils 20 and evaporator coils 30. A hot gas DX expansion valve 28 may be installed after the expansion valve 24 to minimise icing at the evaporator coils 30. A manual balancing valve 29 may be provided, interposed between the liquid receiver 22 and hot gas DX expansion valve 28, to throttle an incoming hot
15 refrigerant gas into the hot gas DX expansion valve 28 in order to regulate excessive flow.

The evaporator coils 30 are disposed in thermal communication with an incoming air flow which may be air drawn from a designated area or room to
20 be cooled, or from other suitable sources including outdoors. More particularly, the evaporator coils 30 may be suitably installed in cooperation with an AHU 200 which is operable to pass an incoming air flow over the evaporator coils 30 to be cooled before the cooled air or outgoing air flow is transferred to the designated area. Particularly, to first cool the evaporator
25 coils 30, refrigerant liquid from the condenser coils 20 may be passed through a suitable valve, e.g. expansion valve 24, during which the liquid refrigerant vaporises into a cold, low pressure refrigerant gas. The evaporator coils 30 are thereby cooled by the cold refrigerant gas and are therefore capable of cooling an incoming air flow passing over the evaporator coils 30. After an
30 incoming air flow is cooled by the evaporator coils 30, the cooled air or outgoing air flow is transferable by the AHU 200 into a designated area or room.

A buffer filter 32 may be provided, interposed between the plurality of evaporator coils 30 and the compressor 10, to remove bubble liquid to refrigerant gas so that the bubble liquid is fully converted to refrigerant gas before entering the compressor 10. An accumulator 34 may be provided, interposed between the buffer filter 32 and the compressor 10 to receive and store refrigerant gas from the buffer filter 32. Further, a suction regulator 36 may be interposed between the buffer filter 32 and the compressor 10 to ensure constant suction of refrigerant gas into the compressor 10, thereby preventing a surge in the compressor 10.

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In certain embodiments, the air conditioning unit 100 may further comprise a plurality of condensation fins 50 (see Figures 1A, 1C, 1D and 3B) or other suitable structures disposed in thermal communication with the reservoir of absorbent material 40. The condensation fins 50 or other suitable structures are operable to condense hot vapour, which is produced from the reservoir of absorbent material 30 due to heat absorption from the condenser coils 20, and return the condensed vapour to the reservoir of absorbent material 40. Accordingly, a closed-loop system is formed in which the reservoir of absorbent material 40 is recyclable. The condensation fins 50 may be formed of a material such as, but not limited to, a polymer plastic or a thermal polymer, which has thermal resistance properties to trap the heat from hot vapour for condensing the hot vapour into cool water vapour, thus further aiding the evaporator coils 30 in the entire cooling process.

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The air conditioning unit 100 may further comprise an air pump 42 connected to the reservoir of absorbent materials 40. The air pump 42 is operable to provide agitation or turbulence to the reservoir of absorbent material 40 to assist in lifting hot vapour from the reservoir of absorbent material 40. The air conditioning unit 100 may include a source and control unit (not shown) to control and operate the above-described and other components.

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In conventional air conditioning systems, condenser coils are normally located outdoors or outside a building because those condenser coils dissipate large amounts of wasted heat into the external atmosphere. Hence, if those condenser coils were placed in the interior of the building, overall load is substantially increased thereby rendering the conventional air conditioning systems less efficient. In contrast with conventional air conditioning systems, various components of the air conditioning unit, according to various embodiments of the invention, are capable of being located or disposed indoors or even within a designated area to be cooled. As explained in the foregoing paragraphs, heat dissipated from the condenser coils 20 would be substantially absorbed by the reservoir of heat absorbent material 40, thereby preventing or minimizing heat dissipation to the ambient air.

