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(54) Free-draining evaporator for refrigeration system.

(57) A refrigeration system has a high efficiency free-draining evaporator incorporated therein. Refrigerant compressed by a compressor and condensed by a condenser flows to the evaporator via expansion means, such as a capillary tube. The evaporator includes a conduit having an inlet at a higher elevation than an outlet. The conduit is free from obstructions and portions which can inhibit free gravitational drainage of the liquid phase of refrigerant flowing from the evaporator into a phase separator positioned below the evaporator.

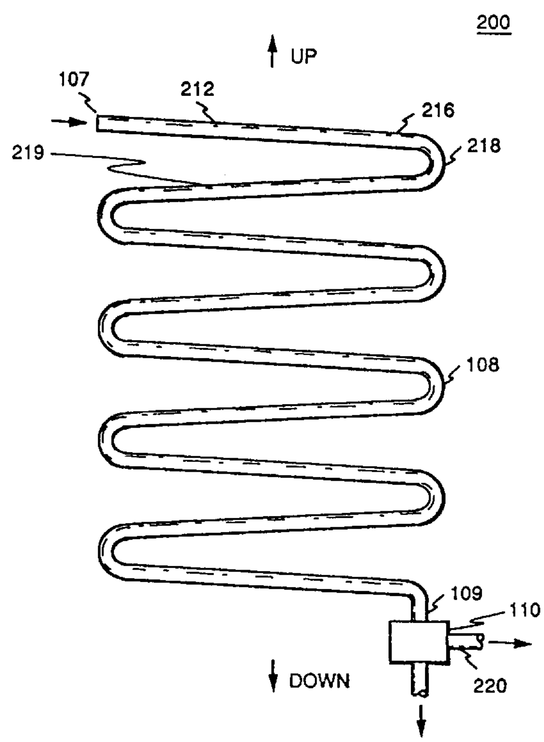

FIG. 2

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Field of the Invention

The present invention generally relates to refrigeration systems, and more particularly relates to placement of a free-draining evaporator and a phase separator in a multievaporator refrigeration system to increase the efficiency thereof.

Background of the Invention

In a typical refrigeration system, refrigerant circulates continuously through a closed circuit. The term "circuit", as used herein, refers to a physical apparatus whereas the term "cycle" as used herein refers to operation of a circuit, e.g., refrigeration cycles in a refrigeration circuit. The term "refrigerant", as used herein, refers to refrigerant in liquid, vapor and/or gas form or phase. Components of the closed circuit cause the refrigerant to undergo temperature/pressure changes. The temperature/pressure changes of the refrigerant result in energy transfer.

Typical components of a refrigeration system include, for example, compressors, condensers, evaporators, expansion valves, phase separators, control valves, and connecting piping all connected or coupled in a refrigerant flow relationship. The terms "coupled" and "connected" are used herein interchangeably. When two components are coupled or connected, this means that the components are linked directly or indirectly in some manner in refrigerant flow relationship, even though another component or components may be positioned between the coupled or connected components. For example, even though other components, such as a phase separator or an expansion valve, are connected or coupled in the link between the compressor and evaporator, the compressor and evaporator are still coupled or connected.

In some apparatus utilizing refrigeration systems, more than one area needs to be refrigerated, and at least one area requires more refrigeration than another area. A typical household refrigerator, which includes a freezer compartment and a fresh food compartment, is one example of such an apparatus. The freezer compartment is preferably maintained between -25° and -10°C, and the fresh food compartment is preferably maintained between +1° and +10°C.

This household refrigerator example is provided for illustrative purposes only. Many devices other than household refrigerators utilize refrigeration systems which include an evaporator operating at a temperature below a temperature at which the evaporator actually needs to operate.

To meet these temperature requirements, a typical high efficiency multievaporator refrigeration system, described in commonly assigned U.S. Patent 4,910,972 which is incorporated herein by reference, includes a first compressor coupled to a first evaporator operating at about -25°C (an actual range of about -35° to -20°C is typically used) for cooling the freezer of a typical household refrigerator and a second compressor coupled to a second evaporator operating at about +5°C for cooling the fresh food compartment of the typical household refrigerator. A phase separator connected in a refrigerant flow relationship between the two evaporators separates the gaseous phase from the liquid phase of the refrigerant used in the refrigeration system and also stores an excess inventory of the liquid refrigerant. Such a system utilizing a dual evaporator two stage cycle uses much less mechanical energy then a typical single evaporator system.

Even though multievaporator refrigeration systems significantly improve the efficiency of refrigeration, further improvements can be made by reducing the amount of liquid refrigerant generally present in the evaporators used therein. Liquid refrigerant, when present in excess in evaporators, cools the respective refrigerator compartments more than the required settings. Additionally, an extra charge of refrigerant is generally provided to compensate for the portion of the liquid refrigerant which is held in the evaporator and is therefore unavailable, thereby increasing the cost of the refrigeration system. Furthermore, the presence of this extra refrigerant leads to increased wear and tear of the refrigeration system components, such as a compressor.

