

(43) **Pub. Date:** **May 21, 2009**

220

215

214

212

213

216

222

228

226

211

Central air handler

210

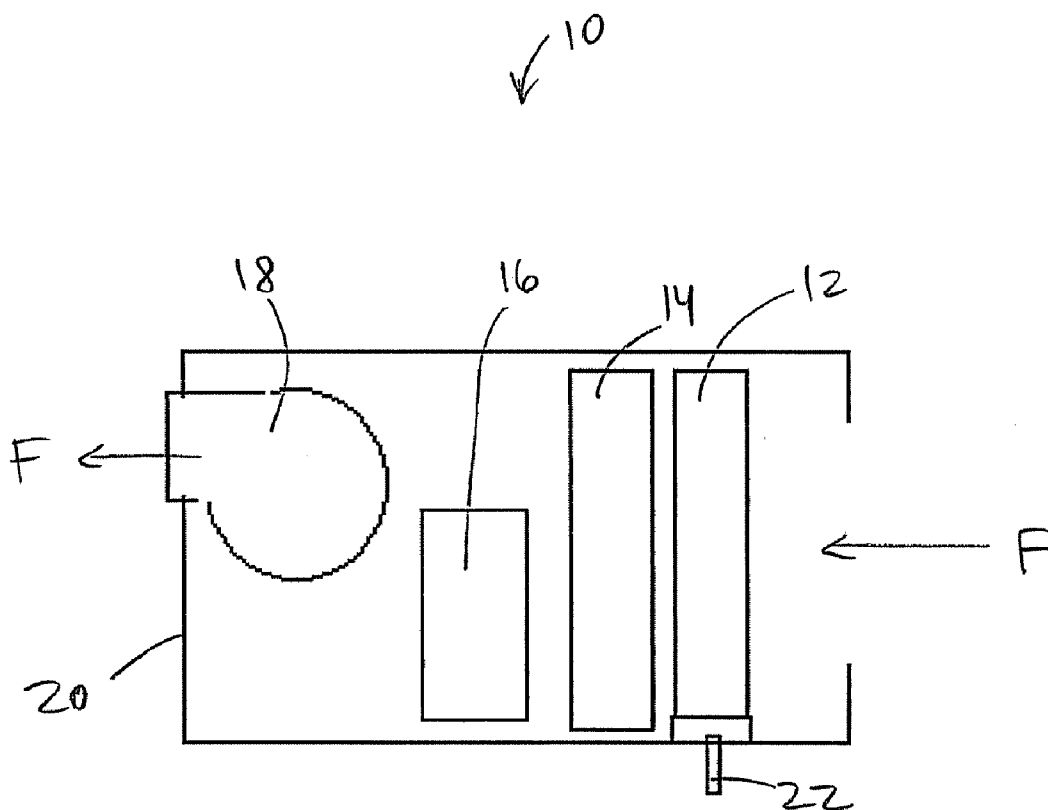


Figure 1

PRIOR ART

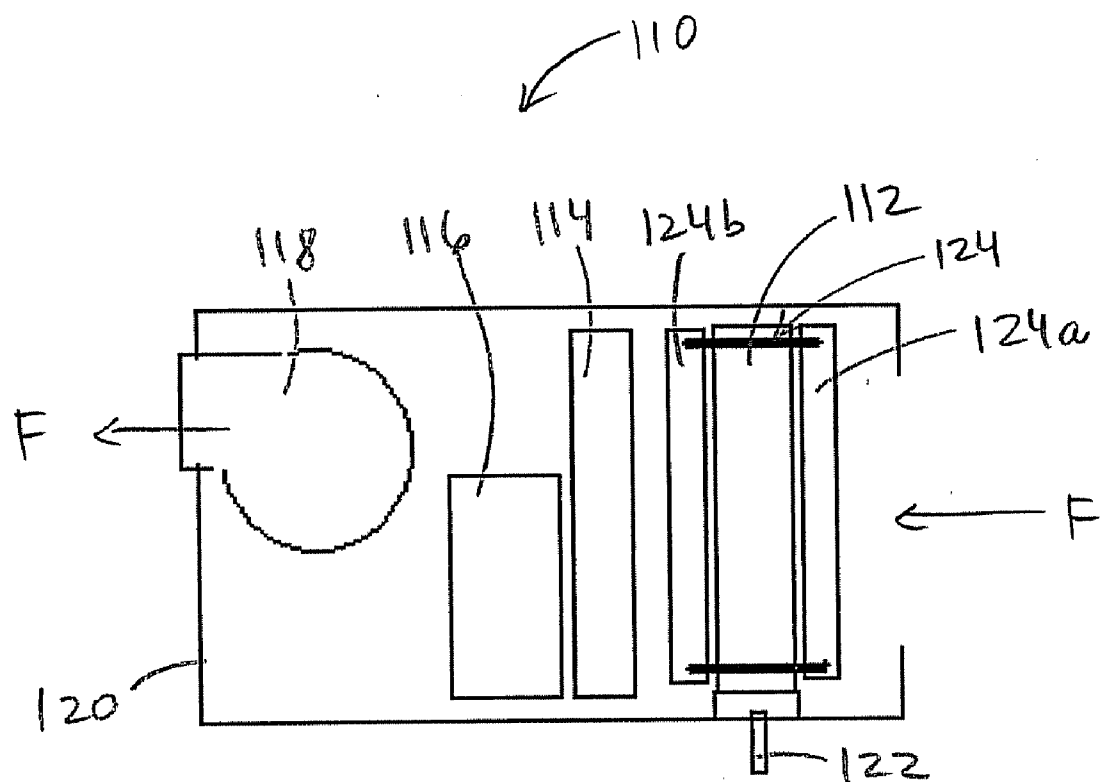
