



An Air-Cooled Condenser and An Air Conditioning Apparatus

Background and Field of the Invention

5 This invention relates to an air-cooled condenser and an air conditioning apparatus, particularly but not exclusively, for industrial applications.

Air conditioning systems are being used in numerous applications to cool or dehumidify the air. As it is well understood, it is inevitable that as a result of the cooling, heat being
10 generated by a condenser needs to be dissipated to its surroundings. As a result, it is common to place the condenser and an evaporator of an air conditioning system at a distance from each other. Even if the condenser and evaporator are co-located near each other, such air conditioning systems are bulky and energy efficiency is poor.

15 It is an object of the present invention to provide an air-cooled condenser and an air conditioning apparatus, which alleviates at least one of the disadvantages of the prior art and/or to provide the public with a useful choice.

Summary of the Invention

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In accordance with a first aspect of the present invention, there is provided an air-cooled condenser for an air conditioning apparatus, the condenser comprising a condenser coil arrangement for condensing a refrigerant from a gaseous state to a liquid state; a plurality of elongate channels for enclosing the condenser coil
25 arrangement, the plurality of elongate channels being spaced from each other to create air gaps therebetween; an air intake opening for directing air into the plurality of elongate channels for dissipating heat from the condenser coil arrangement to produce heated air within the plurality of elongate channels; an air discharge outlet for discharging the heated air out of the condenser; a casing for housing the plurality of
30 channels, the casing having a condenser air intake portion for taking in ambient air for flowing through the air gaps; a condenser air outlet portion for releasing the ambient air from the condenser air intake portion out of the condenser for cooling by an evaporator.

By having the elongate channels enclosing the condenser coil arrangement, the
35 efficiency of the air conditioning apparatus may be improved. Further, if the air-cooled



condenser is co-located with the evaporator within the same housing of the air-conditioning apparatus, this can achieve a much more compact configuration.

It should be appreciated, that ambient air is used to mean air from surroundings of the air conditioning apparatus. Also, the phrase "condenser coil arrangement" may mean an elongate continuous condenser coil or a number of condenser coils connected together to form a continuous path for the refrigerant to flow. Further, air conditioning apparatus is intended to cover a broad scope of products, such as chillers, coolers, air-conditioners etc.

Preferably, each channel is configured to enclose two parallel segments of the condenser coil arrangement. The air-cooled condenser may comprise a replaceable front cover for attaching to the casing, the air intake opening being disposed on the front cover. The air-cooled condenser may also comprise a replaceable back cover for attaching to the casing, the air discharge outlet being disposed on the back cover.

In a second aspect of the invention, there is provided a method of retrofitting the air-cooled condenser as discussed above to an air conditioning apparatus, the method comprising, (i) locating the air-cooled condenser adjacent an evaporator of the air conditioning apparatus, (ii) coupling the air intake opening to a blower outlet of an air blower; (iii) coupling an inlet of the condenser coil arrangement to a compressor of the air conditioning apparatus; and (iv) coupling an outlet of the condenser coil arrangement to the evaporator via an expansion valve.

The air-cooled condenser may also form part of an air conditioning apparatus (for example, included at the factory) and this forms a third aspect of the invention in which there is provided an air conditioning apparatus comprising the air-cooled condenser as discussed above, an evaporator disposed adjacent the air-cooled condenser; and a compressor for receiving the gaseous-state refrigerant from the evaporator and compressing the gaseous-state refrigerant for delivery to the condenser.

Preferably, the air conditioning apparatus further comprises an absorbent sandwiched between the air-cooled condenser and the evaporator; wherein the ambient air released from the condenser flows through the absorbent prior to being cooled by the evaporator. The absorbent may include polymer fins.

The air conditioning apparatus may further comprise an air blower coupled to the air intake opening of the air-cooled condenser. Preferably, the air blower is driven by a compressor motor, which is operable also to drive the compressor.

5 The air conditioning apparatus may further comprise an optimizing device for controlling the flow of the liquid-state refrigerant from the condenser to an expansion valve which regulates the flow to the evaporator. Preferably, the air conditioning apparatus further comprises a distributor for distributing the flow of the liquid-state refrigerant from the expansion valve to a number of inlets of an evaporator coil
10 arrangement of the evaporator.