One approach is disclosed in commonly assigned U.S. Patent 5,134,859, which provides an accumulator used for storing excess liquid refrigerant. The accumulator is positioned at the exit end of a lower temperature evaporator, such as an evaporator used for cooling a freezer section of a typical household refrigerator.

Statement of the Invention

The present invention is directed to an improvement in a refrigeration system having a compressor coupled to a condenser and a phase separator coupled to said evaporator and said condenser, whereby said evaporator comprises a conduit having an inlet connected to said condenser to receive refrigerant discharged from said condenser and an outlet connected to said phase separator, and whereby said phase separator is positioned below said conduit to gravitationally drain a substantial part of the liquid phase of said refrigerant from said outlet into said phase separator, said inlet being at a higher elevation than said outlet and said conduit being free from obstructions and portions which can inhibit gravitational drainage of said liquid phase

The present invention is also directed to a refrigerator comprising:

compressor means;

condenser means connected in a refrigerant flow relationship with said compressor means for condensing refrigerant discharged from said compressor means;

a fresh food compartment;

first evaporator means for refrigerating said fresh food compartment and having an inlet connected to said condenser means to receive refrigerant discharged from said condenser means and an outlet connected to phase separator means positioned below said first evaporator means to gravitationally drain a substantial part of the unevaporated liquid phase of said refrigerant from said outlet into said phase separator means, said first evaporator means comprising a conduit free from any portion which can inhibit said gravitational drainage of said liquid phase of the refrigerant;

a freezer compartment;

second evaporator means for refrigerating said freezer compartment and connected to receive at least part of the refrigerant discharged from said phase separator means; and

a refrigerant flow switching valve for alternately conveying refrigerant from either said first or said second evaporator means to said compressor means of said refrigerator.

In an embodiment of the refrigerator, said evaporator is one in a multi-evaporator system.

In an embodiment of the refrigerator, in use, the fresh food compartment is maintained at a temperature warmer than said freezer compartment.

Brief Description of the Drawings

FIGURE 1 illustrates a refrigeration system incorporating a free-draining evaporator of the present invention.

FIGURE 2 represents a free-draining evaporator of the preferred embodiment.

FIGURE 3 represents a block diagram of a household refrigerator incorporating a refrigeration system having a free-draining fresh food evaporator and a freezer evaporator.

Detailed Description of the Preferred Embodiment

The present invention is believed to have its greatest utility in refrigeration systems and particularly in household refrigerator freezers. However, it also has utility in other refrigeration applications such as control of multiple air conditioner units. The term refrigeration systems, as used herein, therefore not only refers to refrigerator/freezers but also to many other types of refrigeration applications.

FIGURE 1 illustrates a refrigeration system 100 in accordance with the preferred form of the invention. Refrigeration system 100 includes a compressor unit 102 coupled to a condenser 104, which condenses a substantial part of refrigerant used in refrigeration system 100. A first expansion means, such as capillary tube 106, is coupled to the outlet of condenser 104 and inlet 107 of first evaporator 108, also known as a high pressure evaporator. Inlet 107 is positioned at a higher elevation than outlet 109 of first evaporator 108 and said first evaporator is preferably configured so as to slope downward at all points, as shown. The expansion of a portion of the condensed or liquid refrigerant exiting from capillary tube 106 and first evaporator 108 produces a temperature drop in the refrigerant flowing therethrough. The refrigeration effect is preferably captured by blowing air across first evaporator 108 into a fresh food compartment (not shown) of refrigeration system 100 when used as a household refrigerator. First evaporator 108 comprises a conduit free from obstructions and portions that can inhibit free flow of the refrigerant in the liquid phase passing therethrough.

Outlet 109 of first evaporator 108 is then coupled to the inlet of a phase separator 110 positioned below outlet 109 such that a substantial portion of the liquid refrigerant can be readily drained through the force of gravity from first evaporator 108 into phase separator 110. Phase separator 110 includes a screen 112 disposed adjacent to the inlet of phase separator 110, a gas or vapor phase-containing portion 114 and a liquid phase-containing portion 116. Screen 112 prevents clogging of the conduits of the refrigeration system by trapping dirt or sediment passing therethrough. Although sometimes referred to herein as vapor-containing portion 114 or simply as vapor portion 114, it should be understood that this portion of phase separator 110 may have gas and/or vapor disposed therein.

Vapor portion 114 is coupled by conduit 120 to supply a high pressure refrigerant as a first input to refrigerant flow switching valve 118. Particularly, the intake of conduit 120 is so positioned in vapor portion 114 that liquid refrigerant passing through vapor portion 114 to liquid-containing portion 116 does not enter said intake. The outlet of liquid-containing portion 116 is coupled to second expansion means 122, such as an expansion valve or a capillary tube. Second expansion means 122 is sometimes referred to herein as a throttle. Inlet 123 of second evaporator 124, also known as a low pressure evaporator, is coupled to the outlet of second expansion means 122, and outlet 125 of second evaporator 124 is coupled to provide a low pressure refrigerant as a second input to refrigerant flow switching valve 118.