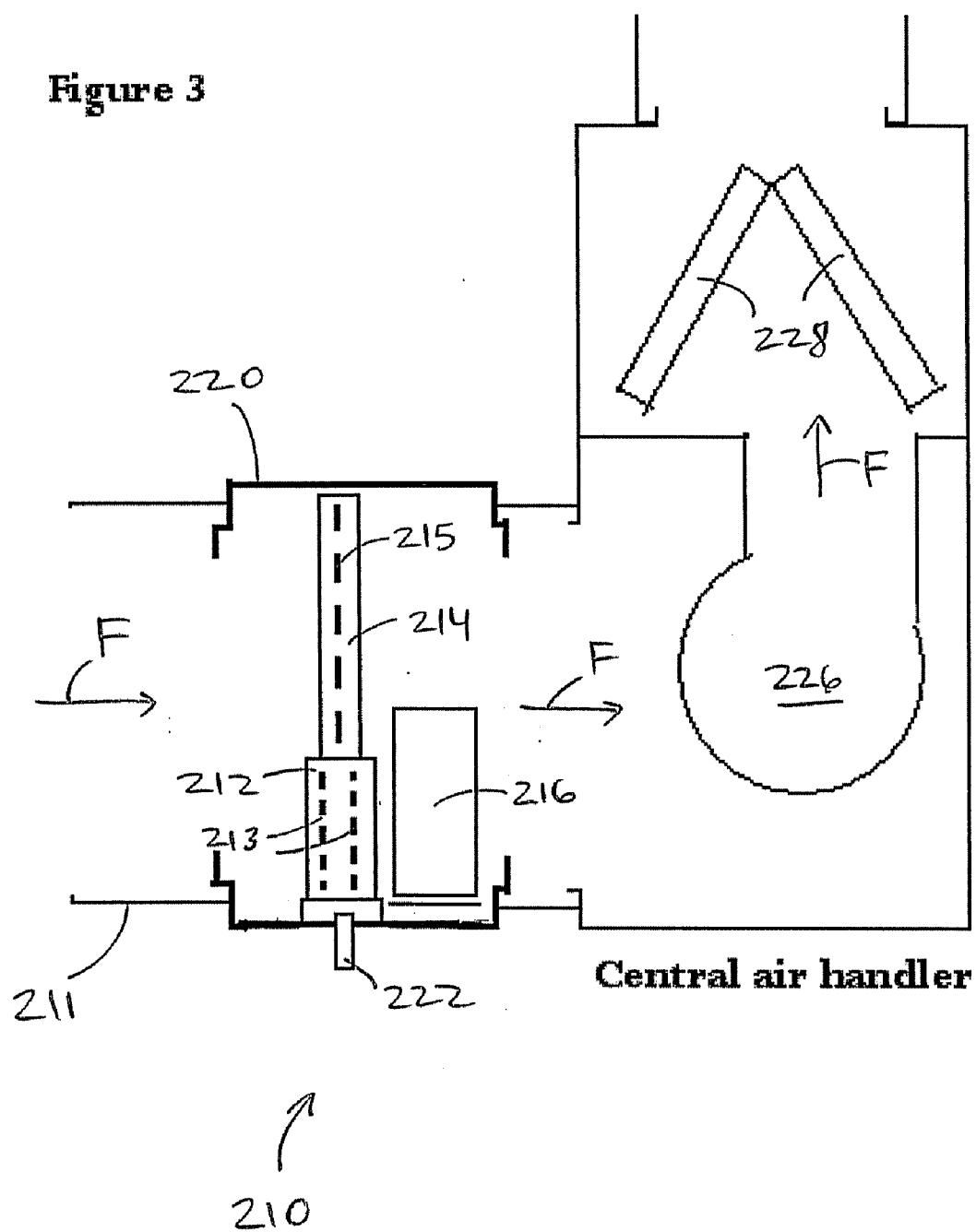
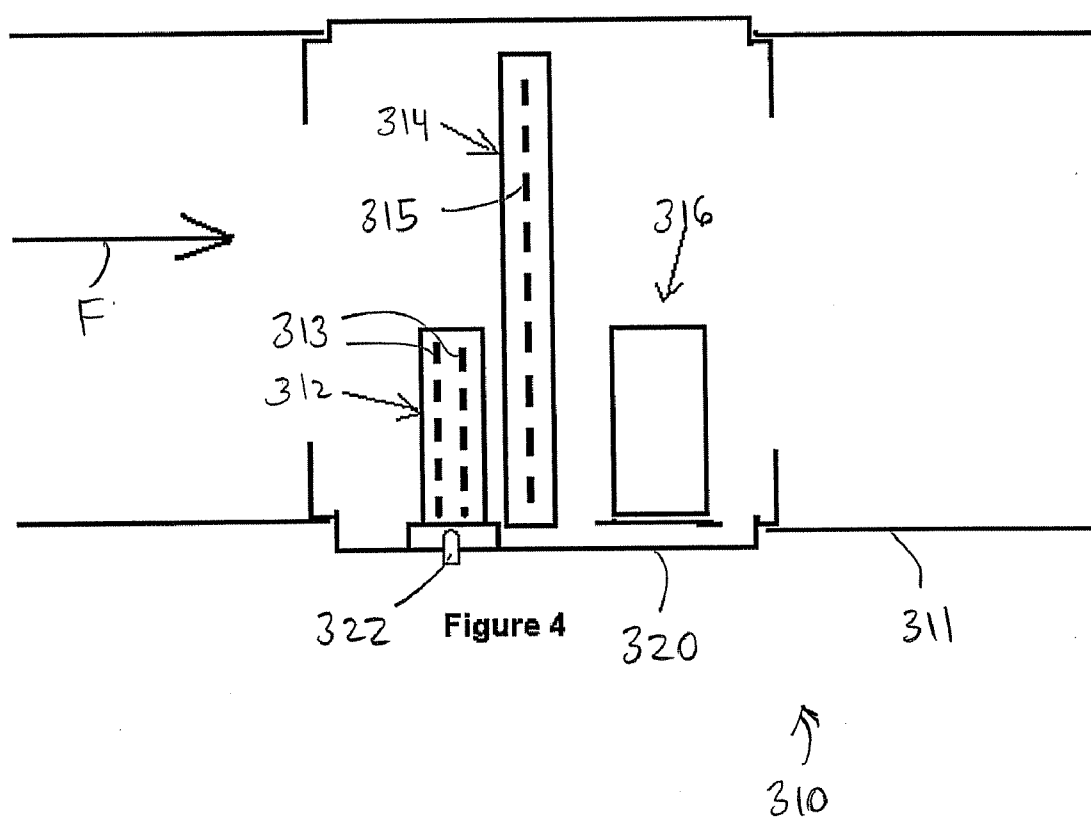