The air conditioning apparatus further comprises an air handler having a compartment and a vacuum suction device for drawing the cooled air from the evaporator into the compartment. Preferably, the air handler includes a blower for blowing the cooled air in
15 the compartment of the air handler out of the air conditioning apparatus' housing.

In a fourth aspect of the invention, there is provided an optimizing device for an air conditioning apparatus, comprising a first control valve arranged to regulate flow of liquid-state refrigerant from a condenser into the chamber; a second control valve
20 arranged to regulate a preset flow of gaseous-state refrigerant from an evaporator into the chamber; and a chamber for mixing the liquid-state refrigerant and gaseous-state refrigerant to enable the liquid-state refrigerant to be converted to vapour; wherein the vapour is arranged to be directed to a compressor together with the gaseous-state refrigerant from the evaporator.

25 Preferably, the optimizing device further comprises a liquid check valve in fluid communication with the first control valve to enable a portion of the liquid refrigerant to be directed to the liquid check valve; a bypass liquid line coupled to the liquid check valve; a spray nozzle coupled to the bypass liquid line and arranged to generate a
30 spray of the liquid refrigerant to direct the liquid refrigerant flowing into the first control valve towards the chamber's base.

The optimizing device may further comprise a membrane for extracting oil from the mixture of liquid-state and gaseous-state. The optimizing device may also comprise an
35 oil check valve arranged to direct the extracted oil to an oil sump of a compressor.

Preferably, the optimizing device comprises a dry bulb sensor for sensing a parameter of the gaseous-state refrigerant from the evaporator and arranged to trigger opening or closing of the first control valve to regulate the flow of the liquid-state refrigerant.

- 5 The optimizing device may be retrofitted to an existing air conditioning apparatus or form part of an air conditioning apparatus.

Brief Description of the Drawings

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Examples of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an air conditioning apparatus comprising a condenser, a compressor, an optimizing device and an evaporator according to a first embodiment of the invention;

Figure 2 is an enlarged view of the compressor of Figure 1.

Figure 3 comprising Figures 3a,3b,3c and 3d are slightly reduced views of different parts of the condenser of Figure 1; and

20 Figure 4 is a schematic diagram of the different parts of the air conditioning apparatus of Figure 1 and showing details of the optimizing device; and

Figure 5 is an enlarged schematic diagram of the optimizing device of Figure 4.

Figure 6 is a close-up view of a number of elongate flat channels used in the condenser of Figure 3;

25 Figure 7 is a close-up view of segments of a condenser coil arrangement used in the condenser of Figure 3;

Figure 8 illustrates how the segments of the condenser coil arrangement of Figure 7 are received within the elongate flat channels of Figure 6;

30 Figure 9 illustrates a number of polymer sheets arranged in two rows which are used as an absorbent in the apparatus of Figure 1; and

Figure 10 is an enlarged view of one of the polymer sheets of Figure 9 and illustrating how air flows through the polymer sheet.

Detailed Description of Preferred Embodiments

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Figure 1 is a perspective view of an air conditioning apparatus 100 according to a first embodiment of the invention which is used to generate cold or cool air to cool a room,

for example. The air conditioning apparatus 100 is self-contained and includes a housing 102 for housing a compressor 200, a condenser 300, an evaporator 400 and an optimizing device 500.

5 Figure 2 shows the compressor 200 more clearly. In this embodiment, the compressor 200 is an open-drive compressor and has a drive shaft (not shown) coupled to a drive pulley 202.

10 The air conditioning apparatus 100 further includes a motor 600 having an output shaft 602 with a first end of the output shaft 602 coupled to a wheel 604. The motor 600 is arranged to drive the output shaft 602 which in turn rotates the wheel 604. The wheel 604 of the motor 600 is coupled to the drive pulley 202 of the compressor 200 via an endless belt 606.