The expansion of substantially all of the condensed refrigerant in second expansion means 122 and second evaporator 124 produces a temperature drop in the refrigerant flowing therethrough. The refrigeration effect is preferably captured by blowing air across second evaporator 124 into a freezer compartment (not shown) of refrigeration system 100 when used as a household refrigerator. Second evaporator 124 preferably has the same physical structure as first evaporator 108.

Thermostat 127, which is preferably user adjustable, receives current flow from an external power source designated by the legend "POWER IN" and is connected to compressor unit 102. When cooling is required, thermostat 127 provides an output signal which activates compressor unit 102 to cause a "refrigeration cycle on" condition. When the desired temperature in, for example, the freezer compartment is reached no more cooling is required and thermostat 127 provides an output signal which deactivates compressor unit 102 to a "refrigeration cycle off" condition. In a household refrigerator, for example, thermostat 127 is preferably located in the freezer compartment.

Capillary tube 106 is shown in thermal contact with conduit 120 which connects phase separator vapor portion 114 with refrigerant flow switching valve 118. Capillary tube 106 is also in thermal contact with conduit 130 which couples second evaporator 124 to refrigerant flow switching valve 118. Thermal contact is achieved, for example, by soldering the exterior of capillary tube 106 and a portion of the exterior of conduits 120 and 130 together side by side. Capillary tube 106 in FIGURE 1 is shown as being wrapped around conduits 120 and 130 in a schematic representation of a heat transfer relationship. The heat transfer occurs in a counterflow arrangement, i.e., the refrigerant flowing in capillary tube 106 proceeds in a direction opposite to the flow of refrigerant in conduits 120 and 130. As is well known in the art, a counterflow heat exchange arrangement increases the heat exchange efficiency in comparison to a heat exchange arrangement wherein the flows proceed in the same direction,.

In operation, and by way of example, first evaporator 108 contains refrigerant at a temperature of approximately -5°C. Second evaporator 124 contains refrigerant at a temperature of approximately -25°C. Second expansion means 122 is adjusted to provide barely superheated vapor flow at the outlet of second evaporator 124. Preferably all the refrigerant exiting from outlet 125 of second evaporator 124 is in gaseous form.

Switching valve 118 controls the flow of refrigerant passing through respective evaporators 108 and 124 to compressor unit 102. When refrigeration is called for, thermostat 127 activates compressor unit 102. Vapor from second evaporator 124 enters compressor unit 102 when switching valve 118 is configured to allow conduits 130 and 132 to be in flow communication. Alternatively, vapor from phase separator 110 enters compressor unit 102 when switching valve 118 is configured to allow conduits 120 and 132 to be in flow communication. For ease of reference, when switching valve 118 is configured to provide flow communication between conduits 130 and 132, or similarly disposed conduits, this condition is hereinafter referred to as STATE 1. When switching valve 118 is configured to provide flow communication between conduits 120 and 132, or similarly disposed conduits, this condition is hereinafter referred to as STATE 2.

In the exemplified operation, and using refrigerant R-12 (dichlorodifluoromethane), refrigerant at about 1.4 kg./cm.^{2} absolute is disposed in conduits 130 and 131, and refrigerant at about 2.8 kg./cm.^{2} absolute is disposed in conduits 120 and 121. The inlet pressure to compressor unit 102 is about 1.4 kg./cm.^{2} when switching valve 118 is in STATE 1 and about 2.8 kg./cm.^{2} when switching valve 118 is in STATE 2. Switching valve 118, operated by utilizing this pressure difference between STATE 1 and STATE 2, is more fully described in commonly assigned U.S. Patents 5,156,016 and 5,184,473, both of which are incorporated herein by reference.

More particularly, when thermostat 127 activates compressor unit 102, such as when the temperature of the freezer compartment rises above some predetermined set temperature, high pressure gas at high temperature discharged from the compressor unit 102 is condensed in condenser 104. Capillary tube 106 is preferably sized to obtain some subcooling of the liquid exiting condenser 104. Subcooling is defined as cooling of a given fluid below its saturation temperature. By subcooling a fluid, more heat can be removed by the refrigeration system. Capillary tube 106 is generally a fixed length, small bore tube. Due to the small tube diameter of capillary tube 106, a high pressure drop occurs across the capillary tube length thus reducing the pressure of the refrigerant to its saturation pressure. Some of the refrigerant evaporates in the capillary tube 106 and at least some of the refrigerant evaporates in first evaporator 108 and changes to a vapor. Capillary tube 106 meters the flow of refrigerant and maintains a pressure difference between condenser 104 and first evaporator 108.