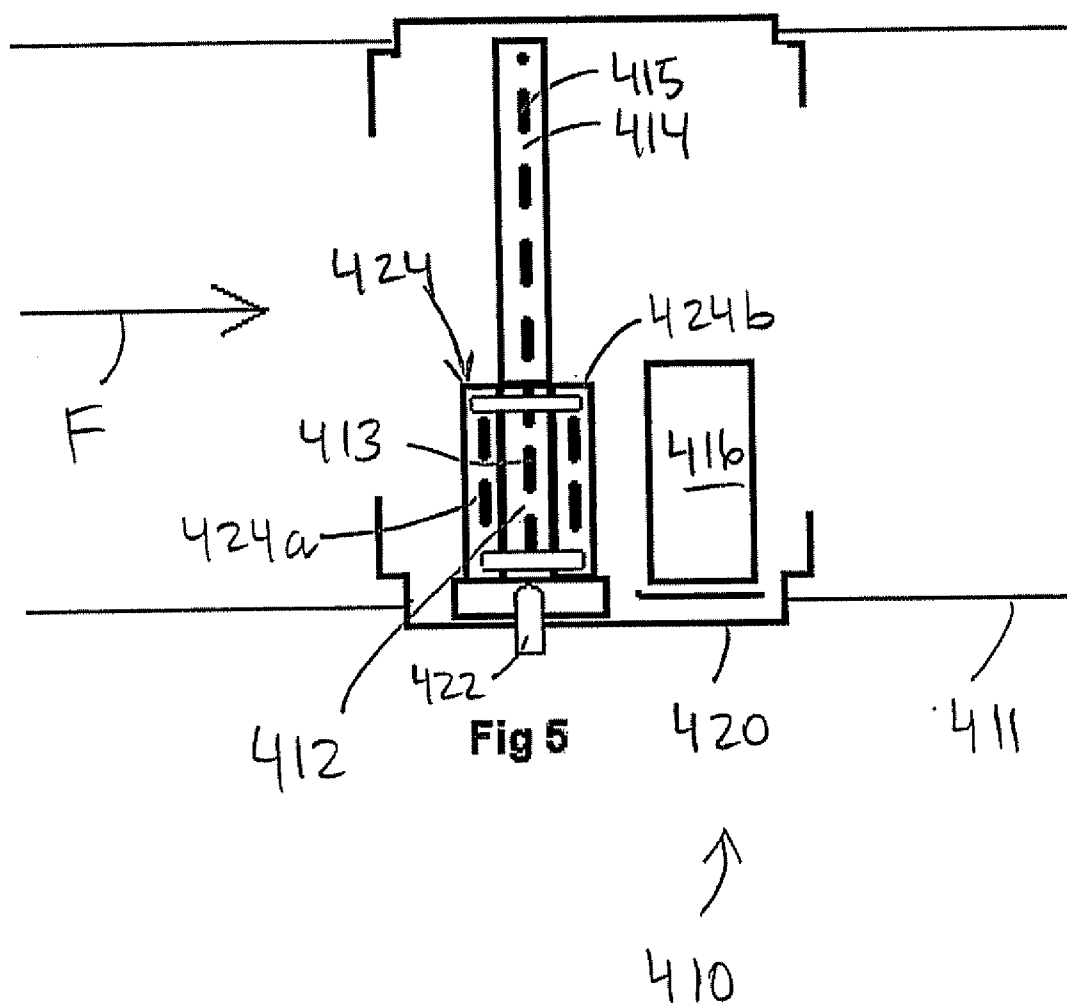
Figure 2

PRIOR ART

Figure 3







DUCT MOUNTED DEHUMIDIFIER USING PARALLEL AIR FLOW

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from, and hereby incorporates by reference, U.S. provisional application Ser. No. 61/003,547, filed Nov. 16, 2007, to Khanh Dinh, entitled "Duct mounted parallel flow heat pipe dehumidifier."

BACKGROUND OF THE INVENTION

[0002] In modern buildings, control of humidity is needed for human comfort, health, as well as for the preservation of items such as books, paintings, and carpets, for example. In hot and humid climates, the use of air conditioners is common to help reduce indoor humidity, and people sometimes use their air conditioners even when temperatures are mild, just to reduce humidity. Whole house dehumidifiers based on the vapor compression cycle are now available from several manufacturers, but most are stand alone units that include their own compressor, blower, evaporator, and condenser. These common machines include the Aprilaire model 1750, for example. These units usually have limited air flow and therefore are not effective for whole-house dehumidification.

[0003] Most vapor compression dehumidifiers are built based on the general configuration shown on FIG. 1. The direction of air flow is indicated by arrow F. A typical dehumidifier **10** includes an evaporator/cooling coil/evaporating coil **12**, a condenser/condensing coil **14**, a compressor **16** and a blower **18**, all of which are enclosed in an enclosure/cabinet **20**. The air is drawn by blower **18** through the evaporator **12**, where water is condensed on the cold surface of the evaporator **12** and removed from the dehumidifier **10** through drain **22**. The cold air exiting from the evaporator **12** is then used to cool the condenser **14**. The compressor **16** provides the vapor compression motive power, and the blower **18** is used to draw air through enclosure **20**.