In the embodiment illustrated in Figures 1A to 1D, the air conditioning unit 100 includes a base for housing a reservoir of absorbent material 40. Condenser coils 20 may be submerged in the reservoir of absorbent material 40. The condenser coils 20 and reservoir of absorbent material 40 may be disposed under the evaporator coils 30 and condensation fins 50. Particularly, the evaporator coils 30 and condensation fins 50 may be disposed or juxtaposed side by side so that an air flow may be passed over the evaporator coils 30 and subsequently passed over the condensation fins 50. The condensation fins 50 may be suitably arranged to trap and condense rising hot vapour from the reservoir of absorbent material 40 and return the condensed vapour to the reservoir.

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In Figures 1A to 1C, while certain components of an air conditioning unit 100, i.e. condenser coils 20, evaporator coils 30 and reservoir of absorbent material 40, are installed as a single modular unit, it is to be appreciated that certain variations may be made. For example, the condenser coils 20 and evaporator coils 30 may be fabricated as separate modular units; however, the condenser coils 20, evaporator coils 30 and reservoir of absorbent material 40 would be installed indoors or even within a designated area to be cooled.

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Figure 1B is a close-up view of a portion of the air conditioning unit as marked in Figure 1A and shows a piping layout and various components in the air conditioning unit of Figure 1A. Figure 1C is a side cross-sectional view of the air conditioning unit of Figure 1A. As illustrated, the compressor 10 of the air conditioning unit 100 may be electrically driven or coupled by a belt 220 connected to a motor 230 of an AHU 200. The belt 220 connecting the compressor 10 and AHU motor 230 provides a coupling for driving the compressor 10. As shown in Figure 1C, the compressor 10 is installed within the AHU 200. Accordingly, in this embodiment, the compressor 10 is fabricated as a separate modular unit from other components of the air conditioning unit 100, and installed separately from the air conditioning unit 100. The compressor 10 may or may not be permanently installed within the AHU 200. In certain other embodiments, the compressor 10 may be fabricated in a single modular unit together with other components of the air conditioning unit 100. Figure 1D is a side view of the air conditioning unit of Figure 1A. As illustrated, the air conditioning unit 100 is installed or positioned at an outlet of an AHU 200, and may be easily removed or uninstalled as and when required.

Figure 3A shows an example layout of the evaporator coils 30. The evaporator coils 30 are arranged with sufficient density so that an air flow passing through the arrangement of evaporator coils 30 comes into sufficient thermal contact with the evaporator coils 30 for adequate cooling. Figure 3B shows an example layout of condensation fins 50 which are to be juxtaposed with the evaporator coils 30. The condensation fins 50 are arranged with sufficient density so that an air flow passed over from the evaporator coils 30 may be further cooled by the condensation fins 50 and rising hot vapour from the reservoir of absorbent material 40 may be trapped and condensed on the condensation fins 50.

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An exemplary method of installing and operating an air conditioning unit 100, according to one embodiment of the invention, will now be described. The air conditioning unit 100, containing the above-described components, is

positioned or installed at an outlet of an AHU 200. Particularly, evaporator coils 30, i.e. cold coils, may be positioned such that an incoming air flow drawn through the AHU 200 may be passed over the evaporator coils 30 to be cooled. For example, the evaporator coils 30 may be inserted within an AHU 200, or installed at an outlet of an AHU 200. In certain embodiments where the compressor 10 is fabricated separately from other components of the air conditioning unit 100, the compressor 100 is disposed within the AHU 200 and connected to the AHU motor 230. Suitable pipelines or tubes may connect the compressor 10 to the condenser coils 20.

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The incoming air flow (or hot air that may be drawn from a designated area to be cooled) is passed or blown by the AHU fan 210 over the evaporator coils 30. The heat from the incoming air flow is transferred to the condenser coils 20 which dissipate or reject heat from the hot air to the reservoir of heat absorbent material 40. To further facilitate the lifting of hot vapour above the reservoir of heat absorbent material 40, an air pump 42 may be used to agitate or stir the reservoir of heat absorbent material 40. The hot vapour from the reservoir would rise up along the condensation fins 50 to condense as cooled water which may be returned to the reservoir, thereby further aiding the evaporator coils 30 to cool the incoming air flow.