The direct contact between the outside of capillary tube 106, into which the warm condensed liquid from condenser 104 enters, and the outside of conduit 120 from phase separator 110 causes cooler conduit 120 to warm up and capillary tube 106 to cool down. Without the heating provided by capillary tube 106, the temperatures for conduits 120 and 130 in STATE 1 and STATE 2, respectively, in the preferred embodiment are about -25° and -5°C, respectively. Additionally, without the heating provided by capillary tube 106, moisture from air at room temperature will condense on conduits 120 and 130. Such condensed moisture tends to drip and create a flooding problem. Conduit heating by means of capillary tube 106 warms conduits 120 and 130 sufficiently to avoid condensation and also cools the refrigerant in capillary tube 106 flowing to first evaporator 108. Even though the warming of refrigerant in conduits 120 and 130 adversely affects system efficiency, the beneficial effect provided by the cooling of refrigerant in capillary tube 106 far outweighs such a loss of efficiency.

The expansion of the liquid refrigerant in first evaporator 108 causes a part of the liquid refrigerant to evaporate. Refrigerant in the liquid and vapor phases exiting from first evaporator 108 then enters phase separator 110. The liquid refrigerant accumulates in liquid-containing portion 116 and vapor accumulates in vapor portion 114 of phase separator 110. By gravitational draining of the liquid refrigerant from first evaporator 108 into phase separator 110, the unevaporated liquid head in first evaporator 108 is significantly reduced. Such a liquid head is typically present in the evaporators of conventional refrigerator systems. Conduit 120 supplies vapor from vapor portion 114 to switching valve 118. The vapor from phase separator 110 is generally at about -5°C.

When thermostat 127 activates compressor unit 102, and when valve 118 is in STATE 1, liquid from liquid-containing portion 116 of phase separator 110 evaporates as it flows through throttle 122 into second evaporator 124. Thus, the temperature and pressure of refrigerant entering second evaporator 124 from throttle 122 significantly drop and any remaining liquid refrigerant evaporates in second evaporator 124, which further cools second evaporator 124 to about -25°C. As previously stated, refrigerant flows, albeit slowly, through first evaporator 108 when valve 118 is in STATE 1. A sufficient refrigerant charge is typically supplied to system 100 to maintain the liquid refrigerant in phase separator 110 at the desired level. However, by gravitationally draining the liquid phase refrigerant from first evaporator 108, the amount of refrigerant charge required to achieve the same refrigeration efficiency is reduced by a factor of two. For example, a conventional dual evaporator refrigeration system requires a charge of about 570-650 grams of refrigerant. By comparison, the dual evaporator refrigeration of the present invention requires only about 310 grams of refrigerant. Such a significant reduction in a refrigerant charge improves system efficiency as well as reducing system cost.

The pressure at the input of compressor unit 102 when valve 118 is in STATE 1 is determined by the pressure at which refrigerant exists in a two-phase equilibrium at -25°C. The pressure at compressor unit 102 when valve 118 is in STATE 2 is determined by the saturation pressure of refrigerant at -5°C.

The temperature of condenser 104 has to be greater than ambient temperature for condenser 104 to function as a condenser. The refrigerant within condenser 104, for example, may be at +40°C. The pressure of refrigerant in condenser 106, of course, depends upon the refrigerant selected.

Compressor unit 102 may be any type of compressor or mechanism which provides a compressed refrigerant output. For example, compressor unit 102 may be a single stage compressor, a plurality of compressors, a compressor having a plurality of stages, or any combination of compressors. Compressor unit 102 may be, for example, a rotary or reciprocating type compressor. A compressor with a small volume inlet chamber is preferred since gases at two different pressures are alternately being compressed. For example, a rotary compressor with an inlet chamber volume of one cubic inch that gets compressed to 4.6 $cm.^2$ per compressor revolution is satisfactory. If a compressor with a large inlet chamber is used, there is a substantial delay between the time when the high pressure refrigerant stops flowing to the compressor and the time when the inlet compressor pressure is reduced sufficiently to start compressing the lower pressure refrigerant. Using a large inlet chamber also reduces system efficiency.

The refrigeration system 100 illustrated in FIGURE 1 requires less energy than a dual evaporator, single-compressor circuit with the same cooling capacity. Some efficiency advantages come about due to the fact that only about half the amount of refrigerant needs to be pumped through the system. Furthermore, once first evaporator 108 attains its equilibrium temperature, the liquid phase refrigerant continually drains into phase separator 110, thereby being made available to cool second evaporator 124 and during the "refrigeration cycle off" condition, all the excess liquid phase refrigerant drains into phase separator 110 and is then immediately made available to second evaporator 124 at the start of the next "refrigeration cycle on" condition without producing the delay inevitably present in a conventional dual evaporator refrigeration system. Another improvement in the refrigeration efficiency results from the absence of the evaporation of the liquid phase refrigerant during the "refrigeration cycle off" condition in first evaporator 108. Such evaporation needlessly increases cooling of first evaporator 108 when it is neither needed nor called for by the system control.

FIGURES 2A and 2B illustrate, in more detail, a preferred embodiment of the invention utilized in the multievaporator refrigeration system described in FIGURE 1, with like elements having the same reference numerals. Referring now to FIGURE 2, there is shown evaporator/phase separator assembly 200 comprising evaporator 108 having inlet 107 and outlet 109 coupled to phase separator 110 positioned below evaporator 108. Evaporator 108 is oriented as shown by "UP" and "DOWN" arrows in FIGURE 2, in such a way that outlet 109 is positioned at a lower elevation than inlet 107. A substantially vertical orientation is preferred.