[0004] U.S. Pat. Nos. 4,607,498 and 5,404,938 by Dinh, hereby incorporated by reference, teach that the dehumidification capacity of the cooling coil can be increased by the use of an air-to-air heat-exchanger such as a heat pipe. Such improved dehumidifiers **110** have been made commercially available by the Heat Pipe Technology, Inc. of Gainesville, Fla., under the trade name of BKPTM Dehumidifiers. Those improved dehumidifiers work based on the principle shown in FIG. 2. Like in a conventional dehumidifier, air is drawn through the different components of the dehumidifier listed analogously as dehumidifier **110**, evaporator **112**, condenser **114**, compressor **116**, blower **118** enclosure **120**, and drain **122**, with the addition of heat exchanger **124**. Heat exchanger **124**, by exchanging heat between the incoming air and the air leaving evaporator **112**, pre-cools the air reaching evaporator **112**, thereby increasing the ability of evaporator **112** to remove moisture.

[0005] One difficult problem with integrating a dehumidifier into a central air conditioning system is matching airflow requirements for the dehumidifier and the central air conditioner. Typically, a dehumidifier only uses 20% to 30% of the airflow that usually goes through a central air conditioning system. For example, a dehumidifier with a capacity of 100 pints per day typically uses 300 cubic feet per minute (cfm) of air, but a typical 3-ton central air conditioning system in a house will require 1500 cfm.

[0006] One cannot successfully run all the air of a central air conditioning system through a dehumidifier because such practice would require too much blower energy, and the excess air will reduce the ability of the dehumidifier to remove water. Therefore, most dehumidifiers must have their own blower, and they are typically installed in parallel with the air-handling portion of the central air conditioning system, requiring complicated duct-work, duct connections and dampers.

BRIEF SUMMARY

[0007] In one aspect, a dehumidifier is provided for installation in an air duct of an HVAC system. The air duct has air flowing therethrough controlled by a blower of the HVAC system. The dehumidifier comprises an enclosure configured for installation in the air duct. The dehumidifier further comprises a compressor connected to an evaporator and a condenser. The evaporator has a first air flow rate for the air flowing therethrough. The condenser has a second air flow rate for the air flowing therethrough, wherein the second air flow rate is higher than the first air flow rate.

[0008] In another aspect, a dehumidifier is provided for installation in an air duct of an HVAC system. The air duct has air flowing therethrough controlled by a blower of the HVAC system. The dehumidifier comprises an enclosure, which comprises a compressor connected to an evaporator and a condenser. The evaporator has a first air impingement surface area for the air flowing therethrough. The condenser has a second air impingement surface area for the air flowing therethrough, wherein the air impingement surface area is larger than the first air impingement surface area.

[0009] In yet another aspect, a dehumidification system comprises a blower of an HVAC system that controls air flowing through an air duct of the HVAC system. A dehumidifier is provided for installation in the air duct. The dehumidifier comprises an enclosure, which comprises a compressor connected to an evaporator and a condenser. The evaporator has a first air flow rate for the air flowing therethrough. The condenser has a second air flow rate for the air flowing therethrough, wherein the second air flow rate is higher than the first air flow rate.

[0010] 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 or essential features of the claimed subject matter, is not intended to describe each disclosed embodiment or every implementation of the claimed subject matter, and is not intended to be used as an aid in determining the scope of the claimed subject matter. Many other novel advantages, features, and relationships will become apparent as this description proceeds. The figures and the description that follow more particularly exemplify illustrative embodiments.

BRIEF DESCRIPTION OF THE FIGURES

[0011] The disclosed subject matter will be further explained with reference to the attached figures, wherein like structure is referred to by like reference numerals throughout the several views.

[0012] FIG. 1 shows a conventional vapor compression dehumidifier.

[0013] FIG. 2 shows an improved dehumidifier with an air-to-air heat-exchanger.

[0014] FIG. 3 shows a duct mounted dehumidifier with separate airflows serving the evaporator and the condenser in parallel, in accordance with an exemplary embodiment of the present disclosure.