15 Coupled to a second end of the output shaft 602 of the motor 600 is an air blower 608 for generating a flow of air to the condenser 300. As shown in Figure 2, the air blower 608 includes a fan 610 with light turbo blades for generating the flow of air and a blower outlet 612 for channeling the flow of air out of the air blower 608. The fan 610 is coupled to the second end of the output shaft 602 and is thus driven by the motor 600
20 and rotation of the fan 610 is synchronized to the rotation of the output shaft 602.

As it can be appreciated, the motor 600 is configured to drive the compressor 200 and to operate or drive the fan blower 608 which helps to reduce the space required to house the various components of the air conditioning apparatus 100.

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The compressor 200 is arranged to compress or pressurize a refrigerant in a gas-state to produce a flow of compressed hot gas refrigerant for delivery to the condenser 300. The compressor 200 includes a compressor outlet 208 coupled to the condenser 300 via a condenser-compressor pipe 206 (see Figure 1). The compressor 200 further
30 includes a compressor inlet 204 for receiving the refrigerant in a liquid-state from the evaporator 400.

Figure 3, comprising Figures 3a, 3b, 3c and 3d, shows the condenser 300 in greater detail with a number of parts of the condenser 300 separated. As shown in Figures 3a
35 and 3c, the condenser 300 includes a casing 302 and a front cover 350 for covering a front 304 of the casing 302. The condenser 300 also includes a back cover 380 for

covering a rear 306 of the casing 302, and a refrigerant receiving tank 316 (see Figure 4) for storing liquid refrigerant. It should be mentioned that the front and back covers 350,380 for may be the replaceable type for easy maintenance.

5 The condenser 300 further includes a condenser air intake portion 308 for drawing air from the surroundings, so called ambient air, into the condenser 300. The air is drawn into the condenser 300 by return and fresh ambient air circulation. The casing 302 is arranged to house a condenser coil arrangement 310 for carrying the compressed hot gas refrigerant delivered by the condenser-compressor pipe 206 from the compressor
10 200. The condenser coil arrangement 310, or segments of it, is enclosed within a plurality of elongate flat channels 312, with the segments of the condenser coil 310 suspended within each channel 312. Preferably, the condenser coil arrangement 310 is arranged to be in physical contact with the channels 312 to enhance the heat dissipation.

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Figure 6 shows a close-up view of a number of the elongate flat channels 312 which are open ended. Each elongate flat channel 312 includes an aluminum housing 320 enclosing an air channel 322. Figure 7 is a close-up view of segments of the condenser coil arrangement 310 which comprises a number of coil pipes 318 with one end shown
20 as unconnected although it would be appreciated that the coil pipes 318 are arranged to be connected together in an end-to-end relationship to form a continuous coil.

Figure 8 illustrates how segments of the condenser coil arrangement 310 are received within the elongate flat channel 312 and heat from the condenser coil arrangement 310
25 is thus dissipated to the air channel 322 within the elongate flat channel 312. The broken lines illustrate connections to create the continuous condenser pipe arrangement 310. The plurality of channels 312 is spaced from each other to create air gaps 313 between the channels.

30 The ambient air drawn into the condenser 300 from the atmosphere via the condenser air intake portion 308 passes through the air gaps 313 and over outer surfaces of the channels 312 with the direction of the ambient air flow traversing the longitudinal direction of the channels 312 (and also the condenser coil arrangement 310). In other words, the condenser coil arrangement 310 is not directly exposed to the ambient air
35 coming into the condenser 300 from the condenser air intake portion 308 and instead the ambient air is exposed to the channels 312.

The channels 312 are open at both ends as shown in Figure 3c which shows the channels 312 without the condenser coil arrangement 310 at the front 304 and back 306 of the casing 302.

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As explained earlier, the condenser coil arrangement 304 receives the compressed hot gas refrigerant from the compressor 200 and is arranged to condense the compressed hot refrigerant gas into liquid refrigerant. In doing so, heat is generated due to the condensation which needs to be dissipated away and this embodiment provides a
10 unique and unpredictable way of achieving this.