Evaporator 108 has no obstruction or portion that would inhibit free drainage due to the force of gravity of substantially all of the liquid phase refrigerant flowing through said evaporator. It preferably comprises a conduit continually sloped from inlet 107 to outlet 109, as shown. Rung portion 212 of the conduit that forms evaporator 108 between inlet 107 and point 216 is shaped to position inlet 107 at a higher elevation than or the same elevation as point 216. Similarly, any point on curved portion 218 is at a higher elevation than any point on rung portion 219. This geometry results in a conduit free from obstructions and portions in which the liquid phase refrigerant may accumulate. Such a geometry is repeated throughout the rung portions of evaporator 108. Preferably, any downstream point on the conduit of evaporator 108 is below any upstream adjacent point.

FIGURE 3 is a block diagram illustration of a household refrigerator 300 including insulated wall 302 forming fresh food compartment 304, discussed earlier, and freezer compartment 306. FIGURE 3 is provided for illustrative purposes only, particularly to show one apparatus which has substantially separate compartments which require refrigeration at different temperatures. In the household refrigerator, fresh food compartment 304 and freezer compartment 306 are typically maintained at about +1 to +10° and -25° to -10°C, respectively.

In accordance with the present invention, first evaporator 108 (high pressure evaporator) is shown located in fresh food compartment 304 and second evaporator 124 (low pressure evaporator) in freezer compartment 306. Phase separator 110 is positioned below first evaporator 108. The location of the evaporators shown in FIGURE 3 is only for illustrative purposes and to facilitate ease of understanding and the present invention is not limited to the physical location of the evaporators, provided first evaporator 108 is oriented to achieve free drainage of the liquid refrigerant therefrom into phase separator 110. It is contemplated that the evaporators 108 and 124 could be located anywhere in the refrigerator or even outside the refrigerator with the evaporator-cooled air from each evaporator directed to the appropriate compartment via conduits, barriers and the like.

First and second evaporators 108 and 124 are respectively driven by compressor unit 102 and condenser 104 shown located in compressor/condenser compartment 316. Control knob 318 is located in fresh food compartment 304 and temperature sensor 320 is disposed in freezer compartment 306. Control knob 318 controls the temperature in compartment 304 and it may be calibrated to read in gradations of temperature desired therein. The operational features of control knob 318 are described in the aforementioned commonly assigned U.S. Patents 5,156,016 and 5,184,473. Temperature sensor 320 sends a signal to compressor 312 to run or stop according to its setting. First evaporator 308 is typically operated at about -10° to 0°C and the second evaporator 310 at about -35° to about -20°C to maintain fresh food compartment 304 at about +1 to +10° and freezer compartment 306 at about -25° to -10°C.

In operation, and by way of example, when control knob 318 of a typical household refrigerator of 0.54 m.3 capacity is set at +3°C in fresh food compartment 304, that setting corresponds to a refrigerant temperature of about -4°C and pressure of about 3.2 kg./cm.^{2} absolute in first evaporator 308. As compressor unit 102 evacuates first evaporator 108, part of the refrigerant present in evaporator 108 boils and thereby lowers the pressure and the temperature of the refrigerant present in first evaporator 108 to about 2.5 kg./cm.^{2} absolute and about -6°C, respectively.

During a typical cycle of about 21 seconds under the aforedescribed exemplary refrigerator conditions, the high pressure refrigerant from evaporator 108 is transported to compressor unit 102 by valve 118 for about 5 seconds and the low pressure refrigerant from evaporator 124 is transported to compressor unit 102 for about 16 seconds. The allocation of conveying time between the high pressure and the low pressure refrigerant to compressor unit 102 is a function of the cooling capacity of first evaporator 108 and second evaporator 124. The capacity ratio between first evaporator 108 and second evaporator 124 for the aforedescribed refrigerator is about 3:1. Capacity ratio is defined as a ratio of the heat removing capacity in kcal. per hour of first evaporator 108 to that of second evaporator 124. Cycling of valve 118 continues until the temperature set on thermostat 320 in freezer compartment 306 is reached; at that time, compressor unit 102 shuts down until a further demand signal from thermostat 320 is received.

Control knob 318 and sensor 320 are preferably user adjustable so that the user selects a temperature, or temperature range, at which each evaporator is to be activated and inactivated. In this manner, operation of the system is adjusted by the user.

As shown in FIGURE 3, the illustrative refrigeration system includes two evaporators which are selected to operate at desired refrigeration temperatures. However, the invention can also employ more than two evaporators. Reduced energy use is provided by utilizing a plurality of evaporators.

It is contemplated that in some refrigeration systems, all of the energy efficiencies and reduced costs provided by the present invention may not be strictly necessary. Thus, the invention may be modified to vary efficiency and costs relative to the described embodiments. For example, the number of rung portions of evaporator means used in the present invention, such as 212 or 219 shown in FIGURE 2, may be increased or decreased in accordance with the requirements of the refrigeration system. Furthermore, single or multiple rows of rung portions are contemplated.