[0015] FIG. 4 shows a modified configuration of FIG. 3, wherein a portion of the condenser is located in the colder air stream leaving the evaporator, for better sub-cooling of the liquid refrigerant, in accordance with an exemplary embodiment of the present disclosure.

[0016] FIG. 5 shows a modified embodiment of FIG. 3, wherein a heat pipe heat exchanger is used to enhance the dehumidifier capacity, in accordance with an exemplary embodiment of the present disclosure.

[0017] While the above-identified figures set forth one or more embodiments of the disclosed subject matter, other embodiments are also contemplated, as noted in this disclosure. In all cases, this disclosure presents the disclosed subject matter by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art which fall within the scope and spirit of the principles of this disclosure.

[0018] The figures may not be drawn to scale. Moreover, where directional terms (such as above, over, left, right, under, below, etc.) are used with respect to the illustrations or in the discussion, they are used for ease of comprehension only and not as limitations. The elements of the devices may be oriented otherwise, as readily appreciated by those skilled in the art.

DETAILED DISCLOSURE

[0019] The present disclosure is directed to a vapor compression dehumidifier that is added to the duct-work of a conventional central air conditioning system. The dehumidifier is actually installed in the main duct of the central air conditioning system and receives the whole air volume used by the central air conditioning. However, unlike conventional dehumidifiers, the airflow does not go through the evaporator and then condenser in series. Rather, the airflow is divided into parallel paths that enter the evaporator and the condenser in parallel flows. Typically, the air flow through the evaporator is the lesser one; generally, the speed of air through the evaporator is slower so that the air has the time to be cooled down to a low temperature, insuring effective dehumidification by condensation of air-borne water vapor. Typically, the airflow through the condenser is the larger one, insuring effective cooling of the condenser for efficient operation. The two airflows exiting the evaporator and condenser then mix together and are directed to the conditioned space.

[0020] The present disclosure is directed to a duct mounted, add-on dehumidifier that uses the blower and air distribution ducts of a central air conditioning system to dehumidify a whole house or building. This innovation combines the two functions of cooling and dehumidifying without conflict by creating parallel flows that allow the large amount of air needed by the central air conditioning system to go through a large area condenser coil and a smaller air flow to go through the evaporator, allowing the evaporator to lower the air temperature below the dew point and effectively condense and remove moisture.

[0021] FIG. 1 shows a conventional vapor compression dehumidifier 10 that includes evaporator 12, condenser 14, compressor 16 and blower 18, all of which are enclosed in a cabinet 20. In this conventional dehumidifier 10, all the air

goes through the evaporator 12 first, then the condenser 14 second. The amount of airflow is relatively small, and usually is a compromise to satisfy both the requirements of the evaporator 12 and the condenser 14. Such relatively small air volume is usually insufficient to distribute over a whole house.

[0022] FIG. 2 shows an improved dehumidifier enhanced by a heat pipe heat exchanger 124 installed in such fashion that the first portion 124a of the heat exchanger 124 receives the incoming air, from which it extracts heat and transfers such heat to the second portion 124b of the heat exchanger 124, as taught by Dinh in U.S. Pat. No. 5,404,938.

[0023] FIG. 3 shows a duct mounted dehumidifier with separate airflows serving the evaporator and the condenser in parallel, in accordance with an exemplary embodiment of the present disclosure. In dehumidifier 210, mounted in duct 211 of a central air conditioning system, evaporator 212 is smaller in size and typically includes two or more rows of finned tubes 213; condenser 214 is larger in size and typically only includes one row of finned tubes 215. Compressor 216 is connected to evaporator 212 and condenser 214 with typical piping, metering devices, electrical supply and controls to a vapor compression cycle.

[0024] Enclosure 220 contains evaporator 212 and condenser 214. In an exemplary embodiment, enclosure 220 also contains compressor 216, though compressor 216 may alternatively be mounted outside enclosure 220. Enclosure 220 is made to fit typical duct 211 sizes found in central air conditioning systems and is installed in the return duct or the supply duct of the central air conditioning system. While we describe that enclosure 220 is installed "in" duct 211, it is to be understood that enclosure 220 need not be completely contained within duct 211. Rather, by installing enclosure 220 "in" duct 211, we mean that enclosure 220 is inserted into the air flow path of duct 211. Drain 222 drains condensate from dehumidifier 210.