As shown in Figure 3a, the front cover 350 of the condenser 300 includes an air intake opening 352 which is circular in shape, and the air intake opening 352 is coupled to the blower outlet 612 of the air blower 608 via a flexible air duct 314. When the cover 350
15 of the condenser 300 is mounted or attached to the front 304 of the condenser 300, the cover 350 provides a spacing (not shown) between the cover 350 and the front 304 of the condenser 300 and forms an air-tight seal with the front 304 of the condenser 300. In this way, the air from the air blower 608 is channeled by the front cover 350 into each of the channels 312 (since portions of the front 304, other than the channels 312,
20 do not allow air to go through) to dissipate the heat generated from the condenser coil arrangement 310 and thus producing heated air within each of the channels. It should be appreciated that the design and structure of the air blower 608 (and the fan 610) are configured to meet the flow rate requirement.

25 The air from the air blower 608 thus flows into and through inner surfaces of the enclosed channels 312 (generally, in the same longitudinal direction as the longitudinal axis of the channels 312) and acts as a medium to absorb and dissipate the heat generated due to the condensation of the compressed hot refrigerant gas into the liquid refrigerant. In other words, the condenser 300 is air-cooled. The heated air in the
30 channels 312 is then directed out of the rear 306 of the casing 302 and into an air discharge outlet 382 of the back cover 380 (, see Figure 3d, when the back cover 380 is mounted to the rear 306 of the casing 302, and the back cover 380 also forms an air-tight seal with the rear 306 of the casing 302). The air discharge outlet 382 is arranged to be coupled to a drainage pipe for discharging the heated or hot air out of the air
35 conditioning apparatus 100 (and away from the room to be cooled).

As it can be appreciated from the above, the air from the air blower 608 acts as a primary means of dissipating the heat from the condenser coil arrangement 310, and since the condenser coil arrangement 310 is enclosed within the plurality of channels 312, most of the heat dissipation is restricted to the space within the enclosed channels 312. Thus, the heat generated by the condenser coil arrangement 310 has little or minimum effect on the ambient air drawn from the condenser air intake portion 308 which passes through the outer surfaces of the channels 312. In other words, the ambient air drawn into the condenser air intake portion 308 is mostly isolated from the heat generated by the condenser coil arrangement 310.

However, it is envisaged that it is possible not all the heat generated by the condenser coil arrangement 310 is dissipated by the air from the air blower 608 and that some of the heat may be transferred to the ambient air drawn in from the condenser air intake portion 308, raising the air temperature by perhaps 1°C.

After passing across the channels 312, the ambient air drawn from the condenser air intake portion 308 leaves the condenser 300 via a condenser air outlet portion (not shown) (which basically is similar to what is illustrated for the condenser air intake portion 308) as outgoing condenser air.

The air conditioning apparatus 100 further includes an absorbent interposed or sandwiched between and in fluid communication with the condenser 300 and the evaporator 400, and this is shown in Figure 1. In this embodiment, the absorbent includes a plurality of condensation fins 700 which are polymer sheets 702 arranged side-by-side to form two rows as shown in Figure 9. Figure 10 shows one of the polymer sheets 702 with arrows AA illustrating the flow of the outgoing condenser air from the condenser 300.

The outgoing condenser air is passed through the plurality of condensation fins 700 which functions as means for absorbing "secondary heat" from the outgoing condenser air which may or may not be heated by the heat from the condenser coil arrangement 310. After passing through the plurality of condensation fins 700, the air leaves the plurality of condensation fins 700 and is passed to the evaporator 400 for cooling.

As it can be appreciated from the above, the condenser 300 condenses the hot gas refrigerant gas (i.e. the refrigerant in gaseous-state) into liquid-state as liquid refrigerant which is flowed to the evaporator 400 via a control system 800.