Claims

1. In a refrigeration system having a compressor coupled to a condenser and a phase separator coupled to said evaporator and said condenser, the improvement whereby said evaporator comprises a conduit having an inlet connected to said condenser to receive refrigerant discharged from said condenser and an outlet connected to said phase separator, and whereby said phase separator is positioned below said conduit to gravitationally drain a substantial part of the unevaporated liquid phase of said refrigerant from said outlet into said phase separator, said inlet being at a higher elevation than said outlet and said conduit being free from obstructions and portions which can inhibit gravitational drainage of said liquid phase.

2. A refrigerator comprising:
compressor means;
condenser means connected in a refrigerant flow relationship with said compressor means for condensing refrigerant discharged from said compressor means;
a fresh food compartment;
first evaporator means for refrigerating said fresh food compartment and having an inlet connected to said condenser means to receive refrigerant discharged from said condenser means and an outlet connected to phase separator means positioned below said first evaporator means to gravitationally drain a substantial part of the unevaporated liquid phase of said refrigerant from said outlet into said phase separator means, said first evaporator means comprising a conduit free from obstructions and portions which can inhibit said gravitational drainage of said liquid phase of the refrigerant;
a freezer compartment;
second evaporator means for refrigerating said freezer compartment and connected to receive at least part of the refrigerant discharged from said phase separator means; and
a refrigerant flow switching valve for alternately conveying refrigerant from either said first or said second evaporator means to said compressor means of said refrigerator.

3. The system or refrigerator of claim 1 or 2 wherein said evaporator is one in a multi-evaporator system.

4. The refrigerator of claim 3 wherein said first evaporator means comprise a continually sloped coil of a material selected from the group consisting of copper, brass, aluminum and stainless steel.

5. The system or refrigerator of claim 3 wherein said conduit is continually sloped from said inlet to said outlet.

6. The system of claim 3 wherein said conduit has a continually sloped tubular structure.

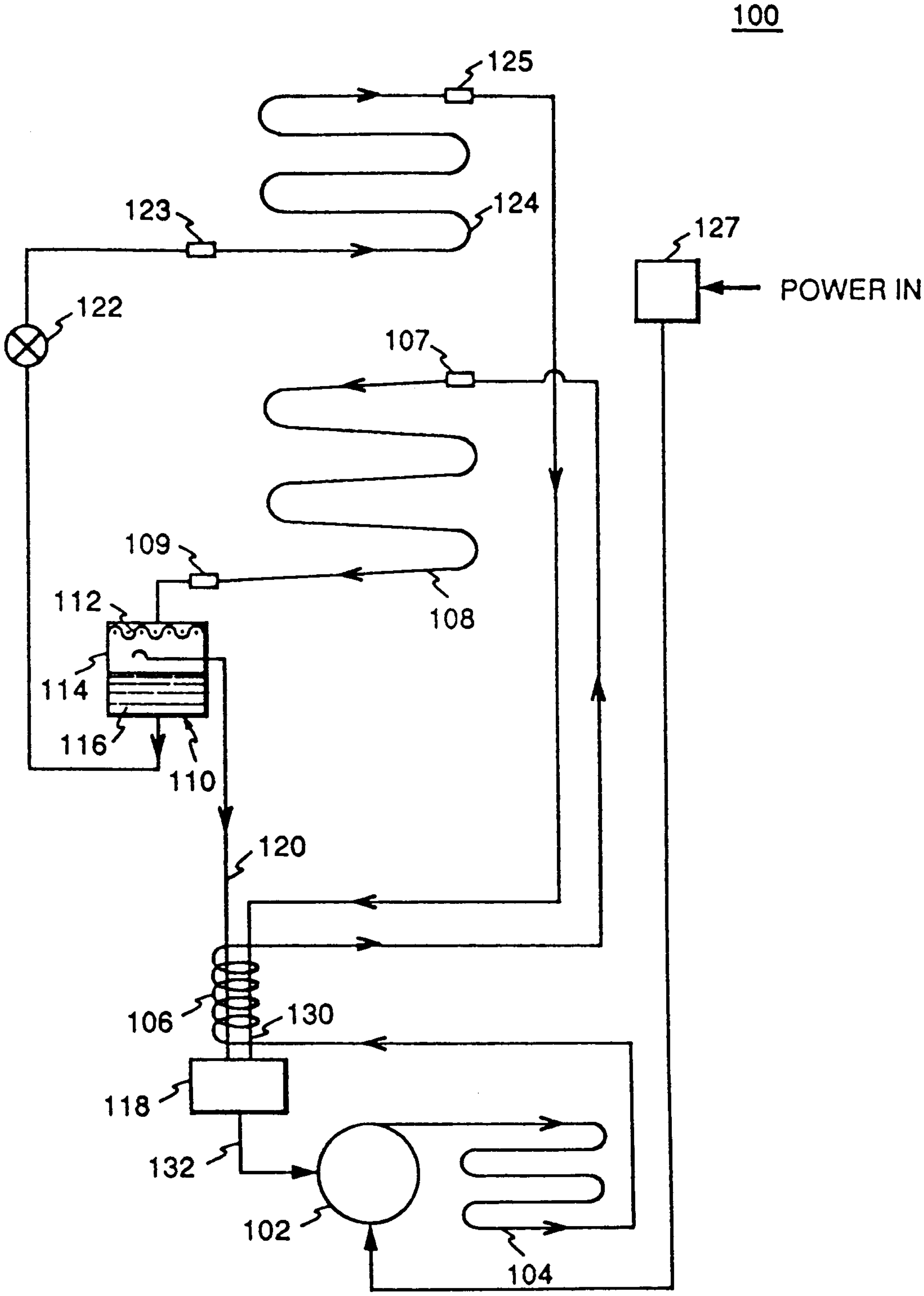
7. The refrigerator of claim 3 further comprising:
first expansion means positioned in a refrigerant flow relationship with said condenser means and said first evaporator means; and
second expansion means positioned in a refrigerant flow relationship with said phase separator means and said second evaporator means.