[0025] All the air from the central air conditioning system goes through enclosure 220, but only a small portion goes through evaporator 212, with the larger remaining airflow going through condenser 214. With the small amount of air going through evaporator 212, the air temperature will drop down to a low point, and moisture will be effectively condensed. On the other hand, the large amount of air going through condenser 214 will insure effective heat removal from the condenser 214 for efficient operation. In exemplary embodiments, compressor 216 is installed in various locations within enclosure 220. For example, compressor 216 may be installed on one side of the enclosure 220 or at the top or at the bottom of enclosure 220. Compressor 216 typically does not need to be in the air stream of the duct 211.

[0026] One important advantage of this innovation is that it will allow optimization of the two airflows to maximize the operation of both evaporator 212 and condenser 214 therefore maximizing the efficiency of the dehumidifier 210. Air flow through air duct 211 is controlled by blower 226 of the HVAC system. Since the blower 226 of the central air conditioning system is used, there is no need for a separate blower like in conventional dehumidifiers 10. Since this innovative design is installed in the existing ductwork 211, there is no need for additional ductwork, ductwork connections or dampers. Duct 211 may be an HVAC (heating, ventilation and air-conditioning) supply duct, return duct, or fresh-air supply duct, for example. An A-coil evaporator 228 of the central air condi-

tioning system is also shown. In an exemplary embodiment, dehumidifier 210 operates only when blower 226 of the central air conditioner operates.

[0027] FIG. 4 shows a modified configuration of FIG. 3, wherein a portion of the condenser 314 is located in the colder air stream leaving the evaporator 312, for better sub-cooling of the liquid refrigerant, in accordance with an exemplary embodiment of the present disclosure. Thus, condenser 314 is positioned to accept outlet air from evaporator 312. In dehumidifier 310, mounted in duct 311 of a central air conditioning system, evaporator 312 is smaller in size and typically includes two or more rows of finned tubes 313; condenser 314 is larger in size and typically only includes one row of finned tubes 315. Compressor 316 is connected to evaporator 312 and condenser 314 with typical piping, metering devices, electrical supply and controls to a vapor compression cycle. Enclosure 320 is made to fit typical duct 311 sizes found in central air conditioning systems and is installed in the return duct or the supply duct of the central air conditioning system. Drain 322 drains condensate from dehumidifier 310.

[0028] FIG. 5 shows a modified embodiment of FIG. 3, wherein air-to-air heat-exchanger 424 such as a heat pipe heat exchanger is used to enhance the dehumidification capacity, in accordance with an exemplary embodiment of the present disclosure. In dehumidifier 410, mounted in duct 411 of a central air conditioning system, evaporator 412 is smaller in size and typically includes two or more rows of finned tubes 413; condenser 414 is larger in size and typically only includes one row of finned tubes 415. Compressor 416 is connected to evaporator 412 and condenser 414 with typical piping, metering devices, electrical supply and controls to a vapor compression cycle. Enclosure 420 is made to fit typical duct 411 sizes found in central air conditioning systems and is installed in the return duct or the supply duct of the central air conditioning system. Drain 422 drains condensate from dehumidifier 410.

[0029] Heat exchanger 424, by exchanging heat between the incoming air and the air leaving evaporator 412, pre-cools the air reaching evaporator 412, thereby increasing the ability of evaporator 412 to remove moisture. Heat pipe heat exchanger 424 is installed in such fashion that the first portion 424a of the heat exchanger 424 receives the incoming air, from which it extracts heat and transfers such heat to the second portion 424b of the heat exchanger 424, as taught by Dinh in U.S. Pat. No. 5,404,938.

[0030] In the illustrated embodiments, the ratio of air flows between evaporator 212, 312, 412 and condenser 214, 314, 414 can vary dramatically depending on the building environment, the central air conditioning system, and the desired climate control result. In some embodiments, the air flow rate through condenser 214, 314, 414 is more than twice the air flow rate through evaporator 212, 312, 412. In an exemplary embodiment, the air flow rate through condenser 214, 314, 414 is about three times the air flow rate through evaporator 212, 312, 412. In other embodiments, the air flow rate through condenser 214, 314, 414 is more than three times the air flow rate through evaporator 212, 312, 412.

[0031] In many applications, it is generally desirable to have the air flow ratio between the condenser 214, 314, 414 and the evaporator 212, 312, 412 as large as possible. However, in some applications, the air flow to the evaporator 212, 312, 412 should be sufficient to prevent freezing on the evaporator coils. In other cases, freezing on the evaporator coils is fine, as long as they are periodically defrosted.