- 5 Figure 4 is a schematic block diagram of the control system 800 and the condenser 300 and the evaporator 400 (with some of the details omitted for easier explanation). The control system 800 includes a dehydrating device 802 or dryer configured to remove moisture from the liquid refrigerant from the condenser coil arrangement 310.
- 10 After the dehydrating device 802, the liquid refrigerant is channeled to an accumulator exchanger 804 and the optimizing device 500. The accumulator exchanger 804 acts as a intermediary to receive the liquid refrigerant from the condenser 300 for directing to the evaporator 400 via an intermediary pipe 805. Part of the intermediary pipe 705 runs through an exchanger body 807 of the accumulator exchanger 804. The exchanger
- 15 body 807 is hollow and allows “returning” gas refrigerant from the evaporator 400 to flow through. In this way, heat from the hot liquid refrigerant carried by the intermediary pipe 805 is transferred to the gas refrigerant from the evaporator flowing through the exchanger body 807 and returning to the compressor 200. In this way, the gas refrigerant returning to the compressor is heated and this reduces formation of jelly-like
- 20 liquids in the air conditioning apparatus 100 which may disturb smooth flowing (or circulation) of the liquid refrigerant. The accumulator exchanger 804 also ensures only refrigerant vapour is channeled to the compressor 200.

- It should be appreciated that the accumulator exchanger 804 is located on the “low
- 25 pressure side” of the apparatus 100 and makes use of the returning cool gas refrigerant to reduce the heat of the liquid refrigerant to the evaporator 400 for better performance.

- As it can be appreciated from Figure 4, the liquid refrigerant flow to the accumulator
- 30 exchanger 804 from the dehydrating device 802 is controlled by the optimizing device 500 and the liquid refrigerant to the accumulator exchanger 804 may be considered as optimized. Figure 5 illustrates an enlarged schematic diagram of the optimizing device 500 of Figure 4. The optimizing device 500 includes a chamber 501, a liquid refrigerant inlet 502, hot gas bypass regulator 504, thermostatic expansion valve 506, spray
- 35 nozzle 508, check valves 510, 512 and brush core membrane 514. The optimizing device 500 is configured to optimize the flow of the liquid refrigerant from the

condenser 300 to the evaporator 400, reduce excessive cycle, coil freeze and improves energy efficiency.

5 The liquid refrigerant inlet 502 is coupled to the output of the dehydrating device 802 via the thermostatic expansion valve 506. The thermostatic expansion valve 506 is controlled (or energized) by a thermostatic dry bulb sensor 816 which is placed in a return path of the evaporator 400 and this will be elaborated in more detail later.

10 When the thermostatic dry bulb sensor 816 detects a particular temperature (for example 4°C) at the return path of the evaporator 400, the thermostatic dry bulb sensor 816 controls the thermostatic expansion valve 506 to open to enable the high pressure (hot) liquid refrigerant from the condenser 300 to flow into the chamber 501. The thermostatic expansion valve 506 includes a bypass inlet 516 connected to the first check valve 510 which is a one-way valve. The first check valve 510 is connected to a
15 bypass liquid line 518 with the other end connected to the spray nozzle 508. In other words, when the thermostatic expansion valve 506 opens, the high pressure liquid refrigerant is directed to the spray nozzle 508 in the direction shown as BB in Figure 5, via the first check valve 510 and the bypass liquid line 518. The spray nozzle 508 is arranged to release the high pressure liquid refrigerant as sprays to direct the liquid
20 refrigerant flowing into the chamber 501 towards the base of the chamber 501.

The optimizing device 500 further includes a gas refrigerant inlet 520 coupled to the hot gas bypass regulator 504 to receive the gas refrigerant from the compressor 200 (as the gas refrigerant flows from the compressor 200 to the condenser 300). The amount
25 of gas refrigerant to allow through the refrigerant inlet 520 is preset or predetermined by a user of the air conditioning apparatus 100, for example during commissioning of the apparatus 100.

30 The gas refrigerant, which is hot, rises upon entering the chamber and this is "mixed" with the liquid refrigerant entering the chamber 501 from the liquid refrigerant inlet 502 and creates hot vapour near the top of the chamber 501. The hot vapour is next sucked into a suction line 522, with the other end of the suction line 522 connected to a pipe between the accumulator exchanger 804 and the compressor 200. In other words, the hot vapour is channeled to the compressor 200 which further warms up the gas
35 refrigerant returning to the compressor 200. In this way, the gas refrigerant to be

compressed by the compressor 200 is of a certain temperature and thus, makes it more efficient to convert the gas refrigerant into high pressure gas refrigerant.