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An outgoing air flow, which is the incoming air flow having passed over the evaporator coils 30, is then transferred by the AHU 200 to return to the designated area or room. The outgoing air flow therefore provides cooled air having a lower temperature than the incoming air flow. In one embodiment, an incoming air flow having a temperature of about 27°C may be cooled to about 25°C in the outgoing air flow. It is to be appreciated that a temperature difference between the incoming and outgoing air flow may be increased or decreased with suitable modifications to the size and capacity of the air conditioning unit 100.

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The air conditioning unit according to embodiments of the invention may be removably installed at selected AHUs as and when a need arises.

For example, when there is a request to cool a particular area after the usual operating hours of a central air conditioning system, the air conditioning unit may be installed at a corresponding AHU serving that particular area. When the air conditioning unit is not required, the air conditioning unit may be
5 uninstalled from or removed from the AHU, or moved to another AHU, or merely switched off while still being physically installed at the AHU.

In the foregoing paragraphs, the air conditioning unit has been described to operate in conjunction with an air circulation system, e.g. AHU,
10 while a central or conventional existing air conditioning system is switched off. In some circumstances, the air conditioning unit may operate in cooperation with an existing or central air conditioning system while the existing air conditioning system is switched on. This combination of the air conditioning unit and the existing or central air conditioning system may be useful to lower
15 the temperature of selected areas or rooms without having to lower the temperature of the central air conditioning system and all the remaining areas. Further, it is to be appreciated that embodiments of the invention may replace a central air conditioning system with suitable modifications.

Embodiments of the invention achieve various advantages including, but not limited to the following. Firstly, a conventional central or existing air conditioning system serving a building does not have to be switched on if only selected areas within the building require air conditioning. Hence, large chillers, cooling towers, and multiple pumps associated with operating
20 conventional central or existing air conditioning system are not required, thus leading to substantially reduced electricity usage and tremendous cost savings in electricity bills. Secondly, the air conditioning unit according to embodiments of the invention may be installed in buildings with existing air conditioning systems with minimal or no modification to the infrastructure of
25 the existing air conditioning systems as long as there is an AHU or an air circulation system. Thirdly, carbon emission is greatly reduced since electricity consumption is substantially reduced, and water consumption is also greatly reduced since cooling towers of a conventional central air
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conditioning system are not in operation. In view of the above, embodiments of the invention assist in energy conservation by substantially reducing electricity and water consumption.

5 Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the invention. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the embodiments as disclosed. The embodiments and features described above should be considered exemplary, with the invention being
10 defined by the appended claims.

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WHAT IS CLAIMED IS:

1. An air conditioning unit comprising:
 - a plurality of condenser coils;
 - 5 a plurality of evaporator coils,wherein the plurality of condenser coils are operable to allow heat dissipation from a hot refrigerant gas for condensing into a refrigerant liquid which is vaporizable into a cool refrigerant gas which is transferable through the plurality of evaporator coils for cooling an incoming air flow; and
- 10 a reservoir of heat absorbent material disposed in thermal communication with the plurality of condenser coils for absorbing the heat dissipation from the plurality of condenser coils, wherein the plurality of condenser coils and the reservoir of absorbent material are disposable to operate indoors.
- 15 2. The air conditioning unit of claim 1, wherein the plurality of evaporator coils, the plurality of condenser coils and the reservoir of absorbent materials are installed as a single modular unit.
- 20 3. The air conditioning unit of claim 2, wherein the plurality of condenser coils and the reservoir of heat absorbent material are disposed under the plurality of evaporator coils.
4. The air conditioning unit of claim 1, wherein the reservoir of heat
- 25 absorbent material includes a hydrophilic macromolecule water-gel.
5. The air conditioning unit of claim 1, further comprising: a plurality of condensation fins disposed in thermal communication with the reservoir of heat absorbent material and operable to condense a vapour produced from
- 30 the reservoir of heat absorbent material.
6. The air conditioning unit of claim 5, further comprising: an air pump operable to agitate the reservoir of absorbent materials to lift the vapour.