8. The refrigerator of claim 7 wherein said phase separator means is adapted for conveying refrigerant in the liquid phase to said second expansion means.

9. The refrigerator of claim 3 wherein said first evaporator means is effective to maintain said fresh food compartment from about +1° to about +10°C and said second evaporator means is effective to maintain said freezer compartment from about -25° to about -10°C.

10. The refrigerator of claim 3 wherein said first evaporator means is operated from about -10° to about 0°C and said second evaporator is operated from about -35° to about -20°C.

FIG. 1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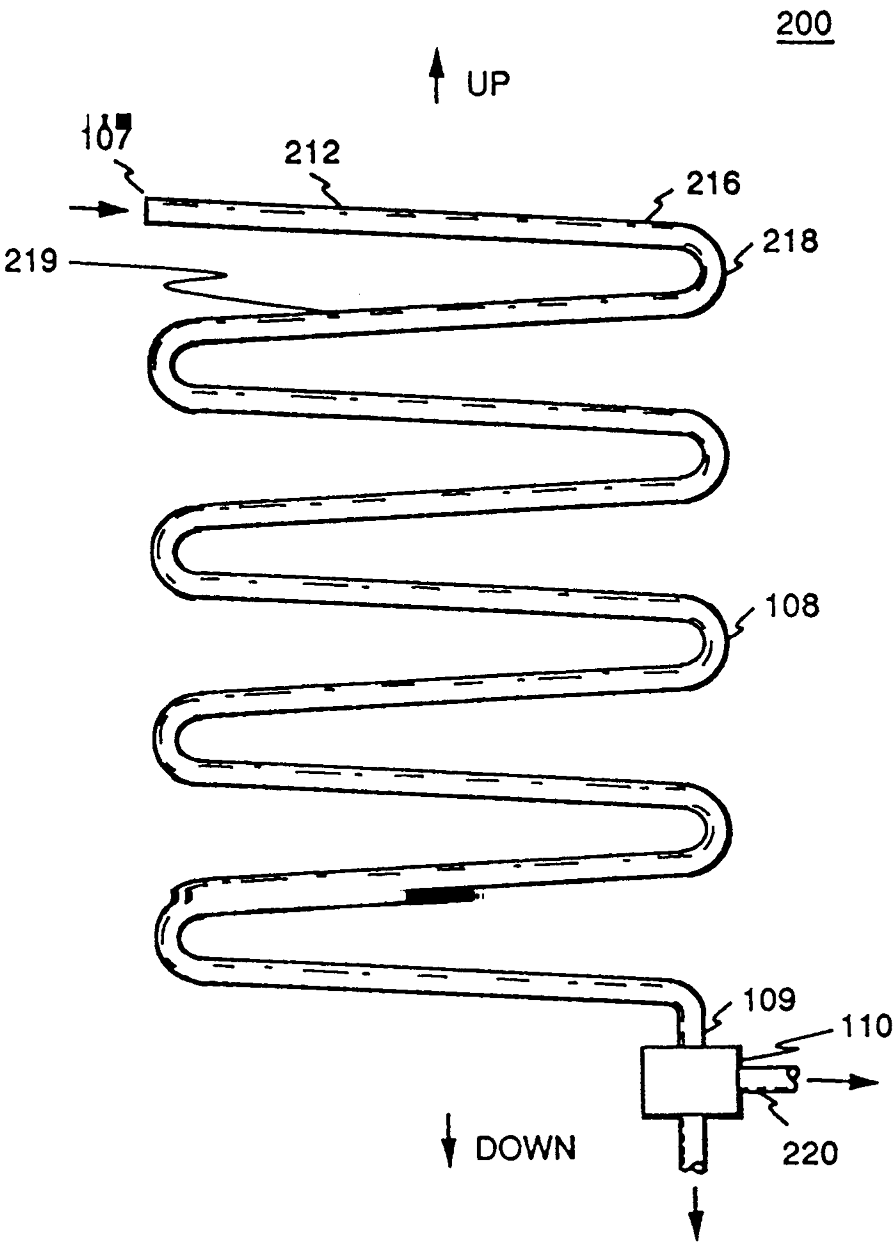
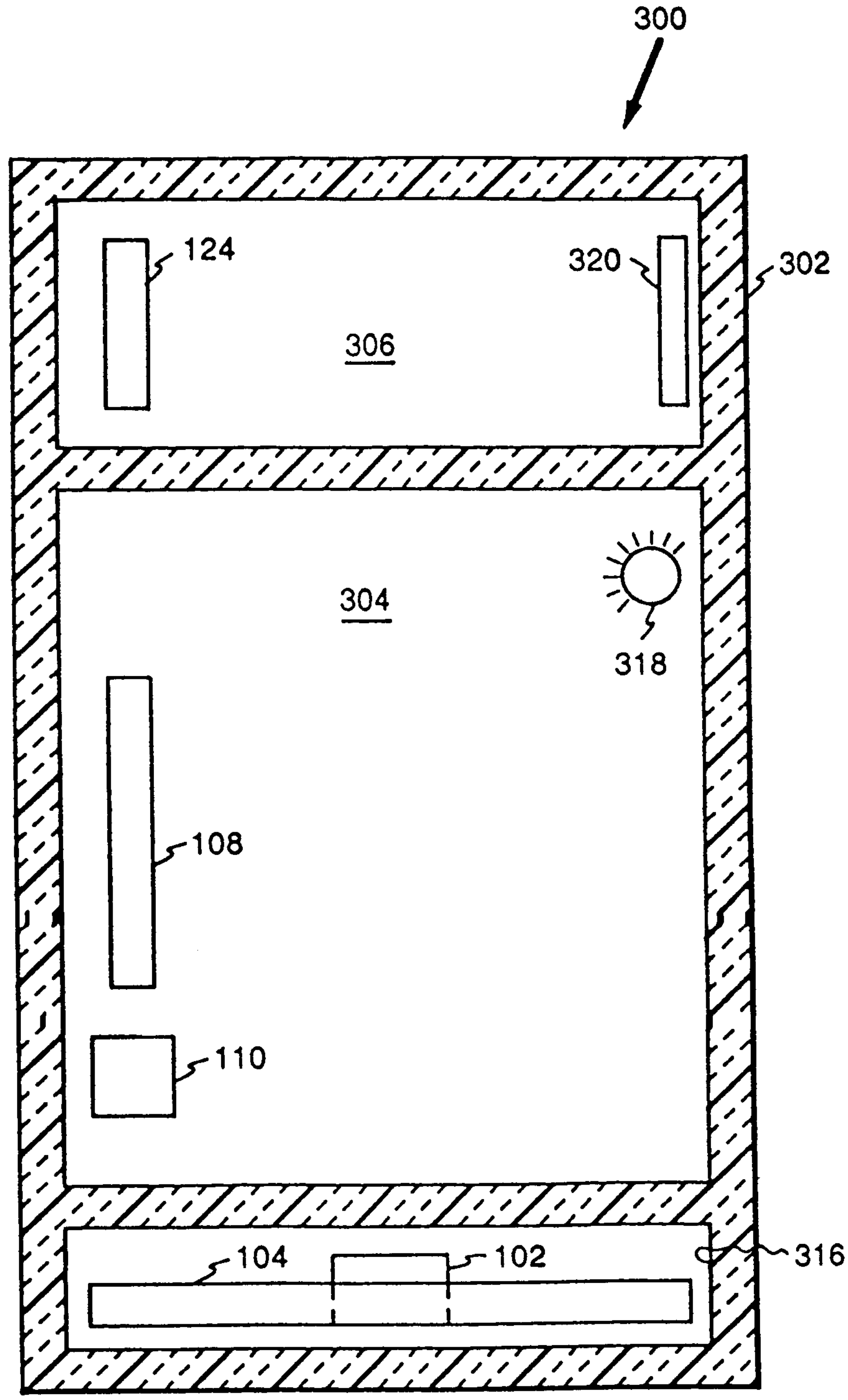


FIG. 2

FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 94 30 3202

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X Y	EP-A-0 485 147 (GENERAL ELECTRIC) * column 7, line 28 - line 31; figures 1,5 * ---	1-3 5-10	F25B41/00 F25B39/02 F25B5/04
Y	US-A-1 853 724 (DAVENPORT) * page 2, line 14 - line 110; figure 2 * ---	5-10	
E	US-A-602 371 (BOSCH-SIEMENS HAUSGERÄTE) * column 2, line 18 - column 3, line 4; figure 2 * ---	1	
A	FR-A-971 034 (UNGARISCHE RADIATOREN FABRIKS AKTIENGESELLSCHAFT) -----	1,3-6	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
F25B
F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 August 1994	Bäcklund, O

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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