Due to the controlled and selective release of liquid refrigerant from the thermostatic expansion valve 506 and the gas refrigerant from the hot gas bypass regulator 504 into the chamber 501, the optimizing device 500 mixes the liquid and gas refrigerant in the chamber 501 proportionately to purge heat from the liquid and gas refrigerant to form vapour of reduced heat which is sucked back to the compressor 200, thus ensuring optimum performance.

The optimizing device 500 further includes a brush core membrane 514 disposed near the base of the chamber 501. More specifically, the brush core membrane 514 is disposed between the first check valve 510 and a second check valve 512. The second check valve 512 is also one-directional and is connected to a compressor oil sump of the compressor 200 via an oil pipe 524 (see also Figure 4). As it can be appreciated, the liquid refrigerant includes oil and the brush core membrane 514 is arranged to extract the oil from the liquid refrigerant and the second check valve 512 directs the extracted oil to the compressor oil sump of the compressor 200 (see arrow CC of Figure 5). In this way, it helps to ensure that the compressor 200 operates in a proper and efficient manner.

As it can be appreciated from the above, the optimizing device 500 is configured to stabilize the gas and liquid refrigerant which is being circulated and to ensure that the portions of the gas and liquid refrigerant are proportionate to each other. In this way, the temperature of the apparatus 100 would be stable (or more or less constant and not fluctuating) and this also eliminates humidity.

The optimizing device 500 also helps to prevent "excessive cycle" or overworking of the compressor 200 which may lead to damage of the compressor 200 and the refrigerant flow would not be smooth.

The optimizing device 500 also helps to prevent coil freeze. For example, this may happen if cool air is not transferred to the designate area (for example, breakdown of fan system). This may also happen if the evaporator 400 low pressure gases are not returned properly to the compressor 200. When this happens, the thermostative expansion valve 506 may open fully to enable all the liquid refrigerant from the condenser 300 to flow into the chamber 501 of the optimizing device 500 and thus,

stops the flow of the liquid refrigerant to the expansion valve 806. The liquid refrigerant is then mixed with the hot gas refrigerant and converted to hot vapour and returned to the compressor 200 via the suction line 522. This will thus help to prevent coil freeze at the evaporator 400.

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The optimizing device 500 aids the circulation of the gas and liquid refrigerants around the apparatus 100 and the compressor lubricating oil is returned immediately to the compressor oil sump. In this way, the compressor efficiency is improved and leads to greater energy savings.

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The optimized liquid refrigerant is channeled after the accumulator exchanger 804 to an expansion valve 806 via a safety pressure release valve 808 coupled to a flow pipe between the accumulator exchanger 804 and the expansion valve 806. The pressure release valve 808 monitors the pressure of the liquid refrigerant which is being flowed to the expansion valve 806 to protect and prevent damage to the air conditioning apparatus 100. If a pressure limit is reached, the pressure release valve 808 opens to release excessive pressure.

In this embodiment, the expansion valve 806 is an orifice-type and is arranged to control amount of liquid refrigerant which is being directed to a distributor 810. The distributor 810 includes a number of feeding tubes 812 for feeding the liquid refrigerant to various inlets 402 of an evaporator coil arrangement 404 of the evaporator 400, which may be one elongate coil similar to the condenser coil arrangement 310 or the evaporator coil arrangement 404 may be a number of coils connected together. When the liquid refrigerant enters the evaporator coil arrangement 404, the liquid refrigerant experiences a pressure drop, expands and changes to a cold and low pressure gas refrigerant, a process known as phase conversion.

As it can be appreciated from Figure 4, the evaporator coil arrangement 404 is arranged in groups of parallel rows with spaces in between to allow air from the condensation fins 700 to flow through and be in fluid communication with the ambient air. As explained above, the liquid refrigerant in the evaporator coil arrangement 404 undergoes phase conversion and as the air from the condensation fins 700 flows over the evaporator coils 404 and comes into thermal contact with the evaporator coil arrangement 404, the refrigerant inside the evaporator coil arrangement 404 absorbs heat from the air as the refrigerant changes from liquid-state to gaseous-state, and as a

result, making the air cool or cold and cold air is created as it departs the evaporator 400.