7. The air conditioning unit of claim 1, further comprising:

a liquid receiver, interposed between the plurality of condenser coils and the plurality of evaporator coils, which is operable to condense the hot refrigerant gas into the refrigerant liquid;

5 a safety relief valve, interposed between the liquid receiver and the plurality of evaporator coils, which is operable to control pressure of the refrigerant liquid;

an expansion valve, interposed between the safety relief valve and the plurality of evaporator coils, which is operable to vaporise the refrigerant
10 liquid;

a buffer filter, interposed between the plurality of evaporator coils and a compressor to ensure conversion of the refrigerant liquid into a refrigerant gas; and

an accumulator, interposed between the buffer filter and the
15 compressor, which is operable to receive the refrigerant gas from the buffer filter.

8. The air conditioning unit of claim 1, wherein the plurality of evaporator coils, the plurality of condenser coils and the reservoir of absorbent material
20 are disposable to operate within a designated area to be cooled.

9. A system comprising:

an air conditioning unit comprising:

a plurality of condenser coils;

25 a plurality of evaporator coils,

wherein the plurality of condenser coils are operable to allow heat dissipation from a hot refrigerant gas for condensing into a refrigerant liquid which is vaporizable into a cool refrigerant gas which is transferable through the plurality of evaporator coils for cooling an
30 incoming air flow; and

a reservoir of heat absorbent material disposed in thermal communication with the plurality of condenser coils for absorbing the heat dissipation from the plurality of condenser coils, wherein the

plurality of condenser coils and the reservoir of absorbent material are disposable to operate indoors;

a compressor operable to supply the hot refrigerant gas to the plurality of condenser coils; and

5 an air circulation system disposed in cooperation with the air conditioning unit to pass the incoming air flow over the plurality of evaporator coils.

10 10. The system of claim 9, wherein the air circulation system is operable to transfer the incoming air flow to the air conditioning unit and transfer an outgoing air flow, which is the incoming air flow having passed over the plurality of evaporator coils, to a designated area.

15 11. The system of claim 9, wherein the air circulation system is one of an Air Handling Unit (AHU) and a circulation fan.

12. The system of claim 9, wherein the air conditioning unit is removably installed with the air circulation system.

20 13. A method for cooling air, comprising:

passing an incoming air flow over a plurality of evaporator coils of an air conditioning unit;

transferring heat from the incoming air flow to a plurality of condenser coils of the air conditioning unit;

25 dissipating the heat to a reservoir of heat absorbent material which is disposed in thermal communication with the plurality of condenser coils, wherein the plurality of condenser coils and the reservoir of heat absorbent material are disposed indoors; and

30 transferring an outgoing air flow, which is the incoming air flow having passed over the plurality of evaporator coils, to a designated area.

14. The method of claim 13, wherein passing an incoming air flow and transferring an outgoing air flow are performed by an air circulation system being one of an Air Handling Unit (AHU) and a circulation fan.
- 5 15. The method of claim 14, wherein the plurality of condenser coils and the reservoir of absorbent materials are installed as a single modular unit.
16. The method of claim 15, wherein transferring heat from the incoming air flow includes the reservoir of heat absorbent material having a hydrophilic
10 macromolecule water-gel.
17. The method of claim 16, further comprising:
agitating the reservoir of heat absorbent materials;
condensing a vapour produced from the reservoir of heat absorbent
15 material; and
returning the condensed vapour to the reservoir of heat absorbent material.
18. The method of claim 13, further comprising: removably installing the
20 plurality of evaporator coils of the air conditioning unit at an outlet of the air circulation system.

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