[0032] In an exemplary embodiment, the difference in air flow rates through condenser 214, 314, 414 and evaporator 212, 312, 412 is due primarily to the air resistance in the duct 211, 311, 411 at condenser 214, 314, 414 and evaporator 212, 312, 412. The air resistance is affected by factors such as the air impingement surface area, thickness, and other design factors of the evaporator 212, 312, 412 and condenser 214, 314, 414 units and the physical arrangement, placement, and sizing of the finned tubes 213, 215, 313, 315, 413, 415, for example. In one exemplary embodiment, the finned tubes 213, 313, 413 are arranged in multiple rows to maintain the same surface area of tubing within a smaller air impingement surface area. In such a design, the thicker, multi-layered design of finned tubes 213, 313, 413 results in more air resistance, and thus slower airflow, through evaporator 212, 312, 412 compared to condenser 214, 314, 414. In another exemplary embodiment, condenser 214, 314, 414 has a larger air impingement surface than evaporator 212, 312, 412.

[0033] All patents, patent applications, provisional applications, and publications referred to or cited herein are incorporated by reference in their entirety, including all figures and tables, to the extent they are not inconsistent with the explicit teachings of this specification.

[0034] It should be understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application.

1. A dehumidifier for installation in an air duct of an HVAC system, wherein the air duct has air flowing therethrough controlled by a blower of the HVAC system, the dehumidifier comprising:

- an enclosure configured for installation in the air duct;
- a compressor;
- an evaporator connected to the compressor, the evaporator having a first air flow rate for the air flowing therethrough; and
- a condenser connected to the compressor, the condenser having a second air flow rate for the air flowing therethrough, the second air flow rate being higher than the first air flow rate.

2. The dehumidifier of claim 1 wherein the evaporator and condenser are arranged so that air flowing through the duct flows through both the evaporator and condenser in parallel.

3. The dehumidifier of claim 1 further comprising a heat exchanger connected to the evaporator.

4. The dehumidifier of claim 3 wherein the heat exchanger is an air-to-air heat pipe heat exchanger.

5. The dehumidifier of claim 1 wherein the condenser is positioned to accept outlet air from the evaporator.

6. A dehumidifier for installation in an air duct of an HVAC system, wherein the air duct has air flowing therethrough controlled by a blower of the HVAC system, the dehumidifier comprising an enclosure comprising:

- an enclosure configured for installation in the air duct;
- a compressor;
- an evaporator connected to the compressor, the evaporator having a first air impingement surface area for the air flowing therethrough; and
- a condenser connected to the compressor, the condenser having a second air impingement surface area for the air flowing therethrough, the second air impingement surface area being larger than the first air impingement surface area.

7. The dehumidifier of claim 6 wherein the evaporator and condenser are arranged so that air flowing through the duct flows through both the evaporator and condenser in parallel.

8. The dehumidifier of claim 6 further comprising a heat exchanger connected to the evaporator.

9. The dehumidifier of claim 8 wherein the heat exchanger is an air-to-air heat pipe heat exchanger.

11. A dehumidification system comprising:

a blower of an HVAC system;

an air duct of the HVAC system, wherein the air duct has air flowing therethrough controlled by the blower;

a dehumidifier enclosure installed in the air duct comprising:

a compressor,

an evaporator connected to the compressor, the evaporator having a first air rate for the air flowing there-through; and

a condenser connected to the compressor, the condenser having a second air flow rate for the air flowing there-through, the second air flow rate being higher than the first air flow rate.

12. The system of claim 11 wherein the evaporator and condenser are arranged so that air flowing through the duct flows through both the evaporator and condenser in parallel.

13. The system of claim 11 further comprising a heat exchanger connected to the evaporator.

14. The system of claim 13 wherein the heat exchanger is an air-to-air heat pipe heat exchanger.

15. The system of claim 11 wherein the condenser is positioned to accept outlet air from the evaporator.

16. The system of claim 11 wherein the air duct is a return duct of the HVAC system.

17. The system of claim 11 wherein the air duct is a supply duct of the HVAC system.

18. The system of claim 11 wherein the air duct is a fresh air supply duct of the HVAC system.

19. The system of claim 11 wherein the compressor operates only when the blower operates.

20. The system of claim 11 wherein the evaporator is thicker than the condenser.

* * * * *