5 The (hot) gas refrigerant from the evaporator coil arrangement 404 is directed to a return pipe 406 to the accumulator exchange 804 which ensures that only refrigerant in gas-state is returned to the compressor 200 via the compressor inlet 204 to be recycled to the condenser 300 for condensation to dissipate away the heat.

10 As shown in Figure 4, the expansion valve 806 is connected to a dry bulb sensor 814 which is located between the evaporator 400 and the accumulator exchanger 804 and specifically, in the return pipe 406 just prior to the accumulator exchanger 804. The thermostatic dry bulb sensor 816 for the thermostatic expansion valve 506 is co-located with the dry bulb sensor 814 and is communicatively coupled to the thermostatic expansion valve 506 via a first sensor line 820. The dry bulb sensor 814 is
15 communicatively coupled to the expansion valve 806 via a second sensor line 818. The thermostatic dry bulb sensor 816 and the dry bulb sensor 814 are arranged to control respectively the thermostatic expansion valve 506 and the expansion valve 806 in order to regulate or optimize the flow of the liquid refrigerant from the dehydrating device 802 to the optimizing device 500 and the evaporator 400. For example, the dry
20 bulb sensor 814 may control the expansion valve 806 to change size of the orifice or boiling point values. Also, the opening of the thermostatic expansion valve 506 is 30% smaller than the opening of the expansion valve 806.

25 The air conditioning apparatus 100 further includes an air handler 900 also driven by the motor 600. The air handler 900 includes a compartment 902, a vacuum suction device (not shown) enclosed within the compartment for drawing the cold air into the compartment 902 via air vents 904 and a blower (not shown) for blowing the cold air in the compartment 902 out of the air conditioning apparatus 100 and into the room to be cooled.

30 It would be appreciated that the temperature of the cold air from the evaporator 400 may be adjusted by a conventional controller.

35 As it can be appreciated, the condenser 300 is able to improve the efficiency of the air conditioning apparatus 100 since the condenser 300 isolates the condenser coil arrangement 310 within the channels 312 and thus, dissipating the heat from the gas

refrigerant is more effective. Further, the air to be cooled is also used to remove secondary heat as the air flow over the channels. With the above arrangement, it is also possible to arrange the condenser 300 beside or adjacent to the evaporator 400 or in this embodiment, directly beside the absorbent 700 to achieve a compact and self-contained air conditioning apparatus 100. For example, to cool an office area of 500m², the motor 600 power should be rated about 7.5hp with the open drive compressor 200 at 10hp, and 25 Tons x 12000BTU and air flow rate volume of 2400 CmH, the size of the air conditioning apparatus 100 is about 6x5x2 ft. Further, with the motor 600 being used to drive the compressor 200 and the air blower 608 for generating the air for dissipating the primary heat from the condenser coil arrangement 310, this achieves energy savings and also saves space, making the air conditioning apparatus 100 more compact.

The described embodiments are not to be construed as limitative. For example, the condenser 300 may be retrofitted to an existing air conditioning system or air handling unit (AHU) to obviate installing a remote condenser at a distance away from the evaporator 400. In other words, the condenser 300 may be used without the optimizing device 500 and the other components described in the first embodiment. Also, the absorbent may not be necessary and the air from the condenser 300 may be directly flowed to the evaporator 400 for cooling.

Having now fully described the invention, it should be apparent to one of ordinary skill in the art that many modifications can be made hereto without departing from the scope as claimed.

CLAIMS

1. An air-cooled condenser for an air conditioning apparatus, the condenser comprising
 - 5 a condenser coil arrangement for condensing a refrigerant from a gaseous state to a liquid state;
 - a plurality of elongate channels for enclosing the condenser coil arrangement, the plurality of elongate channels being spaced from each other to create air gaps therebetween;
 - 10 an air intake opening for directing air into the plurality of elongate channels for dissipating heat from the condenser coil arrangement to produce heated air within the plurality of elongate channels;
 - an air discharge outlet for discharging the heated air out of the condenser;
 - a casing for housing the plurality of channels, the casing having a condenser air intake portion for taking in ambient air for flowing through the air gaps;
 - 15 a condenser air outlet portion for releasing the ambient air from the condenser air intake portion out of the condenser for cooling by an evaporator.
2. An air-cooled condenser according to claim 1, wherein each channel is
 - 20 configured to enclose two parallel segments of the condenser coil arrangement.
3. An air-cooled condenser according to claim 1 or 2, further comprising a replaceable front cover for attaching to the casing, the air intake opening being disposed on the front cover.
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4. An air-cooled condenser according to any preceding claim, further comprising a replaceable back cover for attaching to the casing, the air discharge outlet being disposed on the back cover.
5. A method of retrofitting an air-cooled condenser according to any preceding claim to an air conditioning apparatus, the method comprising,
 - 30 locating the air-cooled condenser adjacent an evaporator of the air conditioning apparatus,
 - coupling the air intake opening to a blower outlet of an air blower;
 - 35 coupling an inlet of the condenser coil arrangement to a compressor of the air conditioning apparatus; and

coupling an outlet of the condenser coil arrangement to the evaporator via an expansion valve.

6. An air conditioning apparatus comprising
 - an air-cooled condenser according to any of claims 1 to 4;
 - an evaporator disposed adjacent the air-cooled condenser;
 - a compressor for receiving the gaseous-state refrigerant from the evaporator and compressing the gaseous-state refrigerant for delivery to the condenser.
7. An air conditioning apparatus according to claim 6, further comprising an absorbent sandwiched between the air-cooled condenser and the evaporator; wherein the ambient air released from the condenser flows through the absorbent prior to being cooled by the evaporator.
8. An air conditioning apparatus according to claim 6 or 7, wherein the absorbent includes polymer fins.
9. An air conditioning apparatus according to any of claims 6-8, further comprising an air blower coupled to the air intake opening of the air-cooled condenser.
10. An air conditioning apparatus according to claim 9, wherein the air blower is driven by a compressor motor, which is operable also to drive the compressor.
11. An air conditioning apparatus according to any of claims 6-10, further comprising an optimizing device for controlling the flow of the liquid-state refrigerant from the condenser to an expansion valve which regulates the flow to the evaporator.
12. An air conditioning apparatus according to claim 11, further comprising a distributor for distributing the flow of the liquid-state refrigerant from the expansion valve to a number of inlets of an evaporator coil arrangement of the evaporator.
13. An air conditioning apparatus according to any of claims 6 to 12, further comprising an air handler having a compartment and a vacuum suction device for drawing the cooled air from the evaporator into the compartment.

14. An air conditioning apparatus according to claim 13, wherein the air handler includes a blower for blowing the cooled air in the compartment of the air handler out of the air conditioning apparatus' housing.
- 5 15. An optimizing device for an air conditioning apparatus, comprising
a first control valve arranged to regulate flow of liquid-state refrigerant from a condenser into the chamber;
a second control valve arranged to regulate a preset flow of gaseous-state refrigerant from an evaporator into the chamber;
- 10 a chamber for mixing the liquid-state refrigerant and gaseous-state refrigerant to enable the liquid-state refrigerant to be converted to vapour;
wherein the vapour is arranged to be directed to a compressor together with the gaseous-state refrigerant from the evaporator.
- 15 16. An optimizing device according to claim 15, further comprising
a liquid check valve in fluid communication with the first control valve to enable a portion of the liquid refrigerant to be directed to the liquid check valve;
a bypass liquid line coupled to the liquid check valve;
a spray nozzle coupled to the bypass liquid line and arranged to generate a
- 20 spray of the liquid refrigerant to direct the liquid refrigerant flowing into the first control valve towards the chamber's base.
17. An optimizing device according to claim 15 or 16, further comprising a membrane for extracting oil from the mixture of liquid-state and gaseous-state.
- 25 18. An optimizing device according to claim 17, further comprising an oil check valve arranged to direct the extracted oil to an oil sump of a compressor.
19. An optimizing device according to any of claims 15-18, further comprising a dry bulb sensor for sensing a parameter of the gaseous-state refrigerant from the evaporator and arranged to trigger opening or closing of the first control valve to regulate the flow of the liquid-state refrigerant.
- 30 20. An air conditioning apparatus comprising an optimizing device according to any of claims 15 to 19.
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